



Geotechnical &
Environmental
Consultants

Our ref: D41153/PK

17th December 2021

Ashwood Homes
Lincs Gateway Business Park
1 Goodison Road
Spalding
PE12 6FY

For the attention of Mr A. Jagger

Dear Adam

Re: Ground Gas Report – Harrington Drive, Crowland

We have now completed the ground gas monitoring programme at the above site and are pleased to report as follows.

PROJECT UNDERSTANDING

We understand that the client is proposing to develop the site for a residential end-use involving the construction of low-rise residential properties, as included on the plan presented within Appendix I (Figure No. D41153/01).

PREVIOUS WORKS

The following report has previously been prepared for the site, which should be read in conjunction with this ground gas report:

- Ground Engineering Ltd. report entitled '*Site Investigation Report – Land off Harrington Drive, Crowland, Lincolnshire*', produced for Seagate Homes, Ref. C15350, dated June 2021.

In summary, the above report stated that '*Potential sources of contamination present on or beneath the site would relate primarily to; the historical use of the site; the presence of contaminated soil; and the potential presence of hazardous or ground gas beneath the site. In order to assess the risks associated with the presence of ground contamination the linkages between the sources and potential receptors to contamination need to be established and evaluated*'.

The report highlighted that a potential contaminant source at the site is '*Potential soil gas generated from made ground or naturally deposited organic soils*'. The report did not include a programme of ground gas monitoring but it concluded that '*If additional boreholes are to be undertaken, it would provide the opportunity to install gas monitoring standpipes to check on the gas regime at the site*'.

It is our understanding that Ashwood Homes have formal written reliance on the above referenced report and that piles are the preferred foundation solution for the proposed development. Based on this information and following instruction from the client, three cable percussive boreholes were recently advanced at the site (under the supervision of GeoDyne) to assist with pile design for the site.

As part of these works, a programme of ground gas monitoring was undertaken at the site in accordance with the recommendations within the above referenced report.



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GROUND GAS MONITORING PROGRAMME

Site Works

A cable percussion drilling rig was mobilised to the site on 3rd November 2021 to advance three boreholes (BH1 to BH3) at the site, to depths of either 12.50m or 14.00m below existing ground level (begl). The three completed boreholes were installed with monitoring wells to depths of 5m begl to facilitate a programme of ground gas monitoring.

A plan showing the approximate locations of the three boreholes is presented in Appendix I of this report (Figure No. D41153/01). The logs of the boreholes are presented in Appendix II of this report.

Ground Conditions

The near surface ground conditions encountered in the boreholes essentially confirmed the near surface ground conditions encountered during the previous works (by others). Drift deposits comprising Tidal Flat Deposits and Abbey Sand and Gravel were proven to variable depths of between 4.60m and 8.10m begl. These drift deposits included Clay, Sand and localised Peat.

The underlying bedrock comprised MUDSTONE of the Oxford Clay, to the base of the boreholes.

Ground Gas Monitoring Results

A total of six ground gas monitoring visits have been undertaken at the site over a six / seven week period during November and December 2021. The ground gas monitoring data obtained from the site is presented in Appendix III of this report. The ground gas monitoring results are summarised in Table 1.

TABLE 1 – SUMMARY OF GAS MONITORING DATA		
Parameter	Minimum % by volume	Maximum % by volume
Methane	0.0	0.0
Carbon Dioxide	0.3	6.6
Oxygen	14.8	20.9
Flow (l/h)	0.0	0.0

Periods of rapidly falling atmospheric pressure are considered to be the optimum barometric conditions for gas emissions from the ground. Two of the gas monitoring visits were carried out following a fall in the atmospheric pressure during the period of approximately 24 hours prior to the start of the monitoring. The remaining gas monitoring visits were undertaken when the atmospheric pressure rose in the 24 hour period prior to the start of the monitoring.

The atmospheric pressure trends are summarised below:

- 10th November 2021 – Rise of 2mb
- 15th November 2021 – Rise of 3mb
- 22nd November 2021 – Rise of 12mb
- 30th November 2021 – Fall of 6mb
- 7th December 2021 – Fall of 10mb
- 14th December 2021 – Rise of 4mb

One of the monitoring visits (7th December 2021) was undertaken following a period of relatively rapidly falling pressure, with a fall of 10mb over the 24 hours prior to monitoring. In addition, the atmospheric pressure was also noted to drop by 6mb in 3 hours immediately prior to monitoring on 7th December 2021. CLAIRE Technical Bulletin TB17 states that gas emission rates from the ground are likely to be at their highest when there are sharp falls in barometric pressure of greater than 4mb in 3 hours (i.e. recording likely 'worse-case' conditions).

The atmospheric pressure trends noted during the monitoring period do not appear to have affected the flow rates, as no flow rates were recorded during the monitoring carried out at the site. The highest carbon dioxide concentration of 6.6% by volume was recorded during the highest fall in atmospheric pressure. However, a similar carbon dioxide concentration of 6.3% by volume was recorded on the following visit when the atmospheric pressure rose by 4mb.

Water was encountered within the borehole installations during the programme of monitoring, at depths ranging between 0.60m and 2.01m begl.

Appropriate Guidance

The results of the gas monitoring have been reviewed with reference to the following documentation:

British Standard & CIRIA

The results of the gas monitoring have been reviewed with reference to the following documentation:

- British Standard BS 8485 'Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings' (2015+A1:2019).
- CIRIA Report C665 'Assessing risks posed by hazardous ground gases to buildings' (2007).
- CIRIA Report C735 'Good practice on the testing and verification of protection systems for buildings against hazardous ground gases' (2014).

BS 8485 and CIRIA Report C665 recommend a risk-based methodology to ground gas assessment, which includes the calculation of a site-specific Gas Screening Value (GSV). The GSV of a particular ground gas regime equates to:

- $GSV (L/h) = (\text{maximum borehole flow rate (L/h)} \times \text{maximum gas concentration})/100$.

The GSV should be calculated for both methane and carbon dioxide to determine a site-specific Characteristic Situation for each gas. The higher the calculated GSV, the greater the risk posed by the presence of ground gas. The CIRIA guidance document notes that '...the GSV is a guideline value and not an absolute threshold'.

The next step in the assessment process is determining the sites classification. Table 2 of BS 8485 (reproduced below) presents a total of six Characteristic Situations (CS) to assist in classification of the site, based on the calculated GSVs for methane and carbon dioxide.

Table 2 — CS by site characteristic GSV

CS	Hazard potential	Site characteristic GSV ^{A)} L/h	Additional factors
CS1	Very low	<0.07	Typically <1% methane concentration and <5% carbon dioxide concentration (otherwise consider an increase to CS2)
CS2	Low	0.07 to <0.7	Typical measured flow rate <70 L/h (otherwise consider an increase to CS3)
CS3	Moderate	0.7 to <3.5	–
CS4	Moderate to high	3.5 to <15	–
CS5	High	15 to <70	–
CS6	Very high	>70	–

^{A)} The figures used in this column are empirical.

NOTE The CS is equivalent to the characteristic GSV in CIRIA C665 [6].

In accordance with BS 8485, the CS classification for the site should be considered in conjunction with the proposed Building Type to determine the appropriate level of ground gas protection measures that should be installed to mitigate the risk posed by ground gases.

BS 8485 notes *'The Building Type is determined based the proposed construction and use of the building, together with the control of future structural changes to the building and its maintenance (the building's management) should be assessed, since potential risks posed by ground gases are strongly influenced by these factors'*.

Subject to the development proposals, each building may be categorised as a whole, or for each different part of the building.

The Building Types presented in Table 3 of BS 8485, are reproduced below.

Table 3 — Building types

	Type A	Type B	Type C	Type D
Ownership	Private	Private or commercial/ public, possible multiple	Commercial/ public	Commercial/ industrial
Control (change of use, structural alterations, ventilation)	None	Some but not all	Full	Full
Room sizes	Small	Small/ medium	Small to large	Large industrial/ retail park style

- **Type A building:** private ownership with no building management controls on alterations to the internal structure, the use of rooms, the ventilation of rooms or the structural fabric of the building. Some small rooms present. Probably conventional building construction (rather than civil engineering). Examples include private housing and some retail premises.
- **Type B building:** private or commercial property with central building management control of any alterations to the building or its uses but limited or no central building management control of the maintenance of the building, including the gas protection measures. Multiple occupancy. Small to medium size rooms with passive ventilation of rooms and other internal spaces throughout ground floor and basement areas. May be conventional building or civil engineering construction. Examples include managed apartments, multiple occupancy offices, some retail premises and parts of some public buildings (such as schools, hospitals, leisure centres) and parts of hotels.
- **Type C building:** commercial building with central building management control of any alterations to the building or its uses and central building management control of the maintenance of the building, including the gas protection measures. Single occupancy of ground floor and basement areas. Small to large size rooms with active ventilation or good passive ventilation of all rooms and other internal spaces throughout ground floor and basement areas. Probably civil engineering construction. Examples include offices, some retail premises, and parts of some public buildings (such as schools, hospitals, leisure centres and parts of hotels).
- **Type D building:** industrial style building having large volume internal space(s) that are well ventilated. Corporate ownership with building management controls on alterations to the ground floor and basement areas of the building and on maintenance of ground gas protective measures. Probably civil engineering construction. Examples are retail park sales buildings, factory shop floor areas, warehouses. (Small rooms within these style buildings should be separately categorized as Type B or Type C).

NOTE 2 Type A buildings are those where the risk of failure of the gas protection measures is likely to be most significant to the safety of the occupants and Type D buildings are those where this same risk is likely to be least significant.

Table 4 of BS 8485, reproduced below, should be used to derive the minimum level of gas protection applicable to the Building Type, based on the CS determined from the calculated GSV. The Gas protection Score in Table 4 below is used to determine the level and type of protection measures used.

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)}	$\boxed{A_1} \ 6 \ \langle A_1 \rangle$ ^{A)}	5.5	4.5
6	— ^{B)}	— ^{B)}	$\boxed{A_1} \text{ — } \langle A_1 \rangle$ ^{B)}	$\boxed{A_1} \ 6 \ \langle A_1 \rangle$

^{A)} Residential buildings should not be built on CS4 or higher sites unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g. in institutional and/or fully serviced contractual situations.

^{B)} The gas hazard is too high for this empirical method to be used to define the gas protection measures.

The appropriate level of precautions, to be designed in accordance with the point scoring system of BS 8485, should therefore be determined for the specific type of developments based on the GSV and CS of the site. These may include a combination of two or more of the following three types of protection measures, which could be used to achieve the required score:

- The structural barrier of the floor slab, or of the basement slab and walls if a basement is present;
- Ventilation measures; and
- Gas resistant membrane which may include an element of verification and potentially integrity testing.

Verification and integrity testing should be undertaken in accordance with CIRIA report C735 'Good practice on the testing and verification of protection systems for buildings against hazardous ground gases' (2014) and would be detailed in a Remediation Method Statement report in advance of construction which should be agreed with the Local Planning Authority.

The points achieved for each element of the ground gas precautions are summarised in Tables 5, 6 and 7 of the British Standard. These tables are reproduced below.

Table 5 — Gas protection scores for the structural barrier

Floor and substructure design (see Annex A)	Score ^A)
Precast suspended segmental subfloor (i.e. beam and block)	0
Cast in situ ground-bearing floor slab (with only nominal mesh reinforcement)	0.5
Cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations	1 or 1.5 ^{B)}
Basement floor and walls conforming to BS 8102:2009, Grade 2 waterproofing ^{C)} $\overline{A_1}$ ^{D)} $\overline{A_1}$	2
Basement floor and walls conforming to BS 8102:2009, Grade 3 waterproofing ^{C)} $\overline{A_1}$ ^{D)} $\overline{A_1}$	2.5

^{A)} The scores are conditional on breaches of floor slabs, etc., being effectively sealed.

^{B)} To achieve a score of 1.5 the raft or suspended slab should be well reinforced to control cracking and have minimal penetrations cast in (see [A.2.2.2](#)).

^{C)} The score is conditional on the waterproofing $\overline{A_1}$ being provided by a suitable structural barrier with the design and detailing of the walls and floor meeting the requirements for Type B protection. The score cannot be assigned for Type A (waterproof membrane) or Type C (drained cavity wall). $\overline{A_1}$

^{D)} $\overline{A_1}$ If a membrane is installed beneath and around the basement to provide Type A waterproofing (BS 8102:2009), it can be assigned a gas protection score in accordance with [Table 7](#), if it meets all the criteria for a gas resistant membrane in that table. $\overline{A_1}$

Table 6 — Gas protection scores for ventilation protection measures

Protection element/system	Score	Comments
(a) Pressure relief pathway (usually formed of low fines gravel or with a thin geocomposite blanket or strips terminating in a gravel trench external to the building)	0.5	Whenever possible a pressure relief pathway (as a minimum) should be installed in all gas protection measures systems. If the layer has a low permeability and/or is not terminated in a venting trench (or similar), then the score is zero.

Table 6 (continued)

Protection element/system	Score	Comments
(b) Passive sub floor dispersal layer:	2.5	Performance criteria for methane and carbon dioxide are shown in Figure B.6 and Figure B.7 , respectively.
Very good performance:	1.5	
Good performance:		
Media used to provide the dispersal layer are:		The ventilation effectiveness of different media depends on a number of different factors including the transmissivity of the medium, the width of the building, the side ventilation spacing and type and the thickness of the layer. The selected score should be assigned taking into account the recommendations in Annex B . Passive ventilation should be designed to meet at least "good performance", see Annex B .
• Clear void • Polystyrene void former blanket • Geocomposite void former blanket • No-fines gravel layer with gas drains • No-fines gravel layer		
(c) Active dispersal layer, usually comprising fans with active abstraction (suction) from a subfloor dilution layer, with roof level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers	1.5 to 2.5	This system relies on continued serviceability of the pumps, therefore alarm and response systems should be in place. There should be robust management systems in place to ensure the continued maintenance of the system, including pumps and vents. Active ventilation should always be designed to meet at least "good performance", as described in Annex B.
(d) Active positive pressurization by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket	1.5 to 2.5	This system relies on continued operation of the pumps, therefore alarm and response systems should be in place. The score assigned should be based on the efficient "coverage" of the building footprint and the redundancy of the system. Active ventilation should always be designed to meet at least "good performance".
(e) Ventilated car park (floor slab of occupied part of the building under consideration is underlain by a basement or undercroft car park)	4	Assumes that the car park is vented to deal with car exhaust fumes, designed to <i>Buildings Regulations 2000, Approved Document F [9]</i> .

Table 7 — Gas protection score for the gas resistant membrane

Protection element/system	Score	Comments
Gas resistant membrane meeting all of the following criteria: • sufficiently impervious $\langle A_1 \rangle$, both in the sheet material ^{A)} and in the sealing of sheets and sealing around sheet penetrations, to prevent any significant passage of methane and/or carbon dioxide through the membrane; $\langle A_1 \rangle$ • sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions; • $\langle A_1 \rangle$ Text deleted $\langle A_1 \rangle$ • sufficiently strong $\langle A_1 \rangle$ ^{B)} $\langle A_1 \rangle$ to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc); $\langle A_1 \rangle$ and to withstand in-service stresses (e.g. settlement if placed below a floor slab); $\langle A_1 \rangle$ • capable, after installation, of providing a complete barrier to the entry of the relevant gas; and • verified in accordance with CIRIA C735 [N1].	2	The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation and integrity of joints. $\langle A_1 \rangle$ Text deleted $\langle A_1 \rangle$ If a membrane is installed that does not meet all the criteria in column 1 then the score is zero.
^{A)} $\langle A_1 \rangle$ A membrane with a methane gas transmission rate $<40.0 \text{ ml/day/m}^2/\text{atm}$ (average) for sheets and joints (tested in accordance with BS ISO 15105-1:2007 manometric method) is regarded as sufficiently impervious. ^{B)} For example, reinforced LDPE (virgin polymer) membranes having a minimum mass per unit area of 370 g/m^2 and not significantly less than 0.4 mm thickness between the reinforcement scrim (tested in accordance with Procedure D (2 mm diameter tip) of BS EN ISO 9863-1:2016) installed above floor slabs are considered sufficiently strong to meet the performance criteria (see also C.3). Thicker and more robust membranes or an additional membrane protection layer should be installed directly beneath cast-in-situ floor slabs. $\langle A_1 \rangle$		

Ground Gas Analysis

The ground gas monitoring has identified no methane and a maximum carbon dioxide concentration of 6.6% v/v. Measurable flow rates were not recorded during the monitoring visits. In the absence of a measurable flow rate, the limit of detection of the gas monitoring instrument (0.1 l/h) should be utilised.

The GSV for carbon dioxide at the site may be calculated as follows:

- $(0.1 \times 6.6)/100 = 0.0066 \text{ l/h}$

Therefore, with a maximum GSV of 0.0066 l/h and a maximum carbon dioxide concentration of 6.6% v/v, together with no measurable methane and no steady gas flow rates, this initially classifies the site as Characteristic Situation CS1, in accordance with Table 2 of BS 8485 and based on the visits undertaken.

However, where carbon dioxide concentrations exceed 5% by volume the British Standard recommends that consideration should be given to increasing the ground gas regime from CS1 to CS2. A CS2 ground gas regime would therefore indicate that gas protection measures would be required in the proposed new buildings to be constructed at the site.

Building Type

We understand that it is proposed to develop the site with low-rise residential properties. In accordance with Table 3 of BS 8485 and as stated in our Combined Report, **Building Type A** is considered to be the most appropriate classification for the proposed development.

Gas Protection Score

On the basis of Characteristic Situation (CS2) and the development proposals with buildings that may be designated as Building Type A and in accordance with Table 4 of BS 8485:2015+A1:2019, the minimum gas protection score for the affected plots is **3.5 points**.

CONCLUSIONS & RECOMMENDATIONS

Based on the results of the ground gas monitoring undertaken, it is considered that gas protection measures should be afforded to the proposed development at the site. Based on the information obtained, it is recommended that gas protection measures corresponding to Characteristic Situation CS2 (in accordance with Table 4 of BS 8485: 2015+A1:2019) should be appropriate. The minimum gas protection score for CS2 is 3.5 points.

Typically, the following mitigation measures are considered appropriate to achieve the required level of protection to dwellings:

- Suspended floors (i.e. beam and block / beam and thermal insulation infill) – 0 Points.
- Provision of a clear ventilated void and periscopic air-brick ventilation and sub-floor cross ventilation – 1.5 Points (Good Performance Clear Void Dispersal Layer).
- To achieve a Very Good Performance Clear Void Dispersal Layer (2.5 points) in accordance with BS8485, the number of side vents (i.e. air-bricks) for a small to medium width buildings (up to 15m) should be 1500mm²/m run of wall on at least two sides, or 500mm² per square metre of floor area, whichever gives the greater area of opening. The minimum clear void space should be 100mm and there should be four or five times the area of the side vents provided to the internal obstructions (i.e. beams) to provide sub-floor cross ventilation.
- Provision of a well installed and verified low permeability proprietary gas resistant membrane (2 Points).
- The membrane should have proven resistance to the ground gases of concern, including methane (as well as carbon monoxide). The membrane should be suitably lapped and sealed and should be extended across wall cavities and lapped with cavity trays to effectively exclude ground gases from the footprint of the proposed buildings. The membrane should be inspected by a third party in accordance with the requirements of CIRIA C735.
- The membrane must be suitably robust to withstand the construction process and should be suitably protected following installation and inspection to minimise damage during construction.
- Service penetrations through the membrane should be kept to a minimum and should be suitably sealed to the membrane. Where the service penetrations (typically 150mm pipes) are to be used as ducting for smaller service pipes (e.g. water, electricity or gas supply etc.) an appropriate method of sealing the smaller pipes within the ducting should be adopted (such as closed cell expanding foam), to minimise the risk of the ducting acting as a conduit for ground gases to enter the dwellings.

The foregoing precautions would score 3.5 Points (based on a Good Performance Clear Void Dispersal Layer) in accordance with BS8485 (2015+A1:2019) and are therefore considered appropriate for the plots. Alternative floor slab and ground gas protection measures that give a minimum protection score of 3.5 Points may be adopted at the site, to suit the requirements of the Client and subject to Local Authority approval.

In order to accord with Table 7 of BS8485 where a gas resistant membrane is proposed as part of gas protection measures, the membrane should be installed, inspected and validated by a third party in accordance with the requirements of CIRIA C735 '*Good practice on the testing and verification of protection systems for buildings against hazardous ground gas*' (2014), for the gas protection points associated with installation of a gas resistant membrane to apply.

We would recommend that the membrane specified for the proposed buildings is installed by a suitably qualified specialist contractor in a quality controlled / quality assured (QA/QC) manner.

Verification of the membrane should include a third party visual inspection of the installed membrane, as a minimum, and may require integrity testing such as air lancing of the joints, dependent on the qualifications of the installer and the characteristic situation of the site. Otherwise, a score of zero is awarded for the membrane and therefore the installed solution would fail to comply with BS 8485.

Once the design of ground gas precautions for the site have been finalised, we would recommend that a site-specific Verification Plan is prepared in accordance with CIRIA guidance, to assist with verification of the gas protection measures.

Where the proposed dwellings are to benefit from a Buildmark warranty (i.e. NHBC, or similar) we would recommend liaison with the warranty provider with respect to the floor slab design and ground gas protection measures to ensure that the proposals fully satisfy their requirements.

In conclusion, notable concentrations of carbon dioxide have been detected at the site, but no significant flow rates have been recorded during the programme of gas monitoring undertaken. It is considered that the carbon dioxide concentrations are likely to be attributable to the peat inclusions and pockets / horizons within the Tidal Flat Deposits.

Statutory Consultation

We would recommend that a copy of this letter report is submitted to the Environmental Health Officer at the Local Authority for approval purposes prior to any irrevocable actions on site.

We trust the above is suitable for your current requirements. If you have any queries, please do not hesitate to contact us.

Yours sincerely

For and on the behalf of GeoDyne Limited

A handwritten signature in blue ink, appearing to read 'P. Kershaw', with a long horizontal stroke extending to the right.

**Paul Kershaw
Director**

Encl	Appendix I	Borehole Location Plan (Figure No. D41153/01)
	Appendix II	Borehole Logs (BH1 – BH3)
	Appendix III	Ground Gas & Water Level Monitoring Results
	Appendix IV	Conditions & Limitations

Cc Gavin Baxter – Ashwood Homes

APPENDIX I

**Borehole Location Plan
(Figure No. D41153/01)**



• © This drawing and the details depicted are the copyright of GeoDyne Limited and may not be reproduced except by written permission.

Project No.	D41153
Client	Ashwood Homes
Project	Harrington Drive, Crowland
Title	Borehole Location Plan
Drawn By	SJ
Checked By	PK
Approved By	PK
Scale	NTS
Date Drawn	23/11/2021
Revision	
Figure No.	D41153/01



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KEY

 BH - Cable Percussive Borehole

NB: All locations shown are approximate

APPENDIX II

Borehole Logs (BH1 to BH3)

Samples and Tests				Description of Strata	Legend	Depth & (Thickness) (m)	Casing (m)	Ground-water	Installation
Depth (m)	Type	Sample Ref	SPT "N" Value						
1.00 - 1.45	S	SD1	2	Grass over dark brown slightly silty clay TOPSOIL (TOPSOIL)		(0.50)	4.00		
1.00 - 1.45	D			Soft orange-brown silty CLAY (TIDAL FLAT DEPOSITS)		0.50			
2.00 - 2.45	S	SD2	4	Soft grey slightly silty CLAY with plant remains and peaty pockets (TIDAL FLAT DEPOSITS)		(1.40)			
2.00 - 2.45	D					1.90			
3.00 - 3.45	S	SD3	7	Soft black pseudofibrous clayey PEAT (TIDAL FLAT DEPOSITS)		(0.50)			
3.00 - 3.45	D					2.40			
4.00 - 4.45	S	SD4	6	Firm grey slightly silty slightly sandy CLAY (TIDAL FLAT DEPOSITS)		(0.90)			
4.00 - 4.45	D					3.30			
5.00 - 5.45	S	SD5	17	Very weak to weak grey clayey MUDSTONE (OXFORD CLAY)		(1.70)			
5.00 - 5.45	D					5.00			
5.90 - 6.00	B	B1							
6.50 - 6.95	S	SD6	26						
6.50 - 6.95	D								
7.50 - 7.60	B	B2							
8.00 - 8.45	S	SD7	30						
8.00 - 8.45	D								
9.50 - 9.95	S	SD8	36	...becoming dark grey and less clayey with depth					
9.50 - 9.95	D					(9.00)			
				...becoming weak to moderately weak and less weathered with depth					
11.00 - 11.45	S	B3	50/275mm						
11.00 - 11.10	B								
11.00 - 11.45	D	SD9							
12.50 - 12.95	S								
12.50 - 12.87	D	SD10	50/225mm						
14.00 - 14.45	S		50/225mm	End of Borehole at 14.00m		14.00			

Remarks

1. Borehole cased to 4.00m as a precautionary measure.
2. No water encountered.
3. Plain pipe installed from ground level to 1.00m in a bentonite surround. Slotted pipe installed from 1.00m to 5.00m in a gravel surround.
4. Bung, valve and lockable cover installed.

Key

D = Disturbed Sample
U = Undisturbed Sample
B = Bulk Sample
J = Jar Sample
V = Vial Sample
W = Water Sample

S = Standard Penetration Test (Split Spoon)
C = Standard Penetration Test (Cone)
 = Water Strike (m)
 = Steady Water Level (m)

Project: Harrington Drive, Crowland

Client: Ashwood Homes

Logged: BG

Checked: PK

Field Book Ref:

Plant: Dando 2000

Drawing Ref:

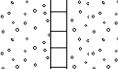
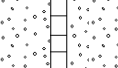
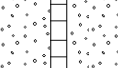
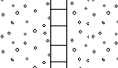
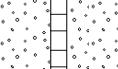
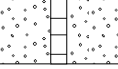
Date: 03/11/2021

Approved: PK

BG21/01

Scale: 1:75

BH1

Samples and Tests				Description of Strata	Legend	Depth & (Thickness) (m)	Casing (m)	Ground-water	Installation
Depth (m)	Type	Sample Ref	SPT "N" Value						
1.00 - 1.45 1.00 - 1.45	S D	SD1	0	Grass over dark brown slightly sandy TOPSOIL (TOPSOIL) Soft light orange slightly sandy CLAY (TIDAL FLAT DEPOSITS) Loose grey slightly sandy CLAY with plant remains and peaty pockets (TIDAL FLAT DEPOSITS)		(0.30) 0.30 (0.30) 0.60			
2.00 - 2.45 2.00 - 2.45	S D	SD2	2			(2.50)			
3.00 - 3.45 3.00 - 3.45	S D	SD3	10			3.10 (0.50) 3.60			
4.00 - 4.45 4.00 - 4.45	S D	SD4	12	Very loose orange-brown slightly silty clayey SAND (TIDAL FLAT DEPOSITS) Soft orange-brown sandy CLAY (TIDAL FLAT DEPOSITS) ...becoming firm with depth		(1.00)			
5.00 - 5.45 5.00 - 5.45	S D	SD5	27	Very weak to weak grey clayey MUDSTONE (OXFORD CLAY)		4.60	5.00		
5.60 - 5.70	B	B1							
6.50 - 6.95 6.50 - 6.95	S D	SD6	31						
8.00 - 8.45 8.00 - 8.45	S D	SD7	28						
8.60 - 8.70	B	B2							
9.50 - 9.95 9.50 - 9.95	S D	SD8	34	...becoming dark grey and less clayey with depth		(9.40)			
11.00 - 11.45 11.00 - 11.42	S D	SD9	50/275mm						
11.50 - 11.60	B	B3							
12.50 - 12.95 12.50 - 12.87	S D	SD10	50/225mm						
13.00 - 13.10	B	B4							
14.00 - 14.45 14.00 - 14.37	S D	SD11	50/220mm	End of Borehole at 14.00m		14.00			

Remarks

1. Borehole cased to 5.00m as a precautionary measure.
2. Slight water seepage at 3.60m.
3. Plain pipe installed from ground level to 1.00m in a bentonite surround. Slotted pipe installed from 1.00m to 5.00m in a gravel surround.
4. Bung, valve and lockable cover installed.

Key

D = Disturbed Sample
U = Undisturbed Sample
B = Bulk Sample
J = Jar Sample
V = Vial Sample
W = Water Sample

S = Standard Penetration Test (Split Spoon)
C = Standard Penetration Test (Cone)
 = Water Strike (m)
 = Steady Water Level (m)

Project: Harrington Drive, Crowland

Client: Ashwood Homes

Logged: BG

Checked: PK

Field Book Ref:

Plant: Dando 2000

Drawing Ref:

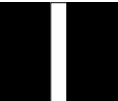
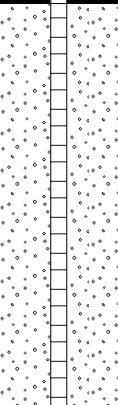
Date: 02/11/2021

Approved: PK

BG21/01

Scale: 1:75

BH2

Samples and Tests				Description of Strata	Legend	Depth & (Thickness) (m)	Casing (m)	Ground-water	Installation
Depth (m)	Type	Sample Ref	SPT "N" Value						
1.00 - 1.45 1.00 - 1.45	S D	SD1	2	Dark brown slightly sandy slightly silty clay with rare brick fragments (MADE GROUND - TOPSOIL) Soft orange-brown slightly silty CLAY (TIDAL FLAT DEPOSITS) Very soft brown slightly silty slightly sandy CLAY (TIDAL FLAT DEPOSITS)		(0.30) 0.30 0.50			
2.00 - 2.45 2.00 - 2.45	S D	SD2	3	Very loose grey silty SAND (TIDAL FLAT DEPOSITS / ABBEY SAND AND GRAVEL)		(1.60) 2.10			
3.00 - 3.45 3.00 - 3.45	S D	SD3	0						
4.00 - 4.45 4.00 - 4.45	S D	SD4	0						
5.00 - 5.45 5.00 - 5.45	S D	SD5	5	...becoming loose and very silty with depth		(6.00)			
6.50 - 6.95 6.50 - 6.95 7.00 - 7.10	S D B	SD6 B1	12	...becoming loose to medium dense with depth ...becoming more clayey with depth					
8.00 - 8.45 8.00 - 8.45	S D	SD7	22	Very weak to weak grey clayey MUDSTONE (OXFORD CLAY)		8.10			
9.50 - 9.95 9.50 - 9.95	S D	SD8	50/275mm	...becoming weak to moderately weak and less weathered with depth			9.00		
10.10 - 10.20	B	B2		...becoming dark grey and less clayey with depth		(4.40)			
11.00 - 11.45 11.00 - 11.45 11.60 - 11.70	S D B	SD9 B3	50/265mm						
12.50 - 12.95 12.50 - 12.82	S D	SD10	50/275mm	End of Borehole at 12.50m		12.50			

Remarks

1. Borehole cased to 9.00m as a precautionary measure.
2. Slight water seepage at 2.50m.
3. Plain pipe installed from ground level to 1.00m in a bentonite surround. Slotted pipe installed from 1.00m to 5.00m in a gravel surround.
4. Bung, valve and lockable cover installed.

Key

D = Disturbed Sample
U = Undisturbed Sample
B = Bulk Sample
J = Jar Sample
V = Vial Sample
W = Water Sample
S = Standard Penetration Test (Split Spoon)
C = Standard Penetration Test (Cone)
 = Water Strike (m)
 = Steady Water Level (m)

Project: Harrington Drive, Crowland

Client: Ashwood Homes

Logged: BG

Checked: PK

Field Book Ref: BG21/01

Plant: Dando 2000

Drawing Ref: BH3

Date: 01/11/2021

Approved: PK

Scale: 1:75

APPENDIX III

Gas and Groundwater Level Monitoring Results



Project No.	D41153
Client	Ashwood Homes
Site Location	Harrington Drive, Crowland
Date	10/11/2021
Weather	Overcast, Slight Drizzle
Atmospheric Pressure Trend	Rise of 2mb in the 24 hours prior to monitoring
Equipment	GA5000 & Dipmeter
Operator	BG

MONITORING OF SOIL GASES AND GROUNDWATER - IN ACCORDANCE WITH CIRIA C665 / BS8485:2015											
Borehole No.	Time (00:00)	Ambient Pressure (mb)		Methane (% v/v)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	Time to steady gas readings (secs)	Duration of gas monitoring (secs)	Gas Flow (l/hr)	Depth to groundwater (m begl)	Other Issues i.e. odour, condition of installation, etc
BH1	09:45	1023	Peak	0.0	5.8	14.8	100	240	0.0	2.01	
			Steady	0.0	5.2	15.4			0.0		
BH2	09:53	1023	Peak	0.0	0.3	19.9	30	180	0.0	0.75	
			Steady	0.0	0.3	19.9			0.0		
BH3	10:02	1023	Peak	0.0	2.8	18.0	40	180	0.0	1.54	
			Steady	0.0	2.8	18.0			0.0		
Ambient				0.0	0.0	20.1					

Notes

Cell is highlighted in the following conditions

1. Where Methane exceeds 1% v/v (after BR212)
2. Where Carbon Dioxide exceeds 5% v/v (after BR212)
3. Where Oxygen is below 16% (Coal Authority guidance)

Where cell is highlighted further consideration of the recorded value is required in accordance with the specified guidance documents

NA - Not Applicable/ Not Available

BOH - Bottom of Hole

ND - Not Determined

NGW - No groundwater encountered

NR - None Recorded



Project No.	D41153
Client	Ashwood Homes
Site Location	Harrington Drive, Crowland
Date	15/11/2021
Weather	Slightly overcast
Atmospheric Pressure Trend	Rise of 3mb in the 24 hours prior to monitoring
Equipment	GA5000 & Dipmeter
Operator	BG

MONITORING OF SOIL GASES AND GROUNDWATER - IN ACCORDANCE WITH CIRIA C665 / BS8485:2015											
Borehole No.	Time (00:00)	Ambient Pressure (mb)		Methane (% v/v)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	Time to steady gas readings (secs)	Duration of gas monitoring (secs)	Gas Flow (l/hr)	Depth to groundwater (m begl)	Other Issues i.e. odour, condition of installation, etc
BH1	10:22	1025	Peak	0.0	4.1	16.4	140	220	0.0	1.27	
			Steady	0.0	3.7	16.8			0.0		
BH2	10:31	1025	Peak	0.0	4.4	16.8	180	240	0.0	0.67	
			Steady	0.0	2.0	20.2			0.0		
BH3	10:38	1025	Peak	0.0	3.6	18.1	40	180	0.0	1.58	
			Steady	0.0	3.6	18.1			0.0		
Ambient				0.0	0.0	20.8					

Notes

Cell is highlighted in the following conditions

1. Where Methane exceeds 1% v/v (after BR212)
2. Where Carbon Dioxide exceeds 5% v/v (after BR212)
3. Where Oxygen is below 16% (Coal Authority guidance)

Where cell is highlighted further consideration of the recorded value is required in accordance with the specified guidance documents

NA - Not Applicable/ Not Available

BOH - Bottom of Hole

ND - Not Determined

NGW - No groundwater encountered

NR - None Recorded



Project No.	D41153
Client	Ashwood Homes
Site Location	Harrington Drive, Crowland
Date	22/11/2021
Weather	Cold with clear skies
Atmospheric Pressure Trend	Rise of 12mb in the 24 hours prior to monitoring
Equipment	GA2000 & Dipmeter
Operator	GH

MONITORING OF SOIL GASES AND GROUNDWATER - IN ACCORDANCE WITH CIRIA C665 / BS8485:2015											
Borehole No.	Time (00:00)	Ambient Pressure (mb)		Methane (% v/v)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	Time to steady gas readings (secs)	Duration of gas monitoring (secs)	Gas Flow (l/hr)	Depth to groundwater (m begl)	Other Issues i.e. odour, condition of installation, etc
BH1	10:54		Peak	0.0	2.6	19.1	20	180	0.0	1.00	
			Steady	0.0	2.6	19.1			0.0		
BH2	11:03		Peak	0.0	3.0	20.1	120	240	0.0	0.73	
			Steady	0.0	2.2	20.7			0.0		
BH3	11:12		Peak	0.0	4.1	18.9	20	180	0.0	1.65	
			Steady	0.0	4.1	18.9			0.0		
Ambient				0.0	0.0	21.1					

Notes

Cell is highlighted in the following conditions

1. Where Methane exceeds 1% v/v (after BR212)
2. Where Carbon Dioxide exceeds 5% v/v (after BR212)
3. Where Oxygen is below 16% (Coal Authority guidance)

Where cell is highlighted further consideration of the recorded value is required in accordance with the specified guidance documents

NA - Not Applicable/ Not Available

BOH - Bottom of Hole

ND - Not Determined

NGW - No groundwater encountered

NR - None Recorded



Project No.	D41153
Client	Ashwood Homes
Site Location	Harrington Drive, Crowland
Date	30/11/2021
Weather	Cloudy and cool with moderate breeze
Atmospheric Pressure Trend	Fall of 6mb in the 24 hours prior to monitoring
Equipment	GA2000+ & Dipmeter
Operator	DB

MONITORING OF SOIL GASES AND GROUNDWATER - IN ACCORDANCE WITH CIRIA C665 / BS8485:2015											
Borehole No.	Time (00:00)	Ambient Pressure (mb)		Methane (% v/v)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	Time to steady gas readings (secs)	Duration of gas monitoring (secs)	Gas Flow (l/hr)	Depth to groundwater (m begl)	Other Issues i.e. odour, condition of installation, etc
BH1	13:50	1009	Peak	0.0	1.5	20.7	20	600	0.0	0.60	
			Steady	0.0	0.6	20.8			0.0		
BH2	14:06	1009	Peak	0.0	3.4	20.0	20	300	0.0	0.77	
			Steady	0.0	0.5	20.9			0.0		
BH3	14:17	1009	Peak	0.0	3.9	18.8	110	600	0.0	1.61	
			Steady	0.0	3.6	18.1			0.0		
Ambient				0.0	0.0	21.3					

Notes

Cell is highlighted in the following conditions

1. Where Methane exceeds 1% v/v (after BR212)
2. Where Carbon Dioxide exceeds 5% v/v (after BR212)
3. Where Oxygen is below 16% (Coal Authority guidance)

Where cell is highlighted further consideration of the recorded value is required in accordance with the specified guidance documents

NA - Not Applicable/ Not Available

BOH - Bottom of Hole

ND - Not Determined

NGW - No groundwater encountered

NR - None Recorded



Project No.	D41153
Client	Ashwood Homes
Site Location	Harrington Drive, Crowland
Date	07/12/2021
Weather	Overcast, rain
Atmospheric Pressure Trend	Fall of 10mb in the 24 hours prior to monitoring
Equipment	GA2000+ & Dipmeter
Operator	GH

MONITORING OF SOIL GASES AND GROUNDWATER - IN ACCORDANCE WITH CIRIA C665 / BS8485:2015											
Borehole No.	Time (00:00)	Ambient Pressure (mb)		Methane (% v/v)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	Time to steady gas readings (secs)	Duration of gas monitoring (secs)	Gas Flow (l/hr)	Depth to groundwater (m begl)	Other Issues i.e. odour, condition of installation, etc
BH1	10:32	998	Peak	0.0	5.7	19.8	35	300	0.0	0.63	
			Steady	0.0	5.3	19.8			0.0		
BH2	10:43	998	Peak	0.0	6.6	19.0	250	300	0.0	0.72	
			Steady	0.0	2.6	20.0			0.0		
BH3	10:57	998	Peak	0.0	3.3	19.6	20	300	0.0	1.46	
			Steady	0.0	3.3	19.6			0.0		
Ambient				0.0	0.0	21.7					

Notes

Cell is highlighted in the following conditions

1. Where Methane exceeds 1% v/v (after BR212)
2. Where Carbon Dioxide exceeds 5% v/v (after BR212)
3. Where Oxygen is below 16% (Coal Authority guidance)

Where cell is highlighted further consideration of the recorded value is required in accordance with the specified guidance documents

NA - Not Applicable/ Not Available

BOH - Bottom of Hole

ND - Not Determined

NGW - No groundwater encountered

NR - None Recorded



Project No.	D41153
Client	Ashwood Homes
Site Location	Harrington Drive, Crowland
Date	14/12/2021
Weather	Cloudy
Atmospheric Pressure Trend	Rise of 4mb in the 24 hours prior to monitoring
Equipment	GA2000 & Dipmeter
Operator	GH

MONITORING OF SOIL GASES AND GROUNDWATER - IN ACCORDANCE WITH CIRIA C665 / BS8485:2015											
Borehole No.	Time (00:00)	Ambient Pressure (mb)		Methane (% v/v)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	Time to steady gas readings (secs)	Duration of gas monitoring (secs)	Gas Flow (l/hr)	Depth to groundwater (m begl)	Other Issues i.e. odour, condition of installation, etc
BH1	10:23	1025	Peak	0.0	5.6	19.3	120	300	0.0	0.76	
			Steady	0.0	4.4	19.9			0.0		
BH2	10:46	1025	Peak	0.0	6.3	18.9	250	300	0.0	0.75	
			Steady	0.0	2.0	20.2			0.0		
BH3	10:34	1025	Peak	0.0	1.9	19.8	10	300	0.0	1.28	
			Steady	0.0	1.9	19.8			0.0		
Ambient				0.0	0.0	21.7					

Notes

Cell is highlighted in the following conditions

1. Where Methane exceeds 1% v/v (after BR212)
2. Where Carbon Dioxide exceeds 5% v/v (after BR212)
3. Where Oxygen is below 16% (Coal Authority guidance)

Where cell is highlighted further consideration of the recorded value is required in accordance with the specified guidance documents

NA - Not Applicable/ Not Available

BOH - Bottom of Hole

ND - Not Determined

NGW - No groundwater encountered

NR - None Recorded

APPENDIX IV
Conditions & Limitations

Conditions & Limitations

Phase I Desk Studies

1. Works undertaken to provide the basis of the Phase I Desk Study report comprise a review of information available from a number of sources/parties (potentially also including the Client) together with a walk over of the site (where applicable and included within the quotation). The opinions given in the Phase I Desk Study are based on the information available from third parties/sources that has been obtained within the available timeframe. GeoDyne Limited assumes all third party information to be true and correct and therefore cannot accept liability for the accuracy of such information supplied.
2. Should additional information become available that may affect the comments and opinions made within the Phase I Desk Study, GeoDyne Limited reserves the right to review such information and make modifications to comments/opinions as appropriate.
3. It should be borne in mind that a Phase I Desk Study collates available information to generate a conceptual model of the site. The actual geotechnical and environmental considerations can only be fully quantified by intrusive investigation works to confirm the accuracy of the conceptual site model.

Phase II Intrusive Investigations

1. Our quotation assumes that access to the site will be arranged by others at no cost to ourselves.
2. We have assumed that free access is available throughout to the entire site and that works can be undertaken during a single mobilisation. Where restricted access is encountered, or where additional unscheduled mobilisations are required, additional costs may be incurred to the client.
3. We have assumed that all available information relating to buried services will be supplied by the Client at no cost to ourselves. No responsibility will be accepted for damage to underground services that have not been brought to our prior attention by the Client.
4. All excavations/boreholes will be backfilled with compacted arisings upon completion, with any excess arisings left proud of ground levels. Excess arisings will not be removed from the site unless specifically requested by the Client. Where we are requested to remove excess arisings, all associated costs will be passed to the Client.
5. We will attempt to leave the site in a clean and tidy state, however, it must be understood that some disturbance of the site is unavoidable during intrusive works.
6. Exploratory holes are positioned approximately on site by GeoDyne Limited. Should the client require precise locations of all exploratory points, additional fees will be incurred. It must be borne in mind that backfilled trial pits can create 'soft spots', therefore, should the Client wish to designate 'no dig' zones, for example under the footprint of proposed structures, these must be brought to our attention prior to commencement of works.
7. Groundwater observations relate to conditions encountered at the time of investigation. It must be understood that groundwater levels may vary as a result of recent climatic conditions or seasonal variation.
8. Trial pits and boreholes examine only a small proportion of the total site area. No liability can be accepted for conditions not revealed in exploratory holes, particularly between positions. All extrapolations of available data are given in good faith.

Payment

1. Payment terms are strictly 28 days from the invoice date.
2. Prior to commencement of works, we require receipt of formal written instruction from the party accepting full financial responsibility for the work. In the absence of such an instruction, we would expect the instructing Consulting Engineers/Architects to accept full financial responsibility for the works.
3. Receipt of instruction to commence work shall be taken as acceptance and compliance of the foregoing conditions.

Liability

1. GeoDyne Limited offer £5,000,000.00 Professional Indemnity Insurance (in aggregate over the year). This shall be the limit of our liability for works undertaken. No individual liability shall be implied to, or accepted by, any employee for works undertaken for and on the behalf of GeoDyne Limited.