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GREEN PARK VILLAGE GROUND GAS RISK ASSESSMENT – PHASE 3 TO 5

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EXECUTIVE SUMMARY

Ramboll UK Ltd (RUK) has been appointed by the Client, St Edward Homes Limited, to undertake a ground gas risk assessment and review the requirement for gas protection on the Phase 3 to 5 as part of the Green Park Village residential housing development in Reading. The development comprises mostly low rise residential buildings with some residential apartments in the Phase 5 area.

Elevated concentrations of methane and carbon dioxide have been obtained from gas monitoring in the Phase 3 to 5 development areas. The worst case gas screening values derived using the peak ground gas concentrations and peak steady state borehole flow rates would be consistent with Amber 1 / Characteristic Situation 2 indicating that gas protection would be required.

Further assessment of gas screening values for the low rise residential housing has been undertaken by revising the NHBC traffic light assessment using for site specific parameters including proposals for ventilation of the subfloor void. The results obtained indicate that the site would be classed as 'green' for the low rise residential housing based on the subfloor ventilation. The equilibrium concentrations derived for gas in the subfloor with dilution from ventilation in accordance with Building Regulations are less than the concentrations indicated within the NHBC guidance for a 'green' site.

A quantitative assessment has also been undertaken to consider the potential risks from the vertical migration of ground gas from a source in the underlying Made Ground and / or alluvium into the ground floor of the low rise housing and the residential apartments in Phase 5 via pressure driven flow. The assessment has been based on the assumption there is no dilution of gas within the subfloor (such as if all the vents were to become blocked) and no attenuation by the building floor which is likely to be conservative.

The results from the assessment indicate the risks from the ingress and accumulation of ground gas to existing buildings should be low from the gas regime encountered at the site with no further mitigation required for gas other than the subfloor ventilation.

The assessment has been based on a number of conservative assumptions and, therefore, the risks from gas ingress are likely to be even lower.

1. INTRODUCTION

Ramboll UK Ltd (RUK) has been appointed by the Client, St Edward Homes Limited, to undertake a ground gas risk assessment and review the requirement for gas protection as part of the Green Park Village residential housing development in Reading. This review considers potential risks from ground gas to buildings being constructed as part of development areas in Phases 3 to 5.

The site is located approximately 4 km to the south of Reading Town Centre, Berkshire.

The site location and development phases are shown in Appendix 1.

Ground gas monitoring has identified the presence of elevated methane and carbon dioxide from a number of wells installed into the Made Ground and alluvium at the site in Phase 3 to 5.

The development comprises mainly low rise residential buildings with a suspended ground floor and clear underfloor void of greater than 150 mm. On this basis, consideration of the potential risks from ground gas using guidance provided by the National House Building Council (NHBC) is considered appropriate for these buildings.

The assessment provides a review of the gas screening values to determine if mitigation will be required in accordance with the approach for low rise residential housing provided by the NHBC taking into account site specific parameters for the development such as subfloor ventilation. In addition, a quantitative risk assessment has been undertaken to assess the potential risks from the migration of gas into the living space of these buildings, for instance if the external vents to the subfloor were to become blocked.

The development will include a number of residential apartments in the Phase 5 area although these are not considered to be consistent with the low rise structures in the NHBC guidance. Therefore, a quantitative risk assessment has also been undertaken to assess the potential risks from the migration of gas into the ground floor space of these structures.

Information relating to the ground conditions and gas monitoring has been obtained from the following reports, these should be referred to for more detailed information on the site conditions:

- Ramboll, June 2017. Green Park Village Ground Contamination Interpretative Report - Phase 3 ref 1620000492/RPT/012;
- Ramboll, June 2017. Green Park Village Ground Contamination Interpretative Report - Phase 4 ref 1620000492/RPT/013; and
- Ramboll, June 2017. Green Park Village Ground Contamination Interpretative Report - Phase 5 ref 1620000492/RPT/014.

2. GAS MONITORING RESULTS - SUMMARY

Historically, gas monitoring has been undertaken by Peter Brett Associates (PBA) in Phase 3 to 5. No elevated methane or carbon dioxide was encountered in Phase 3 or 5. Elevated carbon dioxide (up to 14%) and methane (up to 14.5%) was encountered within a single well in the Phase 4 area. However, the number of monitoring wells and rounds of monitoring undertaken by PBA were noted by Ramboll as being limited.

Six rounds of gas monitoring have been undertaken by Ramboll between 19th April 2017 and 24th May 2017 on wells installed in Phases 3 to 5 as show in Appendix 4 and on Figure 2.

The highest concentration of methane was obtained from RWS609 in Phase 3 during monitoring on 24th April 2017 with a peak and steady state reading of 26.5%. The next highest result of 19.2% was also obtained in Phase 3 from RWS609 during the subsequent monitoring visit on the 5th May 2017. The highest concentrations from other monitoring wells were also obtained from Phase 3 with 15.7% from RWS607 and 12.4% from RWS606. The results for methane from other monitoring wells installed in the Phase 3 area are much lower at 1.9% or less. The peak results for methane from Phase 4 was 6.9% and 1.8% from Phase 5.

The highest concentrations of carbon dioxide were obtained from RWS639 in Phase 4 during monitoring on 19th May 2017 with a peak and steady state reading of 17.9%. The next highest results were obtained from RWS608 in Phase 3 with a peak reading of 13.1%. Concentrations above 5% carbon dioxide were obtained from 6no. wells in Phase 3, and also 3no. wells in both Phase 4 and Phase 5.

The majority of flow rates detected during monitoring visits have been low, typically at below the lower instrument detection limit (<0.1 litres / hour). The highest steady state flow rate of 0.7 litres / hour was recorded in RWS607 in Phase 3. Peak (initial) flow rates of 5.0 litres / hour and 1.4 litres / hour have been obtained from two wells (RWS610 and RWS607) during single rounds of monitoring, although these reduced to 0.2 and 0.7 litres / hour respectively during monitoring.

Although elevated methane and carbon dioxide have been encountered in a number of wells, the flow rates obtained from gas monitoring indicate that the volume of gas present beneath the site is low. This would be consistent with descriptions of ground conditions which show the presence of organic material (such vegetation and peat) within the Made Ground and alluvium.

3. CONCEPTUAL SITE MODEL

The following provides consideration of the potential sources of gas encountered at the site, pathways by which the gas could migrate and receptors following development at the site.

3.1 Sources

There are a number of landfills in the surrounding area, adjacent to the northern and western site boundaries. Other historic and authorised landfills are also located within 500m of the site. The following landfills are located adjacent to the site:

- Smallmead Farm landfill immediately to the north of Phase 3 to 5. This is an authorised landfill which was licensed to accept household, commercial and industrial waste and has been restored to agriculture. This is understood to be lined with external bund walls that are keyed into the Lambeth Group with a clay cap and includes gas venting wells¹.
- Burghfield Landfill Site A is an authorised landfill located to the west of Phase 5 which is licensed to accept material excluding inert waste and is understood to be engineered and lined¹. Burghfield Area D historical landfill is shown at the southern end of Burghfield Landfill Site A.

According to historical investigations by PBA² it is understood that monitoring wells close to the site boundaries adjacent to these landfills do not indicate significant lateral migration of gas from offsite sources such as these landfills is likely to be occurring.

On this basis, the principal source of the ground gas identified at the site is considered to be organic material within the underlying Made Ground and alluvium which has been identified during ground investigations.

3.2 Pathways

The main pathways for gas migration into the underfloor void and subsequently into the building space following development are:

- Vertical migration from soils into the subfloor void; and
- Vertical migration from the subfloor floor into the building via joints between beam and block floors or gaps due to service penetrations.

3.3 Receptors

Potential receptors for gas ingress into structures at the site will be future site residents occupying the houses, and the building structure.

¹ Peter Brett Associates (2002). Geoenvironmental Investigation for Phase III Green Park, Reading ref 11321/300/SNK/KB/RP/LG.

² Peter Brett Associates (2015). Report on Ground Investigation for Phase 1 ref 30158 Geo RPT 02 Rev01

4. ASSESSMENT APPROACH

The assessment has been based on considering the potential risks from the migration of ground gas through the following processes:

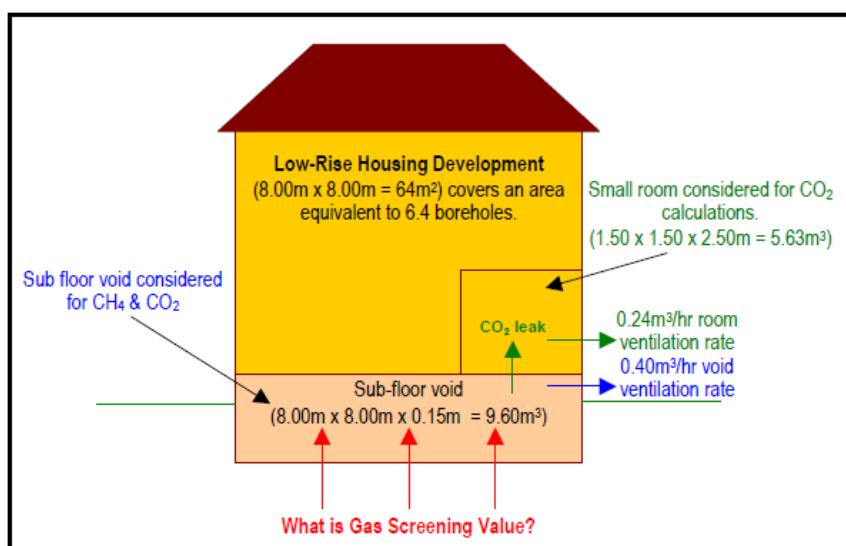
1. Review of the gas screening values derived using the NHBC 'traffic light' ³ approach using site specific parameters for the buildings; and.
2. Potential for vertical migration of gas through pressure driven flow into the building living space which has been assessed using Darcy's Law.

4.1 NHBC 'Traffic Lights' Approach

The NHBC provide a series of 'traffic lights' that are used to determine the ground gas protection measures required for low rise housing developments. The traffic lights comprise 'Green', 'Amber 1', 'Amber 2' and 'Red'. No ground gas protection measures are required for a 'green' site and passive protection measures are required for 'amber' sites. For 'red' sites standard residential housing would not normally be acceptable without further ground gas risk assessment and / or possible remedial mitigation measures to reduce or remove the source of the ground gases.

The model development used in the NHBC traffic light assessment is based upon a model low-rise house with a floor plan of 8.00 m x 8.00 m, giving a floor area of 64 m². Based on the assumption that an individual 50 mm internal diameter borehole relates to an approximate area of 10 m², this would represent 6.4 boreholes for the floor plan of the house.

The following diagram shows the model residential property developed for calculating the maximum permitted equilibrium gas concentrations within the subfloor void (source: NHBC ³).



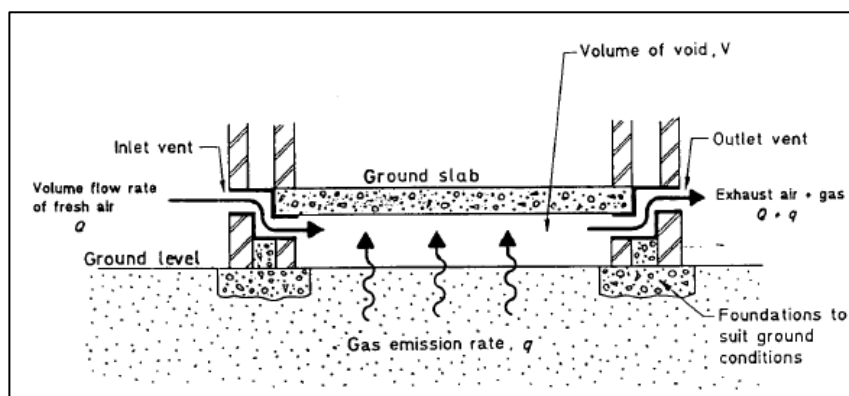
A minimum recommended sub-floor void height of 0.15m as specified in The Building Regulations 'Approved Document C', produces a sub-floor void space of 9.60m³ for a model house. As a worst-case scenario, the NHBC considered that the ventilation rate within the sub-floor void was subject to a complete volume change every 24 hours, which is considered to be highly conservative. The ventilation rate would, therefore, be 9.60m³ / 24 hours = 0.40m³/hr.

³ National House-Building Council and RSK Group (2007). Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present.

The Gas Screening Value which forms the boundary between 'Green' and 'Amber 1' is based on maximum equilibrium concentration in the subfloor for methane of 0.25% and the maximum concentration of 1.25% for carbon dioxide entering a small room inside the building from the subfloor.

The NHBC guidance indicates that "if the designer can adequately demonstrate that vent rates are greater (for example, when calculated using BS 5925⁴) then higher site-specific GSVs may be calculated. However, any such alternative assessment should include a sensitivity analysis to take into account the effects of occupiers blocking air vents, for example by construction of patios." It also states that the typical maximum concentrations can be exceeded in certain circumstances should the Conceptual Site Model indicate it is safe to do so and that the GSV thresholds should not generally be exceeded without the completion of a detailed ground gas risk assessment taking into account site-specific conditions.

Therefore, the approach for revising the NHBC traffic light assessment has been based on estimating the rate of subfloor ventilation (Q) following migration of gas (q) via pressure driven flow into the underfloor, and the subsequent equilibrium concentration of the gas, taking ventilation into account as indicated on the following diagram (source: CIRIA 149⁵, 1995).



The rate of subfloor ventilation from the assessment has also been used to revise the gas screening values within the NHBC's traffic light assessment to determine whether further mitigation for ground gas would be required.

4.2 Vertical Migration of Gas into Building Living Space

The second part of the assessment is based on considering the potential for gas to migrate vertically from underlying soils into the building living space, taking factors such as dilution into account to derive an equilibrium concentration for gas accumulation should vents become blocked. The risks associated with gas migration from pressure driven flow into structures at the site has been undertaken based on guidance provided in the Ground Gas Handbook (2009)⁶. A similar approach has also been adopted for the residential apartment block in Phase 5, this is considered to be acceptable as the apartment buildings will comprise a garage at ground level with one storey living space above and an external staircase providing access to the living area.

⁴ British Standard Institution (1991). Code of Practice for Ventilation Principles and Designing for Natural Ventilation. BS5925

⁵ CIRIA (1995). Protecting Development from Methane

⁶ Source: Wilson, S., Card, G. and Haines, S (2009). Ground Gas Handbook. Dunbeath: Whittles Publishing

5. SITE PARAMETERS

The parameters used in the assessment have been included in Appendix 1 and 2 with further justification provided below:

5.1 Ground Conditions - Gas Migration Pathway

As the source of the gas could be the Made Ground and / or organic alluvium, the depth of the source used in the assessment has been set at 1.0 m depth which is similar to when the ground investigation was undertaken, although sources within the alluvium are also present at greater depth. Therefore, this will be conservative where deeper gas sources are present - as it will be necessary to raise the site levels by approximately 1.5 m to 2.0 m in Phase 3 to 5 for flood defence, this would increase the depth to the gas source to 2.5 m to 3.0 m. Monitoring undertaken to date has been carried out prior to, during and post filling in some phases and has not identified any significant change in the gas regime associated with the fill process.

The sources of the gas are considered to be the Made Ground and / or alluvium which can be summarised as follows:

- Made Ground: Typically comprises silty, sandy or gravelly clay; and/or
- Alluvium: Typically comprises sandy clay and peaty clay.

Although much of the existing shallow soils are more cohesive in nature, although granular Made Ground has been noted in a number of exploratory holes at the site.

Soil permeability is required as part of the assessment for pressure driven flow. A permeability of 1×10^{-6} m/s has been used for the Made Ground and alluvium which is considered to be higher than values typically associated with predominantly clay soils (for instance ConSim indicates a range of 10^{-11} to 10^{-9} m/s for clay with 10^{-6} m/s within the upper range for a silt or lower end of the range for a fine sand).

5.2 Gas Concentrations

Based on guidance provided within BS8485:2015⁷ and BS8576:2013⁸ the highest peak readings obtained from gas monitoring have been used for methane (26.52% within Phase 3) and carbon dioxide (17.9% within Phase 4). The flow rate (0.7 litre / hour) has also been used in the assessment for the NHBC traffic lights.

Although elevated methane and carbon dioxide concentrations have been encountered, gas monitoring indicates the volumes of gas being generated in shallow soils at the site are low or even very low as evidenced by the observed low flow rates.

It has also been assumed that the highest gas concentrations are present across the site / development phases and that there is no degradation or oxidation of methane near surface; these assumptions are considered to be conservative.

⁷ BS8576:2013 Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs)

⁸ BS8485:2015 Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings

5.3 Building Parameters

The houses will be three storeys in height. The dimensions for the smaller of the proposed buildings have been used as this will be more conservative than using larger houses.

The parameters used in the assessment have been based on the smallest footprint for the low rise residential housing being constructed at the site, as indicated within the planning permission for the site (which is located in Phase 3):

- Plan area of 8.950 m (length) by 3.907 m (width) and 8.212 m height (to third floor ceiling joist) based on the living space of all three storeys. The ground floor living space is 2.514 m in height which has been used in this assessment.
- 0.25 m clear height for the subfloor with minimum external ventilation of 3000 mm²/m, although the assessment has been based upon the minimum required ventilation as per Building Regulations of 1500 mm²/m.

The following dimensions have been used for the residential apartments in Phase 5:

- Plan area for the smaller apartments of 3.040 m by 5.596 m, with height of the garage space on the ground floor between 2.442 m and 2.575 m. Access to the first floor living space is gained via open stairs located on the exterior of the building so stairwells have not been included in the assessment.

Plans showing the building dimensions have been provided in Appendix 1.

The pressure difference between the ground and inside the buildings which is used in the assessment for pressure driven flow has been based on guidance provided by the Environment Agency in SR3 (2009)⁹ for residential housing (3.1 Pa). The use of a low pressure in the assessment is considered to be consistent with the ground gas source (Made Ground and / or alluvium) and the low flow rates obtained from the gas monitoring. A lower or even negative pressure difference can also be created between the inside of the building and the ground due to wind effects (Venturi) on the building, internal heating (stack) and / or mechanical ventilation and air conditioning.

An air exchange rate of 0.5 complete changes per hour has been used inside the living space for low rise residential housing which is based on guidance provided by the Environment Agency (2009)⁹. The air exchange rate in the subfloor has been calculated as part of the ventilation assessment for the site specific screening values as part the revised NHBC 'traffic lights' assessment.

A conservative rate of one complete air exchange per day has been assumed for the garage space for the residential apartments in Phase 5.

⁹ Environment Agency (2009). Updated technical background to the CLEA model (Science Report: SC050021/SR3)

6. RESULTS OF THE ASSESSMENT

6.1 Low Rise Residential Buildings

NHBC Traffic Lights - Site Specific Gas Screening Value

Based on exceedances of the NHBC guidance for a 'Green' site for methane and carbon dioxide, further assessment has been undertaken to derive site specific screening values using proposed building parameters and calculations of the ventilation rates for the subfloor.

Calculation of the surface emission rate into the subfloor has been undertaken for pressure driven flow. Assessment of the subfloor ventilation rate has been undertaken using the approach outlined in guidance provided in BS5925:1991¹⁰. This is based on the subfloor building parameters outlined in Section 5 above, and an assumed ventilation area for the subfloor of 1500 mm²/m which is located on opposite sides along the shortest ends of the building.

The input parameters have been provided in Appendix 2.

The ventilation assessment indicates a void flow rate through the subfloor of 3.26 m³/hour, which is significantly higher than that assumed within the NHBC traffic light assessment (0.40 m³/hour). The ventilation rate equates to approximately 8 no. air exchanges per day in the subfloor which is greater than that assumed (one per day) in the NHBC 'traffic lights' assessment.

A review of the gas screening values derived using the NHBC 'traffic light' approach has been undertaken for site specific parameters as follows:

- Building floor plan: 35 m² which equates to an equivalent area of 3.5 boreholes.
- Subfloor volume: 8.75 m³ based on subfloor height of 0.25 m.
- Subfloor ventilation rate: 3.26 m³/hour.
- Maximum allowable gas concentration in the subfloor is based on a 'Green' site: 0.25 % for methane and 1.25 % for carbon dioxide.

The following site specific acceptable gas screening values have been obtained from the assessment for a 'Green' site and are as follows:

- Methane: 2.33 litres / hour (factor of safety of 12 over worst case gas screening value derived from gas monitoring).
- Carbon dioxide: 11.65 litres / hour (factor of safety of 93 over worst case gas screening value from gas monitoring).

The peak gas screening values obtained from monitoring for methane and carbon dioxide are below the acceptable gas screening values derived above. The time indicated for one complete air exchange is less than three hours, providing approximately 8 no. complete exchanges per day.

The equilibrium gas concentrations derived for the subfloor void with 1500 mm²/m external ventilation are as follows:

- Methane: 0.031%.
- Carbon dioxide: 0.016%.

¹⁰ BS5925:1991. Code of Practice for Ventilation Principles and Designing for Natural Ventilation

The equilibrium results derived for gas in the subfloor are lower than the maximum equilibrium concentrations indicated by the NHBC for methane (0.25%) and carbon dioxide (1.25%) for a 'Green' site.

The assessment above is considered to be conservative as the subfloor ventilation will be provided with vents which have a ventilation area greater than that which has been modelled, being of 6000 mm² at 2 m centres (3000 mm²/m). This will increase the volume of fresh air through the underfloor from 3.26 m³ / hour to 6.5 m³ / hour, decreasing the time for one complete air exchange rate from approximately 2.7 hours to 1.25 hours and further reducing the equilibrium gas concentration in the subfloor by half. The site specific gas screening values for a 'Green' site would also increase for methane (to 4.67 litres / hour) and carbon dioxide (to 23 litres / hour).

Vertical Migration into Building Living Space – No Attenuation in the Subfloor

A detailed quantitative risk assessment has been undertaken to consider the potential risk from the ingress of gas associated with the presence of organic material in the underlying Made Ground and / or alluvium at 1.0m depth via pressure driven flow into new buildings based on the peak results obtained from gas monitoring. This assessment has been undertaken to consider potential risk if the vents to the subfloor were to become blocked.

The following assessment has been based on the potential for migration and accumulation within the ground floor space which comprises a volume of 87.9m³ based on 8.950m (length) by 3.907m (width) and 2.514m in height.

The assessment has also been based on the assumption there would be no attenuation of gas within the subfloor due to dilution or from the building floor. In reality this will be conservative.

The input parameters used in the assessment have been provided in Appendix 3.

The results obtained from the assessment have been summarised in the following table.

Table 6.1 Calculated Equilibrium Gas Concentration

Scenario	Methane	Carbon Dioxide
Gas Concentration within Building	0.00233%	0.00116%

The results obtained from the assessment are very low. The result shown in Table 6.1 for methane is over 2000 times below the lower explosive limit (5%) for methane in air. The result for carbon dioxide is also over 2000 times below the level at which headaches and shortness of breath can occur (3%).

The surface emission rates calculated for pressure driven flow would be equivalent to a borehole flow rate of 0.29 litres / hour for methane and 0.15 litres / hour for carbon dioxide. This is slightly higher than the peak / worst case gas screening value obtained from monitoring visits for methane and carbon dioxide and provides further confidence that the risk assessment is based on similar conditions for ground gas to those present at the site.

This assessment is likely to be conservative for a number of reasons. Firstly, it assumes there is no attenuation from the floor slabs. Whilst precast suspended segmental subfloors such as beam and block flooring would not prevent gas ingress into the building, they should still provide some attenuation over no flooring being present.

In addition, the assessment assumes all the subfloor vents are blocked so there is no attenuation in the subfloor, which is unlikely to occur. Therefore, gas concentrations within the subfloor following dilution are likely to be much lower than the peak gas concentrations assumed for this assessment.

The assessment has been based on the gas source being located at 1.0m depth below the ground floor. However, increasing the site levels by 1.5m to 2.0m for flood defence would increase the distance between the gas source and development to around 2.5m to 3.0m and would reduce the estimated gas concentrations inside the building. For example, the methane concentration would reduce from 0.00233% to 0.00093% if the source was located at 2.5m below the ground floor.

Sensitivity – Vertical Migration into Building Living Space

BS8485:2015 indicates that a sensitivity analysis should be undertaken when a quantitative assessment of risks from gas is carried out.

The following scenarios have been considered for the sensitivity analysis:

- Migration of gas into only the ground floor living space with an increase in pressure difference between the source and building.
- Migration and dilution of gas into the ground floor WC.

The sensitivity analysis has been based on migration by pressure driven flow with no attenuation of gas within the subfloor or from the floor.

Ground floor Living Space

Increasing the pressure difference between the ground and inside of the building for the ground floor space by an order of magnitude from 3.1 to 30 Pa results in equilibrium concentration for methane of 0.023% (with all other parameters remaining the same).

This is still significantly below the lower explosive limit for methane and would result in an equivalent borehole flow rate of 2.84 litres / hour which is higher than has been obtained from gas monitoring.

Ground Floor Toilet

The development includes a ground floor toilet with the following dimensions obtained from development plans:

- Plan area of 3.6m² (1.90m x 1.90m).
- Height of 2.514m.

For the purpose of this assessment we have assumed that there is one air exchange per day within this space (similar to that assumed in the NHBC traffic lights assessment) and there is no attenuation from the floor. The equilibrium concentrations obtained for gas within the ground floor of 0.028% for methane and 0.0139% for carbon dioxide.

Using a more realistic (higher) air exchange rate, as would be expected for areas such as toilets, would reduce the estimated gas concentrations inside this space, for example 0.5 air exchanges per hour would reduce the estimated methane concentration from 0.028% to 0.0023%.

The results of the sensitivity analysis indicate the concentrations derived for methane and carbon dioxide inside the building living area would be low.

6.2 Residential Apartments

Residential apartments will be constructed in Phase 5. These will comprise a block of four apartments each with garage space on the ground floor and living space on the first floor. Two of the apartments will also have living space on the second floor. The subfloor will comprise a ventilated open void.

The two smaller apartments will have plan dimensions of 3.040 m by 5.596 m with the garage space being 2.442 m to 2.575 m in height. Access to the first floor living space is gained from stairs located on the outside of the building with no access from inside the garages.

Assessment of the potential for vertical migration of gas into the ground floor garage space has been undertaken using a similar approach to that above for migration into the living space. This assessment has been undertaken based on pressure driven flow from a source at 1.0m in the underlying Made Ground and / or alluvium using the peak results from gas monitoring. Again, the assessment has been based on the assumption there would be no attenuation of gas within the subfloor due to dilution or from the building floor which is conservative.

The results give estimated equilibrium concentrations in the subfloor void of 0.0288 % for methane and 0.0143 % for carbon dioxide.

The results obtained from the assessment are very low. The result obtained for methane is over 170 times below the lower explosive limit (5%) for methane in air. The result for carbon dioxide is also over 200 times below the level at which headaches and shortness of breath can occur (3%).

This assessment is still likely to be conservative as it assumes one complete air exchange per day in the garage space and that there is no attenuation of gas within the subfloor due to dilution or from the building floor.

7. CONCLUSIONS

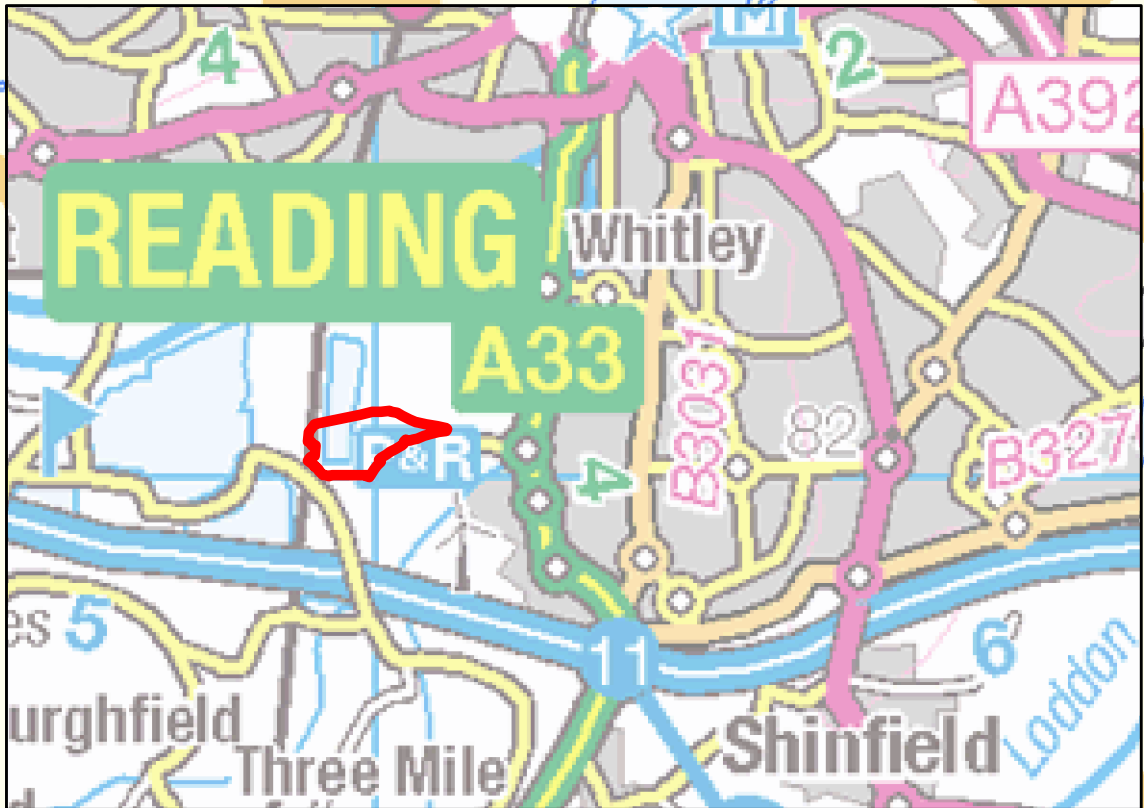
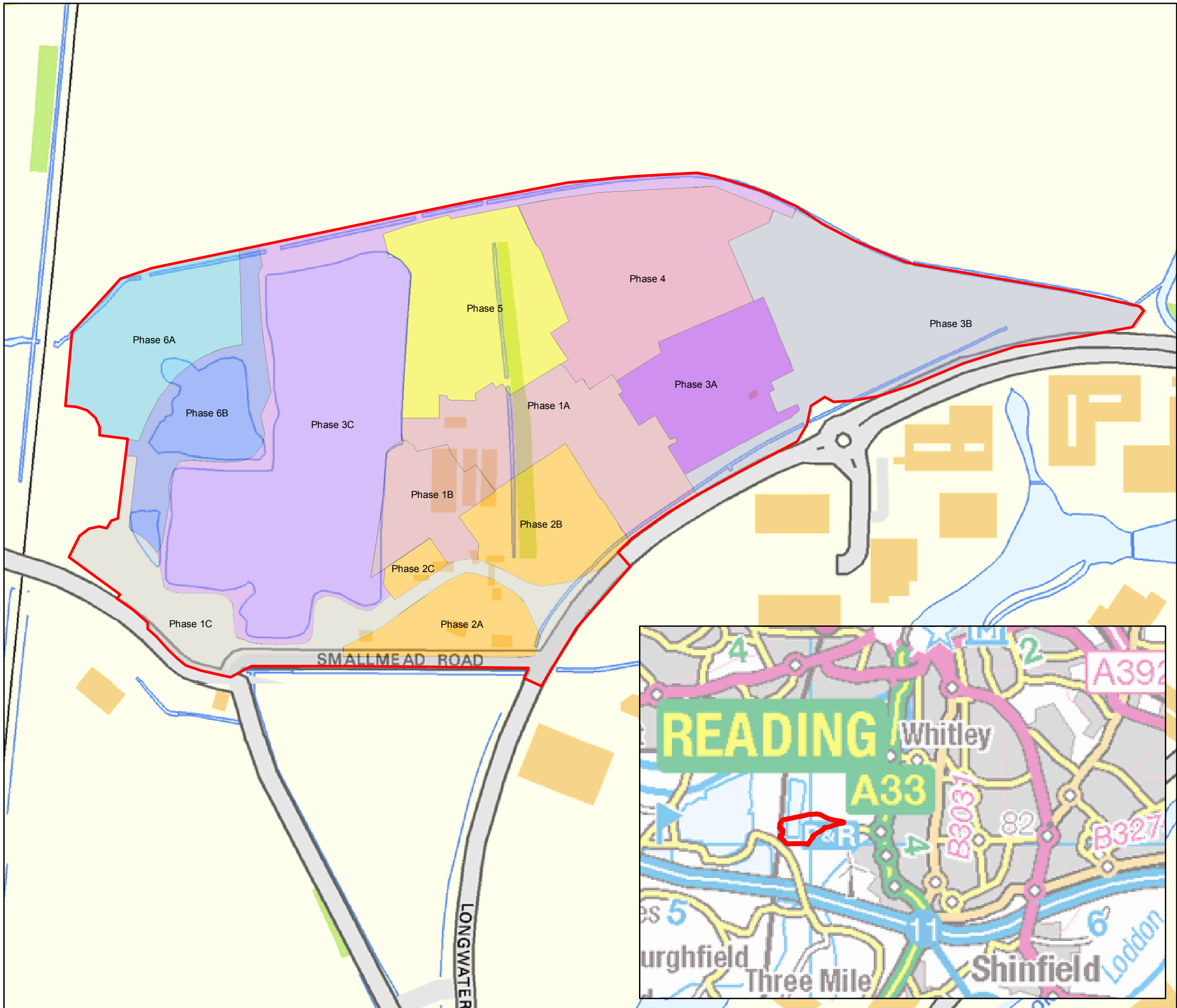
The results obtained from revising the NHBC traffic light assessment for site specific parameters indicates that the site would be classed as 'Green' for the low rise residential housing. The equilibrium concentrations derived for gas in the subfloor with dilution from ventilation in accordance with Building Regulations are less than the concentrations indicated within the NHBC guidance for a 'Green' site.

A quantitative assessment has also been undertaken to consider the potential risks from the vertical migration of ground gas from a source in the underlying Made Ground and / or alluvium into the ground floor of the low rise housing and the residential apartments in Phase 5 through pressure driven flow. The assessment has been based on the assumption that there is no dilution of gas within the subfloor (such as if all the vents were to become blocked), and no attenuation by the building floor which is likely to be conservative.

The results from the assessment indicate the risks from the ingress and accumulation of ground gas to existing buildings should be low from the gas regime encountered at the site with no further mitigation required for gas other than the subfloor ventilation.

The assessment has been undertaken based on a number of conservative assumptions. This includes assuming the highest result obtained for methane and carbon dioxide concentrations from site monitoring exists across the site and excludes any attenuation from the floor. In addition, although precast suspended segmental subfloors such as beam and block flooring would not prevent gas ingress, they should still provide some attenuation over no floor being present. The source of the gas has been based on site levels prior to raising them for flood defence, increasing the depth to the source of the gas would reduce the estimated concentrations within the subfloor and living spaces. Therefore, given the conservative nature of the assessment the risks from gas ingress are likely to be even lower.

APPENDIX 1 FIGURES



Site Boundary



1:3,000

1:50,000

Drawn at A3

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Client

St Edward Homes Ltd

Project Title

Green Park Village

Project Number

1620000492

Figure Title

Site Location Plan

RAMBOLL

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southampton@ramboll.co.uk
www.ramboll.co.uk

Date

May 2017

Prepared By

TS

Figure No.

Figure 1

Revision

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APPENDIX 2

SUBFLOOR VENTILATION – AIR FLOW THROUGH THE SUBFLOOR VOID

Parameter	Methane	Carbon Dioxide	Comments
Building Subfloor Parameters			
Length	9.55 m	9.55 m	Development plans
Width	4.182 m	4.182 m	Development plans
Subfloor Height	0.25m	0.25m	Development plans
Surface emission rate of gas beneath building			
Hydraulic conductivity of gas migration pathway	1×10^{-6} m/s	1×10^{-6} m/s	Estimates for sandy clay and sand based on guidance provided in Fetter (1993) and ConSim v2.5 manual.
Intrinsic permeability of gas migration pathway	1.02×10^{-13} m ²	1.02×10^{-13} m ²	Calculated
Unit weight of gas	7.2 N/m ³	19.4 N/m ³	Ground Gas Handbook (2009)
Viscosity of gas	1.03×10^{-5} Ns/m ³	1.4×10^{-5} Ns/m ³	Ground Gas Handbook (2009)
Pressure within the ground	3.1 Pa	3.1 Pa	Environment Agency SR3 (2009) for residential semi-detached housing - pressure difference between gas in soils and inside the building
Vertical migration distance	1.0m	1.0m	Based on source within the Made Ground / alluvium
Pressure gradient along gas migration route (i)	0.43	0.16	Calculated from pressure within the source and length of migration pathway
Gas concentration at source	26.5%	17.9%	Peak results from monitoring
Surface emission rate beneath building (q)	2.93×10^{-5} m ³ /hr/m ²	1.46×10^{-5} m ³ /hr/m ²	Calculated
Calculation of Air Flow Rate through the Void (Q)			
Design wind speed being exceeded for a given proportion of time (u_m)			
Hourly mean wind speed for the site area exceeded 50% of the time (u_{50})	4.0 m/s	4.0 m/s	Figure 5 BS5925
Correction ratio for the mean wind speed (u_{50}) being exceeded for a given percentage of time - based on 80%	0.46	0.46	Table 9 BS5925 for sheltered inland areas
Design wind speed being exceeded (u_m)	1.84	1.84	Calculated
Reference Wind Speed (u_r) at Vent Height			
Factors determining mean wind speed at different heights and for different types of terrain	k:0.35 a: 0.25	k:0.35 a: 0.25	Table 8 BS5925 for an urban location
Height of subfloor vents (z)	0.15 m	0.15 m	Development plans
Reference Wind Speed at vent height (U_r)	0.401 m/s	0.401 m/s	Calculated
Calculation of Air Flow Rate through the Void (Q)			
Equivalent area of openings / ventilation in subfloor (A_w)	1500 mm ² /m	1500 mm ² /m	Minimum requirement in Building Regulations

Parameter	Methane	Carbon Dioxide	Comments
Discharge coefficient of opening (Cd)	0.61	0.61	BS5925
Reference wind speed (U _r)	0.401	0.401	Calculated
Surface pressure coefficient (C _p)	0.4	0.4	Conservative value
Air flow through the void (Q)	3.26 m ³ /hour	3.26 m ³ /hour	Calculated
Equilibrium Concentration in Subfloor and Time to Reach Critical Concentration			
Critical gas concentration in subfloor	1%	1%	Assumed critical concentration
Equilibrium gas concentration in subfloor	0.031%	0.016%	Calculated
Time to fill the subfloor to the critical concentration during a period of still wind	85 hours	171 hours	Calculated – greater than period of still wind (10 hours) indicated in Ground Gas Handbook (6 hours in Partners in Technology, 1997)

APPENDIX 3

INPUT PARAMETERS FOR PRESSURE DRIVEN FLOW INTO GROUND FLOOR LIVING SPACE

Parameter	Methane	Carbon Dioxide	Comments
Hydraulic conductivity of gas migration pathway	1×10^{-6} m/s	1×10^{-6} m/s	Estimates for sandy clay and sand based on guidance provided in Fetter (1993) and ConSim v2.5 manual
Intrinsic permeability of gas migration pathway	1.02×10^{-13} m ²	1.02×10^{-13} m ²	Calculated
Unit weight of gas	7.2 N/m ³	19.4 N/m ³	Ground Gas Handbook (2009)
Viscosity of gas	1.03×10^{-5} Ns/m ³	1.4×10^{-5} Ns/m ³	Ground Gas Handbook (2009)
Pressure within the ground	3.1 Pa	3.1 Pa	Environment Agency SR3 (2009) for residential semi-detached housing - pressure difference between gas in soils and inside the building
Vertical migration distance	1.0m	1.0m	Based on source within the Made Ground / alluvium
Pressure gradient along gas migration route (i)	0.43	0.16	Calculated from pressure within the source and length of migration pathway
Gas concentration at source	26.5%	17.9%	Peak results from monitoring
Surface emission rate beneath building	2.93×10^{-5} m ³ /hr/m ²	1.46×10^{-5} m ³ /hr/m ²	Calculated
Equilibrium Concentration in Receptor			
Height of building space	2.514m	2.514m	Development plans
Length of building space	8.950m	8.950m	Development plans
Width of building space	3.907m	3.907m	Development plans
Number of air exchanges per hour	0.5	0.5	Environment Agency SR3 (2009) for residential housing
Equilibrium gas concentration in building	0.00233%	0.00116%	Calculated

APPENDIX 4

GROUND GAS MONITORING DATA

Ground Gas Risk Assessment
1620000492 Green Park Village

Notes: Assessment based on Guidance published in CIRIA C665 "Assessing risks posed by hazardous ground gases to buildings"

Information from Table 8.5 of CIRIA C665

Characteristic Situation 1 Conditions

Gas Screening Value (CH4 or CO2) <0.7
Typically methane <1% by volume
Typically carbon dioxide <5% by volume

Characteristic Situation 2 Conditions

Gas screening values (CH4 or CO2) <0.7
Borehole air flow rate <70l/h

Characteristic Situation 3 Conditions

Gas screening values (CH4 or CO2) <3.5

Approach

Maximum concentrations and flow rates are used in the assessment below (minimum values for oxygen)

Where no detectable flow the instrument limit of detection is used (0.1/hr)

Where concentrations are recorded below LoD, the instrument LoD is used in the assessment (0.5%)

BH ID	Phase	Height m OD	Response Zone	Water Depth mbgl	Water Depth mAOD	Round	Date	Atmos. Pressure mB	Gas Flow l/h	SS CH4 %v/v	SS CO2 %v/v	SS O2 %v/v	SS CO ppm	SS H2S ppm	VOCs ppm	CH4 Peak %v/v	CO2 Peak %v/v	O2 Min %v/v	GSV CH4	GSV CO2	Characteristic Situation CH4	Characteristic Situation CO2
RWS601	3	38.972	0.5 to 3.0 MG and RTD	1.49	37.48	1	19.04.2017	1032	0.0	0.1	10.5	7.9	1	0	0.6	0.2	10.5	7.9	0.00	0.00	1	2
				1.49	37.48	2	25.04.2017	1010	0.0	0.1	10.9	8	2	0	0.7	0.2	10.9	8	0.00	0.00	1	2
				1.49	37.48	3	05.05.2017	1019	0.0	0.1	6.8	13.3	1	0	0.3	0.1	6.8	13.3	0.00	0.00	1	2
				1.55	37.42	4	15.05.2017	1019	0.0	0.1	7.5	12.2	2	0	1.1	0.1	7.5	12.2	0.00	0.00	1	2
				1.90	37.07	5	19.05.2017	1007	0.0	0.2	7.2	11	3	0	-	0.2	7.2	11	0.00	0.00	1	2
				1.87	37.10	6	24.05.2017	1022	0.0	0.1	8	11.2	3	0	0.9	0.1	8	15.6	0.00	0.00	1	2
RWS602	3	39.121	1.5 to 4.0 ALV and RTD	1.92	37.20	1	19.04.2017	1032	0.0	0.1	1	19.4	2	1	1.2	0.1	1	19.2	0.00	0.00	1	1
				1.90	37.22	2	25.04.2017	1010	0.0	0.1	1	19.8	1	0	1.1	0.1	1	19.8	0.00	0.00	1	1
				1.94	37.18	3	05.05.2017	1019	0.0	0.1	0.7	20	1	0	0.5	0.1	0.7	20	0.00	0.00	1	1
				1.95	37.17	4	15.05.2017	1019	0.0	0.1	1.7	19.5	1	0	0.7	0.1	1.7	17.3	0.00	0.00	1	1
				1.85	37.27	5	19.05.2017	1007	0.0	0.2	0.6	20.4	1	0	0.6	0.2	0.8	16.4	0.00	0.00	1	1
				1.90	37.22	6	24.05.2017	1022	0.0	0	0.4	19.6	3	1	0.5	0	0.7	19.3	0.00	0.00	1	1
RWS603	3	39.275	2.5 to 3.0 MG and RTD	2.17	37.11	1	19.04.2017	1032	0.0	0.1	1.2	18.8	1	1	1.1	0.1	1.3	14.5	0.00	0.00	1	1
				2.18	37.10	2	25.04.2017	1010	0.0	0.1	0.9	19.6	1	0	0.7	0.1	0.9	18	0.00	0.00	1	1
				2.35	36.93	3	05.05.2017	1019	0.0	0.1	2.1	18.4	1	0	0.8	0.1	2.1	18.3	0.00	0.00	1	1
				2.26	37.02	4	15.05.2017	1019	0.0	0.1	1.7	19.9	1	0	-	0.1	1.7	18.9	0.00	0.00	1	1
				-	-	5	19.05.2017	Borehole area flooded - inaccessible										0.00	0.00	-	-	
				2.58	36.70	6	24.05.2017	1022	0.0	0.1	0.7	18.4	2	0	-	0.1	0.9	16.4	0.00	0.00	1	1
RWS604	3	39.976	2.5 to 4.0 ALV and RTD	2.85	37.13	1	19.04.2017	1032	0.0	0.2	1.3	15	3	1	2.2	0.2	1.3	12.8	0.00	0.00	1	1
				2.86	37.12	2	25.04.2017	1010	0.0	0.2	1.5	15.1	2	0	1.8	0.2	1.6	14.5	0.00	0.00	1	1
				2.86	37.12	3	05.05.2017	1019	0.0	0.1	2.2	14.8	1	0	0.4	0.1	2.2	14.7	0.00	0.00	1	1
				2.85	37.13	4	15.05.2017	1019	0.0	0.3	4.6	9.4	2	0	1.3	0.3	4.6	9.4	0.00	0.00	1	1
				2.65	37.33	5	19.05.2017	1007	0.0	0.2	1.7	16.9	0	0	1	0.3	3.4	13.9	0.00	0.00	1	1
				2.75	37.23	6	24.05.2017	1022	0.0	0.2	0.9	16.5	2	1	0.7	0.2	1.4	14.3	0.00	0.00	1	1
RWS605	3	39.974	2.5 to 3.65 - MG, ALV and RTD	-	-	2	25.04.2017	Borehole Buried and Inaccessible										0.00	0.00	-	-	
				-	-	3	05.05.2017											0.00	0.00	-	-	
				-	-	4	15.05.2017											0.00	0.00	-	-	
				-	-	5	19.05.2017											0.00	0.00	-	-	
				-	-	6	24.05.2017											0.00	0.00	-	-	
				-	-	1	19.04.2017											0.00	0.00	-	-	
RWS606	3	40.037	1.7 to 3.0 - MG and RTD	2.79	37.25	1	19.04.2017	1032	0.0	0.3	1.1	19.1	2	0	1.3	0.3	1.2	17.7	0.00	0.00	1	1
				2.94	37.10	2	25.04.2017	1010	0.1	1.4	7.5	6.2	3	0	1.1	1.4	7.5	6.2	0.00	0.01	2	2
				2.92	37.12	3	05.05.2017	1019	0.0	0.5	2.5	15.7	1	0	0.5	0.5	2.5	15.7	0.00	0.00	1	1
				2.94	37.10	4	15.05.2017	1019	0.0	0.6	1.5	18.8	1	0	0.8	0.6	1.7	16.8	0.00	0.00	1	1
				2.80	37.24	5	19.05.2017	1007	0.0	11.2	10.3	0.2	3	0	0.1	11.2	10.3	0.2	0.00	0.00	2	2
				Dry	Dry	6	24.05.2017	1022	0.0	12.4	9.4	2.4	4	0	0.2	12.4	9.4	2.4	0.00	0.00	2	2
RWS607	3	40.353	1.5 to 4.1 - MG , ALV and RTD	3.02	37.33	1	19.04.2017	1032	0.0	2.3	3.9	15.3	3	0	0.9	2.5	3.9	15.3	0.00	0.00	2	1
				3.27	37.08	2	25.04.2017	1010	0.0	4.3	4.7	14	1	0	0.7	4.5	4.9	14	0.00	0.00	2	1
				2.31	38.04	3	05.05.2017	1019	0.0	3.3	4.9	14.3	2	0	0.8	3.3	4.9	14.3	0.00	0.00	2	1
				3.26	37.09	4	15.05.2017	1019	0.0	2.7	3.3	16.6	1	0	0.5	2.8	3.4	16.5	0.00	0.00	2	1
				3.10	37.25	5	19.05.2017	1007	1.4	8.2	3.6	9.7	1	0	0.3	8.2	3.6	9.7	0.11	0.05	2	1
				3.15	37.20	6	24.05.2017	1022	0.0	12.9	6.1	5.8	5	0	0.2	15.7	7.4	5.8	0.00	0.00	2	2
RWS608	3	39.901	1.5 to 4.0 - MG , ALV and RTD	3.00	36.90	1	19.04.2017	1032	0.0	0.1	9.7	5.8	2	0	2.1	0.2	13.1	5.8	0.00	0.00	1	2
				-	-	2	25.04.2017	Gas tap/bung removed										0.00	0.00	-	-	
				3.01	36.89	3	05.05.2017											0.00	0.00	-	-	
				2.98	36.92	4	15.05.2017											0.00	0.00	-	-	
				2.85	37.05	5	19.05.2017	1007	0.0	0.1	10.9	6.3	0	0	0.2	0.1	12.5	7.9	0.00	0.00	1	2
				2.96	36.94	6	24.05.2017	1022	0.0	0.1	0.7	18.2	3	0	0.3	0.1	0.8	18.2	0.00	0.00	1	1
RWS609	3	40.218	1.0 to 2.0 - MG	3.04	37.18	1	19.04.2017	1032	0.0	2.1	2.4	11	2	0	1.1	2.4	2.5	11	0.00	0.00	2	1
				2.90	37.32	2	25.04.2017	1010	0.0	26.5	9.4	0.6	1	0	0	26.5	9.4	0.6	0.00	0.00	2	2
				Dry	Dry	3	05.05.2017	1019	0.0	19.1	8.7	1.1	3	0	0	19.2	8.7	1.1	0.00	0.00	2	2
				Dry	Dry	4	15.05.2017	1019	0.0	1.1	2.7	12.2	1	0	0.7	1.1	2.7	12.2	0.00	0.00	2	1
				Dry	Dry	5	19.05.2017	1007	0.0	4.8	2.6	14.6	0	0	0.2	5.7	2.6	14.6	0.00	0.00	2	1
				Dry	Dry	6	24.05.2017	1022	0.0	0.1	0.6	18	0	0	0.4	1	0.6	16.6	0.00	0.00	2	1
RWS610	3	40.364	1.5 to 4.0 - MG, ALV and RTD	1.65	38.71	1	19.04.2017	1032	5.0	0.2	1.6	19.3	5	0	2.9	0.2	1.6	17.1	0.01	0.08	1	2
				Dry	Dry	2	25.04.2017	1010	0.0	1.7	12.3	3.9	4	0	1.2	1.9	12.3	3.9	0.00	0.00	2	2
				Dry	Dry	3	05.05.2017	1019	0.0	0.1	6.3	17.2	0	0	0.9	0.2	6.4	16.9	0.00	0.00	1	2
				-	-	4	15.05.2017	Gas tap/bung removed										0.00	0.00	-	-	
				Dry	Dry	5	19.05.2017	Borehole removed										0.00	0.00	-	-	
				Dry	Dry	6	24.05.2017											0.00	0.00	-	-	

Ground Gas Risk Assessment
1620000492 Green Park Village

Notes: Assessment based on Guidance published in CIRIA C665 "Assessing risks posed by hazardous ground gases to buildings"

Information from Table 8.5 of CIRIA C665

Characteristic Situation 1 Conditions

Gas Screening Value (CH4 or CO2) <0.7

Typically methane <1% by volume

Typically carbon dioxide <5% by volume

Characteristic Situation 2 Conditions

Gas screening values (CH4 or CO2) <0.7

Borehole air flow rate <70l/h

Characteristic Situation 3 Conditions

Gas screening values (CH4 or CO2) <3.5

Approach

Maximum concentrations and flow rates are used in the assessment below (minimum values for oxygen)

Where no detectable flow the instrument limit of detection is used (0.1l/hr)

Where concentrations are recorded below LoD, the instrument LoD is used in the assessment (0.5%)

Key for Shading

	CO2 > 5% by volume
	CH4 > 1% by volume
	GSV < 0.07l/hr i.e. CS1
	GSV > or = 0.07l/hr i.e. CS2
	GSV > or = 0.7l/hr i.e. CS3

BH ID	Phase	Height m OD	Response Zone	Water Depth	Water Depth	Round	Date	Atmos. Pressure	Peak Gas Flow	SS CH4	SS CO2	SS O2	SS CO	SS H2S	VOCs	CH4	CO2	O2	GSV CH4	GSV CO2	Characteristic Situation CH4	Characteristic Situation CO2
				mbgl	mAOD			mB	l/h	%v/v	%v/v	%v/v	ppm	ppm	ppm	Peak %v/v	Peak %v/v	Min %v/v				
RWS611	4	39.997	1.5 to 4.0 MG, ALV and RTD	2.79	37.21	1	19.04.2017	1032	0.0	0.1	1.2	10.2	3	1	2.4	0.1	1.2	10.2	0.000	0.000	1	1
				2.82	37.18	2	26.04.2017	1010	0.1	0.1	2	5.4	3	1	1.5	0.1	2	5.2	0.000	0.002	1	1
				2.83	37.17	3	05.05.2017	1019	0.0	0.1	2	8	2	0	1.2	0.1	2	8	0.000	0.000	1	1
				2.80	37.20	4	15.05.2017	1019	0.1	0	2.2	9.1	2	0	1.7	0.2	2.2	9.1	0.000	0.002	1	1
				2.67	37.33	5	19.05.2017	1007	0.0	0.6	2.9	3	4	0	1.1	0.6	2.9	3	0.000	0.000	1	1
				2.81	37.19	6	24.05.2017	1022	0.0	0.1	2.7	8.1	4	1	1.3	0.1	2.7	8.1	0.000	0.000	1	1
RWS612	4	40.267	2.0 to 4.0 MG, ALV and RTD	3.09	37.18	1	19.04.2017	1032	0.0	0.2	0.4	14.4	3	0	1.6	0.2	0.4	14.4	0.000	0.000	1	1
				3.10	37.17	2	26.04.2017	1010	0.0	0.1	0.5	10.1	1	0	1.4	0.2	0.6	10.1	0.000	0.000	1	1
				3.13	37.14	3	05.05.2017	1019	0.0	0.1	0.7	15	2	0	0.8	0.1	0.7	14.9	0.000	0.000	1	1
				3.12	37.15	4	15.05.2017	1019	0.0	0.1	0.9	15	1	0	0.7	0.1	0.9	15	0.000	0.000	1	1
				2.95	37.32	5	19.05.2017	1007	0.0	0.1	0.6	11.8	1	0	0.6	0.1	0.6	11	0.000	0.000	1	1
				3.00	37.27	6	24.05.2017	1022	0.0	0	0.2	16.1	1	0	0.6	0	0.1	16.1	0.000	0.000	1	1
RWS613	4	38.173	0.5 to 3.0 MG and RTD	1.01	37.16	1	19.04.2017	1032	0.0	0.2	0.5	20	2	0	0.5	0.2	0.5	19.9	0.000	0.000	1	1
				1.06	37.11	2	26.04.2017	1010	0.0	0.1	0.1	19.8	2	0	0.5	0.1	1	19.8	0.000	0.000	1	1
				1.07	37.10	3	05.05.2017	1019	0.0	0.1	0.7	18.9	2	0	0.3	0.1	0.7	18.9	0.000	0.000	1	1
				1.00	37.17	4	15.05.2017	1019	0.0	0.1	3	13.3	1	0	0.3	0.1	3	13.3	0.000	0.000	1	1
				0.85	37.32	5	19.05.2017	1007	0.0	0.1	7	4.1	0	0	0.2	0.1	7	4.1	0.000	0.000	1	2
				1.33	36.84	6	24.05.2017	1023	0.0	0	4.9	7.2	5	1	0.4	0	4.9	7.2	0.000	0.000	1	1
RWS614	4	38.605	0.5 to 4.0 MG, ALV and RTD	1.41	37.20	1	19.04.2017	1032	0.1	0.1	2.4	17.7	1	0	0.6	0.2	2.4	17.7	0.000	0.002	1	1
				1.45	37.16	2	26.04.2017	1010	0.0	0.1	3.1	17.1	1	0	0.5	0.1	3.1	17.1	0.000	0.000	1	1
				1.49	37.12	3	05.05.2017	1019	0.0	0.1	4.1	15.1	2	0	0.3	0.1	4.1	15.1	0.000	0.000	1	1
				1.46	37.15	4	15.05.2017	1019	0.0	0.1	3.4	17	1	0	0.3	0.1	3.4	17	0.000	0.000	1	1
				1.27	37.34	5	19.05.2017	1007	0.0	0.1	1.8	9.9	1	0	0.2	0.1	1.8	9.9	0.000	0.000	1	1
				1.37	37.24	6	24.05.2017	1022	0.0	0	2.8	15	3	0	0.6	0	2.8	15	0.000	0.000	1	1
RWS615	4	38.658	0.5 to 4.0 ALV and RTD	1.85	36.81	1	04.04.2017	1020	0.0	0.2	6.2	14.1	3	0	-	0.2	6.2	14.1	0.000	0.000	1	2
				1.49	37.17	2	19.04.2017	1032	0.1	0.1	8.1	13	2	0	0.7	0.2	8.1	13	0.000	0.008	1	2
				1.55	37.11	3	26.04.2017	1010	0.0	0.1	8.6	13.1	2	0	0.5	0.1	8.6	13.1	0.000	0.000	1	2
				1.59	37.07	4	05.05.2017	1019	0.0	0.1	8.1	13.7	2	0	0.6	0.1	8.1	13.7	0.000	0.000	1	2
				1.55	37.11	5	15.05.2017	1019	0.0	0.1	10.9	11	1	0	0.5	0.1	10.9	11	0.000	0.000	1	2
				1.42	37.24	6	19.05.2017	1007	0.0	0.2	11.3	7.2	0	0	0.5	0.2	11.3	7.2	0.000	0.000	1	2
RWS638	4	38.279	0.5 to 2.9 MG, ALV and RTD	1.10	37.18	1	19.04.2017															
				1.14	37.14	2	26.04.2017	1014	0.0	0.1	0.3	20.5	1	0	6	0.1	0.3	20.5	0.000	0.000	1	1
				1.14	37.14	3	05.05.2017	1019	0.0	0.1	0.3	20.5	2	0	0.5	0.1	0.3	20.5	0.000	0.000	1	1
				1.26	37.02	4	15.05.2017	1019	0.0	0.1	0.3	17.9	3	0	1.7	0.1	0.3	17.9	0.000	0.000	1	1
				-	-	5	19.05.2017															
				1.19	37.09	6	24.05.2017	1023	0.0	0	0.4	19.6	1	0	0.3	0	0.4	19.6	0.000	0.000	1	1
RWS639	4	38.616	0.5 to 3.7 MG, ALV and RTD	1.45	37.17	1	19.04.2017															
				1.49	37.13	2	26.04.2017	1014	0.0	0.5	7.9	9.8	2	0	0.8	0.5	7.9	9.8	0.000	0.000	1	2
				1.49	37.13	3	05.05.2017	1019	0.0	0.1	1.8	15.4	2	0	0.5	0.1	1.8	15.4	0.000	0.000	1	1
				1.47	37.15	4	15.05.2017	1019	0.0	0.1	0.5	18.7	1	0	1.2	0.1	0.5	18.7	0.000	0.000	1	1
				1.27	37.35	5	19.05.2017	1007	0.0	6.9	17.9	0	2	0	0.2	6.9	17.9	0	0.000	0.000	2	2
				1.38	37.24	6	24.05.2017	1023	0.0	0	0.5	19.9	4	1	0.4	0	0.5	19.9	0.000	0.000	1	1

Worst Case	0.1	6.9	17.9	0	5	1	6	6.9	17.9	0	0.007	0.018	2	2
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italics - response zone full saturated

italics height - approximate from topo survey

Ground Gas Risk Assessment
1620000492 Green Park Village

Notes: Assessment based on Guidance published in CIRIA C665 "Assessing risks posed by hazardous ground gases to buildings"

Information from Table 8.5 of CIRIA C665

Characteristic Situation 1 Conditions

Gas Screening Value (CH4 or CO2) <0.7

Typically methane <1% by volume

Typically carbon dioxide <5% by volume

Characteristic Situation 2 Conditions

Gas screening values (CH4 or CO2) <0.7

Borehole air flow rate <70l/h

Characteristic Situation 3 Conditions

Gas screening values (CH4 or CO2) <3.5

Key for Shading

CO2 > 5% by volume

CH4 > 1% by volume

GSV < 0.07l/hr i.e. CS1

GSV > or = 0.07l/hr i.e. CS2

GSV> or = 0.7l/hr i.e. CS3

Approach

Maximum concentrations and flow rates are used in the assessment below (minimum values for oxygen)

Where no detectable flow the instrument limit of detection is used (0.1l/hr)

Where concentrations are recorded below LoD, the instrument LoD is used in the assessment (0.5%)

BH ID	Phase	Height	Response Zone	Water Depth	Water Depth	Round	Date	Atmos. Pressure	Peak Gas Flow	SS CH4	SS CO2	SS O2	SS CO	SS H2S	VOCs	CH4	CO2	O2	GSV CH4	GSV CO2	Characteristic Situation CH4	Characteristic Situation CO2	
		m OD		mbgl	mAOD			mB	l/h	%v/v	%v/v	%v/v	ppm	ppm	ppm	Peak %v/v	Peak %v/v	Min %v/v					
RWS615	485	39.66	0.5 to 4.0 m ALV and RTD	1.85	37.81	1	04.04.2017	1020	0.0	0.2	6.2	14.1	3	0	-	0.2	6.2	14.1	0.00	0.00	1	2	
				1.49	38.17	2	19.04.2017	1032	0.1	0.1	8.1	13	2	0	0.7	0.2	8.1	13	0.00	0.01	1	2	
				1.55	38.11	3	25.04.2017	1010	0.0	0.1	8.6	13.1	2	0	0.5	0.1	8.6	13.1	0.00	0.00	1	2	
				1.59	38.07	4	05.05.2017	1019	0.0	0.1	8.1	13.7	2	0	0.6	0.1	8.1	13.7	0.00	0.00	1	2	
				1.55	38.11	5	15.05.2017	1019	0.0	0.1	10.9	11	1	0	0.5	0.1	10.9	11	0.00	0.00	1	2	
				1.42	38.24	6	19.05.2017	1007	0.0	0.2	11.3	7.2	0	0	0.5	0.2	11.3	7.2	0.00	0.00	1	2	
				RWS616	485	39.73	0.5 to 4.5 m MG, ALV and RTD	2.59	37.14	1	27.03.2017	1017	0.0	1.8	8.3	14.4	6	1	2.2	1.8	8.3	14.4	0.00
2.05	37.68	2	04.04.2017					1020	0.0	0.4	1.3	18.2	2	0	-	0.4	1.3	18.2	0.00	0.00	1	1	
2.52	37.21	3	05.05.2017					1019	0.0	0.1	1	18.3	2	0	0.4	0.1	1	18.3	0.00	0.00	1	1	
2.63	37.10	4	15.05.2017					1019	0.0	0.1	0.8	17.7	1	0	0.3	0.1	0.8	17.7	0.00	0.00	1	1	
2.45	37.28	5	19.05.2017					1007	0.0	1.6	0.8	7	2	0	0.5	1.6	0.8	7	0.00	0.00	2	1	
2.70	37.03	6	24.05.2017					1022	0.0	0.1	0.4	19.1	2	0	0.4	0.1	0.4	19.1	0.00	0.00	1	1	
RWS617	5	40.4	1.5 5.0 m MG, ALV and RTD					3.30	37.10	1	27.03.2017	1017	0.0	0	3.3	4.2	5	10	2.7	0	3.3	4.2	0.00
				3.37	37.03	2	04.04.2017	1020	0.0	0.2	0.4	19	3	0	-	0.2	0.4	19	0.00	0.00	1	1	
				3.47	36.93	3	19.04.2017	1032	0.0	0.2	1.1	17.2	3	0	0.9	0.2	1.1	17.2	0.00	0.00	1	1	
				3.45	36.95	4	26.04.2017	1010	0.0	0.1	3.5	11.5	2	0	0.9	0.1	3.6	12.9	0.00	0.00	1	1	
				3.24	37.16	5	05.05.2017	1019	0.0	0.1	4.3	5.5	3	0	0.8	0.1	4.3	5.5	0.00	0.00	1	1	
				3.25	37.15	6	15.05.2017	1019	0.0	0.1	4	12	2	2	0.8	0.1	4	12	0.00	0.00	1	1	
				RWS618	5	38.62	1.0 to 3.5 m ALV, RTD and LMBE	1.79	36.83	1	27.03.2017	1017	0.0	0	3.6	15.6	2	1	2.1	0	3.6	15.6	0.00
1.85	36.77	2	04.04.2017					1020	0.0	0.2	0.1	20.7	2	0	-	0.2	0.1	20.7	0.00	0.00	1	1	
1.96	36.66	3	19.04.2017					1032	-0.1	0.2	2.1	18.4	1	0	0.4	0.2	2.2	18.2	0.00	0.00	1	1	
1.97	36.65	4	26.04.2017					1010	0.0	0.1	5.7	12.6	2	0	0.7	0.1	5.7	12.6	0.00	0.00	1	2	
1.94	36.68	5	05.05.2017					1019	0.0	0.1	5.6	1.8	2	0	0.5	0.1	5.6	13.8	0.00	0.00	1	2	
1.92	36.70	6	15.05.2017					1019	0.0	0.1	1.8	16.9	1	0	0.3	0.1	1.8	16.9	0.00	0.00	1	1	
RWS620	5	40.18	2.0 to 5.0 m MG, ALV and RTD					3.30	36.88	1	04.04.2017	1020	0.0	0.2	0.4	19.8	3	0	-	0.2	0.4	19.8	0.00
				3.41	36.77	2	26.04.2017	1014	0.0	0.1	0.6	20.3	1	0	0.3	0.1	0.6	20.2	0.00	0.00	1	1	
				3.30	36.88	3	05.05.2017	1019	0.0	0.1	0.1	21.2	1	0	0.4	0.1	0.1	21.2	0.00	0.00	1	1	
				3.36	36.82	4	15.05.2017	1019	0.0	0.1	0.3	19.7	2	0	0.7	0.1	0.3	19.7	0.00	0.00	1	1	
				3.12	37.06	5	19.05.2017	1007	0.0	0.1	0.2	18.2	2	0	0.8	0.1	0.2	18.2	0.00	0.00	1	1	
				—	—	6	24.05.2017	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
				RWS621	5	40.3	1.0 to 7.5 m MG, ALV, RTD and LMBE	3.32	36.98	1	04.04.2017	1020	0.0	0.1	0	18.3	11	0	-	0.1	0.1	18.3	0.00
3.41	36.89	2	26.04.2017					1014	0.0	0.1	1.5	18.1	1	0	0.8	0.1	1.5	18.1	0.00	0.00	1	1	
3.24	37.06	3	05.05.2017					1019	0.0	0.1	1.2	19.1	1	0	0.7	0.1	1.7	15.9	0.00	0.00	1	1	
3.28	37.02	4	15.05.2017					1019	0.0	0.1	0.2	20.6	2	0	0.9	0.1	0.2	20.6	0.00	0.00	1	1	
2.96	37.34	5	19.05.2017					1007	0.0	0.1	0.3	20.9	1	0	0.2	0.1	0.3	20.9	0.00	0.00	1	1	
—	—	6	24.05.2017					—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worst Case									0.1	1.8	11.3	1.8	11	10	2.7	1.8	11.3	4.2	0.0018	0.0113	2	2	