APPENDIX 14

OCCUPATIONAL MONITORING OF HEADSPACE AIR WITHIN HOUSE NO. 25, 26, 52 & 53 AND HEADSPACE MONITORING OF GAS WELL 1, GAS WELL 2, GAS WELL 3, AND GAS WELL 4 LOCATED IN BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN.
PERFORMED BY
ODOUR MONITORING IRELAND.
12TH JUNE 2018 VER.4. REPORT NUMBER: 2018014(4)

OCCUPATIONAL MONITORING OF HEADSPACE AIR WITHIN HOUSE NO. 47, BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN.
PERFORMED BY
ODOUR MONITORING IRELAND.
31ST AUGUST 2018 VER.3. REPORT NUMBER: 2018356(3)

MULROY ENVIRONMENTAL TEST REPORT – TO EXAMINE IF VOLATILE ORGANIC COMPOUNDS (VOCs) ARE BEING EMITTED FROM THE WATER MAINS FROST PROTECTION PLUG
USED IN HAMILTON PLACE, BARNAGEERAGH COVE, SKERRIES, COUNTY
DUBLIN

GAS ANALYSIS OF HEADSPACE AIR WITHIN GAS SAMPLING BAG CONTAINING FROST PROTECTION CAPS FROM HOUSE 26 & 52, BARNAGEERAGH COVE, SKERRIES, COUNTY DUBLIN

31ST JANUARY 2019, REPORT NUMBER: 2019035 (1)

OCCUPATIONAL MONITORING OF HEADSPACE AIR WITHIN HOUSE NO. 25, 26, 52 & 53 AND HEADSPACE MONITORING OF GAS WELL 1, GAS WELL 2, GAS WELL 3, AND GAS WELL 4 LOCATED IN BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN.

PERFORMED BY

ODOUR MONITORING IRELAND.

12TH JUNE 2018 VER.4. REPORT NUMBER: 2018014(4)

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OCCUPATIONAL MONITORING OF HEADSPACE AIR WITHIN HOUSE NO. 25, 26, 52 & 53 AND HEADSPACE MONITORING OF GAS WELL 1, GAS WELL 2, GAS WELL 3, AND GAS WELL 4 LOCATED IN BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN.

PERFORMED BY ODOUR MONITORING IRELAND ON THE BEHALF OF MULROY ENVIRONMENTAL LTD.

REPORT PREPARED BY:	Dr. Brian Sheridan
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ATTENTION:	Mr. Patrick McCabe & Mr. Padraic Mulroy
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Project: **OCCUPATIONAL MONITORING OF HEADSPACE AIR WITHIN HOUSE NO. 25, 26, 52 & 53 AND HEADSPACE MONITORING OF GAS WELL 1, GAS WELL 2, GAS WELL 3, AND GAS WELL 4 LOCATED IN BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN.**

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This document is submitted as part of occupational monitoring works carried out by Odour Monitoring Ireland Ltd on behalf of Mulroy Environmental Ltd on four named houses and four named swallow gas wells GS1 – GS4. The results reported are representative of actual conditions and activities on the days of monitoring.

Respectively submitted,

Brian Sheridan B.Sc. M.Sc. (Agr) Ph.D (Eng).

For and on behalf of Odour Monitoring Ireland™

Executive Summary

Odour Monitoring Ireland Ltd was commissioned by Mulroy Environmental Ltd to perform occupational monitoring of air located within four houses (namely Hse. No. 25, 52 & 53 Barnageeragh, Skerries, Co. Dublin) on the 15th Dec 2017. Additional monitoring was carried out on one house (namely Hse. 26) and four shallow gas monitoring wells GS1 to 4 on the 14th Feb 2018. The aim of the study was to ascertain the potential level of specified air contaminants within the headspace air of the monitored houses and gas wells. Data collected on each house was compare with published occupational exposure levels, where applicable.

Monitoring was performed for a number of compound groups to include:

- Temperature, Relative humidity and Carbon dioxide levels in houses 25, 26, 52 and 53 only;
- Arsenic (Houses 25, 26, 52, 53 and GS1-4);
- Mercury (Houses 25, 26, 52, 53 and GS1-4);
- Trace Landfill gas screen (Houses 25, 26, 52, 53 and GS1-4);
- Formaldehyde and Acetaldehyde (Houses 25, 26, 52, 53 and GS1-4),
- Methane ground surface screen inside and outside the monitored Houses 25, 26, 52 and 53.

It is understood that an historic landfill is located in Barnageeragh Cove, Skerries (see Figures OMI-1 to OMI-3 – Section 6 – Figures 6.1 to 6.3). An extensive site investigation programme was conducted to delineate the boundary of the waste body. This was achieved through trial pit investigation, borehole installation and geophysical surveying. In total 14 deep boreholes (BH1 – BH14) were installed on the periphery or within the landfill body and 4 shallow gas wells (GS01 – GS04) were installed between the residences No. 25 – 34 (i.e. approx. 5m to the front of the houses) and the waste body to the south and southwest (see Figures OMI-2 & OMI-3 - Section 6 – Figures 6.1 to 6.3) (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 3). A programme of landfill gas (LF) and volatile organic carbon (VOC) analysis was carried out by Mulroy Environmental on each of these wells. This involved taking LF gas and VOC readings on 12 occasions from gas wells GS01 – GS04 during both high and low pressure weather events. Methane (CH4) was not recorded at a concentration above 1% during the monitoring period in these wells. On one occasion CH4 was recorded at a concentration of 0.8% with concentrations of 0.2% or below recorded on all other monitoring events. The results of each of the ground gas monitoring events from gas wells (GS01 – GS04) were assessed for risk according to CIRIA Report C665 *'Assessing risks posed by hazardous ground gases in buildings' by S. Wilson, S. Oliver, H. Mallett, H. Hutchings & G. Card. (July 2007).* The modified Wilson and Card Classification system detailed in CIRIA665 indicates a 'very low risk classification' for gas wells GS01 – GS04 (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 8).

It understood that VOC readings were taken with a MiniRae 2000 Photo-Ionisation Detector (PID) equipped with a 10.6eV bulb and that VOCs were not monitored during times where heavy rainfall persisted. VOC concentrations taken from 27th June 2017 to the 11th of August 2017 ranged from 0ppm to 6.6ppm. No VOCs were detected during any of the subsequent monitoring rounds. It is understood from the Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 8, that the initial VOC readings were down to phthalates/plasticisers in the newly installed HDPE standpipes (i.e. installed on the 15th June 2017) and that the decrease in VOC concentration to undetectable levels was down principally to natural weathering (i.e. ventilation) (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 8).

The following conclusions were developed for the study. These include:

1. With regards to comfort conditions with finished Houses 25 and 26, temperatures, relative humidity and Carbon dioxide levels were normal for the environment they were monitored within (ASHRAE Standard 62.1-2004).

2. With regards to House 25 – Location 1 and 2, trace concentrations of Benzene, Carbon tetrachloride, Dichloromethane, Styrene, Toluene, Formaldehyde and Acetaldehyde were detected in the headspace of the house. All detected compounds

were well within the 8 hr occupational exposure limits for the each of the respective compounds. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Formaldehyde (i.e. fractional exposure limit value 0.0026mg/Nm^3) were in excess of the fractional exposure limit value. Concentration values of 0.019 and 0.014 mg/Nm^3 were measured. There was a noticeable odour of paints, varnishes and glues in the house. The cumulative factorial value was less than 7.5% of the prescribed limit value. It is recommended that further compound monitoring is performed on this property in order to access whether these concentration levels have dissipated over time given the house has been lived within and background levels of compounds associated with building products should dissipate over time and this information will provide useful indicator of this decay over time.

3. With regards to Houses 52 and 53, trace concentrations of Benzene, Toluene, Carbon tetrachloride, Mercury and Hydrogen sulphide were detected in the headspace of the house. These houses were not finishes and had no windows present and therefore more susceptible to outside influences from compounds in the ambient environment. The concentration levels of these compounds were trace and well with any respective 8 hr occupational exposure limits. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Mercury (i.e. fractional limit value 0.0001 mg/Nm^3) were in excess of the fractional exposure limit value. A concentration value of 0.00015 mg/Nm^3 was measured on Hse 53 - Location 1. The cumulative factorial value was less than 0.10 and 2.2% of the prescribed limit value, respectively.

4. With regards to House 26 – Location 1 and 2, trace concentrations of 1,2 Dichloroethylene, Benzene, Carbon tetrachloride, Dichloromethane, Dimethyl sulphide, Styrene, Toluene, Formaldehyde and Acetaldehyde were detected in the headspace of the house. All detected compounds were well within the 8 hr occupational exposure limit values for the each of the respective compounds. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Formaldehyde (i.e. fractional exposure limit value 0.0026 mg/Nm^3) and Benzene (i.e. fractional exposure limit value 0.030 mg/Nm^3) were in excess of the fractional exposure limit values. Concentration values for Benzene and Formaldehyde were measured at 0.078 and 0.105 mg/Nm^3 for Location 1 and 0.059 and 0.060 mg/Nm^3 for Location 2. There was a weak odour of paints, varnishes and glues in the house. The cumulative factorial value was less than 44% of the prescribed limit value. It is recommended that further compound monitoring is performed on this property in order to access whether these concentration levels have dissipated over time given the house has been lived within and background levels of compounds associated with building products should dissipate over time and this information will provide useful indicator of this decay over time.

5. With regards to Gas well GS1, GS2, GS3 and GS4, trace concentrations of Benzene, Carbon tetrachloride, Toluene and Formaldehyde were detected in the headspace of the well. Benzene and Toluene are ubiquitous in the environment as a result of traffic related sources and therefore these trace amounts can be attributed to this source.

6. As part of Mulroy Environmental site investigation, a number of soil samples and groundwater samples were taken with VOC analysis conducted. In total 21 groundwater samples were taken across two monitoring rounds from the 11 groundwater monitoring wells on-site. No VOCs were detected within the groundwater above the method detection limit in any of these samples (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 6). Five soil samples were analysed for VOCs. Only two VOCs namely vinyl chloride and -1,2-dichloroethane were detected in one soil sample (i.e. SO-TP21-01) (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 5). It should be noted that this sample was taken from a trial pit located 51m from the nearest residence (i.e. House No.25). Neither of these compounds were detected in the sorbent tubes/thermal desorption/capillary gas chromatography analysis conducted for GS01 – GS04, therefore it is unlikely that they are migrating from the landfill towards the residence (see Mulroy Environmental, Environmental Risk Assessment

Report, 2018, Section 12). Carbon tetrachloride is a common constituent of paints and varnishes. It is likely that the concentrations of carbon tetrachloride identified within the 4 gas wells to the west of the residences is as a result of a spillage and/or poor management of solvent based paints during the fit-out phase of construction (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 12). Formaldehyde is a basic constituent of rubber cement products which are used on building sites as either sealants and or glues. Empty rubber cement tubes were observed outside some of the residences during the fit-out phase of construction (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 12).

7. In relation to the surface emissions Methane / VOC screen, the levels detected were around background and were no greater than 1.74 mg/Nm^3.

1. Introduction and scope

1. Introduction

Odour Monitoring Ireland Ltd was commissioned by Mulroy Environmental Ltd to perform occupational monitoring of air located within four houses namely 25, 26, 52 and 53 Barnageeragh Cove on the 15th Dec 2017 and 14th Feb 2018. The aim of the study was to ascertain the potential level of specified air contaminants within the headspace air of the houses and to compare with published occupational exposure levels, where applicable.

Additional monitoring was carried out on the 14th Feb 2018 on the headspace gas in shallow gas monitoring wells GS1 to GS4.

Monitoring was performed for a number of compound groups to include:

- Temperature, Relative humidity and Carbon dioxide levels in houses 25, 26, 52 and 53 only;
- Arsenic (Houses 25, 26, 52, 53 and GS1-4);
- Mercury (Houses 25, 26, 52, 53 and GS1-4);
- Trace Landfill gas screen (Houses 25, 26, 52, 53 and GS1-4);
- Formaldehyde and Acetaldehyde (Houses 25, 26, 52, 53 and GS1-4),
- Methane ground surface screen inside and outside the monitored Houses 25, 26, 52 and 53.

All continuous and active grab sampling techniques were in accordance with international sampling methodologies contained in *Section 2* and all grab samples were tested in a UKAS accredited test house (UKAS1549).

This report presents the materials and methods, results and discussion and conclusions from the study carried out on the monitoring date 15th Dec 2017 and 14th Feb 2018.

In addition, the report discusses the significant body of work and conclusions formed by Mulroy Environmental Ltd – see Mulroy Environmental Ltd, Environmental Risk Assessment Report, 2018.

1.2 Scope of the study

The main aims of the study included:

- Occupational monitoring at two locations located within each of four houses for a range of compounds that could be present in the air stream and comparison with published occupational exposure levels in order to ascertain the level of occupational impact during a normal operation day,
- Headspace gas monitoring of shallow gas monitoring wells GS1 to GS4 for the same range of compounds.
- Monitoring of each location in houses only for Temperature, Relative humidity and Carbon dioxide levels throughout the survey period to provide a tag on conditions within the houses throughout the monitoring.
- Interpretation of results, where applicable.

2. Materials and methods

This section describes the materials and methods used throughout the survey.

The following standards and documents were used for reference and adhered to where possible:

- Compendium method TO-17-Determination of volatile organic compounds in ambient air using active sampling onto sorbent tubes.
- MDHS 70 – General method for sampling airborne gases and vapours.
- MDHS 72 – Volatile organic compounds in air (1993). Laboratory methods using pumped solid sorbent tubes, thermal desorption and gas chromatography.
- MDHS 96 – Volatile organic compounds in air, Laboratory methods using pumped solid sorbent tubes, solvent desorption and gas chromatography. March 2000.
- NIOSH (NMAM) fourth Edition (1996). Volatile organic compounds (Screening) Method 2549).
- NIOSH 1500 and 1501 for Total and aromatic hydrocarbons sampling and measurement,
- NIOSH 6001 – Arsine.
- NIOSH 6009 – Mercury.
- NIOSH 2539 – Aldehydes screening.
- ISO 16017-1:2000, Indoor, ambient and workplace air. Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography. Part 1: Pumped sampling.

All data generated during the assessment survey was compared to occupational exposure levels and risk categories contained within the publications:

- 2016 Code of practice for Chemical Agents Regulations.

2.1 General description of sampling and analysis techniques

A number of sampling techniques were used to characterise the ambient air at the named locations at the four houses 25, 26, 52 and 53 (*see Table 2.1*). In addition, the same sampling techniques were used to characterise the headspace air in four shallow gas monitoring stations GS1 to GS4. Active grab sampling using sorption tubes was performed. Sorption tube sampling and analysis were performed to allow for the characterisation (i.e. both qualitative and semi quantitative) of sampled air for named compound concentrations throughout the sampling event.

In addition, solid fixed state analysers were utilised to perform Temperature, Relative humidity and Carbon dioxide monitoring and analysis at each house.

Table 2.1 provides information on the following items and includes*:*

- Sample location identity key,
- Description of monitoring location,
- Type of monitoring performed,
- Monitoring standards applied where applicable,
- Monitoring details,
- Analysis laboratory details,
- Description of sampling media.

Figure 2.1 presents a graphical plan layout of the monitoring locations located on site.

Table 2.1. Monitoring campaign description for monitoring carried out in Hse. 25, 26, 52 and 53 and gas monitoring wells GS1 to GS4, Barnageeragh Cove, Skerries, Dublin on the 15th Dec 2017 and 14th Feb 2018.

Monitoring location key	Description of monitoring location and Date	Monitoring performed	Standards applied	Monitoring details	Analysis laboratory	Sampling media
1	Hse 25 – Utility (15/12/17)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen, Methane screen	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549, AG6	Monitored in room headspace	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption, FID analyser
2	Hse 25 – Front sitting room (15/12/17)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen, Methane screen	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549, AG6	Monitored in room headspace	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption, FID analyser
3	Hse. 52 Ground floor (House not built fully) (15/12/17)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen, Methane screen	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549, AG6	Monitored in building headspace	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption, FID analyser
4	Hse. 52 Ground floor (House not built fully) (15/12/17)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen, Methane screen	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549, AG6	Monitored in building headspace	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption, FID analyser
5	Hse. 53 Ground floor (House not built fully) (15/12/17)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen, Methane screen	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549, AG6	Monitored in building headspace	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption, FID analyser
6	Hse. 53 Ground floor (House not built fully) (15/12/17)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen, Methane screen	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549, AG6	Monitored in building headspace	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption, FID analyser
7	Hse 26 – Front room (14/02/18)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen, Methane screen	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549, AG6	Monitored in room headspace	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption, FID analyser
8	Hse 26 – Utility (14/02/18)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen, Methane screen	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549, AG6	Monitored in room headspace	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption, FID analyser
9	GS1 (14/02/18)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen,	ISO16017, USEPA TO17, MDHS 70, 72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549.	Monitored in well headspace – min approx. 1 m down	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption
10	GS2 (14/02/18)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen,	ISO16017, USEPA TO17, MDHS 70, 72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549.	Monitored in well headspace – min approx. 1 m down	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption
11	GS3 (14/02/18)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen,	ISO16017, USEPA TO17, MDHS 70, 72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549.	Monitored in well headspace – min approx. 1 m down	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption
12	GS4 (14/02/18)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen,	ISO16017, USEPA TO17, MDHS 70, 72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549.	Monitored in well headspace – min approx. 1 m down	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption

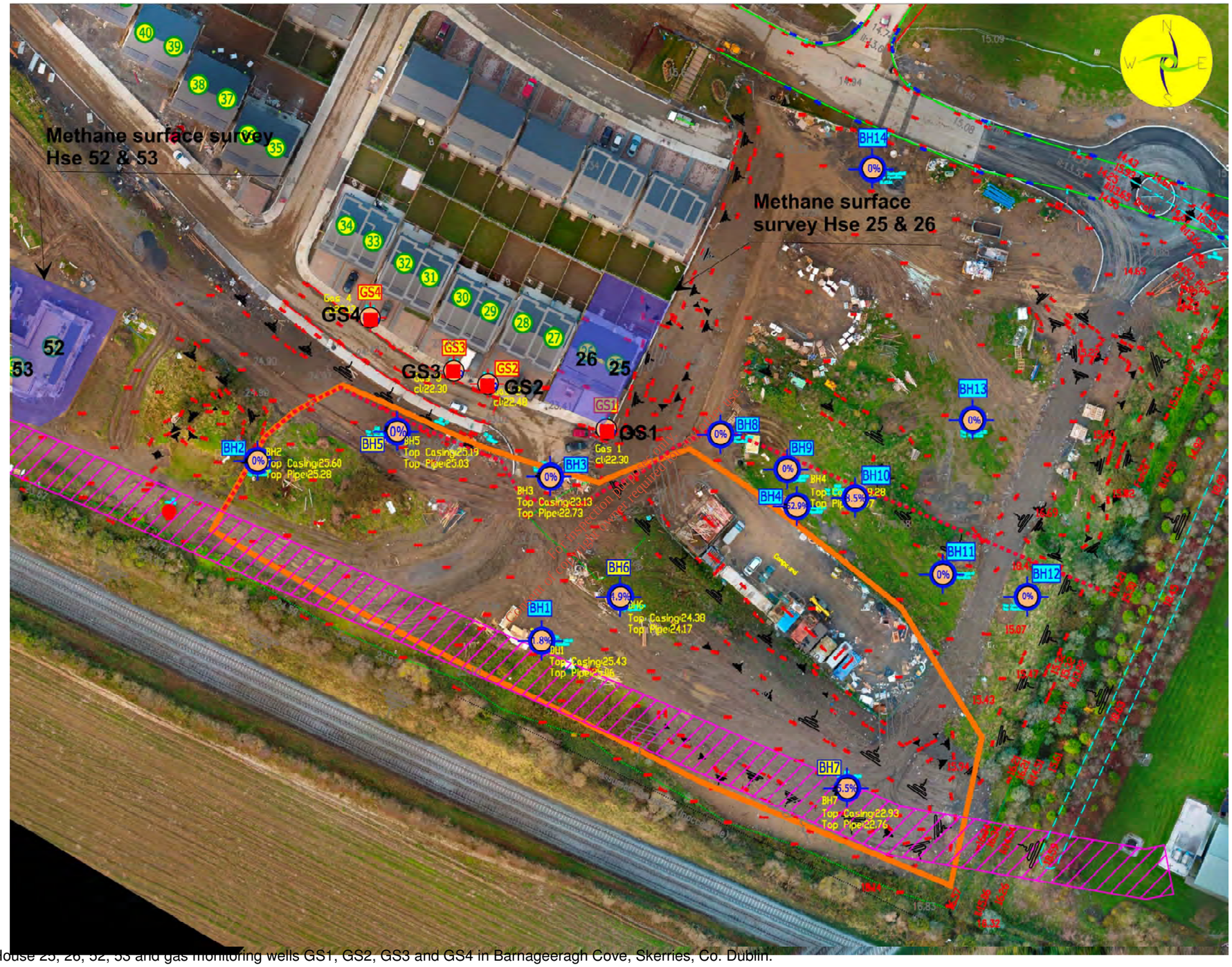

Figure 2.1. Location of House 25, 26, 52, 53 and gas monitoring wells GS1, GS2, GS3 and GS4 in Barnageeragh Cove, Skerries, Co. Dublin.

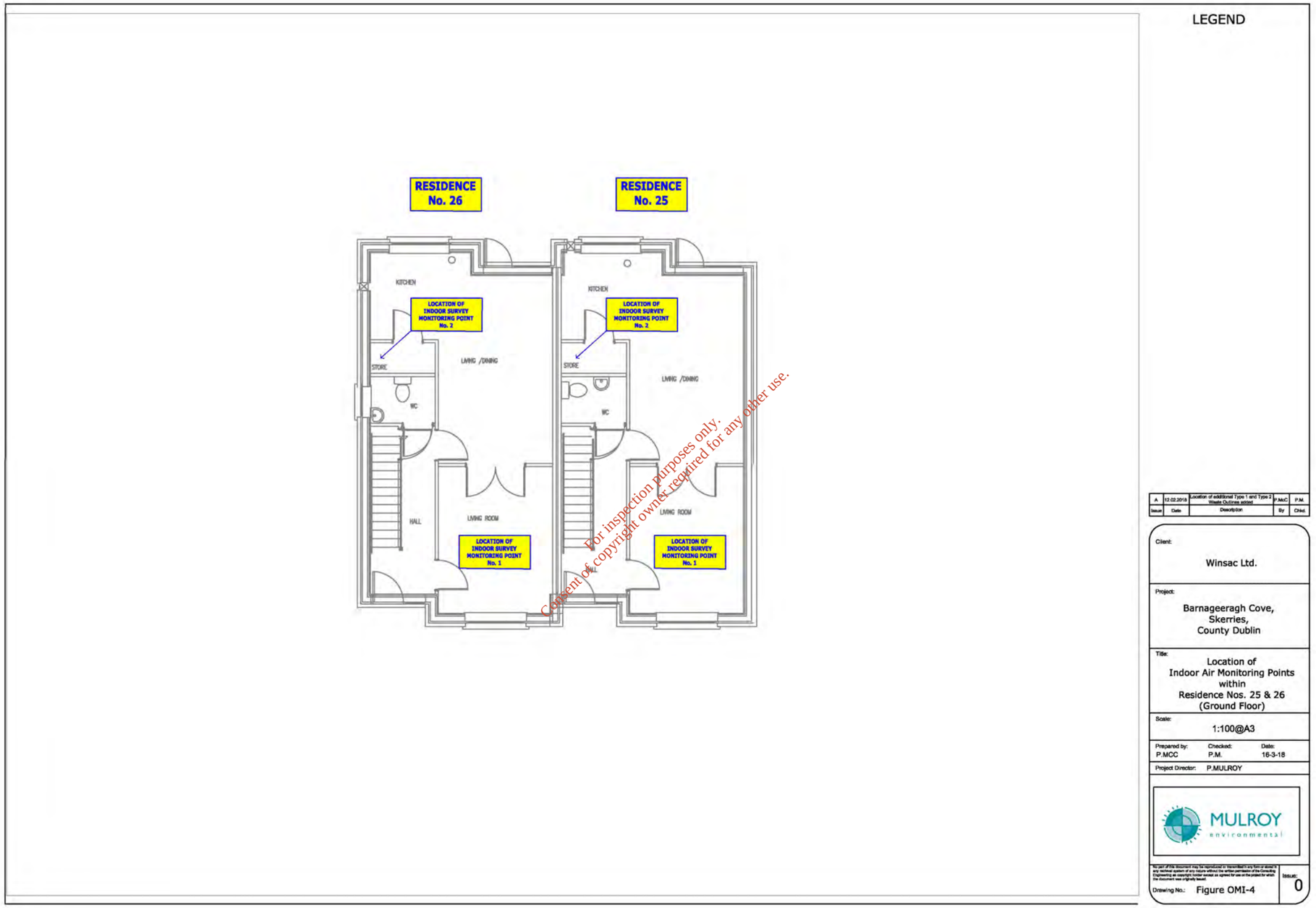

Figure 2.2. Location of monitoring locations within House 25 & 26 in Barnageeragh Cove, Skerries, Co. Dublin.

2.2 Monitoring for specified compounds in Houses 25, 26, 52 and 53 and gas wells GS1 to GS4 Barnageeragh Cove, Skerries, Co. Dublin on the 15th Dec 2017 and 14th Feb 2018.

The following range of compounds / parameters that were actively monitored using sorbent based media are detailed in *Table 2.1*. An overview of the monitoring standards applied is detailed in *Section 2*. The graphical location of each monitoring location is presented in *Figure 2.1*.

In order to pre-concentrate each compound upon each sorbent, a pre-calibrated controlled volume of sample air was drawn through each tube by a SKC air sampling pump for the monitoring period (Active sampling/pumped sampling). Each SKC pump was pre-calibrated with their specific sorbent using a Bios Primary flow calibrator (UKAS traceable Cert No. N022746).

Each pump was calibrated to an optimal flow rate (of between approx. 200 mls/min depending on sample location and sample type) for sorbent tubes.

When sampling was completed all tubes were sealed and stored in flexible air / light tight containers and transported to the analysing laboratory and analysed by means of thermal desorption / solvent extraction GCMS, GCFID, in a UKAS accredited laboratory (UKAS 1549).

In terms of Temperature, Relative humidity and Carbon dioxide, monitoring was performed utilising a Testo 400 handheld and associated probes.

A number of QA procedures were implemented into the sampling and analysis run to include:

- Front and back sorbent beds were analysed. The back bed was confirmed to be less than 5% of the total sample conc. which is a stated requirement of EN13649:2014.
- All sorbent tubes were sealed and contained in air tight and light proof containers for transport to the laboratory. All samples were stored below 25 deg. C. This is a requirement of EN13649:2014.
- Travel/Sample blanks were incorporated into the measurement sequence. In addition, the laboratory included instrument and method blanks into their measurement sequence.
- Sample volume flow rate and pump calibration was performed before sampling and after sampling and these were recorded in the site data sheets. In addition, it was confirmed that the variation between before and after calibration was less than 1% of the flow range on the day of sampling for all samples taken on the 15th Dec 2017 and 14th Feb 2018. The sample flow rate primary flow standard measured flow to an accuracy of 0.001 L/min over the range with a calibration accuracy of less than or equal to 1%.
- Total sample volumes chosen were a combination of analytical techniques lower limit of detection calculations and as specified in standard requirements.

3. Results of the monitoring exercise and discussion

This section provides the results obtained during the survey.

3.1 Temperature, Relative Humidity and Carbon dioxide results

Table 3.1 presents the result for the monitoring of Temperature, Relative humidity and Carbon dioxide monitoring of each location over the sampling event. Average values through the sample events are presented. Temperature, relative humidity and carbon dioxide values were measured at the start and end of monitoring. Monitoring was carried out between the hours of 09.30AM and 15.00PM on the 15th Dec 2017 and between the hours of 16.30PM and 18.30PM on the 14th Feb 2018. The average values are reported for clarity.

As can be observed in *Table 3.1*, the average temperature in House 25 was 22.4 Deg C. The average relative humidity and CO_2 concentration were 62% and 820 ppm, respectively.

The average temperature in House 26 was 22.8 Deg C. The average relative humidity and CO_2 concentration were 59% and 841 ppm, respectively

Houses 52 and 53 were not finished construction and therefore temperatures, relative humidity and Carbon dioxide approached ambient values.

The average temperature in House 52 and 53 was 5.0 and 4.9 Deg C, respectively. The average relative humidity and CO_2 concentration were 78 and 79% and 490 and 510 ppm, respectively.

Table 3.1. Temperature, Relative humidity and Carbon dioxide monitoring results of each house monitoring location over the sampling events.

Monitoring location area	Temperature (Deg C)	Relative humidity (%)	CO_2 conc. (ppm)
Hse 25 - 1 and 2	22.4	62	820
Hse 52 - 3 and 4	5	78	490
Hse 53 - 5 and 6	4.9	79	510
Hse 26 – 1 and 2	22.80	59	841

3.2 Gas analysis results

Tables 3.2 to 3.7 present the result of the monitoring at each sampling location throughout the sampling period carried out on the 15th Dec 2017.

Tables 3.8 to 3.13 present the result of the monitoring at each sampling location throughout the sampling period carried out on the 14th Feb 2018.

As can be observed from the analysis results across the sampling locations in all four properties (Hse 25, 26, 52 and 53), all results were compliant with the published 8 hr OEL value, where applicable. In terms of the measured concentration, in most circumstances all measured values were well within the published 8 hr OEL where applicable. This is also published within each table (*see Tables 3.2 to 3.9*). Cumulative OEL risk was assessed for the speciated VOC's detected. The cumulative assessment value was well within the stated limit value of 1.0 for cumulative VOC's (see 2011 Code of practice for the Safety, Health and Welfare at work (Chemical Agents) Regulations 2001 (SI No. 619 of 2001) & updated COP 2016).

In addition to screening the 8 hr OEL limit value and given the fact that properties could be occupied for periods in excess of 8 hr / day 5 days per week up to period of 24hrs / days and 7 days per week, fractional exposure limit values were compared to the recorded concentrations. In terms of overall results, Formaldehyde was in excess of the fractional exposure limit value at House 25 Location 1 and 2 and House 26 Location 1 and 2. Benzene was in excess of the fractional limit value at House 26 Location 1 and 2. Mercury was in excess of the fractional exposure limit value at House 53 Location 1. Therefore considering the compounds and the fact that the houses were newly built, it is recommended that repeat monitoring be completed to examine whether compound concentrations have dissipated with time of occupancy within the houses.

In relation to results obtained, Benzene and Toluene is found in the ambient environment as a result of traffic based emissions and given the concentration levels, this would be in keeping with typical ambient air concentration levels and given the machinery in operation in the area.

With regards to House 25 – Location 1 and 2, trace concentrations of Benzene, Carbon tetrachloride, Dichloromethane, Styrene, Toluene, Formaldehyde and Acetaldehyde were detected in the headspace of the house. All detected compounds were well within the 8 hr occupational exposure limits for the each of the respective compounds. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Formaldehyde (i.e. fractional exposure limit value 0.0026mg/Nm^3) were in excess of the fractional exposure limit value. Concentration values of 0.019 and 0.014 mg/Nm^3 were measured. There was a noticeable odour of paints, varnishes and glues in the house. The cumulative factorial value was less than 7.5% of the prescribed limit value. It is recommended that further compound monitoring is performed on this property in order to access whether these concentration levels have dissipated over time given the house has been lived within and background levels of compounds associated with building products should dissipate over time and this information will provide useful indicator of this decay over time.

With regards to Houses 52 and 53, trace concentrations of Benzene, Toluene, Carbon tetrachloride, Mercury and Hydrogen sulphide were detected in the headspace of the house. These houses were not finishes and had no windows present and therefore more susceptible to outside influences from compounds in the ambient environment. The concentration levels of these compounds were trace and well with any respective 8 hr occupational exposure limits. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Mercury (i.e. fractional limit value 0.0001 mg/Nm^3) were in excess of the fractional exposure limit value. A concentration value of 0.00015 mg/Nm^3 was measured on Hse 53 - Location 1. The cumulative factorial value was less than 0.10 and 2.2% of the prescribed limit value, respectively.

With regards to House 26 – Location 1 and 2, trace concentrations of 1,2 Dichloroethylene, Benzene, Carbon tetrachloride, Dichloromethane, Dimethyl sulphide, Styrene, Toluene, Formaldehyde and Acetaldehyde were detected in the headspace of the house. All detected compounds were well within the 8 hr occupational exposure limit values for the each of the respective compounds. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Formaldehyde (i.e. fractional exposure limit value 0.0026 mg/Nm^3) and Benzene (i.e. fractional exposure limit value 0.030 mg/Nm^3) were in excess of the fractional exposure limit values. Concentration values for Benzene and Formaldehyde were measured at 0.078 and 0.105 mg/Nm^3 for Location 1 and 0.059 and 0.060 mg/Nm^3 for Location 2. There was a weak odour of paints, varnishes and glues in the house. The cumulative factorial value was less than 44% of the prescribed limit value. It is recommended that further compound monitoring is performed on this property in order to access whether these concentration levels have dissipated over time given the house has been lived within and background levels of compounds associated with building products should dissipate over time and this information will provide useful indicator of this decay over time.

In relation to the Methane TOC screen, the levels detected were around background and were no greater than 1.74 mg/Nm^3.

It is understood that an historic landfill is located in Barnageeragh Cove, Skerries (see Figures OMI-1 to OMI-3 – Section 6 – *Figures 6.1 to 6.3*). An extensive site investigation programme was conducted to delineate the boundary of the waste body. This was achieved through trial pit investigation, borehole installation and geophysical surveying. In total 14 deep boreholes (BH1 – BH14) were installed on the periphery or within the landfill body and 4 shallow gas wells (GS01 – GS04) were installed between the residences No. 25 – 34 (i.e. approx. 5m to the front of the houses) and the waste body to the south and southwest (see Figures OMI-2 & OMI-3 - Section 6 – *Figures 6.1 to 6.3*) (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 3). A programme of landfill gas (LF) and volatile organic carbon (VOC) analysis was carried out by Mulroy Environmental on each of these wells. This involved taking LF gas and VOC readings on 12 occasions from gas wells GS01 – GS04 during both high and low pressure weather events. Methane (CH4) was not recorded at a concentration above 1% during the monitoring period in these wells. On one occasion CH4 was recorded at a concentration of 0.8% with concentrations of 0.2% or below recorded on all other monitoring events. The results of each of the ground gas monitoring events from gas wells (GS01 – GS04) were assessed for risk according to CIRIA Report C665 *'Assessing risks posed by hazardous ground gases in buildings' by S. Wilson, S. Oliver, H. Mallett, H. Hutchings & G. Card. (July 2007).* The modified Wilson and Card Classification system detailed in CIRIA665 indicates a 'very low risk classification' for gas wells GS01 – GS04 (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 8).

It understood that VOC readings were taken with a MiniRae 2000 Photo-Ionisation Detector (PID) equipped with a 10.6eV bulb and that VOCs were not monitored during times where heavy rainfall persisted. VOC concentrations taken from 27th June 2017 to the 11th of August 2017 ranged from 0ppm to 6.6ppm. No VOCs were detected during any of the subsequent monitoring rounds. It is understood from the Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 8, that the initial VOC readings were down to phthalates/plasticisers in the newly installed HDPE standpipes (i.e. installed on the 15th June 2017) and that the decrease in VOC concentration to undetectable levels was down principally to natural weathering (i.e. ventilation) (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 8).

3.2.1 House 25 Monitoring results

Table 3.2. Results from monitoring of House 25 – Location 1

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	8 hr OEL value (mg/Nm^3)	15 min OEL value (mg/Nm^3)	Environmental Assessment Levels (EAL's) – Long term ($\mu g/m^3$)	Examination of additive / cumulative effects	Limit value for cumulative effect	Other risk factors
1	Mi136392 – trace landfill gas screen	09.15 – 12.30 – 195 min 15/12/17	1-Pentene	<10	0.042627	<0.00023	-	-	-	0.075	1.0	-
			1,1 Di chloroethane	<10	0.042627	<0.00023	268	-	2.68			IOELV
			1,1-Dichloroethylene	<10	0.042627	<0.00023	20	-	0.2			-
			1,2-Dichloroethane	**140**	0.042627	**0.0033**	412	-	4.12			Sk, IOELV
			1,2-Dichloroethylene	<30	0.042627	<0.00070	20		0.2			-
			1,3-Butadiene	<10	0.042627	<0.00023	-	-	-			-
			1,4 epoxy 1,3-butadiene	<10	0.042627	<0.00023	-	-	-			-
			1-Propanethiol	<10	0.042627	<0.00023	-	-	-			-
			2-butoxyethanol	<10	0.042627	<0.00023	8	246	0.08			Sk , IOELV
			Benzene	**180**	0.042627	**0.0042**	3.0	-	0.03			BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.042627	<0.00023		-	-			-
			Carbon disulphide	<10	0.042627	<0.00023	15	-	0.15			Sk, IOELV
			Carbon tetrachloride	**120**	0.042627	**0.0028**	12.6	-	0.126			Sk
			Chloroethane	<30	0.042627	<0.00070	268	-	2.68			IOELV
			Dichloromethane	**1200**	0.042627	**0.028**	174	-	1.74			-
			Dimethyl disulphide	<10	0.042627	<0.00023	1.90	-	0.019			-
			Dimethyl sulphide	<10	0.042627	<0.00023	55.47	-	0.5547			-
			Ethyl butyrate	<25	0.042627	<0.00059	-	-	-			-
			Ethyl Mercaptan	<10	0.042627	<0.00023	1	3	0.01			-
			Hydrogen sulphide	<60	0.042627	<0.0010	7	14	0.07			IOELV
			Methyl Mercaptan	<30	0.042627	<0.00070	1	-	0.01			-
			N-Butyl Mercaptan	<10	0.042627	<0.00023	1.8	-	0.018			-
			Styrene	**79**	0.042627	**0.0019**	85	170	0.85			-
			Toluene	**1800**	0.042627	**0.042**	192	384	1.92			Sk, IOELV
			Trichloroethylene	<10	0.042627	<0.00023	58.66	146.65	0.5866			Sk, Carc.1B
			Vinyl chloride monomer	<10	0.042627	<0.00023	7.77	-	0.0777			Carc.1A, BOELV
1	7218300767		Formaldehyde	**800**	0.042276	**0.019**	0.26	0.53	0.0026			Carc.1B, Sens.
			Acetaldehyde	**900**	0.042276	**0.021**	45	45	0.45			-
1	7114507934		Arsenic	<1000	0.022698	<0.040	0.01	-	0.0001			Carc.1A
1	7532605396		Mercury	<5	0.051987	<0.00010	0.01	0.03	0.0001			Sk
1	Methane screen - FID	09.15- 10.15 – 60 min	Methane as TOC	-	-	0.71 to 1.42	-	-	-	-	-	-

Table 3.3. Results from monitoring of House 25 – Location 2

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	8 hr OEL value (mg/Nm^3)	15 min OEL value (mg/Nm^3)	Environmental Assessment Levels (EAL's) – Long term ($\mu g/m^3$)	Examination of additive / cumulative effects	Limit value for cumulative effect	Other risk factors
2	Mi177242 – trace landfill gas screen	09.33 – 12.33 – 180 min 15/12/17	1-Pentene	<10	0.080802	<0.00012	-	-	-	0.056	1.0	-
			1,1 Di chloroethane	<10	0.080802	<0.00012	268	-	2.68			IOELV
			1,1-Dichloroethylene	<10	0.080802	<0.00012	20	-	0.2			-
			1,2-Dichloroethane	**95**	0.080802	**0.0012**	412	-	4.12			Sk, IOELV
			1,2-Dichloroethylene	<30	0.080802	<0.00037	20		0.2			-
			1,3-Butadiene	<10	0.080802	<0.00012	-	-	-			-
			1,4 epoxy 1,3-butadiene	<10	0.080802	<0.00012	-	-	-			-
			1-Propanethiol	<10	0.080802	<0.00012	-	-	-			-
			2-butoxyethanol	<10	0.080802	<0.00012	8	246	0.08			Sk , IOELV
			Benzene	**420**	0.080802	**0.0052**	3.0	-	0.03			BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.080802	<0.00012	-	-	-			-
			Carbon disulphide	<10	0.080802	<0.00012	15	-	0.15			Sk, IOELV
			Carbon tetrachloride	**41**	0.080802	**0.00051**	12.6	-	0.126			Sk
			Chloroethane	<30	0.080802	<0.00037	268	-	2.68			IOELV
			Dichloromethane	**3300**	0.080802	**0.041**	174	-	1.74			-
			Dimethyl disulphide	<10	0.080802	<0.00012	1.90	-	0.019			-
			Dimethyl sulphide	<10	0.080802	<0.00012	55.47	-	0.5547			-
			Ethyl butyrate	<25	0.080802	<0.00031	-	-	-			-
			Ethyl Mercaptan	<10	0.080802	<0.00012	1	3	0.01			-
			Hydrogen sulphide	<60	0.080802	<0.00074	7	14	0.07			IOELV
			Methyl Mercaptan	<30	0.080802	<0.00037	1	-	0.01			-
			N-Butyl Mercaptan	<10	0.080802	<0.00012	1.8	-	0.018			-
			Styrene	**140**	0.080802	**0.0017**	85	170	0.85			-
			Toluene	**2200**	0.080802	**0.027**	192	384	1.92			Sk, IOELV
			Trichloroethylene	<10	0.080802	<0.00012	58.66	146.65	0.5866			Sk, Carc.1B
			Vinyl chloride monomer	<10	0.080802	<0.00012	7.77	-	0.0777			Carc.1A, BOELV
2	72183000769		Formaldehyde	**1100**	0.07977	**0.014**	0.26	0.53	0.0026			Carc.1B, Sens.
			Acetaldehyde	**900**	0.07977	**0.011**	45	45	0.45			-
2	7114507928		Arsenic	<1000	0.06649	<0.020	0.01	-	0.0001			Carc.1A
2	7532605397		Mercury	<5	0.01983	<0.00025	0.01	0.03	0.0001			Sk
2	Methane screen - FID	10.20- 11.20 – 60 min	Methane as TOC	-	-	0.88 to 1.66	-	-	-	-	-	-

3.2.2 House 52 Monitoring results

Table 3.4. Results from monitoring of House 52 – Location 1

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	8 hr OEL value (mg/Nm^3)	15 min OEL value (mg/Nm^3)	Environmental Assessment Levels (EAL's) – Long term ($\mu g/m^3$)	Examination of additive / cumulative effects	Limit value for cumulative effect	Other risk factors
3	Mi126424 – trace landfill gas screen	11.49 – 14.49 – 180 min 15/12/17	1-Pentene	<10	0.05663	<0.00018	-	-	-	0.00014	1.0	-
			1,1 Di chloroethane	<10	0.05663	<0.00018	268	-	2.68			IOELV
			1,1-Dichloroethylene	<10	0.05663	<0.00018	20	-	0.2			-
			1,2-Dichloroethane	<10	0.05663	<0.00018	412	-	4.12			Sk, IOELV
			1,2-Dichloroethylene	<30	0.05663	<0.00053	20		0.2			-
			1,3-Butadiene	<10	0.05663	<0.00018	-	-	-			-
			1,4 epoxy 1,3-butadiene	<10	0.05663	<0.00018	-	-	-			-
			1-Propanethiol	<10	0.05663	<0.00018	-	-	-			-
			2-butoxyethanol	<10	0.05663	<0100018	8	246	0.08			Sk , IOELV
			Benzene	**19**	0.05663	**0.00034**	3.0	-	0.03			BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.05663	<0.00018		-	-			-
			Carbon disulphide	<10	0.05663	<0.00018	15	-	0.15			Sk, IOELV
			Carbon tetrachloride	<10	0.05663	<0.00018	12.6	-	0.126			Sk
			Chloroethane	<30	0.05663	<0.00053	268	-	2.68			IOELV
			Dichloromethane	<10	0.05663	<0.00018	174	-	1.74			-
			Dimethyl disulphide	<10	0.05663	<0.00018	1.90	-	0.019			-
			Dimethyl sulphide	<10	0.05663	<0.00018	55.47	-	0.5547			-
			Ethyl butyrate	<25	0.05663	<0.000093	-	-	-			-
			Ethyl Mercaptan	<10	0.05663	<0.00018	1	3	0.01			-
			Hydrogen sulphide	<60	0.05663	<0.0011	7	14	0.07			IOELV
			Methyl Mercaptan	<30	0.05663	<0.00053	1	-	0.01			-
			N-Butyl Mercaptan	<10	0.05663	<0.00018	1.8	-	0.018			-
			Styrene	<10	0.05663	<0.00018	85	170	0.85			-
			Toluene	**12**	0.05663	**0.00021**	192	384	1.92			Sk, IOELV
			Trichloroethylene	<10	0.05663	<0.00018	58.66	146.65	0.5866			Sk, Carc.1B
			Vinyl chloride monomer	<10	0.05663	<0.00018	7.77	-	0.0777			Carc.1A, BOELV
3	72183000768		Formaldehyde	<100	0.04421	<0.0020	0.26	0.53	0.0026			Carc.1B, Sens.
			Acetaldehyde	<100	0.04421	<0.0020	45	45	0.45			-
3	7114507931		Arsenic	<1000	0.037998	<0.030	0.01	-	0.0001			Carc.1A
3	7532605402		Mercury	<5	0.037728	<0.00013	0.01	0.03	0.0001			Sk
3	Methane screen - FID	10.20- 11.20 – 60 min	Methane as TOC	-	-	0.71 to 1.42	-	-	-	-	-	-

Table 3.5. Results from monitoring of House 52 – Location 2

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	8 hr OEL value (mg/Nm^3)	15 min OEL value (mg/Nm^3)	Environmental Assessment Levels (EAL's) – Long term ($\mu g/m^3$)	Examination of additive / cumulative effects	Limit value for cumulative effect	Other risk factors
4	Mi175249 – trace landfill gas screen	10.00 – 13.00 – 180 min 15/12/17	1-Pentene	<10	0.058248	<0.00017	-	-	-	-	1.0	-
			1,1 Di chloroethane	<10	0.058248	<0.00017	268	-	2.68			IOELV
			1,1-Dichloroethylene	<10	0.058248	<0.00017	20	-	0.2			-
			1,2-Dichloroethane	<10	0.058248	<0.00017	412	-	4.12			Sk, IOELV
			1,2-Dichloroethylene	<30	0.058248	<0.00052	20		0.2			-
			1,3-Butadiene	<10	0.058248	<0.00017	-	-	-			-
			1,4 epoxy 1,3-butadiene	<10	0.058248	<0.00017	-	-	-			-
			1-Propanethiol	<10	0.058248	<0.00017	-	-	-			-
			2-butoxyethanol	<10	0.058248	<0.00017	8	246	0.08			Sk , IOELV
			Benzene	<10	0.058248	<0.00017	3.0	-	0.03			BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.058248	<0.00017	-	-	-			-
			Carbon disulphide	<10	0.058248	<0.00017	15	-	0.15			Sk, IOELV
			Carbon tetrachloride	<10	0.058248	<0.00017	12.6	-	0.126			Sk
			Chloroethane	<30	0.058248	<0.00052	268	-	2.68			IOELV
			Dichloromethane	<10	0.058248	<0.00017	174	-	1.74			-
			Dimethyl disulphide	<10	0.058248	<0.00017	1.90	-	0.019			-
			Dimethyl sulphide	<10	0.058248	<0.00017	55.47	-	0.5547			-
			Ethyl butyrate	<25	0.058248	<0.00043	-	-	-			-
			Ethyl Mercaptan	<10	0.058248	<0.00017	1	3	0.01			-
			Hydrogen sulphide	<60	0.058248	<0.00074	7	14	0.07			IOELV
			Methyl Mercaptan	<30	0.058248	<0.00052	1	-	0.01			-
			N-Butyl Mercaptan	<10	0.058248	<0.00017	1.8	-	0.018			-
			Styrene	<10	0.058248	<0.00017	85	170	0.85			-
			Toluene	<10	0.058248	<0.00017	192	384	1.92			Sk, IOELV
			Trichloroethylene	<10	0.058248	<0.00017	58.66	146.65	0.5866			Sk, Carc.1B
			Vinyl chloride monomer	<10	0.058248	<0.00017	7.77	-	0.0777			Carc.1A, BOELV
4	72183000771		Formaldehyde	<100	0.031356	<0.0030	0.26	0.53	0.0026			Carc.1B, Sens.
			Acetaldehyde	<100	0.031356	<0.0030	45	45	0.45			-
4	7114507935		Arsenic	<1000	0.023958	<0.040	0.01	-	0.0001			Carc.1A
4	7532605398		Mercury	<5	0.038628	<0.00013	0.01	0.03	0.0001			Sk
4	Methane screen - FID	11.30- 12.35 – 65 min	Methane as TOC	-	-	0.98 to 1.66	-	-	-	-	-	-

3.2.3 House 53 Monitoring results

Table 3.6. Results from monitoring of House 53 – Location 1

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	8 hr OEL value (mg/Nm^3)	15 min OEL value (mg/Nm^3)	Environmental Assessment Levels (EAL's) – Long term ($\mu g/m^3$)	Examination of additive / cumulative effects	Limit value for cumulative effect	Other risk factors
5	1042204 – trace landfill gas screen	10.45 – 13.45 – 180 min 15/12/17	1-Pentene	<10	0.050328	<0.00020	-	-	-	0.016	1.0	-
			1,1 Di chloroethane	<10	0.050328	<0.00020	268	-	2.68			IOELV
			1,1-Dichloroethylene	<10	0.050328	<0.00020	20	-	0.2			-
			1,2-Dichloroethane	<10	0.050328	<0.00020	412	-	4.12			Sk, IOELV
			1,2-Dichloroethylene	<30	0.050328	<0.00060	20		0.2			-
			1,3-Butadiene	<10	0.050328	<0.00020	-	-	-			-
			1,4 epoxy 1,3-butadiene	<10	0.050328	<0.00020	-	-	-			-
			1-Propanethiol	<10	0.050328	<0.00020	-	-	-			-
			2-butoxyethanol	<10	0.050328	<0.00020	8	246	0.08			Sk , IOELV
			Benzene	**100**	0.050328	**0.0020**	3.0	-	0.03			BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.050328	<0.00020		-	-			-
			Carbon disulphide	<10	0.050328	<0.00020	15	-	0.15			Sk, IOELV
			Carbon tetrachloride	**28**	0.050328	**0.00056**	12.6	-	0.126			Sk
			Chloroethane	<30	0.050328	<0.00060	268	-	2.68			IOELV
			Dichloromethane	<10	0.050328	<0.00020	174	-	1.74			-
			Dimethyl disulphide	<10	0.050328	<0.00020	1.90	-	0.019			-
			Dimethyl sulphide	<10	0.050328	<0.00020	55.47	-	0.5547			-
			Ethyl butyrate	<25	0.050328	<0.00050	-	-	-			-
			Ethyl Mercaptan	<10	0.050328	<0.00020	1	3	0.01			-
			Hydrogen sulphide	<60	0.050328	<0.00086	7	14	0.07			IOELV
			Methyl Mercaptan	<30	0.050328	<0.00060	1	-	0.01			-
			N-Butyl Mercaptan	<10	0.050328	<0.00020	1.8	-	0.018			-
			Styrene	<10	0.050328	<0.00020	85	170	0.85			-
			Toluene	**100**	0.050328	**0.0020**	192	384	1.92			Sk, IOELV
			Trichloroethylene	<10	0.050328	<0.00020	58.66	146.65	0.5866			Sk, Carc.1B
			Vinyl chloride monomer	<10	0.050328	<0.00020	7.77	-	0.0777			Carc.1A, BOELV
5	72183000762		Formaldehyde	<100	0.066744	<0.0010	0.26	0.53	0.0026			Carc.1B, Sens.
			Acetaldehyde	<100	0.066744	<0.0010	45	45	0.45			-
5	7114507933		Arsenic	<1000	0.050868	<0.020	0.01	-	0.0001			Carc.1A
5	7532605403		Mercury	**6**	0.039024	**0.00015**	0.01	0.03	0.0001			Sk
5	Methane screen - FID	12.40- 13.40 – 60 min	Methane as TOC	-	-	0.68 to 1.56	-	-	-	-	-	-

Table 3.7. Results from monitoring of House 53 – Location 2

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	8 hr OEL value (mg/Nm^3)	15 min OEL value (mg/Nm^3)	Environmental Assessment Levels (EAL's) – Long term ($\mu g/m^3$)	Examination of additive / cumulative effects	Limit value for cumulative effect	Other risk factors
6	Mi110717 – trace landfill gas screen	11.30 – 14.30 – 180 min 15/12/17	1-Pentene	<10	0.056268	<0.00018	-	-	-	0.022	1.0	-
			1,1 Di chloroethane	<10	0.056268	<0.00018	268	-	2.68			IOELV
			1,1-Dichloroethylene	<10	0.056268	<0.00018	20	-	0.2			-
			1,2-Dichloroethane	<10	0.056268	<0.00018	412	-	4.12			Sk, IOELV
			1,2-Dichloroethylene	<30	0.056268	<0.00053	20		0.2			-
			1,3-Butadiene	<10	0.056268	<0.00018	-	-	-			-
			1,4 epoxy 1,3-butadiene	<10	0.056268	<0.00018	-	-	-			-
			1-Propanethiol	<10	0.056268	<0.00018	-	-	-			-
			2-butoxyethanol	<10	0.056268	<0.00018	8	246	0.08			Sk , IOELV
			Benzene	**110**	0.056268	**0.0020**	3.0	-	0.03			BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.056268	<0.00018	-	-	-			-
			Carbon disulphide	<10	0.056268	<0.00018	15	-	0.15			Sk, IOELV
			Carbon tetrachloride	<10	0.056268	<0.00018	12.6	-	0.126			Sk
			Chloroethane	<30	0.056268		268	-	2.68			IOELV
			Dichloromethane	<10	0.056268	<0.00018	174	-	1.74			-
			Dimethyl disulphide	<10	0.056268	<0.00018	1.90	-	0.019			-
			Dimethyl sulphide	<10	0.056268	<0.00018	55.47	-	0.5547			-
			Ethyl butyrate	<10	0.056268	<0.00018	-	-	-			-
			Ethyl Mercaptan	<10	0.056268	<0.00018	1	3	0.01			-
			Hydrogen sulphide	**60**	0.056268	**0.011**	7	14	0.07			IOELV
			Methyl Mercaptan	<30	0.056268	<0.00053	1	-	0.01			-
			N-Butyl Mercaptan	<10	0.056268	<0.00018	1.8	-	0.018			-
			Styrene	<10	0.056268	<0.00018	85	170	0.85			-
			Toluene	**12**	0.056268	**0.00021**	192	384	1.92			Sk, IOELV
			Trichloroethylene	<10	0.056268	<0.00018	58.66	146.65	0.5866			Sk, Carc.1B
			Vinyl chloride monomer	<10	0.056268	<0.00018	7.77	-	0.0777			Carc.1A, BOELV
6	72183000765		Formaldehyde	<100	0.039816	<0.0030	0.26	0.53	0.0026			Carc.1B, Sens.
			Acetaldehyde	<100	0.039816	<0.0030	45	45	0.45			-
6	7114507932		Arsenic	<1000	0.036882	<0.030	0.01	-	0.0001			Carc.1A
6	7532605401		Mercury	<5	0.052416	<0.00010	0.01	0.03	0.0001			Sk
6	Methane screen - FID	13.50- 14.50 – 60 min	Methane as TOC	-	-	0.55 to 1.74	-	-	-	-	-	-

3.2.4 House 26 Monitoring results

Table 3.8. Results from monitoring of House 26 – Location 1

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	8 hr OEL value (mg/Nm^3)	15 min OEL value (mg/Nm^3)	Environmental Assessment Levels (EAL's) – Long term ($\mu g/m^3$)	Examination of additive / cumulative effects	Limit value for cumulative effect	Other risk factors
7	1053252 – trace landfill gas screen	16.25 – 18.36 – 131 min 14/02/18	1-Pentene	<10	0.02554	<0.00039	-	-	-	0.44	1.0	-
			1,1 Di chloroethane	<10	0.02554	<0.00039	268	-	2.68			IOELV
			1,1-Dichloroethylene	<10	0.02554	<0.00039	20	-	0.2			-
			1,2-Dichloroethane	**190**	0.02554	**0.0074**	412	-	4.12			Sk, IOELV
			1,2-Dichloroethylene	<30	0.02554	<0.0012	20		0.2			-
			1,3-Butadiene	<10	0.02554	<0.00039	-	-	-			-
			1,4 epoxy 1,3-butadiene	<10	0.02554	<0.00039	-	-	-			-
			1-Propanethiol	<10	0.02554	<0.00039	-	-	-			-
			2-butoxyethanol	<10	0.02554	<0.00039	8	246	0.08			Sk , IOELV
			Benzene	**2000**	0.02554	**0.078**	3.0	-	0.03			BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.02554	<0.00039	-	-	-			-
									0			Sk
			Carbon tetrachloride	**18**	0.02554	**0.00070**	12.6	-	0.126			IOELV
			Chloroethane	<30	0.02554	<0.0012	268	-	2.68			-
			Dichloromethane	**24000**	0.02554	**0.94**	174	-	1.74			-
			Dimethyl disulphide	<10	0.02554	<0.00039	1.90	-	0.019			-
			Dimethyl sulphide	**33**	0.02554	**0.0013**	55.47	-	0.5547			-
			Ethyl butyrate	<25	0.02554	<0.00098	-	-	-			-
			Ethyl Mercaptan	<10	0.02554	<0.00039	1	3	0.01			-
			Hydrogen sulphide	<60	0.02554	<0.0023	7	14	0.07			IOELV
			Methyl Mercaptan	<30	0.02554	<0.0012	1	-	0.01			-
			N-Butyl Mercaptan	<10	0.02554	<0.00039	1.8	-	0.018			-
			Styrene	**510**	0.02554	**0.020**	85	170	0.85			-
			Toluene	**1700**	0.02554	**0.067**	192	384	1.92			Sk, IOELV
			Vinyl chloride monomer	<10	0.02554	<0.00039	7.77	-	0.0777			Carc.1A, BOELV
7	6240704999		Formaldehyde	**5800**	0.05515	**0.105**	0.26	0.53	0.0026			Carc.1B, Sens.
			Acetaldehyde	**4300**	0.05515	**0.078**	45	45	0.45			-
7	6700215271		Arsenic	<1000	0.06514	<0.020	0.01	-	0.0001			Carc.1A
7	3277405764		Mercury	<5	0.05998	<0.00010	0.01	0.03	0.0001			Sk
7	Methane screen - FID	17.20- 18.20– 60 min	Methane as TOC	-	-	0.82 to 1.42	-	-	-	-	-	-

Table 3.9. Results from monitoring of House 26 – Location 2

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	8 hr OEL value (mg/Nm^3)	15 min OEL value (mg/Nm^3)	Environmental Assessment Levels (EAL's) – Long term ($\mu g/m^3$)	Examination of additive / cumulative effects	Limit value for cumulative effect	Other risk factors
8	Mi136065 – trace landfill gas screen	16.39 – 18.36 – 117 min 14/02/18	1-Pentene	<10	0.02383	<0.00042	-	-	-	0.021	1.0	-
			1,1 Di chloroethane	<10	0.02383	<0.00042	268	-	2.68			IOELV
			1,1-Dichloroethylene	<10	0.02383	<0.00042	20	-	0.2			-
			1,2-Dichloroethane	**280**	0.02383	**0.0012**	412	-	4.12			Sk, IOELV
			1,2-Dichloroethylene	<30	0.02383	<0.0013	20		0.2			-
			1,3-Butadiene	<10	0.02383	<0.00042	-	-	-			-
			1,4 epoxy 1,3-butadiene	<10	0.02383	<0.00042	-	-	-			-
			1-Propanethiol	<10	0.02383	<0.00042	-	-	-			-
			2-butoxyethanol	<10	0.02383	<0.00042	8	246	0.08			Sk , IOELV
			Benzene	**1400**	0.02383	**0.059**	3.0	-	0.03			BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.02383	<0.00042	-	-	-			-
			Carbon tetrachloride	**56**	0.02383	**0.0023**	12.6	-	0.126			Sk
			Chloroethane	<30	0.02383	<0.0013	268	-	2.68			IOELV
			Dichloromethane	**3700**	0.02383	**0.16**	174	-	1.74			-
			Dimethyl disulphide	<10	0.02383	<0.00042	1.90	-	0.019			-
			Dimethyl sulphide	**20**	0.02383	**0.00084**	55.47	-	0.5547			-
			Ethyl butyrate	<25	0.02383	<0.0010	-	-	-			-
			Ethyl Mercaptan	<10	0.02383	<0.00042	1	3	0.01			-
			Hydrogen sulphide	<60	0.02383	<0.0025	7	14	0.07			IOELV
			Methyl Mercaptan	<30	0.02383	<0.0013	1	-	0.01			-
			N-Butyl Mercaptan	<10	0.02383	<0.00042	1.8	-	0.018			-
			Styrene	**400**	0.02383	**0.017**	85	170	0.85			-
			Toluene	**1500**	0.02383	**0.063**	192	384	1.92			Sk, IOELV
			Vinyl chloride monomer	<10	0.02383	<0.00042	7.77	-	0.0777			Carc.1A, BOELV
8	6240705004		Formaldehyde	**1300**	0.02102	**0.060**	0.26	0.53	0.0026			Carc.1B, Sens.
			Acetaldehyde	**3100**	0.02102	**0.15**	45	45	0.45			-
8	7118615835		Arsenic	<1000	0.05688	<0.020	0.01	-	0.0001			Carc.1A
8	3950903432		Mercury	<5	0.05082	<0.00010	0.01	0.03	0.0001			Sk
8	Methane screen - FID	17.20- 18.20 – 60 min	Methane as TOC	-	-	See *Table 3.8*	-	-	-	-	-	-

3.2.5 Gas well 1 Monitoring results

Table 3.10. Results from monitoring headspace of shallow gas monitoring well - GS1

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	Risk factors
9	1042340 – trace landfill gas screen	14.35 – 15.35 – 60 min 14/02/18	1-Pentene	<10	0.01104	<0.00091	-
			1,1 Di chloroethane	<10	0.01104	<0.00091	IOELV
			1,1-Dichloroethylene	<10	0.01104	<0.00091	-
			1,2-Dichloroethane	<10	0.01104	<0.00091	Sk, IOELV
			1,2-Dichloroethylene	<30	0.01104	<0.0027	-
			1,3-Butadiene	<10	0.01104	<0.00091	-
			1,4 epoxy 1,3-butadiene	<10	0.01104	<0.00091	-
			1-Propanethiol	<10	0.01104	<0.00091	-
			2-butoxyethanol	<10	0.01104	<0.00091	Sk , IOELV
			Benzene	**310**	0.01104	**0.028**	BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.01104	<0.00091	-
			Carbon tetrachloride	**170**	0.01104	**0.0015**	Sk
			Chloroethane	<30	0.01104	<0.0027	IOELV
			Dichloromethane	<10	0.01104	<0.00091	-
			Dimethyl disulphide	<10	0.01104	<0.00091	-
			Dimethyl sulphide	<10	0.01104	<0.00091	-
			Ethyl butyrate	<25	0.01104	<0.0023	-
			Ethyl Mercaptan	<10	0.01104	<0.00091	-
			Hydrogen sulphide	<60	0.01104	<0.0054	IOELV
			Methyl Mercaptan	<30	0.01104	<0.0027	-
			N-Butyl Mercaptan	<10	0.01104	<0.00091	-
			Styrene	<10	0.01104	<0.00091	-
			Toluene	**72**	0.01104	**0.0065**	Sk, IOELV
			Vinyl chloride monomer	<10	0.01104	<0.00091	Carc.1A, BOELV
9	6240705005		Formaldehyde	**300**	0.02472	**0.013**	Carc.1B, Sens.
			Acetaldehyde	<100	0.02472	0.004	-
9	6700215272		Arsenic	<1000	0.01842	<0.050	Carc.1A
9	3277405428		Mercury	<5	0.02678	<0.00019	Sk

3.2.6 Gas well 2 Monitoring results

Table 3.10. Results from monitoring headspace of shallow gas monitoring well – GS2

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	Risk factors
10	1025547 – trace landfill gas screen	15.46 – 16.46 – 60 min 14/02/18	1-Pentene	<10	0.01012	<0.00099	-
			1,1 Di chloroethane	<10	0.01012	<0.00099	IOELV
			1,1-Dichloroethylene	<10	0.01012	<0.00099	-
			1,2-Dichloroethane	<10	0.01012	0.00099	Sk, IOELV
			1,2-Dichloroethylene	<30	0.01012	<0.0030	-
			1,3-Butadiene	<10	0.01012	<0.00099	-
			1,4 epoxy 1,3-butadiene	<10	0.01012	<0.00099	-
			1-Propanethiol	<10	0.01012	<0.00099	-
			2-butoxyethanol	<10	0.01012	<0.00099	Sk , IOELV
			Benzene	**73**	0.01012	**0.0072**	BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.01012	<0.00099	-
			Carbon tetrachloride	**160**	0.01012	**0.016**	Sk
			Chloroethane	<30	0.01012	<0.0030	IOELV
			Dichloromethane	<10	0.01012	<0.00099	-
			Dimethyl disulphide	<10	0.01012	<0.00099	-
			Dimethyl sulphide	<10	0.01012	<0.00099	-
			Ethyl butyrate	<25	0.01012	<0.0025	-
			Ethyl Mercaptan	<10	0.01012	<0.00099	-
			Hydrogen sulphide	<60	0.01012	<0.0059	IOELV
			Methyl Mercaptan	<30	0.01012	<0.0030	-
			N-Butyl Mercaptan	<10	0.01012	<0.00099	-
			Styrene	<10	0.01012	<0.00099	-
			Toluene	**30**	0.01012	**0.0030**	Sk, IOELV
			Vinyl chloride monomer	<10	0.01012	<0.00099	Carc.1A, BOELV
10	6240705008		Formaldehyde	**200**	0.02292	**0.0090**	Carc.1B, Sens.
			Acetaldehyde	<100	0.02292	<0.0040	-
10	7118615893		Arsenic	<1000	0.02005	<0.050	Carc.1A
10	3277405610		Mercury	<5	0.02638	<0.00019	Sk

3.2.7 Gas well 3 Monitoring results

Table 3.10. Results from monitoring headspace of shallow gas monitoring well – GS3

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	Risk factors
11	1052721 – trace landfill gas screen	15.20 – 16.25 – 65 min 14/02/18	1-Pentene	<10	0.01564	<0.00064	-
			1,1 Di chloroethane	<10	0.01564	<0.00064	IOELV
			1,1-Dichloroethylene	<10	0.01564	<0.00064	-
			1,2-Dichloroethane	<10	0.01564	0.00064	Sk, IOELV
			1,2-Dichloroethylene	<30	0.01564	<0.0019	-
			1,3-Butadiene	<10	0.01564	<0.00064	-
			1,4 epoxy 1,3-butadiene	<10	0.01564	<0.00064	-
			1-Propanethiol	<10	0.01564	<0.00064	-
			2-butoxyethanol	<10	0.01564	<0.00064	Sk , IOELV
			Benzene	**770**	0.01564	**0.049**	BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.01564	<0.00064	-
			Carbon tetrachloride	**38**	0.01564	**0.0024**	Sk
			Chloroethane	<30	0.01564	<0.0019	IOELV
			Dichloromethane	<10	0.01564	<0.00064	-
			Dimethyl disulphide	<10	0.01564	<0.00064	-
			Dimethyl sulphide	<10	0.01564	<0.00064	-
			Ethyl butyrate	<25	0.01564	<0.0016	-
			Ethyl Mercaptan	<10	0.01564	<0.00064	-
			Hydrogen sulphide	<60	0.01564	<0.0038	IOELV
			Methyl Mercaptan	<30	0.01564	<0.0019	-
			N-Butyl Mercaptan	<10	0.01564	<0.00064	-
			Styrene	<10	0.01564	<0.00064	-
			Toluene	**63**	0.01564	**0.0040**	Sk, IOELV
			Vinyl chloride monomer	<10	0.01564	<0.00064	Carc.1A, BOELV
11	6240705007		Formaldehyde	**500**	0.02338	**0.019**	Carc.1B, Sens.
			Acetaldehyde	<100	0.02338	<0.0040	-
11	7118615890		Arsenic	<1000	0.01271	<0.080	Carc.1A
11	3950903435		Mercury	<5	0.02411	<0.00021	Sk

3.2.8 Gas well 4 Monitoring results

Table 3.10. Results from monitoring headspace of shallow gas monitoring well – GS4

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	Risk factors
12	1051117 – trace landfill gas screen	14.54 – 15.55 – 61 min 14/02/18	1-Pentene	<10	0.01219	<0.00082	-
			1,1 Di chloroethane	<10	0.01219	<0.00082	IOELV
			1,1-Dichloroethylene	<10	0.01219	<0.00082	-
			1,2-Dichloroethane	<10	0.01219	<0.00082	Sk, IOELV
			1,2-Dichloroethylene	<30	0.01219	<0.0025	-
			1,3-Butadiene	<10	0.01219	<0.00082	-
			1,4 epoxy 1,3-butadiene	<10	0.01219	<0.00082	-
			1-Propanethiol	<10	0.01219	<0.00082	-
			2-butoxyethanol	<10	0.01219	<0.00042	Sk , IOELV
			Benzene	**190**	0.01219	**0.0049**	BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.01219	<0.00082	-
			Carbon tetrachloride	**11**	0.01219	**0.00090**	Sk
			Chloroethane	<30	0.01219	<0.0025	IOELV
			Dichloromethane	<10	0.01219	<0.00082	-
			Dimethyl disulphide	<10	0.01219	<0.00082	-
			Dimethyl sulphide	<10	0.01219	<0.00082	-
			Ethyl butyrate	<25	0.01219	<0.0021	-
			Ethyl Mercaptan	<10	0.01219	<0.00082	-
			Hydrogen sulphide	<60	0.01219	<0.0049	IOELV
			Methyl Mercaptan	<30	0.01219	<0.0025	-
			N-Butyl Mercaptan	<10	0.01219	<0.00082	-
			Styrene	<10	0.01219	<0.00082	-
			Toluene	**39**	0.01219	**0.0032**	Sk, IOELV
			Vinyl chloride monomer	<10	0.01219	<0.00082	Carc.1A, BOELV
12	6240705002		Formaldehyde	**600**	0.02515	**0.025**	Carc.1B, Sens.
			Acetaldehyde	<100	0.02515	<0.0040	-
12	7118615895		Arsenic	<1000	0.03012	<0.030	Carc.1A
12	3277405474		Mercury	<5	0.02966	<0.00017	Sk

4. Conclusions

The following conclusions are drawn for the study:

1. With regards to comfort conditions with finished Houses 25 and 26, temperatures, relative humidity and Carbon dioxide levels were normal for the environment they were monitored within (ASHRAE Standard 62.1-2004).

2. With regards to House 25 – Location 1 and 2, trace concentrations of Benzene, Carbon tetrachloride, Dichloromethane, Styrene, Toluene, Formaldehyde and Acetaldehyde were detected in the headspace of the house. All detected compounds were well within the 8 hr occupational exposure limits for the each of the respective compounds. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Formaldehyde (i.e. fractional exposure limit value 0.0026mg/Nm^3) were in excess of the fractional exposure limit value. Concentration values of 0.019 and 0.014 mg/Nm^3 were measured. There was a noticeable odour of paints, varnishes and glues in the house. The cumulative factorial value was less than 7.5% of the prescribed limit value. It is recommended that further compound monitoring is performed on this property in order to access whether these concentration levels have dissipated over time given the house has been lived within and background levels of compounds associated with building products should dissipate over time and this information will provide useful indicator of this decay over time.

3. With regards to Houses 52 and 53, trace concentrations of Benzene, Toluene, Carbon tetrachloride, Mercury and Hydrogen sulphide were detected in the headspace of the house. These houses were not finishes and had no windows present and therefore more susceptible to outside influences from compounds in the ambient environment. The concentration levels of these compounds were trace and well with any respective 8 hr occupational exposure limits. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Mercury (i.e. fractional limit value 0.0001 mg/Nm^3) were in excess of the fractional exposure limit value. A concentration value of 0.00015 mg/Nm^3 was measured on Hse 53 - Location 1. The cumulative factorial value was less than 0.10 and 2.2% of the prescribed limit value, respectively.

4. With regards to House 26 – Location 1 and 2, trace concentrations of 1,2 Dichloroethylene, Benzene, Carbon tetrachloride, Dichloromethane, Dimethyl sulphide, Styrene, Toluene, Formaldehyde and Acetaldehyde were detected in the headspace of the house. All detected compounds were well within the 8 hr occupational exposure limit values for the each of the respective compounds. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Formaldehyde (i.e. fractional exposure limit value 0.0026 mg/Nm^3) and Benzene (i.e. fractional exposure limit value 0.030 mg/Nm^3) were in excess of the fractional exposure limit values. Concentration values for Benzene and Formaldehyde were measured at 0.078 and 0.105 mg/Nm^3 for Location 1 and 0.059 and 0.060 mg/Nm^3 for Location 2. There was a weak odour of paints, varnishes and glues in the house. The cumulative factorial value was less than 44% of the prescribed limit value. It is recommended that further compound monitoring is performed on this property in order to access whether these concentration levels have dissipated over time given the house has been lived within and background levels of compounds associated with building products should dissipate over time and this information will provide useful indicator of this decay over time.

5. With regards to Gas well GS1, GS2, GS3 and GS4, trace concentrations of Benzene, Carbon tetrachloride, Toluene and Formaldehyde were detected in the headspace of the well. Benzene and Toluene are ubiquitous in the environment as a result of traffic related sources and therefore these trace amounts can be attributed to this source.

6. As part of Mulroy Environmental site investigation, a number of soil samples and groundwater samples were taken with VOC analysis conducted. In total 21 groundwater samples were taken across two monitoring rounds from the 11 groundwater monitoring wells on-site. No VOCs were detected within the groundwater above the method detection limit in any of these samples (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 6). Five soil samples were analysed for VOCs. Only two VOCs namely vinyl chloride and -1,2-dichloroethane were detected in one soil sample (i.e. SO-TP21-01) (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 5). It should be noted that this sample was taken from a trial pit located 51m from the nearest residence (i.e. House No.25). Neither of these compounds were detected in the sorbent tubes/thermal desorption/capillary gas chromatography analysis conducted for GS01 – GS04, therefore it is unlikely that they are migrating from the landfill towards the residence (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 12). Carbon tetrachloride is a common constituent of paints and varnishes. It is likely that the concentrations of carbon tetrachloride identified within the 4 gas wells to the west of the residences is as a result of a spillage and/or poor management of solvent based paints during the fit-out phase of construction (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 12). Formaldehyde is a basic constituent of rubber cement products which are used on building sites as either sealants and or glues. Empty rubber cement tubes were observed outside some of the residences during the fit-out phase of construction (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 12).

7. In relation to the surface emissions Methane / VOC screen, the levels detected were around background and were no greater than 1.74 mg/Nm^3.

5. References

1. 2011 Code of Practice for the Safety, Health and Welfare at work (Chemical Agents) Regulations 2001 (S.I. No. 619 of 2001)". (www.hse.ie).
2. ASHRAE Standard 62.1-2004, www.ashrae.org.
3. Chemical Agents COP 2016, HSE, Ireland.
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5. ILVs – Commission Directive 91/322/EEC of 29 May 1991
6. IOELVs 1 – Commission Directive 2000/39/EC of 8 June 2000
7. IOELVs 2 – Commission Directive 2006/15/EC of 7 February 2006.
8. ISO 16017-1:2000, Indoor, ambient and workplace air. Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography. Part 1: Pumped sampling.
9. MDHS 70 – General method for sampling airborne gases and vapours.
10. MDHS 72 – Volatile organic compounds in air (1993). Laboratory methods using pumped solid sorbent tubes, thermal desorption and gas chromatography.
11. MDHS 91 – Metals and metalloids in workspace air by X-ray fluorescence spectrometry, July 1998.
12. MDHS 96 – Volatile organic compounds in air, Laboratory methods using pumped solid sorbent tubes, solvent desorption and gas chromatography. March 2000.
13. Mulroy Environmental Ltd., (2018), Environmental Risk Assessment Report.
14. NIOSH (NMAM) fourth Edition (1996). Volatile organic compounds (Screening) Method 2549).
15. NIOSH 1500 and 1501 for Total and aromatic hydrocarbons sampling and measurement,
16. NIOSH 2539 – Aldehydes screening.
17. NIOSH 6001 – Arsine.
18. NIOSH 6009 – Mercury.

6. *Appendix I* – Site location map of site boundary and monitoring locations

Reference purposes only.

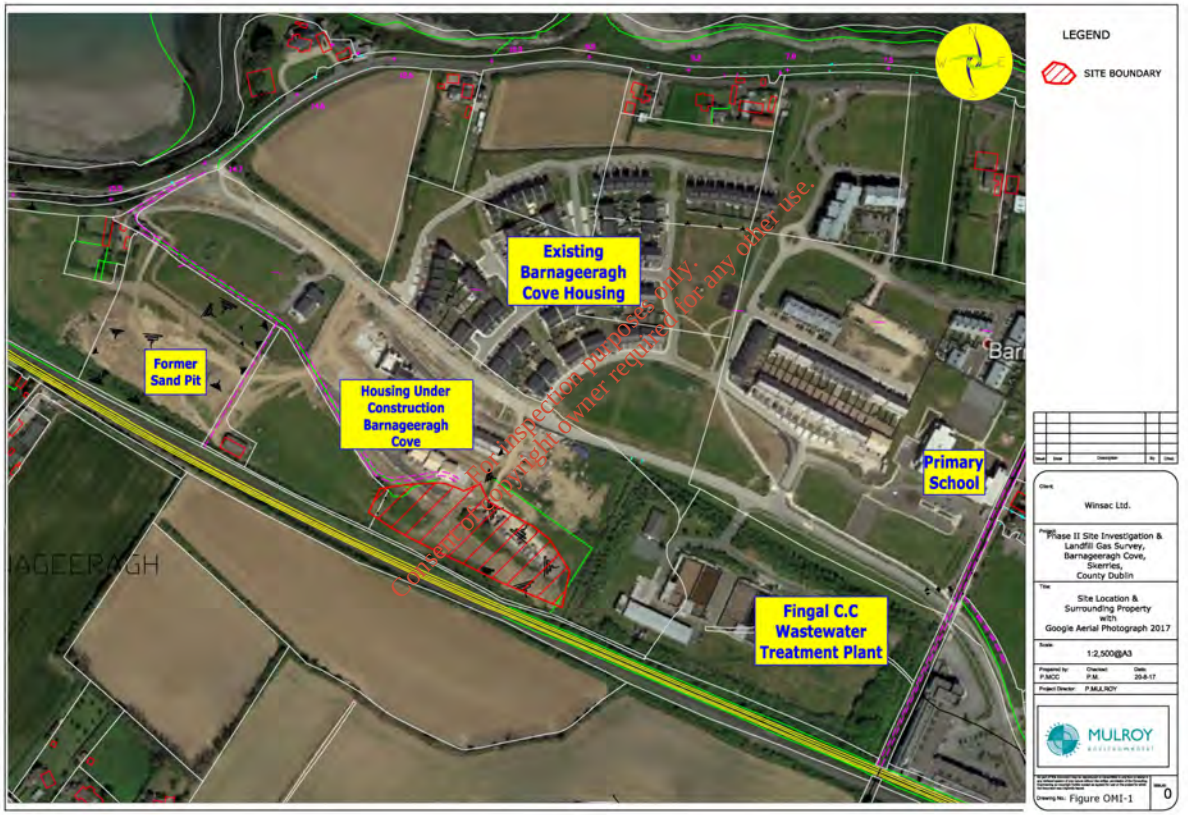

Figure 6.1. Facility layout map showing the location of the development.

Figure 6.2. Facility layout map showing the location Hse 25, 26, 52 and 53 and GS1-GS4.

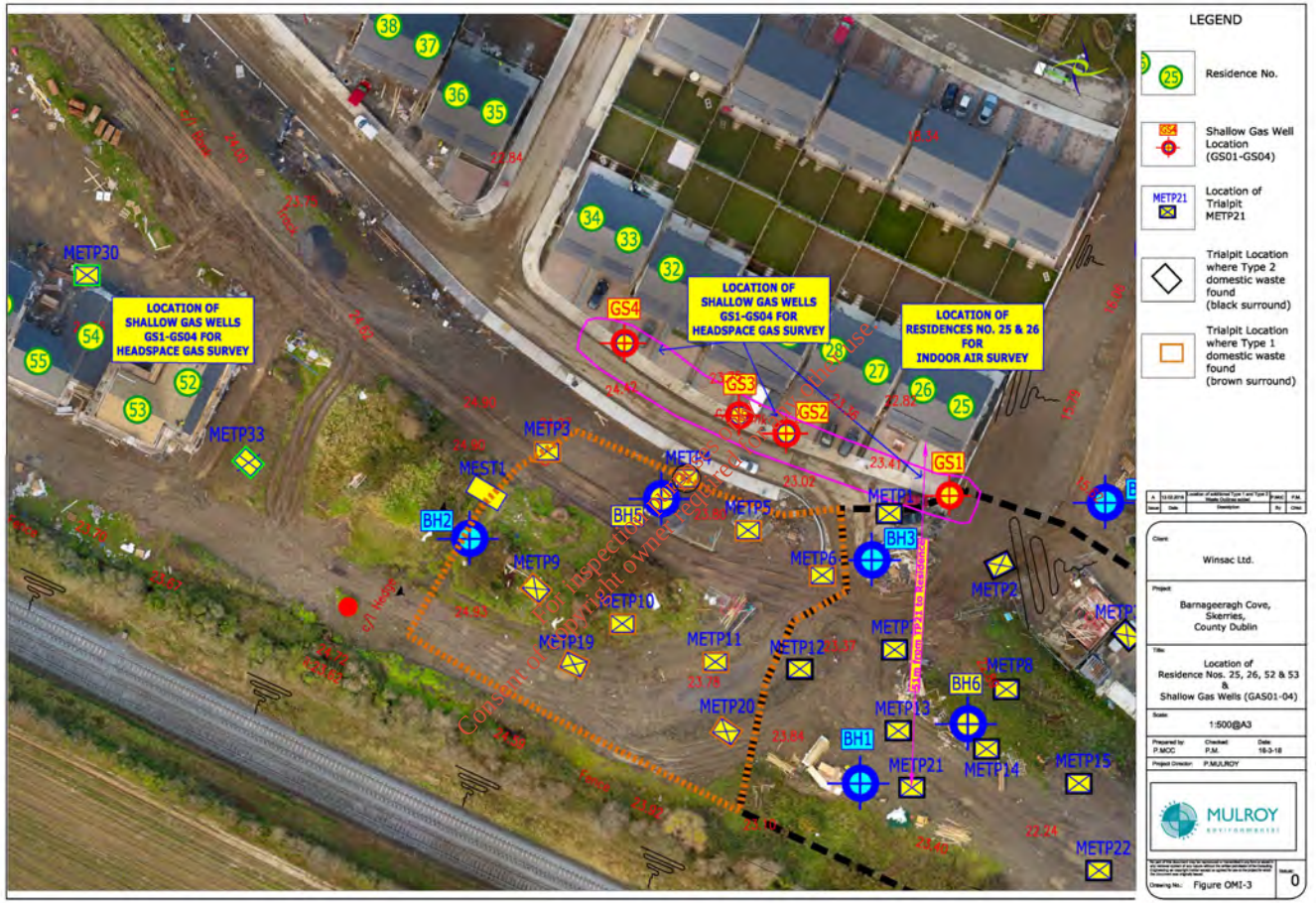

Figure 6.3. Figure showing extent of monitoring completed in new development in Barnageeragh Cove, Co. Dublin.

7. *Appendix II* – Pictures of sampling system and locations

Reference purposes only.

Figure 7.1. Location of monitoring in Hse 25, Front room

Figure 7.2. Location of monitoring in Hse 25, Utility

Notes: Location of monitors place in Hse 26 were in identical locations to Hse 25 within the property. Pictures were not taken as people resident within property at the time of monitoring.

Figure 7.3. Location of monitoring in Hse 52

Figure 7.4. Location of monitoring in Hse 53

Figure 7.5. Location of monitoring on gas wells – GS4

Figure 7.6. Location of monitoring on gas wells – GS1

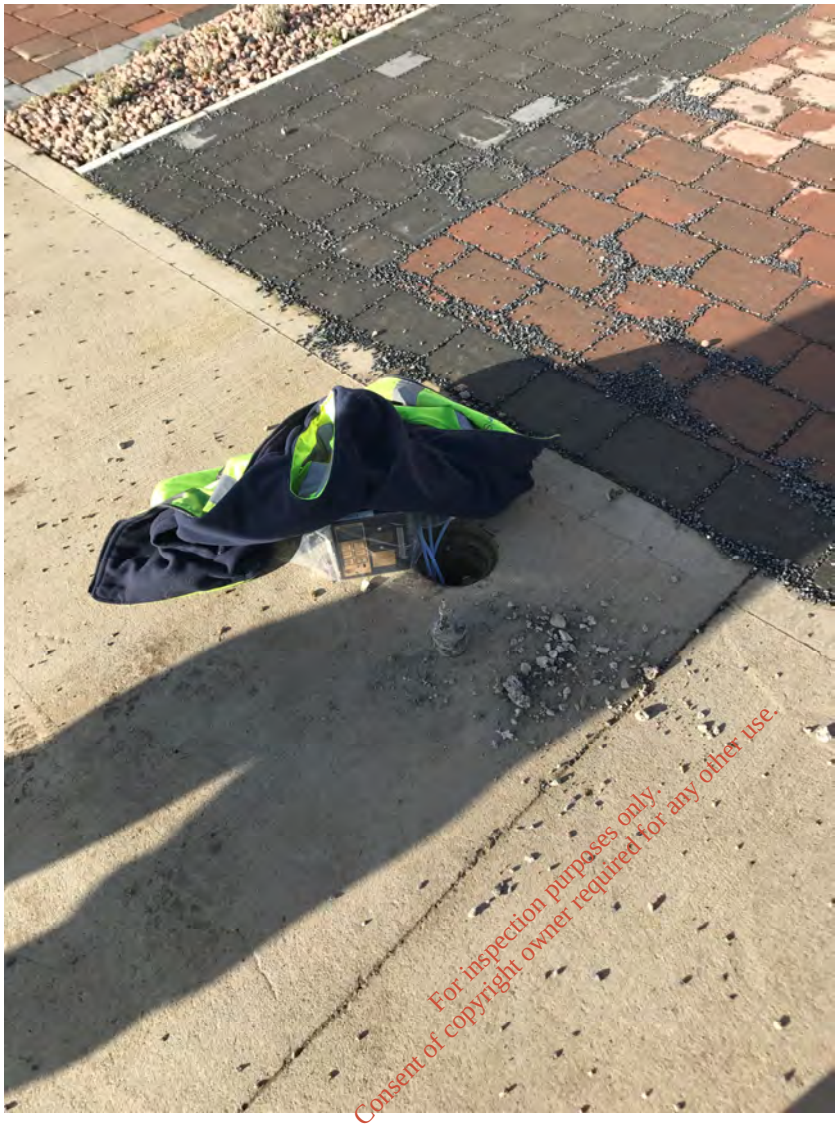

Figure 7.7. Location of monitoring on gas wells – GS2

8. *Appendix III* – Fractional exposure limits.

For many substances which are released to air, Environmental Quality Standards have not been defined. Where the necessary criteria are absent then Regulators in general have adopted interim values known as Environmental Assessment Levels (EALs). The EAL is the concentration of a substance which in a particular environmental medium the Regulators regard as a comparator value to enable a comparison to be made between the environmental effects of different substances in that medium and between environmental effects in different media and to enable the summation of those effects.

Ideally EALs to fulfil this objective would be defined for each pollutant:

- based on the sensitivity of particular habitats or receptors (in particular three main types of receptor should be considered, protection of human health, protection of natural ecosystems and protection of specific sensitive receptors, e.g. materials, commercial activities requiring a particular environmental quality;
- be produced according to a standardised protocol to ensure that they are consistent, reproducible and readily understood;
- provide similar measure of protection for different receptors both within and between media;
- take account of habitat specific environmental factors such as pH, nutrient status, bioaccumulation, transfer and transformation processes where necessary.

A suite of EALs derived in this consistent manner is not currently available; therefore, interim values based on published information have been adopted.

Ideally EALs for those substances where there are no existing criteria would be derived direct from toxicological data on the effects of the pollutant on a particular receptor. However, an assessment of this type would be a very substantial undertaking which could only be considered over an extended timescale. One approach to overcoming this problem is to make use of occupational exposure limits which provide an assessment for a specific receptor (i.e. adult human workforce) of the toxicological effects of a pollutant. These values might then be progressively revised as further information and resources allow. Indeed a similar approach to this was followed by the then Factory Inspectorate in 1968 when a large number of occupational standards were adopted from the American Conference of Governmental Industrial Hygienists (HMSO 1968) which have since been progressively revised by the Health and Safety Executive on the basis of new information and UK experience.

Occupational exposure limits are intended to set a level of exposure based on 8 hours per day, 5 days per week during a normal employment lifetime below which adverse effects are unlikely to arise for the majority of the working population who may be exposed. Occupational limit values may be derived from either actual data on workers or animal toxicity data; in addition, factors such as the ability to achieve or measure the proposed limit may also be taken into consideration. Consequently, the precise basis on which limit values have been set is difficult to determine and a cautious approach needs to be taken in deriving EALs from occupational exposure limits.

In deriving EALs for long-term exposure from occupational limits two factors need to be taken into consideration, the duration of exposure of the general population compared with the workforce and the sensitivity of the group at risk. The weekly exposure of the local population could be up to 168 hours per week (7*24 hrs) rather than the 40 hours (5*8 hrs) which might be expected for the workforce. Moreover, exposure for the general population may extend to 52 weeks compared with an average working year of 44 weeks. On this basis the minimum safety factor would be 4.96 (i.e. (168/40 * 52/44). In addition, since there may be no recovery period between exposure sessions and exposure could be for a lifetime a further safety factor of 2 could be introduced giving a total safety factor of 10.

It might also be expected that the general population will contain more sensitive individuals, for example, children, the elderly or those with diseases such as asthma, than workers who are typically between the ages of 16 and 65. In the absence of other information a factor of 10 is normally used to allow for differences between the population mean and the response of

sensitive individuals (WHO 1994). This is likely to be conservative since, in setting occupational limit values, some allowance will have been made for variation in the sensitivity of the workforce to the pollutant concerned. Combining the safety factors for exposure and sensitivity of the general population gives a long-term air quality standard of 1/100th of the 8-hour occupational exposure limit.

In the UK the Health and Safety Executive distinguish two types of long term occupational exposure limits, occupational exposure standards (OESs) and maximum exposure limits (MELs). MELs are set for chemicals where there is particular concern, for example carcinogens, or doubt over the actual no effect level and for occupational health purposes it is an offence to exceed a MEL. Within the workplace this leads to an emphasis on reducing average levels of exposure of the chemical to ensure that the MEL is not exceeded. In practice this leads to an additional safety margin of up to 5 for chemicals which have MELs over those which have OES values. Effectively, therefore, an additional safety factor of up to 5 is achieved in the workplace by setting an MEL and this factor has been incorporated in determining an EAL for those chemicals listed as having an MEL in HSE Guidance Note EH40/2001 (ref 19). For example a safety factor of 500 (10*10*5) is used to set the long term EAL for such substances.

Where no short-term environmental criteria have been identified in the literature a similar approach to their derivation from occupational exposure limits can be adapted to that described above for long-term EALs. However, in this instance it would be more appropriate to calculate values based on the short-term exposure limits (STELs) set by HSE. Where STELs are not listed then a value of 3 times the 8 hour time weighted average occupational exposure limit may be used.

Since STELs are by definition appropriate for consideration of short-term impacts there is no need for additional safety factors relating to the duration of exposure as suggested for the derivation of long term EALs. Moreover, as STELs already incorporate a limited safety margin for variation in the sensitivity of the workforce an additional factor of 10 is likely to be adequate to account for the increased sensitivity of the general population (ref 20). However, since many atmospheric dispersion models are only able to produce estimates for time averaging periods in the order of 1 hour it would be convenient for the short term EALS also to be expressed on this basis. Typically ratios between concentrations measured over a 15 minute averaging period and those taken over an hour may be between 1.3 - 2.3. Given this relatively small range and the likely over estimate of the safety factor representing variation in human sensitivity it is proposed to adopt a value of 1/10th of the STEL as the short-term EAL.

Where the substance attracts a maximum exposure limit value then an additional safety factor of 5 can be included on a similar basis to that described for the derivation of long term EALS.

It is recognised that the derived safety factors have been derived largely on the basis of experience and that for some substances the “true” EAL derived from a more fundamental study of the toxicological data may be very different. EALs derived in this manner need therefore to be treated with caution and where necessary further work undertaken to assess the implication of any actual or potential breaches. However, some comfort in the use of these safety factors may be gained from the fact that they have been applied in many permits in the past and therefore have been subjected to considerable public scrutiny (Environment Agency, H1 – Part 2 080328).

9. *Appendix IV* – Laboratory test results.

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Concept Life Sciences

Certificate of Analysis

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Report Number: 704869-1

Date of Report: 10-Jan-2018

Customer: Air Scientific
Unit 32 Degranville Court
Dublin Road
Trim
Co. Meath
Ireland.

Customer Contact: Project Management

Customer Job Reference: BAHOTL2151217
Date Job Received at Concept: 19-Dec-2017
Date Analysis Started: 19-Dec-2017
Date Analysis Completed: 10-Jan-2018

The results reported relate to samples received in the laboratory and may not be representative of a whole batch.

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

This report should not be reproduced except in full without the written approval of the laboratory

Tests covered by this certificate were conducted in accordance with Concept Life Sciences SOPs

All results have been reviewed in accordance with Section 25 of the Concept Life Sciences, Analytical Services Quality Manual

UKAS TESTING
1549

Report checked
and authorised by :
Mary Hughes
Customer Service Manager

Issued by :
Mary Hughes
Customer Service Manager

Concept Reference: 704869
Customer Reference: BAHOTL2151217

Tube Silica Gel DNPH (226-119) Analysed as Tube Silica Gel DNPH (226-119)
(Acetaldehyde, Formaldehyde)

				Concept Reference	**704869 002**	**704869 006**	**704869 010**	**704869 014**	**704869 018**
				Customer Sample Reference	**7218300767**	**7218300769**	**7218300771**	**7218301977**	**7218300762**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
				Volume l	**42.276**	**79.776**	**31.356**		**66.744**
				Date Sampled	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Acetaldehyde	HPLC (DNPH derivative)	0.1	µg	U	(13) **0.9**	(13) **0.9**	<0.1	<0.1	<0.1
	Calc	Calc	mg/m3	N	**0.021**	**0.011**	<0.003		<0.001
	Calc	Calc	ppm	N	**0.012**	**0.0062**	<0.0018		<0.00083
Formaldehyde	HPLC (DNPH derivative)	0.1	µg	U	(13) **0.8**	(13) **1.1**	<0.1	<0.1	(13) <0.1
	Calc	Calc	mg/m3	N	**0.019**	**0.014**	<0.003		<0.001
	Calc	Calc	ppm	N	**0.016**	**0.012**	<0.0026		<0.0012

Concept Reference: 704869
Customer Reference: BAHOTL2151217

Tube Silica Gel DNPH (226-119) Analysed as Tube Silica Gel DNPH (226-119)
(Acetaldehyde, Formaldehyde)

				Concept Reference	**704869 022**	**704869 026**
				Customer Sample Reference	**7218300765**	**7218300768**
				Test Sample	**AR**	**AR**
				Volume l	**39.816**	**44.208**
				Date Sampled	**15-DEC-2017**	**15-DEC-2017**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Acetaldehyde	HPLC (DNPH derivative)	0.1	µg	U	<0.1	<0.1
	Calc	Calc	mg/m3	N	<0.003	<0.002
	Calc	Calc	ppm	N	<0.0014	<0.0013
Formaldehyde	HPLC (DNPH derivative)	0.1	µg	U	<0.1	<0.1
	Calc	Calc	mg/m3	N	<0.003	<0.002
	Calc	Calc	ppm	N	<0.0020	<0.0018

Concept Reference: 704869
Customer Reference: BAHOTL2151217

Tube (Charcoal) Analysed as Tube (Charcoal 226-01)
Arsenic

				Concept Reference	**704869 003**	**704869 007**	**704869 011**	**704869 015**	**704869 019**
				Customer Sample Reference	**7114507934**	**7114507928**	**7114507935**	**7114507930**	**7114507933**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
				Volume l	**22.698**	**66.492**	**23.958**		**50.868**
				Date Sampled	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Arsenic	ICP/OES	1	µg	U	<1	<1	<1	<1	<1
	Calc	Calc	mg/m3	N	<0.04	<0.02	<0.04		<0.02
	Calc	Calc	ppm	N	<0.014	<0.0049	<0.014		<0.0064

Concept Reference: 704869
Customer Reference: BAHOTL2151217

Tube (Charcoal) Analysed as Tube (Charcoal 226-01)
Arsenic

				Concept Reference	**704869 023**	**704869 027**
				Customer Sample Reference	**7114507932**	**7114507931**
				Test Sample	**AR**	**AR**
				Volume l	**36.882**	**37.998**
				Date Sampled	**15-DEC-2017**	**15-DEC-2017**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Arsenic	ICP/OES	1	µg	U	<1	<1
	Calc	Calc	mg/m3	N	<0.03	<0.03
	Calc	Calc	ppm	N	<0.0088	<0.0086

Concept Reference: 704869
Customer Reference: BAHOTL2151217

Tube Anasorb C300 (226-17-1A) Analysed as Tube Anasorb C300 (226-17-1A)
Mercury

				Concept Reference	**704869 004**	**704869 008**	**704869 012**	**704869 016**	**704869 020**
				Customer Sample Reference	**7532605396**	**7532605397**	**7532605398**	**7532605404**	**7532605403**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
				Volume l	**51.987**	**19.836**	**38.628**		**39.024**
				Date Sampled	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Mercury	CVAFS	5	ng	U	(13) <5	(13) <5	(13) <5	(13) <5	**(13) 6**
	Calc	Calc	mg/m3	N	<0.00010	<0.00025	<0.00013		**0.00015**
	Calc	Calc	ppm	N	<0.000012	<0.000031	<0.000016		**0.000018**

Concept Reference: 704869
Customer Reference: BAHOTL2151217

Tube Anasorb C300 (226-17-1A) Analysed as Tube Anasorb C300 (226-17-1A)
Mercury

				Concept Reference	**704869 024**	**704869 028**
				Customer Sample Reference	**7532605401**	**7532605402**
				Test Sample	**AR**	**AR**
				Volume l	**52.416**	**37.728**
				Date Sampled	**15-DEC-2017**	**15-DEC-2017**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Mercury	CVAFS	5	ng	U	(13) <5	(13) <5
	Calc	Calc	mg/m3	N	<0.00010	<0.00013
	Calc	Calc	ppm	N	<0.000012	<0.000016

Concept Reference: 704869

Customer Reference: BAHOTL2151217

Tube (Tenax/Carbon/Molecular Sieve) Analysed as Tube (Tenax/Carbon/Molecular Sieve)

Trace Landfill Gas Suite

				Concept Reference	**704869 001**	**704869 005**	**704869 009**	**704869 013**	**704869 017**
				Customer Sample Reference	**mi 136392**	**mi 177242**	**mi 175249**	**mi 175246**	**1042204**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
				Volume l	**42.627**	**80.802**	**58.248**		**50.328**
				Date Sampled	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
1 Pentene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000082	<0.000043	<0.000060		<0.000069
1,1-Dichloroethane	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000058	<0.000031	<0.000042		<0.000049
1,1-Dichloroethylene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000059	<0.000031	<0.000043		<0.000050
1,2-Dichloroethane	GC/MS (TD SIR)	10	ng	N	**140**	**95**	<10	<10	<10
	Calc	Calc	mg/m3	N	**0.0033**	**0.0012**	<0.00017		<0.00020
	Calc	Calc	ppm	N	**0.00081**	**0.00029**	<0.000042		<0.000049
1,2-Dichloroethylene	GC/MS (TD SIR)	30	ng	U	<30	<30	<30	<30	<30
	Calc	Calc	mg/m3	N	<0.00070	<0.00037	<0.00052		<0.00060
	Calc	Calc	ppm	N	<0.00018	<0.000094	<0.00013		<0.00015
1,3-Butadiene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.00011	<0.000056	<0.000078		<0.000090
1,4 epoxy 1,3-butadiene	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000084	<0.000044	<0.000062		<0.000071
1-Propanethiol	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000075	<0.000040	<0.000055		<0.000064
2-butoxyethanol	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000049	<0.000026	<0.000036		<0.000041
Benzene	GC/MS (TD SIR)	10	ng	U	**180**	**420**	<10	**93**	**100**
	Calc	Calc	mg/m3	N	**0.0042**	**0.0052**	<0.00017		**0.0020**
	Calc	Calc	ppm	N	**0.0013**	**0.0016**	<0.000054		**0.00062**
Butyric acid	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000065	<0.000034	<0.000048		<0.000055
Carbon disulphide	GC/MS (TD SIR)	10	ng	N	(13) <10	(13) <10	(13) <10	(13) <10	(13) <10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000075	<0.000040	<0.000055		<0.000064
Carbon tetrachloride	GC/MS (TD SIR)	10	ng	U	**120**	**41**	<10	<10	**28**
	Calc	Calc	mg/m3	N	**0.0028**	**0.00051**	<0.00017		**0.00056**
	Calc	Calc	ppm	N	**0.00045**	**0.000081**	<0.000027		**0.000088**
Chloroethane	GC/MS (TD SIR)	30	ng	N	<30	<30	<30	<30	<30
	Calc	Calc	mg/m3	N	<0.00070	<0.00037	<0.00052		<0.00060
	Calc	Calc	ppm	N	<0.00027	<0.00014	<0.00020		<0.00023
Dichloromethane	GC/MS (TD SIR)	10	ng	N	(175,13) **1200**	(13) **3300**	(13) <10	(13) <10	(13) <10
	Calc	Calc	mg/m3	N	**0.028**	**0.041**	<0.00017		<0.00020
	Calc	Calc	ppm	N	**0.0081**	**0.012**	<0.000049		<0.000057
Dimethyl disulphide	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000061	<0.000032	<0.000045		<0.000052
Dimethyl sulphide	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000092	<0.000049	<0.000068		<0.000078
Ethyl butyrate	GC/MS (TD SIR)	25	ng	N	<25	<25	<25	<25	<25
	Calc	Calc	mg/m3	N	<0.00059	<0.00031	<0.00043		<0.00050
	Calc	Calc	ppm	N	<0.00012	<0.000065	<0.000090		<0.00010
Ethyl Mercaptan	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000092	<0.000049	<0.000068		<0.000078
Hydrogen sulphide	GC/MS (TD SIR)	60	ng	N	<60	<60	<60	<60	<60

Concept Reference: 704869

Customer Reference: BAHOTL2151217

Tube (Tenax/Carbon/Molecular Sieve) Analysed as Tube (Tenax/Carbon/Molecular Sieve)

Trace Landfill Gas Suite

				Concept Reference	**704869 001**	**704869 005**	**704869 009**	**704869 013**	**704869 017**
				Customer Sample Reference	**mi 136392**	**mi 177242**	**mi 175249**	**mi 175246**	**1042204**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
				Volume l	**42.627**	**80.802**	**58.248**		**50.328**
				Date Sampled	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**	**15-DEC-2017**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
	Calc	Calc	mg/m3	N	<0.0014	<0.00074	<0.0010		<0.0012
	Calc	Calc	ppm	N	<0.0010	<0.00053	<0.00074		<0.00086
Methyl Mercaptan	GC/MS (TD SIR)	30	ng	N	<30	<30	<30	<30	<30
	Calc	Calc	mg/m3	N	<0.00070	<0.00037	<0.00052		<0.00060
	Calc	Calc	ppm	N	<0.00036	<0.00019	<0.00026		<0.00030
N-Butyl Mercaptan	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000064	<0.000034	<0.000047		<0.000054
Styrene	GC/MS (TD SIR)	10	ng	N	**79**	**140**	<10	<10	<10
	Calc	Calc	mg/m3	N	**0.0019**	**0.0017**	<0.00017		<0.00020
	Calc	Calc	ppm	N	**0.00044**	**0.00041**	<0.000040		<0.000047
Toluene	GC/MS (TD SIR)	10	ng	N	**(175) 1800**	**(175) 2200**	<10	**76**	**100**
	Calc	Calc	mg/m3	N	**0.042**	**0.027**	<0.00017		**0.0020**
	Calc	Calc	ppm	N	**0.011**	**0.0072**	<0.000046		**0.00053**
Trichloroethylene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000044	<0.000023	<0.000032		<0.000037
Vinyl chloride monomer	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00023	<0.00012	<0.00017		<0.00020
	Calc	Calc	ppm	N	<0.000092	<0.000048	<0.000067		<0.000078

Concept Reference: 704869

Customer Reference: BAHOTL2151217

Tube (Tenax/Carbon/Molecular Sieve) Analysed as Tube (Tenax/Carbon/Molecular Sieve)

Trace Landfill Gas Suite

				Concept Reference	**704869 021**	**704869 025**
				Customer Sample Reference	**mi 110717**	**mi 126424**
				Test Sample	**AR**	**AR**
				Volume l	**56.268**	**56.628**
				Date Sampled	**15-DEC-2017**	**15-DEC-2017**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
1 Pentene	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000062	<0.000062
1,1-Dichloroethane	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000044	<0.000044
1,1-Dichloroethylene	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000045	<0.000045
1,2-Dichloroethane	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000044	<0.000044
1,2-Dichloroethylene	GC/MS (TD SIR)	30	ng	U	<30	<30
	Calc	Calc	mg/m3	N	<0.00053	<0.00053
	Calc	Calc	ppm	N	<0.00013	<0.00013
1,3-Butadiene	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000080	<0.000080
1,4 epoxy 1,3-butadiene	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000064	<0.000063
1-Propanethiol	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000057	<0.000057
2-butoxyethanol	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000037	<0.000037
Benzene	GC/MS (TD SIR)	10	ng	U	**110**	**19**
	Calc	Calc	mg/m3	N	**0.0020**	**0.00034**
	Calc	Calc	ppm	N	**0.00061**	**0.00011**
Butyric acid	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000049	<0.000049
Carbon disulphide	GC/MS (TD SIR)	10	ng	N	(13) <10	(13) <10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000057	<0.000057
Carbon tetrachloride	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000028	<0.000028
Chloroethane	GC/MS (TD SIR)	30	ng	N	<30	<30
	Calc	Calc	mg/m3	N	<0.00053	<0.00053
	Calc	Calc	ppm	N	<0.00020	<0.00020
Dichloromethane	GC/MS (TD SIR)	10	ng	N	(13) <10	(13) <10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000051	<0.000051
Dimethyl disulphide	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000046	<0.000046
Dimethyl sulphide	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000070	<0.000069
Ethyl butyrate	GC/MS (TD SIR)	25	ng	N	<25	<25
	Calc	Calc	mg/m3	N	<0.00044	<0.00044
	Calc	Calc	ppm	N	<0.000094	<0.000093
Ethyl Mercaptan	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000070	<0.000069
Hydrogen sulphide	GC/MS (TD SIR)	60	ng	N	(13) **60**	<60

Concept Reference: 704869

Customer Reference: BAHOTL2151217

Tube (Tenax/Carbon/Molecular Sieve) Analysed as Tube (Tenax/Carbon/Molecular Sieve)

Trace Landfill Gas Suite

				Concept Reference	**704869 021**	**704869 025**
				Customer Sample Reference	**mi 110717**	**mi 126424**
				Test Sample	**AR**	**AR**
				Volume l	**56.268**	**56.628**
				Date Sampled	**15-DEC-2017**	**15-DEC-2017**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
	Calc	Calc	mg/m3	N	**0.0011**	<0.0011
	Calc	Calc	ppm	N	**0.00077**	<0.00076
Methyl Mercaptan	GC/MS (TD SIR)	30	ng	N	<30	<30
	Calc	Calc	mg/m3	N	<0.00053	<0.00053
	Calc	Calc	ppm	N	<0.00027	<0.00027
N-Butyl Mercaptan	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000048	<0.000048
Styrene	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000042	<0.000041
Toluene	GC/MS (TD SIR)	10	ng	N	**12**	**12**
	Calc	Calc	mg/m3	N	**0.00021**	**0.00021**
	Calc	Calc	ppm	N	**0.000057**	**0.000056**
Trichloroethylene	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000033	<0.000033
Vinyl chloride monomer	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00018	<0.00018
	Calc	Calc	ppm	N	<0.000070	<0.000069

Index to symbols used in 704869-1

Value	Description
AR	As Received
13	Results have been blank corrected
175	Results should be viewed with caution due to being outside of the instrument calibration range
U	Analysis is UKAS accredited
N	Analysis is not UKAS accredited
C	Calculation

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Concept Life Sciences

Certificate of Analysis

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Report Number: Second supplement to 716673-2

Date of Report: 20-Mar-2018

Customer: Air Scientific
Unit 32 Degranville Court
Dublin Road
Trim
Co. Meath
Ireland.

Customer Contact: Project Management

Customer Job Reference: BAHOTL2140218
Date Job Received at Concept: 19-Feb-2018
Date Analysis Started: 19-Feb-2018
Date Analysis Completed: 12-Mar-2018

The results reported relate to samples received in the laboratory and may not be representative of a whole batch.

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

This report should not be reproduced except in full without the written approval of the laboratory

Tests covered by this certificate were conducted in accordance with Concept Life Sciences SOPs

All results have been reviewed in accordance with Section 25 of the Concept Life Sciences, Analytical Services Quality Manual

UKAS TESTING
1549

Report checked
and authorised by :
Mr Saber Chaudhry
Laboratory Manager (Air)

Issued by :
Mary Hughes
Customer Service Manager

Concept Reference: 716673
Customer Reference: BAHOTL2140218

Tube Anasorb C300 (226-17-1A) Analysed as Tube Anasorb C300 (226-17-1A)
Mercury

				Concept Reference	**716673 004**	**716673 008**	**716673 012**	**716673 016**	**716673 020**
				Customer Sample Reference	**3277405428**	**3277405474**	**3950903435**	**3277405610**	**3299405411**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
				Volume l	**26.784**	**29.6643**	**24.115**	**26.388**	
				Date Sampled	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Mercury	CVAFS	5	ng	U	<5	<5	<5	<5	<5
	Calc	Calc	mg/m3	N	<0.00019	<0.00017	<0.00021	<0.00019	
	Calc	Calc	ppm	N	<0.000023	<0.000021	<0.000025	<0.000023	

Concept Reference: 716673
Customer Reference: BAHOTL2140218

Tube Anasorb C300 (226-17-1A) Analysed as Tube Anasorb C300 (226-17-1A)
Mercury

				Concept Reference	**716673 024**	**716673 028**
				Customer Sample Reference	**3277405764**	**3950903432**
				Test Sample	**AR**	**AR**
				Volume l	**59.9849**	**50.8248**
				Date Sampled	**14-FEB-2018**	**14-FEB-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Mercury	CVAFS	5	ng	U	<5	<5
	Calc	Calc	mg/m3	N	<0.00008	<0.00010
	Calc	Calc	ppm	N	<0.000010	<0.000012

Concept Reference: 716673
Customer Reference: BAHOTL2140218

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Arsenic

				Concept Reference	**716673 001**	**716673 005**	**716673 009**	**716673 013**	**716673 018**
				Customer Sample Reference	**6900215272**	**7118615895**	**7118615890**	**7118615893**	**7118615839**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
				Volume l	**15.426**	**30.1279**	**12.714**	**20.052**	
				Date Sampled	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Arsenic	ICP/OES	1	µg	U	<1	<1	<1	<1	<1
	Calc	Calc	mg/m3	N	<0.05	<0.03	<0.08	<0.05	
	Calc	Calc	ppm	N	<0.018	<0.011	<0.026	<0.016	

Concept Reference: 716673
Customer Reference: BAHOTL2140218

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Arsenic

				Concept Reference	**716673 021**	**716673 025**
				Customer Sample Reference	**6900215271**	**7118615835**
				Test Sample	**AR**	**AR**
				Volume l	**65.1463**	**56.8854**
				Date Sampled	**14-FEB-2018**	**14-FEB-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Arsenic	ICP/OES	1	µg	U	<1	<1
	Calc	Calc	mg/m3	N	<0.02	<0.02
	Calc	Calc	ppm	N	<0.0050	<0.0057

Concept Reference: 716673

Customer Reference: BAHOTL2140218

Tube (Tenax/Carbon/Molecular Sieve) Analysed as Tube (Tenax/Carbon/Molecular Sieve)

Trace Landfill Gas Suite

				Concept Reference	**716673 002**	**716673 006**	**716673 010**	**716673 014**	**716673 017**
				Customer Sample Reference	**1042340**	**1051117**	**1052721**	**1025547**	**MI 126669**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
				Volume l	**11.046**	**12.1939**	**15.6455**	**10.128**	
				Date Sampled	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
1 Pentene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00032	<0.00029	<0.00022	<0.00034	
1,1-Dichloroethane	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00022	<0.00020	<0.00016	<0.00024	
1,1-Dichloroethylene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00023	<0.00021	<0.00016	<0.00025	
1,2-Dichloroethane	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00022	<0.00020	<0.00016	<0.00024	
1,2-Dichloroethylene	GC/MS (TD SIR)	30	ng	U	<30	<30	<30	<30	<30
	Calc	Calc	mg/m3	N	<0.0027	<0.0025	<0.0019	<0.0030	
	Calc	Calc	ppm	N	<0.00068	<0.00062	<0.00048	<0.00075	
1,3-Butadiene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00041	<0.00037	<0.00029	<0.00045	
1,4 epoxy 1,3-butadiene	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00033	<0.00029	<0.00023	<0.00035	
1-Propanethiol	GC/MS (TD SIR)	10	ng	U	(68) <10	(68) <10	(68) <10	(68) <10	(68) <10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00029	<0.00026	<0.00021	<0.00032	
2-butoxyethanol	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00019	<0.00017	<0.00013	<0.00020	
Benzene	GC/MS (TD SIR)	10	ng	U	(13) **210**	(13) **190**	(13) **770**	(13) **73**	(13) <10
	Calc	Calc	mg/m3	N	**0.028**	**0.016**	**0.049**	**0.0072**	
	Calc	Calc	ppm	N	**0.0088**	**0.0049**	**0.015**	**0.0023**	
Butyric acid	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00025	<0.00023	<0.00018	<0.00027	
Carbon tetrachloride	GC/MS (TD SIR)	10	ng	U	**170**	**11**	**38**	**160**	<10
	Calc	Calc	mg/m3	N	**0.015**	**0.00090**	**0.0024**	**0.016**	
	Calc	Calc	ppm	N	**0.0024**	**0.00014**	**0.00039**	**0.0025**	
Chloroethane	GC/MS (TD SIR)	30	ng	N	<30	<30	<30	<30	<30
	Calc	Calc	mg/m3	N	<0.0027	<0.0025	<0.0019	<0.0030	
	Calc	Calc	ppm	N	<0.0010	<0.00093	<0.00073	<0.0011	
Dichloromethane	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00026	<0.00024	<0.00018	<0.00028	
Dimethyl disulphide	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00024	<0.00021	<0.00017	<0.00026	
Dimethyl sulphide	GC/MS (TD SIR)	10	ng	U	(68) <10	(68) <10	(68) <10	(68) <10	(68) <10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00036	<0.00032	<0.00025	<0.00039	
Ethyl butyrate	GC/MS (TD SIR)	25	ng	N	<25	<25	<25	<25	<25
	Calc	Calc	mg/m3	N	<0.0023	<0.0021	<0.0016	<0.0025	
	Calc	Calc	ppm	N	<0.00048	<0.00043	<0.00034	<0.00052	
Ethyl Mercaptan	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00036	<0.00032	<0.00025	<0.00039	
Hydrogen sulphide	GC/MS (TD SIR)	60	ng	N	<60	<60	<60	<60	<60
	Calc	Calc	mg/m3	N	<0.0054	<0.0049	<0.0038	<0.0059	
	Calc	Calc	ppm	N	<0.0039	<0.0035	<0.0028	<0.0043	
Methyl Mercaptan	GC/MS (TD SIR)	30	ng	N	<30	<30	<30	<30	<30

Concept Reference: 716673

Customer Reference: BAHOTL2140218

Tube (Tenax/Carbon/Molecular Sieve) Analysed as Tube (Tenax/Carbon/Molecular Sieve)

Trace Landfill Gas Suite

				Concept Reference	**716673 002**	**716673 006**	**716673 010**	**716673 014**	**716673 017**
				Customer Sample Reference	**1042340**	**1051117**	**1052721**	**1025547**	**MI 126669**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
				Volume l	**11.046**	**12.1939**	**15.6455**	**10.128**	
				Date Sampled	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
	Calc	Calc	mg/m3	N	<0.0027	<0.0025	<0.0019	<0.0030	
	Calc	Calc	ppm	N	<0.0014	<0.0013	<0.00097	<0.0015	
N-Butyl Mercaptan	GC/MS (TD SIR)	10	ng	U	(68) <10	(68) <10	(68) <10	(68) <10	(68) <10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00025	<0.00022	<0.00017	<0.00027	
Styrene	GC/MS (TD SIR)	10	ng	N	<10	<10	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00021	<0.00019	<0.00015	<0.00023	
Toluene	GC/MS (TD SIR)	10	ng	N	(13) **72**	(13) **39**	(13) **63**	(13) **30**	(13) **130**
	Calc	Calc	mg/m3	N	**0.0065**	**0.0032**	**0.0040**	**0.0030**	
	Calc	Calc	ppm	N	**0.0017**	**0.00085**	**0.0011**	**0.00079**	
Vinyl chloride monomer	GC/MS (TD SIR)	10	ng	U	(68) <10	(68) <10	(68) <10	(68) <10	(68) <10
	Calc	Calc	mg/m3	N	<0.00091	<0.00082	<0.00064	<0.00099	
	Calc	Calc	ppm	N	<0.00035	<0.00032	<0.00025	<0.00039	

Concept Reference: 716673

Customer Reference: BAHOTL2140218

Tube (Tenax/Carbon/Molecular Sieve) Analysed as Tube (Tenax/Carbon/Molecular Sieve)

Trace Landfill Gas Suite

				Concept Reference	**716673 022**	**716673 026**
				Customer Sample Reference	**1053252**	**MI 136065**
				Test Sample	**AR**	**AR**
				Volume l	**25.545**	**23.8329**
				Date Sampled	**14-FEB-2018**	**14-FEB-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
1 Pentene	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.00014	<0.00015
1,1-Dichloroethane	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.000097	<0.00010
1,1-Dichloroethylene	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.000099	<0.00011
1,2-Dichloroethane	GC/MS (TD SIR)	10	ng	N	**190**	**280**
	Calc	Calc	mg/m3	N	**0.0074**	**0.012**
	Calc	Calc	ppm	N	**0.0018**	**0.0029**
1,2-Dichloroethylene	GC/MS (TD SIR)	30	ng	U	<30	<30
	Calc	Calc	mg/m3	N	<0.0012	<0.0013
	Calc	Calc	ppm	N	<0.00030	<0.00032
1,3-Butadiene	GC/MS (TD SIR)	10	ng	U	<10	<10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.00018	<0.00019
1,4 epoxy 1,3-butadiene	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.00014	<0.00015
1-Propanethiol	GC/MS (TD SIR)	10	ng	U	(68) <10	(68) <10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.00013	<0.00013
2-butoxyethanol	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.000081	<0.000087
Benzene	GC/MS (TD SIR)	10	ng	U	(175,13) **2000**	(13,175) **1400**
	Calc	Calc	mg/m3	N	**0.078**	**0.059**
	Calc	Calc	ppm	N	**0.025**	**0.018**
Butyric acid	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.00011	<0.00012
Carbon tetrachloride	GC/MS (TD SIR)	10	ng	U	**18**	**56**
	Calc	Calc	mg/m3	N	**0.00070**	**0.0023**
	Calc	Calc	ppm	N	**0.00011**	**0.00037**
Chloroethane	GC/MS (TD SIR)	30	ng	N	<30	<30
	Calc	Calc	mg/m3	N	<0.0012	<0.0013
	Calc	Calc	ppm	N	<0.00045	<0.00048
Dichloromethane	GC/MS (TD SIR)	10	ng	N	(175) **24000**	(175) **3700**
	Calc	Calc	mg/m3	N	**0.94**	**0.16**
	Calc	Calc	ppm	N	**0.27**	**0.045**
Dimethyl disulphide	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.00010	<0.00011
Dimethyl sulphide	GC/MS (TD SIR)	10	ng	U	(68) **33**	(68) **20**
	Calc	Calc	mg/m3	N	**0.0013**	**0.00084**
	Calc	Calc	ppm	N	**0.00051**	**0.00033**
Ethyl butyrate	GC/MS (TD SIR)	25	ng	N	<25	<25
	Calc	Calc	mg/m3	N	<0.00098	<0.0010
	Calc	Calc	ppm	N	<0.00021	<0.00022
Ethyl Mercaptan	GC/MS (TD SIR)	10	ng	N	<10	<10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.00015	<0.00017
Hydrogen sulphide	GC/MS (TD SIR)	60	ng	N	<60	<60
	Calc	Calc	mg/m3	N	<0.0023	<0.0025
	Calc	Calc	ppm	N	<0.0017	<0.0018
Methyl Mercaptan	GC/MS (TD SIR)	30	ng	N	<30	<30

Concept Reference: 716673
Customer Reference: BAHOTL2140218

Tube (Tenax/Carbon/Molecular Sieve) Analysed as Tube (Tenax/Carbon/Molecular Sieve)

Trace Landfill Gas Suite

				Concept Reference	**716673 022**	**716673 026**
				Customer Sample Reference	**1053252**	**MI 136065**
				Test Sample	**AR**	**AR**
				Volume l	**25.545**	**23.8329**
				Date Sampled	**14-FEB-2018**	**14-FEB-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
	Calc	Calc	mg/m3	N	<0.0012	<0.0013
	Calc	Calc	ppm	N	<0.00060	<0.00064
N-Butyl Mercaptan	GC/MS (TD SIR)	10	ng	U	(68) <10	(68) <10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.00011	<0.00011
Styrene	GC/MS (TD SIR)	10	ng	N	**510**	**400**
	Calc	Calc	mg/m3	N	**0.020**	**0.017**
	Calc	Calc	ppm	N	**0.0047**	**0.0039**
Toluene	GC/MS (TD SIR)	10	ng	N	(13,175) **1700**	(13,175) **1500**
	Calc	Calc	mg/m3	N	**0.067**	**0.063**
	Calc	Calc	ppm	N	**0.018**	**0.017**
Vinyl chloride monomer	GC/MS (TD SIR)	10	ng	U	(68) <10	(68) <10
	Calc	Calc	mg/m3	N	<0.00039	<0.00042
	Calc	Calc	ppm	N	<0.00015	<0.00016

Concept Reference: 716673
Customer Reference: BAHOTL2140218

Tube Silica Gel DNPH (226-119) Analysed as Tube Silica Gel DNPH (226-119)

(Acetaldehyde, Formaldehyde)

				Concept Reference	**716673 003**	**716673 007**	**716673 011**	**716673 015**	**716673 019**
				Customer Sample Reference	**6240705005**	**6240705002**	**6240705007**	**6240705008**	**6240705003**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
				Volume l	**24.726**	**25.1503**	**23.3805**	**22.92**	
				Date Sampled	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**	**14-FEB-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Acetaldehyde	HPLC (DNPH derivative)	0.1	µg	U	<0.1	<0.1	<0.1	<0.1	<0.1
	Calc	Calc	mg/m3	N	<0.004	<0.004	<0.004	<0.004	
	Calc	Calc	ppm	N	<0.0022	<0.0022	<0.0024	<0.0024	
Formaldehyde	HPLC (DNPH derivative)	0.1	µg	U	(13) **0.3**	(13) **0.6**	(13) **0.5**	(13) **0.2**	(13) **0.2**
	Calc	Calc	mg/m3	N	**0.013**	**0.025**	**0.019**	**0.009**	
	Calc	Calc	ppm	N	**0.011**	**0.020**	**0.016**	**0.0071**	

Concept Reference: 716673
Customer Reference: BAHOTL2140218

Tube Silica Gel DNPH (226-119) Analysed as Tube Silica Gel DNPH (226-119)

(Acetaldehyde, Formaldehyde)

				Concept Reference	**716673 023**	**716673 027**
				Customer Sample Reference	**6240704999**	**6240705004**
				Test Sample	**AR**	**AR**
				Volume l	**55.151**	**21.0249**
				Date Sampled	**14-FEB-2018**	**14-FEB-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Acetaldehyde	HPLC (DNPH derivative)	0.1	µg	U	(13) **4.3**	(13) **3.1**
	Calc	Calc	mg/m3	N	**0.078**	**0.15**
	Calc	Calc	ppm	N	**0.043**	**0.082**
Formaldehyde	HPLC (DNPH derivative)	0.1	µg	U	(13) **5.8**	(13) **1.3**
	Calc	Calc	mg/m3	N	**0.10**	**0.060**
	Calc	Calc	ppm	N	**0.085**	**0.049**

Index to symbols used in Second supplement to 716673-2

Value	Description
AR	As Received
13	Results have been blank corrected.
68	Outside scope of UKAS accreditation
175	Results should be viewed with caution due to being outside of the instrument calibration range
U	Analysis is UKAS accredited
N	Analysis is not UKAS accredited
C	Calculation

Notes

.
Supplemental report issued to include Formaldehyde on Sample 027 as requested by the client.

OCCUPATIONAL MONITORING OF HEADSPACE AIR WITHIN HOUSE NO. 47, BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN. PERFORMED BY ODOUR MONITORING IRELAND. 31ST AUGUST 2018 VER.3. REPORT NUMBER: 2018356(3)

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OCCUPATIONAL MONITORING OF HEADSPACE AIR WITHIN HOUSE NO. 47 LOCATED IN BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN.

PERFORMED BY ODOUR MONITORING IRELAND ON THE BEHALF OF MULROY ENVIRONMENTAL LTD.

REPORT PREPARED BY:	Dr. Brian Sheridan
REPORT VERSION:	Document Ver.3
ATTENTION:	Mr. Patrick McCabe & Mr. Padraic Mulroy
DATE:	24th July 2018 Ver.1, 20th Aug 2018 Ver.2 & 31st Aug 2018
REPORT NUMBER:	2018356(3)
REVIEWERS:	Mr. Padraic Mulroy

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DOCUMENT AMENDMENT RECORD

Client: ***Mulroy Environmental Ltd***

Project: **OCCUPATIONAL MONITORING OF HEADSPACE AIR WITHIN HOUSE NO. 47 LOCATED IN BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN.**

Project Number: 2018356(3)		**DOCUMENT REFERENCE: OCCUPATIONAL MONITORING OF HEADSPACE AIR WITHIN HOUSE NO. 47 LOCATED IN BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN.**			
2018356(1)	Document for review	B.A.S.	JMC	BAS	24/07/2018
2018356(2)	Minor edits	PM	BAS	BAS	20/08/2018
2018356(3)	Minor edits	PM	BAS	BAS	31/08/2018
Revision	**Purpose/Description**	**Originated**	**Checked**	**Authorised**	**Date**

This document is submitted as part of occupational monitoring works carried out by Odour Monitoring Ireland Ltd on behalf of Mulroy Environmental Ltd on one named house. The results reported are representative of actual conditions and activities on the days of monitoring.

Respectively submitted,

Brian Sheridan B.Sc. M.Sc. (Agr) Ph.D (Eng).

For and on behalf of Odour Monitoring Ireland™

Executive Summary

Odour Monitoring Ireland Ltd was commissioned by Mulroy Environmental Ltd to perform occupational monitoring of air located within one house (namely Hse. No. 47, Barnageeragh, Skerries, Co. Dublin) on the 27th June 2018. The aim of the study was to ascertain the potential level of specified air contaminants within the headspace air of the monitored house. Data collected on the house was compared with published occupational exposure levels, where applicable.

Monitoring was performed for a number of compound groups to include:

- Temperature, Relative humidity and Carbon dioxide levels in house 47 only;
- Arsenic (House 47);
- Mercury (House 47);
- Trace Landfill gas screen (House 47);
- Formaldehyde and Acetaldehyde (House 47);

The following conclusions were developed for the study. These include:

1. With regards to comfort conditions with finished House 47, temperatures, relative humidity and Carbon dioxide levels were normal for the environment it was monitored within (ASHRAE Standard 62.1-2004).

2. As can be observed from the analysis results across the sampling locations in the property (Hse 47), all results were compliant with the published 8 hr OEL value, where applicable. In terms of the measured concentration, all measured values were well within the published 8 hr OEL where applicable. This is also published within each table (*see Tables 3.2 and 3.3*). Cumulative OEL risk was assessed for the speciated VOC's detected. The cumulative assessment value was within the stated limit value of 1.0 for cumulative VOC's (see 2011 Code of practice for the Safety, Health and Welfare at work (Chemical Agents) Regulations 2001 (SI No. 619 of 2001) & updated COP 2016).

3. In addition to screening the 8 hr OEL limit value and given the fact that properties could be occupied for periods in excess of 8 hr / day 5 days per week up to period of 24hrs / days and 7 days per week, fractional exposure limit values were compared to the recorded concentrations. In terms of overall results, Formaldehyde was in excess of the fractional exposure limit value at House 47 Location 1 and 2. Mercury was in excess of the fractional exposure limit value at House 47 Location 1 and 2. Therefore considering the compounds and the fact that the houses were newly built, it is recommended that repeat monitoring be completed to examine whether compound concentrations have dissipated with time of occupancy within the houses.

4. With regards to House 47 – Location 1 and 2, trace concentrations of Benzene, Chloroethane, Styrene, Toluene, Mercury, Formaldehyde and Acetaldehyde were detected in the headspace of the house. All detected compounds were well within the 8 hr occupational exposure limits for the each of the respective compounds. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Formaldehyde (i.e. fractional exposure limit value 0.0026 mg/Nm^3) were in excess of the fractional exposure limit value. Concentration values of 0.023 and 0.017 mg/Nm^3 were measured.

5. With regards to Total Organic Carbon (TOC) as Methane monitoring utilising FID technique,
    a. House No. 47: the detected levels of TOC as Methane at the Radon barrier sump was 0.053 mg/Nm^3. The external areas outside the house was 0.053 mg/Nm^3. No other areas of the House were checked as there was no access to the internal of the house.
    b. House No. 53: the detected levels of TOC as Methane at the Utility was 2.385 mg/Nm^3, Toilet TOC as Methane level was 3.604 mg/Nm^3, Kitchen

TOC as Methane level was 1.484 mg/Nm^3 and Living room TOC as Methane value was 2.756 mg/Nm^3. The Radon barrier sump detected levels was 0.106 mg/Nm^3. Areas screened outside the house were 0.106 mg/Nm^3. House 53 was been painted at the time of the survey.

c. House No. 52, the detected levels of TOC as Methane in the Utility was 0.106 mg/Nm^3, Toilet TOC as Methane level was 0.106 mg/Nm^3, Kitchen TOC as Methane level was 0.212 mg/Nm^3. The Radon barrier sump was 0 mg/Nm^3. Areas outside the house were 0.053 mg/Nm^3.

1. Introduction and scope

1.1 Project Background

It should be noted that in 2017, Odour Monitoring Ireland Ltd were commissioned by Mulroy Environmental Ltd. to perform occupational monitoring of air located within four houses namely Nos. 25, 26, 52 and 53 Barnageeragh Cove on the 15th December 2017 and 14th February 2018. The aim of the study was to ascertain the potential level of specified air contaminants within the headspace air of the houses and to compare with published occupational exposure levels, where applicable.

Additional monitoring was carried out on the 14th February 2018 on the headspace gas in shallow gas monitoring wells GS1 to GS4. In this study Monitoring was performed for a number of compound groups to include:

- Temperature, Relative humidity and Carbon dioxide levels in houses 25, 26, 52 and 53 only;
- Arsenic (Houses 25, 26, 52, 53 and GS1-4);
- Mercury (Houses 25, 26, 52, 53 and GS1-4);
- Trace Landfill gas screen (Houses 25, 26, 52, 53 and GS1-4);
- Formaldehyde and Acetaldehyde (Houses 25, 26, 52, 53 and GS1-4); and
- Methane ground surface screen inside and outside the monitored Houses 25, 26, 52 and 53.

All continuous and active grab sampling techniques were in accordance with international sampling methodologies contained in Section 2 and all grab samples were tested in a UKAS accredited test house (UKAS1549).

It is understood that an historic landfill is located in Barnageeragh Cove, Skerries (see Figures OMI-1 to OMI-3 – Section 6 – Figures 6.1 to 6.3). An extensive site investigation programme was conducted to delineate the boundary of the waste body. This was achieved through trial pit investigation, borehole installation and geophysical surveying. In total 14 deep boreholes (BH1 – BH14) were installed on the periphery or within the landfill body and 4 shallow gas wells (GS01 – GS04) were installed between the residences No. 25 – 34 (i.e. approx. 5m to the front of the houses) and the waste body to the south and southwest (see Figures OMI-2 & OMI-3 - Section 6 – Figures 6.1 to 6.3) (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 3). A programme of landfill gas (LF) and volatile organic carbon (VOC) analysis was carried out by Mulroy Environmental on each of these wells. This involved taking LF gas and VOC readings on 12 occasions from gas wells GS01 – GS04 during both high and low-pressure weather events. Methane (CH4) was not recorded at a concentration above 1% during the monitoring period in these wells. On one occasion CH4 was recorded at a concentration of 0.8% with concentrations of 0.2% or below recorded on all other monitoring events. The results of each of the ground gas monitoring events from gas wells (GS01 – GS04) were assessed for risk according to CIRIA Report C665 'Assessing risks posed by hazardous ground gases in buildings' by S. Wilson, S. Oliver, H. Mallett, H. Hutchings & G. Card. (July 2007). The modified Wilson and Card Classification system detailed in CIRIA665 indicates a 'very low risk classification' for gas wells GS01 – GS04 (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 8).

It understood that VOC readings were taken with a MiniRae 2000 Photo-Ionisation Detector (PID) equipped with a 10.6eV bulb and that VOCs were not monitored during times where heavy rainfall persisted. VOC concentrations taken from 27th June 2017 to the 11th of August 2017 ranged from 0ppm to 6.6ppm. No VOCs were detected during any of the subsequent monitoring rounds. It is understood from the Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 8, that the initial VOC readings were down to phthalates/plasticisers in the newly installed HDPE standpipes (i.e. installed on the 15th June 2017) and that the decrease in VOC concentration to undetectable levels was down principally to natural weathering (i.e. ventilation) (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 8).

The following conclusions were developed for the study. These include:

1. With regards to comfort conditions with finished Houses 25 and 26, temperatures, relative humidity and Carbon dioxide levels were normal for the environment they were monitored within (ASHRAE Standard 62.1-2004).

2. With regards to House 25 – Location 1 and 2, trace concentrations of Benzene, Carbon tetrachloride, Dichloromethane, Styrene, Toluene, Formaldehyde and Acetaldehyde were detected in the headspace of the house. All detected compounds were well within the 8 hr occupational exposure limits for the each of the respective compounds. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Formaldehyde (i.e. fractional exposure limit value 0.0026mg/Nm3) were in excess of the fractional exposure limit value. Concentration values of 0.019 and 0.014 mg/Nm3 were measured. There was a noticeable odour of paints, varnishes and glues in the house. The cumulative factorial value was less than 7.5% of the prescribed limit value. It is recommended that further compound monitoring is performed on this property in order to access whether these concentration levels have dissipated over time given the house has been lived within and background levels of compounds associated with building products should dissipate over time and this information will provide useful indicator of this decay over time.

3. With regards to Houses 52 and 53, trace concentrations of Benzene, Toluene, Carbon tetrachloride, Mercury and Hydrogen sulphide were detected in the headspace of the house. These houses were not finishes and had no windows present and therefore more susceptible to outside influences from compounds in the ambient environment. The concentration levels of these compounds were trace and well with any respective 8 hr occupational exposure limits. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Mercury (i.e. fractional limit value 0.0001 mg/Nm3) were in excess of the fractional exposure limit value. A concentration value of 0.00015 mg/Nm3 was measured on Hse 53 - Location 1. The cumulative factorial value was less than 0.10 and 2.2% of the prescribed limit value, respectively.

4. With regards to House 26 – Location 1 and 2, trace concentrations of 1,2 Dichloroethylene, Benzene, Carbon tetrachloride, Dichloromethane, Dimethyl sulphide, Styrene, Toluene, Formaldehyde and Acetaldehyde were detected in the headspace of the house. All detected compounds were well within the 8 hr occupational exposure limit values for the each of the respective compounds. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Formaldehyde (i.e. fractional exposure limit value 0.0026 mg/Nm3) and Benzene (i.e. fractional exposure limit value 0.030 mg/Nm3) were in excess of the fractional exposure limit values. Concentration values for Benzene and Formaldehyde were measured at 0.078 and 0.105 mg/Nm3 for Location 1 and 0.059 and 0.060 mg/Nm3 for Location 2. There was a weak odour of paints, varnishes and glues in the house. The cumulative factorial value was less than 44% of the prescribed limit value. It is recommended that further compound monitoring is performed on this property in order to access whether these concentration levels have dissipated over time given the house has been lived within and background levels of compounds associated with building products should dissipate over time and this information will provide useful indicator of this decay over time.

5. With regards to Gas well GS1, GS2, GS3 and GS4, trace concentrations of Benzene, Carbon tetrachloride, Toluene and Formaldehyde were detected in the headspace of the well. Benzene and Toluene are ubiquitous in the environment as a result of traffic related sources and therefore these trace amounts can be attributed to this source.

6. As part of Mulroy Environmental's site investigation, a number of soil samples and groundwater samples were taken with VOC analysis conducted. In total 21 groundwater samples were taken across two monitoring rounds from the 11 groundwater monitoring wells on-site. No VOCs were detected within the groundwater above the method detection limit in any of these samples (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 6). Five soil samples were analysed for VOCs. Only two VOCs namely vinyl chloride and -1,2- dichloroethane were detected in one soil sample (i.e. SO-TP21-01) (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 5). It should be noted that this sample was taken from a trial pit located 51m from the nearest residence (i.e. House No.25). Neither of these compounds were detected in the sorbent tubes/thermal desorption/capillary gas chromatography analysis conducted for GS01 – GS04, therefore it is unlikely that they are migrating from the landfill towards the residence (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 12). Carbon tetrachloride is a common constituent of paint and varnishes. It is likely that the concentrations of carbon tetrachloride identified within the 4 gas wells to the west of the residences is as a result of a spillage and/or poor management of solvent based paints during the fit-out phase of construction (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 12). Formaldehyde is a basic constituent of rubber cement products which are used on building sites as either sealants and or glues. Empty rubber cement tubes were observed outside some of the residences during the fit-out phase of construction (see Mulroy Environmental, Environmental Risk Assessment Report, 2018, Section 12).

7. With regards to Total Organic Carbon (TOC) as Methane monitoring utilising FID technique,
    a. House No. 47: the detected levels of TOC as Methane at the Radon barrier sump was 0.053 mg/Nm^3. The external areas outside the house was 0.053 mg/Nm^3. No other areas of the House were checked as there was no access to the internal of the house.
    b. House No. 53: the detected levels of TOC as Methane at the Utility was 2.385 mg/Nm^3, Toilet TOC as Methane level was 3.604 mg/Nm^3, Kitchen TOC as Methane level was 1.484 mg/Nm^3 and Living room TOC as Methane value was 2.756 mg/Nm^3. The Radon barrier sump detected levels was 0.106 mg/Nm^3. Areas screened outside the house were 0.106 mg/Nm^3. House 53 was been painted at the time of the survey.
    c. House No. 52, the detected levels of TOC as Methane in the Utility was 0.106 mg/Nm^3, Toilet TOC as Methane level was 0.106 mg/Nm^3, Kitchen TOC as Methane level was 0.212 mg/Nm^3. The Radon barrier sump was 0 mg/Nm^3. Areas outside the house were 0.053 mg/Nm^3.

1.2 Context to Subsequent Monitoring

Following the submission of the 1st report to Fingal County Council on the 12th June, 2018, it was agreed that it would be beneficial to ascertain the indoor air quality on another house(s) which were recently decorated (i.e. with fresh solvent and acrylic based paints) but which were a significant distance from the landfill. The results obtained from the additional study would be regarded as a 'Control' to compare against those results obtained for the other residences, namely No. 25 and 26 which are the closest residences to the landfill body.

In this respect, Residence No. 47 was chosen to carry out another Indoor Air Monitoring survey on the 27th June, 2018. In order to gather further air quality data, methane readings were also taken of the radon sump for Residence No. 47 on the 14th August, 2018.

Given that previous indoor air quality assessments had been carried out on Residences No. 52 and 53, it was decided to taken internal methane readings and radon gas sump readings for both of these properties. It should be noted that in Residence No. 53 painting was

underway (i.e. open cans of paint in the house during the survey). No paint were observed in Residence No. 52 as the internal decorating for this house had been completed in June, 2018.

1.3 Scope of the works

Odour Monitoring Ireland Ltd was commissioned by Mulroy Environmental Ltd to perform occupational monitoring of air located within one house namely 47, Barnageeragh Cove on the 27th June 2018. The aim of the study was to ascertain the potential level of specified air contaminants within the headspace air of the house and to compare with published occupational exposure levels, where applicable.

Monitoring was performed for a number of compound groups to include:

- Temperature, Relative humidity and Carbon dioxide levels in house 47only;
- Arsenic (House 47);
- Mercury (House 47);
- Trace Landfill gas screen (House 47);
- Formaldehyde and Acetaldehyde (House 47);
- Total organic carbon as Methane monitoring by FID on Hse 47, 52 and 53 Radon sump and external area of house.
- Total organic carbon as Methane monitoring by FID on internal of Hse 52 and 53.

All continuous and active grab sampling techniques were in accordance with international sampling methodologies contained in *Section 2* and all grab samples were tested in a UKAS accredited test house (UKAS1549).

This report presents the materials and methods, results and discussion and conclusions from the study carried out on the monitoring date 27th June 2018.

In addition, the report discusses the significant body of work and conclusions formed by Mulroy Environmental Ltd – see Mulroy Environmental Ltd, Environmental Risk Assessment Report, 2018.

1.4 Project Aims/Objectives

The main aims of the study included:

- Occupational monitoring at two locations located within the house for a range of compounds that could be present in the air stream and comparison with published occupational exposure levels in order to ascertain the level of occupational impact during a normal operation day,
- Monitoring of each location in the house only for Temperature, Relative humidity and Carbon dioxide levels throughout the survey period to provide a tag on conditions within the houses throughout the monitoring.
- Monitoring of TOC as Methane by FID on Radon sump and external on Houses 47, 52 and 53.
- Monitoring of TOC as Methane by FID on Internal of Houses 52 and 53.
- Interpretation of results, where applicable.

2. Materials and methods

This section describes the materials and methods used throughout the survey.

The following standards and documents were used for reference and adhered to where possible:

- Compendium method TO-17-Determination of volatile organic compounds in ambient air using active sampling onto sorbent tubes.
- MDHS 70 – General method for sampling airborne gases and vapours.
- MDHS 72 – Volatile organic compounds in air (1993). Laboratory methods using pumped solid sorbent tubes, thermal desorption and gas chromatography.
- MDHS 96 – Volatile organic compounds in air, Laboratory methods using pumped solid sorbent tubes, solvent desorption and gas chromatography. March 2000.
- NIOSH (NMAM) fourth Edition (1996). Volatile organic compounds (Screening) Method 2549).
- NIOSH 1500 and 1501 for Total and aromatic hydrocarbons sampling and measurement,
- NIOSH 6001 – Arsine.
- NIOSH 6009 – Mercury.
- NIOSH 2539 – Aldehydes screening.
- ISO 16017-1:2000, Indoor, ambient and workplace air. Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography. Part 1: Pumped sampling.

All data generated during the assessment survey was compared to occupational exposure levels and risk categories contained within the publications:

- 2016 Code of practice for Chemical Agents Regulations.

2.1 General description of sampling and analysis techniques

A number of sampling techniques were used to characterise the ambient air at the named locations at house 47. (*see Table 2.1*). Active grab sampling using sorption tubes was performed. Sorption tube sampling and analysis were performed to allow for the characterisation (i.e. both qualitative and semi quantitative) of sampled air for named compound concentrations throughout the sampling event.

In addition, solid fixed state analysers were utilised to perform Temperature, Relative humidity and Carbon dioxide monitoring and analysis at the house.

Table 2.1 provides information on the following items and includes*:*

- Sample location identity key,
- Description of monitoring location,
- Type of monitoring performed,
- Monitoring standards applied where applicable,
- Monitoring details,
- Analysis laboratory details,
- Description of sampling media.

Figure 2.1 presents a graphical plan layout of the monitoring locations located on site.

Table 2.1. Monitoring campaign description for monitoring carried out in Hse. 47, Barnageeragh Cove, Skerries, Dublin on the 29th June 2018.

Monitoring location key	Description of monitoring location and Date	Monitoring performed	Standards applied	Monitoring details	Analysis laboratory	Sampling media
1	Hse 47 – Kitchen (27/06/18)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen.	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549, AG6	Monitored in room headspace	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption
2	Hse 47 – Bedroom (27/06/18)	Arsenic, Mercury, Formaldehyde, Acetaldehyde, Trace landfill gas screen.	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 6001, 6009, 2539, 2549, AG6	Monitored in room headspace	UKAS 1549	Sorbent tube SKC226-119, 226-09, 226-17-1A, Multibed silcosteel dual layer thermal desorption
3	Hse 47, 52 and 53	TOC as Methane monitoring by FID	Adapted EN12619:2013	Monitoring on Radon sump and house external on Hse 47, 52 and 53 and Internal of Hse 52 and 53	OMI	FID

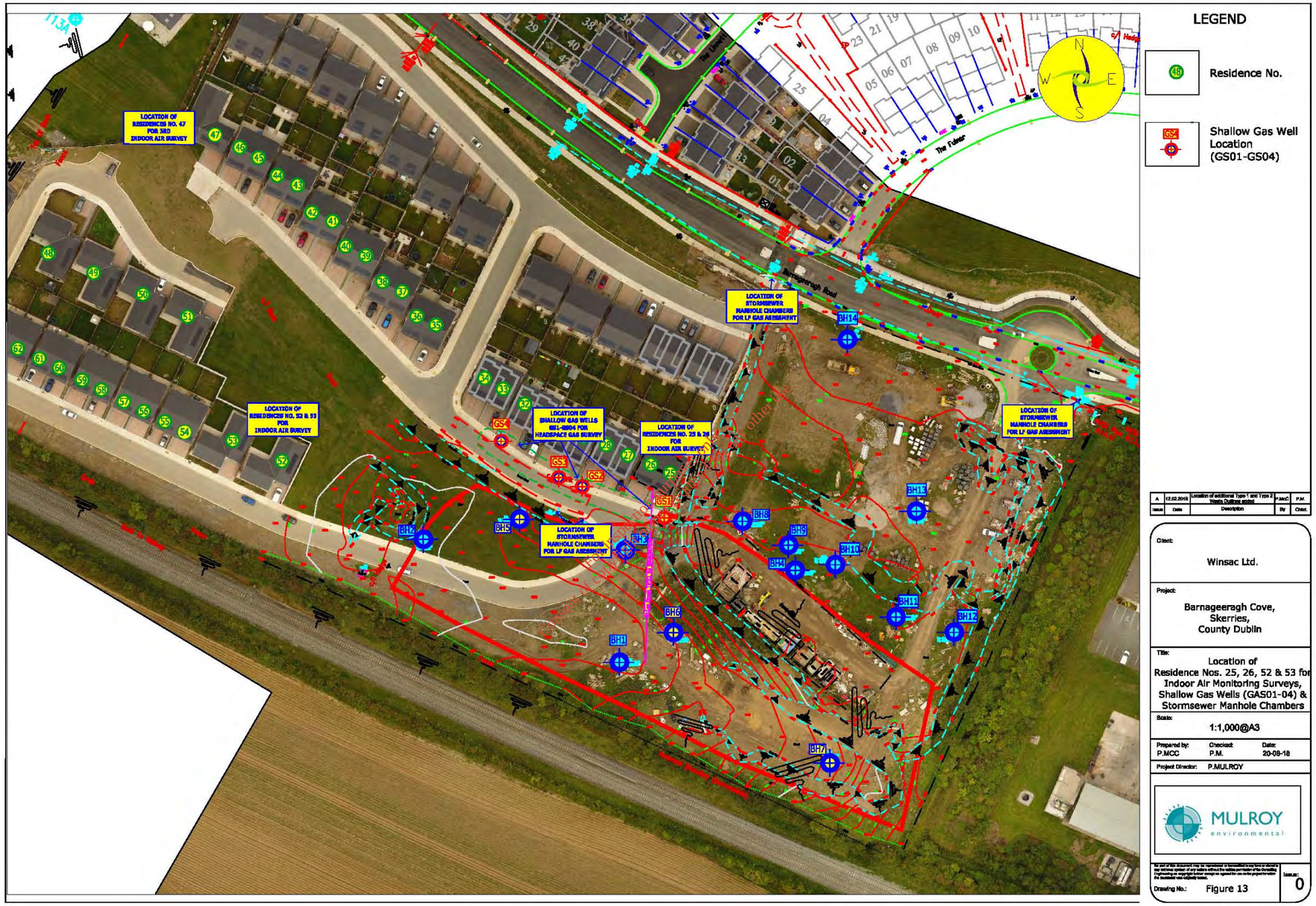

Figure 2.1. Location of House 47 in Barnageeragh Cove, Skerries, Co. Dublin.

2.2 Monitoring for specified compounds in House 47, Barnageeragh Cove, Skerries, Co. Dublin on the 27th June 2018.

The following range of compounds / parameters that were actively monitored using sorbent based media are detailed in *Table 2.1*. An overview of the monitoring standards applied is detailed in *Section 2*. The graphical location of each monitoring location is presented in *Figure 2.1*.

In order to pre-concentrate each compound upon each sorbent, a pre-calibrated controlled volume of sample air was drawn through each tube by a SKC air sampling pump for the monitoring period (Active sampling/pumped sampling). Each SKC pump was pre-calibrated with their specific sorbent using a Bios Primary flow calibrator (UKAS traceable Cert No. N022746).

Each pump was calibrated to an optimal flow rate (of between approx. 200 mls/min depending on sample location and sample type) for sorbent tubes.

When sampling was completed all tubes were sealed and stored in flexible air / light tight containers and transported to the analysing laboratory and analysed by means of thermal desorption / solvent extraction GCMS, GCFID, in a UKAS accredited laboratory (UKAS 1549).

In terms of Temperature, Relative humidity and Carbon dioxide, monitoring was performed utilising a Testo 400 handheld and associated probes.

A number of QA procedures were implemented into the sampling and analysis run to include:

- Front and back sorbent beds were analysed. The back bed was confirmed to be less than 5% of the total sample conc. which is a stated requirement of EN13649:2014.
- All sorbent tubes were sealed and contained in air tight and light proof containers for transport to the laboratory. All samples were stored below 25 deg. C. This is a requirement of EN13649:2014.
- Travel/Sample blanks were incorporated into the measurement sequence. In addition, the laboratory included instrument and method blanks into their measurement sequence.
- Sample volume flow rate and pump calibration was performed before sampling and after sampling and these were recorded in the site data sheets. In addition, it was confirmed that the variation between before and after calibration was less than 1% of the flow range on the day of sampling for all samples taken on the 27th June 2018. The sample flow rate primary flow standard measured flow to an accuracy of 0.001 L/min over the range with a calibration accuracy of less than or equal to 1%.
- Total sample volumes chosen were a combination of analytical techniques lower limit of detection calculations and as specified in standard requirements.

3. Results of the monitoring exercise and discussion

This section provides the results obtained during the survey.

3.1 Temperature, Relative Humidity and Carbon dioxide results

Table 3.1 presents the result for the monitoring of Temperature, Relative humidity and Carbon dioxide monitoring of each location over the sampling event. Average values through the sample events are presented. Temperature, relative humidity and carbon dioxide values were measured at the start and end of monitoring. Monitoring was carried out between the hours of 09.30AM and 15.00PM on the 27th June 2018. The average values are reported for clarity.

As can be observed in *Table 3.1*, the average temperature in House 47 was 26 Deg C. The average relative humidity and CO_2 concentration were 59% and 840 ppm, respectively.

Table 3.1. Temperature, Relative humidity and Carbon dioxide monitoring results of the house monitoring location over the sampling events.

Monitoring location area	Temperature (Deg C)	Relative humidity (%)	CO_2 conc. (ppm)
Hse 47 - 1 and 2	26	59	840

3.2 Gas analysis results

Tables 3.2 and 3.3 present the result of the monitoring at each sampling location throughout the sampling period carried out on the 27th June 2018.

As can be observed from the analysis results across the sampling locations in the property (Hse 47), all results were compliant with the published 8 hr OEL value, where applicable. In terms of the measured concentration, all measured values were well within the published 8 hr OEL where applicable. This is also published within each table (*see Tables 3.2 and 3.3*). Cumulative OEL risk was assessed for the speciated VOC's detected. The cumulative assessment value was within the stated limit value of 1.0 for cumulative VOC's (see 2011 Code of practice for the Safety, Health and Welfare at work (Chemical Agents) Regulations 2001 (SI No. 619 of 2001) & updated COP 2016) *see tables 3.2 and 3.3*.

In addition to screening the 8 hr OEL limit value and given the fact that properties could be occupied for periods in excess of 8 hr / day 5 days per week up to period of 24hrs / days and 7 days per week, fractional exposure limit values were compared to the recorded concentrations. In terms of overall results, Formaldehyde was in excess of the fractional exposure limit value at House 47 Location 1 and 2. Mercury was in excess of the fractional exposure limit value at House 47 Location 1 and 2. Therefore considering the compounds and the fact that the houses were newly built, it is recommended that repeat monitoring be completed to examine whether compound concentrations have dissipated with time of occupancy within the houses.

With regards to House 47 – Location 1 and 2, trace concentrations of Benzene, Chloroethane, Styrene, Toluene, Mercury, Formaldehyde and Acetaldehyde were detected in the headspace of the house. All detected compounds were well within the 8 hr occupational exposure limits for the each of the respective compounds. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Formaldehyde (i.e. fractional exposure limit value 0.0026 mg/Nm^3) were in excess of the fractional exposure limit value. Concentration values of 0.023 and 0.017 mg/Nm^3 were measured.

With regards to Total Organic Carbon (TOC) as Methane monitoring utilising FID technique, the following was determined:

House No. 47: the detected levels of TOC as Methane at the Radon barrier sump was 0.053 mg/Nm^3. The external areas outside the house was 0.053 mg/Nm^3. No other areas of the House were checked as there was no access to the internal of the house.

House No. 53: the detected levels of TOC as Methane at the Utility was 2.385 mg/Nm^3, Toilet TOC as Methane level was 3.604 mg/Nm^3, Kitchen TOC as Methane level was 1.484 mg/Nm^3 and Living room TOC as Methane value was 2.756 mg/Nm^3. The Radon barrier sump detected levels was 0.106 mg/Nm^3. Areas screened outside the house were 0.106 mg/Nm^3. House 53 was been painted at the time of the survey.

House No. 52, the detected levels of TOC as Methane in the Utility was 0.106 mg/Nm^3, Toilet TOC as Methane level was 0.106 mg/Nm^3, Kitchen TOC as Methane level was 0.212 mg/Nm^3. The Radon barrier sump was 0 mg/Nm^3. Areas outside the house were 0.053 mg/Nm^3.

All results are tabulated in *Table 3.3*.

3.2.1 House 47 Monitoring results

Table 3.2. Results from monitoring of House 47 – Location 1

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	8 hr OEL value (mg/Nm^3)	15 min OEL value (mg/Nm^3)	Environmental Assessment Levels (EAL's) – Long term (mg/m^3)	Examination of additive / cumulative effects	Limit value for cumulative effect	Other risk factors
1	1106260 – trace landfill gas screen	09.42 – 14:20 – 278 min 27/06/18	1-Pentene	<10	0.04925	<0.00019	-	-	-	0.1	1.0	-
			1,1 Di chloroethane	<10	0.04925	<0.00019	268	-	2.68			IOELV
			1,1-Dichloroethylene	<10	0.04925	<0.00019	20	-	0.2			-
			1,2-Dichloroethane	<10	0.04925	<0.00019	412	-	4.12			Sk, IOELV
			1,2-Dichloroethylene	<30	0.04925	<0.00056	20		0.2			-
			1,3-Butadiene	<10	0.04925	<0.00019	-	-	-			-
			1,4 epoxy 1,3-butadiene	<10	0.04925	<0.00019	-	-	-			-
			1-Propanethiol	<10	0.04925	<0.00019	-	-	-			-
			2-butoxyethanol	<10	0.04925	<0.00019	8	246	0.08			Sk , IOELV
			Benzene	**21**	0.04925	**0.00039**	3.0	-	0.03			BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.04925	<0.00019		-	-			-
			Carbon disulphide	<10	0.04925	<0.00019	15	-	0.15			Sk, IOELV
			Carbon tetrachloride	<10	0.04925	<0.00019	12.6	-	0.126			Sk
			Chloroethane	**44**	0.04925	**0.00082**	268	-	2.68			IOELV
			Dichloromethane	<10	0.04925	<0.00019	174	-	1.74			-
			Dimethyl disulphide	<10	0.04925	<0.00019	1.90	-	0.019			-
			Dimethyl sulphide	<10	0.04925	<0.00019	55.47	-	0.5547			-
			Ethyl butyrate	<25	0.04925	<0.00047	-	-	-			-
			Ethyl Mercaptan	<10	0.04925	<0.00019	1	3	0.01			-
			Hydrogen sulphide	<60	0.04925	<0.0011	7	14	0.07			IOELV
			Methyl Mercaptan	<30	0.04925	<0.00056	1	-	0.01			-
			N-Butyl Mercaptan	<10	0.04925	<0.00019	1.8	-	0.018			-
			Styrene	**160**	0.04925	**0.0030**	85	170	0.85			-
			Toluene	**720**	0.04925	**0.013**	192	384	1.92			Sk, IOELV
			Trichloroethylene	<10	0.04925	<0.00019	58.66	146.65	0.5866			Sk, Carc.1B
			Vinyl chloride monomer	<10	0.04925	<0.00019	7.77	-	0.0777			Carc.1A, BOELV
1	7422700099		Formaldehyde	**2800**	0.11305	**0.023**	0.26	0.53	0.0026			Carc.1B, Sens.
			Acetaldehyde	**900**	0.11305	**0.0073**	45	45	0.45			-
1	7221505172		Arsenic	<1000	0.11755	<0.008	0.01	-	0.0001			Carc.1A
1	7611800867		Mercury	**15**	0.09445	**0.00014**	0.01	0.03	0.0001			Sk

Table 3.3. Results from monitoring of House 47 – Location 2

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	8 hr OEL value (mg/Nm^3)	15 min OEL value (mg/Nm^3)	Environmental Assessment Levels (EAL's) – Long term (mg/m^3)	Examination of additive / cumulative effects	Limit value for cumulative effect	Other risk factors
2	1025594 – trace landfill gas screen	09.48 – 13:49 – 241 min 27/06/18	1-Pentene	<10	0.06057	<0.00015	-	-	-	0.08	1.0	-
			1,1 Di chloroethane	<10	0.06057	<0.00015	268	-	2.68			IOELV
			1,1-Dichloroethylene	<10	0.06057	<0.00015	20	-	0.2			-
			1,2-Dichloroethane	<10	0.06057	<0.00015	412	-	4.12			Sk, IOELV
			1,2-Dichloroethylene	<30	0.06057	<0.00046	20		0.2			-
			1,3-Butadiene	<10	0.06057	<0.00015	-	-	-			-
			1,4 epoxy 1,3-butadiene	<10	0.06057	<0.00015	-	-	-			-
			1-Propanethiol	<10	0.06057	<0.00015	-	-	-			-
			2-butoxyethanol	<10	0.06057	<0.00015	8	246	0.08			Sk , IOELV
			Benzene	**14**	0.06057	**0.00021**	3.0	-	0.03			BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.06057	<0.00015	-	-	-			-
			Carbon disulphide	<10	0.06057	<0.00015	15	-	0.15			Sk, IOELV
			Carbon tetrachloride	<10	0.06057	0.00015	12.6	-	0.126			Sk
			Chloroethane	**38**	0.06057	**0.00058**	268	-	2.68			IOELV
			Dichloromethane	<10	0.06057	<0.00015	174	-	1.74			-
			Dimethyl disulphide	<10	0.06057	<0.00015	1.90	-	0.019			-
			Dimethyl sulphide	<10	0.06057	<0.00015	55.47	-	0.554			-
			Ethyl butyrate	<25	0.06057	<0.00038	-	-	-			-
			Ethyl Mercaptan	<10	0.06057	<0.00015	1	3	0.01			-
			Hydrogen sulphide	<60	0.06057	<0.00091	7	14	0.07			IOELV
			Methyl Mercaptan	<30	0.06057	<0.00046	1	-	0.01			-
			N-Butyl Mercaptan	<10	0.06057	<0.00015	1.8	-	0.018			-
			Styrene	**170**	0.06057	**0.0026**	85	170	0.85			-
			Toluene	**370**	0.06057	**0.0056**	192	384	1.92			Sk, IOELV
			Trichloroethylene	<10	0.06057	<0.00015	58.66	146.65	0.586			Sk, Carc.1B
			Vinyl chloride monomer	<10	0.06057	<0.00015	7.77	-	0.077			Carc.1A, BOELV
2	7422700092		Formaldehyde	**1800**	0.09470	**0.017**	0.26	0.53	0.002			Carc.1B, Sens.
			Acetaldehyde	**700**	0.09470	**0.0068**	45	45	0.45			-
2	7221505506		Arsenic	<1000	0.11791	<0.008	0.01	-	0.0001			Carc.1A
2	7611800094		Mercury	**23**	0.11793	**0.00018**	0.01	0.03	0.0001			Sk

Table 3.4. Results from TOC as Methane monitoring of House 47, 52 and 53

Monitoring location identity	Sample ID	Sample duration and times	Specific location	Compound identity	Compound conc. (mg/Nm^3)
3	Hse 47	14/08/2018 15.10PM to 15.14PM	Radon sump	Total Organic Carbon (TOC) as Methane	0.053
			House external	Total Organic Carbon (TOC) as Methane	0.053
	Hse 53	14/10/2018 15.38PM to 15.48PM	Utility	Total Organic Carbon (TOC) as Methane	2.385
			Toilet	Total Organic Carbon (TOC) as Methane	3.604
			Kitchen	Total Organic Carbon (TOC) as Methane	1.484
			Living room	Total Organic Carbon (TOC) as Methane	2.756
			Radon sump	Total Organic Carbon (TOC) as Methane	0.106
			House external	Total Organic Carbon (TOC) as Methane	0.106
	Hse 52	14/10/2018 16.00PM to 16.12PM	Utility	Total Organic Carbon (TOC) as Methane	0.106
			Toilet	Total Organic Carbon (TOC) as Methane	0.106
			Kitchen	Total Organic Carbon (TOC) as Methane	0.212
			Radon sump	Total Organic Carbon (TOC) as Methane	0
			House External	Total Organic Carbon (TOC) as Methane	0.053

4. Conclusions

The following conclusions are drawn for the study:

1. With regards to comfort conditions with finished House 47, temperature, relative humidity and Carbon dioxide levels were normal for the environment they were monitored within (ASHRAE Standard 62.1-2004).

2. With regards to House 47 – Location 1 and 2, trace concentrations of Benzene, Chloroethane, Styrene, Toluene, Mercury, Formaldehyde and Acetaldehyde were detected in the headspace of the house. All detected compounds were well within the 8 hr occupational exposure limits for the each of the respective compounds. When compound concentrations were compared to fractional exposure limit values (i.e. to represent 24 hr exposure), the detected concentration levels of Formaldehyde (i.e. fractional exposure limit value 0.0026 mg/Nm^3) were in excess of the fractional exposure limit value. Concentration values of 0.023 and 0.017 mg/Nm^3 were measured. Therefore, considering the compounds and the fact that the houses were newly built, it is possible that compounds maybe present as a result of the building materials used within the house. Adequate venting of the house over a period of time should alleviate such compounds if present from building materials and the reduction of the levels of such compounds can be verified following a period of time.

3. With regards to Total Organic Carbon (TOC) as Methane monitoring utilising FID technique,
    a. House No. 47: the detected levels of TOC as Methane at the Radon barrier sump was 0.053 mg/Nm^3. The external areas outside the house was 0.053 mg/Nm^3. No other areas of the House were checked as there was no access to the internal of the house.
    b. House No. 53: the detected levels of TOC as Methane at the Utility was 2.385 mg/Nm^3, Toilet TOC as Methane level was 3.604 mg/Nm^3, Kitchen TOC as Methane level was 1.484 mg/Nm^3 and Living room TOC as Methane value was 2.756 mg/Nm^3. The Radon barrier sump detected levels was 0.106 mg/Nm^3. Areas screened outside the house were 0.106 mg/Nm^3. House 53 was been painted at the time of the survey.
    c. House No. 52, the detected levels of TOC as Methane in the Utility was 0.106 mg/Nm^3, Toilet TOC as Methane level was 0.106 mg/Nm^3, Kitchen TOC as Methane level was 0.212 mg/Nm^3. The Radon barrier sump was 0 mg/Nm^3. Areas outside the house were 0.053 mg/Nm^3.

5. References

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12. Mulroy Environmental Ltd., (2018), Environmental Risk Assessment Report.
13. NIOSH (NMAM) fourth Edition (1996). Volatile organic compounds (Screening) Method 2549).
14. NIOSH 1500 and 1501 for Total and aromatic hydrocarbons sampling and measurement,
15. NIOSH 2539 – Aldehydes screening.
16. NIOSH 6001 – Arsine.
17. NIOSH 6009 – Mercury.

6. *Appendix I* – Site location map of site boundary and monitoring locations

Reference purposes only.

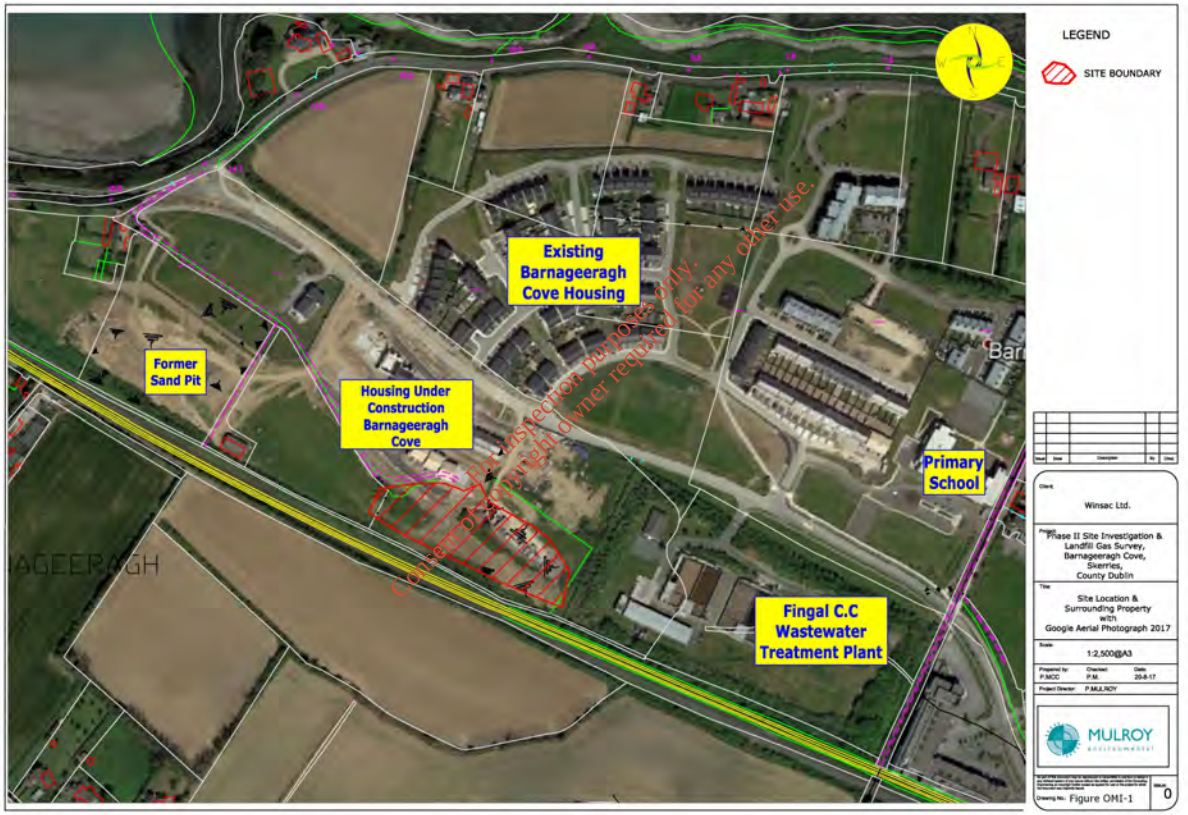

Figure 6.1. Facility layout map showing the location of the development.

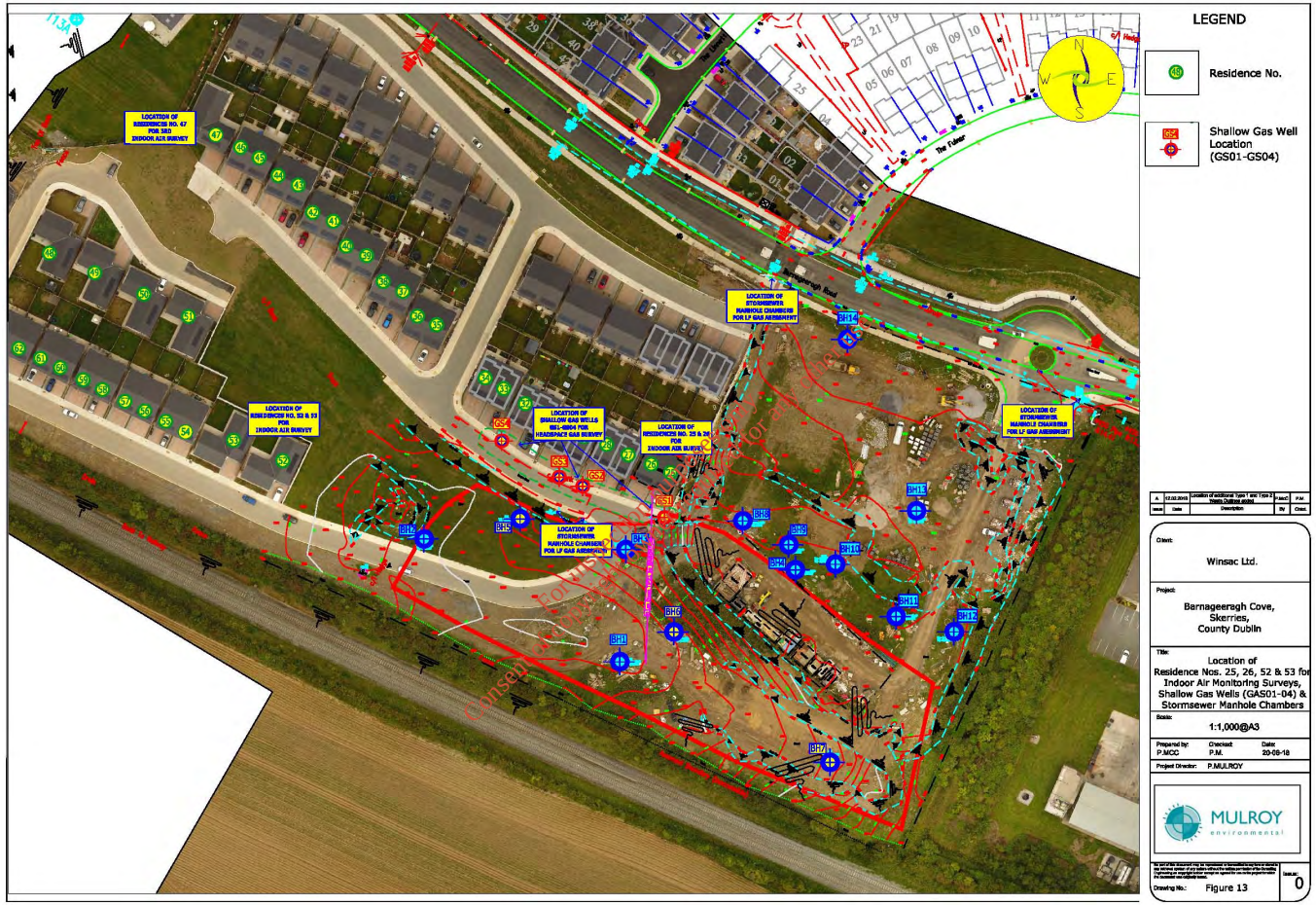

Figure 6.2. Facility layout map showing the location Hse 47.

7. *Appendix II* – Pictures of sampling system and locations

Reference purposes only.

Figure 7.1. Location of monitoring in Hse 47, Bedroom

Figure 7.2. Location of monitoring in Hse 47, Kitchen

8. *Appendix III* – Fractional exposure limits.

For many substances which are released to air, Environmental Quality Standards have not been defined. Where the necessary criteria are absent then Regulators in general have adopted interim values known as Environmental Assessment Levels (EALs). The EAL is the concentration of a substance which in a particular environmental medium the Regulators regard as a comparator value to enable a comparison to be made between the environmental effects of different substances in that medium and between environmental effects in different media and to enable the summation of those effects.

Ideally EALs to fulfil this objective would be defined for each pollutant:

- based on the sensitivity of particular habitats or receptors (in particular three main types of receptor should be considered, protection of human health, protection of natural ecosystems and protection of specific sensitive receptors, e.g. materials, commercial activities requiring a particular environmental quality;
- be produced according to a standardised protocol to ensure that they are consistent, reproducible and readily understood;
- provide similar measure of protection for different receptors both within and between media;
- take account of habitat specific environmental factors such as pH, nutrient status, bioaccumulation, transfer and transformation processes where necessary.

A suite of EALs derived in this consistent manner is not currently available; therefore, interim values based on published information have been adopted.

Ideally EALs for those substances where there are no existing criteria would be derived direct from toxicological data on the effects of the pollutant on a particular receptor. However, an assessment of this type would be a very substantial undertaking which could only be considered over an extended timescale. One approach to overcoming this problem is to make use of occupational exposure limits which provide an assessment for a specific receptor (i.e. adult human workforce) of the toxicological effects of a pollutant. These values might then be progressively revised as further information and resources allow. Indeed a similar approach to this was followed by the then Factory Inspectorate in 1968 when a large number of occupational standards were adopted from the American Conference of Governmental Industrial Hygienists (HMSO 1968) which have since been progressively revised by the Health and Safety Executive on the basis of new information and UK experience.

Occupational exposure limits are intended to set a level of exposure based on 8 hours per day, 5 days per week during a normal employment lifetime below which adverse effects are unlikely to arise for the majority of the working population who may be exposed. Occupational limit values may be derived from either actual data on workers or animal toxicity data; in addition, factors such as the ability to achieve or measure the proposed limit may also be taken into consideration. Consequently, the precise basis on which limit values have been set is difficult to determine and a cautious approach needs to be taken in deriving EALs from occupational exposure limits.

In deriving EALs for long-term exposure from occupational limits two factors need to be taken into consideration, the duration of exposure of the general population compared with the workforce and the sensitivity of the group at risk. The weekly exposure of the local population could be up to 168 hours per week (7*24 hrs) rather than the 40 hours (5*8 hrs) which might be expected for the workforce. Moreover, exposure for the general population may extend to 52 weeks compared with an average working year of 44 weeks. On this basis the minimum safety factor would be 4.96 (i.e. (168/40 * 52/44). In addition, since there may be no recovery period between exposure sessions and exposure could be for a lifetime a further safety factor of 2 could be introduced giving a total safety factor of 10.

It might also be expected that the general population will contain more sensitive individuals, for example, children, the elderly or those with diseases such as asthma, than workers who are typically between the ages of 16 and 65. In the absence of other information a factor of 10 is normally used to allow for differences between the population mean and the response of

sensitive individuals (WHO 1994). This is likely to be conservative since, in setting occupational limit values, some allowance will have been made for variation in the sensitivity of the workforce to the pollutant concerned. Combining the safety factors for exposure and sensitivity of the general population gives a long-term air quality standard of 1/100th of the 8-hour occupational exposure limit.

In the UK the Health and Safety Executive distinguish two types of long term occupational exposure limits, occupational exposure standards (OESs) and maximum exposure limits (MELs). MELs are set for chemicals where there is particular concern, for example carcinogens, or doubt over the actual no effect level and for occupational health purposes it is an offence to exceed a MEL. Within the workplace this leads to an emphasis on reducing average levels of exposure of the chemical to ensure that the MEL is not exceeded. In practice this leads to an additional safety margin of up to 5 for chemicals which have MELs over those which have OES values. Effectively, therefore, an additional safety factor of up to 5 is achieved in the workplace by setting an MEL and this factor has been incorporated in determining an EAL for those chemicals listed as having an MEL in HSE Guidance Note EH40/2001 (ref 19). For example a safety factor of 500 (10*10*5) is used to set the long term EAL for such substances.

Where no short-term environmental criteria have been identified in the literature a similar approach to their derivation from occupational exposure limits can be adapted to that described above for long-term EALs. However, in this instance it would be more appropriate to calculate values based on the short-term exposure limits (STELs) set by HSE. Where STELs are not listed then a value of 3 times the 8 hour time weighted average occupational exposure limit may be used.

Since STELs are by definition appropriate for consideration of short-term impacts there is no need for additional safety factors relating to the duration of exposure as suggested for the derivation of long term EALs. Moreover, as STELs already incorporate a limited safety margin for variation in the sensitivity of the workforce an additional factor of 10 is likely to be adequate to account for the increased sensitivity of the general population (ref 20). However, since many atmospheric dispersion models are only able to produce estimates for time averaging periods in the order of 1 hour it would be convenient for the short term EALS also to be expressed on this basis. Typically ratios between concentrations measured over a 15 minute averaging period and those taken over an hour may be between 1.3 - 2.3. Given this relatively small range and the likely over estimate of the safety factor representing variation in human sensitivity it is proposed to adopt a value of 1/10th of the STEL as the short-term EAL.

Where the substance attracts a maximum exposure limit value then an additional safety factor of 5 can be included on a similar basis to that described for the derivation of long term EALS.

It is recognised that the derived safety factors have been derived largely on the basis of experience and that for some substances the “true” EAL derived from a more fundamental study of the toxicological data may be very different. EALs derived in this manner need therefore to be treated with caution and where necessary further work undertaken to assess the implication of any actual or potential breaches. However, some comfort in the use of these safety factors may be gained from the fact that they have been applied in many permits in the past and therefore have been subjected to considerable public scrutiny (Environment Agency, H1 – Part 2 080328).

9. *Appendix IV* – Laboratory test results.

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Concept Life Sciences

Certificate of Analysis

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Report Number: 750595-1

Date of Report: 24-Jul-2018

Customer: Air Scientific
Unit 32 Degranville Court
Dublin Road
Trim
Co. Meath
Ireland.

Customer Contact: Project Management

Customer Job Reference: BAN47270618
Customer Site Reference: Barnageerogh Cove
Date Job Received at Concept: 09-Jul-2018
Date Analysis Started: 13-Jul-2018
Date Analysis Completed: 24-Jul-2018

The results reported relate to samples received in the laboratory and may not be representative of a whole batch.

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

This report should not be reproduced except in full without the written approval of the laboratory

Tests covered by this certificate were conducted in accordance with Concept Life Sciences SOPs

All results have been reviewed in accordance with Section 25 of the Concept Life Sciences, Analytical Services Quality Manual

UKAS TESTING
1549

Report checked and authorised by :
Lauren Clarke
Customer Service Advisor

Issued by :
Lauren Clarke
Customer Service Advisor

Concept Reference: 750595
Project Site: Barnageerogh Cove
Customer Reference: BAN47270618

Tube XAD Piperidine (226-118) Analysed as Tube XAD Piperidine (226-118)
Subcontracted anlaysis

				Concept Reference	**750595 002**	**750595 006**	**750595 011**
				Customer Sample Reference	**7422700099**	**7422700092**	**7422700097**
				Test Sample	**AR**	**AR**	**AR**
				Volume l	**122.848**	**102.907**	
				Date Sampled	**27-JUN-2018**	**27-JUN-2018**	**27-JUN-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**			
Acetaldehyde	GC/FID (Sub)	0.1	µg	SN	**0.9**	**0.7**	<0.1
	Calc	Calc	mg/m3	N	**0.0073**	**0.0068**	
	Calc	Calc	ppm	N	**0.0041**	**0.0038**	
Formaldehyde	GC/FID (Sub)	0.1	µg	SU	**2.8**	**1.8**	**0.1**
	Calc	Calc	mg/m3	N	**0.023**	**0.017**	
	Calc	Calc	ppm	N	**0.019**	**0.014**	

Concept Reference: 750595
Project Site: Barnageerogh Cove
Customer Reference: BAN47270618

Tube Anasorb C300 (226-17-1A) Analysed as Tube Anasorb C300 (226-17-1A)
Mercury

				Concept Reference	**750595 004**	**750595 008**	**750595 012**
				Customer Sample Reference	**7611800867**	**7611800094**	**7611801065**
				Test Sample	**AR**	**AR**	**AR**
				Volume l	**102.6376**	**128.1498**	
				Date Sampled	**27-JUN-2018**	**27-JUN-2018**	**27-JUN-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**			
Mercury	CVAFS	5	ng	U	[13] **15**	[13] **23**	[13] <5
	Calc	Calc	mg/m3	N	**0.00014**	**0.00018**	
	Calc	Calc	ppm	N	**0.000018**	**0.000022**	

Concept Reference: 750595
Project Site: Barnageerogh Cove
Customer Reference: BAN47270618

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Arsenic

				Concept Reference	**750595 003**	**750595 007**	**750595 010**
				Customer Sample Reference	**7221505172**	**7221505506**	**7221411361**
				Test Sample	**AR**	**AR**	**AR**
				Volume l	**127.741**	**128.1224**	
				Date Sampled	**27-JUN-2018**	**27-JUN-2018**	**27-JUN-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**			
Arsenic	ICP/OES	1	µg	U	<1	<1	<1
	Calc	Calc	mg/m3	N	<0.008	<0.008	
	Calc	Calc	ppm	N	<0.0026	<0.0025	

Concept Reference: 750595
Project Site: Barnageerogh Cove
Customer Reference: BAN47270618

Tube (Tenax/Carbon/Molecular Sieve) Analysed as Tube (Tenax/Carbon/Molecular Sieve)

Trace Landfill Gas Suite

				Concept Reference	**750595 001**	**750595 005**	**750595 009**
				Customer Sample Reference	**1106260**	**1025594**	**MI 110728**
				Test Sample	**AR**	**AR**	**AR**
				Volume l	**53.515**	**65.8171**	
				Date Sampled	**27-JUN-2018**	**27-JUN-2018**	**27-JUN-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**			
1 Pentene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000065	<0.000053	
1,1-Dichloroethane	GC/MS (TD SIR)	10	ng	U	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000046	<0.000038	
1,1-Dichloroethylene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000047	<0.000038	
1,2-Dichloroethane	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000046	<0.000038	
1,2-Dichloroethylene	GC/MS (TD SIR)	30	ng	U	<30	<30	<30
	Calc	Calc	mg/m3	N	<0.00056	<0.00046	
	Calc	Calc	ppm	N	<0.00014	<0.00011	
1,3-Butadiene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000084	<0.000069	
1,4 epoxy 1,3-butadiene	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000067	<0.000055	
1-Propanethiol	GC/MS (TD SIR)	10	ng	U	(68) <10	(68) <10	(68) <10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000060	<0.000049	
2-butoxyethanol	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000039	<0.000031	
Benzene	GC/MS (TD SIR)	10	ng	U	**21**	**14**	<10
	Calc	Calc	mg/m3	N	**0.00039**	**0.00021**	
	Calc	Calc	ppm	N	**0.00012**	**0.000067**	
Butyric acid	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000052	<0.000042	
Carbon disulphide	GC/MS (TD SIR)	10	ng	N	(13) <10	(13) <10	(13) <10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000060	<0.000049	
Carbon tetrachloride	GC/MS (TD SIR)	10	ng	U	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000030	<0.000024	
Chloroethane	GC/MS (TD SIR)	30	ng	N	**44**	**38**	<30
	Calc	Calc	mg/m3	N	**0.00082**	**0.00058**	
	Calc	Calc	ppm	N	**0.00031**	**0.00022**	
Dichloromethane	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000054	<0.000044	
Dimethyl disulphide	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000049	<0.000039	
Dimethyl sulphide	GC/MS (TD SIR)	10	ng	U	(68) <10	(68) <10	(68) <10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000074	<0.000060	
Ethyl butyrate	GC/MS (TD SIR)	25	ng	N	<25	<25	<25
	Calc	Calc	mg/m3	N	<0.00047	<0.00038	
	Calc	Calc	ppm	N	<0.000098	<0.000080	
Ethyl Mercaptan	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000074	<0.000060	

Concept Reference: 750595
Project Site: Barnageerogh Cove
Customer Reference: BAN47270618

Tube (Tenax/Carbon/Molecular Sieve) Analysed as Tube (Tenax/Carbon/Molecular Sieve)

Trace Landfill Gas Suite

				Concept Reference	**750595 001**	**750595 005**	**750595 009**
				Customer Sample Reference	**1106260**	**1025594**	**MI 110728**
				Test Sample	**AR**	**AR**	**AR**
				Volume l	**53.515**	**65.8171**	
				Date Sampled	**27-JUN-2018**	**27-JUN-2018**	**27-JUN-2018**
Determinand	**Method**	**LOD**	**Units**	**Symbol**			
Hydrogen sulphide	GC/MS (TD SIR)	60	ng	N	<60	<60	<60
	Calc	Calc	mg/m3	N	<0.0011	<0.00091	
	Calc	Calc	ppm	N	<0.00080	<0.00065	
Methyl Mercaptan	GC/MS (TD SIR)	30	ng	N	<30	<30	<30
	Calc	Calc	mg/m3	N	<0.00056	<0.00046	
	Calc	Calc	ppm	N	<0.00028	<0.00023	
N-Butyl Mercaptan	GC/MS (TD SIR)	10	ng	U	(68) <10	(68) <10	(68) <10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000051	<0.000041	
Styrene	GC/MS (TD SIR)	10	ng	N	**160**	**170**	<10
	Calc	Calc	mg/m3	N	**0.0030**	**0.0026**	
	Calc	Calc	ppm	N	**0.00070**	**0.00061**	
Toluene	GC/MS (TD SIR)	10	ng	N	**720**	**370**	(13) <10
	Calc	Calc	mg/m3	N	**0.013**	**0.0056**	
	Calc	Calc	ppm	N	**0.0036**	**0.0015**	
Trichloroethylene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000035	<0.000028	
Vinyl chloride monomer	GC/MS (TD SIR)	10	ng	U	(68) <10	(68) <10	(68) <10
	Calc	Calc	mg/m3	N	<0.00019	<0.00015	
	Calc	Calc	ppm	N	<0.000073	<0.000059	

Index to symbols used in 750595-1

Value	Description
AR	As Received
13	Results have been blank corrected.
68	Outside scope of UKAS accreditation
S	Analysis was subcontracted
U	Analysis is UKAS accredited
N	Analysis is not UKAS accredited
C	Calculation

MULROY ENVIRONMENTAL TEST REPORT TO EXAMINE IF VOLATILE ORGANIC COMPOUNDS (VOCs) ARE BEING EMITTED FROM THE WATER MAINS FROST PROTECTION PLUG USED IN HAMILTON PLACE, BARNAGEERAGH COVE, SKERRIES, COUNTY DUBLIN

TEST – TO EXAMINE IF VOLATILE ORGANIC COMPOUNDS (VOCs) ARE BEING EMITTED FROM THE WATER MAINS FROST PROTECTION PLUG USED IN HAMILTON PLACE, BARNAGEERAGH COVE, SKERRIES, COUNTY DUBLIN

Plate 1: Water main meter box viewed from above

Plate 2: Water main meter box with black HDPE circular cap removed

Plate 3: Water main meter box with black HDPE circular cap removed and frost protection plug removed (see to left)

Plate 4: Closer view of water main meter without frost protection plug

TEST – TO EXAMINE IF VOLATILE ORGANIC COMPOUNDS ARE BEING EMITTED FROM WATER MAINS FROST PROTECTION PLUG

Procedure:

1) On the 26th November, the frost protection plug was removed from the water meter box at the front of Residence No. 26 and tested for VOCs within 24 hours.
2) MiniRae2000 Photoionization Detector (PID) was turned on and zeroed out.
3) An empty plastic 'food grade' zip lock bag was opened up with some fresh air introduced and re-zipped and allowed to equilibrate for 15 minutes. Following this it was tested for background VOCs using the MiniRae2000 Photoionization Detector (PID). No VOCs were detected (please see Plate 5 below).

Plate 5: Headspace reading of empty zip lock bag (i.e. Control)

4) The frost protection plug was placed into the same ziploc bag, the ziploc bag was sealed and alowed to equilibrate for 15 minutes. Following this, the headspace within the ziploc bag was tested for VOCs. The instrument showed a steady reading of 20.4ppm VOC reading (please see plate 6 following).

It should be noted that prior to examination, the frost protection plug was examined for odours. It was observed that it was wet from exposure to moisture within the manhole chamber and gave off a plastic/solvent type odour.

Plate 6: Headspace reading of zip lock bag with frost protection plug tested after the frost protection plug

This procedure was repeated on a further 3 occasions and on each occasion, a headspace VOC reading of in excess of 20ppm was obtained. Prior to each reading, the PID was removed from the zip lock back and allowed to 'zero' for up to 5 minutes.

GAS ANALYSIS OF HEADSPACE AIR WITHIN GAS SAMPLING BAG CONTAINING FROST PROTECTION CAPS FROM HOUSE 26 & 52, BARNAGEERAGH COVE, SKERRIES, COUNTY DUBLIN31ST

JANUARY 2019, REPORT NUMBER: 2019035 (1)

MULROY environmental

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GAS ANALYSIS OF HEADSPACE AIR WITHIN GAS SAMPLING BAG CONTAINING FROST PROTECTION CAP FROM HOUSE 26 AND 52 BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN.

PERFORMED BY ODOUR MONITORING IRELAND ON THE BEHALF OF MULROY ENVIRONMENTAL LTD.

REPORT PREPARED BY:	Dr. Brian Sheridan
REPORT VERSION:	Document Ver.1
ATTENTION:	Mr. Padraic Mulroy
DATE:	31st Jan 2019 Rev 1
REPORT NUMBER:	2019035(1)
REVIEWERS:	

TABLE OF CONTENTS

DOCUMENT AMENDMENT RECORD

Client: ***Mulroy Environmental Ltd***

Project: **GAS ANALYSIS OF HEADSPACE AIR WITHIN GAS SAMPLING BAG CONTAINING FROST PROTECTION CAP FROM HOUSE 26 AND 52 BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN.**

Project Number: 2019035(1)		**DOCUMENT REFERENCE: GAS ANALYSIS OF HEADSPACE AIR WITHIN GAS SAMPLING BAG CONTAINING FROST PROTECTION CAP FROM HOUSE 26 AND 52 BARNAGEERAGH COVE, SKERRIES, CO. DUBLIN.**			
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Revision	**Purpose/Description**	**Originated**	**Checked**	**Authorised**	**Date**

This document is submitted as part of an investigative study of the emissions from two frost protection caps. The frost protection caps were delivered to OMI Ltd in zip lok bags.

Respectively submitted,

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For and on behalf of Odour Monitoring Ireland™

Executive Summary

Odour Monitoring Ireland Ltd was commissioned by Mulroy Environmental Ltd to perform headspace gas analysis of two frost protection caps taken from outside House 26 and 52, Barnageeragh Cove, Skerries, Co. Dublin). The frost caps were delivered to OMI Ltd premises on the 09th Jan 2019. The frost caps were remove from their zip lok transport sample bags and placed inside Nalophan gas sampling bags. These were then filled with 6.0 Grade Nitrogen and allowed to sit within this sealed environment for a period of three days. Following this period of time, the gas sample bag was subsampled using appropriate sample media to allow for characterisation of compounds that could potentially diffuse from the frost protection cap into the nitrogen atmosphere.

Subsampling was performed in accordance with appropriate sampling techniques. Once sampling was complete, the sample media was transported to the laboratory for analysis HPLC and Thermal desorption GCMS.

The following conclusions were developed for the study. These include:

1. With regards to the monitoring of Frost protection cap located outside House 26, a number of compounds were detected. These include Hydrogen sulphide, Styrene, Toluene, Formaldehyde and Acetaldehyde. The concentrations range from 0.002723 to 0.149393 mg/Nm^3. No other compound above the LLOD was detected within the analysis screen.

2. With regards to the monitoring of frost protection cap from outside House 52, a number of compounds were detected. These include Hydrogen sulphide, Toluene, Formaldehyde and Acetaldehyde. The concentrations range from 0.03725 to 0.10663 mg/Nm^3. No other compound above the LLOD was detected within the analysis screen.

1. Introduction and scope

1. Introduction

Odour Monitoring Ireland Ltd was commissioned by Mulroy Environmental Ltd to perform headspace gas analysis of two frost protection caps taken from outside House 26 and 52, Barnageeragh Cove, Skerries, Co. Dublin). The aim of the study was to ascertain the potential for the frost protection caps to degas compounds to atmosphere.

Monitoring was performed for a number of compound groups to include:

- Trace Landfill gas screen;
- Formaldehyde and Acetaldehyde.

All continuous and active grab sampling techniques were in accordance with international sampling methodologies contained in *Section 2* and all grab samples were tested in a UKAS accredited test house (UKAS1549).

This report presents the materials and methods, results and discussion and conclusions from the sampling and analysis study on the 14th Jan 2019.

1.2 Scope of the study

The main aims of the study included:

- Headspace gas analysis monitoring of two frost protection caps located within gas tight sampling bags containing an inert Nitrogen atmosphere.
- Interpretation of results, where applicable.

2. Materials and methods

This section describes the materials and methods used throughout the survey.

The following standards and documents were used for reference and adhered to where possible:

- Compendium method TO-17-Determination of volatile organic compounds in ambient air using active sampling onto sorbent tubes.
- MDHS 70 – General method for sampling airborne gases and vapours.
- MDHS 72 – Volatile organic compounds in air (1993). Laboratory methods using pumped solid sorbent tubes, thermal desorption and gas chromatography.
- MDHS 96 – Volatile organic compounds in air, Laboratory methods using pumped solid sorbent tubes, solvent desorption and gas chromatography. March 2000.
- NIOSH (NMAM) fourth Edition (1996). Volatile organic compounds (Screening) Method 2549).
- NIOSH 1500 and 1501 for Total and aromatic hydrocarbons sampling and measurement,
- NIOSH 2539 – Aldehydes screening.
- ISO 16017-1:2000, Indoor, ambient and workplace air. Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography. Part 1: Pumped sampling.

2.1 General description of sampling and analysis techniques

A number of sampling techniques were used to characterise the headspace air in the gas tight sampling bags for the frost protection caps from outside House 26 and 52, Barnageeragh Cove, Skerries, Co. Dublin (*see Table 2.1*). Active grab sampling using sorption tubes was performed. Sorption tube sampling and analysis were performed to allow for the characterisation (i.e. both qualitative and semi quantitative) of sampled air for named compound concentrations throughout the sampling event.

Table 2.1 provides information on the following items and includes*:*

- Sample identity key,
- Description of monitoring location,
- Type of monitoring performed,
- Monitoring standards applied where applicable,
- Monitoring details,
- Analysis laboratory details,
- Description of sampling media.

Table 2.1. Description for headspace air analysis carried out on frost protection caps from outside House 26 and 52 Barnageeragh Cove, Skerries, Dublin on the 14th Jan 2019.

Monitoring location key	Description of monitoring location and Date	Monitoring performed	Standards applied	Monitoring details	Analysis laboratory	Sampling media
1	Frost protection cap – House 26	Formaldehyde, Acetaldehyde, Trace landfill gas screen	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 2539, 2549	Frost protection cap was placed inside Nalophan sample bag and sealed. The sample bag was filled (70 litres) with 6.0 Nitrogen. The bag was left to stand for a period of 3 days to allow for any compounds to diffuse into the nitrogen atmosphere where by this could then be sampled onto specific sorption tubes for the target analytes.	UKAS 1549	Sorbent tube SKC226-119, Multibed silcosteel dual layer thermal desorption
2	Frost protection cap – House 52	Formaldehyde, Acetaldehyde, Trace landfill gas screen	ISO16017, USEPA TO17, MDHS 70,72 and 96, NIOSH 1500, 1501, 2539, 2549	Frost protection cap was placed inside Nalophan sample bag and sealed. The sample bag was filled (70 litres) with 6.0 Nitrogen. The bag was left to stand for a period of 3 days to allow for any compounds to diffuse into the nitrogen atmosphere where by this could then be sampled onto specific sorption tubes for the target analytes.	UKAS 1549	Sorbent tube SKC226-119, Multibed silcosteel dual layer thermal desorption

2.2 Monitoring for specified compounds in headspace of gas sampling bag containing frost protection caps from House 26 and 52 Barnageeragh Cove, Skerries, Co. Dublin on the 14th Jan 2019.

The following range of compounds / parameters that were actively monitored using sorbent based media are detailed in *Table 2.1*. An overview of the monitoring standards applied is detailed in *Section 2*.

In order to pre-concentrate each compound upon each sorbent, a pre-calibrated controlled volume of sample air was drawn through each tube by a SKC air sampling pump for the monitoring period (Active sampling/pumped sampling). Each SKC pump was pre-calibrated with their specific sorbent using a Bios Primary flow calibrator (UKAS traceable Cert No. N022746).

Each pump was calibrated to an optimal flow rate (of between approx. 200 and 400 mls/min depending on sample location and sample type) for sorbent tubes.

When sampling was completed all tubes were sealed and stored in flexible air / light tight containers and transported to the analysing laboratory and analysed by means of HPLC and thermal desorption / solvent extraction GCMS, GCFID, in a UKAS accredited laboratory (UKAS 1549).

A number of QA procedures were implemented into the sampling and analysis run to include:

- Front and back sorbent beds were analysed. The back bed was confirmed to be less than 5% of the total sample conc. which is a stated requirement of EN13649:2014.
- All sorbent tubes were sealed and contained in air tight and light proof containers for transport to the laboratory. All samples were stored below 25 deg. C. This is a requirement of EN13649:2014.
- Travel/Sample blanks were incorporated into the measurement sequence. In addition, the laboratory included instrument and method blanks into their measurement sequence.
- Sample volume flow rate and pump calibration was performed before sampling and after sampling and these were recorded in the site data sheets. In addition, it was confirmed that the variation between before and after calibration was less than 1% of the flow range on the day of sampling for all samples taken on the 14th Jan 2019. The sample flow rate primary flow standard measured flow to an accuracy of 0.001 L/min over the range with a calibration accuracy of less than or equal to 1%.
- Total sample volumes chosen were a combination of analytical techniques lower limit of detection calculations and as specified in standard requirements.

3. Results of the monitoring exercise and discussion

This section provides the results obtained during the survey.

3.1 Gas analysis results

Tables 3.1 to 3.2 present the result of the monitoring on each frost protection cap from outside House 26 and 52.

As can be observed from the analysis results from the sampling of headspace air from Frost protection cap located outside House 26, a number of compounds were detected. These include Hydrogen sulphide, Styrene, Toluene, Formaldehyde and Acetaldehyde. The concentrations range from 0.002723 to 0.149393 mg/Nm^3. No other compound above the LLOD was detected within the analysis screen.

Table 3.2 presents the results of the monitoring of frost protection cap from outside House 52. As can be observed from the analysis results from the sampling of headspace air from Frost protection cap located outside House 52, a number of compounds were detected. These include Hydrogen sulphide, Toluene, Formaldehyde and Acetaldehyde. The concentrations range from 0.03725 to 0.10663 mg/Nm^3. No other compound above the LLOD was detected within the analysis screen.

3.1.1 Gas analysis results for Frost cap from outside House 26

Table 3.1. Results from monitoring of headspace air for Frost protection cap from outside House 26.

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	Risk factors
1	1042204 – trace landfill gas screen	12:06 – 12:41 – 35 min 14/01/18	1-Pentene	<10	0.00661	<0.001513	-
			1,1 Di chloroethane	<10	0.00661	<0.001513	IOELV
			1,1-Dichloroethylene	<10	0.00661	<0.001513	-
			1,2-Dichloroethane	<10	0.00661	<0.001513	Sk, IOELV
			1,2-Dichloroethylene	<30	0.00661	<0.004539	-
			1,3-Butadiene	<10	0.00661	<0.001513	-
			1,4 epoxy 1,3-butadiene	<10	0.00661	<0.001513	-
			1-Propanethiol	<10	0.00661	<0.001513	-
			2-butoxyethanol	<10	0.00661	<0.001513	Sk , IOELV
			Benzene	<10	0.00661	<0.001513	BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.00661	<0.001513	-
			Carbon tetrachloride	<10	0.00661	<0.001513	Sk
			Chloroethane	<30	0.00661	<0.004539	IOELV
			Dichloromethane	<10	0.00661	<0.001513	-
			Dimethyl disulphide	<10	0.00661	<0.001513	-
			Dimethyl sulphide	<10	0.00661	<0.001513	-
			Ethyl butyrate	<25	0.00661	<0.003782	-
			Ethyl Mercaptan	<10	0.00661	<0.001513	-
			Hydrogen sulphide	**820**	0.00661	**0.124054**	IOELV
			Methyl Mercaptan	<30	0.00661	<0.004539	-
			N-Butyl Mercaptan	<10	0.00661	<0.001513	-
			Styrene	**18**	0.00661	**0.002723**	-
			Toluene	**220**	0.00661	**0.033283**	Sk, IOELV
			Trichloroethylene	<10	0.00661	<0.001513	Sk, Carc 1B
			Vinyl chloride monomer	<10	0.00661	<0.001513	Carc.1A, BOELV
1	5263207077	12:44 – 13:40 – 56 min 14/01/18	Formaldehyde	**900**	0.02142	**0.042017**	Carc.1B, Sens.
			Acetaldehyde	**3200**	0.02142	**0.149393**	-

3.1.2 Gas analysis results for Frost cap from outside House 52

Table 3.2. Results from monitoring of headspace air for Frost protection cap from outside House 52.

Monitoring location identity	Sample ID	Sample duration and times	Compound identity	Compound mass (ng)	Sample volume (Nm^3)	Compound conc. (mg/Nm^3)	Risk factors
2	1051251 – trace landfill gas screen	12:06 – 12:41 – 35 min 14/01/18	1-Pentene	<10	0.00671	<0.00149	-
			1,1 Di chloroethane	<10	0.00671	<0.00149	IOELV
			1,1-Dichloroethylene	<10	0.00671	<0.00149	-
			1,2-Dichloroethane	<10	0.00671	<0.00149	Sk, IOELV
			1,2-Dichloroethylene	<30	0.00671	<0.004471	-
			1,3-Butadiene	<10	0.00671	<0.00149	-
			1,4 epoxy 1,3-butadiene	<10	0.00671	<0.00149	-
			1-Propanethiol	<10	0.00671	<0.00149	-
			2-butoxyethanol	<10	0.00671	<0.00149	Sk , IOELV
			Benzene	<10	0.00671	<0.00149	BOELV, Sk, Carc.1A, Muta.1B
			Butyric acid	<10	0.00671	<0.00149	-
			Carbon tetrachloride	<10	0.00671	<0.00149	Sk
			Chloroethane	<30	0.00671	<0.004471	IOELV
			Dichloromethane	<10	0.00671	<0.00149	-
			Dimethyl disulphide	<10	0.00671	<0.00149	-
			Dimethyl sulphide	<10	0.00671	<0.00149	-
			Ethyl butyrate	<25	0.00671	<0.003726	-
			Ethyl Mercaptan	<10	0.00671	<0.00149	-
			Hydrogen sulphide	**670**	0.00671	**0.099851**	IOELV
			Methyl Mercaptan	<30	0.00671	<0.004471	-
			N-Butyl Mercaptan	<10	0.00671	<0.00149	-
			Styrene	<10	0.00671	<0.00149	-
			Toluene	**250**	0.00671	**0.037258**	Sk, IOELV
			Trichloroethylene	<10	0.00671	<0.00149	Sk, Carc 1B
			Vinyl chloride monomer	<10	0.00671	<0.00149	Carc.1A, BOELV
2	5263207070	12:44 – 13:40 – 56 min 14/01/18	Formaldehyde	**700**	0.02157	**0.032452**	Carc.1B, Sens.
			Acetaldehyde	**2300**	0.02157	**0.10663**	-

4. Conclusions

The following conclusions are drawn for the study:

1. With regards to the monitoring of Frost protection cap located outside House 26, a number of compounds were detected. These include Hydrogen sulphide, Styrene, Toluene, Formaldehyde and Acetaldehyde. The concentrations range from 0.002723 to 0.149393 mg/Nm^3. No other compound above the LLOD was detected within the analysis screen.

2. With regards to the monitoring of frost protection cap from outside House 52, a number of compounds were detected. These include Hydrogen sulphide, Toluene, Formaldehyde and Acetaldehyde. The concentrations range from 0.03725 to 0.10663 mg/Nm^3. No other compound above the LLOD was detected within the analysis screen.

5. References

1. 2011 Code of Practice for the Safety, Health and Welfare at work (Chemical Agents) Regulations 2001 (S.I. No. 619 of 2001)". (www.hse.ie).
2. ASHRAE Standard 62.1-2004, www.ashrae.org.
3. Chemical Agents COP 2016, HSE, Ireland.
4. Compendium method TO-17-Determination of volatile organic compounds in ambient air using active sampling onto sorbent tubes.
5. ILVs – Commission Directive 91/322/EEC of 29 May 1991
6. IOELVs 1 – Commission Directive 2000/39/EC of 8 June 2000
7. IOELVs 2 – Commission Directive 2006/15/EC of 7 February 2006.
8. ISO 16017-1:2000, Indoor, ambient and workplace air. Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography. Part 1: Pumped sampling.
9. MDHS 70 – General method for sampling airborne gases and vapours.
10. MDHS 72 – Volatile organic compounds in air (1993). Laboratory methods using pumped solid sorbent tubes, thermal desorption and gas chromatography.
11. MDHS 91 – Metals and metalloids in workspace air by X-ray fluorescence spectrometry, July 1998.
12. MDHS 96 – Volatile organic compounds in air, Laboratory methods using pumped solid sorbent tubes, solvent desorption and gas chromatography. March 2000.
13. Mulroy Environmental Ltd., (2018), Environmental Risk Assessment Report.
14. NIOSH (NMAM) fourth Edition (1996). Volatile organic compounds (Screening) Method 2549).
15. NIOSH 1500 and 1501 for Total and aromatic hydrocarbons sampling and measurement,
16. NIOSH 2539 – Aldehydes screening.
17. NIOSH 6001 – Arsine.
18. NIOSH 6009 – Mercury.

6. *Appendix IV* – Laboratory test results.

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Certificate of Analysis

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Report Number: 795744-1

Date of Report: 30-Jan-2019

Customer: Air Scientific
Unit 32 Degranville Court
Dublin Road
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Customer Contact: Project Management

Customer Job Reference: BACOTL2140119
Date Job Received at Concept: 16-Jan-2019
Date Analysis Started: 17-Jan-2019
Date Analysis Completed: 30-Jan-2019

The results reported relate to samples received in the laboratory and may not be representative of a whole batch.

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

This report should not be reproduced except in full without the written approval of the laboratory

Tests covered by this certificate were conducted in accordance with Concept Life Sciences SOPs

All results have been reviewed in accordance with Section 25 of the Concept Life Sciences, Analytical Services Quality Manual

UKAS TESTING
1549

Report checked and authorised by :
Kathryn Gleaves
Customer Service Advisor

Issued by :
Kathryn Gleaves
Customer Service Advisor

Concept Reference: 795744
Customer Reference: BACOTL2140119

Tube (Tenax/Carbon/Molecular Sieve) Analysed as Tube (Tenax/Carbon/Molecular Sieve)

Trace Landfill Gas Suite

	Concept Reference	795744 001	795744 002	795744 003
	Customer Sample Reference	1042204	1051251	1106260
	Test Sample	AR	AR	AR
	Date Sampled	14-JAN-2019	14-JAN-2019	14-JAN-2019
Determinand	**Method**	**LOD**	**Units**	**Symbol**			
1 Pentene	GC/MS (TD SIR)	10	ng	U	<10[68]	<10[68]	<10[68]
1,1-Dichloroethane	GC/MS (TD SIR)	10	ng	U	<10	<10	<10
1,1-Dichloroethylene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10
1,2-Dichloroethane	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
1,2-Dichloroethylene	GC/MS (TD SIR)	30	ng	U	<30	<30	<30
1,3-Butadiene	GC/MS (TD SIR)	10	ng	U	<10[68]	<10[68]	<10[68]
1,4 epoxy 1,3-butadiene	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
1-Propanethiol	GC/MS (TD SIR)	10	ng	U	<10[68]	<10[68]	<10[68]
2-butoxyethanol	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
Benzene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10
Butyric acid	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
Carbon disulphide	GC/MS (TD SIR)	10	ng	N	<10	<10	<10[13]
Carbon tetrachloride	GC/MS (TD SIR)	10	ng	U	<10	<10	<10
Chloroethane	GC/MS (TD SIR)	30	ng	N	<30	<30	<30
Dichloromethane	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
Dimethyl disulphide	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
Dimethyl sulphide	GC/MS (TD SIR)	10	ng	U	<10[68]	<10[68]	<10[68]
Ethyl butyrate	GC/MS (TD SIR)	25	ng	N	<25	<25	<25
Ethyl Mercaptan	GC/MS (TD SIR)	10	ng	N	<10	<10	<10
Hydrogen sulphide	GC/MS (TD SIR)	60	ng	N	**820**[13,27]	**670**[27,13]	**78**[13]
Methyl Mercaptan	GC/MS (TD SIR)	30	ng	N	<30	<30	<30
N-Butyl Mercaptan	GC/MS (TD SIR)	10	ng	U	<10[68]	<10[68]	<10[68]
Styrene	GC/MS (TD SIR)	10	ng	N	**18**	<10	<10
Toluene	GC/MS (TD SIR)	10	ng	N	**220**	**250**[13]	<10
Trichloroethylene	GC/MS (TD SIR)	10	ng	U	<10	<10	<10
Vinyl chloride monomer	GC/MS (TD SIR)	10	ng	U	<10[68]	<10[68]	<10[68]

Concept Reference: 795744
Customer Reference: BACOTL2140119

Tube Silica Gel DNPH (226-119) Analysed as Tube Silica Gel DNPH (226-119)

Acetaldehyde & Formaldehyde

	Concept Reference	795744 004	795744 005	795744 006
	Customer Sample Reference	5263207077	5263207070	5263207074
	Test Sample	AR	AR	AR
	Date Sampled	14-JAN-2019	14-JAN-2019	14-JAN-2019
Determinand	**Method**	**LOD**	**Units**	**Symbol**			
Acetaldehyde	HPLC (DNPH derivative)	0.1	µg	U	**3.2**[13]	**2.3**[13]	<0.1
Formaldehyde	HPLC (DNPH derivative)	0.1	µg	U	**0.9**[13]	**0.7**[13]	**0.5**[13]

Index to symbols used in 795744-1

Value	Description
AR	As Received
13	Results have been blank corrected.
68	Outside scope of UKAS accreditation
27	Result should be considered as a minimum due to detector saturation.
U	Analysis is UKAS accredited
N	Analysis is not UKAS accredited