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**W00201-03-VOC/SURFACE EMISSIONS/2022/4 LANDFILL GAS SURFACE EMISSIONS
SURVEY AT DREHID LANDFILL FACILITY, KILLINAGH UPPER, CARBURY, CO. KILDARE**

Performed by Odour Monitoring Ireland on behalf of bord na mona plc

PREPARED BY:	Dr. John Casey
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LICENCE NUMBER:	WL0201-3
LICENCE HOLDER:	Bord Na Mona Plc.
FACILITY NAME:	Drehid Landfill Facility
DATE OF MONITORING VISIT:	24 st Nov. 2022
NAME AND ADDRESS OF CLIENT ORGANISATION:	Drehid landfill facility, Killinagh Upper, Carbury, Co. Kildare
NAME AND ADDRESS OF MONITORING ORGANISATION:	Odour Monitoring Ireland, Unit 32 DeGranville Court, Dublin Road, Trim, Co. Meath
DATE OF REPORTING:	09 th Jan. 2023
NAME AND THE FUNCTION OF THE PERSON APPROVING THE REPORT:	Dr. Brian Sheridan, Managing Partner, Odour Monitoring Ireland
REPORT NUMBER:	20221523(1)
REVIEWERS:	

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Document Amendment Record

Client: *Bord Na Mona Plc.*

Title: W00201-03-VOC/SurfaceEmissions/2022/4 Landfill Gas Surface emissions Survey at Drehid landfill facility, Killinagh Upper, Carbury, Co. Kildare.

Project Number: 20221523			Document Reference: W00201-03-VOC/SurfaceEmissions/2022/4		
20221523(1)	Document for review	JWC	BAS	JWC	09/01/2023
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Executive Summary

Bord Na Mona Plc. commissioned Odour Monitoring Ireland to perform a landfill gas surface emissions survey of Drehid landfill facility (i.e. Waste licence number 201-03) in order to ascertain any likely sources of landfill gas surface emissions from the operating landfill. Landfill gas surface emissions are the predominant source of odour emissions from landfills in Ireland. The survey was carried out on the 24st Nov. 2022.

During the surface emissions survey, the following tasks were performed on site:

1. Identification the key mechanisms that lead to the release of landfill gas surface emissions from the site.
2. Identify geographically on a site map, the locations of landfill gas surface emissions in order to perform remediation of the identified surface emissions areas.

The following conclusions were drawn from survey:

- Four zones of surface emissions were identified within the landfill facility that exceeded recommended trigger levels. These zones are identified geographically on a site map contained in *Appendix I* of this report.
- There was one surface emissions zone greater than or equal to 500 ppm around identified features. There were three surface emissions zones greater than or equal to 100 ppm instantaneous reading on open surfaces within the landfill footprint.
- On the 21st Sept. 2022 there were three surface emissions zones. There was one surface emissions zone greater than or equal to 500 ppm around identified features. There were two surface emissions zones greater than or equal to 100 ppm instantaneous reading on open surfaces within the landfill footprint.

1. Introduction

1.1. Background to work

Odour Monitoring Ireland was commissioned by Bord Na Mona Plc. to perform a specified independent Volatile organic compound surface emissions survey at Drehid landfill facility. The assessment involved a Volatile organic compound (VOC) surface emissions survey of the landfill facility in order to ascertain the VOC emission points and mark them upon a map for remediation. This report presents a summary of the findings of a VOC surface emissions survey at Drehid landfill facility, Killinagh Upper, Carbury, Co. Kildare. The report is based on scientific measurements and observations made during a site visit conducted on the 24th Nov. 2022.

1.2. Scope of work

The main aims of the survey included:

- Surface emissions monitoring in accordance with AG6 requirements.
- Discussion meeting with landfill manager once survey was complete in order to communicate main surface emissions areas for immediate remediation, where necessary.
- Identification of short-term mitigation measures to be implemented within the operating landfill to reduce surface emissions,

2. Techniques used

This section describes the techniques used throughout the study. The surface emissions surveying and reporting was performed by Dr. John Casey, Odour Monitoring Ireland. Dr. John Casey has performed surface emissions monitoring surveys on behalf of Odour Monitoring Ireland for regulatory bodies in Ireland and Northern Ireland, local authorities in Ireland, private waste operators in Ireland and borough councils in Northern Ireland. A full documented list of previous surveys is available upon request.

2.1. “Odour hog” monitoring within the landfill

The “Odour hog” (i.e. Version 2, 4 years old with less than 3.5 second response time for the FID) VOC analyser is a portable, intrinsically safe, survey VOC dual monitor, which provides fast and accurate readings of organic and inorganic vapours. A Photo ionisation detector (PID) uses an Ultraviolet (UV) light source (*photo*) to ionise a gas sample and detect its concentration. Ionisation occurs when a molecule absorbs the high energy UV light, ejecting a negatively charged electron and forming of positively charged molecular ion. The gas becomes electrically charged. These charged particles produce a current that is easily measured at the sensor electrodes. Only a small fraction of the VOC molecules are ionised. A PID does not respond to methane. A FID is similar to a flame thermocouple detector, but measures the ions from the flame instead of the heat generated. The FID detects the methane fraction, which provides greater sensitivity in terms of methane surface emissions detection but not necessarily odour hence why the PID data is also interpreted. The FID/PID analyser was calibrated with certified reference material isobutylene and methane before commencement of the survey, see calibration certificates for gases used in Appendix II. The calibration readings were rechecked in accordance with AG6 requirements.

Using the continuous kinematic “Odour hog” with integrated GPS (i.e Magellan Professional with sub centimetre accuracy post processed), the capping of the landfill was surveyed for potential surface emissions areas. Those areas identified were geo-referenced and highlighted for remediation. This technique is useful for comparison in surface emissions area within the same landfill facility on different survey’s. The surface emissions maps generated for the particular facility can be used to assess the effectiveness of implemented mitigation techniques and to qualitatively assess the nature of surface emissions from the facility. All surface emissions surveying was carried out in accordance with “*Surface VOC Emissions Monitoring on Landfill Facilities (AG6)*”.

Efforts should be made to attain surface emissions <100 ppm from open surfaces and <500 ppm around features such as vertical wells, leachate collection sumps, leachate slope risers and other projections out of the waste body (Casey et al., 2008). These are minimum standards, which should lead to greater landfill collection efficiencies thus reducing the impact on the general environment.

2.2. Meteorological conditions

Table 2.1 illustrates the predominant wind direction during the monitoring exercise. The meteorological conditions were characterised for the day of monitoring and were as follows:

Table 2.1. Meteorological conditions during Drehid facility TVOC survey.

24 th Nov. 2022	
Average wind speed 4 m s ⁻¹	Wind direction SW
Temperature 6 ^o C	987 mbar
Dry weather	Capping moisture content high

During the TVOC and gas field survey, wind deviated from SW direction. Capping moisture content was high.

2.3 Current landfill gas collection infrastructure on the facility

There a total of 70 horizontal radial wells 50 vertical wells and 5 pumped condensate removal devices on the facility. Horizontal and Vertical landfill gas abstraction is employed in the facility which is installed with the filling of waste. Following review of the performance of these wells vertical open flight augured wells are installed for the permanent long-term extraction system prior to final capping. Drehid has 5MW of Landfill Gas Utilisation Plant with a combined capacity of 5,000m³/hr of Enclosed Flaring, 2,400m³/hr is utilised with one enclosed flare operating as a duty flare and a second is a 2,500m³/hr contingency Flare. A 1,500m³/hr flare is used for odour management in the active area. Drehid has a further 2,500m³/hr booster and flare set which is also contingency in the event of a grid outage on the export line from the site.

The Total landfill Area is approximately 200,000m² of which Phase 1 to 10 is permanently capped, Phase 11, 12 ,13 and 14 are intermediately capped with a mixture of soil and a geo-synthetic membrane. Phase 13 & 14 are active and inactive areas are either clay covered or capped with Fines and Woodchip and clay. In areas or prolonged exposure prior to capping sacrificial synthetic cover is used (Figure 6.1).

3. Results

3.1. Volatile organic compound surface emissions locations identified within Drehid landfill facility

Figure 6.2 and Table 3.1 illustrates the results obtained for the capping surface emissions survey. A total of four individual surface emissions zones were identified. Each surface emissions zone is discussed separately in this manner in order to allow for the development of remediation strategies to mitigate the individual surface emissions areas.

Table 3.1. Capping VOC surface emissions locations results with source identities correlating with *Figure 6.2 (see Appendix I)*.

Location ID	Easting (m)	Northing (m)	Max VOC conc. (ppm)	Identification and Mitigation	Recommended trigger levels
D1	274768	232060	380	Discrete Location: Intermediate Cap, P13, Surface area flank. Investigate and remediate the cause of the surface emissions.	<100ppm
D2	274795	232124	220	Discrete Location: Intermediate Cap, P14, Surface area flank. Investigate and remediate the cause of the surface emissions.	<100ppm
D3	274842	232106	345	Discrete Location: Intermediate Cap, P14, Surface area flank. Investigate and remediate the cause of the surface emissions.	<100ppm
D4	274960	232085	1,620	Discrete Feature: Intermediate Cap, P14, Vertical Well. Investigate and remediate the cause of the surface emissions.	<500ppm

Four sources of landfill gas surface emissions were identified (*see Figures 6.2 and Table 3.1*) within the landfill.

There was one surface emissions zone greater than or equal to 500 ppm around identified features. There were three surface emissions zones greater than or equal to 100 ppm instantaneous reading on open surfaces within the landfill footprint.

3.2. Close out meeting with landfill manager

Following completion of the surface emissions survey, the surface emissions team and the landfill manager discussed all aspects and general conclusions of the survey. The landfill manager was informed of the potential areas of surface emissions.

4. Conclusions

The following conclusions were drawn from the survey of Drehid Landfill facility:

- The surface emissions contour map generated from the kinematic Volatile organic compound (VOC) survey illustrated surface areas of landfill gas surface emissions.
- There was one surface emissions zone greater than or equal to 500 ppm around identified features. There were three surface emissions zones greater than or equal to 100 ppm instantaneous reading on open surfaces within the landfill footprint.

5. References

- Casey, J.W., Sheridan, B.A., Henry, M., Reynolds, K., (2008). Effective tools for managing odours from landfill facilities. International Conference on Environmental Odour Monitoring and Control, Rome, Italy, July 6-8, 2008.

6. *Appendix I- Volatile organic compound surface emissions contour map & Cell capping outline & LFG infrastructure map*

Figure 6.1. Cell capping outline & LFG infrastructure on the facility.

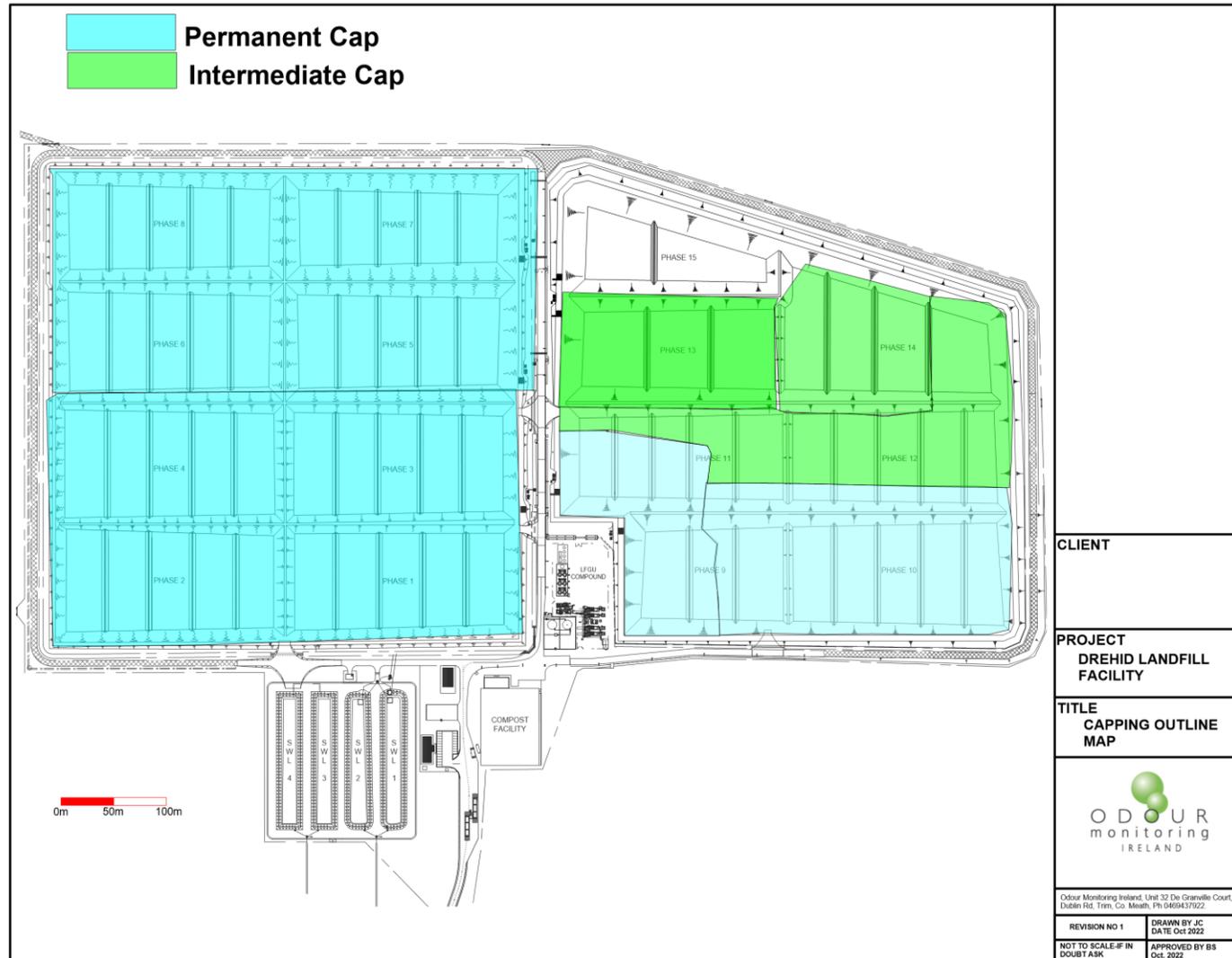


Figure 6.2. Landfill gas surface emissions monitoring within the operating landfill facility (colour scale area indicating TVOC gas colour scale).



CLIENT

PROJECT
 DREHID LANDFILL
 FACILITY

TITLE
 LEAKAGE SURVEY
 MONITORING MAP



Odour Monitoring Ireland, Unit 32 De Granville Court,
 Dublin Rd, Trm, Co. Meath, Ph 0469437922.

REVISION NO 1	DRAWN BY JC DATE Jan. 23
NOT TO SCALE-IF IN DOUBT ASK.	APPROVED BY BS Jan. 23

7. Appendix II-Calibration certificates and procedures.

7.1 Span & Calibration procedure

Necessary Calibration gases: Zero gas (0ppm), 100.2ppm and 1003ppm methane (Calibration certificates below).

Calibration is carried out in accordance with manufacturers guidelines.

Location: Zero span instrument onsite.

Frequency: Before, midway through, and after the surface emissions survey, typically therefore at 3-4 hour intervals. If the survey only last 2 to 3 hours the instrument is checked before and after the event.

Instrument settling: The FID is switched on and left to settle for a period of 30 minutes minimum.

Span Procedure: The zero and span gases shall be introduced under the same flow and pressure conditions using the sample probe at the end of the sample line. The adjustment procedure shall be as follows:

- a) Feed the zero gas (0ppm) into the FID and set the zero;
- b) Feed the span gas (100ppm) and adjust the instrument accordingly;
- c) Feed the zero gas into the FID once more and check that the reading returns to zero; if not repeat steps a) to c).
- d) repeat procedure A to C to verify

Equipment is maintained and operated as specified by the manufacturer.



Certificate of Analysis

Air Products PLC
 Hershaw Place Technology Park
 Molesey Road
 WALTON-ON-THAMES
 Surrey
 KT12 4RZ
 UNITED KINGDOM
 Date Printed: 02 MAR 2021

Container Type: C1.6A - 1.6L Aluminum Canister
 Outlet Valve Connection: 5/8" - 18 UNF
 Fill Pressure @ 15 °C: 69.0 bar-g
 Fill Pressure @ 15 °C: 70.360 kg/cm2
 Contents @ 0°C, 1013 mbar: 0.107 Nm3

Material 322144 Mixture of Gases	Mfg. Date 26 FEB 2021	Analysis Date 26 FEB 2021	Best if Used By 26 FEB 2026
Batch 2981830	Source Location 0925		

LOWER LIMIT	UPPER LIMIT	NOMINAL VALUE	ACTUAL VALUE	UNIT	EXPANDED UNCERT.	ANALYTICAL				
						NO REPS	STD DEV	PHASE	FREQ	METHOD
		100.0	100.2	ppm mo	± 2%rel			B		Ana
		20.90	21.13	% mole	± 2%rel			B		Ana
			78.8	% mole	± 2%rel			B		Ana

REMARKS:

This certificate is issued electronically and is valid without a signature.

Analytic Freq : I = Individual analysis, B = Batch analysis, C = Calculated value, S = Source.
 The suffix (m) in the Unit of Measure refers to mass.

The expanded uncertainty has been calculated with a coverage factor k=2.

This certificate is produced in accordance with ISO 6141.
 The results shown above are traceable to national or international standards through a rigorous preparation system in which International Reference Materials, ISO 6142 and ISO 6143 are used.

To obtain details about the applicable traceability, please contact us.

Do not use below a pressure of 3 bar (excluding product supplied at less than 10 bar).
 Maintain storage and use temperature between -10 and 50 °C.

ASLTM 21 ING 5 16



Certificate of Analysis

Air Products PLC
 Hershaw Place Technology Park
 Molesey Road
 WALTON-ON-THAMES
 Surrey
 KT12 4RZ
 UNITED KINGDOM
 Date Printed: 02 MAR 2021

Container Type: C1.6A - 1.6L Aluminum Canister
 Outlet Valve Connection: 5/8" - 18 UNF
 Fill Pressure @ 15 °C: 69.0 bar-g
 Fill Pressure @ 15 °C: 70.380 kg/cm2
 Contents @ 0 °C, 1013 mbar: 0.110 Nm3

Material 314092 Mixture of Gases	Mfg. Date 19 FEB 2021	Analysis Date 19 FEB 2021	Best if Used By 19 FEB 2026
Batch 2977266		Source Location 0925	

LOWER LIMIT	UPPER LIMIT	NOMINAL VALUE	ACTUAL VALUE	UNIT	EXPANDED UNCERT.	NO REPS STD DEV	ANALYTICAL		
							PHASE	FREQ	METHOD
		1000	1003	ppm mo	± 2%rel		B		Ana
		20.90	21.01	% mole	± 2%rel		B		Ana
			78.8	% mole	± 2%rel		B		Ana

REMARKS:

This certificate is issued electronically and is valid without a signature.

Analytic Freq : I = Individual analysis, B = Batch analysis, C = Calculated value, S = Source.
 The suffix (m) in the Unit of Measure refers to mass.

The expanded uncertainty has been calculated with a coverage factor k=2.

This certificate is produced in accordance with ISO 6141.
 The certified results are traceable to gas reference materials, or to mass traceable to national standards.

To obtain details about the applicable traceability, please contact us.

Do not use below a pressure of 3 bar (excluding product supplied at less than 10 bar).
 Maintain storage and use temperature between -10 and 50 °C or lower if stipulated by local regulation.

ASLTM 2110517