



Gwynedd Council

LLWYN ISAF LANDFILL

Annual Environmental Report 2023





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GASSIM LANDFILL GAS PRODUCTION CURVE



EXECUTIVE SUMMARY

The 2023 Annual Environmental Report for Llwyn Isaf has been prepared in accordance with the EP requirements for the site. In summary the following trends have been noted at the site :

- LEACHATE levels remained below the EP compliance limit of 1.50m. Cell 1 results remain stable and shows a similar seasonal pattern in both ammoniacal nitrogen and chloride concentrations (also observed since 2021) with lower levels noted in May increasing in November. Concentrations in Cell 2 and Cell 3 have remained stable throughout 2023. The leachate results in all three cells since 2021 have shown less variation than noted in previous years and remain within the historical range.
- GROUNDWATER levels continue to show seasonal fluctuations and remained within the range of historical data, apart from a few suspect values recorded at M17 and M18. Groundwater quality continued to show little or no impact from Area 2 and no impact from Area 3. Groundwater compliance limits were within EP compliance limits.
- SURFACE WATER quality in the River Desach showed no impact from the landfill. Results are comparable with previous years, with low chloride concentrations at all surface water monitoring locations.
- LANDFILL GAS monitoring data has shown methane concentrations in the external boreholes remained below the EP compliance limits during 2023. Methane was noted in all boreholes in November 2023 and in BHG1A, BHG6 and BHG7 in April 2023. There are no compliance limits for BHG6 & BHG7.

A timer was fitted at the flare in April 2018, with subsequent improvements seen in methane concentrations and a reduction in balance gas. Yearly flare emissions and bulk gases undertaken in December 2023 and are within the compliance limits.

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1 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

This report constitutes the January to December 2023 annual monitoring report for Llwyn Isaf Landfill ('the site') in accordance with the requirements of Condition 4.2 of the site's Environmental Permit (EP).

1.2 BACKGROUND

The site' is located approximately 17 km southwest of Caernarfon, at National Grid Reference (NGR) SH450 488 (Figure 1.1). The site includes Areas 1, 2 and 3. Area 1 comprises the main elements of the site infrastructure and anaerobic digestion (AD) facility, Area 2 is an unlined closed landfill and Area 3 is a closed engineered landfill. The site is operated by Gwynedd Council.

Area 3 was issued with an EP (ref EPR/YP3138UJ) in October 2008. In 2009, WSP re-assessed the risks to groundwater in accordance with an EP Improvement Condition using additional information on groundwater levels and organic carbon content of the aquifer (Amec Foster Wheeler, 2009). The site entered 'definitive closure' on 18 July 2014 and is regulated under the conditions of a revised EP (ref. EPR/YP3138UJ/V006). Area 2 was regulated under the conditions of Waste Management Licence (WML) 37044 but the WML has since been superseded by an EP.

1.3 LAYOUT OF THIS REPORT

Following this introduction, a summary of the environmental monitoring requirements is provided in Section 2. The site monitoring data for January to December 2023 is reviewed in Section 3 followed by a review of the stability risk assessments and a summary of energy consumption in Section 4.

Data is summarised in the text and more detailed information and charts are provided in the Appendices to this report.

2 ENVIRONMENTAL MONITORING

The environmental monitoring requirements under the site's EP are summarised in Sections 2.1 to 2.4 below.

2.1 LEACHATE MONITORING

Leachate quality and levels are monitored in Cells 1, 2 and 3 of Area 3 as per the requirements of the EP (**Table 2.1**). Monitoring locations are shown on **Figure 1.1**.

Table 2.1 - Leachate Monitoring Regime

Frequency	Monitoring Location	Measurement/Determinand
Quarterly unless a reduced frequency is agreed in with Natural Resources Wales (NRW). Not less than six-monthly.	All leachate monitoring points	Leachate level
Six-monthly	All leachate wells /abstraction wells/ sumps identified on drawing ESID 7 of the permit application documents	Electrical conductivity (EC), Cl, NH4-N, pH, mecoprop, toluene, Chemical oxygen demand (COD), Biological oxygen demand (BOD), Ca, Mg, K, Na, Cd, Alkalinity, Total organic carbon (TOC), SO4, total organic nitrogen (TON) and phenol.
Annually	All leachate wells /abstraction wells/ sumps identified on drawing ESID 7 of the permit application documents	As quarterly/ six-monthly plus: Cr, Cu, Fe, Pb, Mn, Ni, Zn and Hazardous substances.

2.2 GROUNDWATER MONITORING

Groundwater quality and levels are monitored around the perimeter of Areas 2 and 3 as per the requirements of the EP (**Table 2.2**). Monitoring locations are shown on **Figure 1.1**.

Table 2.2 - Groundwater Monitoring Regime

Frequency	Monitoring Location	Measurement/Determinand
Area 2 requirements		
Monthly	M10, BH1, M18, M19, M20, M21, M22, M30, M31, M33, M34, M35 and soakaway NS	Water level, Temperature, pH, Cl, EC, NH4-N, Dissolved oxygen (DO)
Quarterly	M10, BH1, M18, M19, M20, M21, M22, M30, M31, M33, M34, M35 and 'Soakaway NS'	As monthly plus:

Frequency	Monitoring Location	Measurement/Determinand
		Alkalinity, Ca, Cd, Cr, Ni, Pb, K, Mg, Na, SO ₄ , Fe, Mn, Zn, Cu, TOC and TON.
Area 3 requirements		
Six-monthly	M17, M36, M47, DAS, GW2, GW3, GW4 and GW5.	Water level, EC, DO, Cl, NH ₄ -N, Hg, Zn, mecoprop Ca, Mg, K, Na, Cd, Alkalinity, TOC, SO ₄ , TON and phenol.
Annually	M17, M36, M47, DAS, GW2, GW3, GW4 and GW5.	As six-monthly plus: Cr, Cu, Fe, Pb, Mn, Ni, Zn, hazardous substances suite.

2.3 SURFACE WATER MONITORING

The surface water management system comprises surface water drainage pipework and an interceptor connected to an attenuation lagoon which discharges into the Afon Desach. Surface water collected from Area 3 drains to both the attenuation lagoon and the infiltration basin (soakaway located to the east of the site boundary). Most of Area 2 drains to the attenuation lagoon except for the northernmost part which drains to the 'Soakaway NS'.

Surface water quality is monitored as per the requirements of the EP (**Table 2.3**). Monitoring locations are shown on **Figure 1.1** and comprise:

- **Sample point B** is located to the north of the site on a small tributary which feeds into the Afon Desach;
- **Sample point C** is located to the north-east of the site in the Afon Desach and is the downstream sample point (approximately 330 m downstream of Area 3);
- **Sample point D** is the permitted discharge from the new surface water attenuation lagoon into the Afon Desach. Sampling commenced in September 2012 following commissioning of the attenuation lagoon;
- **Sample point D2** is from a lake to the north of the site;
- **Sample point E** is located approximately 300 m downstream from sample point C on Afon Desach (off the site plan **Figure 2.1**);
- **Sample point W** is located to the east of the site on the Afon Desach downgradient of the infiltration basin;
- **Sample point Y** is situated to the south-east of the site in Afon Desach and is the upstream sample point; and
- **Infiltration basin** is located east of the site near to Sample point W. Draining surface water is collected from Area 3 of the landfill.

Table 2.3 - Surface Water Monitoring Regime

Frequency	Monitoring locations	Measurement/determinand
Quarterly*	SW D (discharge)	NH4-N, DO, BOD and suspended solids
Six-monthly	Infiltration Basin	EC, pH, Cl, NH4-N, Cd.
Six-monthly	SWY, SWW, SWD (Discharge), SWB, SWC, SWD2, SWY	EC, pH, Alkalinity, Cl, NH4-N, TOC, BOD, COD, DO
Annually	SWY, SWW, SWD (Discharge), SWB, SWC, SWD2, SWY	As 6-monthly plus: Ca, Mg, K, Na, SO4, NO3, NO2, TON, Cd, Cu, Fe, Pb, Mn, Ni and Zn.

Note: Following exchange of letters between Gwynedd Council and NRW, and subsequent agreement on the 13th January 2023, the sampling frequency at point D was reduced from two-monthly to quarterly frequency.

2.4 GAS MONITORING

Landfill gas is monitored in perimeter and in-waste boreholes for Area 3 in accordance with the EP (Table 2.4). Monitoring locations are shown on Figure 1.1.

Table 2.4 - Gas Monitoring Area 3

Frequency	Monitoring Location	Measurement/Determinand
Six-monthly	Peripheral gas monitoring boreholes G1A, G2, G3, G4, G5, G6 and G7	Methane, carbon dioxide, oxygen, atmospheric pressure, differential pressure, temperature and meteorological data.
Six-monthly	In-waste monitoring boreholes (at least two monitoring wells within each cell)	Methane, carbon dioxide, oxygen, carbon monoxide, atmospheric pressure, differential pressure and meteorological data.

3 REVIEW OF MONITORING DATA

3.1 INTRODUCTION

This section presents a summary of the results of environmental monitoring for January to December 2023 as specified in the site’s EP’s (Sections 2.1 to 2.4).

Surface water, groundwater, leachate and landfill gas monitoring at the site was undertaken by Gwynedd Council during 2023. Surface water, groundwater and leachate samples were sent to ALS Laboratories (UK) Ltd for analysis). Laboratory analytical report references are included as Appendix A.

3.2 LEACHATE LEVELS AND QUALITY

Time series plots for leachate levels monitored in Area 3 since January 2010 are shown in Appendix B. Leachate levels for the period January to December 2023 are provided in **Table 3.1**. The data show that leachate levels were well below the EP compliance level of 1.5 m above base across all three cells.

Table 3.1 - Leachate Level data for 2023 (m above base)

Date	Cell 1 (LM1/1)	Cell 1 (LM1/2)	Cell 2 (LM2/1)	Cell 2 (LM2/2)	Cell 3 (LM3/1)	Cell 3 (LM3/2)
17/01/2023	0	0	0.22	1.00	0.77	0.29
17/04/2023	0.03	0.09	0.19	0.95	0.85	0.55
17/07/2023	0.03	0.09	0.11	0.89	0.80	0.36
16/10/2023	0.03	0.09	0.30	1.06	0.72	0.55
EP Compliance Limit	1.5	1.5	1.5	1.5	1.5	1.5

Note: Quarterly monitoring data.

Samples of leachate were collected individually from each of the three cells for Area 3. Time series plots for ammoniacal nitrogen and chloride concentrations (leachate indicators for the site) since February 2009 are shown in Appendix B. A summary of selected results for January to December 2023 is presented in **Table 3.2**.

The data for 2023 shows that both chloride and ammoniacal-nitrogen concentrations show little variability (257-456 mg/l and 239-301 mg/l respectively) and remain within the historical data range. Overall concentrations remain below the elevated peaks (up to 2750 mg/l chloride and 2490 mg/l ammoniacal-nitrogen respectively) recorded in 2016 to 2019.



Table 3-2 - Selected Leachate Quality Data for 2023

Cell	pH		Electrical Conductivity (µS/cm)		Ammoniacal Nitrogen (mg/l)		Chloride (mg/l)	
	May	Nov	May	Nov	May	Nov	May	Nov
Cell 1	7.3	7.8	4330	3900	299	246	394	410
Cell 2	7.0	7.1	4030	3210	276	239	448	257
Cell 3	7.1	7.4	3950	4160	301	244	309	456

Note: Six-monthly sampling (May and November 2023)

The annual extended analytical suite comprising additional metals and hazardous organic substances as required by the EP for Area 3 was carried out in May 2023. Most of the hazardous organic substances were found at concentrations below the laboratory detection limits (<0.02 to <100 µg/l). Hazardous organic substances above the detection limit (Table 3.3) include BTEX (Benzene, Toluene, Ethylbenzene, Xylene), some hydrocarbons and mecoprop.

Table 3-3 - Summary of Leachate Organic Hazardous Substances Screen 2023 (Substances Above Detection Limit)

Hazardous Organic Substance	Concentrations (µg/l)		
	Cell 1	Cell 2	Cell 3
Pesticides			
Mecoprop	3.27	4.22	2.67
Hydrocarbon Band			
EH >C6 – C40	75	<100	<100
EH >C6 - C8	<40	<100	<100
EH >C8 - C10	<40	<100	<100
EH >C16 - C24	<40	<100	<100
EH >C24 - C40	<40	<100	<100
EH >C10 - C16	75	<100	<100
BTEX			
Benzene	1.2	2.26	1.85
Ethyl Benzene	0.27	<0.50	<0.50

Hazardous Organic Substance	Concentrations (µg/l)		
Toluene	0.17	<0.50	<0.50
m&p-Xylene	0.45	<1.00	1.05
o-Xylene	0.47	<0.50	0.66
Total Xylenes	0.92	<1.00	1.71

3.3 GROUNDWATER LEVELS

Groundwater level time-series plots since April 2008 are provided as Appendix C. Data for January to December 2023 are summarised in **Table 3.4** and show:

- Seasonal variation in Area 2 boreholes with higher groundwater levels typically recorded during the winter months before falling away during the summer (where monitored). Changes in levels are attributable to rainfall variations across the year (rainfall records from the site’s manual rain gauging station are included in Appendix F). This variability is less apparent in the Area 3 boreholes which are monitored six-monthly;
- Groundwater levels remain within the range of previous data, except for lower than historical levels at borehole M17 (May and December) and higher than historical levels at borehole M18 (between July and October). These results are several (approximately between 2 and 8) metres different than what is typically recorded at these boreholes and a change in trend is not observed in groundwater levels for other boreholes across the site suggesting that these results are erroneous;
- Groundwater levels continue to be below the base of Area 3 except for historical borehole DAS. This borehole is located within waste of Area 2 suggesting that levels are likely to represent perched leachate within the waste rather than groundwater levels. This is supported by the poor water quality measured at this borehole. The log for this borehole is not available to confirm the screened geology; and
- The highest groundwater levels continue to be recorded to the south of the site and fall to the north/northeast towards Afon Desach, and to the north-west.

Table 3-4 - Summary of Groundwater Levels for 2023

Borehole	Borehole Datum (m AOD)	Groundwater Levels (m AOD)		
		Min	Mean	Max
GW3	134.42	128.10	128.56	129.02
GW4	138.07	128.27	128.61	128.94
GW5	134.21	129.81	130.59	131.37
M10	134.91	124.51	125.91	127.94

Borehole	Borehole Datum (m AOD)	Groundwater Levels (m AOD)		
BH1	132.64	122.72	125.88	127.84
M17	129.29	119.89	121.14	122.39
M18	132.50	127.64	129.12	131.20
M19	127.41	122.43	122.74	123.10
M20	128.77	122.07	122.92	123.56
M21	130.98	122.70	123.06	123.43
M22	127.33	Borehole buried by landowner		
M31	128.90	122.91	123.85	124.85
M33	134.16	123.94	126.85	129.03
M34	131.18	124.40	126.24	131.18
M35	127.62	123.72	124.62	125.45
M36	138.29	129.31	129.70	130.09
M47	139.20	129.80	130.29	130.78
DAS	140.68	132.84	134.50	136.15

Notes: Six-monthly (May and November 2023) monitoring data for Area 3 (boreholes GW3, GW4, GW5, M17, M36, M47 and DAS) and monthly monitoring data for Area 2 (boreholes BH1, M10, M18, M19, M20, M21, M31, M33, M34 and M35).

3.4 GROUNDWATER QUALITY

Although Area 2 and Area 3 are regulated under separate EPs and this report, as with previous ones, discusses these areas separately, some of the monitoring locations may not intuitively belong in the operational areas under which they are being discussed given their location in relation to the two landfill sites.

Analytical results for ammoniacal-nitrogen and chloride (site leachate indicators) since April 2008 are presented graphically in Appendix D. A summary of the data for the reporting period January to December 2023 is provided in **Table 3.5**.

Table 3-5 - Selected Groundwater Quality Data for 2023

Borehole	pH			Electrical Conductivity (µS/cm)			Ammoniacal Nitrogen (mg/l)			Chloride (mg/l)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Area 3 EP												
Upgradient												
GW5	6.7	7.1	7.4	159	161	163	<0.41		<0.41	8.3	6.5	10.6
M47	7.4	7.6	7.7	120	131	142	<0.41		<0.41	7.6	10.1	12.6
Downgradient												
GW3	7.5	7.6	7.6	326	362	397	<0.41		<0.41	11.2	12.5	13.7
GW4	6.8	7.1	7.4	128	162	195	<0.41		<0.41	11.3	13.0	14.7
M17	6.7	6.8	6.8	221	229	237	<0.41		<0.41	21.3	24.7	28.0
M36	6.9	6.9	6.9	145	159	172	<0.41		<0.41	11.6	13.9	16.2
Other Boreholes												
DAS	6.7	7.0	7.3	176	220	263	<0.41		<0.41	<3.7	4.9	6.0
Area 2 EP												
BH1	6.9	7.4	8.2	268	374	444	<0.06		<0.41	8.3	11.9	13.6
M18	6.5	7.0	8.0	173	204	255	<0.06		<0.41	7.6	15.2	30.2
M19	6.1	6.5	6.9	74.2	79.8	88.2	<0.06		<0.41	7.5	8.3	9.7
M20	7.6	7.9	8.2	377	493	545	0.19	2.47	4.24	15.2	27.4	31.7
M21	7.5	7.9	8.1	300	353	384	0.11	0.33	0.57	11.5	14.4	16.1

Note: Six Monthly monitoring data for Area 3 (GW5, M47, GW3, GW4, M17, M36, DAS). Monthly monitoring data for Area 2.

AREA 3 MONITORING

Upgradient Boreholes

Boreholes GW2, GW5 and M47 are situated to the south of, and are upgradient of, Area 3 and therefore provide an indication of background groundwater quality. Borehole GW2 continued to remain dry during 2023. Data for the remaining two boreholes, GW5 and M47 indicate:

- Ammoniacal-nitrogen concentrations were below the laboratory detection limit (0.41 mg/l) for all boreholes; and
- Chloride concentrations continued to be relatively low (<20 mg/l) and within historical data.

Downgradient Boreholes

Boreholes GW3, GW4, M17 and M36 are located downgradient of Area 3. Compliance limits for mercury, zinc, ammoniacal-nitrogen, chloride and mecoprop are set in the EP for boreholes GW3, GW4 and M36 and are presented in **Table 3.6**.

Table 3-6 - EP Groundwater Compliance Limits for Area 3

Borehole	Ammoniacal Nitrogen (mg/l)	Chloride (mg/l)	Zinc (mg/l)	Mercury (µg/l)	Mecoprop (µg/l)	Toluene (µg/l)
GW3	0.54	21	0.133	0.1	0.04	3
GW4	0.48	21	0.156	0.1	0.04	3
M36	0.49	22	0.094	0.1	0.04	3

The data for the reporting period show that:

- Ammoniacal-nitrogen concentrations were below the laboratory detection limit (0.41 mg/l) and the EP compliance limits. The slightly higher concentration (3.89 mg/l) recorded at borehole GW4 in November 2022 dropped and remained below detection limit in 2023;
- Chloride concentrations at GW3 (11.2 to 13.7 mg/l), at GW4 (11.3 to 14.7 mg/l) and at M36 (11.6 to 16.2 mg/l) were within both the historical data range and below the EP compliance limits. No upward trend was observed;
- Mecoprop concentrations were below the laboratory detection limit (0.04 µg/l) and the EP compliance limits;
- Mercury concentrations were recorded above detection limit in May at M36 (0.034 µg/l) but otherwise remained below the laboratory detection limit (0.1 µg/l). All samples were below EP compliance limits; and
- Zinc concentrations were above the laboratory detection limit (0.018 mg/l) and below the EP compliance limits.

Overall, groundwater quality data downgradient of Area 3 for this reporting period show no impact from Area 3.

Other Boreholes

Borehole DAS is situated within and close to the perimeter of Area 2. Historically ammoniacal nitrogen and chloride concentrations at this borehole have been elevated compared to other boreholes at the site but groundwater quality has improved since 2015. Contamination at this location is most likely to be the result of the borehole being located within waste deposits in the unlined closed landfill (Area 2). During 2023 both ammoniacal nitrogen and chloride concentrations have remained lower than the elevated pre-2015 data. Chloride concentrations remain within the range measured at other boreholes at the site whilst ammoniacal nitrogen remain low, with all samples below the laboratory detection limit (0.41 mg/l).

AREA 2 MONITORING

Downgradient Boreholes

Boreholes BH1, M18, M19, M20, M21, M22, M30, M31, M34 and M35 are downgradient of the unlined closed landfill (Area 2).

Boreholes M19, M20, M21 and M22 were not monitored between 2020 and 2022 due to access issues as a result of ongoing landscape work by the landowner. After monitoring recommenced in March 2023, boreholes M18 and M20 have shown rising concentrations of chloride but remain within and consistent with the variability in previous data. Chloride concentrations recorded at M35 also remain within the range observed since 2020. Ammoniacal nitrogen concentrations are below the laboratory detection limit (<0.41mg/l) for all boreholes except M35 and M20. Concentrations at these boreholes exceed slightly baseline water quality and are likely to reflect some impact from the unlined landfill Area 2.

Boreholes within Area 2 Boundary

Boreholes M10 and M33 are located within the northern part of Area 2. Ammoniacal-nitrogen concentrations during the reporting period were below the detection limit (0.41 mg/l). Chloride concentrations continue to be low (8.0 to 17.4 mg/l) and within the range recorded previously at both boreholes. The results therefore indicate no evidence of contamination by leachate at boreholes M10 and M33.

Soakaway

A summary of the monitoring results at soakaway NS during the reporting period are presented in **Table 3.7** and time-series plots for chloride and ammoniacal-nitrogen included in Appendix D. Ammoniacal nitrogen concentrations were mostly below the detection limit (0.06 mg/l) except for a spike observed in the spring (0.07 to 0.47 mg/l). Chloride concentrations remain low and within the historical data, ranging from below detection limit (<3.7 mg/l) to 12.5 mg/l.

On this basis, the results for the soakaway indicate no evidence of contamination by leachate of surface water runoff.

Table 3-7 - Selected Water Quality Data for Soakaway NS for 2023

	pH			Electrical Conductivity (µS/cm)			Ammoniacal Nitrogen (mg/l)			Chloride		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
NS	7.4	7.7	7.9	81	112	134	<0.06	0.1	0.47	3.7	6.5	12.5

Note: Monthly monitoring data.

An extended analytical suite for hazardous organic substances in groundwater at boreholes GW3, GW4, GW5, M17, M36, M47 and DAS was carried in May 2023. Due to some parameters being analysed outside recommended stability times at boreholes GW5, M17, M47 and DAS pH, Dissolved Oxygen, Fixed, Ammoniacal Nitrogen as N, Nitrogen, Total Oxidised as N, TOC (Filtered) were recorded but the hazardous suite was repeated in November 2023. The data for 2023 is summarised in **Table 3.8**. The data shows that all substances were below the laboratory detection

limits (<0.000002 mg/l for pesticides to <0.01 mg/l for hydrocarbon bands) except for three substances: two hydrocarbon bands detected marginally above the detection limit (10 µg/l) at borehole GW4 (downgradient of the site) but these have also been detected at low concentrations in previous data both up and downgradient of the site; and the pesticide chlorpyriphos detected marginally above the detection limit (0.002 µg/l) at borehole DAS which is likely to monitor perched leachate within Area 2.

Table 3-8 - Summary of Groundwater Organic Hazardous Substances Screen 2023 (Substances Above Detection Limit)

Hazardous Organic Substance	Downgradient	Within Area 2 Perimeter
	GW4	DAS
Pesticides (µg/l)		
Chlorpyriphos	<0.002	0.003 (November)
Hydrocarbon Band (µg/l)		
EH >C6 - C40	16 (May)	<10
EH >C24 - C40	16 (May)	<10

Note: N/S- not sampled.

3.5 SURFACE WATER QUALITY

The EP for Area 3 sets emission limits at sample point D for pH, chloride, ammoniacal-nitrogen, suspended solids and BOD as detailed in **Table 3.9** along with a summary of the monitoring undertaken in the period January to December 2023. Time-series plots for ammoniacal nitrogen and chloride are presented in Appendix E. The data for the reporting period show:

- **Afon Desach (locations B, C, E, Y and W):** ammoniacal-nitrogen concentrations remained below the detection limit (0.06 mg/l) whilst chloride concentrations remained stable and within the historical range. Concentrations upstream (location Y) and downstream (locations W, C and E) of the site and in the tributary of the Afon Desach (location B) continue to be similar indicating no impact from Area 3;
- **Lake (location D2):** ammoniacal-nitrogen concentrations continue to show some variability but remained within the range of historical data. As discussed in the latest Hydrogeological Risk Assessment (HRA) Review for the site (WSP, 2023), the ammoniacal-nitrogen elevated spikes appear to be seasonal and may be associated with an agricultural pollution source (e.g. runoff of fertiliser from adjacent fields). Chloride concentrations remained low and within the historical range;
- **Discharge point (location D):** there were no exceedances of the EP compliance limit for the reporting period; and
- **Infiltration basin:** Ammoniacal-nitrogen concentrations were below the detection limit (<0.06 mg/l) and chloride concentrations remain low and within the historic baseline. There is no



chloride data recorded in 2022 because the infiltration basin remained dry during the May monitoring round and only dissolved oxygen was measured in November 2022.

In summary, the data continued to show no discernible impact from Area 3 on the Afon Desach or lake to the north of the site.



Table 3-9 - Selected Surface water Quality Data for 2023

Sample Point	pH			Electrical Conductivity (µS/cm)			Ammoniacal Nitrogen (mg/l)			Chloride (mg/l)			Dissolved Oxygen (mg/l) & (%)			Suspended Solids (mg/l) ^a			Biological Oxygen Demand (mg/l)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
B	7.3	7.4	7.5	61.1	63.9	66.7	<0.06		<0.06	7.5	7.9	8.3	8.5	9.3	10		2.0		<1		<1
C	7.5	7.6	7.6	103	107	110	<0.06		<0.06	6.9	8.0	9.1	6.6	7.4	8.1		4.0		<1		<1
D	7.2	7.6	8.1	122	154	211	<0.06	0.10	0.12	3.7	9.2	13.8	6.8 (57.5%)	8.9 (82.6%)	13.9 (116%)	2.0	15.8	47.0	<1	1.3	2
D2	7.7	7.8	7.9	282	313	343	0.46	0.53	0.60	19.6	19.7	19.7	4.2	5.0	5.7		23.0		<1		<1
E	7.5	7.6	7.7	136	136	136	<0.06		<0.06	9.2	9.2	9.2	9.1	9.8	10.4		20.0		<1		<1
W	7.1	7.2	7.3	71.0	79.1	87.1	<0.06		<0.06	6.6	7.1	7.6	7.6	8.0	8.3		5.0		1	1	1
Y	7.3	7.3	7.3	52.9	59.8	66.6	<0.06		<0.06	6.1	6.8	7.4	9.1	9.3	9.5				<1	2	3
Infiltration Basin ^b		8			172			<0.06			4.5			8.0		Not monitored				-	
EP Emission Limits for D	6.0		9.0				<0.3						>80%			<25			<4		

Notes: Six-monthly monitoring data for sample points (May and November 2023)

- a) Suspended solids measurements for sampling point D only, as per the requirements of the EP.
- b) Only one sample for infiltration basin.

3.6 LANDFILL GAS

PERIMETER GAS MONITORING

Landfill gas monitoring was carried out at perimeter gas boreholes G1A and G2 to G7 on a six-monthly basis in accordance with the Area 3 EP (see **Table 2.4**). The locations of the gas monitoring boreholes (both current and former) are shown on **Figure 1.1**. The results of the monitoring undertaken from January to December 2023 along with the compliance limits are presented in **Table 3.10**.

Methane and carbon dioxide concentrations during this reporting period were consistent with previous data and show that:

- Methane was below the EP compliance limit in borehole G1A during the reporting period and was not detected in boreholes G2, G3, G4 and G5. The compliance limit for carbon dioxide for borehole G4 (2.5% v/v) was exceeded in November (2.8% v/v) and NRW have not yet been notified of this exceedance. Carbon dioxide concentrations were below the EP compliance limits in other boreholes, although the control level (2% v/v) in borehole G4 was exceeded. This is consistent with spikes in historical data at borehole G4;
- Higher levels of methane (up to 7.1%) and carbon dioxide (up to 3.7%) continue to be detected at G6 and G7 compared to other boreholes. No upward trend is observed. They are located between the engineered landfill in Area 3 and the unlined landfill in Area 2 which suggests that any methane and carbon dioxide detected are likely to be derived from Area 2.



Table 3-10 Monitoring Results from Perimeter Landfill Gas Boreholes for 2023

Date	G1A ^a			G2			G3			G4		
	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)
17/04/2023 ^c	0.1	0.9	0.4	0	0.7	19.9	0	0.3	20.3	0	0	20.6
06/11/2023	0.4	1.5	0.6	0.1	0.1	21.2	0.2	0.1	21.1	0.2	2.8	18.3
Control Levels % v/v	0.8	4.7	-	0.8	1.9	-	0.8	4.5	-	0.8	2.0	-
Compliance Limits % v/v	1.0	5.9	-	1.0	2.3	-	1.0	5.7	-	1.0	2.5	-
Date	G5			G6			G7					
	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)			
17/04/2023 ^c	0	1.5	16.2	1.5	3.4	1.7	2.4	1.9	0.4			
06/11/2023	0.1	0.1	21.6	1.9	3.7	5.0	7.1	3.6	1.0			
Control Levels % v/v	2.1	5.0	-	b	b	-	b	b	-			
Compliance Limits % v/v	2.6	6.2	-	b	b	-	b	b	-			

Notes: Monthly monitoring, but EP requirement is for six-monthly monitoring

a) Borehole G1A is a replacement for G1 which was removed in July 2012 during construction works associated with the AD plant. Sampling of borehole G1A started in June 2013.

b) Compliance limits and control levels for boreholes G6 and G7 have not been set as monitoring data suggest that they are being affected by landfill gas derived from the closed unlined landfill (Area 2).

c) Data for May 2023 at G5 is missing, so all sites have been infilled with April data.



IN WASTE GAS MONITORING (AREA 3)

In waste gas monitoring locations include combined leachate and gas monitoring wells and gas extraction wells (**Figure 1.1**). The data are summarised in **Appendix F** and show that the wastes continue to produce landfill gas with methane and carbon dioxide concentrations consistent with historical data.

Meteorological data (daily measurements of rainfall, temperature and wind speed) for the reporting period are presented as **Appendix G**.

SURFACE EMISSIONS (AREA 3)

Following exchange of letters between Gwynedd Council and NRW, and subsequent agreement on 13th January 2023, the surface emissions monitoring frequency has been reduced from yearly to every two years. The latest survey was carried out on the 28th of September 2022 and the next is due in September 2024. The maximum result for methane emissions during the survey of the cap was 4ppm. No further actions were taken – as no action is required below 100ppm.

FLARE EMISSIONS AND BULK GASES

An average flow of 28 m³/hr (based on telemetry readings) was recorded at the flare in 2023, reflecting very similar conditions seen at the site in previous years (25-28 m³/hr between 2019 – 2022).

In total, a volume of 104,272 m³ of landfill gas was combusted at the site in 2023, which is based on 1.99% downtime.

Flare emissions and bulk gas carried out at the site in December 2023 and are within the compliance limits.

4 REVIEW OF HYDROGEOLOGICAL, LANDFILL GAS AND STABILITY RISK ASSESSMENTS

4.1 REVIEW OF HYDROGEOLOGICAL RISK ASSESSMENT

The conceptual hydrogeological model for Area 3 was recently reviewed in the 2023 HRA Review (WSP, 2023) and is summarised in Table 4.1.

Table 4.1 Hydrogeological Conceptual Model for Area 3 of Llwyn Isaf Landfill (2023 HRA Review)

Source	Potential Pathways	Potential Receptors
Leachate derived from non-hazardous waste	Leakage through the engineered liner Migration through underlying unsaturated sands and gravels Lateral migration northwards within the sand and gravel aquifer	Groundwater within the sand and gravel deposits Local private water supplies downgradient of the site Local streams supported by baseflow

The 2023 HRA Review (WSP, 2023) predicted no impact on groundwater quality or receptors receiving groundwater baseflow (Afon Desach) and downgradient private abstractions as a consequence of leachate from Area 3.

4.2 REVIEW OF LANDFILL GAS RISK ASSESSMENT

GAS COLLECTION SUMMARY

Waste previously deposited in engineered containment Cells 1 to 4B has been capped and a landfill gas collection system (including extraction wells, collector pipework and condensate knockout pots) is in operation. Landfill gas collection wells are available for monitoring in Cell 1 (C11, C12, C13 and C14) and Cell 2 (C21 to C25), Cell 3 (C31 to C36), Cell 4A (C41 to C46) and Cell 4B (C51-C5).

LANDFILL GAS FLARING AND UTILISATION

Landfill gas from Cells 1-3 is collected and combusted in a 200 m³/hr capacity flare high temperature flare installed in September 2013.

Socotec undertook the annual monitoring of the emissions from the enclosed flare on 14 December 2023. (Appendix H). All results are within the emission limits specified in the EP.

A trace gas analysis of the raw landfill gas taken from the gas main at the time of the emission testing is also included in Appendix H.

MONITORING

Landfill gas is monitored at a number of locations within and around the perimeter of the landfill. Monitoring of landfill gas is discussed in Section **Error! Reference source not found..**



GASSIM MODEL

The latest gas production curve using GasSim v2.5 was produced in February 2015 and is based on:

- Actual waste inputs 2009-2012;
- Waste composition data from 2009;
- Final waste volumes based on construction of three cells.

The gas prediction curve is presented as Appendix I. The GasSim model suggests that gas production in Area 3 peaked in 2012, at 114 m³/hr. The average gas production predicted for 2023 is around 40 m³/hr, which is approximately 1.4 times the actual measured average landfill gas flow of 28 m³/hr.

4.3 REVIEW OF STABILITY RISK ASSESSMENT

CAPPING SYSTEM

The detailed design of the capping system depends on the final waste profile achieved in the cell. As a part of the detailed design phase undertaken for the capping to Cells 1/2 and Cells 2/3 a review of the capping stability was undertaken based on the proposed final slope profiles. The associated design reports were submitted to the Environment Agency (now NRW). These assessments concluded that the restored capping slope will remain stable during construction and in the long term. Further information was provided in support of the Closure Plan (submitted in October 2013).

Site inspections have not recorded any evidence of instability within the landfill during the reporting period.

5 PRODUCTION/TREATMENT VOLUMES

5.1 INTRODUCTION

This section summarises the volumes produced and treated (if applicable) at the site of landfill leachate, surface water and/or groundwater and landfill gas between January and December 2023.

5.2 LANDFILL LEACHATE

The effective management of leachate levels is a key element in the operation of Area 3 to ensure there are no adverse impacts on groundwater.

Monitoring data for Area 3 between January and December 2023 indicates that leachate levels were below the EP compliance level of 1.5 m above base (see Section 2.2). This suggests that the leachate extraction rates were effective and the on site leachate storage capacity was sufficient to ensure leachate level compliance in Area 3. A total of 577.25 tonnes of leachate was extracted from Area 3 during 2023. Leachate was removed from both a sump in the base of each cell via an upslope riser. The leachate extracted was stored on-site in the leachate collection tank prior to removal off-site by tanker for disposal.

5.3 SURFACE WATER/GROUNDWATER

No dewatering has been carried out in association with landfill aftercare. On this basis there is no groundwater disposal or treatment at the site.

A new surface water management system was installed at the site in September 2012 comprising new surface water drainage pipework and an interceptor connected to a new attenuation lagoon discharging into the Afon Desach. Surface water collected from the Area 3 landfill drains both into the attenuation lagoon and an infiltration basin (soakaway located to the east of the site boundary).

5.4 LANDFILL GAS

The landfill gas collected from the capped Cells 1 to 3 is combusted within an enclosed high temperature flare. Site records indicate that the flare had minimal (<1%) downtime during the year. Average flow rate at the flare during 2023 was 28 m³/hour. This equates to combustion of some 104,272 m³ of landfill gas from Cells 1-3 during the year; this based on 1.99 % flare downtime.

6 WASTE SETTLEMENT AND REMAINING CAPACITY

6.1 REMAINING CAPACITY

The landfill closed to receipt of waste on 2 March 2012 when filling was completed in Cell 3 and there has been no waste input for this reporting period.

6.2 SETTLEMENT BEHAVIOUR

Capping of Cells 2 north and Cell 3 was completed in August 2012. An annual topographical survey is carried out in accordance with the permit. There is no evidence of instability within the landfill.

7 ENERGY CONSUMPTION

The total energy consumed at the site between January and December 2023 was 47,376 KWh; a slight reduction on the 53,444 KWh consumed in 2022.

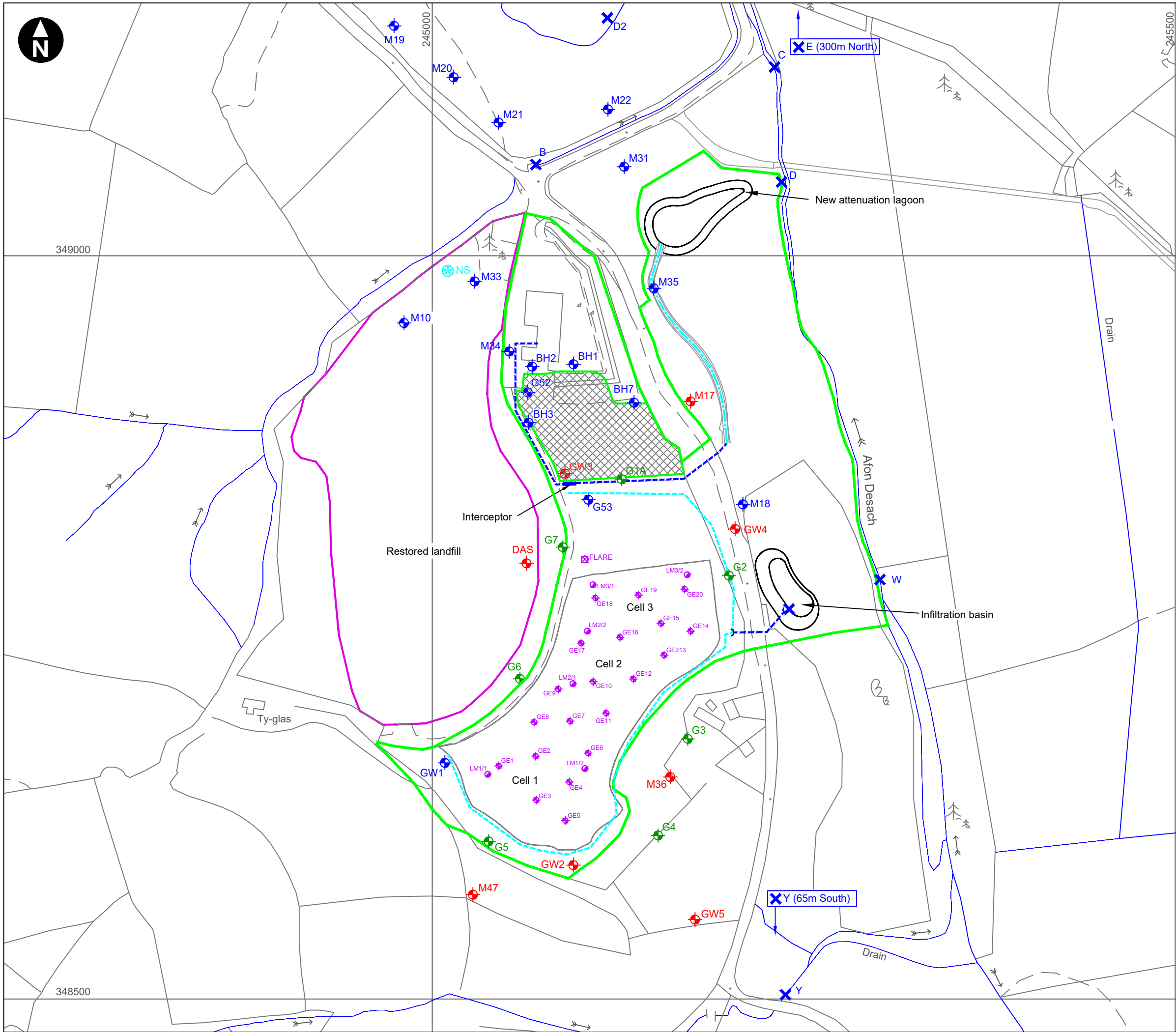


8 REFERENCES

WSP, 2023. Llwyn Isaf Landfill- Area 3: Hydrogeological Risk Assessment Review. Report reference: 853398-WOOD-RP-OW-00002_C02.

Amec Foster Wheeler, 2015. Llwyn Isaf Landfill- Area 3: Hydrogeological Risk Assessment Review. Report reference 28587rr970i2.

Amec Foster Wheeler, 15 October 2013. Llwyn Isaf Landfill Closure Report. Report reference 28587rr754i2.



- Key
- Revised installation boundary
 - Proposed area for partial surrender
 - Groundwater monitoring borehole
 - Perimeter landfill gas monitoring borehole
 - Groundwater monitoring boreholes required by the Environmental Permit
 - Gas extraction well
 - Gas flare
 - Surface water quality sampling location
 - Leachate monitoring point
 - Notional related surface flow
 - Approximate extent of closed landfill site (Area 2)
 - Surface water drainage pipes
 - Surface water drainage ditch
 - Proposed surface water drainage ditch
 - Full retention class 1 interceptor tank
 - Soakaway monitored until August 2012
 - Soakaway

0 m 500 m
 Scale 1:10,000 @ A3

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Llwyn Isaf Landfill
 Annual Environmental Report 2023

Figure 1.1
Site layout and monitoring locations

February 2024



Appendix A

LABORATORY ANALYSIS CERTIFICATE REFERENCES



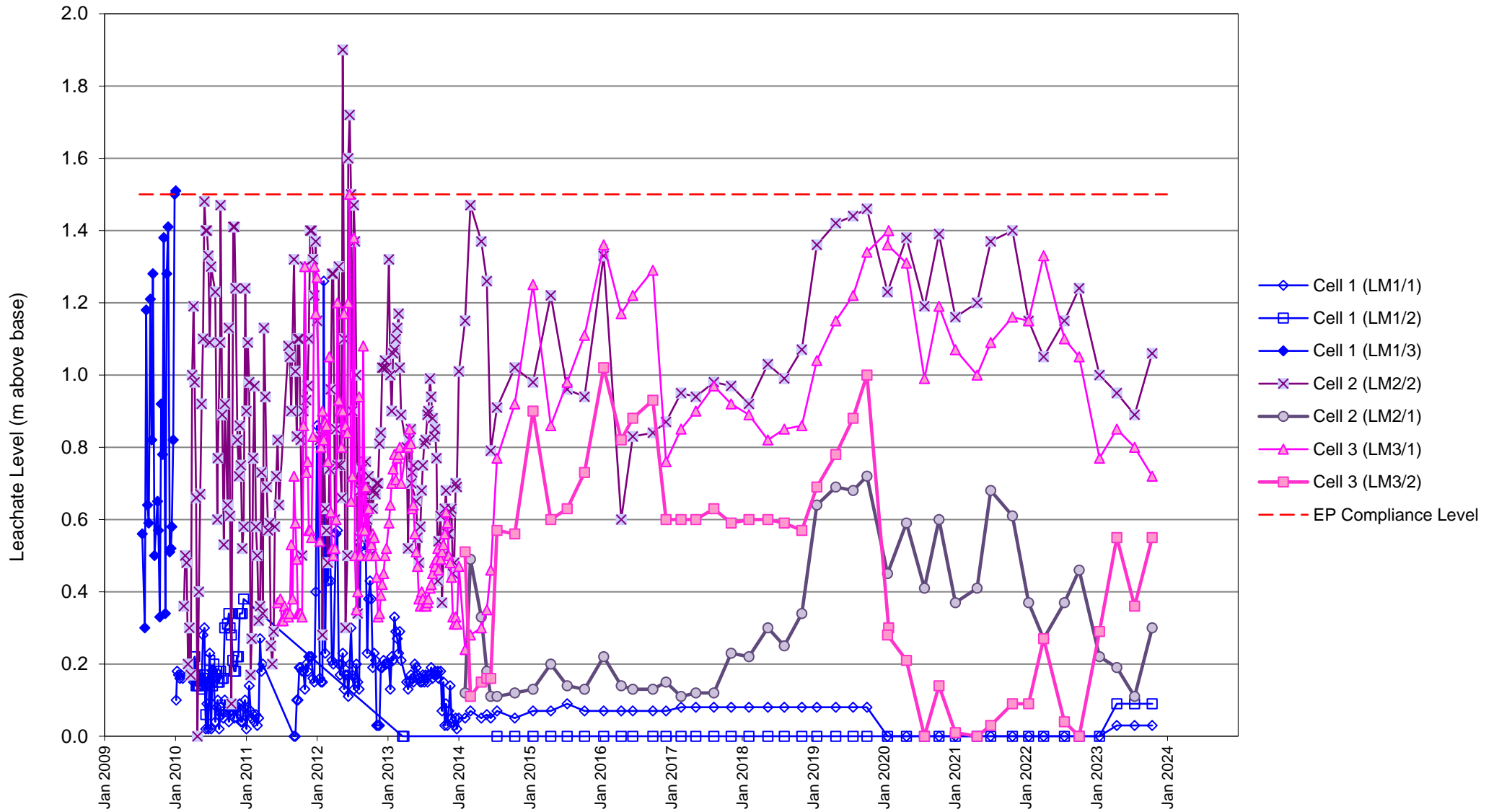
Sampling	Report number for scheduled analyses		
January (10 th)	2424389		
February (7 th)	2437373		
March (22 nd)	2457948		
April (4 th)	2463542		
May (2 nd , 9 th and 19 th)	2475710	2478712	2481902
June (20 th)	2498608		
July (5 th)	2506982		
August (1 st)	2519126		
September (4 th)	2538936		
October (3 rd)	2551654		
November (16 th)	2573153		
December (13 th)	2587016		

Appendix B

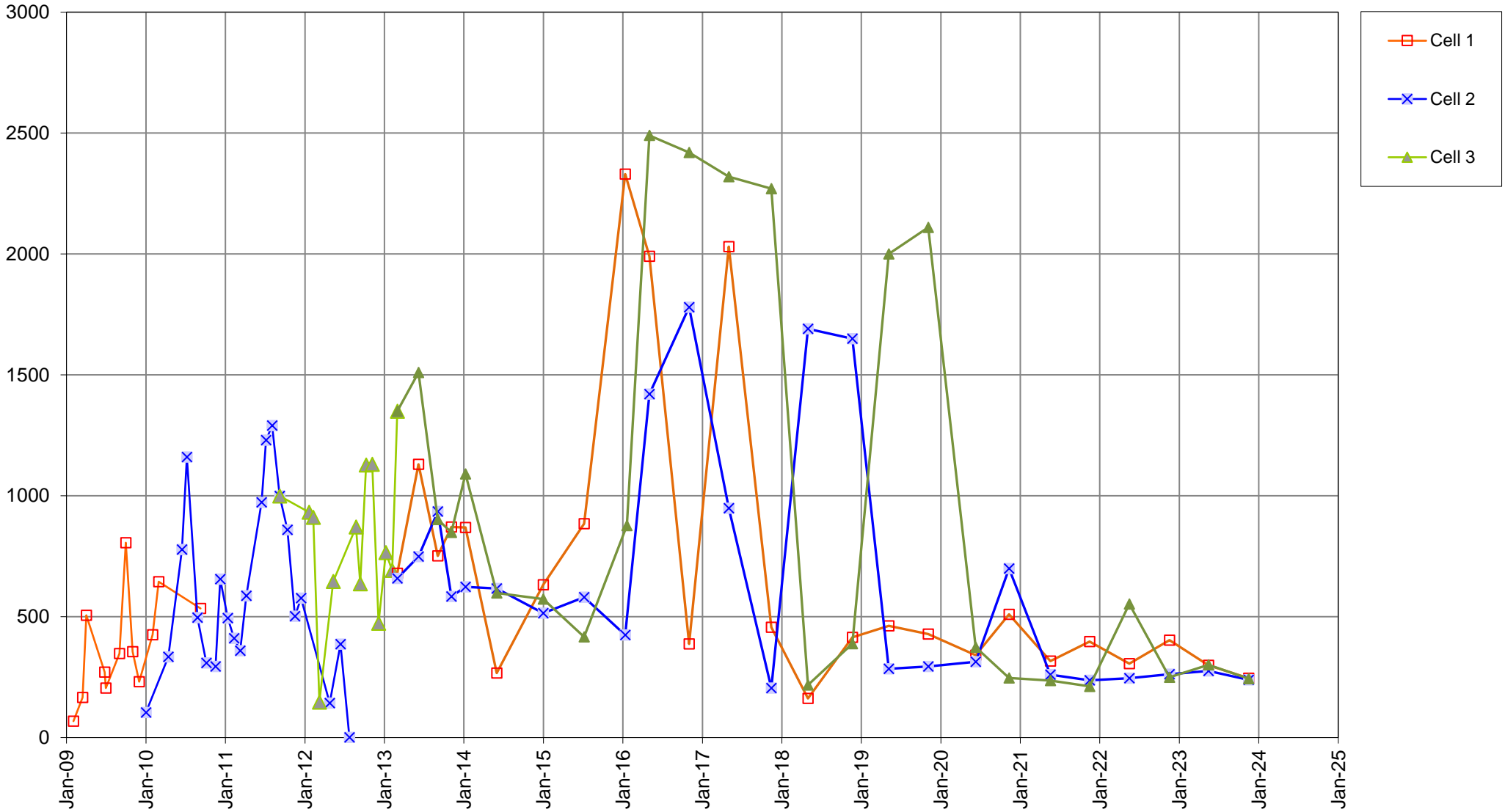
LEACHATE LEVEL AND QUALITY PLOTS



Llwyn Isaf Landfill: Leachate Levels



Llwyn Isaf Landfill: Ammoniacal-Nitrogen Concentrations in Landfill Leachate

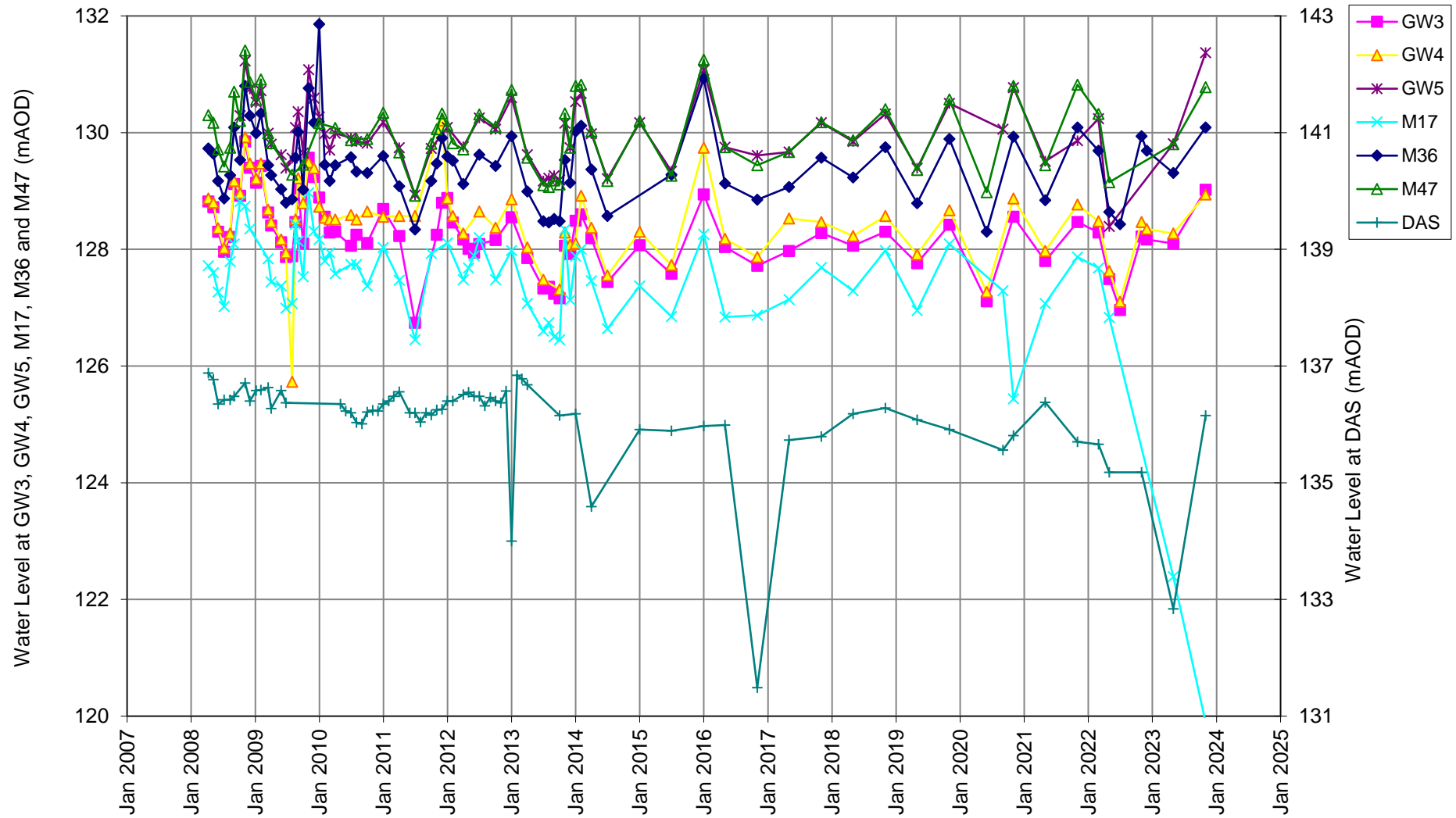


Appendix C

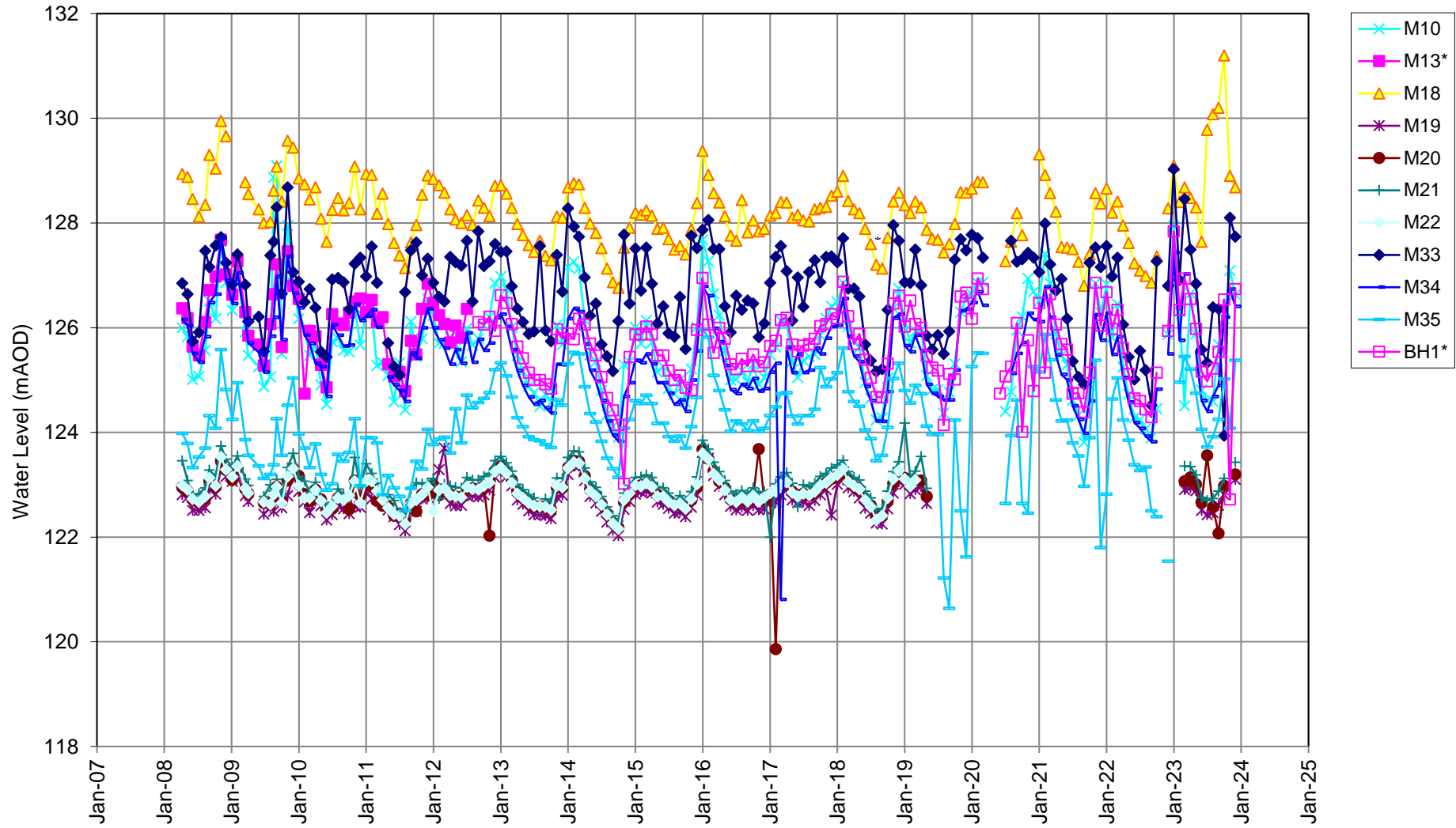
GROUNDWATER LEVEL PLOTS



Llwyn Isaf Landfill: Groundwater Levels (Area 3)



Llwyn Isaf Landfill: Groundwater Levels (Area 2)

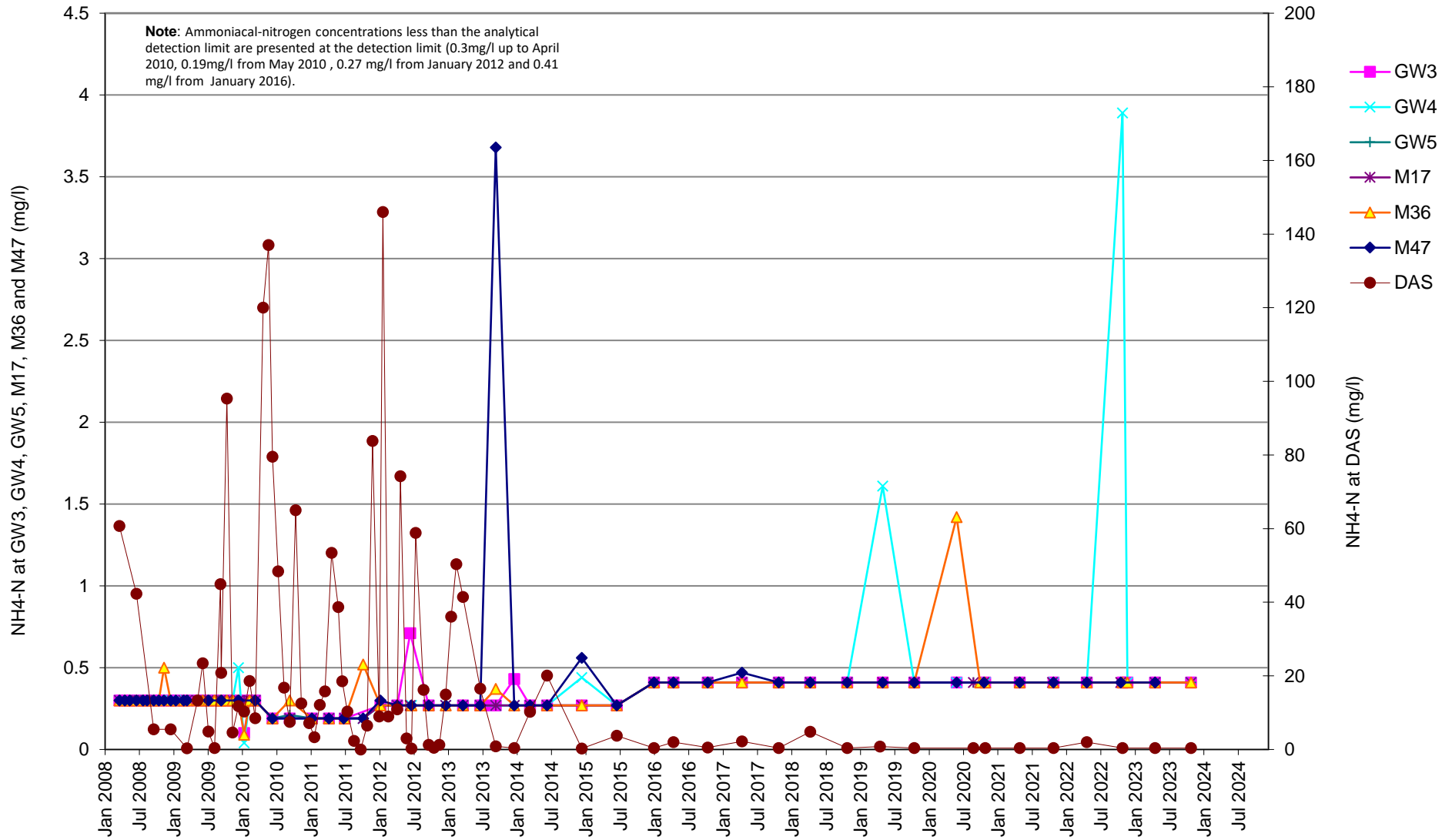


Appendix D

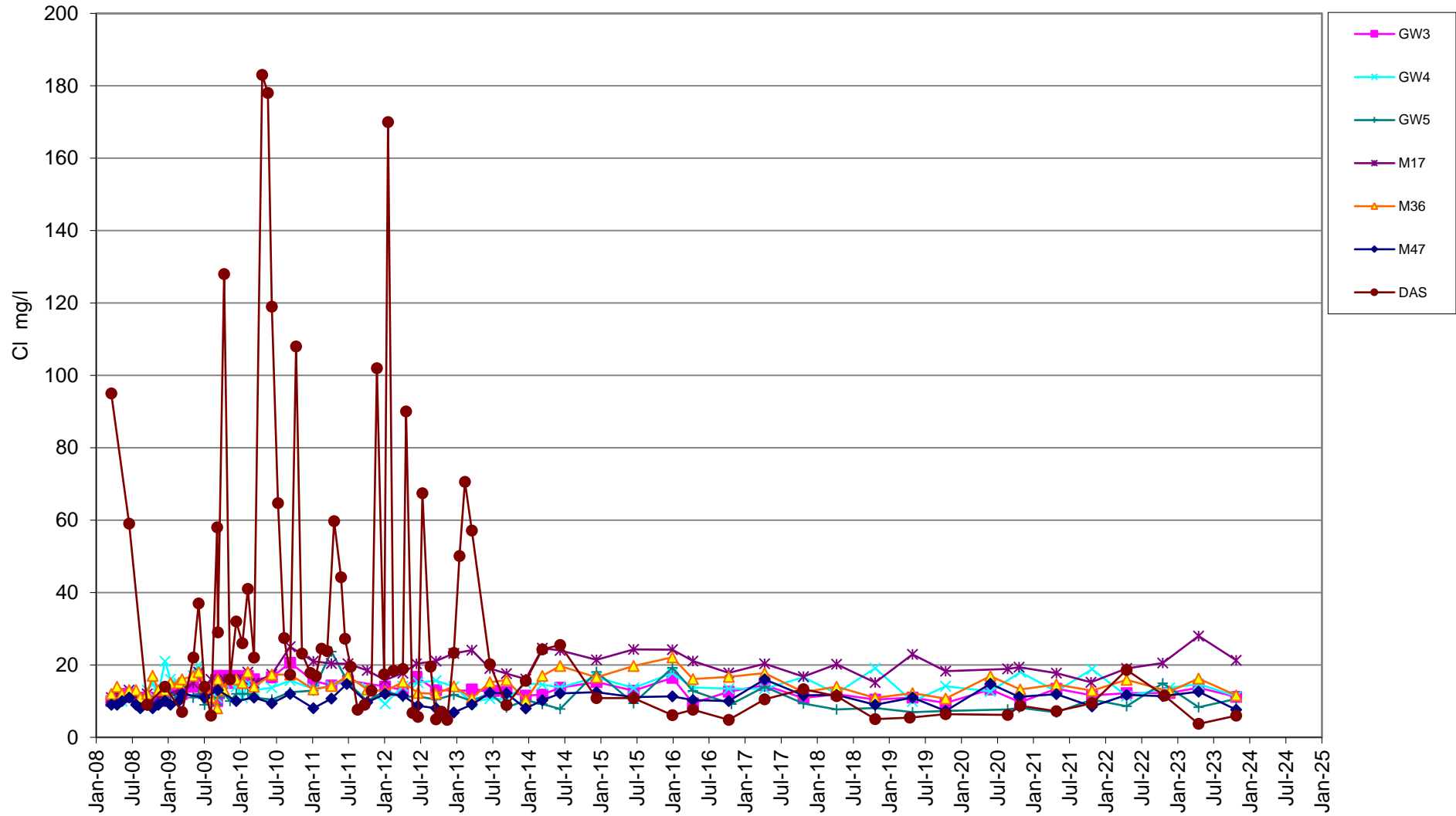
GROUNDWATER QUALITY PLOTS



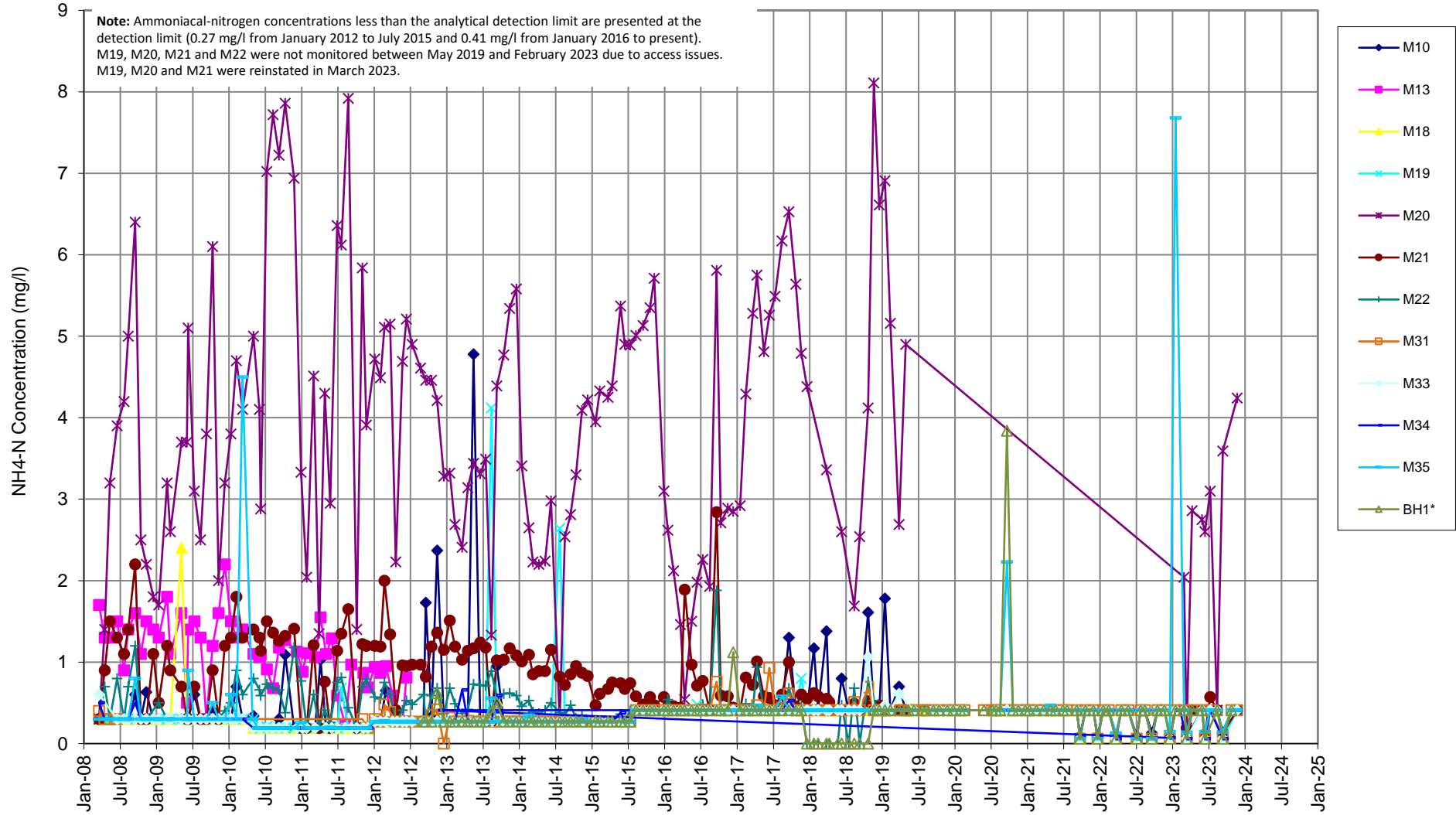
Llwyn Isaf Landfill - Ammoniacal-Nitrogen Groundwater Concentrations (Boreholes under EP for Area 3)



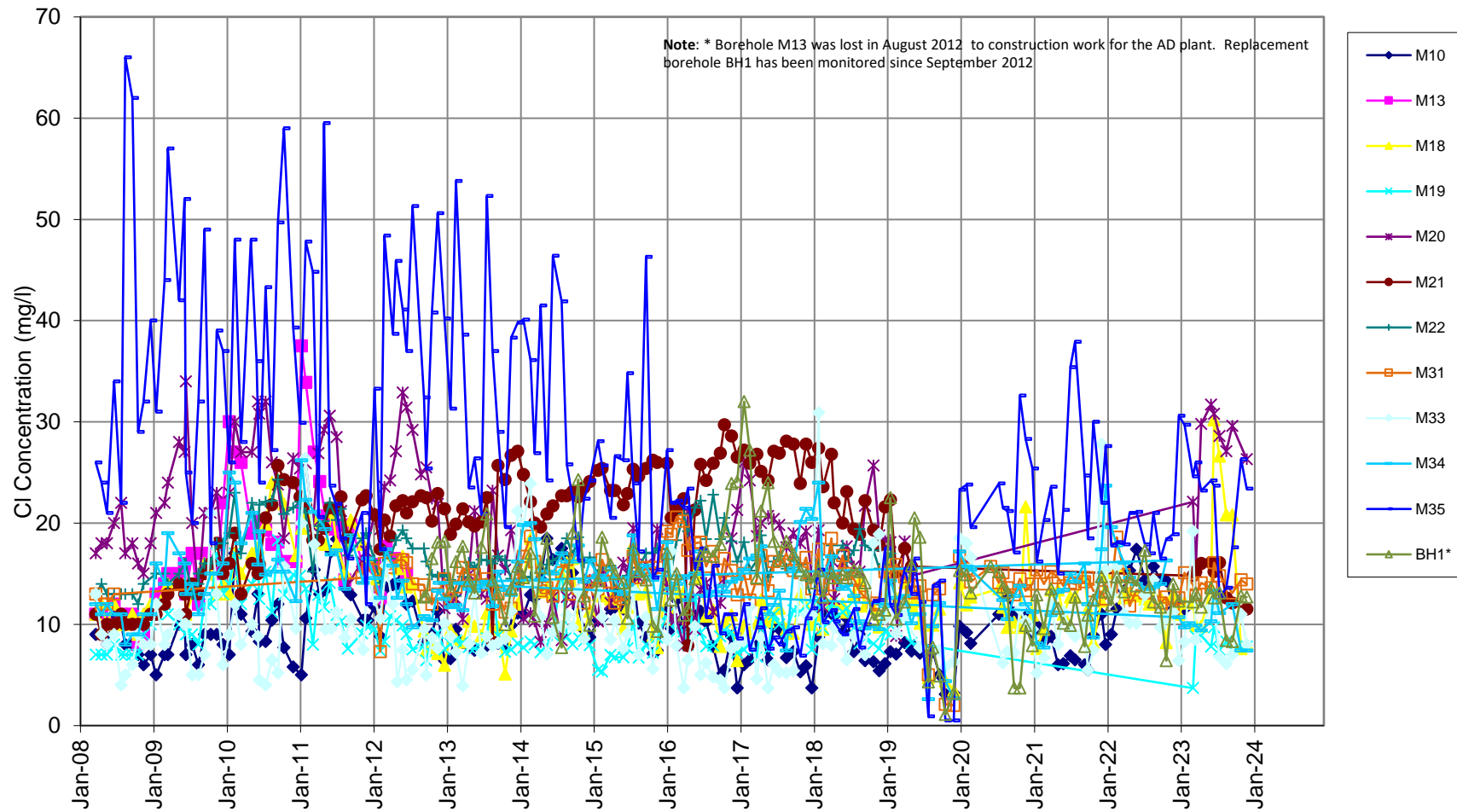
Llwyn Isaf Landfill - Chloride Groundwater Concentrations (Boreholes under EP for Area 3)



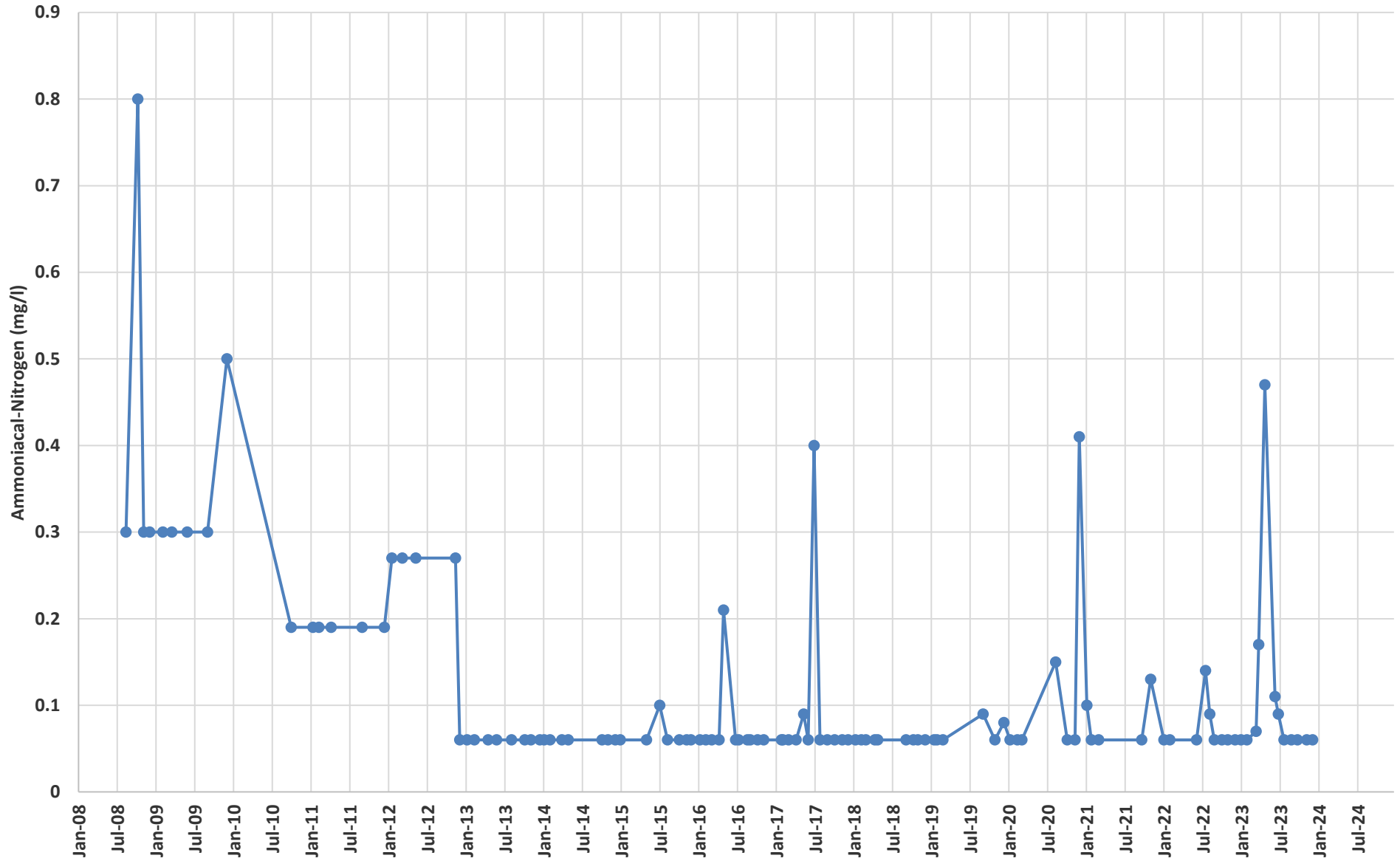
Llwyn Isaf Landfill - Ammoniacal-Nitrogen Groundwater Concentrations (Boreholes under former WML for Area 2)



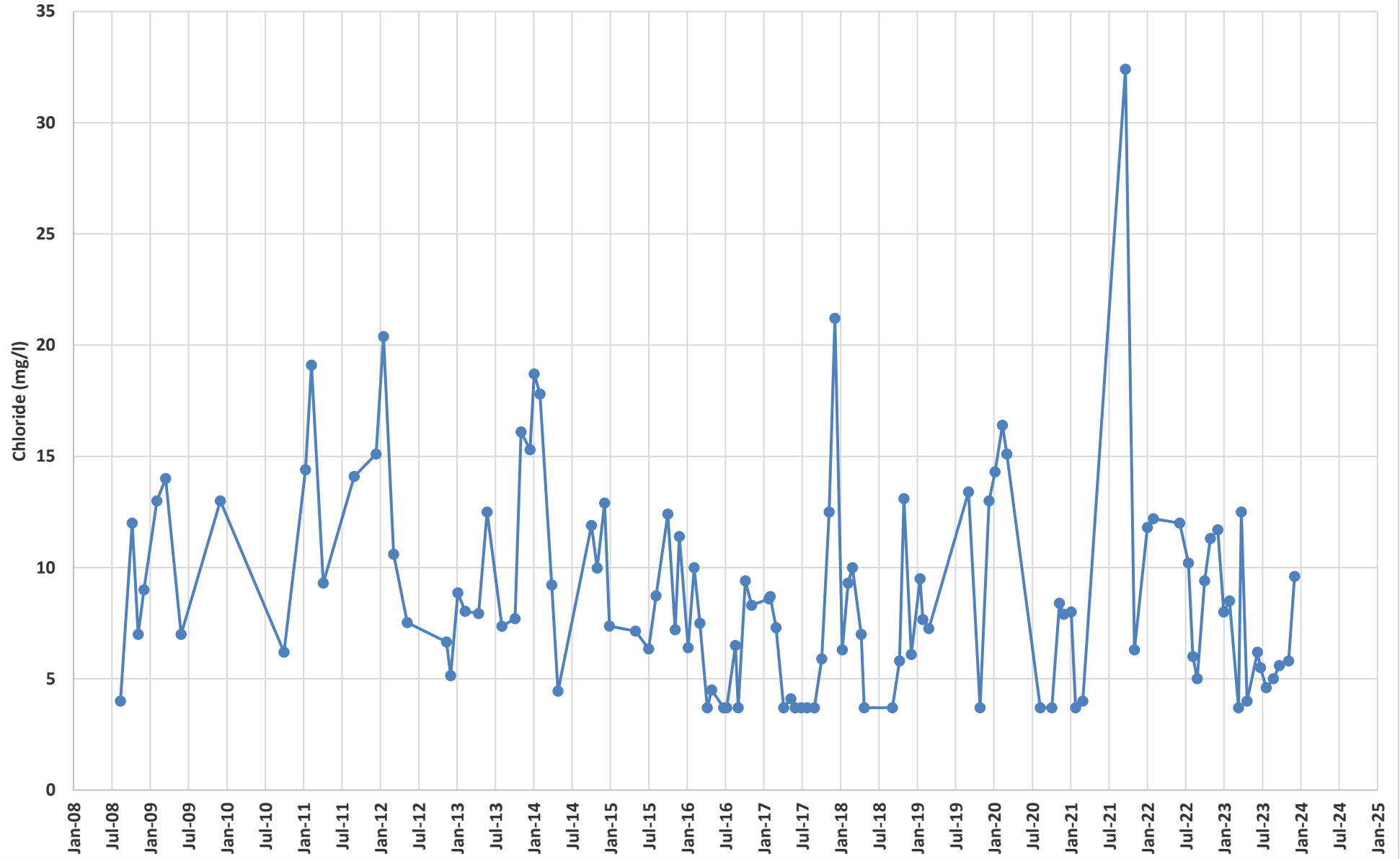
Llwyn Isaf Landfill - Chloride Groundwater Concentration (Boreholes under former WML for Area 2)



Llwyn Isaf Landfill - Soakaway NS Water Quality (Ammoniacal-N)



Llwyn Isaf Landfill - Soakaway NS Water Quality (Chloride)

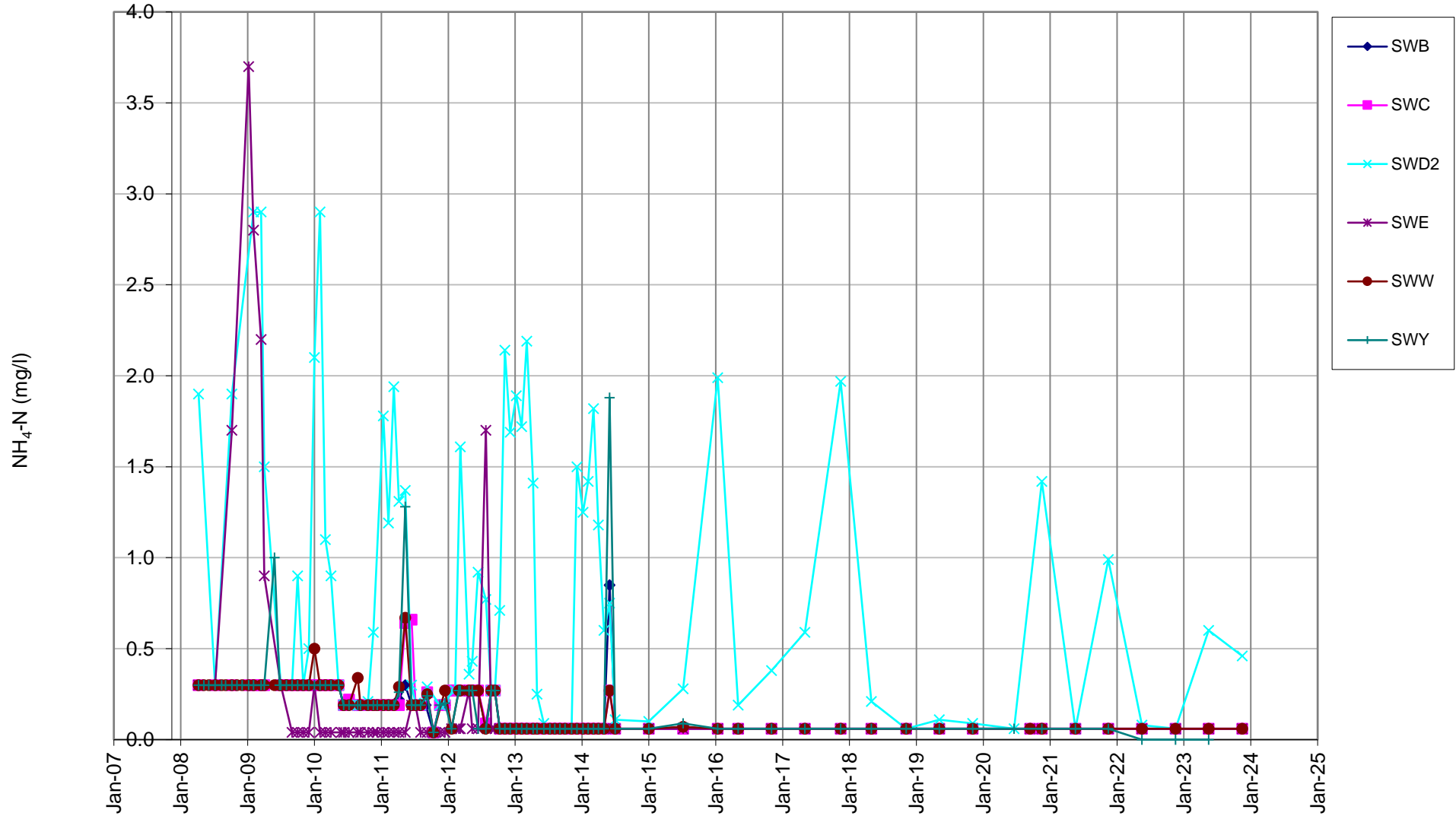


Appendix E

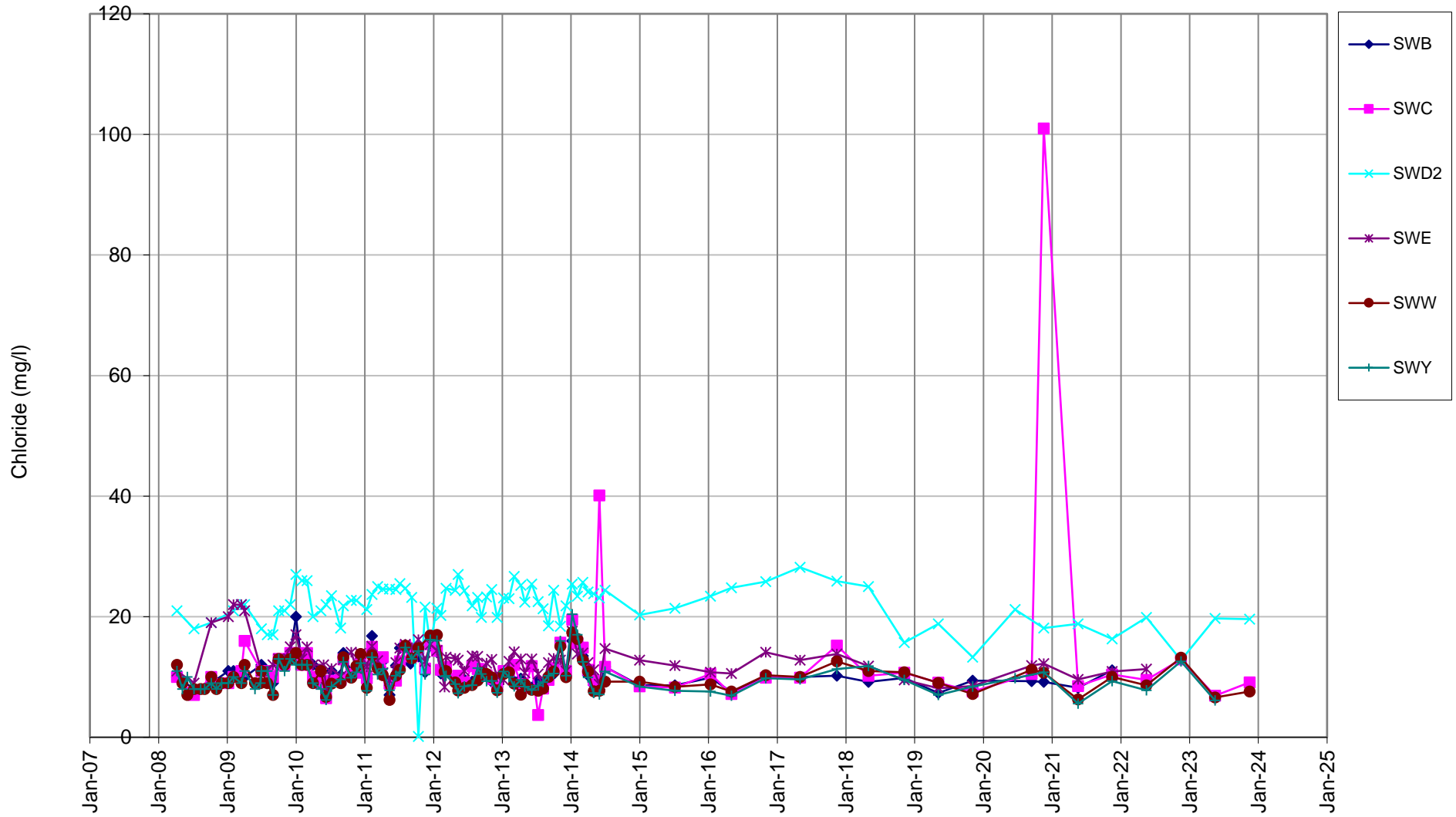
SURFACE WATER QUALITY PLOTS

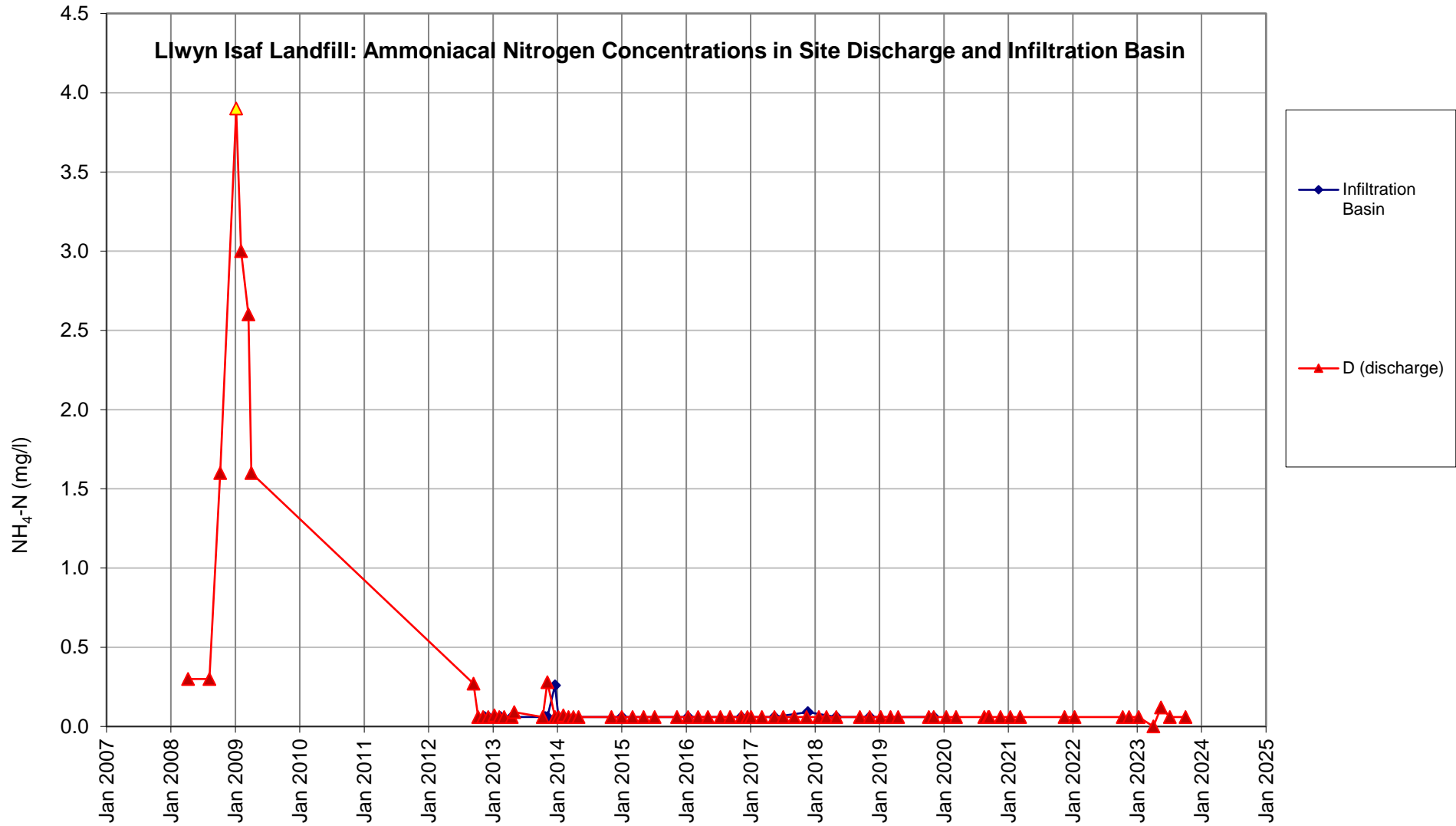


Llwyn Isaf Landfill: Ammoniacal Nitrogen Concentrations in Afon Desach and Lake to the North of Site

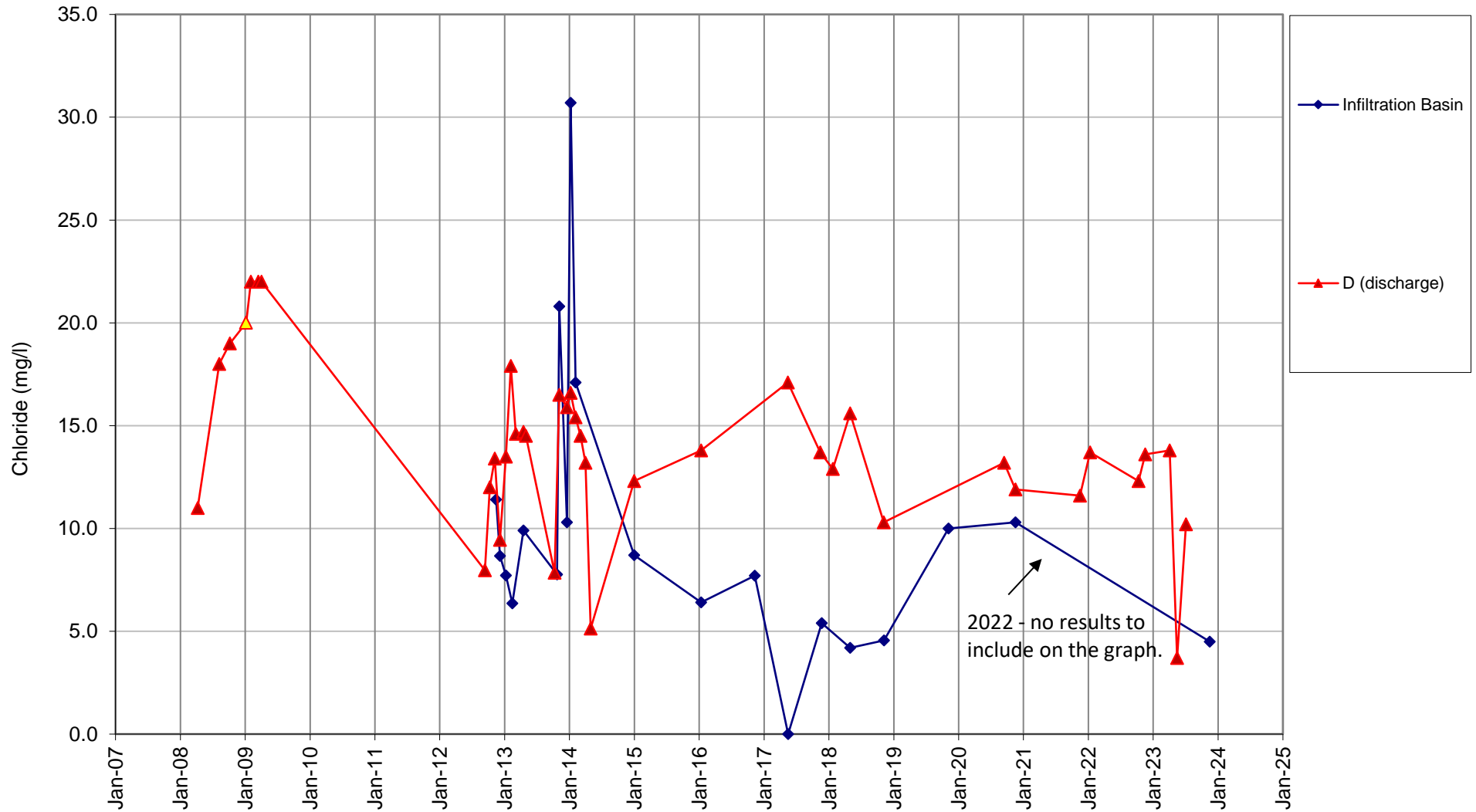


Llwyn Isaf Landfill: Chloride Concentrations in Afon Desach and Lake to the North of Site





Llwyn Isaf Landfill: Chloride Concentrations in Site Discharge and Infiltration Basin



Appendix F

GAS BALANCING DATA



Security code [EF02472D]

ID	DATE	CH4 %	CO2 %	O2 %	BALANCE %	Res Nitrog %	CO ppm	H2S ppm	BARO mb	REL.PRESS mb	ANSWER 1
LI_FLARE	25/01/2023 13:14	57.3	22.9	0.3	19.5	18.37		1	3	1033	-4.66
LI_FLARE	02/02/2023 14:21	55.4	22.5	0.5	21.6	19.71		1	3	1029	-4.83
LI_FLARE	10/02/2023 13:12	53.8	22.3	0.4	23.5	21.99		1	3	1037	-4.8
LI_FLARE	14/02/2023 13:46	53.8	22.5	0.5	23.2	21.31		1	3	1032	-4.55
LLIFTRG4	23/02/2023 13:26	0	1.3	19.5	79.2	5.49		0	0	1025	0.11
LLIFTRG3	23/02/2023 13:28	0	0.2	20.9	78.9	0		0	0	1027	0.09
LLIFTRG2	23/02/2023 13:33	0	1.8	18.2	80	11.2		0	0	1028	0.09
LLIFTR1A	23/02/2023 13:38	0	1.5	3.7	94.8	80.81		1	0	1027	0.32
LLIFTRG7	23/02/2023 13:41	2.8	2.5	0.9	93.8	90.4		0	0	1027	0.09
LLIFTRG6	23/02/2023 13:43	2.3	4.1	0.5	93.1	91.21		0	0	1026	0.11
LLIFTRG5	23/02/2023 13:47	0	0.1	21.7	78.2	0		0	0	1027	0.09
LI_FLARE	23/02/2023 13:51	52.6	22.6	0.3	24.5	23.37		3	2	1026	-4.59
LI_FLARE	02/03/2023 14:49	52.6	22.5	0.3	24.6	23.47		2	4	1031	-4.15
LI_FLARE	09/03/2023 14:10	55.5	23.3	0.3	20.9	19.77		1	5	993	-3.94
LI_FLARE	17/03/2023 14:04	53.5	22.5	0.3	23.7	22.57		2	6	1005	-4.15
LI_FLARE	23/03/2023 14:41	55	22.8	0.3	21.9	20.77		2	5	994	-3.97
LLIFTRG4	30/03/2023 13:36	0.1	0.2	20.9	78.8	0		0	0	1006	0.18
LLIFTRG3	30/03/2023 13:38	0.1	0.2	20.8	78.9	0.28		0	0	1004	0.14
LLIFTRG2	30/03/2023 13:43	0.1	0.2	21	78.7	0		0	0	1004	0.16
LLIFTR1A	30/03/2023 13:48	0.1	1	2	96.9	89.34		0	0	1004	0.74
LLIFTRG7	30/03/2023 13:50	1.2	1.9	0.7	96.2	93.55		0	0	1004	0.21
LLIFTRG6	30/03/2023 13:52	4	2.7	0.6	92.7	90.43		0	0	1004	0.16
LLIFTRG5	30/03/2023 13:56	0.1	0.4	20.3	79.2	2.47		0	0	1003	0.18
LI_FLARE	30/03/2023 14:00	50.5	22.4	0.3	26.8	25.67		2	3	1004	-4.57
LI_FLARE	06/04/2023 13:20	48.6	22.1	0.3	29	27.87		2	3	1023	-4.83
LI_FLARE	14/04/2023 14:11	49.2	22.7	0.3	27.8	26.67		1	4	1013	-4.81
LLIFTRG4	19/04/2023 14:36	0	0	20.6	79.4	1.53		1	0	1032	-0.05
LLIFTRG3	19/04/2023 14:38	0	0.3	20.3	79.4	2.67		1	0	1031	-0.05
LLIFTRG2	19/04/2023 14:43	0	0.7	19.9	79.4	4.18		1	0	1031	0.02
LLIFTR1A	19/04/2023 14:49	0.1	0.9	0.4	98.6	97.09		1	0	1030	0.95
LLIFTRG7	19/04/2023 14:52	2.4	1.9	0.4	95.3	93.79		1	0	1030	0.02
LLIFTRG6	19/04/2023 14:55	1.5	3.4	1.7	93.4	86.97		1	0	1031	0.07
LLIFTRG5	19/04/2023 14:59	0	1.1	16.2	82.7	21.46		0	0	1029	0.21
LI_FLARE	19/04/2023 15:03	46.7	21.7	0.4	31.2	29.69		3	2	1028	-4.25
LLIFTRG4	11/05/2023 12:37	0.2	0.2	21.1	78.5	0		0	0	1021	0.23
LLIFTRG3	11/05/2023 12:40	0.1	0.7	20.1	79.1	3.12		0	0	1021	0.19
LLIFTRG2	11/05/2023 12:47	0.1	0.1	21.2	78.6	0		0	0	1021	0.18
LLIFTR1A	11/05/2023 12:54	0	1.5	0.8	97.7	94.68		0	0	1021	-0.44
LLIFTRG7	11/05/2023 12:57	0.3	3	5.9	90.8	68.5		0	0	1023	0.14
LLIFTRG6	11/05/2023 13:00	1.4	4.2	0.8	93.6	90.58		0	0	1020	0.11
LLIFTRG5	11/05/2023 13:04	0	0.1	21.2	78.7	0		0	0	1020	0.14
LI_FLARE	11/05/2023 13:10	43.4	19.1	2.8	34.7	24.12		2	1	1020	-3.75
LLIFTRG3	15/06/2023 12:22	0.1	1.1	19.6	79.2	5.11		1	0	1026	0.16
LLIFTRG4	15/06/2023 12:28	0	0.1	21	78.9	0		1	0	1024	0.07
LLIFTRG2	15/06/2023 12:38	0	0	21	79	0		2	0	1024	-0.02
LLIFTR1A	15/06/2023 12:56	0	4.8	15.2	80	22.54		2	0	1015	-0.02
LLIFTRG7	15/06/2023 13:00	0	0	21	79	0		2	0	1024	-0.07
LLIFTRG5	15/06/2023 13:07	0	0	21.4	78.6	0		2	0	1025	-0.07
LLIFTRG6	15/06/2023 13:14	0.4	3.3	7.1	89.2	62.36		2	0	1024	-0.04
LI_FLARE	15/06/2023 13:17	37.3	16.6	5.9	40.2	17.9		5	0	1024	-3.26
LLIFTRG4	06/07/2023 11:20	0.1	0.1	21.8	78	0		0	0	1017	0
LLIFTRG3	06/07/2023 11:23	0.1	1.8	18.3	79.8	10.63		0	0	1019	0.16
LLIFTRG2	06/07/2023 11:33	0	0.1	21.1	78.8	0		0	0	1019	0.11
LLIFTR1A	06/07/2023 11:44	0	5.5	15.5	79	20.41		0	0	1017	0.07
LLIFTRG7	06/07/2023 11:47	0	0.1	21.2	78.7	0		0	0	1018	0.09
LLIFTRG6	06/07/2023 11:50	0.8	4.6	4.6	90	72.61		1	0	1017	0.12
LLIFTRG5	06/07/2023 11:54	0	2.8	16.2	81	19.76		0	0	1018	0.09
LI_FLARE	06/07/2023 12:01	45.9	21.7	2.6	29.8	19.97		3	2	1017	-3.87
LLWISAG4	01/08/2023 12:50	0.1	2.3	18.2	79.4	10.6		0	0	1008	0.18
LLWISAG3	01/08/2023 12:53	0	3.7	16.5	79.8	17.43		0	0	1010	0.11
LLWISAG2	01/08/2023 13:01	0	0.1	20.6	79.3	1.43		0	0	1008	0.14
LLIFTG1A	01/08/2023 13:12	0	4	1.7	94.3	87.87		1	0	999	0.12
LLIFTRG7	01/08/2023 13:15	0	4.5	7.3	88.2	60.61		1	0	1009	0.02
LLIFTRG6	01/08/2023 13:17	1.7	4.5	0.4	93.4	91.89		1	0	1008	0.05
LLIFTRG5	01/08/2023 13:21	0	3.6	14	82.4	29.48		0	0	1008	0.05
LI_FLARE	01/08/2023 13:26	44.3	20.7	3.6	31.4	17.79		2	1	1007	-3.36
LLIFTRG4	20/09/2023 12:51	0.1	3	17.8	79.1	11.82		0	0	996	0.16
LLIFTRG3	20/09/2023 12:54	0.1	3	15.9	81	20.9		0	0	996	0.18
LLIFTRG2	20/09/2023 12:59	0	5.2	15	79.8	23.1		0	0	997	0.19
LLIFTG1A	20/09/2023 13:05	0.2	4.4	0.2	95.2	94.44		0	0	996	0.18
LLIFTRG7	20/09/2023 13:08	0.2	4.6	1	94.2	90.42		0	1	998	0.19
LLIFTRG6	20/09/2023 13:10	0.2	3.1	0.4	92.2	91.60		0	1	996	0.19

Appendix G

METEOROLOGICAL DATA



CYNGOR GWYNEDD - GWASANAETH TRIN GWASTRAFF

RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

JANUARY 2023		RAINFALL		WIND		CLOUD DESCRIPTION	WEATHER DESCRIPTION
DATE	HOUR	DAILY	MONTH TODATE				
1	A.M./P.M.	MM.	MM.	M.P.H.			
2	A.M./P.M.	MM.	MM.	M.P.H.			
3	A.M./P.M.	68 MM.	68 MM.	88.0 M.P.H.	Cloudy	RAIN	
4	A.M./P.M.	30 MM.	98 MM.	17.0 M.P.H.	Cloudy	RAIN	
5	A.M./P.M.	0 MM.	98 MM.	11.9 M.P.H.	Cloudy	RAIN	
6	A.M./P.M.	20 MM.	118 MM.	8.9 M.P.H.	Cloudy	Dry	
7	A.M./P.M.	MM.	MM.	M.P.H.			
8	A.M./P.M.	MM.	MM.	M.P.H.			
9	A.M./P.M.	45 MM.	163 MM.	23.8 M.P.H.	Cloudy	RAIN	
10	A.M./P.M.	48 MM.	211 MM.	8.6 M.P.H.	Cloudy	Heavy Rain	
11	A.M./P.M.	18 MM.	229 MM.	17.7 M.P.H.	Cloudy	Dry	
12	A.M./P.M.	2 MM.	237 MM.	17.7 M.P.H.	Cloudy	Dry	
13	A.M./P.M.	2 MM.	245 MM.	12.5 M.P.H.	Cloudy	Dry	
14	A.M./P.M.	3 MM.	MM.	M.P.H.			
15	A.M./P.M.	MM.	MM.	M.P.H.			
16	A.M./P.M.	45 MM.	290 MM.	10.8 M.P.H.	Cloudy	Dry	
17	A.M./P.M.	MM.	290 MM.	5.1 M.P.H.	Cloudy	Dry	
18	A.M./P.M.	4 MM.	294 MM.	21.5 M.P.H.	Cloudy	Dry	
19	A.M./P.M.	MM.	294 MM.	7.4 M.P.H.	Cloudy	RAIN	
20	A.M./P.M.	MM.	294 MM.	1.6 M.P.H.	Cloudy	RAIN	
21	A.M./P.M.	MM.	MM.	M.P.H.		Dry	
22	A.M./P.M.	MM.	MM.	M.P.H.			
23	A.M./P.M.	MM.	294 MM.	7.2 M.P.H.	Cloudy	Dry	
24	A.M./P.M.	MM.	294 MM.	6.7 M.P.H.	Cloudy	Dry	
25	A.M./P.M.	MM.	294 MM.	8.1 M.P.H.	Cloudy	SHALE RAIN	
26	A.M./P.M.	MM.	MM.	M.P.H.			
27	A.M./P.M.	MM.	MM.	M.P.H.			
28	A.M./P.M.	MM.	MM.	M.P.H.			
29	A.M./P.M.	MM.	MM.	M.P.H.			
30	A.M./P.M.	MM.	MM.	M.P.H.			
31	A.M./P.M.	MM.	MM.	M.P.H.			

RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

FEBRUARY 2023		RAINFALL		WIND		CLOUD DESCRIPTION	WEATHER DESCRIPTION	
DATE	HOUR	DAILY	MONTH TODAY					
1	A.M./P.M.	MM.	MM.		M.P.H.			
2	A.M./P.M.	MM.	MM.		M.P.H.			
3	A.M./P.M.	5	5	7	4	M.P.H.	Clear	
4	A.M./P.M.	MM.	MM.		M.P.H.		Dry	
5	A.M./P.M.	MM.	MM.		M.P.H.			
6	A.M./P.M.	MM.	MM.	6		M.P.H.	Clear	
7	A.M./P.M.	MM.	MM.	5	8	M.P.H.	Clear	
8	A.M./P.M.	MM.	MM.	5	4	M.P.H.	Dry	
9	A.M./P.M.	MM.	MM.	5	28	9	M.P.H.	Clear
10	A.M./P.M.	MM.	MM.	5		M.P.H.	Clear	
11	A.M./P.M.	MM.	MM.		8	9	M.P.H.	Cloudy
12	A.M./P.M.	MM.	MM.		M.P.H.		Dry	
13	A.M./P.M.	5	10	4	5	M.P.H.	Clear	
14	A.M./P.M.	MM.	MM.	10	5	M.P.H.	Clear	
15	A.M./P.M.	MM.	MM.	10	12	5	M.P.H.	Clear
16	A.M./P.M.	5	13	11	2	M.P.H.	Clear	
17	A.M./P.M.	5	20	9	5	M.P.H.	Clear	
18	A.M./P.M.	MM.	MM.		M.P.H.		Dry	
19	A.M./P.M.	MM.	MM.		M.P.H.			
20	A.M./P.M.	20	40	14	1	M.P.H.	Cloudy	
21	A.M./P.M.	MM.	MM.		M.P.H.		Dry	
22	A.M./P.M.	15	40	15	4	M.P.H.	Cloudy	
23	A.M./P.M.	MM.	MM.	12	5	M.P.H.	Clear	
24	A.M./P.M.	15	55	12	5	M.P.H.	Clear	
25	A.M./P.M.	MM.	MM.	10	3	M.P.H.	Clear	
26	A.M./P.M.	MM.	MM.		M.P.H.			
27	A.M./P.M.	MM.	MM.	6	7	M.P.H.	Clear	
28	A.M./P.M.	MM.	MM.	60		M.P.H.	Clear	
29	A.M./P.M.	MM.	MM.		2	2	M.P.H.	Clear
30	A.M./P.M.	MM.	MM.		M.P.H.		Dry	
31	A.M./P.M.	MM.	MM.		M.P.H.		Clear	

CYNGOR GWYNEDD - GWASANAETH TRIN GWASTRAFF
RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

MARCH 2023		RAINFALL		WIND		CLOUD DESCRIPTION	WEATHER DESCRIPTION
DATE	HOUR	DAILY	MONTH TODATE				
1	A.M./P.M.	—	MM.	5.1	M.P.H.	Clear	Dry / Clear
2	A.M./P.M.	—	MM.	0.2	M.P.H.	Clear	Slight Rain
3	A.M./P.M.	—	MM.	2.9	M.P.H.	Clear	Dry / Frosty
4	A.M./P.M.		MM.				
5	A.M./P.M.		MM.				
6	A.M./P.M.		MM.				
7	A.M./P.M.		MM.				
8	A.M./P.M.		MM.				
9	A.M./P.M.		MM.				
10	A.M./P.M.		MM.				
11	A.M./P.M.		MM.				
12	A.M./P.M.		MM.				
13	A.M./P.M.	50	MM.	19.7	M.P.H.	Cloudy	Rain
14	A.M./P.M.	10	MM.	8.1	M.P.H.	Clear	Dry
15	A.M./P.M.	10	MM.	5.1	M.P.H.	Clear	Clear
16	A.M./P.M.	27	MM.	1.7	M.P.H.	Cloudy	Heavy Rain
17	A.M./P.M.	25	MM.	4.2	M.P.H.	Clear	Dry
18	A.M./P.M.		MM.				
19	A.M./P.M.		MM.				
20	A.M./P.M.	25	MM.	11.2	M.P.H.	Cloudy	Rain
21	A.M./P.M.	20	MM.	8.1	M.P.H.	Cloudy	Rain
22	A.M./P.M.	30	MM.	5.8	M.P.H.	Clear	Dry
23	A.M./P.M.	5	MM.	16.3	M.P.H.	Cloudy	Rain
24	A.M./P.M.	8	MM.	15.2	M.P.H.	Cloudy	Rain
25	A.M./P.M.	5	MM.	2.2	M.P.H.	Clear	Dry / Clear
26	A.M./P.M.	0	MM.	14.0	M.P.H.	Cloudy	Rain
27	A.M./P.M.	23	MM.	11.2	M.P.H.	Clear	Rain
28	A.M./P.M.	25	MM.	12.5	M.P.H.	Clear	Rain
29	A.M./P.M.	10	MM.	10.2	M.P.H.	Cloudy	Rain
30	A.M./P.M.		MM.				
31	A.M./P.M.		MM.				

RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

APRIL 2023		RAINFALL		WIND		CLOUD DESCRIPTION	WEATHER DESCRIPTION
DATE	HOUR	DAILY	MONTH TODATE				
1	A.M./P.M.	MM.	MM.		M.P.H.		
2	A.M./P.M.	MM.	MM.		M.P.H.		
3	A.M./P.M.	8	5	9-6	M.P.H.	Clear	Dr
4	A.M./P.M.	1	5	2-4	M.P.H.	Clear	Dr
5	A.M./P.M.	8	13	10-3	M.P.H.	Cloudy	Dr
6	A.M./P.M.	20	33	9-2	M.P.H.	Cloudy	Rain
7	A.M./P.M.	MM.	MM.		M.P.H.		Strong Rain
8	A.M./P.M.	MM.	MM.		M.P.H.		
9	A.M./P.M.	MM.	MM.		M.P.H.		
10	A.M./P.M.	MM.	MM.		M.P.H.		
11	A.M./P.M.	MM.	MM.		M.P.H.		
12	A.M./P.M.	MM.	MM.		M.P.H.		
13	A.M./P.M.	MM.	MM.		M.P.H.		
14	A.M./P.M.	42	75	7-4	M.P.H.	Cloudy	Rain
15	A.M./P.M.	MM.	MM.		M.P.H.		
16	A.M./P.M.	MM.	MM.		M.P.H.		
17	A.M./P.M.	5	80	4-5	M.P.H.	Cloudy	Light Rain
18	A.M./P.M.	1	80	4-5	M.P.H.	Clear	Dr
19	A.M./P.M.	1	80	16-3	M.P.H.	Clear	Dr / Sunny
20	A.M./P.M.	1	80	6-7	M.P.H.	Clear	Dr
21	A.M./P.M.	1	80	6-7	M.P.H.	Cloudy	Rain
22	A.M./P.M.	MM.	MM.		M.P.H.		
23	A.M./P.M.	MM.	MM.		M.P.H.		
24	A.M./P.M.	7	80	2-2	M.P.H.	Cloudy	Rain
25	A.M./P.M.	1	80	6-7	M.P.H.	Clear	Dr
26	A.M./P.M.	MM.	MM.		M.P.H.		
27	A.M./P.M.	MM.	MM.		M.P.H.		
28	A.M./P.M.	5	85	2-00	M.P.H.	Cloudy	Rain
29	A.M./P.M.	MM.	MM.		M.P.H.		
30	A.M./P.M.	MM.	MM.		M.P.H.		
31	A.M./P.M.	MM.	MM.		M.P.H.		

CYNGOR GWYNEDD - GWASANAETH TRIN GWASTRAFF
RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

MAY 2023		RAINFALL		WIND		CLOUD DESCRIPTION		WEATHER DESCRIPTION	
DATE	HOUR	DAILY	MONTH TODAY						
1	A.M./P.M.	MM.	MM.		M.P.H.				
2	A.M./P.M.	20	20	9.10	M.P.H.	Cloudy	Rain		
3	A.M./P.M.	0	20	1.2	M.P.H.	Clear	Day/Sunny		
4	A.M./P.M.	0	20	7.4	M.P.H.	Clear	Day		
5	A.M./P.M.	5	25	14.2	M.P.H.	Cloudy	Rain		
6	A.M./P.M.				M.P.H.				
7	A.M./P.M.				M.P.H.				
8	A.M./P.M.				M.P.H.				
9	A.M./P.M.	35	60	0.9	M.P.H.	Cloudy	Rain		
10	A.M./P.M.	-	60	14.1	M.P.H.	Cloudy	Some Rain		
11	A.M./P.M.	5	65	2.9	M.P.H.	Cloudy	Some Rain		
12	A.M./P.M.	-	65	22.5	M.P.H.	Clear	Day		
13	A.M./P.M.				M.P.H.				
14	A.M./P.M.				M.P.H.				
15	A.M./P.M.		65	9.4	M.P.H.	Clear	Day		
16	A.M./P.M.	-	65	5.1	M.P.H.	Clear	Day		
17	A.M./P.M.	-	65	2.9	M.P.H.	Clear	Day/Sunny		
18	A.M./P.M.	-	65	3.8	M.P.H.	Clear	Day/Sunny		
19	A.M./P.M.	-	65	8.8	M.P.H.	Cloudy	Fine Rain		
20	A.M./P.M.				M.P.H.				
21	A.M./P.M.				M.P.H.				
22	A.M./P.M.	-	65	6.9	M.P.H.	Clear	Day/Sunny		
23	A.M./P.M.	-	65	6.5	M.P.H.	Clear	Day/Sunny		
24	A.M./P.M.	-	65	6.9	M.P.H.	Clear	Day/Sunny		
25	A.M./P.M.	-	65	5.1	M.P.H.	Clear	Day/Sunny		
26	A.M./P.M.	-	65	2.2	M.P.H.	Clear	Day/Sunny		
27	A.M./P.M.				M.P.H.				
28	A.M./P.M.				M.P.H.				
29	A.M./P.M.				M.P.H.				
30	A.M./P.M.	-	65	2.9	M.P.H.	Clear	Day/Sunny		
31	A.M./P.M.	-	65	7.4	M.P.H.	Clear	Day/Sunny		

CYNGOR GWYNEDD - GWASANAETH TRIN GWASTRAFF

RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

JUNE 2023		RAINFALL		WIND		CLOUD DESCRIPTION		WEATHER DESCRIPTION	
DATE	HOUR	DAILY	MONTH	TODATE	WIND	CLOUD DESCRIPTION	WEATHER DESCRIPTION		
1	A.M./P.M.	→	MM.	MM.	2.9 M.P.H.	Clear	Day/Sunny		
2	A.M./P.M.	—	MM.	MM.	2.2 M.P.H.	Clear	Day/Sunny		
3	A.M./P.M.	MM.	MM.	MM.	M.P.H.		Day/Sunny		
4	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
5	A.M./P.M.	—	MM.	MM.	2.4 M.P.H.	Clear	Day/Sunny		
6	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
7	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
8	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
9	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
10	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
11	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
12	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
13	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
14	A.M./P.M.	15	MM.	15	4.5 M.P.H.	Clear	Day/Sunny		
15	A.M./P.M.	—	MM.	15	1.6 M.P.H.	Clear	Day/Sunny		
16	A.M./P.M.	—	MM.	15	2.9 M.P.H.	Clear	Day/Sunny		
17	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
18	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
19	A.M./P.M.	13	MM.	28	7.4 M.P.H.	Cloudy	Rain		
20	A.M./P.M.	—	MM.	28	1.6 M.P.H.	Clear	Day		
21	A.M./P.M.	—	MM.	MM.	7.4 M.P.H.	Clear	Day		
22	A.M./P.M.	—	MM.	MM.	1.6 M.P.H.	Clear	Day		
23	A.M./P.M.	—	MM.	MM.	11.2 M.P.H.	Cloudy	Rain		
24	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
25	A.M./P.M.	MM.	MM.	MM.	M.P.H.				
26	A.M./P.M.	23	MM.	51	12.6 M.P.H.	Clear	Day/Sunny		
27	A.M./P.M.	—	MM.	51	8.5 M.P.H.	Clear	Slight Rain		
28	A.M./P.M.	—	MM.	MM.	3.2 M.P.H.	Clear	Day		
29	A.M./P.M.	5	MM.	56	4.5 M.P.H.	Clear	Day		
30	A.M./P.M.	—	MM.	56	8.1 M.P.H.	Clear	Day		
31	A.M./P.M.	MM.	MM.	MM.	M.P.H.		Rain		

CYNGOR GWYNEDD - GWASANAETH TRIN GWASTRAFF
RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

JULY 2023		RAINFALL		WIND		CLOUD DESCRIPTION	WEATHER DESCRIPTION
DATE	HOUR	DAILY	MONTH TODATE				
1	A.M./P.M.	MM.	MM.		M.P.H.		
2	A.M./P.M.	MM.	MM.		M.P.H.		
3	A.M./P.M.	10	10	2.9	M.P.H.	Cloud	Dry
4	A.M./P.M.	-	10	3.8	M.P.H.	Cloud	Dry / Sun
5	A.M./P.M.	5	15	7.6	M.P.H.	Cloud	Dry
6	A.M./P.M.	-	15	10.3	M.P.H.	Cloud	Dry
7	A.M./P.M.	5	15	14.8	M.P.H.	Cloud	Dry
8	A.M./P.M.	MM.	MM.		M.P.H.		
9	A.M./P.M.	MM.	MM.		M.P.H.		
10	A.M./P.M.	5	20	11.0	M.P.H.	Cloud	Dry / Rain
11	A.M./P.M.	25	45	4.5	M.P.H.	Cloud	Clouds
12	A.M./P.M.	-	45	10.3	M.P.H.	Cloud	Rain
13	A.M./P.M.	-	45	2.2	M.P.H.	Cloud	Dry
14	A.M./P.M.	MM.	MM.		M.P.H.		
15	A.M./P.M.	MM.	MM.		M.P.H.		
16	A.M./P.M.	MM.	MM.		M.P.H.		
17	A.M./P.M.	25	70	8.8	M.P.H.	Cloud	Dry
18	A.M./P.M.	5	75	8.1	M.P.H.	Cloud	Dry
19	A.M./P.M.	23	98	4.5	M.P.H.	Cloud	Rain
20	A.M./P.M.	-	98	1.6	M.P.H.	Cloud	Dry
21	A.M./P.M.	-	98	6.2	M.P.H.	Cloud	Dry
22	A.M./P.M.	MM.	MM.		M.P.H.		
23	A.M./P.M.	MM.	MM.		M.P.H.		
24	A.M./P.M.	MM.	MM.		M.P.H.		
25	A.M./P.M.	52	150	2.2	M.P.H.	Cloud	Dry
26	A.M./P.M.	0	150	22.8	M.P.H.	Cloud	Dry
27	A.M./P.M.	24	174	6.9	M.P.H.	Cloud	Rain
28	A.M./P.M.	-	178	7.5	M.P.H.	Cloud	Dry
29	A.M./P.M.	MM.	MM.		M.P.H.		
30	A.M./P.M.	MM.	MM.		M.P.H.		
31	A.M./P.M.	20	198	8.1	M.P.H.	Cloud	Dry

RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

AUGUST 2023		RAINFALL		WIND		CLOUD DESCRIPTION		WEATHER DESCRIPTION	
DATE	HOUR	DAILY	MONTH	WIND	CLOUD DESCRIPTION	WEATHER DESCRIPTION	WEATHER DESCRIPTION	WEATHER DESCRIPTION	WEATHER DESCRIPTION
		MM.	MM.	M.P.H.					
1	A.M./P.M.	5	5	81	Clear	Dry			
2	A.M./P.M.	8	12	74	Cloud	Sunny			
3	A.M./P.M.	1	13	96	Cloud	Cloud			
4	A.M./P.M.	5	18	74	Cloud	Dry			
5	A.M./P.M.								
6	A.M./P.M.								
7	A.M./P.M.								
8	A.M./P.M.	25	43	14.5	Cloud	Dry			
9	A.M./P.M.	1	43	51	Cloud	Dry			
10	A.M./P.M.	1	43	11.9	Cloud	Dry / Sunny			
11	A.M./P.M.	5	48	14.1	Cloud	Dry			
12	A.M./P.M.								
13	A.M./P.M.								
14	A.M./P.M.	1	48	14.1	Cloudy	Very Dry			
15	A.M./P.M.								
16	A.M./P.M.	10	58	16	Cloud	Dry / Sunny			
17	A.M./P.M.	1	58	81	Cloud	Dry / Sunny			
18	A.M./P.M.	1	58	10.2	Cloud	Very			
19	A.M./P.M.								
20	A.M./P.M.								
21	A.M./P.M.	23	81	14.8	Cloud	Sunny			
22	A.M./P.M.	7	88	74	Cloud	Cloudy			
23	A.M./P.M.	5	93	6.9	Cloud	Dry			
24	A.M./P.M.	12	105	2.9	Cloud	Dry			
25	A.M./P.M.	1	105		Cloud	Very			
26	A.M./P.M.								
27	A.M./P.M.								
28	A.M./P.M.								
29	A.M./P.M.	5	110	2.2	Cloudy	Dry			
30	A.M./P.M.	1	110	7.4	Cloud	Very			
31	A.M./P.M.	1	110	10.2	Cloud	Dry			

CYNGOR GWYNEDD - GWASANAETH TRIN GWASTRAFF

RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

SEPTEMBER 2023		RAINFALL		WIND		CLOUD DESCRIPTION		WEATHER DESCRIPTION	
DATE	HOUR	DAILY	MONTH	TODATE					
1	A.M./P.M.	10	MM.	10	MM.	9-6	M.P.H.	Cloudy	Level
2	A.M./P.M.		MM.		MM.		M.P.H.		
3	A.M./P.M.		MM.		MM.		M.P.H.		
4	A.M./P.M.		MM.	10	MM.	4.2	M.P.H.	Cloudy	1st+ Rain
5	A.M./P.M.		MM.		MM.		M.P.H.		
6	A.M./P.M.		MM.		MM.		M.P.H.		
7	A.M./P.M.		MM.		MM.		M.P.H.		
8	A.M./P.M.		MM.		MM.		M.P.H.		
9	A.M./P.M.		MM.		MM.		M.P.H.		
10	A.M./P.M.		MM.		MM.		M.P.H.		
11	A.M./P.M.		MM.		MM.		M.P.H.		
12	A.M./P.M.		MM.		MM.		M.P.H.		
13	A.M./P.M.	23	MM.	33	MM.	8.9	M.P.H.	Cloudy	Dry
14	A.M./P.M.	13	MM.	46	MM.	7.4	M.P.H.	Cloudy	Dry
15	A.M./P.M.	8	MM.	54	MM.	9.6	M.P.H.	Cloudy	Wet
16	A.M./P.M.		MM.		MM.		M.P.H.		
17	A.M./P.M.		MM.		MM.		M.P.H.		
18	A.M./P.M.	23	MM.	79	MM.	3.8	M.P.H.	Cloudy	Rain
19	A.M./P.M.	29	MM.	104	MM.	22.8	M.P.H.	Cloudy	Rain
20	A.M./P.M.	28	MM.	132	MM.	19.9	M.P.H.	Cloudy	Heavy Rain
21	A.M./P.M.	15	MM.	149	MM.	2.2	M.P.H.	Cloudy	Dry
22	A.M./P.M.	15	MM.	162	MM.	2.4	M.P.H.	Dry	Cloudy
23	A.M./P.M.		MM.		MM.		M.P.H.		
24	A.M./P.M.		MM.		MM.		M.P.H.		
25	A.M./P.M.	6	MM.	232	MM.	10.3	M.P.H.	Dry	Cloudy
26	A.M./P.M.	1	MM.	232	MM.	12.5	M.P.H.	Cloudy	Dry
27	A.M./P.M.	7	MM.	229	MM.	8.9	M.P.H.	Cloudy	Rain
28	A.M./P.M.	7	MM.	236	MM.	4.5	M.P.H.	Cloudy	Dry
29	A.M./P.M.	5	MM.	241	MM.	8.1	M.P.H.	Cloudy	Dry
30	A.M./P.M.		MM.		MM.		M.P.H.		
31	A.M./P.M.		MM.		MM.		M.P.H.		

RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

OCTOBER 2023		RAINFALL		WIND		CLOUD DESCRIPTION		WEATHER DESCRIPTION	
DATE	HOUR	DAILY	MONTH TODATE						
1	A.M./P.M.	MM.	MM.		M.P.H.				
2	A.M./P.M.	32 MM.	32 MM.	2.9 M.P.H.	Clear	Dry			
3	A.M./P.M.	7 MM.	42 MM.	4.5 M.P.H.	Clear	Dry			
4	A.M./P.M.	MM.	42 MM.	67 M.P.H.	Clear	Dry			
5	A.M./P.M.	MM.	42 MM.	89 M.P.H.	Clear	Partly			
6	A.M./P.M.	22 MM.	64 MM.	192 M.P.H.	Clear	Partly			
7	A.M./P.M.	MM.	MM.	M.P.H.					
8	A.M./P.M.	MM.	MM.	M.P.H.					
9	A.M./P.M.	MM.	64 MM.	10.2 M.P.H.	Clear	Dry			
10	A.M./P.M.	MM.	64 MM.	11.9 M.P.H.	Clear	Dry			
11	A.M./P.M.	10 MM.	74 MM.	14.1 M.P.H.	Clear	Partly			
12	A.M./P.M.	7 MM.	81 MM.	2.9 M.P.H.	Clear	Dry			
13	A.M./P.M.	15 MM.	96 MM.	4.5 M.P.H.	Clear	Partly			
14	A.M./P.M.	MM.	MM.	M.P.H.					
15	A.M./P.M.	MM.	MM.	M.P.H.					
16	A.M./P.M.	MM.	96 MM.	7.4 M.P.H.	Clear	Dry			
17	A.M./P.M.	MM.	96 MM.	6.9 M.P.H.	Clear	Lightly			
18	A.M./P.M.	MM.	96 MM.	16.8 M.P.H.	Dry	Lightly			
19	A.M./P.M.	25 MM.	121 MM.	10.3 M.P.H.	Cloudy	Partly			
20	A.M./P.M.	14 MM.	135 MM.	176 M.P.H.	Cloudy	Partly			
21	A.M./P.M.	MM.	MM.	M.P.H.					
22	A.M./P.M.	MM.	MM.	M.P.H.					
23	A.M./P.M.	15 MM.	150 MM.	2.1 M.P.H.	Clear	Dry			
24	A.M./P.M.	MM.	150 MM.	9.6 M.P.H.	Cloudy	Dry			
25	A.M./P.M.	MM.	150 MM.	2.9 M.P.H.	Clear	Dry (Cool)			
26	A.M./P.M.	MM.	150 MM.	10.3 M.P.H.	Clear	Lightly			
27	A.M./P.M.	29 MM.	179 MM.	5.8 M.P.H.	Clear	Dry			
28	A.M./P.M.	MM.	MM.	M.P.H.					
29	A.M./P.M.	MM.	MM.	M.P.H.					
30	A.M./P.M.	22 MM.	199 MM.	11.9 M.P.H.	Clear	Dry			
31	A.M./P.M.	39 MM.	236 MM.	3.8 M.P.H.	Clear	Partly			

RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

NOVEMBER 2023		RAINFALL		WIND		CLOUD DESCRIPTION	WEATHER DESCRIPTION
DATE	HOUR	DAILY	MONTH	TODATE	WIND	CLOUD DESCRIPTION	WEATHER DESCRIPTION
1	A.M./P.M.	20 MM.	20	MM.	28.0 M.P.H.	Cloudy	Partly Day
2	A.M./P.M.	15 MM.	35	MM.	12.2 M.P.H.	Cloudy	Windy Day
3	A.M./P.M.	5 MM.	40	MM.	0 M.P.H.	Cloudy	Day
4	A.M./P.M.			MM.			
5	A.M./P.M.			MM.			
6	A.M./P.M.	3	45	MM.	11.9 M.P.H.	Cloudy	Day
7	A.M./P.M.	1	45	MM.	8.1 M.P.H.	Cloudy	Sunny Day
8	A.M./P.M.	2.3	68	MM.	2.9 M.P.H.	Cloudy	Day
9	A.M./P.M.	5	70	MM.	3.8 M.P.H.	Cloudy	Day
10	A.M./P.M.	2.5	98	MM.	7.4 M.P.H.	Cloudy	Day
11	A.M./P.M.			MM.			
12	A.M./P.M.			MM.			
13	A.M./P.M.	3.5	133	MM.	19.0 M.P.H.	Cloudy	Partly Day
14	A.M./P.M.	1	133	MM.	4.6 M.P.H.	Cloudy	Day
15	A.M./P.M.	1	133	MM.	5.8 M.P.H.	Cloudy	Day
16	A.M./P.M.	1	133	MM.	3.8 M.P.H.	Cloudy	Day
17	A.M./P.M.	1.4	149	MM.	6.7 M.P.H.	Cloudy	Day
18	A.M./P.M.			MM.			
19	A.M./P.M.			MM.			
20	A.M./P.M.			MM.			
21	A.M./P.M.			MM.			
22	A.M./P.M.			MM.			
23	A.M./P.M.			MM.			
24	A.M./P.M.			MM.			
25	A.M./P.M.			MM.			
26	A.M./P.M.			MM.			
27	A.M./P.M.	3.5	182	MM.	6.9 M.P.H.	Cloudy	Partly Day
28	A.M./P.M.	1	182	MM.	7.2 M.P.H.	Cloudy	Day
29	A.M./P.M.	5	189	MM.	2.9 M.P.H.	Cloudy	Day
30	A.M./P.M.	1	190	MM.	3.0 M.P.H.	Cloudy	Day
31	A.M./P.M.			MM.			

RAINFALL / WEATHER RECORD - FFRIDD RASUS LANDFILL SITE

DECEMBER 2023		RAINFALL		WIND		CLOUD DESCRIPTION		WEATHER DESCRIPTION	
DATE	HOUR	DAILY	MONTH TODAY						
1	A.M./P.M.	—	—	1-6	M.P.H.	Cloud	Freshy Snow		
2	A.M./P.M.				M.P.H.				
3	A.M./P.M.				M.P.H.				
4	A.M./P.M.	23	23	23	M.P.H.	Cloud	Rain		
5	A.M./P.M.	—	22	29	M.P.H.	Cloud	Slight Rain		
6	A.M./P.M.	5	28	25	M.P.H.	Cloud	Dry Freshy		
7	A.M./P.M.	5	38	25	M.P.H.	Cloud	Wet		
8	A.M./P.M.	—	33	24	M.P.H.	Cloud	Rain		
9	A.M./P.M.				M.P.H.				
10	A.M./P.M.				M.P.H.				
11	A.M./P.M.	30	63	38	M.P.H.	Cloud	Dry		
12	A.M./P.M.	25	68	22	M.P.H.	Cloud	Wet Rain		
13	A.M./P.M.	20	118	26	M.P.H.	Cloud	Rain		
14	A.M./P.M.	5	123	31	M.P.H.	Cloud	Rain		
15	A.M./P.M.	—	122	28	M.P.H.	Cloud	Dry		
16	A.M./P.M.				M.P.H.				
17	A.M./P.M.				M.P.H.				
18	A.M./P.M.	20	142	25	M.P.H.	Cloud	Rain		
19	A.M./P.M.	10	153	25	M.P.H.	Cloud	Rain		
20	A.M./P.M.	—	152	24	M.P.H.	Cloud	Dry		
21	A.M./P.M.	15	168	22	M.P.H.	Cloud	Rain		
22	A.M./P.M.	—	168	22	M.P.H.	Cloud	Rain		
23	A.M./P.M.				M.P.H.				
24	A.M./P.M.				M.P.H.				
25	A.M./P.M.				M.P.H.				
26	A.M./P.M.				M.P.H.				
27	A.M./P.M.	30	198	28	M.P.H.	Cloud	Wet Rain		
28	A.M./P.M.	15	212	22	M.P.H.	Cloud	Rain		
29	A.M./P.M.	15	228	12	M.P.H.	Cloud	Rain		
30	A.M./P.M.				M.P.H.				
31	A.M./P.M.				M.P.H.				

Appendix H

FLARE EMISSIONS TEST REPORTS



STACK EMISSIONS MONITORING REPORT



Unit 5 Crown Industrial Estate
Kenwood Road
Stockport
SK5 6PH
Tel: 0161 443 0980
Fax: 0161 443 0989

Your contact at SOCOTEC LTD

Dominic Houghton
Business Manager - North
Tel: 0161 443 0982
Fax: 0161 443 0989
Email: dominic.houghton@socotec.com

Operator & Address:

Auto Flare Systems
Llwyn Isaf
Clynnod Fawr
Gwynedd
LL46 5DF
-
-
-

Permit Reference:

EPR Permit: TBC

Release Point:

Flare

Sampling Date(s):

14th December 2023

SOCOTEC Job Number:	LNO 18295
Report Date:	22nd January 2024
Version:	1
Report By:	Mark Derbyshire
MCERTS Number:	MM 07 824
MCERTS Level:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Report Approved By:	Johnathon Orley
MCERTS Number:	MM 08 983
Business Title:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Signature:	

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EXECUTIVE SUMMARY

MONITORING OBJECTIVES

Auto Flare Systems operates a flare process at Llwyn Isaf which is subject to EPR Permit TBC, under the Environmental Permitting Regulations 2010.

SOCOTEC LTD were commissioned by Auto Flare Systems to carry out stack emissions monitoring to determine the release of prescribed pollutants from the following Plant under normal operating conditions.

The results of these tests shall be used to demonstrate compliance with a set of emission limit values for prescribed pollutants as specified in the Plant's EPR Permit, TBC.

Plant

Flare

Operator

Auto Flare Systems
Llwyn Isaf
Clynnod Fawr
Gwynedd
LL46 5DF
-
-

Stack Emissions Monitoring Test House

SOCOTEC - Stockport Laboratory
Unit 5 Crown Industrial Estate
Kenwood Road
Stockport
SK5 6PH
UKAS and MCERTS Accreditation Number: 1015

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

The results of this testing relate only to the emission release point(s) listed in the report.

MCERTS accredited results will only be claimed where both the sampling and analytical stages are MCERTS accredited.

This test report shall not be reproduced, except in full, without written approval of SOCOTEC LTD.

EXECUTIVE SUMMARY

EMISSIONS SUMMARY					
Parameter	Units	Result	Calculated Uncertainty +/-	Emission Limit Value (ELV)	Accreditation
Total Volatile Organic Compounds	mg/m ³	3.4	2.6	10	None
Oxides of Nitrogen (as NO ₂)	mg/m ³	131	2.8	150	None
Carbon Monoxide	mg/m ³	6.4	2.7	50	None
Oxygen	% v/v	9.4	0.07	-	None
Stack Gas Temperature	°C	990	-	-	None

ND = None Detected,

Results at or below the limit of detection are highlighted by bold italic text.

The above volumetric flow rate is an average of the data collected during the isokinetic tests. Mass emissions for non isokinetic tests are also calculated using these values.

Reference conditions are 273K, 101.3kPa, dry gas 3% Oxygen.

EXECUTIVE SUMMARY

MONITORING TIMES			
Parameter	Sampling Date(s)	Sampling Times	Sampling Duration
Total Volatile Organic Compounds Run 1	14 December 2023	10:15 - 11:15	60 minutes
Combustion Gases	14 December 2023	10:15 - 11:15	60 minutes

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Flare
Continuous or batch	Continuous when required
Product Details	N/A
Part of batch to be monitored (if applicable)	60 minute period
Normal load, throughput or continuous rating	Normal load
Fuel used during monitoring	Landfill gas
Abatement	None
Plume Appearance	Visible heat haze

EXECUTIVE SUMMARY

Monitoring Methods

The selection of standard reference / alternative methods employed by SOCOTEC is determined, wherever possible by the hierarchy of method selection outlined in Environment Agency technical Guidance 'Monitoring stack emissions: techniques and standards for periodic monitoring'.

MONITORING METHODS							
Species	Method Standard Reference Method / Alternative Method	SOCOTEC Technical Procedure	UKAS Lab Number	Method Accreditation	Limit of Detection (LOD)	Calculated MU +/- % Result	Calculated MU +/- % ELV
Total Volatile Organic Compounds	SRM - BS EN 12619:2013	AE 102	1015	None	0.59 mg/m ³	76%	26%
Oxides of Nitrogen	SRM - BS EN 14792:2017	AE 102	1015	None	0.64 mg/m ³	2.1%	1.9%
Carbon Monoxide	SRM - BS EN 15058:2017	AE 102	1015	None	0.43 mg/m ³	42%	3.4%
Oxygen	AM - BS EN 14789:2017	AE 102	1015	None	0.01%	0.71%	N/A - No ELV

EXECUTIVE SUMMARY

Analytical Methods

The following tables list the analytical methods employed together with the custody details. Unless otherwise stated the samples are archived at the analysis lab location.

SAMPLING METHODS WITH SUBSEQUENT ANALYSIS							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	Analysis Accreditation	Analysis Lab	Analysis Report number	Archive Period
-	-	-	-	-	-	-	-

ON-SITE TESTING							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	Accreditation	Laboratory	Data Archive Location	Archive Period
Total Volatile Organic Compounds	Flame Ionisation Detection	AE 102	1015	None	SOCOTEC (Stockport)	SOCOTEC (Stockport)	5 years
Oxides of Nitrogen	Chemiluminescence	AE 102	1015	None	SOCOTEC (Stockport)	SOCOTEC (Stockport)	5 years
Carbon Monoxide	Non Dispersive Infra Red	AE 102	1015	None	SOCOTEC (Stockport)	SOCOTEC (Stockport)	5 years
Oxygen	Zirconia Cell	AE 102	1015	None	SOCOTEC (Stockport)	SOCOTEC (Stockport)	5 years

EXECUTIVE SUMMARY

SAMPLING LOCATION					
Sampling Plane Validation Criteria	Value	Units	Requirement	Compliant	Method
Lowest Differential Pressure	-	Pa	≥ 5 Pa	-	BS EN 15259
Lowest Gas Velocity	-	m/s	-	-	-
Highest Gas Velocity	-	m/s	-	-	-
Ratio of Gas Velocities	-	:1	$< 3 : 1$	-	BS EN 15259
Mean Velocity	-	m/s	-	-	-
Maximum angle of flow with regard to duct axis	-	$^{\circ}$	$< 15^{\circ}$	-	BS EN 15259
No local negative flow	-	-	-	-	BS EN 15259

DUCT CHARACTERISTICS		
	Value	Units
Shape	Circular	-
Depth	0.75	m
Width	-	m
Area	0.44	m ²
Port Depth	-	mm

SAMPLING LINES & POINTS		
	Isokinetic	Non-Iso & Gases
Sample port size	-	Fixed Heated Line
Number of lines used	-	1
Number of points / line	-	1
Duct orientation	-	Vertical
Filtration	-	Out Stack

SAMPLING PLATFORM	
General Platform Information	
Permanent / Temporary Platform / Ground level / Floor Level / Roof	Ground Level
Inside / Outside	Outside

M1 Platform requirements	
Is there a sufficient working area so work can be performed in a compliant manner	Yes
Platform has 2 levels of handrails (approximately 0.5 m & 1.0 m high)	N/A
Platform has vertical base boards (approximately 0.25 m high)	N/A
Platform has removable chains / self closing gates at the top of ladders	N/A
Handrail / obstructions do not hamper insertion of sampling equipment	N/A
Depth of Platform = $>$ Stack depth / diameter + wall and port thickness + 1.5m	Yes

Sampling Platform Improvement Recommendations (if applicable)

A suitable platform should be installed to meet EA Guidance Note M1.

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

Flow Traverse

It is not possible to carry out a flow traverse whilst the flare is in operation due to safety issues.

MCERTS Accreditation

A leak check of the sample system could only be performed from a location upstream of the fixed heated line and not at the sample inlet in the stack due to access. Therefore MCERTS accreditation could not be claimed for the testing.

APPENDICES

CONTENTS

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

APPENDIX 3 - Measurement Uncertainty Budget Calculations

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

MONITORING SCHEDULE					
Species	Method Standard Reference Method / Alternative Method	SOCOTEC Technical Procedure	UKAS Lab Number	MCERTS Accredited Method	Number of Samples
Total Volatile Organic Compounds	SRM - BS EN 12619:2013	AE 102	1015	None	1
Oxides of Nitrogen	SRM - BS EN 14792:2017	AE 102	1015	None	1
Carbon Monoxide	SRM - BS EN 15058:2017	AE 102	1015	None	1
Oxygen	AM - BS EN 14789:2017	AE 102	1015	None	1

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

CALIBRATEABLE EQUIPMENT CHECKLIST					
Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	Equipment I.D.	Equipment	Equipment I.D.	Equipment	Equipment I.D.
Control Box DGM	-	Horiba PG-250 Analyser	LNO 21-58	Laboratory Balance	-
Box Thermocouples	-	FT-IR Gasmeter	-	Tape Measure	LNO 24-MD
Meter In Thermocouple	-	FT-IR Oven Box	-	Stopwatch	LNO 17-MD
Meter Out Thermocouple	-	Bernath 3006 FID	-	Protractor	-
Control Box Timer	-	Signal 3030 FID	-	Barometer	LNO 08-MD
Oven Box	-	Servomex	-	Digital Micromanometer	LNO 03-MD
Probe	-	JCT Heated Head Filter	-	Digital Temperature Meter	LNO 01-MD
Probe Thermocouple	-	Thermo FID	LNO 21-55	Stack Thermocouple	LNO 10-MD
Probe	-	Stackmaster	-	Mass Flow Controller	LNO 29-71
Probe Thermocouple	-	FTIR Heater Box for Heated Line	-	MFC Display module	LNO 29-71
S-Pitot	-	Anemometer	-	1m Heated Line (1)	-
L-Pitot	-	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	LNO 14-MD	Chiller (JCT/MAK 10)	LNO 21-105	1m Heated Line (3)	-
Last Impinger Arm	-	Heated Line Controller (1)	LNO 03-99	5m Heated Line (1)	LNO 18-22
Dioxins Cond. Thermocouple	-	Heated Line Controller (2)	-	10m Heated Line (1)	-
Callipers	-	Site temperature Logger	LNO 12-MD	10m Heated Line (2)	-
Small DGM	-			15m Heated Line (1)	-
Heater Controller	-			20m Heated Line (1)	-
Inclinometer (Swirl Device)	-			20m Heated Line (2)	-

NOTE: If the equipment I.D is represented by a dash (-), then this piece of equipment has not been used for this test.

CALIBRATION GASES					
Gas (traceable to ISO 17025)	Cylinder I.D Number	Supplier	ppm	%	Analytical Tolerance +/- %
Propane	HPC 2124	BOC	9.9	-	2.0
Nitric Oxide	HPC 2124	BOC	81.1	-	2.0
Carbon Monoxide	HPC 2124	BOC	77	-	2.0

STACK EMISSIONS MONITORING TEAM

MONITORING TEAM								
Personnel	MCERTS Number	MCERTS		TE / H&S Qualifications and Expiry Date				
		Level	Expiry	TE1	TE2	TE3	TE4	H&S
Mark Derbyshire	MM 07 824	MCERTS Level 2	Nov-26	Nov-26	Apr-27	May-28	Jul-27	Feb-25
Mark Strachan	MM 23 1861	MCERTS Trainee	Oct-28	-	-	-	-	Oct-28

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL VOLATILE ORGANIC COMPOUNDS SUMMARY

Test	Sampling Times	Concentration mg/m ³	LOD mg/m ³	ELV mg/m ³	Emission Rate g/hr
Run 1	10:15 - 11:15 14 December 2023	3.4	0.40	10	-

Reference conditions are 273K, 101.3kPa, dry gas 3% Oxygen.

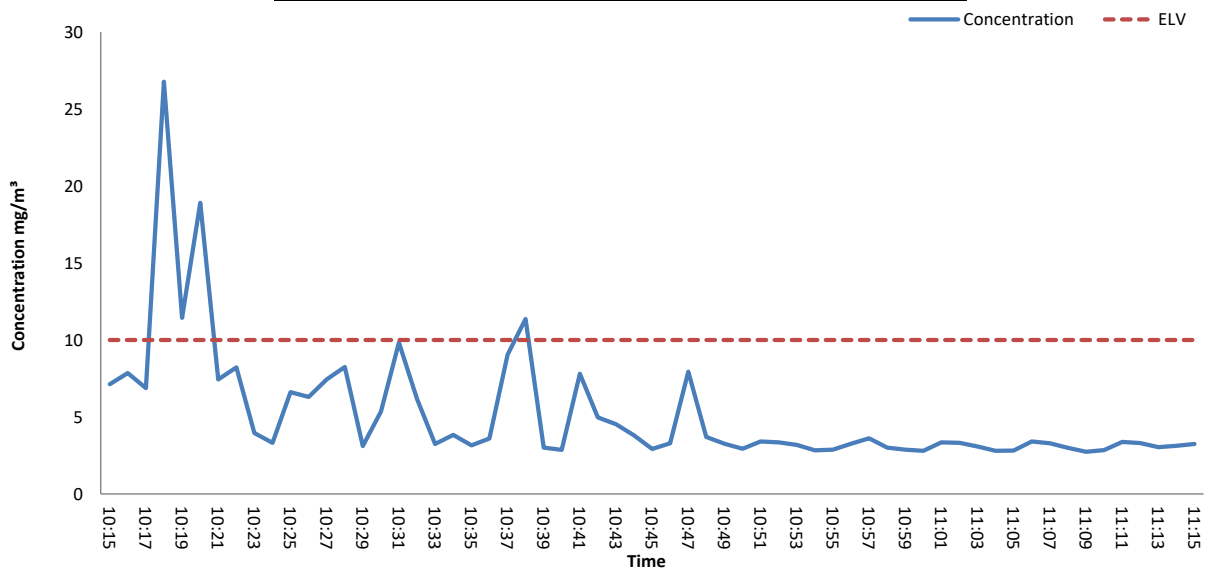
INSTRUMENTAL SPAN & ZERO CHECKS

PRE-SAMPLING CALIBRATION CHECKS								
Date	14 December 2023							
Start Time	09:52							
End Time	10:05							
Gas	Gas Conc (ppm)	Range	Instrument Zero Reading	Instrument Span Reading	Instrument Zero Reading	Zero Down line reading	Span down line reading	Leak Rate (%)
Propane	9.9	100	0.00	9.9	0.00	0.05	9.8	1.01

Zero and Span gas contained -% Oxygen

POST-SAMPLING CALIBRATION CHECKS								
Date	14 December 2023							
Start Time	11:20							
End Time	11:30							
Gas	Mean Raw Value ppm	Zero down line reading	Span down line reading	Zero Drift (%)	Span Drift (%)	Corrected for Zero Drift	Corrected for Span Drift	Corrected Values ppm / %
Propane	1.97	0.11	9.7	0.61	-1.62	x	x	N/A - not corrected

TOTAL VOLATILE ORGANIC COMPOUNDS EMISSIONS CHART



Reference conditions are 273K, 101.3kPa, dry gas 3% Oxygen.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

COMBUSTION GASES SUMMARY

Test	Sampling Time and Date	Concentration mg/m ³	LOD mg/m ³	ELV mg/m ³	Emission Rate g/hr
Oxides of Nitrogen	10:15 - 11:15 14 December 2023	131	0.64	150	-
Carbon Monoxide	10:15 - 11:15 14 December 2023	6.4	0.43	50	-

Test	Sampling Time and Date	Concentration %	LOD %
Oxygen	10:15 - 11:15 14 December 2023	9.4	0.01

Reference conditions are 273K, 101.3kPa, dry gas 3% Oxygen.

PRE-SAMPLING CALIBRATION DATA

Date	14 December 2023
Start Time	09:45
End Time	10:00

Chiller Temperature (°C)	2.5
Requirement	< 4°C
Compliant	Yes

Gas	Range (ppm / %)	Zero Reading at analyser	Span Reading at analyser	Zero Check at analyser	Zero Check down line	Span Check down line	Response Time (Secs)	Leak Rate %
Nitric Oxide	200	0.00	81.1	0.07	0.20	81.0	20	0.12
Carbon Monoxide	200	0.00	77.0	0.09	0.30	76.8	20	0.26
Oxygen	25	0.00	9.78	0.03	0.05	9.77	20	0.10

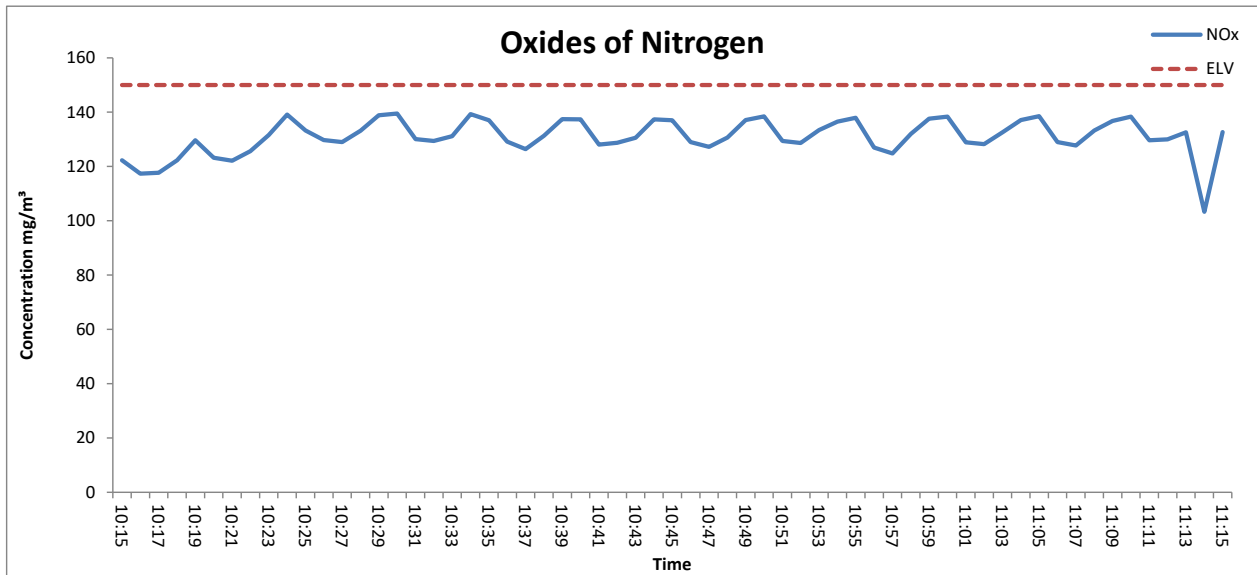
POST-SAMPLING CALIBRATION DATA

Date	14 December 2023
Start Time	11:20
End Time	11:30

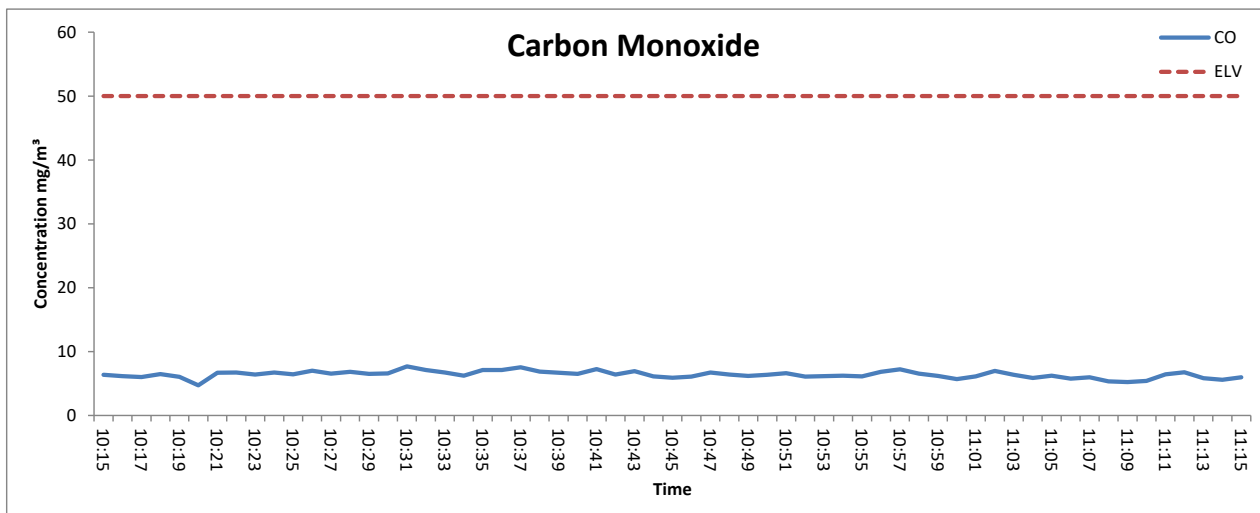
Chiller Temperature (°C)	2.2
Requirement	< 4°C
Compliant	Yes

Gas	Zero Check at Analyser	Span Check at Analyser	Zero Drift (%)	Span Drift (%)	Corrected for Zero Drift	Corrected for Span Drift	Corrected Values ppm / %
Nitric Oxide	0.20	79.9	0.16	-1.64	x	x	N/A - not corrected
Carbon Monoxide	0.20	76.7	0.14	-0.53	x	x	N/A - not corrected
Oxygen	0.06	9.76	0.31	-0.51	x	x	N/A - not corrected

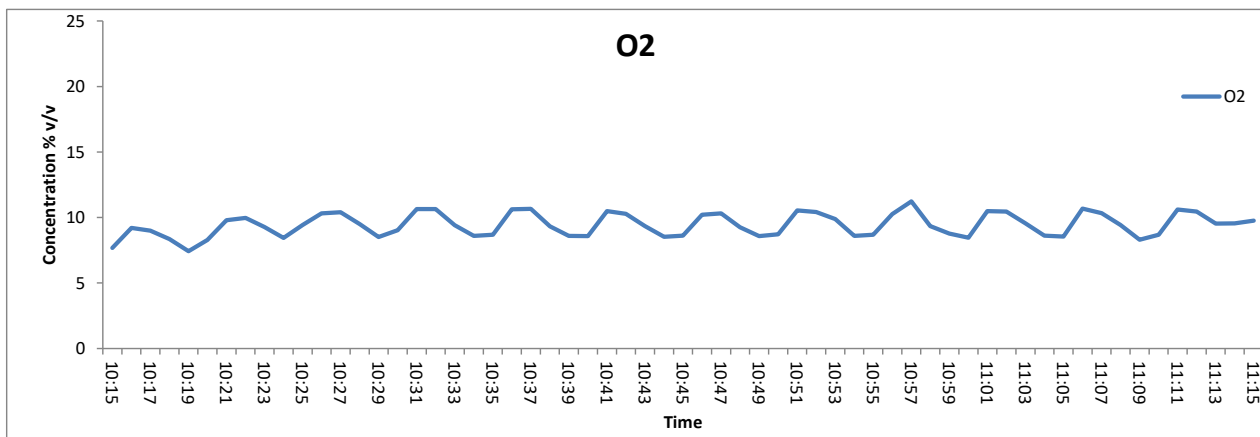
APPENDIX 2 - Summaries, Calculations, Raw Data and Charts
OXIDES OF NITROGEN (as NO_x) EMISSIONS CHART



CARBON MONOXIDE EMISSIONS CHART



OXYGEN EMISSIONS CHART



MEASUREMENT UNCERTAINTY BUDGET - VOLATILE ORGANIC COMPOUNDS RUN 1

Measured Concentration	3.37	mg/m ³
Limit	10	mg/m ³
Calibration Gas Concentration	15.84	mg/m ³
Range	160	mg/m ³

Performance characteristics	Value	Units	specification	MU Met?
Response time	10	seconds	<180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
Repeatability at zero	0.25	% full scale	<1 % range	Yes
Repeatability at span level	0.15	% full scale	<2 % range	Yes
Deviation from linearity	0.70	% of value	<2 % range	Yes
Zero drift	0.61	% full scale	<2% range / 24hr	Yes
Span drift	-1.62	% full scale	<2% range / 24hr	Yes
volume or pressure flow dependence	0.02	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.80	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence	0.01	% full scale/10K	<3% range / 10 K	Yes
dependence on voltage	0.10	% full scale/10V	< 0.1%vol /10 volt	Yes
losses in the line (leak)	1.01	% of value	< 2% of span gas value	Yes
Uncertainty of calibration gas	1.0	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	ur0	0.02
Standard deviation of repeatability at span level	urs	0.02
Lack of fit	ufit	0.65
Drift	u0dr	0.15
volume or pressure flow dependence	uspres	0.0006
atmospheric pressure dependence	uapres	0.04
ambient temperature dependence	utemp	0.00001
Dependence on voltage	uvolt	0.14
losses in the line (leak)	uleak	0.0197
Uncertainty of calibration gas	ucalib	0.019
Uncertainty in factor	uf	1.13

Measurement uncertainty Measured Concentration	3.37	mg/m ³
Combined uncertainty	1.32	mg/m ³
Expanded uncertainty	2.58	mg/m ³

Expanded uncertainty expressed with a level of confidence of 95%	25.79	% ELV
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Expanded uncertainty expressed with a level of confidence of 95%	2.58	mg/m ³
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Expanded uncertainty expressed with a level of confidence of 95%	76	% value
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Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXIDES OF NITROGEN

Limit value	150	mg/m ³
Concentration @ Ref conditions	131.0	mg/m ³
Cal gas conc	166	mg/m ³
Analyser Full Scale	410	mg/m ³

	Value	Units	specification	MU Met?
Response time	20	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
Repeatability at zero	0.11	% full scale	<1 % range	Yes
Repeatability at span level	0.1	% full scale	<2 % range	Yes
Deviation from linearity	-0.40	% of value	<2 % range	Yes
Zero drift	0.16	% full scale	<2% range / 24hr	Yes
Span drift	-1.64	% full scale	<2% range/24hr	Yes
volume or pressure flow dependence	0.2	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.20	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence zero / span	0.20	% full scale/10K	<3% range / 10 K	Yes
Combined interference	2.40	% range	<4% of Range	Yes
dependence on voltage	0.03	% full scale/10V	< 0.1%vol / 10 volt	Yes
Influence of Vibration	N/A	% of upper limit of Cal range	<2%	-
losses in the line (leak)	0.03	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.0037
lack of fit	U_{lof}	-0.2309
short term zero drift	$U_{d,z}$	0.0950
short term span drift	$U_{d,s}$	-0.9468
influence of Ambient Temp at Zero	$U_{t,z}$	0.0351
influence of Ambient Temp at Span	$U_{t,s}$	0.6321
influence of sample gas pressure	U_p	0.0000
influence of sample gas flow	U_{fit}	0.1386
influence of supply voltage	U_v	0.0725
Combined Interference	U_i	0.0042
Uncertainty of Cal gas	U_{adj}	0.8110

Measurement uncertainty (Concentration Measured)	131.01	mg/m ³
Combined uncertainty	1.43	ma/m ³
Expanded at a 95% confidence interval	2.80	ma/m ³

Expanded uncertainty expressed with a level of confidence of 95%	1.87	% ELV
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Expanded uncertainty expressed with a level of confidence of 95%	2.8	mg/m³
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Expanded uncertainty expressed with a level of confidence of 95%	2.1	% value
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Developed for the STA by R Robinson, NPL

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - CARBON MONOXIDE

Limit value	50	mg/m ³
Concentration @ Ref conditions	6.4	mg/m ³
Cal gas conc	96.3	mg/m ³
Analyser Full Scale	250	mg/m ³

Performance characteristics	Value	Units	specification	MU Met?
Response time	20	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
Repeatability at zero	0.1	% full scale	<1 % range	Yes
Repeatability at span level	0.2	% full scale	<2 % range	Yes
Deviation from linearity	0.61	% of value	<2 % range	Yes
Zero drift	0.14	% full scale	<2% range / 24hr	Yes
Span drift	-0.53	% full scale	<2% range/24hr	Yes
volume or pressure flow dependence	0.2	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.44	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence zero / span	1	% full scale/10K	<3% range / 10 K	Yes
Combined interference	0.03	% of Range	<4% of Range	Yes
dependence on voltage	-0.06	% full scale/10V	< 0.1%vol /10 volt	Yes
Influence of Vibration	N/A	% of upper limit of Cal range	<2%	N/A
losses in the line (leak)	0.00	% of value	< 2% of value	Yes
Uncertainty of calibration gas	1.00	% of value	< 2% of value	Yes

N/A - Horiba's are not effected by Vibration

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.003
lack of fit	U_{lof}	0.12
short term zero drift	$U_{d,z}$	0.35
short term span drift	$U_{d,s}$	0.08
influence of Ambient Temp zero	$U_{t,z}$	0.04
influence of Ambient Temp span	$U_{t,s}$	0.06
influence of sample gas pressure	U_p	0.00000
influence of sample gas flow	U_{fit}	0.14
influence of supply voltage	U_v	-0.09
Combined Interference	U_i	0.67
Uncertainty of Cal gas	U_{adj}	0.39

Measurement uncertainty (Concentration Measured)	4.1	mg/m ³
Combined uncertainty	0.9	mg/m ³
Expanded uncertainty	1.7	mg/m ³

Expanded uncertainty expressed with a level of confidence of 95%	3.4	% ELV
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Expanded uncertainty expressed with a level of confidence of 95%	1.7	mg/m ³
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Expanded uncertainty expressed with a level of confidence of 95%	42.2	% value
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Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXYGEN

Reference	3	%vol
Reported Concentration	9.44	%vol
Calibration gas	9.78	%vol
Analyser Full Scale	25	%vol

	Value	Units	specification	MU Met?
Response time	20	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
Repeatability at zero	0.25	% full scale	<1 % range	Yes
Repeatability at span level	0.15	% full scale	<2 % range	Yes
Deviation from linearity	0.13	% of value	<2 % range	Yes
Zero drift	0.31	% full scale	<2% range / 24hr	Yes
Span drift	-0.51	% full scale	<2% range/24hr	Yes
volume or pressure flow dependence	0.03	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.05	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence	-0.08	% full scale/10K	<3% range / 10 K	Yes
Combined interference	0.14	% range	<4% of Range	Yes
dependence on voltage	0.0005	% full scale/10V	< 0.1%vol /10 volt	Yes
losses in the line (leak)	0.14	% of value	< 2% of value	Yes
Uncertainty of calibration gas	0.1	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.0083
lack of fit	U_{lof}	0.0751
short term zero drift	$U_{d,z}$	0.1795
short term span drift	$U_{d,s}$	-0.2952
influence of Ambient Temp at Zero	$U_{t,z}$	0.0001
influence of Ambient Temp at Span	$U_{t,s}$	0.000790
influence of sample gas pressure	U_p	0.000000
influence of sample gas flow	U_{fit}	0.0173
influence of supply voltage	U_v	0.0001
Combined Interference	U_i	0.0485
Uncertainty of Cal gas	U_{adj}	0.0489

Measurement uncertainty (Concentration Measured)	9.44	%
Combined uncertainty	0.36	%
Expanded uncertainty	0.71	%

Expanded uncertainty expressed with a level of confidence of 95%	0.71	%
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Expanded uncertainty expressed with a level of confidence of 95%	7.49	% vol
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END OF REPORT

Thank you for choosing SOCOTEC for your environmental monitoring needs. We hope our services have met your requirements and that you are fully satisfied with your experience of working with us, we really do value your custom and would welcome your feedback. We would appreciate it if you could take a moment to complete a short online questionnaire so that we can improve our operations and address any areas that have not met with your expectations, by clicking on the following

https://www.surveymonkey.co.uk/r/CAE_customer_feedback_weblink

Auto Flare Systems

Periodic monitoring of raw landfill gas

Llwyn Isaf Landfill Site

Report	LNO 18295
Date	23 rd January 2024
Issue	1



PERIODIC MONITORING OF RAW LANDFILL GAS

Llwyn Isaf Landfill Site

Report prepared for

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Issue history

Issue	Date	Approved	
LNO17581	23/01/2024	Mark Derbyshire	
First issue			

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1 Introduction

Veolia Environmental Services (Veolia) contracted SOCOTEC UK Limited (SOCOTEC) to undertake monitoring of the landfill gas supply to its combustion operations at the Croft Farm Landfill Site

2 Test methodology

Veolia requested that samples of landfill gas be collected and analysed for the priority trace components (LFGTGN04, Table 1.1) specified in Environment Agency guidance (Guidance for monitoring trace components in landfill gas – LFGTGN04 v3.0, 2010). The test methodology should be in accordance with that specified within LFGTGN04.

Based on LFGTGN04 the priority trace gas components are sampled using a combination of four sampling media as shown in Table 1.

Table 1 Sampling media and analytical methods

Trace component	CAS number	Sampling method	Analytical method
1,1-dichloroethane	75-34-3	Dual solid sorbent	ATD-GC-MS
1,2-dichloroethane	107-06-2	Dual solid sorbent	ATD-GC-MS
1,1-dichloroethene	75-35-4	Dual solid sorbent	ATD-GC-MS
1,2-dichloroethene	540-59-0	Dual solid sorbent	ATD-GC-MS
1,3-butadiene	106-99-0	Dual solid sorbent	ATD-GC-MS
1-butanethiol	109-79-5	Dual solid sorbent	ATD-GC-MS
1-pentene	109-67-1	Dual solid sorbent	ATD-GC-MS
1-propanethiol	107-03-9	Dual solid sorbent	ATD-GC-MS
2-butoxyethanol	111-76-2	Dual solid sorbent	ATD-GC-MS
Arsenic (as As)	7440-38-2	Charcoal	ICP-MS
Benzene	71-43-2	Dual solid sorbent	ATD-GC-MS
Butyric acid	107-92-6	Dual solid sorbent	ATD-GC-MS
Carbon disulphide	75-15-0	Dual solid sorbent	ATD-GC-MS
Chloroethane	75-00-3	Dual solid sorbent	ATD-GC-MS
Chloroethene (vinyl chloride)	75-01-4	Dual solid sorbent	ATD-GC-MS
Dichloromethane	75-09-2	Dual solid sorbent	ATD-GC-MS
Dimethyl disulphide	624-92-0	Dual solid sorbent	ATD-GC-MS
Dimethyl sulphide	75-18-3	Dual solid sorbent	ATD-GC-MS
Ethanal (acetaldehyde)	75-07-0	Silica gel/2,4 DNPH	HPLC-DAD
Ethanethiol	75-08-1	Dual solid sorbent	ATD-GC-MS
Ethyl butyrate	105-54-4	Dual solid sorbent	ATD-GC-MS
Furan (1,4-epoxy-1,3-butadiene)	110-00-9	Dual solid sorbent	ATD-GC-MS
Hydrogen sulphide	7783-06-4	Charcoal	IC
Methanal (formaldehyde)	50-00-0	Silica gel/2,4 DNPH	HPLC-DAD
Methanethiol	74-93-1	Dual solid sorbent	ATD-GC-MS
Siloxanes	-	Dual solid sorbent	ATD-GC-MS
Styrene	100-42-5	Dual solid sorbent	ATD-GC-MS
Tetrachloromethane	56-23-5	Dual solid sorbent	ATD-GC-MS
Toluene	108-88-3	Dual solid sorbent	ATD-GC-MS
Trichloroethene	79-01-6	Dual solid sorbent	ATD-GC-MS

ATD – automated thermal desorption

GC-MS – gas chromatography and mass spectrometry

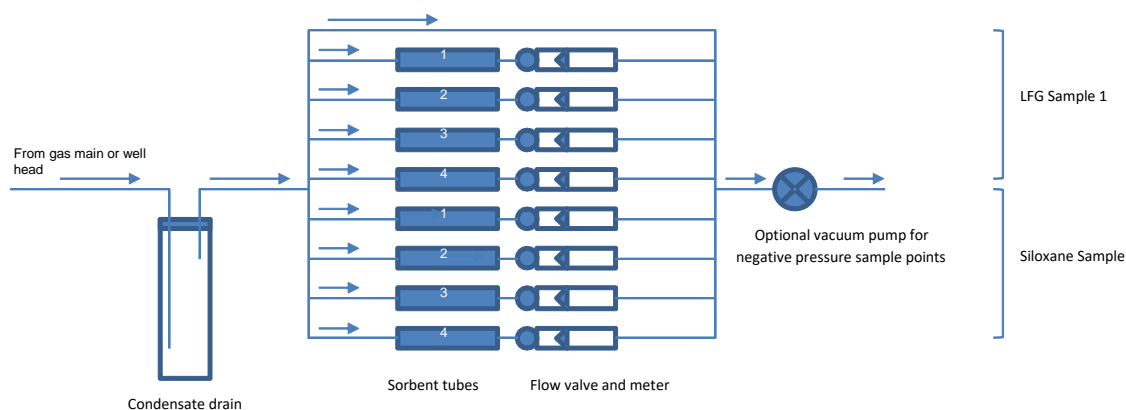
ICP-MS – inductively couple plasma/mass spectrometry

HPLC-DAD – high performance liquid chromatography and diode array detection

IC – ion chromatography

Sampling for all components is undertaken simultaneously using a multiple stream sampler as shown in Figure 1.

Figure 1 Landfill gas sampling arrangement



A sample is taken from either the gas main or well head and passed through a condensate drain to remove excess moisture. The sample gas is then split to pass through a series of up to eight regulated rotameters arranged in two banks of four. Only four of the pathways are employed to collect the samples. There is also a bypass stream for excess sample. The flow rates and sampling duration are set in accordance with LFGTGN04 requirements as summarised in Table 2.

Table 2 Sampling media and analytical methods

Media	Target species	Sampling rate (ml/min)	Sampling duration (min)	Sample volume (l)
Dual solid sorbent (Tenax/Sulficarb)	VOCs	20	10	0.2
Silica gel and 2,4 DNPH (SKC 226-119)	Aldehydes	20	50	1.0
Activated carbon 1 (SKC 226-09)	Arsenic	100	50	5.0
Activated carbon 2 (SKC 226-09)	Hydrogen sulphide	100	50	5.0
Dual solid sorbent (Tenax/Sulficarb)	Siloxanes	100	50	5.0

In the case of negative pressure sources it is necessary to employ a vacuum pump at the sampler's common outlet. This is not normally required with positive pressure systems

This results in one sample of landfill gas with each sample comprising the four sub-samples above covering all of the priority trace components within Table 1.

The samples are subject to the analytical procedures described in Table 1 to provide a mass on the collected sample which can then be related to the volume of gas sampled to provide a component concentration in the sampled landfill gas.

The sampling followed internal procedure GAS14 and is accredited under test certificate 1015.

3 Site information

Sample point details			
Date	14 th December 2023	Site	Llwyn Isaf Landfill Site
Ambient temperature	9°C	Atmospheric pressure	99.3 kPa
Monitoring organisation	SOCOTEC UKAS 1015	Analytical laboratory	SOCOTEC UKAS 1252
Location of sampling point	Next to Flare	Area of influence of collection system sampled	All
Type of sample point	¼" Tefen	Temperature of gas	20°C
Pressure at sample point	Positive (not recorded)	Type of waste	Not recorded
Status of gas system	Active	Age of waste	Not recorded

4 Preliminary checks and field measurements

Parameter		Concentration
Methane	%	49.4
Carbon dioxide	%	25.8
Oxygen	%	0.3
Nitrogen (by difference)	%	24.5
Hydrogen sulphide	ppmv	10
Carbon monoxide	ppmv	0

*carbon monoxide is measured with a hydrogen sulphide filter in the sampling line.

Preliminary bulk gas measurements were undertaken using a GFM 436 electrochemical cell analyser (no. 5167). Reported measurements are spot readings following gas sampling for a period of 5 minutes.

5 Results of landfill gas analysis

The results of the sampling and analysis are summarised in Table 3 and 4 below.

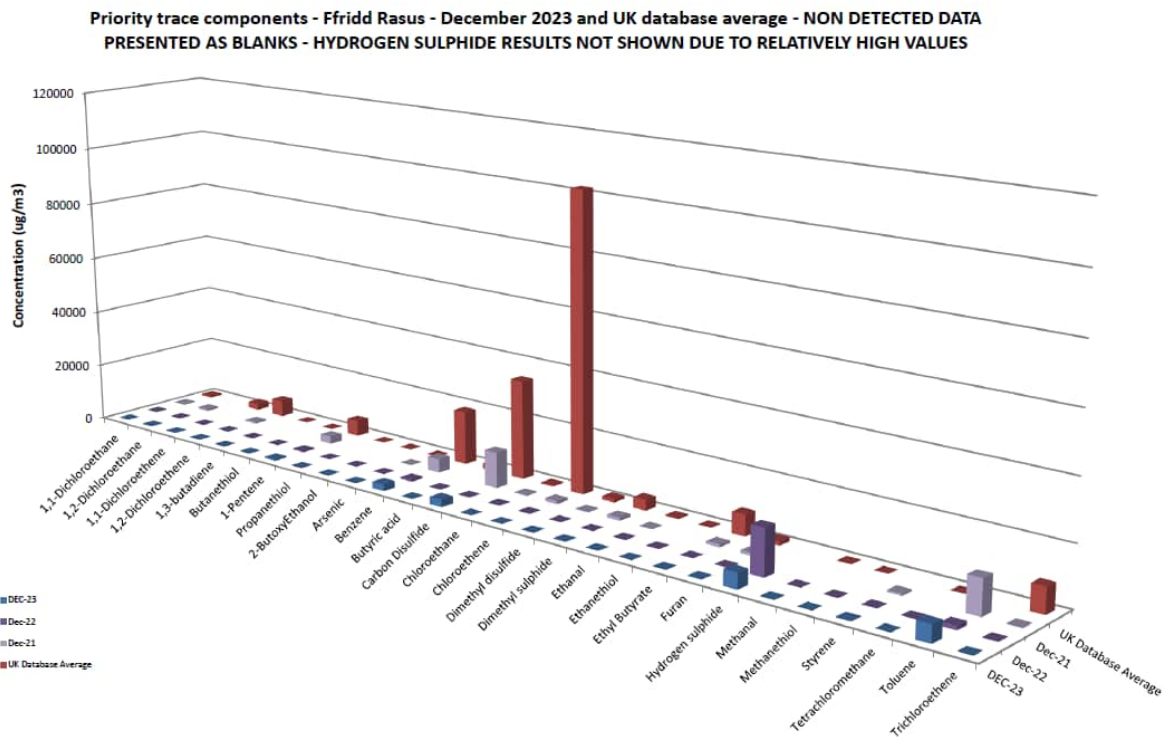
Table 3 Priority trace component measurement results

Parameter		Concentration ($\mu\text{g}/\text{m}^3, \text{STP}$)
1 Pentene		526
1,1-Dichloroethane		<31
1,1-Dichloroethene		<47
1,2-Dichloroethane		<52
1,2-Dichloroethene		<26
1,3-Butadiene		<37
Furan (1,4 epoxy 1,3 butadiene)		105
1-Propanethiol		<104
2-butoxyethanol		<104
Benzene		2263
Butyric acid		<209
Carbon disulphide		2579
Tetrachloromethane		<52
Chloroethane		<52
Dichloromethane		36319
Dimethyl disulphide		<52
Dimethyl sulphide		<52
Ethyl butyrate		<47
Ethanethiol		<157
Methanethiol		<522
1-butanethiol		<157
Styrene		158
Toluene		5790
Trichloroethene		<52
Chloroethene (Vinyl chloride)		<157
Arsenic		1
Hydrogen sulphide		5264
Ethanal (Acetaldehyde)	*	<104
Methanal (Formaldehyde)	*	<104

* indicates result is UKAS accredited

< indicates result is below the method limit of detection

Figure 2 Historical priority trace component analysis results at Llwyn Isaf landfill site



6 Notes

Sampling of landfill gas was undertaken in accordance with SOCOTEC procedure GAS14 and is UKAS accredited under certificate 1015.

Analysis of collected samples was undertaken by SOCOTEC's Bretby laboratory. The analytical results which fall within SOCOTEC's scope of accreditation under certificate 1252 are identified in Table 3.

The priority component measurements which can be considered to be within the scope of UKAS accreditation are identified in Table 3.

Any interpretations and opinions expressed are outside of the scope of UKAS accreditation.

The lab analysis of the trace gas is a VOC screen in relation to the compounds listed in the LTGN04. The lab holds an approved method for VOC analysis but does not hold accreditation for each VOC. This is due to the number of VOCs present and concentration of VOC's that exist. As it is not possible to know the exact matrix of any sample no laboratory can claim accreditation for each individual VOC.



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Appendix I

GASSIM LANDFILL GAS PRODUCTION CURVE

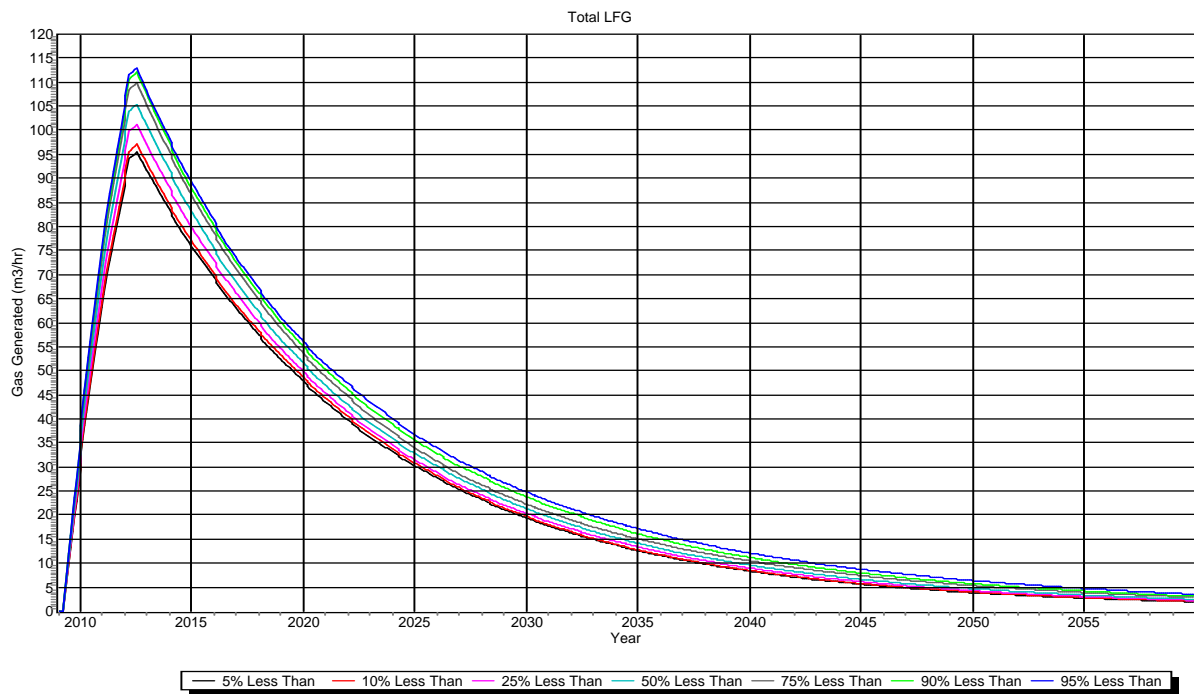


GasSim Version V 2.05

Project Name: Llwyn Isaf PPC

Project Client: Gwynedd Council

Total: Total Bulk LFG Produced



llwyn isaf 2015 update.gss

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