C&P Environmental Ltd

Giants Grave Landfill Site

Annual Environmental Monitoring Report 2023

Environmental Permit EPR/SP3298FT/T009

Prepared for: Neath Port Talbot County Borough Council

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Neath
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By: C & P Environmental Limited

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EXECUTIVE SUMMARY

C&P Environmental Ltd has been commissioned by Neath Port Talbot County Borough Council (NPTCBC) to produce an Annual Environmental Monitoring Report for Giants Grave Landfill Site in accordance with the environmental permit EPR/SP3298FT and section 8 of the Landfill Aftercare Plan. This Annual Environmental Monitoring Report summarises the monitoring data recorded at the Giants Grave Landfill Site between 1st January and 31st December 2023.

The following key points have been observed during 2023:

Leachate Monitoring

For leachate levels, there was a single exceedance of the compliance limit for both LW5 and LW8 in March, with LW17b exceeding on a total of eight occasions, although this well remains difficult to monitor the leachate levels. The well A1305 also exceeded the compliance level on four occasions at the end of the year.

For leachate quality the mean concentration for ammoniacal nitrogen across all leachates sampled was similar to 2022, with chloride and potassium continuing a falling trend. Some individual wells recorded increases in ammoniacal nitrogen, but no adverse trends noted.

There were no breaches of the compliance levels for the Discharge Flap Valve in 2023. The concentrations of each of the other measured parameters within the effluent discharged via the Discharge Flap Valve are well within the compliance limits as stated within the Discharge Consent Number BP0236201.

The calculated flows of water over the Vee Notch Weir in 2023 are significantly higher than those recorded in recent years and is the highest mean flow recorded since the data logger was used for measurements.

Groundwater Monitoring

The groundwater levels across the boreholes follow a similar pattern to each other throughout the year and are of a similar mean level to recent years. The most significant change observed is an increasing water level in BH12 from dry conditions in July to an elevated level (for this borehole) in December.

For groundwater quality, the main concerns arising in 2023 are the breaches of the trigger level for ammoniacal nitrogen in BH9B (on two occasions) and in BH45B which exceeded the trigger level on all but one occasion.

There were no rising trends in ammoniacal nitrogen recorded. For potassium and chloride there were no significant adverse trends.

In general, no significant adverse trends noted in the biannual hazardous substances monitoring nor the hazardous substances monitored on a two-yearly basis. The most significant differences are for higher concentrations for nitrite as N in several samples.

Surface Water Monitoring

Trigger and control levels for ammoniacal nitrogen are detailed in the Aftercare Plan for the surface water monitoring. For the River Neath there was a single exceedance of the trigger level for ammoniacal nitrogen in the upstream River North monitoring location in January and this was concurrent with an exceedance of the control level in the River South monitoring location. The ammoniacal nitrogen results in the River Neath suggest that the potential contamination is arising from upstream of the River North monitoring location.

For the canal monitoring locations, both upstream and downstream recorded occasional elevated results of ammoniacal nitrogen. The trigger level was exceeded on one occasion at each location but during different months. The downstream location also exceeded the control levels on three further occasions. In general, the data shows that the downstream sample tends to record slightly higher ammoniacal nitrogen concentrations, which may suggest some impact from the landfill.

Perimeter Gas Monitoring

There was one breach of a methane compliance level during 2023 – for BH8 in September. The methane was recorded at 7.1% (concurrent with a spike in carbon dioxide). No other methane readings in BH8 exceeded 0.2%. This methane and carbon dioxide spike is the first recorded for many years and appears to suggest a spike of landfill gas within the location represented by this borehole. As all subsequent readings were back to typical low concentrations then this appears to be only a transitory landfill gas migration event.

Other than BH8 the methane concentrations were low across the boreholes except for BH40B, BH43B and BH45B which were at their expected elevated levels. There were no action level exceedances for methane during 2023 in any boreholes other than BH8.

In addition to BH8, the action level for carbon dioxide was exceeded in only one other location (BH4 on three occasions).

Other than the spike of methane and carbon dioxide in BH8 in September, no borehole showed any significant adverse or unusual trend in gas quality.

Surface Emissions Monitoring

For the surface emissions survey in 2023 (undertaken early 2024) there were fewer surface areas recording elevated methane emissions compared with 2022 and no discrete features (compared with three in 2022). However, there was one location to the west of LW4 that has now shown some of the highest emissions of methane in both 2022 and 2023.

Monitoring and Reporting Recommendations

A full description and list of recommendations is provided at the end of each section. The more significant recommendations for the different monitoring programmes are provided below.

Leachate

The leachate samples have been taken in accordance with the requirements of the landfill aftercare plan and permit requirements with respect to the leachate level monitoring and the quarterly monitoring schedule. However, as part of the October monitoring (which is the month used for annual monitoring requirements) the range of toxic metals and some other leachate parameters were not analysed for as per the requirements.

Therefore, a set of leachate samples should be organised for the following suite of analysis, in addition to the normal quarterly parameters:

- Chemical Oxygen Demand, Biological Oxygen Demand, Nickel, Sulphate, Alkalinity, Total Organic Carbon, Sodium, Calcium, Magnesium, Iron, Manganese, Cadmium, Chromium, Copper, Lead, Zinc & Arsenic

Groundwater

There are no specific recommendations for actions for the groundwater monitoring at Giants Grave.

Section 3.5.1 provides details of those boreholes where the control and trigger (C&T) levels for groundwater quality do not necessarily provide an appropriate early warning, although this report does not suggest any current action to amend these.

Surface water

There are no specific recommendations for actions for the surface water monitoring at Giants Grave.

Perimeter Gas

There are no recommendations for change in the perimeter gas monitoring programme with respect to the frequency and parameters monitored.

A recommendation retained from previous reports and to be considered during the next Landfill Aftercare Plan review:

> It is recommended that the revised action levels and compliance limits for borehole BH1B are more appropriate for ongoing monitoring and to determine any significant change in gas quality.

Surface Emissions Monitoring

Due to some discrete areas of the surface recording elevated methane emissions in both January 2022 and 2023 it is recommended that an action plan is considered and implemented to remediate the discrete locations of the surface recording elevated methane – and especially the area to the west of LW4.

To understand the issues better and to formulate the appropriate level of remediation that may be required it is first suggested to organise a surface emissions survey earlier in 2024 (late summer would be recommended) to ensure that the surface emissions monitoring is undertaken in a different season to the recent years. In recent years the surface emissions survey has been completed in the winter or later autumn with typically wet ground conditions.

However, the actions should initially consider visual inspections of the area to the west of LW4 and determine whether there are any obvious surface cracks or fissures or evidence of vegetation stress (photographical evidence should be obtained). Subsequent remediation measures should then be considered and implemented following the 2024 surface emissions survey.

Overall, the average surface emissions from across the site are not elevated, but there are limited discrete features of elevated methane emissions through the cap. The feature to the west of LW4 was determined in both the 2022 and 2023 surface emissions surveys (completed in January 2023 and 2024 respectively).

LW14 has been referred to as an open well and this should be repaired/remediated.

Contents

Tables in text

1 Introduction

C&P Environmental Ltd has been commissioned by Neath Port Talbot County Borough Council (NPTCBC) to develop an Annual Environmental Monitoring Report for Giants Grave landfill site in accordance with the requirement of the environmental permit EPR/SP3298FT and Section 8 of the Landfill Aftercare Plan.

In November 2013, NRW accepted the Closure Report (which included the Landfill Aftercare Plan) and confirmed that the site at Giants Grave is now definitively closed and is now in Aftercare. The Landfill Aftercare Plan now supersedes Section 7 of the Working Plan (the environmental monitoring requirements).

In addition, NRW issued an environmental permit (EPR/SP3298FT) in July 2015. This permit incorporates the environmental monitoring requirements.

The analysis and monitoring regime for the site was revised in June 2017 for the leachate, groundwater and surface water monitoring. In September 2020 the compliance limits for the leachate levels were revised following acceptance of the hydrogeological risk assessment and compliance limits for several groundwater parameters (chloride, arsenic, mercury and phenol) were removed.

This report makes reference to the environmental permit, the Landfill Aftercare Plan and the revised monitoring schedule for the monitoring requirements.

Since April 2018 the routine environmental monitoring has been undertaken by NPTCBC. The annual reporting has been undertaken by C&P Environmental since December 2012.

This Annual Environmental Monitoring Report covers the period of 1st January to 31st December 2023. This report includes the following information:

- Tabular and graphical summaries of key leachate, groundwater, surface water and perimeter gas monitoring results.
- A summary assessment of leachate, groundwater, surface water and perimeter gas monitoring results, including comparison to compliance limits where they exist and determination of any significant trends.
- Recommendations for changes and improvements to the monitoring programme going forward.
- Discussion of historical and previous monitoring data reviews to enable the site monitoring data to be put into perspective.

1.1 Site Location and Description

Giants Grave Landfill Site is located approximately 2.5km southwest of Neath, at NGR 733 957 (see Site Location Plan, Drawing B1404900/EP/APR2010/01). The site encompasses a total of sixty-five hectares and is bounded to the west by the River Neath, to the north by the main line railway embankment and to the east by the Neath Canal.

The Giants Grave Landfill Site was issued with a Waste Disposal Licence by Neath Borough Council on 1st April 1993, for the disposal of municipal waste to landfill. Subsequently, the Waste Disposal Licence was superseded by a Waste Management Licence (WML), Number EAWML 34060. It was considered that the in-situ permeability of the underlying ground was sufficiently low to act as a containment seal. As such, there are no records of more formal engineered lining or containment, and the landfill is considered a 'dilute and disperse landfill'. Giants Grave Landfill Site ceased accepting waste during July 2003 and subsequently the operational status of the landfill progressed from an operational landfill to a closed landfill. In September 2003, the site was progressively capped and restored with a landfill gas extraction system installed in April 2004.

In May 2005, a Pollution Prevention and Control Permit (HP3535PS) was issued by the Environment Agency (EA) for a new landfill sited directly adjacent to the existing closed landfill. No waste material was accepted under this permit and the permit was surrendered during 2018.

1.2 Site Development and Maintenance During 2023

C & P Environmental are not aware of, or been informed of, any significant site development or maintenance during 2023.

1.3 Report Structure

The remainder of this report is structured as follows:

Section 2: Leachate Monitoring:

Sets out details of the leachate monitoring infrastructure and locations; Permit requirements; compliance with the site discharge consent; and an assessment of leachate monitoring data obtained during 2023.

Section 3: Groundwater Monitoring:

Sets out details of the groundwater monitoring infrastructure and locations; Permit requirements; and an assessment of groundwater monitoring data obtained during 2023.

Section 4: Surface Water Monitoring:

Sets out details of the surface water monitoring infrastructure and locations; Permit requirements; and an assessment of surface water monitoring data obtained during 2023.

Section 5: Landfill Gas Monitoring:

Sets out details of the perimeter gas and in-waste monitoring infrastructure and locations; Permit requirements; and an assessment of gas monitoring data obtained during 2023.

2 Leachate Monitoring

This section provides a summary of the leachate level and quality monitoring at Giants Grave for 2023 in addition to the water quality at the Discharge Flap Valve as required by Schedule 3, Tables 3.2 and 3.3 of the environmental permit EPR/SP3298FT and Appendix A2 of the Landfill Aftercare Plan.

2.1 Leachate Monitoring Locations

Leachate monitoring points are situated throughout the existing waste mass at Giants Grave Landfill Site.

Previously (and until May 2017) a total of 6 leachate wells were required to be monitored although further leachate wells installed during the closure and aftercare period are also required to be monitored. Additional wells may also be monitored as substitutes when wells are dry. From June 2017 onwards, leachate level monitoring has been undertaken at all leachate monitoring and extraction wells.

Compliance levels for leachate levels are now in place for 6 dedicated leachate wells and these are monitored monthly.

The locations of the leachate wells, Vee Notch Weir and Discharge Flap Valve monitoring points are shown on the sampling location plan in Appendix E.

2.2 Leachate Monitoring Requirements

Tables 2A and 2B identify the leachate wells that will be monitored, the type of monitoring and the frequency of the monitoring.

Table 2A – Leachate Level Monitoring Schedule – 2023

Monitoring Point	Parameter	Monitoring Frequency
6 leachate wells with compliance levels: Leachate Wells (LW): 5, 8, 15, 17b *and A1302, and A1305CV*	Level / Dip	Monthly
	Base Level	Monthly

Note – until June 2023 several further leachate wells were monitored for the leachate level and base level. This report concentrates on those with permit compliance levels.

Table 2B – Leachate Quality Monitoring Schedule

Monitoring Point	Parameter	Monitoring Frequency
Leachate Wells (LW): 3, 5, 8, 15, 16, 17 and 18 plus A1301, A1302, A1303, A1304 and A1305CV	pH, Temperature, Electrical Conductivity, Ammoniacal Nitrogen, chloride, potassium	Quarterly
	Chemical Oxygen Demand, Biological Oxygen Demand, Nickel, Sulphate, Alkalinity, Total Organic Carbon, Sodium, Calcium, Magnesium, Iron, Manganese, Cadmium, Chromium, Copper, Lead, Zinc & Arsenic	Annually
	Hazardous substances	Every four years

Note the quarterly monitoring was attempted in January, April and October for all wells, although some wells were unable to be sampled due to low leachate levels. From July onwards wells LW16, LW18, A1301, A1302, A1303 and A1304 are only required to be monitored annually (October) in accordance with the aftercare plan. This was conveyed to C&P Environmental as part of the development of the July to September 2023 data submission.

The annual hazardous substances suite in October was not completed on the leachate samples. The four yearly hazardous substances suite was completed on samples in October 2021 and so not due again until 2025.

Table 2C specifies the required flow monitoring at the Vee Notch Weir. This flow monitoring was previously undertaken through the recording of a single water depth at the Vee Notch Weir each month. Following discussions with NRW there was an option for using a calculated flow (on a 15-minute basis) from the automated telemetry set up at the site. Although there is some potentially unreliable flow data, this is considered to provide more reliable and relevant data overall.

Table 2C – Leachate Flow Monitoring Schedule

Monitoring Point	Parameter	Monitoring Frequency
Vee Notch Weir	Flow measurement	Monthly

Table 2D identifies the monitoring required at the Discharge Flap Valve and the compliance limits for each parameter.

Table 2D – Discharge Flap Valve Leachate Level Monitoring Schedule

Parameter	Compliance Level	Monitoring Frequency
Ammoniacal Nitrogen (mg/l)	190	Monthly
Nickel (µg/l)	90	
Copper (µg/l)	85	
Zinc (µg/l)	376	
Lead (µg/l)	40	
Chromium (µg/l)	40	
Cadmium (µg/l)	3	
Arsenic (µg/l)	130	
Iron (µg/l)	40,000	

2.3 Leachate Control and Trigger Levels

Control and trigger levels, along with observed trends from control and trigger charts, provide a warning to the site operator that a problem may be occurring. They can be used to spot adverse trends in the monitoring data, or changes because of natural variations in the background water quality. Control levels are intended to provide an early warning indicator for when the landfill is beginning to deviate from its design performance so that corrective or remedial measures can be implemented before a trigger level is exceeded.

For leachate levels a trigger level of 1m above cell basal liner is stated in the environmental permit (unless otherwise agreed in writing with Natural Resources Wales). Well specific levels were developed using statistical assessment of previous data and, from these, several well leachate compliance levels were proposed to NRW in April 2019[1]. The wells selected attempt to provide a geographical coverage of the site and are detailed in Table 2E. Following agreement by NRW these well specific revised leachate levels were applicable from September 2020.

Table 2E - Leachate Compliance Levels

Monitoring Point	From September 2020 - Leachate Level Above Base (m)
LW5	1.6
LW8	1.0
LW15	2.1
LW17b *	1.0
A1302	3.0
A1305CV	2.8
Any additional wells installed after April 2019	1.0

**Note - for LW17b there has remained difficulty with monitoring accurate leachate levels due to a constriction in the well.*

There are no control or trigger levels set for the quality of the leachate.

Compliance levels are set for several parameters at the Discharge Flap Valve as specified in Table 2D.

2.4 Leachate Monitoring Results and Data Assessment

2.4.1 Leachate Level Monitoring

Leachate level data is obtained by measuring the well base and the height of the leachate head within the well during each monitoring visit. The data is shown in depth above the well base and is not directly indicative of the overall leachate head in metres, as the actual depth to the bottom of the waste mass is unknown.

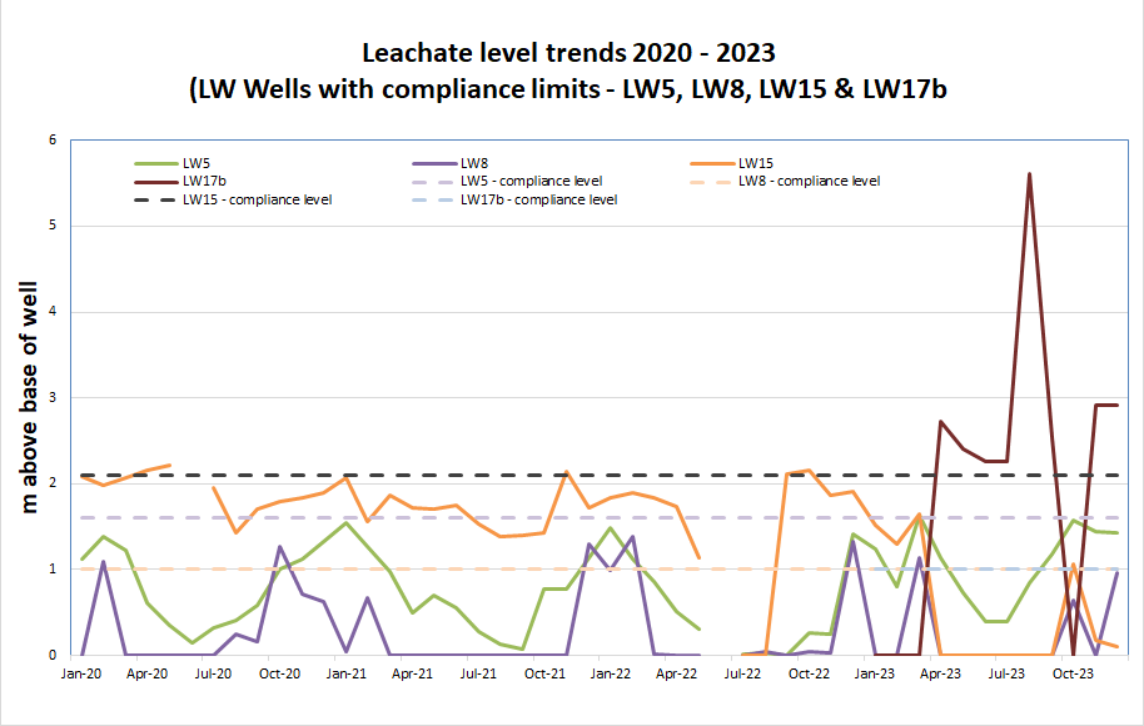
[1] Addendum to the Hydrogeological Risk Assessment Review 2016, Neath Port Talbot Waste Management Co Ltd, 30th April 2019.

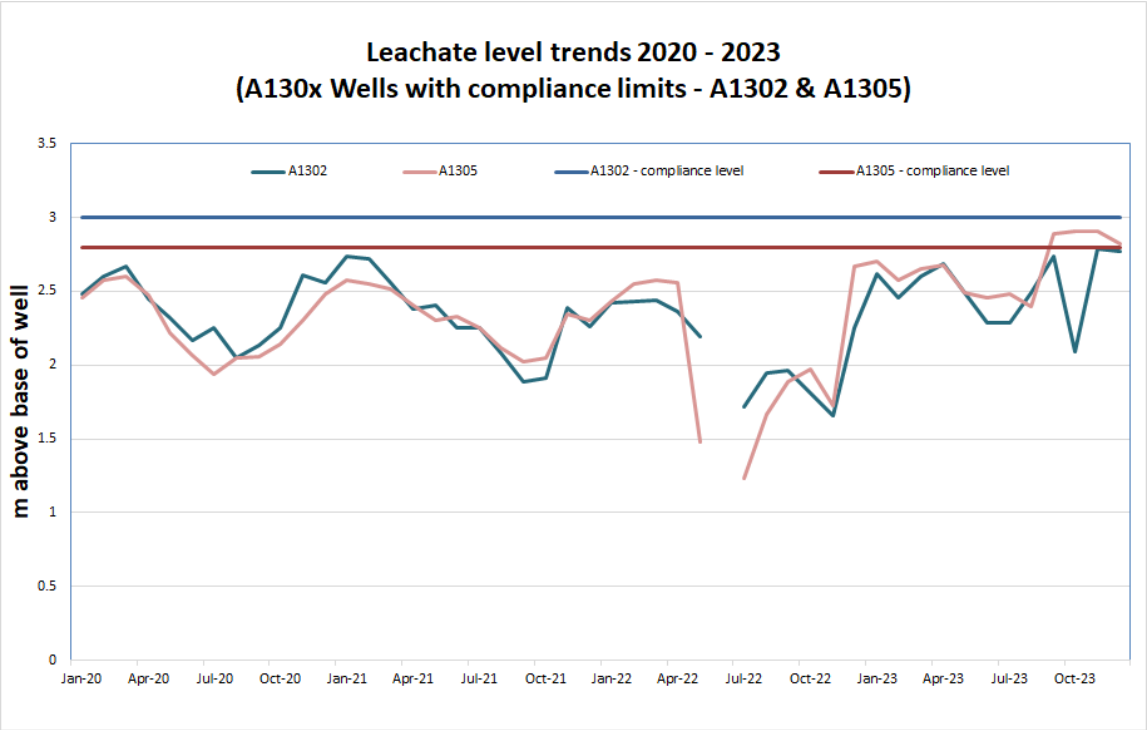
A summary table of the leachate level data obtained during 2023 for those wells with compliance levels is given in Table 2F. All leachate monitoring data is provided in Appendix A.

Table 2F - Summary of Leachate Levels

Monitoring Point	Minimum Leachate Level Above Base (m)	Maximum Leachate Level Above Base (m)	Comment
LW5	0.39	1.63	Leachate >1m in many of the winter and autumn months but <1m across May to August. One month (March) exceeded the compliance level of 1.6m above base.
LW8	Dry	1.14	Either recorded as 'dry' or zero leachate depth across many months of the year. Leachate recorded in 3 months (March, October & December) between 0.64m and 1.14m in March (which exceeds the compliance level of 1.0m)
LW15	Dry	1.65	Either recorded as 'dry' or zero leachate depth between April and September. Leachate levels recorded at >1m in in January to March and again in October. No leachate recorded above the compliance level of 2.1m
LW17b	0	5.61	There remains a difficulty in recording accurate leachate level data in this well and some of the results should be viewed with caution (especially a leachate level of 5.61m in August. The remaining months were either four months of zero readings (January to March inclusive plus October) or a range between 2.26m to 2.92m. Towards the end of the year it was mentioned by the monitoring team that the constriction can be by-passed for a more accurate reading. Further monitoring into 2024 will determine whether this is the case. When leachate recorded then all readings above the compliance level of 1.0m.
A1302	2.09	2.79	All readings >2m with the highest in the months of September, November and December. The lower readings between May and August. All readings below the compliance level of 3.0m.
A1305CV	2.4	2.91	All readings >2m with the highest in the months of September through to December, which all exceed the compliance level of 2.8m.

Graphs of the leachate levels for these wells are provided below (and reproduced again in Appendix A).





Direct comparison of the leachate level above the base of each well against the revised compliance levels (from September 2020) for selected boreholes can be seen in Table 2G.

Table 2G - Summary of Leachate Trigger level exceedance

Leachate Levels (m above base of well)													Leachate compliance level (from September 2020 onwards)
Leachate well	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	
LW5	1.24	0.8	**1.63**	1.14	0.73	0.39	0.39	0.85	1.18	1.58	1.45	1.43	1.6
LW8	0	0	**1.14**	0	0	0	0	0	0	0.64	0	0.96	1
LW15	1.52	1.3	1.65	0	0	0	0	0	0	1.06	0.17	0.1	2.1
LW17b	0	0	0	**2.72**	**2.4**	**2.26**	**2.26**	**5.61**	**2.53**	0	**2.92**	**2.92**	1
A1302	2.62	2.46	2.6	2.69	2.49	2.29	2.29	2.49	2.74	2.09	2.79	2.77	3
A1305	2.7	2.58	2.65	2.68	2.49	2.46	2.48	2.4	**2.89**	**2.91**	**2.91**	**2.82**	2.8

Empty cells signifies unable to be monitored

Some wells recorded as 'dry' on the monitoring records - these have been consider zero in the above table

Red text indicates exceedence of the well specific leachate level threshold (From September 2020)

In summary:

- The exceedances of the revised compliance levels in 2023 was for the following:
    - LW5 in March at 1.63m compared with compliance level of 1.6m (above well base). This is the first exceedance of the leachate compliance levels since they were revised in 2020.
    - LW8 in March at 1.14m compared with compliance level of 1.0m (above well base). This compares to two exceedances in 2022 and a single exceedance in 2021.
    - LW17b in April to September inclusive and November and December at between 2.26m and 5.61m. This compares to a compliance level of 1.0m. There remain some difficulties in obtaining accurate readings at the location, although the typical leachate level appears to be between approximately 2.2m and 2.9m
    - A1305 in September through to December inclusive with levels during these months marginally above the 2.8m compliance level.

2.4.2 Leachate Quality Monitoring

a) Leachate Wells

The frequency of testing on the leachate (including samples analysed at the laboratory) is quarterly. There is on-site field monitoring for temperature, but pH and conductivity are completed in the laboratory along with the quarterly components of chloride, ammoniacal nitrogen and potassium.

Quarterly monitoring data

The range of data for the key contaminants from quarterly monitoring of leachate wells is summarised in Table 2H.

Table 2H – Summary of Components from Quarterly Leachate Monitoring

Parameter	Unit	Minimum	Maximum	Mean 2023	Mean 2022	Mean 2021
pH	-	6.7	7.7	-	-	-
Temperature	°C	13.2	28.7	-	-	-
Conductivity	µS	670	7800	-	-	-
Ammoniacal Nitrogen (N)	mg/l	0.05	540	146	143	191
Chloride	mg/l	8.5	860	200	209	224
Potassium (diss.filt)	mg/l	8.3	360	118	124	136

Note – The calculated means were taken from the four quarterly monitoring results across the wells monitored. In total there were 36 results for ammoniacal nitrogen, chloride and potassium across 12 separate wells.

Samples not able to be taken in the following locations due to dry wells; or insufficient sample able to be obtained; or unable to retrieve sample: LW8 (Jan, Apr & Jul); LW9 (Jan & Apr); LW15 (Apr); LW17b (all)

From the quarterly leachate quality monitoring the following observations can be made:

- When considering all leachate samples across 2023, the mean ammoniacal nitrogen concentration is similar to 2022, although the ongoing falling trend since 2018 has not continued.
- The ammoniacal nitrogen concentrations between the samples taken from individual wells was relatively consistent (within the same order of magnitude) other than for:
    - LW3 - range from 0.58mg/l to 71mg/l across the four samples taken.
    - LW9 - range from 0.05mg/l to 1.5mg/l across the two samples taken.
    - LW16 - range from 0.23mg/l to 350mg/l across the three samples taken. The laboratory stated that the low concentration recorded was from a high dilution, but the result is much lower than typical results for this well.
    - For the wells monitored on 3 or more occasions during 2023 only the well A1301 recorded a rising trend between 200mg/l in January to 540mg/l in October, although the range of values is not dissimilar to previous years.
- The highest concentrations of ammoniacal nitrogen continue to be recorded in the A130x wells, with A1301 being the highest at up to 540mg/l with the next highest A1303 at up to 420mg/l. The mean concentrations for each well are detailed in Table 2I. Although some wells show an increase in the mean concentration of ammoniacal nitrogen there are no significant adverse trends noted.
- The mean chloride and potassium concentrations from all samples in 2023 show mean concentrations at slightly lower concentrations that 2022 and continue a gradual falling trend over recent years.
- The results across the individual wells generally recorded a range in concentrations for chloride and potassium within an order of magnitude. However, the following locations show the most variance:

  - LW3 records a range of more than an order of magnitude difference for chloride (range from 9.6mg/l to 65mg/l).

- The pH across the wells is 7 within the range pH 6.7 to 7.7, which remains similar to recent years.

Table 2I – Summary of Ammoniacal Nitrogen, Chloride and Potassium in Leachate

Monitoring Point	Number of Samples (for NH_3-N)	Ammoniacal Nitrogen mean (mg/l)		Chloride mean (mg/l)		Potassium mean (mg/l)	
		2023	2022	2023	2022	2023	2022
LW3	4	30.1	15.9	28.4	36.8	21.5	17.5
LW5	4	4.3	1.2	10.3	82	12.3	60.8
LW8	1	13	82	20	12	21	9.9
LW15	3	183	198	220	268	126	175
LW16	3	213	230	470	400	323	253
LW18	3	10.3	58.5	12	21.3	11.3	16.5
A1301	3	367	370	597	630	280	280
A1302	3	163	210	120	180	93.7	125
A1303	3	250	Insufficient sample	247	190	140	Insufficient sample
A1304	3	143	177	112	132	87.3	99.7
A1305CV	4	278	200	415	437	220	237

No leachate is able to be obtained from LW17b due to constrictions in the well.

The mean ammoniacal nitrogen and chloride across the LWx wells is consistent with a leachate from an aged waste mass, although the results from the 2013 A130x installed leachate wells continue to record higher concentrations.

Annual monitoring data

Samples from all required wells were taken in October 2023, although the annual hazardous substances suite was not completed on these samples.

The four yearly hazardous substances suite was completed on samples in October 2021 and so not due again until 2025.

b) Discharge Flap Valve

A summary of the data collected from the consented discharge quality monitoring point at the Discharge Flap Valve during 2023 is given in Table 2J. Compliance levels for leachate quality are only specified for samples taken from the consented discharge monitoring point. Further detailed data for the Discharge Flap Valve are presented within Appendix A.

Table 2J – Summary of Leachate Quality Data from the Discharge Flap Valve

Parameter		Compliance Level	Minimum	Maximum	2023 Mean[1]	2022 Mean[1]
Ammoniacal Nitrogen as N	mg/l	190	0.034	15	3.75	2.17
Arsenic	µg/l	130	1.44	8.43	3.82	11.78
Cadmium	µg/l	3	0.04	0.1	0.06	0.04
Chromium	µg/l	40	0.4	1.9	0.84	1.51
Copper	µg/l	85	2.3	8	4.75	4.43
Iron	mg/l	40	0.008	0.055	0.02	0.03
Lead	µg/l	40	<0.2	0.8	0.26	0.2
Nickel	µg/l	130	1.5	7.4	4.12	4.6
Zinc	µg/l	376	4.8	17	7.84	5.3

NOTE [1] – When compiling summary statistics (e.g. mean values), where a parameter has not been detected at a concentration greater than the detection limit, the detection limit has been used in the calculations.

Concentrations in red indicate a breach of the compliance limit.

There were no breaches of the discharge consent for the discharge from the flap valve in 2023. This follows no breaches of the discharge consent for the discharge from the flap valve in 2022 and a single breach of the copper compliance level in August 2021 at 150µg/l compared with the 85µg/l limit.

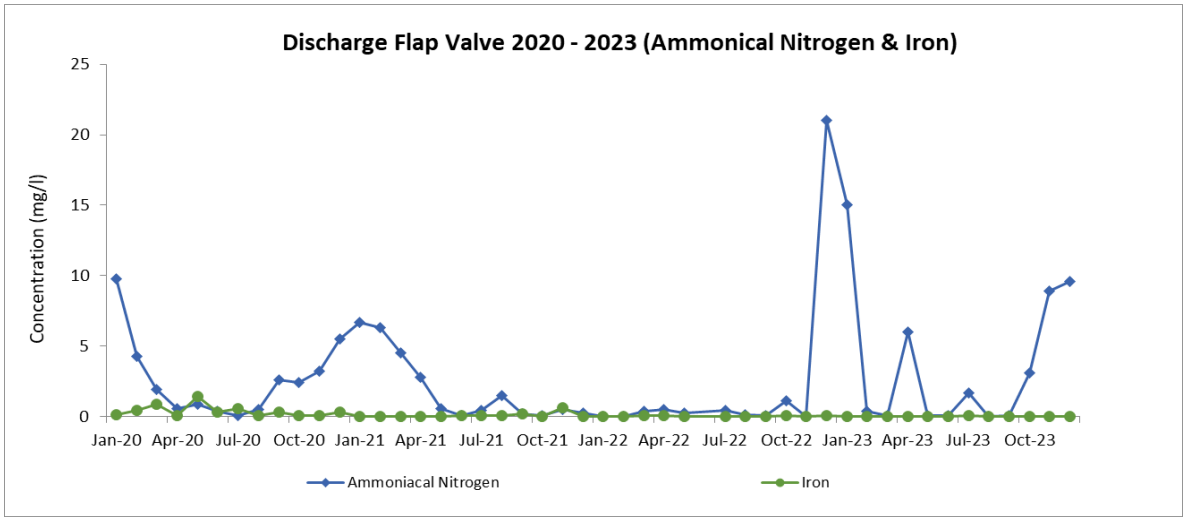
The analysis of samples collected throughout 2023 has shown that the concentrations of all of the measured parameters within the effluent discharged are well within the compliance limits as stated within the Discharge Consent Number BP0236201 (as reproduced in the Landfill Aftercare Plan).

Most parameters have recorded a similar or lower mean concentration in 2023 compared with the results from 2022. The parameters recording a higher mean concentration are:

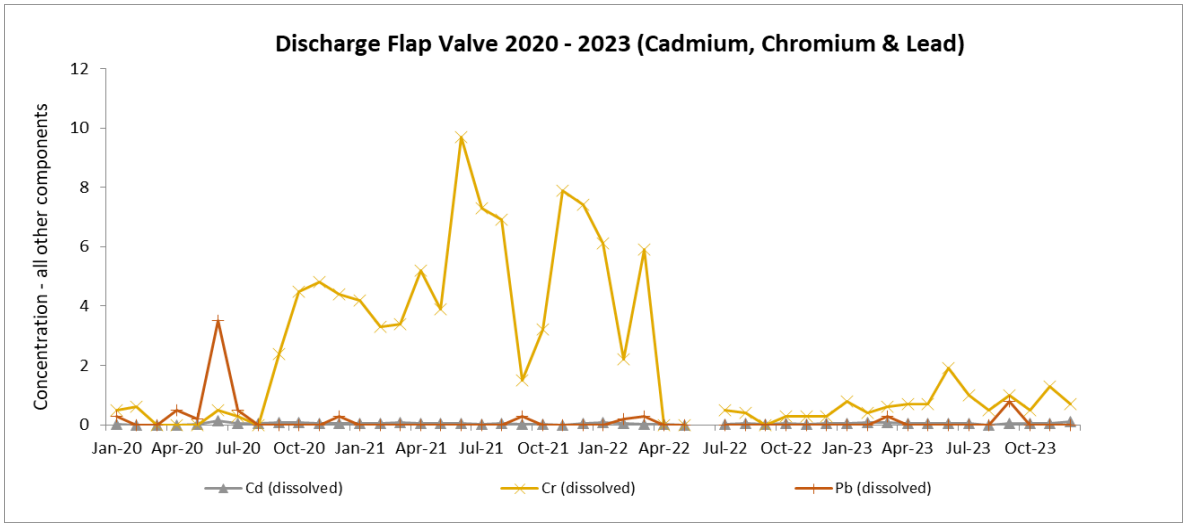
- Ammoniacal nitrogen has recorded a higher mean concentration in 2023 with the highest concentration in January at 15mg/l. This follows the highest 2022 result in December at 21mg/l. The graph below indicates that higher concentrations for ammoniacal nitrogen have been recorded during 2023. The mean concentration from December 2022 onwards is 5.1mg/l compared to <0.3mg/l for the prior 11 months of 2022.
- Zinc – A higher mean concentration recorded in 2023 compared with 2022. The concentration ranged between 4.8µg/l and 10µg/l until a slightly higher result of 17µg/l in December 2023. No specific adverse trend noted.

The mean concentration of all parameters is below 10% of their respective compliance limit in 2021 and no parameter closely approaches the compliance limit.

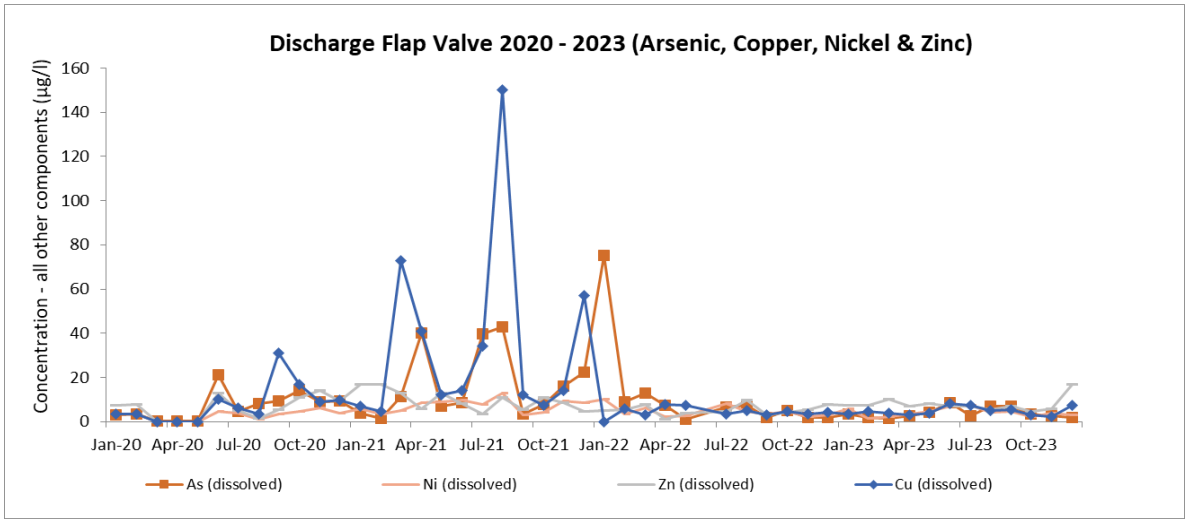
The graphs below provide visual trends since January 2020.



The graph below shows that the chromium concentrations in 2023 were much lower than recent years.



The mean concentration for arsenic has reduced in 2023. A spike of 75µg/l recorded in January 2022 has not been repeated since (as can be seen in the graph below).



2.4.3 Leachate Flow Monitoring

Leachate flow data was obtained from the Vee Notch Weir during 2023 as summarised in Table 2K. The value recorded represents a calculated flow from the continuous level monitor connected to a data logger used by NRW to provide flow data for the site.

The data provided was on a 15-minute time period for each reading and provided in m^3/s. This data has been used to calculate averaged flow rate for the month (in m^3/day) for comparison to the data from previous years.

NRW provide the following important details regarding the use of the data:

> *The operational range of the thinplate weir located at this site is 0.0m to 0.26m stage (0.0 m^3/s to 0.046 m^3/s). Recorded level values outside this range will not generate reliable flows.*
>
> *The site is also significantly influenced by water level changes resulting from tidal cycles. Data recorded at the site suggests that moderately high tidal peaks can result in a variable backwater effect through the thinplate weir. Water level data recorded during periods of tidal influence should be treated as suspect, as should the calculated flow for such periods. The variable nature of the tidal influence at this site makes it very difficult to identify precise times when tidal influence begins and ends. I would suggest the only reliable means of identifying conditions which are unaffected by the tide would be to physically observe free flow of water through the thinplate weir.*

The following table states the proportion (%) of readings in that month that are above the reliable range and the maximum flows recorded to provide an indication of the appropriateness of the data.

Table 2K - Summary of Flow Monitoring Data (Vee Notch Weir)

Month of Monitoring	Averaged Flow in 2023 (m^3/day)	Maximum flow rate reading (m^3/s)	Proportion (%) of readings greater than 0.046m^3/s (or no readings)	Averaged Flow in 2022 (m^3/day)	Averaged Flow in 2021 (m^3/day)
Jan-23	3875	1.52	17.4	1282	4136
Feb-23	528	0.08	0.6	2623	1834
Mar-23	3023	1.32	13.4	29426 (947 if suspect data removed)	769
Apr-23	1044	0.15	1.5	277	389
May-23	336	0.03	0.0	154	1580
Jun-23*	88	0.00	0.0	89	193
Jul-23	329	0.06	7.1	45	263
Aug-23	595	0.16	1.2	89	246
Sep-23	1162	0.30	5.5	155	268
Oct-23	3928	2.96	12.5	446	3298
Nov-23	3256	1.35	16.1	3280	800
Dec-23	3709	0.97	19.4	1965	1928

*The instrumentation seemed to fail during July (between 23rd and 24th and again between 25th and 26th) with no readings provided. This makes up the vast proportion of the readings outside the accepted range.

A daily flow rate (based on the 15-minute flow measurements) during 2023 was on average 1838m^3/day. This is significantly higher than recent years and compares to a mean of 932m^3/day in 2022, 1314 m^3/day in 2021, 1429 m^3/day in 2020, 953m^3/day in 2019 and 1486m^3/day in 2018.

Overall, the reliability of the data-logged measurements would likely be significantly better than the single month readings that were used prior to 2018.

Specific rainfall data for the site has not been provided or reviewed for this annual report.

2.5 Summary and Recommendations for Leachate Monitoring Programme

The leachate samples have been taken in accordance with the requirements of the landfill aftercare plan and permit requirements with respect to the leachate level monitoring and the quarterly monitoring schedule. However, as part of the October monitoring (which is the month used for annual monitoring requirements) the range of toxic metals and some other leachate parameters were not analysed for as per the requirements.

Therefore, a set of leachate samples should be organised for the following suite of analysis, in addition to the normal quarterly parameters:

- Chemical Oxygen Demand, Biological Oxygen Demand, Nickel, Sulphate, Alkalinity, Total Organic Carbon, Sodium, Calcium, Magnesium, Iron, Manganese, Cadmium, Chromium, Copper, Lead, Zinc & Arsenic

For leachate levels, there was a single exceedance of the compliance limit for both LW5 and LW8 in March, with LW17b exceeding on all occasions that leachate was detected (total of eight occasions), although this well remains difficult to monitor the leachate levels. The well A1305 also exceeded the compliance level on four occasions at the end of the year.

For leachate quality the mean concentration for ammoniacal nitrogen across all leachates sampled was similar to 2022 with chloride and potassium continuing a falling trend. Some individual wells recorded increases in ammoniacal nitrogen, but no adverse trends noted.

The mean ammoniacal nitrogen and chloride across the LWx wells continues to be lower than those from the 2013 installed A130x wells.

There were no breaches of the compliance levels for the Discharge Flap Valve in 2023. The concentrations of each of the other measured parameters within the effluent discharged via the Discharge Flap Valve are well within the compliance limits as stated within the Discharge Consent Number BP0236201.

The calculated flows of water over the Vee Notch Weir are significantly higher in 2023 (a mean flow of 1838m^3/day compared to a mean of 932m^3/day in 2022) and is the highest mean flow recorded since the data logger was used for measurements.

3 Groundwater Monitoring

This section provides a summary of the groundwater monitoring at Giants Grave for 2023 as required by Schedule 3, Tables 3.4 and 3.5 of the environmental permit EPR/SP3298FT and Appendix A3 of the Landfill Aftercare Plan.

Following a revision to the hydrogeological risk assessment the compliance limits for the parameters, arsenic, mercury and phenol have been removed from the permit (from September 2020).

3.1 Groundwater Monitoring Locations

Groundwater quality monitoring is undertaken from a total of eight boreholes from around the site including two from within each of the western and southern extension areas. The monitoring locations are as shown on the sampling location plan in Appendix E.

Groundwater level monitoring is also monitored from a further seven boreholes: BH3W, BH5B and BH7B (north); BH4, BH6, BH7 (west); and BH40B (east).

Groundwater quality was monitored from four boreholes to the north and east of the capped and restored area of the site. These boreholes are located as follows:

- Borehole BH9B is located on the northern boundary of the site, north of the Northern Leachate Drain; and
- Boreholes BH1B, BH45B and BH43B are situated along the eastern boundary adjacent to the canal from the north-eastern tip of the site (BH1B) proceeding south west along the eastern boundary (BH45B and BH43B).

The monitoring from within the Western Extension Area comprises boreholes BH5 and BH8 which run along the eastern boundary of the western extension. Both boreholes are located at the bottom of the west bund of the Cut (in which the reed bed system is located).

The monitoring from within the Southern Extension Area comprises boreholes BH12 and BH15. These boreholes are located as follows:

- Borehole BH12 is located towards the middle of the Southern Extension Area; and
- Borehole BH15 is located at the bottom of the river bund on the western edge of the Southern Extension Area.

3.2 Groundwater Monitoring Requirements

Tables 3A and 3B identify the groundwater wells that will be monitored, the type of monitoring and the frequency of the monitoring.

Table 3A - Groundwater Level Monitoring Schedule (June 2017 onwards)

Monitoring Point	Parameter	Monitoring Frequency
North: BH9B East: BH43B, BH1B, BH45B South: BH12, BH15 West: BH5, BH8 *Note – additional boreholes are also required to be monitored from June 2017: BH3W, BH5B and BH7B (north); BH4, BH6, BH7 (west); and BH40B (east)*	Water Level	Monthly

Table 3B - Groundwater Quality Monitoring Schedule (June 2017 onwards)

Monitoring Point	Parameter	Monitoring Frequency
North: BH9B East: BH43B, BH1B, BH45B South: BH12, BH15 West: BH5, BH8	pH, Temperature, Electrical Conductivity, Ammoniacal Nitrogen, Chloride, Potassium	Monthly
	Mercury, Chemical Oxygen Demand, Biological Oxygen Demand, Nickel, Chloride, Sulphate, Alkalinity, Total Organic Carbon, Sodium, Calcium, Magnesium, Iron, Manganese, Cadmium, Chromium, Copper, Lead, Zinc & Arsenic	6-monthly
	Hazardous substances	Every two years

The above quality monthly monitoring schedule was followed throughout 2023 (where monitoring was possible and where samples were able to be taken). Monitoring in April and October was completed for the 6-monthly monitoring. The full 2-yearly hazardous substances suite was undertaken in October.

3.3 Groundwater Control and Trigger Levels

Control and trigger levels, along with observed trends from control and trigger charts, provide a warning to the site operator that a problem may be occurring. They can be used to spot adverse trends in the monitoring data, or changes because of natural variations in the background water quality. Control levels are intended to provide an early warning indicator for when the landfill is beginning to deviate from its design performance so that corrective or remedial measures can be implemented before a trigger level is exceeded.

From September 2020, the only permit compliance levels are for ammoniacal nitrogen.

The current trigger and control levels for ammoniacal nitrogen date back to 2010 and so, as part of every annual review, the levels will be considered for revision to determine whether they remain fit for purpose (to provide the early warning). The potential for revision is discussed further in section 3.5.1.

Table 3C - Groundwater Control and Trigger Levels

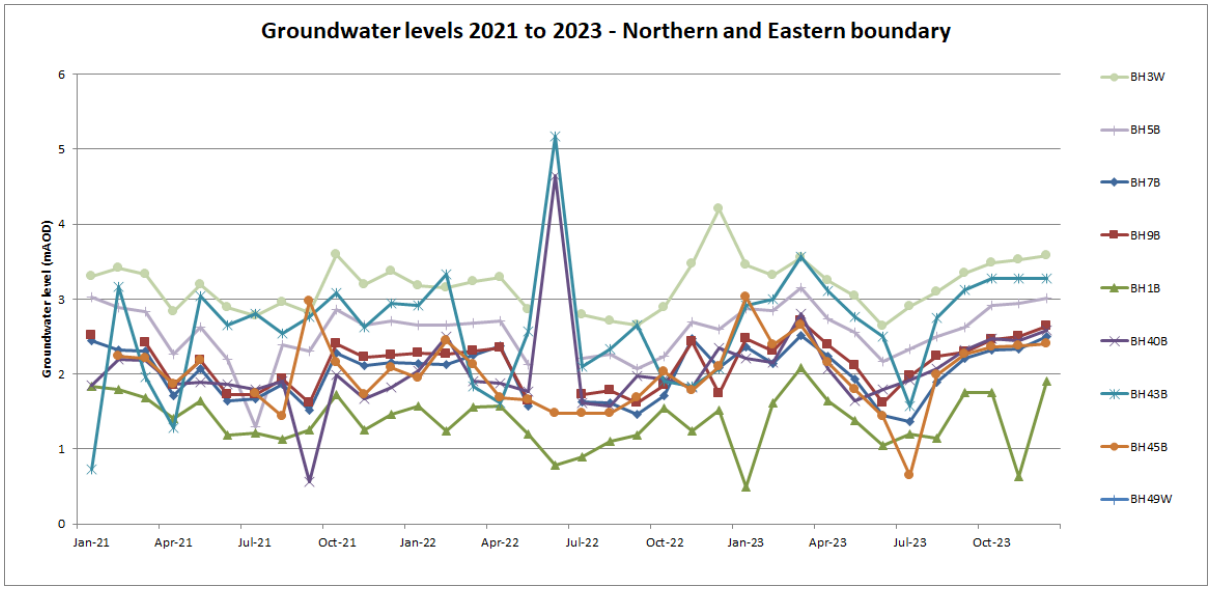
Parameter	Borehole	Permit compliance (Trigger) Level	Landfill Aftercare Plan Action (Control) Level
Ammoniacal Nitrogen (mg/l)	BH1B	3.1	2
	BH5	23.3	15.5
	BH8	88.6	59.1
	BH9B	1.6	1
	BH12	2.5	1.6
	BH15	2.3	1.5
	BH43B	108.9	72.6
	BH45B	59.5	39.7

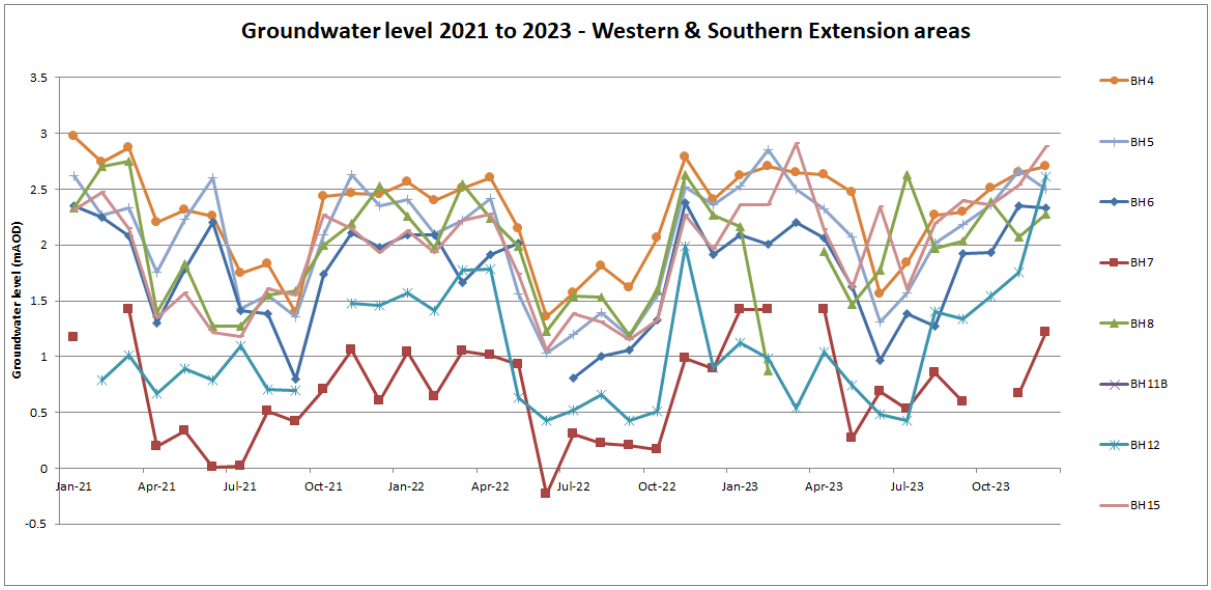
3.4 Groundwater Monitoring Results and Data Assessment

3.4.1 Groundwater Level Monitoring

Groundwater level monitoring has been carried out monthly during 2023 in accordance with the Landfill Aftercare Plan. The data obtained during 2023 is presented in Appendix B. A summary of the groundwater levels is set out in Table 3D.

The groundwater levels across the boreholes are illustrated below (water depth above AOD).





Note - for consistency the well depth and top of casing for 2017 have been used to calculate the levels for subsequent years including the 2023 levels. These mAOD depths have been used for many years to report the groundwater level data and were provided to C&P when compiling the first annual report in 2013.

Table 3D - Summary of Groundwater Level Monitoring

Borehole	Well Base (mAOD)	Top of casing (mAOD)	Minimum Groundwater Level (mAOD)	Maximum Groundwater Level (mAOD)	Difference in groundwater levels (max-min) (m)
Northern boundary					
BH3W	-1.40	6.51	2.64	3.58	0.94
BH5B	-3.91	7.36	2.17	3.15	0.98
BH7B	-4.39	6.87	1.37	2.51	1.14
BH9B	-3.06	7.42	1.61	2.71	1.10
Eastern boundary					
BH1B	-2.76	5.76	0.5	2.08	1.58
BH40B	-0.55	6.43	1.65	2.8	1.15
BH43B	-1.56	6.59	1.58	3.57	1.99
BH45B	-3.08	6.37	0.64	3.03	2.39
Western extension					
BH4	0.31	3.32	1.56	2.7	1.14
BH5	-0.51	3.27	1.31	2.85	1.54
BH6	-0.42	3.45	0.97	2.35	1.38
BH7	-1.58	3.06	0.27	1.42	1.15
BH8	-0.82	2.47	0.87	2.63	1.76
Southern extension					
BH12	0.43	5.31	0.43	2.61	2.13
BH15	0.50	4.38	1.61	2.91	1.30

Note - all groundwater wells were monitored on every occasion in 2023 except: BH7 (flooded in March and October) and BH8 (flooded in March).

The tidal nature of the River Neath Estuary, which is close to the Site, influences the groundwater beneath the site, and as such, there is relatively low (close to zero) hydraulic gradient beneath the site. The hydrogeological risk assessments have established the direction of groundwater flow beneath Giants Grave Landfill Site indicating that there is a slight hydraulic gradient within the superficial deposits towards the western side of the landfill and the River Neath, broadly consistent with local topography.

From Table 3D and the groundwater fluctuation graphs, the following observations can be made:

- The difference between the lowest and highest groundwater levels in each well is between 0.94m and 2.39m.
    - The most significant variation between minimum and maximum groundwater levels are in BH45B (2.39m) and BH12 (2.18m).
        - BH45B recorded its highest level in January and the lowest level in July.
        - For BH12 a reading in July recorded dry conditions but there was a significant increasing trend until the water level of 2.61mAOD recorded in December.
- For the western and southern locations, the 2023 groundwater level data generally follows a similar pattern of the highest levels at the start and end of the year with lowest levels typically in July.
- A similar pattern is observed in the eastern and northern locations with the lowest levels typically in June and July. The well BH1A records a more fluctuating pattern with unusually low water levels in January and November. The most pronounced trend is the increase in BH12 between July and December.

3.4.2 Groundwater Quality Monitoring – Key Parameters

A review of the groundwater quality monitoring data has been undertaken. Table 3E provides a summary of the concentrations for ammoniacal nitrogen which has trigger levels stated within the environmental permit (Schedule 3 Table 3.5) and control levels in accordance with the Landfill Aftercare Plan as detailed in Table 3C.

For Table 3E, when compiling summary statistics (e.g. mean values), where a parameter has not been detected at concentrations greater than the detection limit, the detection limit has been used in the calculations.

Table 3E - Groundwater Quality Indicator - Ammoniacal Nitrogen

Parameter	Borehole	Minimum 2023	Maximum 2023	Mean 2023	Minimum 2022	Maximum 2022	Mean 2022
Ammoniacal Nitrogen (mg/l)	BH1B	<0.015	1.9	0.6	<0.015	1.5	0.3
	BH5	<0.015	0.084	0.029	<0.015	0.31	0.5
	BH8	<0.015	35	11.1	<0.015	38	12.3
	BH9B	0.054	2.8	1.0	0.13	1.8	0.8
	BH12	<0.015	2	0.3	<0.015	1.5	0.29
	BH15	<0.015	0.13	0.05	<0.015	0.71	0.17
	BH43B	26	85	63.8	29	95	57.1
	BH45B	0.021	130	89.7	14	96	58.8

For ammoniacal nitrogen the maximum values in red exceed the trigger level and those in orange exceed the control level.
BH12 – insufficient sample for May and June 2023. BH15 – December 2023 - Water levels monitored a week prior to groundwater sampling - but location flooded at the time of sampling

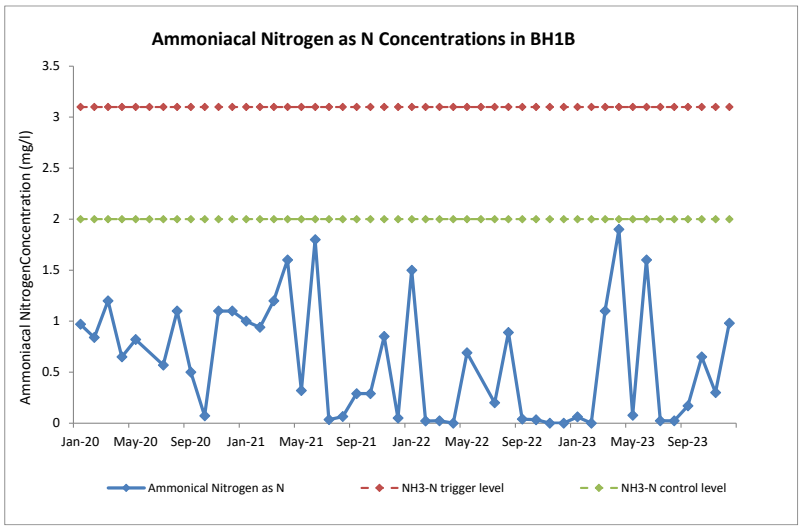
When comparing the 2023 groundwater data in Table 3E with the control and trigger levels specified in Table 3C, the following general comments can be provided:

- **Ammoniacal Nitrogen** – four of the eight boreholes exceeded either the trigger level or control level during 2023 (compares to three boreholes in 2022):
    - BH9B - Exceeded the trigger level of 1.6mg/l on two occasions (March and September) with the highest concentration being 2.8mg/l. BH9B also exceeded the control level of 1.0mg/l on one occasion (February). The mean concentration was 1mg/l. The mean concentration in 2022 was 0.8mg/l and in 2021 was 1.3mg/l.
    - BH45B – The trigger level of 59.5mg/l was exceeded on eleven occasions (January to November). The concentration recorded was up to a maximum concentration of 130mg/l in October. The December result was unusually low at reported by the laboratory at 0.021mg/l.
    - BH43B - exceeded the control level of 72.6mg/l on three occasions (March, October and November) with the highest concentration being 85mg/l. This compares to the highest concentration in 2022 of 95mg/l and 2021 of 91mg/l.
    - BH12 – The control level of 1.6mg/l was exceeded in February when a reading of 2mg/l was record. The next highest reading across the year was at 0.56mg/l.

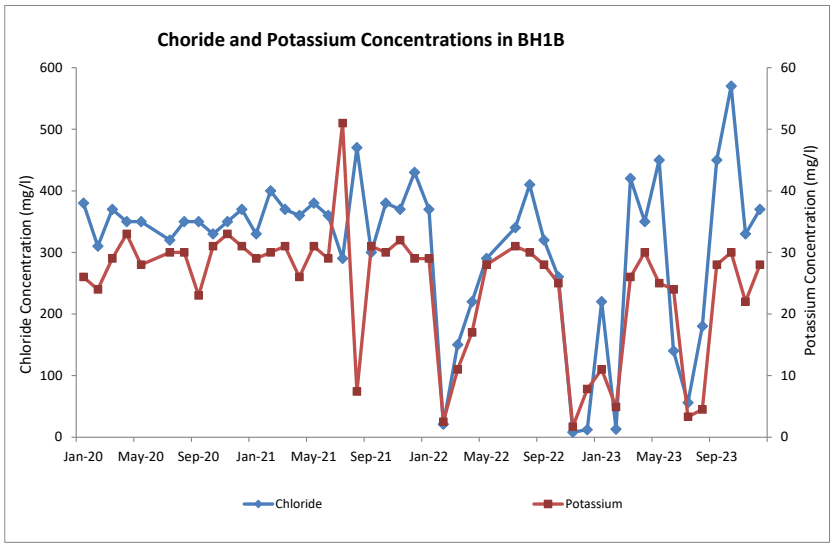
Note – graphical illustration of the ammoniacal nitrogen, chloride and potassium concentrations are provided for all boreholes below.

Borehole BH1B

The ammoniacal nitrogen concentration continues to fluctuate but has remained below the control level throughout 2023 and continues a pattern observed since 2020. The current ammoniacal nitrogen control and trigger levels for this location appear to remain relevant as an early warning of any adverse changes in groundwater quality.



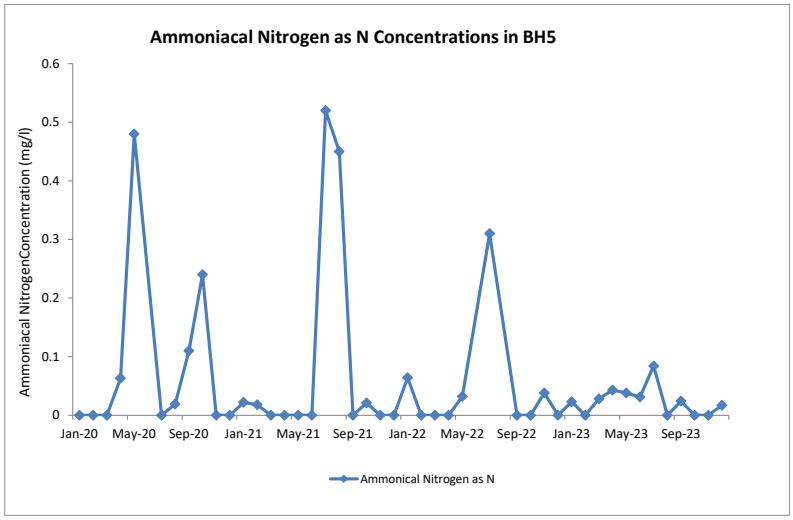
The chloride and potassium concentrations remained relatively consistent up until significant fluctuations in mid-2021 for both parameters. These fluctuating results have continued into 2023 with concentrations ranging from near zero up to over 500mg/l for chloride and 30mg/l for potassium. The chloride recorded in October is the highest recorded in the last 4 years. The mean concentration for chloride has increased from approximately 218mg/l in 2022 to 296mg/l in 2023.



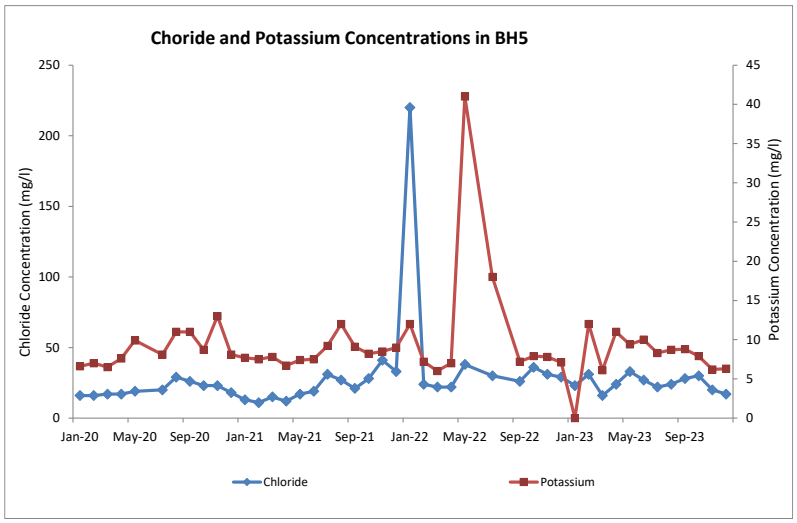
Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

Borehole BH5

All concentrations since March 2018 have been <1mg/l with all 2023 concentrations <0.1mg/l. The control and trigger levels are not shown on the graph as they are set at concentrations of 15mg/l and 23mg/l respectively. Based on the data for the last few years, these control and trigger levels would not be considered fit for purpose as they are more than an order of magnitude above the typical concentrations recorded. This report does not consider a recalculation of the control and trigger levels – which would be considered as part of a separate project aligned with any permit variation application if considered applicable.



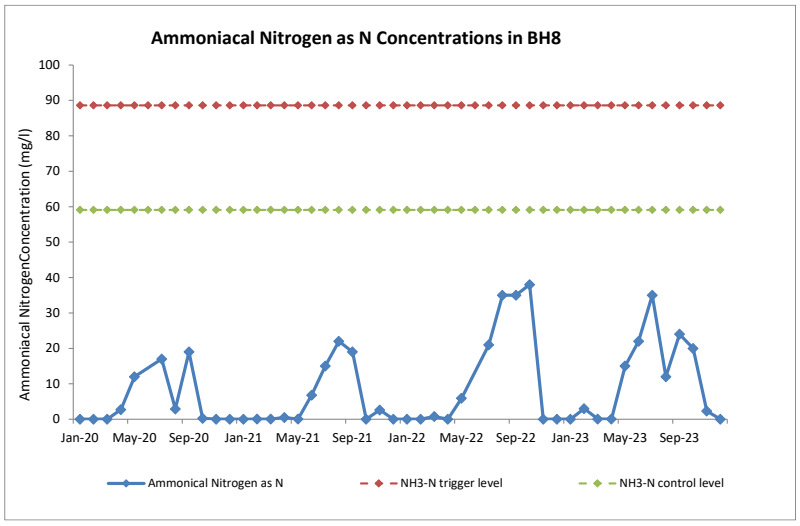
The graph below illustrates some significant spikes for the chloride and potassium in this groundwater in 2022, although these have not been repeated during 2023, leading to lower means for both parameters. No adverse trends noted for these parameters.



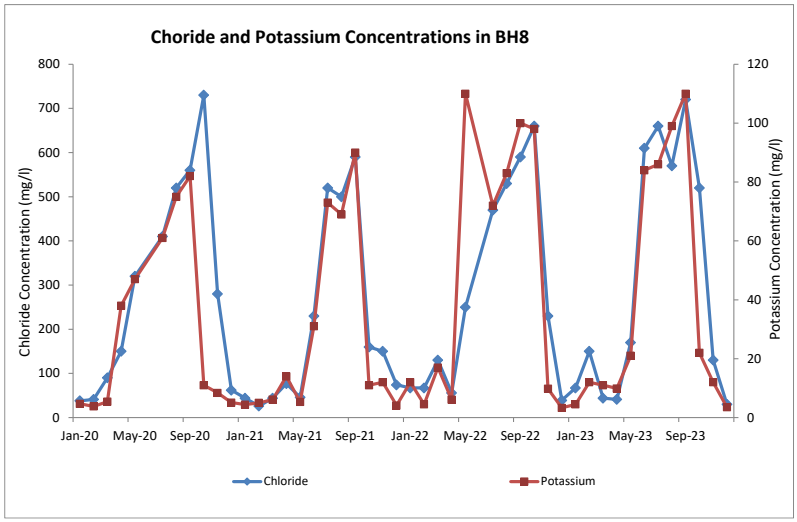
Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

Borehole BH8

The ammoniacal nitrogen concentrations since early 2018 have remained below the control and trigger levels. The highest ammoniacal nitrogen concentrations recorded in 2023 are in the months May to October and continues to suggest a seasonal pattern of higher detection in the summer months. No adverse trend noted for ammoniacal nitrogen in this groundwater. Based on the graphical below the control level for ammoniacal nitrogen at 59mg/l (and higher trigger level of 88mg/l) would appear to be relevant to provide an early warning to any adverse change in quality.



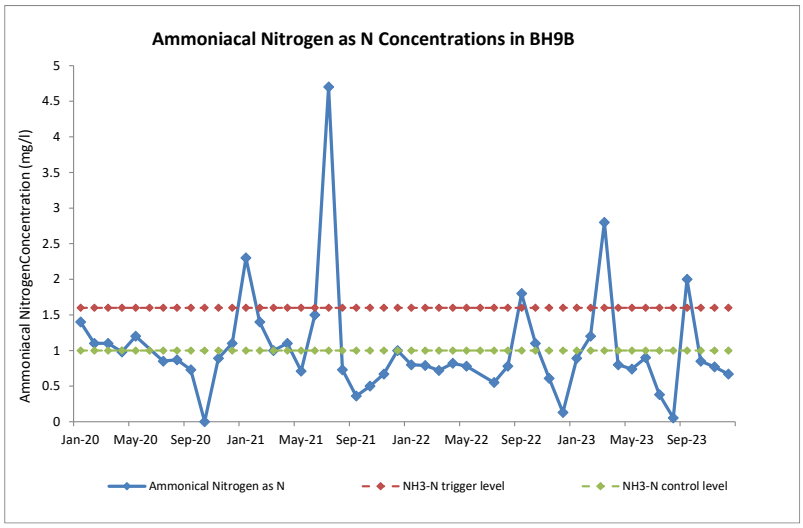
The chloride and potassium in borehole BH8 continue to show a close correlation throughout the recent years and including 2023. The highest concentrations for both potassium and chloride occur during the summer months with significantly lower concentration early and late in the year. Although the seasonal spikes are noted there are no apparent adverse trends.



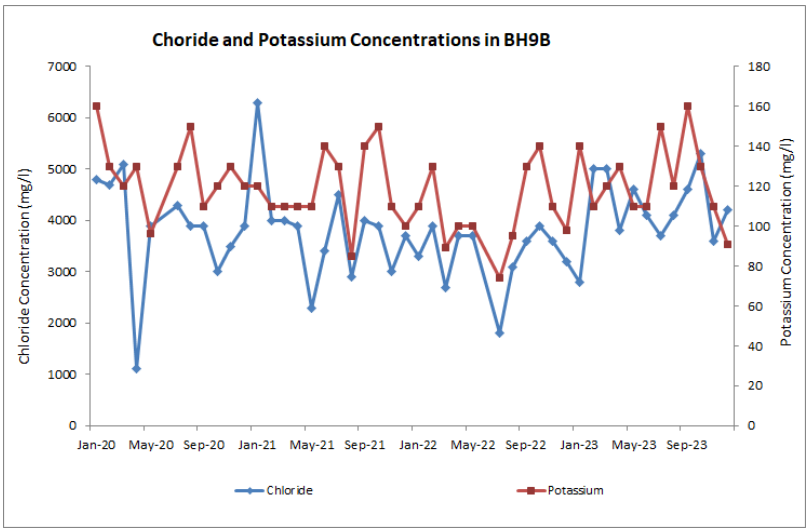
Note - there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

Borehole BH9B

This borehole continues to record occasional ammoniacal nitrogen results above the control and trigger levels. During 2023 this has included a breach of the trigger level in March at 2.8mg/l and September at 2.0mg/l plus the control level being exceeded in February. In 2018 and 2019 there were spikes recorded at 73mg/l and 10mg/l respectively with the highest since then in 2021 as illustrated in the graph. The mean concentration has increased slightly in 2023 at 1.0mg/l compared to 0.8mg/l in 2022. Although occasional breaches of the trigger level are noted there are no adverse trends and the control level for ammoniacal nitrogen at 1.0mg/l (and higher trigger level of 1.6mg/l) would appear to be relevant.



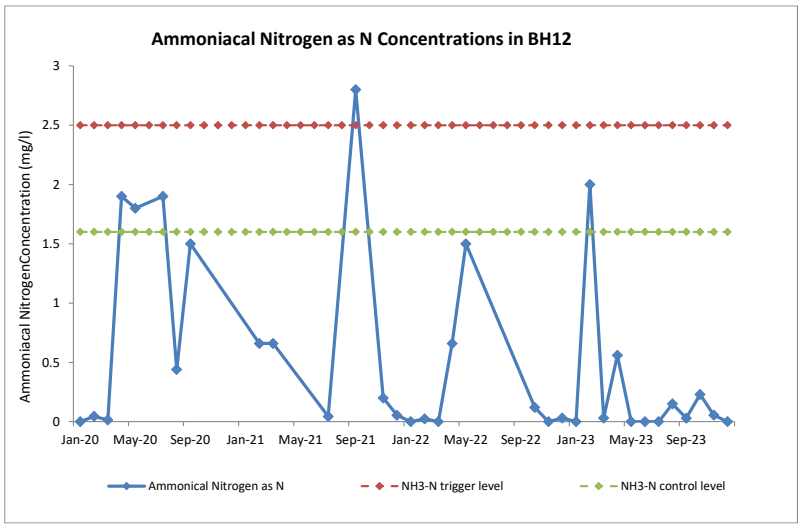
Borehole BH9B continues to record the highest chloride concentrations of all the groundwater. The concentration of chloride and potassium follow a similar pattern in 2023 and no significant adverse trends noted, although the mean concentration of chloride has increased from 3318mg/l in 2002 to 4042mg/l in 2023.



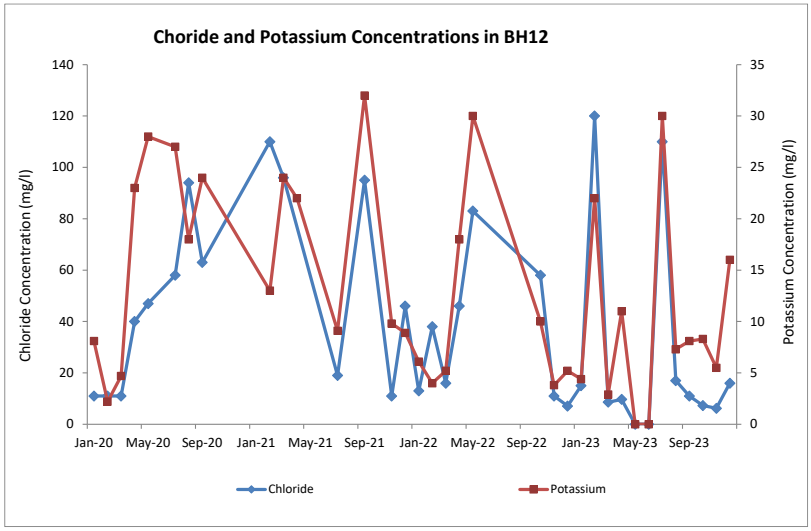
Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

Borehole BH12

Due to insufficient groundwater being present, samples were not able to be obtained in May and June. No exceedance of the trigger levels was recorded at this location in 2023, although one result at 2mg/l in February exceeded the 1.6mg/l control level. The groundwater continues to record fluctuating results, but the control and trigger levels remain relevant to this groundwater.



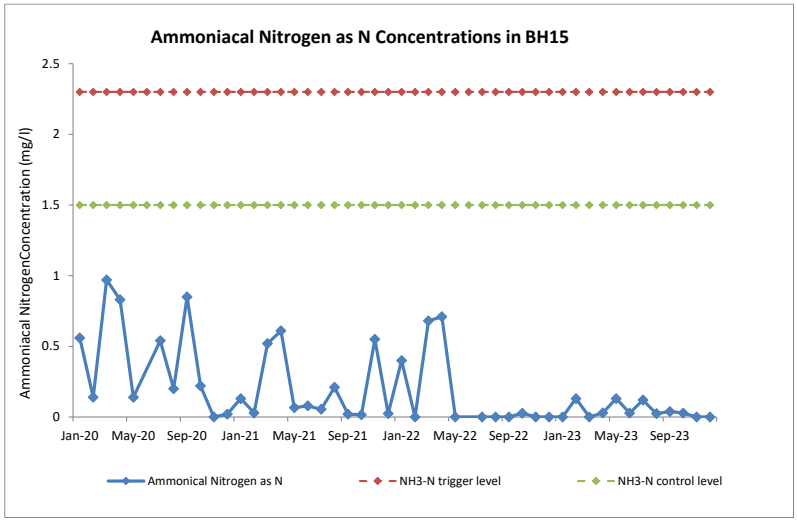
The 2023 concentrations continue to record highly fluctuating pattern for both chloride and potassium, although the two parameters typically correlate well. The range measured for both parameters are within the concentrations recorded over recent years and no adverse trends noted.



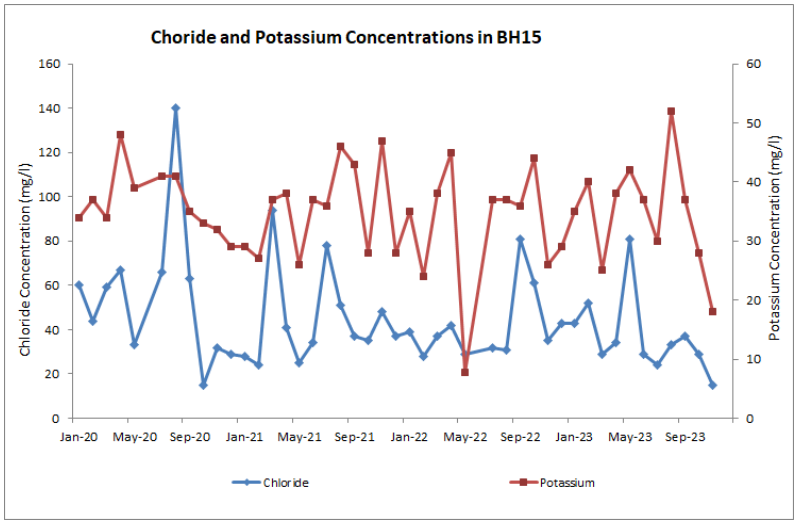
Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

Borehole BH15

Although no longer on the graph below, an elevated spike of ammoniacal nitrogen was recorded in October 2018 at 7.6mg/l and so significantly above the trigger level. However, all subsequent readings have been well below the control level set at 1.5mg/l. The highest concentration recorded in 2023 is 0.13mg/l with several results below detection. The graph shows that the control and trigger levels are relevant to the data observed over the last few years.



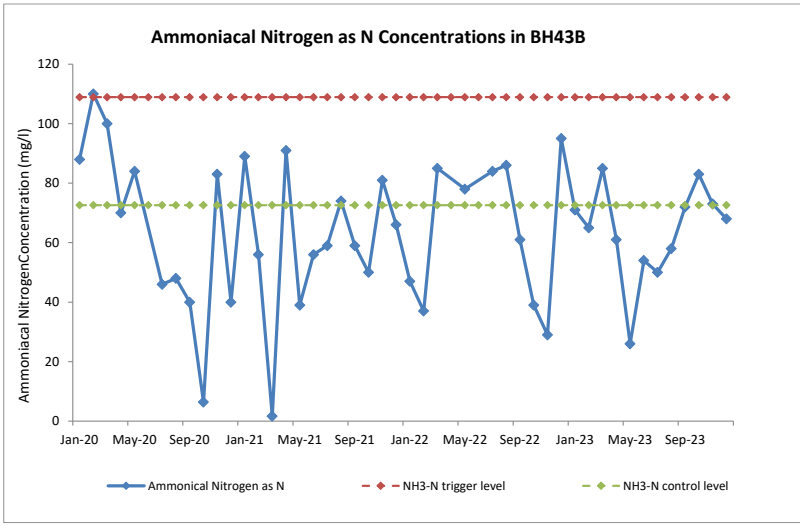
Fluctuating results continue to be recorded for chloride and potassium, although no adverse trends noted. Following the highest concentration recorded for potassium in recent years (in August at 52mg/l) a falling trend was then recorded until the end of the year.



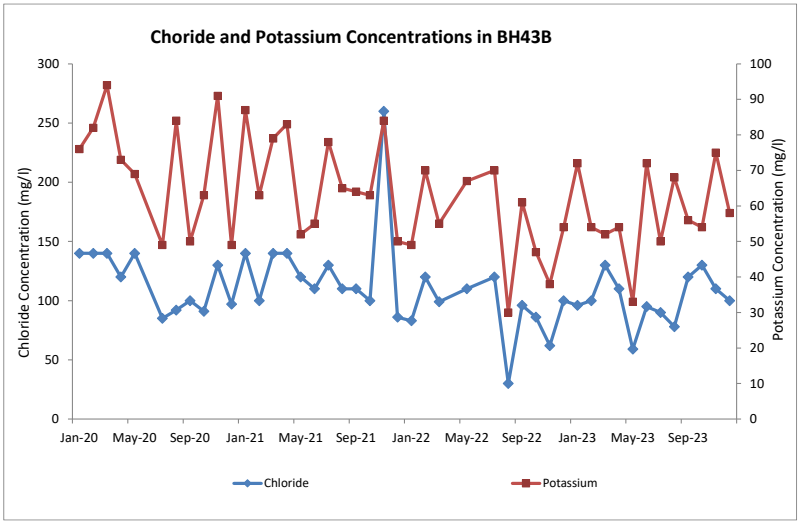
Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

Borehole BH43B

The ammoniacal nitrogen in 2023 continues a fluctuating pattern around the control level of 72.6mg/l. Three results are above the control level compared with five in 2022, but all continue to be below the trigger level of 108.9mg/l. Although fluctuating there is no adverse trend apparent. From the graph it suggests that the current trigger level for ammoniacal nitrogen remains relevant.



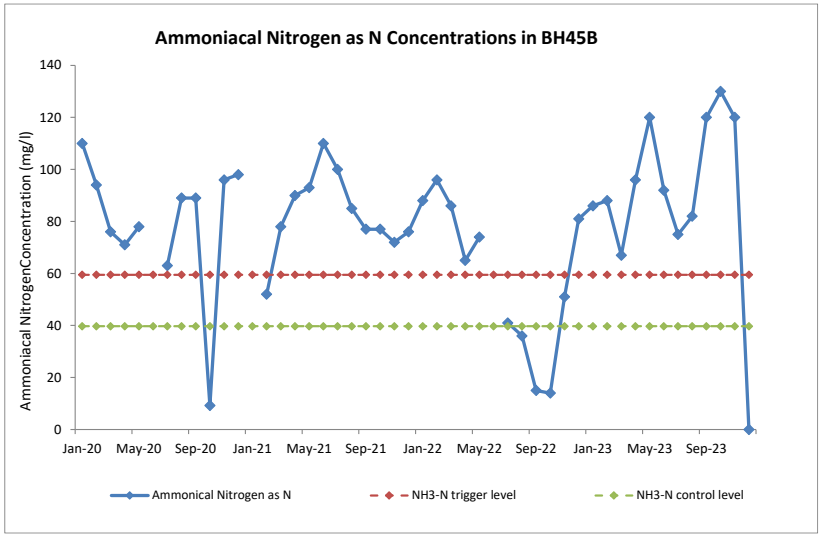
Slightly fluctuating results continue to be recorded for potassium and chloride although no adverse trends noted in 2023. The concentrations in 2023 for both parameters are within the ranges recently recoded.



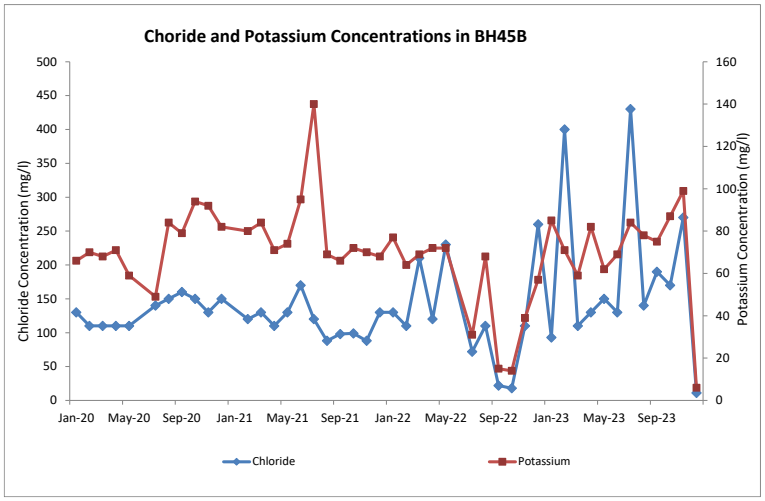
Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

Borehole BH45B

Eleven results (January through to November) have exceeded the trigger level of 59.5mg/l. The only result below this trigger level was recorded in December at an unusually low 0.021mg/l. Overall, the mean concentration in 2023 has increased to approximately 90mg/l compared with 58.8mg/l in 2022, but similar to the 82.7mg/l mean calculated in 2021. It is recognised that this location also records elevated methane and the likely presence of landfill gas as it is believed that this borehole (along with BH43B and BH40B) are buried in waste outside the landfill boundary and therefore outside the influence of the any onsite leachate and gas control infrastructure. The continued elevated ammoniacal nitrogen concentrations suggest that the current control and trigger levels for ammoniacal nitrogen may not be relevant as an appropriate early warning of changes in the groundwater quality.



The chloride concentrations in 2023 have continued to show considerable fluctuation compared to results to early 2022 with an increased mean concentration of 185mg/l compared with 126mg/l in 2022. The potassium concentrations have shown a gradual rising trend falling trend throughout much of 2023 (although this followed a falling trend at the end of 2022).



Similar to the ammoniacal nitrogen concentration, the December reading for both chloride and potassium were unusually low. Overall, there are no significant adverse trends noted.

Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

3.4.3 Groundwater Quality Monitoring – Other Parameters

a) Six-monthly

The six-monthly monitoring of groundwater for a range of metals and other parameters (such as COD, BOD etc) was undertaken in April and October in 2023 for all locations.

For the components monitored then the most significant observations are:

BH5

- All components' results are similar (within an order of magnitude) in BH5 in 2023 compared with 2022 other than for manganese which recorded 410µg/l In April 2023 compared with a highest concentration of 2.6µg/l in 2022.
- There is a slight decreasing trend for COD across 2022 to 2023, although all results within the same order of magnitude.

BH8

- For this borehole the October sample in 2022 recorded elevated concentrations of many components when compared with previous six-monthly samples for components such as alkalinity; arsenic; BOD; COD; iron; magnesium; manganese; nickel; and sodium. The results for these components were lower across 2023, although for many components the October 2023 sample recorded higher concentrations than the April sample. This effect was most pronounced for alkalinity, arsenic, manganese and BOD.
- The concentrations for COD and manganese recorded an order of magnitude decrease from the highs recorded in October 2022.
- Trace mercury detected at 0.0051µg/l in April (although the minimum reporting value is 0.005µg/l).

BH12

- All components' results are similar (within an order of magnitude) in BH12 in 2023 compared with 2022 other than for COD and sodium (which record order of magnitude decreases) and chromium that records a detected concentration of 1µg/l compared to recent samples being <0.2µg/l.
- The manganese concentration records a falling trend from 2022 to 2023.
- A slight increase in zinc recorded in October 2023 at 19µg/l compared to 5.4µg/l in April 2023 (and similar concentrations in 2022).
- No detection of mercury in 2023 following detection in April 2022 of 0.0088µg/l.

BH15

- All components' results are similar (within an order of magnitude) in BH15 in 2023 compared with 2022 other than for the following:
- An increasing trend in zinc from 5.9µg/l in April 23 to 50µg/l in October 2023.
- Falling trends across 2022 to 2023 in manganese, sodium and sulphate.

BH9B

- All components' results are similar (within an order of magnitude) in BH9B in 2023 compared with 2022.
- Cadmium detected in both samples in 2023 (up to 0.07µg/l) compared with below detection in 2022 (<0.02µg/l)
- No detection of mercury in 2023 following detection in April 2022 of 0.0065µg/l.

BH1B

- All components' results are similar (within an order of magnitude) in BH1B in 2023 compared with 2022, although slight rising trends are observed in COD, Alkalinity and manganese.
- Cadmium undetected in both samples in 2023 (<0.02µg/l) compared with detections in 2022 (up to 0.09µg/l)
- Detection of mercury in both samples in 2023 with April at 0.0121µg/l and October at 0.0058µg/l – this compares to April 2022 (0.0065µg/l). This is the highest mercury recorded across the groundwater.
- BH1B has the highest iron concentration across the groundwaters -typically at least an order of magnitude higher than most locations.

BH43B

- Two samples taken in 2023 compared with only one in 2022 (October).
- All components' results are similar (within an order of magnitude) in BH43B in 2023 compared with October 2022 with no adverse trends or significantly different results.
- This groundwater consistently records the highest manganese concentrations.

BH45B

- All components' results are similar (within an order of magnitude) in BH43B in 2023 compared with 2022 other than chromium (that has been detected in 2023 in both samples compared with non-detected in 2022).
- A falling trend recorded in zinc concentrations across 2022 to 2023.

There have been limited order of magnitude increases in 2023 samples compared with 2022 and no significant adverse trends noted.

b) 2 yearly monitoring

The 2-yearly monitoring for other hazardous substances was undertaken in October 2023 with samples collected from all eight wells.

The full analysis is reported in Appendix B, although any significant detections or changes from the hazardous suite in 2021 are commented on below:

Organic parameters

- No detection of phenol compounds including methylphenols, nitrophenols or chlorophenols in any sample compared to a detection in BH9B of phenol at 17.8µg/l in 2021.
- All benzo(a)pyrene and naphthalene analysis in 2023 was undetected (<0.01µg/l) which is the same as for 2021 compared to positive detections across several samples up to 0.08µg/l in 2018.
- The 2023 analysis does not record any positive detections of TPH (all carbon ranges) which is the same as for 2021.
- No detection of BTEX in any of the groundwaters in 2023 as it was for 2021.
- Mecoprop was detected in 3 samples (BH8, BH43B and BH45B) up to a concentration of 1.5µg/l. In 2021 the locations BH43B and BH45B also recorded mecoprop up to 0.87µg/l.

Inorganic parameters

- The concentration of hazardous metals including antimony, barium, boron, cobalt, molybdenum, selenium, uranium and vanadium is variable across the groundwater locations. No significant (order of magnitude) increases have been observed for any metal in any location.
- An increase in the number of positive detections for Nitrite as N has been observed with significant increases in the concentrations. In 2021 the highest concentration was 3.7µg/l. The highest concentration recorded in 2023 is 860µg/l (in BH8) and between 19µg/l and 80µg/l in four other locations (BH12, BH9B, BH43B and BH45B).
- The phosphate and phosphorous concentrations are within the same order of magnitude in the different locations when comparing 2023 with 2021. The locations recording the highest concentrations remain BH1B and BH8.
- All cyanide analysis in 2023 was undetected (<0.01mg/l) which was the same in 2021.
- A slight increase in fluoride concentrations across all samples in 2023, although all remains within the same order of magnitude.

3.5 Summary and Recommendations for the Groundwater Monitoring Programme

The groundwater levels across the boreholes follow a similar pattern to each other throughout the year and are of a similar mean level to recent years. The most significant change observed is an increasing water level in BH12 from dry conditions in July to an elevated level (for this borehole) in December.

For groundwater quality, the main concerns arising in 2023 are the breaches of the trigger level for ammoniacal nitrogen in BH9B (on two occasions) and in BH45B which exceeded the trigger level on all but one occasion.

There were no rising trends in ammoniacal nitrogen recorded. For potassium and chloride there were no significant adverse trends.

In general, no significant adverse trends noted in the biannual hazardous substances monitoring nor the hazardous substances monitored on a two-yearly basis. The most significant differences are for higher concentrations for nitrite as N in several samples.

3.5.1 Review of Control and Trigger Levels

The Landfill Aftercare Plan suggests that the control and trigger levels are considered as part of the Annual Environmental Performance Report. From a review of the data for each borehole monitored and a consideration of the concentrations recorded during 2023 most of the current control and trigger levels would appear to be relevant (fit for purpose) to provide a warning to adverse conditions in the groundwater.

A general review of the adequacy of the control and trigger levels was provided in section 3.4.2 above.

The locations that appear not to have relevant control and trigger levels are in:

- BH5 – the ammoniacal nitrogen C & T levels are set at concentrations two orders of magnitude *higher* than the results observed.
- BH45B – the continued elevated ammoniacal nitrogen concentrations suggest that the current control and trigger levels for ammoniacal nitrogen may not be relevant as an appropriate early warning of changes in the groundwater quality.

Although the control and trigger levels for groundwater quality in the above-mentioned boreholes do not necessarily provide an appropriate early warning, this report does not suggest any current action to amend these.

4 Surface Water Monitoring

This section provides a summary of the surface water monitoring at Giants Grave for 2023 in accordance with Schedule 3, Table 3.9 of the environmental permit EPR/SP3298FT and Appendix A4 of the Landfill Aftercare Plan.

A new monitoring regime was agreed with NRW from June 2017 onwards. For surface water monitoring the only change was to remove the requirement to analyse for chloride and to remove the visual inspection for any evidence of contamination.

Within the Addendum to the HRA[2] (approved by NRW and ratified by the NPTWM Board during 2020), the following is stated:

> "Once the proposal to revise compliance limits, as set out in this Addendum, have been determined by NRW, NPTWM will submit a revision to the Aftercare Plan in respect of control and trigger levels for surface water:
>
> - To remove Chloride limits from River North and River South (in accordance with Section 8.2 of HRA2016); and
> - To revise Ammoniacal Nitrogen limits at River North and River South (in accordance with the 2018 Annual Report)."

Although the changes to chloride were implemented from June 2017, the changes to compliance limits for ammoniacal nitrogen have not been implemented and are awaiting a revision to the Landfill Aftercare Plan.

4.1 Surface Water Monitoring Locations

Surface water monitoring is undertaken at four monitoring locations near the site:

- The Neath Canal forms the eastern boundary of Giants Grave Landfill Site. The Canal has only minimal flow from north to south. The monitoring points, Canal North and Canal South, are located on the Canal, adjacent to the Northern and Southern extents of the site respectively.
- The River Neath forms the south western boundary to the western extension and also forms part of the western boundary to the southern extension. The river flows from north to south and is considered tidal at this point. Monitoring points – River North and River South - are located on the River Neath, adjacent to the Northern and Southern extents of the site respectively.

The locations of the surface water monitoring points are shown on the sampling location plan in Appendix E.

[2] Giants Grave Landfill Site (in Aftercare) – EPR/SP3298FT – Addendum to the Hydrogeological Risk Assessment Review 2016 (NPTWM, April 2016)

4.2 Surface Water Monitoring Requirements

Table 4A summarises the surface water monitoring requirements of the environmental permit and Landfill Aftercare Plan.

Table 4A - Surface Water Monitoring Schedule

Monitoring Point	Parameter	Monitoring Frequency
Canal North; Canal South; River North; River South NB River North and River South sampled at high tide to help minimise the safety risk to monitoring personnel at these locations	pH, Temperature, Electrical Conductivity, Ammoniacal Nitrogen, Suspended Solids, Chemical Oxygen Demand, Biological Oxygen Demand, Dissolved Oxygen, Nickel, Nitrate, Phenol	Monthly

The above monitoring schedule was completed for the surface water monitoring points, although several parameters (pH, Electrical conductivity and BOD) were unable to be monitored in July for all four locations due to an unsuitable sample.

4.3 Surface Water Control and Trigger Levels

Control and trigger levels, along with observed trends from control and trigger charts, provide a warning to the site operator that a problem may be occurring. They can be used to spot adverse trends in the monitoring data, or changes because of natural variations in the background water quality. Control levels are intended to provide an early warning indicator for when the landfill is beginning to deviate from its design performance so that corrective or remedial measures can be implemented before a trigger level is exceeded.

Surface water control and trigger charts for the key parameter of ammoniacal nitrogen have been prepared for the surface water monitoring locations specified in Table 4B. These limits are not stated in the environmental permit but were set within the Landfill Aftercare Plan. This annual environmental report reviews and recommends whether these control and trigger levels are relevant.

Table 4B - Surface Water Control and Trigger Levels

Parameter	Surface Water Monitoring Location	2010 Trigger Level	2010 Control Level
Ammoniacal Nitrogen (mg/l)	Canal North	1.0	0.7
	Canal South	0.5	0.3
	River North	0.4	0.3
	River South	0.5	0.3

4.4 Surface Water Monitoring Results and Data Assessment

4.4.1 Surface Water Quality Monitoring

Table 4C provides a summary of the key surface water indicator parameters analysed monthly.

Table 4C – Surface Water Quality Indicator Parameters

Parameter	Monitoring Location	Minimum	Maximum	Mean	Comments
Parameters with Control and Trigger Levels					
Ammoniacal Nitrogen (mg/l)	Canal North	0.035	3.5	0.47	One exceedance of trigger level (3.5mg/l in August)
	Canal South	0.1	0.85	0.29	One exceedance of trigger level (0.85mg/l in January), three exceedances of control level (Mar, Apr & Sept)
	River North	0.035	0.53	0.13	One exceedance of trigger level (January).
	River South	<0.015	0.38	0.12	One exceedance of control level (January)

Parameter	Monitoring Location	Minimum	Maximum	Mean	Comments
Nickel (µg/l)	Canal North	0.8	7.5	2.7	All samples recorded positive detections The maximum and mean concentrations are similar to 2022
	Canal South	1.4	7.6	2.8	
	River North	1.0	4.8	2.1	All samples recorded positive detections. The mean concentrations are lower than in 2022 (RN at 8.96µg/l and RS at 4.23µg/l). Insufficient sample RN August & RS June.
	River South	0.9	2.7	1.8	
Chemical Oxygen Demand (mg/l)	Canal North	10	3900	384	Variable levels with spike in August at 3900mg/l in N (otherwise 340mg/l is next highest)
	Canal South	5.7	67	18.6	
	River North	15	1600	466	Variable levels between N & S with RS location showing spike of 5200mg/l in August (although this corresponds to highest N at 1600mg/l)
	River South	15	5200	889	
Biological Oxygen Demand (mg/l)	Canal North	1.1	61	8.4	Variable concentrations recorded with spikes in August in S and September in S.
	Canal South	<1	48	7.8	
	River North	<1	9.7	3.9	Minimum, maximum and mean concentrations in River N and S within the same order of magnitude during 2023.
	River South	1.0	8.9	2.8	
Phenol (mg/l)	Canal North	<0.0005	10.2	-	Phenol detected at in CN at 10.2mg/l and CS at 23.3mg/l during August, otherwise no other phenol detected
	Canal South	<0.0005	23.3	-	
	River North	<0.0005	<0.0005	-	
	River South	<0.0005	<0.0005	-	

Parameter	Monitoring Location	Minimum	Maximum	Mean	Comments
Nitrate as NO_3 (mg/l)	Canal North	0.09	0.59	0.35	Significant difference between north & south in Canal in March. RN and RS concentrations within the same order of magnitude. Insufficient sample RS June
	Canal South	0.06	2.19	0.48	
	River North	0.05	0.58	0.3	
	River South	0.09	1.19	0.36	
Total Suspended Solids (mg/l)	Canal North	2	1400	196.67	Highly variable data across the monitoring locations
	Canal South	<2	610	76.25	
	River North	16	26000	2821.4	Highly variable data across the monitoring locations
	River South	13	1300	430.6	

General Note - (Unless otherwise stated in the table above) when compiling summary statistics (e.g. mean values), where a parameter has not been detected at concentrations greater than the detection limit, the detection limit has been used in the calculations.

a) Canal North and Canal South

Surface water monitoring data was collected from Canal North and Canal South monthly throughout 2023 other than in July (where pH, Electrical conductivity and BOD were unable to be measured). Table 4D summarises the ammoniacal nitrogen concentration range in 2023 and compares with those observed during 2021 and 2022.

For Canal North the trigger level was exceeded on one occasion – August 2023 at a significantly elevated 3.5mg/l.

For Canal South the trigger level was exceeded on one occasion – January 2023 at 0.85mg/l, with the control level also exceeded in March, April and September 2023.

The trends for ammoniacal nitrogen compared to the control and trigger levels for Canal North and Canal South can be observed graphically below.

Table 4D - Summary of Canal North and Canal South Monitoring Data

Monitoring Point	Ammoniacal Nitrogen Ranges (mg/l)		
	2021	2022	2023
Canal North	<0.015 – 0.52	<0.015 – 0.53	0.035 – 3.5
Canal South	0.019 – 0.91	<0.015 - 4	0.1 – 0.85

From the information in Tables 4C and 4D, and a review of the 2023 data in Appendix C the following observations can be made:

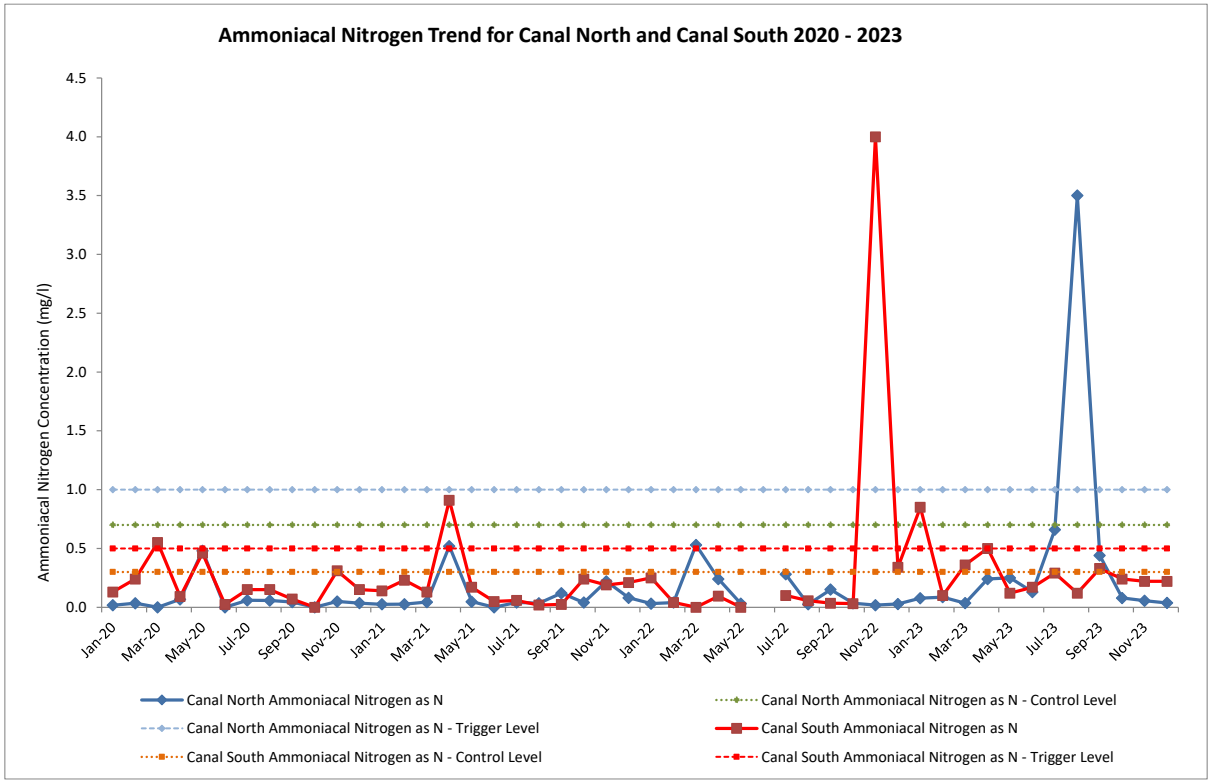
- The mean, minimum and maximum concentrations for nickel and phenol are generally similar for the upstream (Canal North) and downstream (Canal South) monitoring locations, although a recording of phenol in both samples in August was unusual but suggests a source from north of the landfill.

- The other parameters record occasional readings where there is a more significant difference between the upstream and downstream readings. These differences are described below.

Ammoniacal nitrogen

Graphical analysis for the ammoniacal nitrogen concentrations in the upstream and downstream samples is provided below. The upstream and downstream results were within 0.2mg/l on most occasions in 2023 except in the following months:

- January, March and April - in which the Canal South location recorded concentrations higher than Canal North. This includes order of magnitude differences in January (0.85mg/l in South compared with 0.077mg/l in North) and March (0.36mg/l in South compared with 0.035mg/l in North).
- July and August – in which Canal North recorded concentration higher than Canal South. Of these the most significant is in August where Canal North recorded its highest concentration of 3.5mg/l (compared to 0.12mg/l in South).



For understanding the potential environmental impact of the site then the most important of these is when the downstream sample records significantly elevated levels – such as in January and March. Other than low detection in February the Canal South recorded elevated ammoniacal nitrogen across the period from November 2022 to April 2023 – starting with the highest recording in November 2022. All readings in 2023 were significantly lower with the readings from May onwards being between 0.12mg/l and 0.33mg/l. The difference between the Canal North and South during the period November 2022 to April 2023 may suggest an impact from the landfill, although any such impact was not observed from May onwards.

Canal North recorded a spike in ammoniacal nitrogen in August (with the next highest readings in July and September). This is significantly elevated compared to recent years and suggests a contamination source from north of the landfill.

Other parameters

Note - There is no control or trigger level set for the any of the parameters monitored at these monitoring locations except ammoniacal nitrogen.

- For chemical oxygen demand there were two months where the upstream sample recorded an order of magnitude higher result than the downstream (July and August). This suggests a source from north of the landfill. The mean concentration for COD was much higher in 2023 due to the significantly elevated result in August of 3900mg/l. There were no months where the downstream sample was significantly higher than the upstream.
    - COD: July (340mg/l upstream compared with 18mg/l downstream) and August (3900mg/l upstream compared with 28mg/l)

- For biological oxygen demand the September results showed a significantly higher downstream reading
    - BOD: September (48mg/l downstream compared with 3.2mg/l upstream).

- Nitrate nitrogen recorded some results where the upstream and downstream samples were more than an order of magnitude difference.
    - Downstream higher than upstream
        - Nitrate nitrogen: March (2.19mg/l compared with 0.37mg/l).
    - Upstream higher than downstream
        - Nitrate nitrogen: July (0.59mg/l compared with 0.07mg/l downstream)

- For suspended solids there were several results where the upstream and downstream samples were more than an order of magnitude difference, although typically the upstream sample recorded higher suspended solids.
    - Downstream higher than upstream
        - Suspended solids: March (610mg/l compared with 2mg/l upstream)
    - Upstream higher than downstream
        - Suspended solids: February (130mg/l compared with <2mg/l downstream); April (150mg/l compared with 17mg/l downstream); July (1400mg/l compared with 11mg/l downstream); August (210mg/l compared with 24mg/l downstream); October (54mg/l compared with 4mg/l downstream); December (27mg/l compared with <2mg/l downstream)

Overall, the results from the 2023 Canal monitoring locations suggests that the ammoniacal nitrogen data from the end of 2022 and early 2023 raise concerns about the potential impact on the canal from the landfill, although this impact was not observed from May onwards. The control and trigger levels set for ammoniacal nitrogen continue to be relevant for the monitoring locations.

For the other parameters, there was an unusual phenol detection both upstream and downstream in August, although this was not repeated and there were only occasional readings where the downstream result was significantly higher than the upstream result.

b) River North and River South

Surface water monitoring data was collected from River North and River South monthly throughout 2023 other than in July for pH, electrical conductivity and BOD (plus August for Ammoniacal N in River North). The River North and River South monitoring points are subject to both tidal influence (saltwater) and the flow of the river (freshwater). Both are sampled at high tide to minimise the safety risks posed to monitoring personnel – with both samples being taken within approximately 15mins of each other in the same tidal cycle. The samples tend to be taken from the downstream sampling point prior to the upstream, although there is no specific rule for this order.

During 2023 there was one exceedance of the trigger level in River North during January 2023 and one exceedance of the of the control level in River South during January 2023.

For the control levels the following exceedances were recorded:

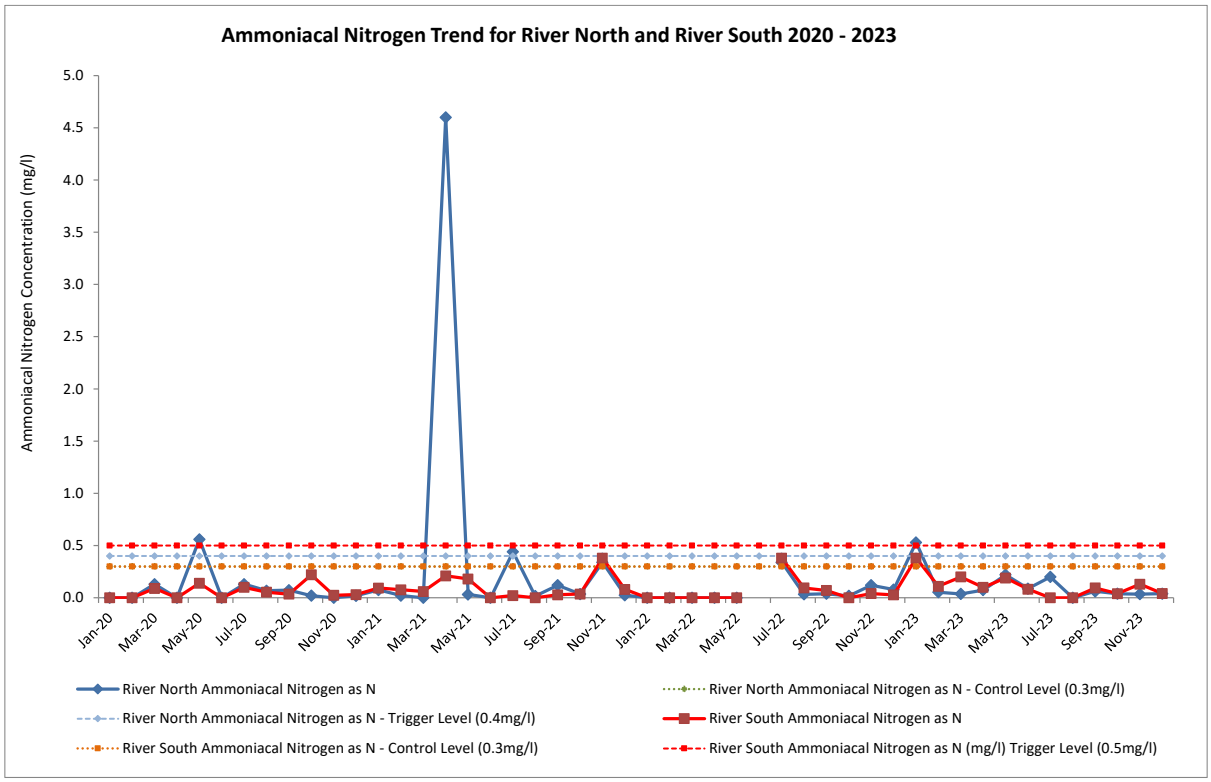
- **River North - Ammoniacal nitrogen**: The trigger level was exceeded in January at 0.53mg/ (compared with trigger level of 0.4mg/l).
- **River South - Ammoniacal nitrogen:** The control level was exceeded in January at 0.38mg/ (compared with control level of 0.3mg/l).

Table 4E summarises the ammoniacal nitrogen concentration range in 2023 and compares with those observed during 2021 and 2022. The trend for ammoniacal nitrogen compared to the control and trigger levels for River North and River South can be observed graphically below.

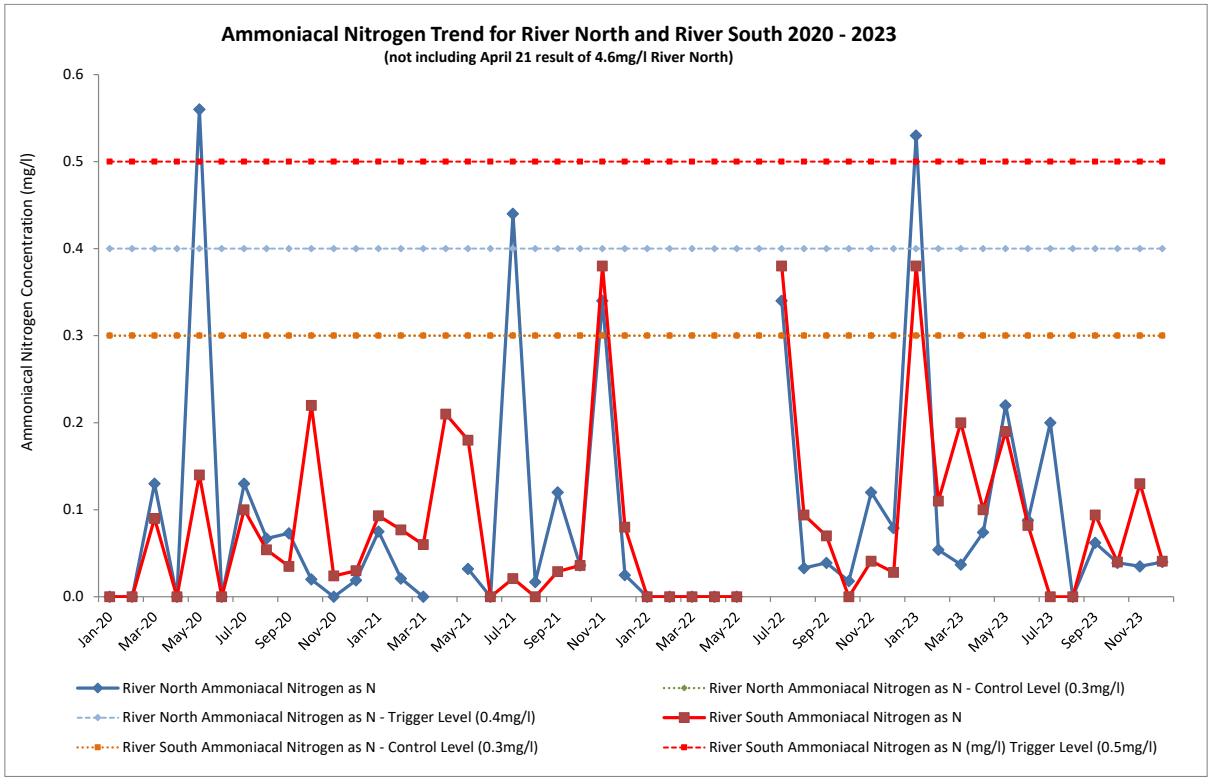
Table 4E – Summary of River North and River South Monitoring Data

Monitoring Point	Ammoniacal Nitrogen Ranges (mg/l)		
	2021	2022	2023
River North	<0.015 – 4.6	<0.015 – 0.34	0.035 – 0.53
River South	<0.015 – 0.38	<0.015 – 0.38	<0.015 – 0.38

The ammoniacal nitrogen concentrations in the upstream and downstream samples were within 0.2mg/l on all occasions in 2023 – as was the case in 2022.



The following graph provides the above ammoniacal nitrogen results but without the significantly elevated value of 4.6mg/l for the River North sample in April 2021.



As can be seen from the graph the ammoniacal nitrogen concentrations at River North and River South correlate reasonably well during 2023 (all within 0.2mg/l).

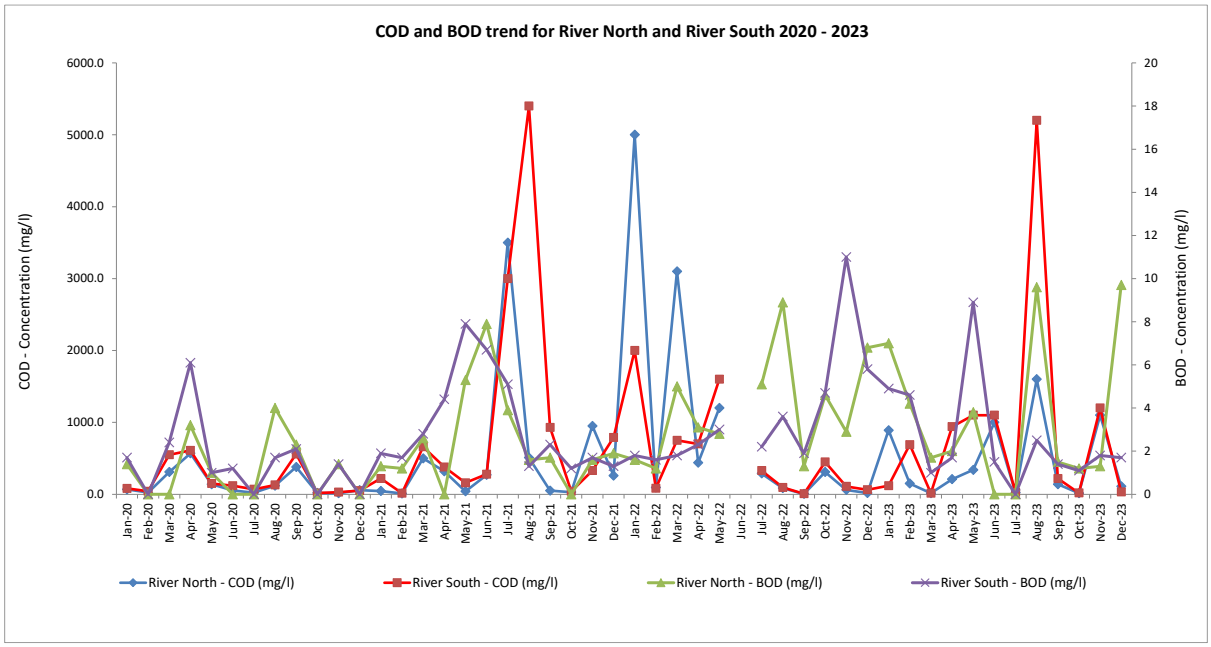
The downstream samples are occasionally higher than upstream but, for 2023, are all within 0.2mg/l. The highest difference where downstream exceeds upstream is in March at 0.163mg/l. For the only time the downstream sample exceeds the control level, there is an elevated concentration upstream (0.38mg/l and 0.53mg/l respectively). There is no evidence from 2023 that suggests an impact on the river Neath from ammoniacal nitrogen arising from the landfill.

The ammoniacal nitrogen concentrations since September 2019 generally fall below the trigger and control levels – suggesting that the previously calculated and currently used control and trigger levels in the River sampling locations are fit for purpose.

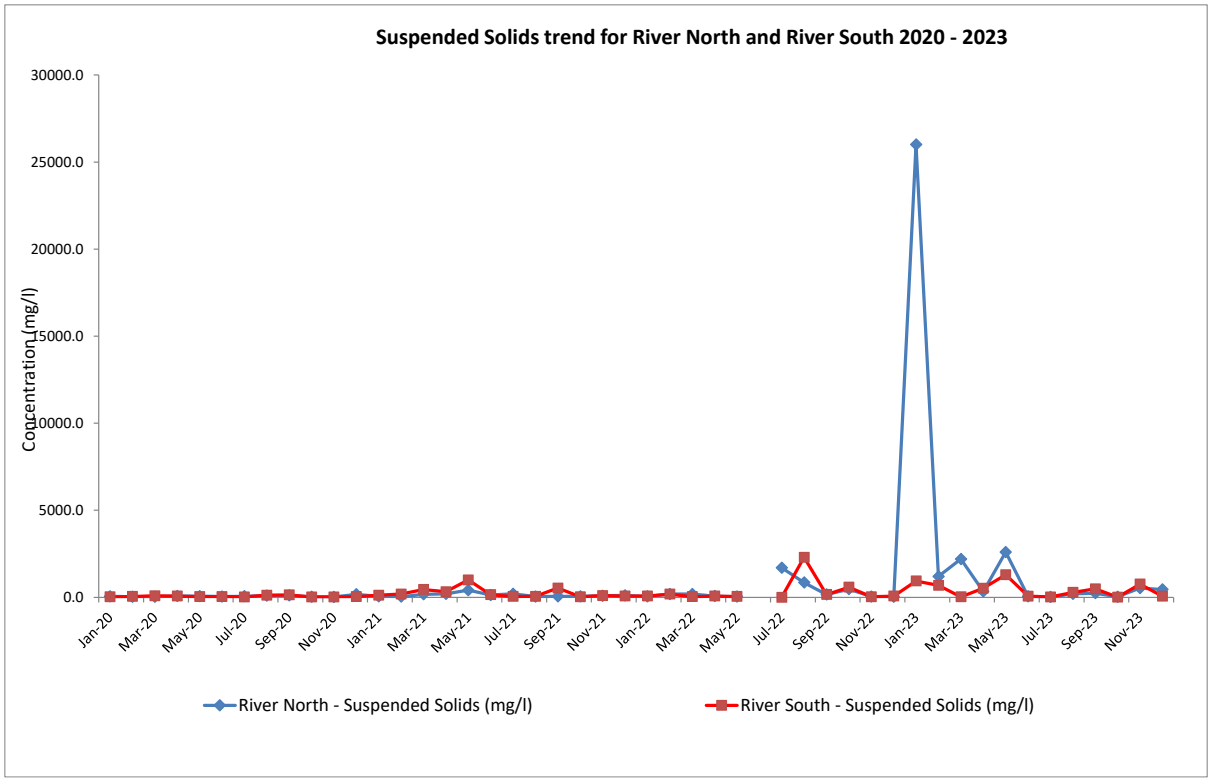
For the other parameters, the maximum and mean concentrations were similar between upstream and downstream locations other than for COD and suspended solids.

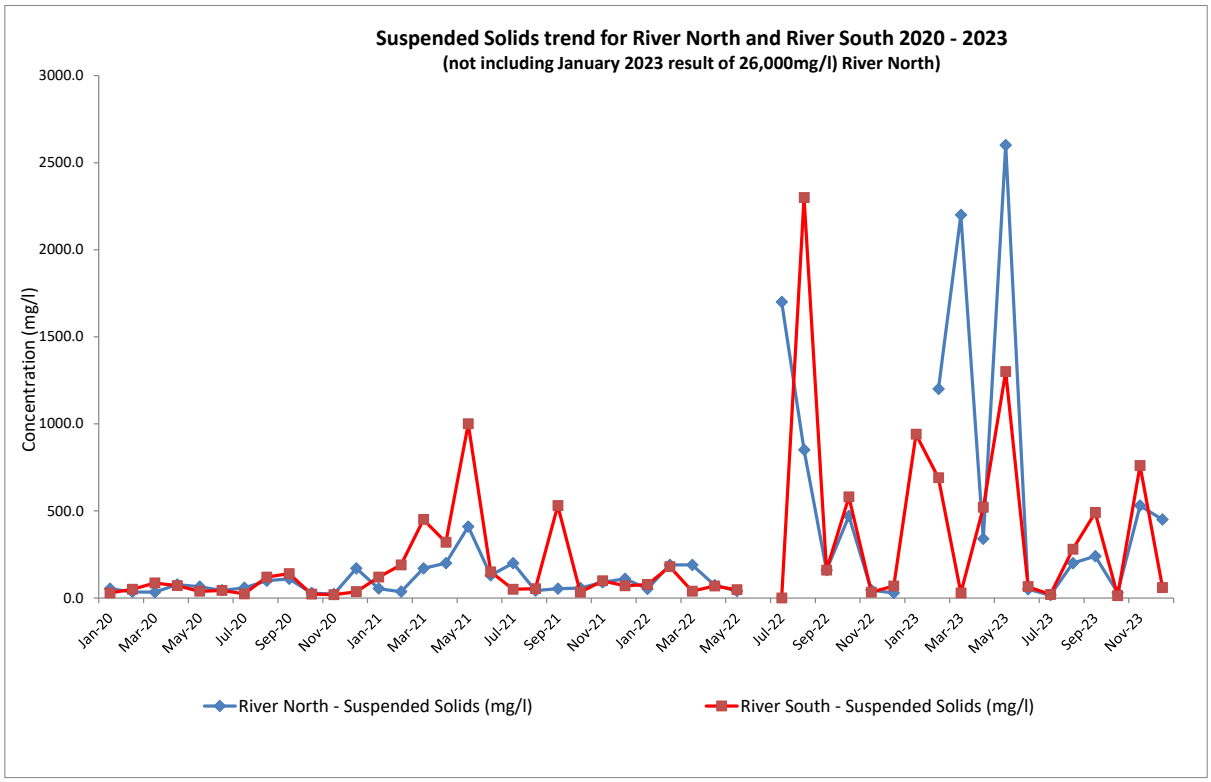
Note - There is no control or trigger level set for the any of the parameters monitored at these monitoring locations except ammoniacal nitrogen.

For COD the downstream location recorded a mean concentration of approximately 888mg/l compared to the upstream location (466mg/l). The most significant differences were in February, April, May and August in which the downstream result was between three and five times higher. The August result were the highest concentrations recorded at 5200mg/l downstream (compared with 1600mg/l upstream). Graphical analysis of COD and BOD is provided below which shows the highly fluctuating data and does not indicate any obvious ongoing trends apparent.

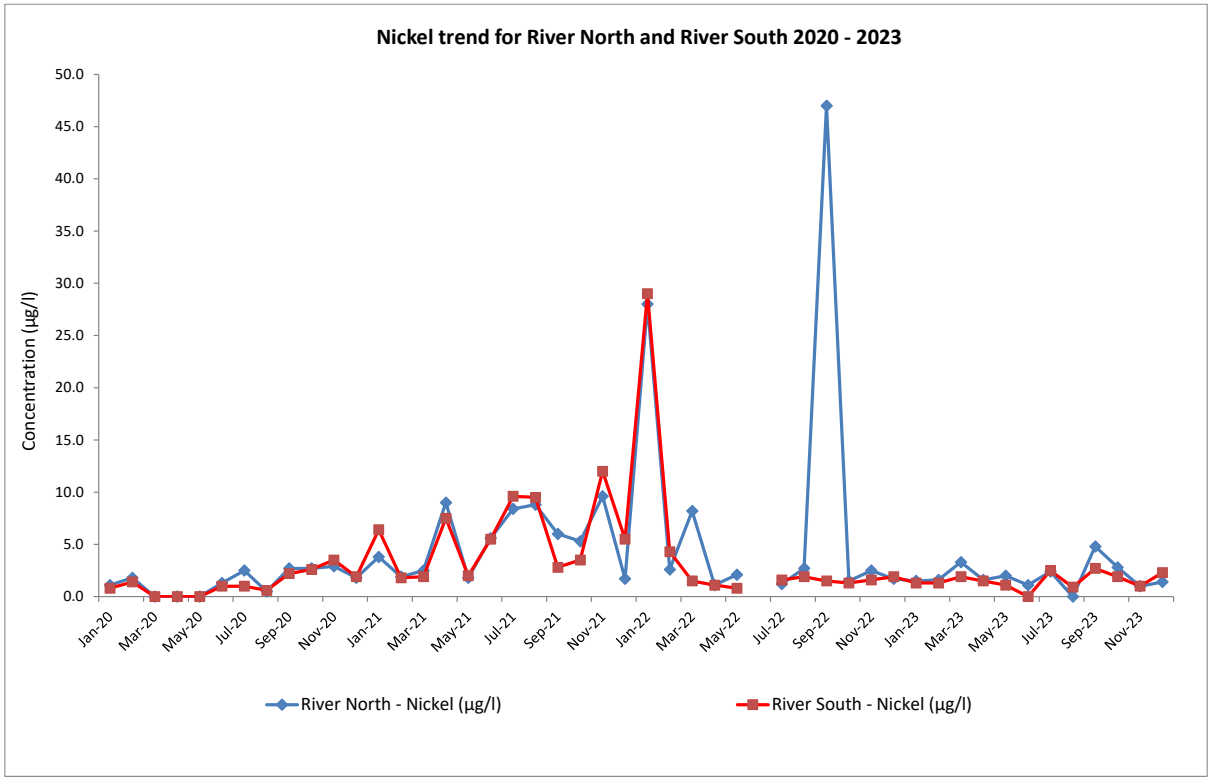


For suspended solids then the upstream sample typically records higher concentrations than downstream. The most significant difference was in January where the upstream was at 26000mg/l compared with 940mg/l downstream. This result is the highest recorded and causes the mean concentration to be significantly greater than in 2022. The mean concentration upstream across 2023 was approximately 2800mg/l compared with 430mg/l downstream.





In 2022 there were some elevated nickel concentrations recorded, although these were not repeated in 2023 as the following graph shows.



For the river monitoring locations, the main concern noted for the 2023 data is the higher concentrations for COD typically recorded in the downstream sample. However, the important parameter of ammoniacal nitrogen does not indicate any adverse impact from the landfill to the River Neath receptor.

4.5 Summary and Recommendations for Surface Water Monitoring

Based on the 2023 data the control and trigger levels for the River and Canal monitoring locations remain relevant. No recommendations to change the surface water monitoring is considered necessary.

Trigger and control levels for ammoniacal nitrogen are detailed in the Aftercare Plan for the surface water monitoring. For the River Neath there was a single exceedance of the trigger level for ammoniacal nitrogen in the upstream River North monitoring location in January and this was concurrent with an exceedance of the control level in the River South monitoring location. The ammoniacal nitrogen results in the River Neath suggest that the potential contamination is arising from upstream of the River North monitoring location.

For the canal monitoring locations both upstream and downstream recorded occasional elevated results of ammoniacal nitrogen. The trigger level was exceeded on one occasion at each location but during different months (August up stream and

January downstream). The downstream location also exceeded the control levels on three further occasions (March, April and September).

In general, the data shows that the downstream sample tends to record slightly higher ammoniacal nitrogen concentrations, which may suggest some impact from the landfill.

5 Landfill Gas Monitoring

This section provides a summary of the perimeter gas monitoring at Giants Grave for 2023 as required by the environmental permit EPR/SP3298FT and Appendix A1 of the Landfill Aftercare Plan.

5.1 Landfill Gas Monitoring Locations

5.1.1 Perimeter Gas Monitoring Locations

Perimeter gas monitoring is undertaken from a total of 16 boreholes around the landfill site. The locations of these perimeter gas monitoring points are shown on the sampling location plan in Appendix E.

Perimeter gas is monitored from eleven boreholes to the north and east of the capped and restored area of the site. These boreholes are located as follows:

- Boreholes BH9B, BH7B, BH5B and BH3W are located on the northern boundary of the site in a clockwise direction from the northern tip of the site proceeding southeast along the northern boundary; and
- Boreholes BH1B, BH49W, BH47W, BH45B, BH43B and BH40B are located along the eastern boundary adjacent to the canal in a clockwise direction from the north-eastern tip of the site proceeding southwest along the eastern boundary.
- Borehole BH55B is located to the east of the site on the opposite side of the Neath Canal on latitude just north of BH45B.

The monitoring from along the western edge of the site comprises boreholes BH4, BH5 and BH8. These boreholes are located along the eastern boundary of the Western Extension Area (towards the bottom of the west bund of the Cut).

The monitoring from within the Southern Extension Area comprises boreholes BH12 and BH15. These boreholes are located as follows:

- Borehole BH12 is located towards the middle of the Southern Extension Area; and
- Borehole BH15 is located at the bottom of the river bund on the western edge of the extension area.

5.1.2 In-Waste Landfill Gas Monitoring Locations

It is understood that the in-waste landfill gas monitoring is conducted at the monitoring point locations Manifolds A to D, although this information has not been received or reviewed by C&P Environmental Ltd.

Annual report requirements for the landfill gas elements of the permit are provided in Appendix F.

5.2 Landfill Gas Monitoring Requirements

5.2.1 Perimeter Gas Monitoring Requirements

Tables 5A summarises the perimeter gas monitoring requirements of the environmental permit EPR/SP3298FT and Landfill Aftercare Plan.

Table 5A – Perimeter Landfill Gas Monitoring Schedule

Monitoring Point	Parameter	Monitoring Frequency
North: BH3W, BH9B, BH5B, BH7B East: BH1B, BH40B, BH43B, BH45B, BH47W, BH49W, BH55B South: BH12, BH15 West: BH4, BH5, BH8	Oxygen, Temperature, Atmospheric Pressure, Differential Pressure, Carbon Monoxide, Meteorological Conditions	Monthly
	Methane	Monthly
	Carbon Dioxide	Monthly

All locations were able to be monitored during 2023 other than BH8 in March due to flooding in the area.

5.2.2 In-Waste Landfill Gas Monitoring Requirements

Tables 5B summarises the in-waste gas monitoring undertaken on a monthly schedule at Giants Grave landfill site (Schedule 3, Table 3.8 of the environmental permit). As no data is provided by the monitoring contractor for the in-waste landfill gas wells then it cannot be confirmed that the monitoring regime was complied with. Annual report requirements for the landfill gas elements of the permit are provided in Appendix F.

Table 5B – In-Waste Landfill Gas Monitoring Schedule

Monitoring Point	Parameter	Monitoring Frequency
All gas collection wells and any other (in-waste) gas monitoring points	Methane, Carbon Dioxide, Oxygen, Balance gas, Atmospheric Pressure, Differential Pressure, Carbon Monoxide, Meteorological Conditions	Monthly
	Hydrogen sulphide	Six-monthly

5.3 Perimeter Gas Control and Trigger Levels

The control and trigger levels for perimeter landfill gas monitoring for 2023 are presented as a single action level for carbon dioxide and an action and compliance level for methane. No methane action or compliance levels are currently applicable for unstable data – including for boreholes BH3W, BH40B, BH43B and BH45B. The environmental permit EPR/SP3298FT does not state any limits for carbon dioxide.

The compliance limits are detailed in Schedule 3, Table 3.6 of the environmental permit. These levels are presented in Table 5C below.

Table 5C – Perimeter Gas Emission Action and Compliance Levels

Borehole	Data Stability	CO_2 Action %	CH_4 Action %	CH_4 Compliance %
Northern boundary				
BH3W	Unstable	8.4	n/a	n/a
BH5B	Stable	1.4	0.9	1.4
BH7B	Stable	1.1	0.7	1.2
BH9B	Stable	1.2	0.7	1.2
Western boundary (Western Extension)				
BH4	Stable	2.0	0.7	1.2
BH5	Stable	3.5	0.7	1.2
BH8	Stable	1.6	0.7	1.2
Southern boundary (Southern Extension)				
BH12	Stable	1.9	0.7	1.2
BH15	Stable	3.1	0.7	1.2
Eastern boundary				
BH1B	Stable	2.7	3.6 (1.3)[1]	4.1 (1.8)[1]
BH40B	Unstable	4.7	n/a	n/a
BH43B	Unstable	12.8	n/a	n/a
BH45B	Unstable	13.9	n/a	n/a
BH47W	Stable	4.5	2.5	3.0
BH49W	Stable	4.8	0.9	1.4
BH55B	Stable	7.9	0.9	1.4

Note 1 – for BH1B the 2017 annual report recalculated the CH_4 action and compliance levels which indicated that the concentrations of 1.3% and 1.8% respectively were more relevant. However, the permit remains at 4.1% as a compliance level for CH_4. The review of this gas quality below considers each of these levels.

There are no control and trigger levels for in-waste landfill gas monitoring, although the gas extraction system is subject to management and control systems as detailed by the Landfill Gas Management Plan.

5.4 Landfill Gas Monitoring Results and Data Assessment

5.4.1 Perimeter Landfill Gas Monitoring

A summary of the perimeter gas monitoring data obtained during 2023 is presented in Table 5D with the full results provided in Appendix D.

Table 5D – Summary of Perimeter Gas Monitoring

Borehole	Methane (%v/v)				Carbon Dioxide (%v/v)		
	Mean	Maximum	Action level breach	Compliance limit breach	Mean	Maximum	Action level breach
Northern Boundary							
BH3W[1]	<	0.1	-	-	1.2	3.2	(Jan)
BH5B	<	0.1	-	-	0.1	0.2	-
BH7B	<	0.1	-	-	0.3	0.7	-
BH9B	<	0.1	-	-	0.1	0.2	-
Western Boundary (Western Extension)							
BH4	<	0.1	-	-	1.3	4.1	Jan, Feb, Nov
BH5	<	0.2	-	-	1.4	3.1	-
BH8	0.7	7.1	-	Sept	1.1	6.9	Sept
Southern Boundary (Southern Extension)							
BH12	0.1	0.2	-	-	0.4	1.2	-
BH15	0.1	0.2	-	-	1.3	2.6	-
Eastern Boundary							
BH1B	0.1	0.2	-	-	0.6	1.0	-
BH40B	17.2	81.5	n/a	n/a	2.0	4.3	-
BH43B	56.1	92	n/a	n/a	7.5	11.1	-
BH45B	25.7	52	n/a	n/a	8.1	13.7	-
BH47W	<	0.1	-	-	0.4	1.5	-
BH49W	<	0.1	-	-	0.5	0.9	-
BH55B	0.1	0.1	-	-	3.8	6.4	-

General note – The mean concentrations for methane and carbon dioxide have been rounded to one decimal place. '<' means a mean concentration of <0.1%.

NOTE 1 There is no permit compliance limit set for borehole BH3W as the gas data for this location has been unstable in the past. A compliance limit of 1.6% was calculated following the 2017 annual report review and this level was not exceeded during 2023. For carbon dioxide, the action level for BH3W was recalculated to be 3.1% (from 8.4%). This proposed revised action level has not been implemented into the Landfill Aftercare Plan but if it had been, then the carbon dioxide readings from January 2023 would have exceeded. Due to the change in gas conditions at this borehole then these revised levels may not be applicable but are further discussed below.

Locations and months where monitoring was unable to be completed fully:

- *Unable to access BH8 in March 2023 due to flooding*

Permit compliance limit breaches - methane

There was a single compliance breach for methane in 2023 and this is for BH8 in September 2023. This compares to no permit compliance limit breaches for methane during 2022, 2021 and 2020. Before the BH8 breach in September, the last breach of a perimeter gas compliance limit was in 2019 (BH12 in September).

Action level exceedances - methane

There were no action level exceedances for methane during 2023, as was the case for 2022, 2021 and 2020.

Action level exceedances – carbon dioxide

The action level for carbon dioxide was exceeded on several occasions in the boreholes around the perimeter of the site:

Northern Boundary

- Note – the aftercare action level of 8.4% for BH3W was not exceeded during 2023, although the 2017 recalculated action level of 3.1% would have been exceeded on one occasion during 2023 (January).

Western extension

- BH4 on three occasions: January, February and November
- BH8 on one occasion: September

Southern extension – no exceedance of the carbon dioxide action levels

Eastern boundary - no exceedance of the carbon dioxide action levels

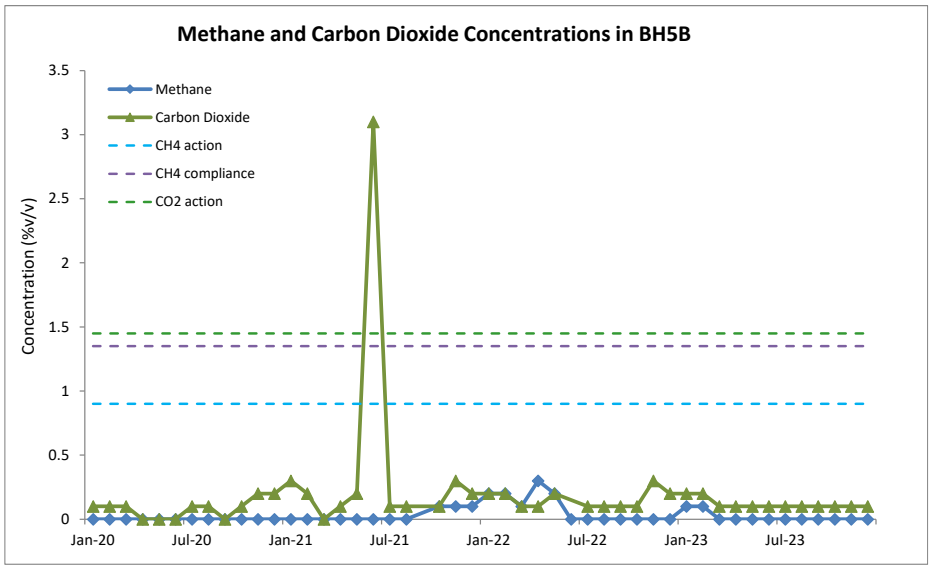
a) Northern boundary boreholes

A review of the gas conditions in the northern boundary boreholes is provided below, although none of the locations recorded any exceedances of a permitted action or compliance level for methane.

Unless noted the carbon monoxide concentrations were at or below 1ppm throughout 2023.

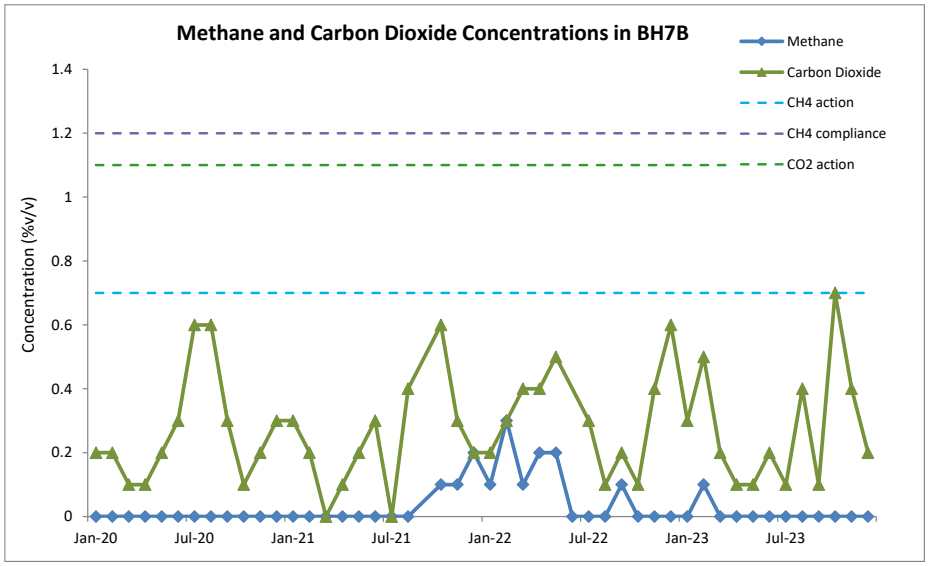
Borehole BH5B

BH5B has not recorded any elevated carbon dioxide or methane in 2023 – and there has been no repeat of the elevated carbon dioxide spikes in January 2019 (21.1%) and June 2021 (3.1%). The highest methane reading was at 0.1% with all carbon dioxide at 0.2% or below. No adverse trends in gas conditions noted at this location.



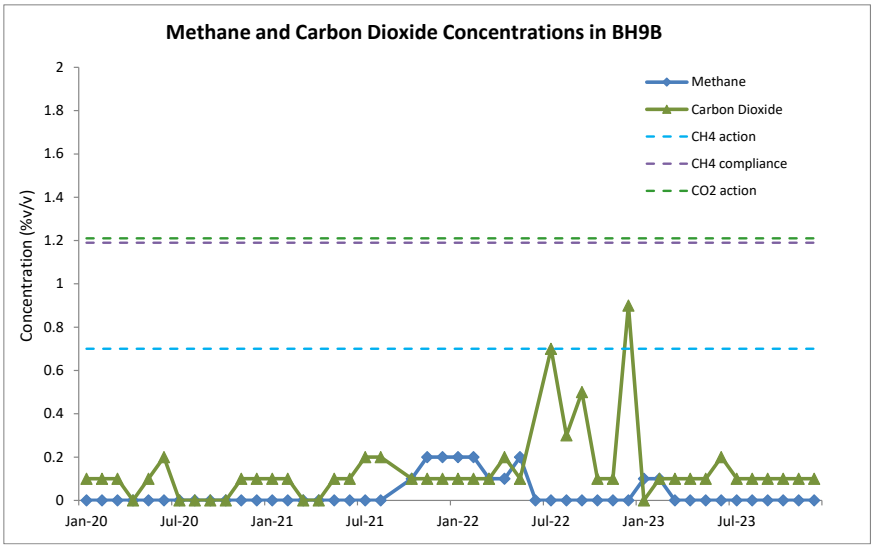
Borehole BH7B

Methane was only recorded at this location in February 2023 at 0.1% which is well below the methane action level of 0.7% at this location. The carbon dioxide continues to show fluctuation but remains well below the action level of 1.1%. No adverse trends in gas conditions noted at this location.



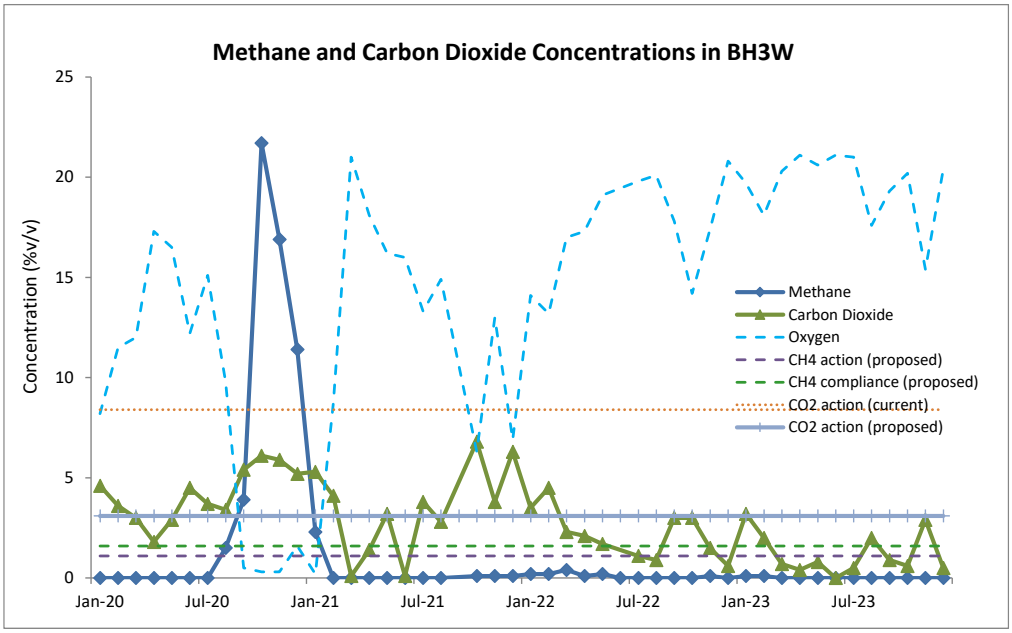
Borehole BH9B

BH9B has recorded no elevated methane detection since the elevated concentration of 0.8% in August 2019, recording positive detection of methane at 0.1% in January and February 2023 only. The carbon dioxide concentrations remain low when compared with the action level of 1.2% with the highest being 0.2% in June. The 2023 readings for carbon dioxide indicate less fluctuation than for 2022.



Borehole BH3W

The most significant perimeter gas concern across the site in recent years was the elevated methane presence in borehole BH3W in 2020. However, the 2023 data, does not record any presence of methane. This follows the 2022 data with no significantly elevated methane (with the highest being 0.4%). There is no permit compliance limit set for methane at this location and the 2023 data falls well below the potential recalculated methane compliance levels from 2017 of 1.6%.



The carbon dioxide concentrations were well below the current action level of 8.4% with the highest reading of 3.2%. The oxygen concentrations continue to fluctuate with the lower oxygen concentrations concurrent with the higher carbon dioxide concentrations. The lowest oxygen concentrations were at approximately 15% and were concurrent with the highest carbon dioxide readings.

The graph includes the Landfill Aftercare Plan carbon dioxide action level of 8.4% which, based on data between 2019 and 2022, seems to be set at an appropriate level. However, the 2017 recalculated action level for carbon dioxide of 3.1% (which was exceeded only in January 2023) seems to be more relevant to the 2023 results.

The graph has also retained the proposed methane compliance limit at 1.6% which also appears to be an appropriate level. Future annual reports will consider against these two levels (even though there is no specific compliance limit in the permit).

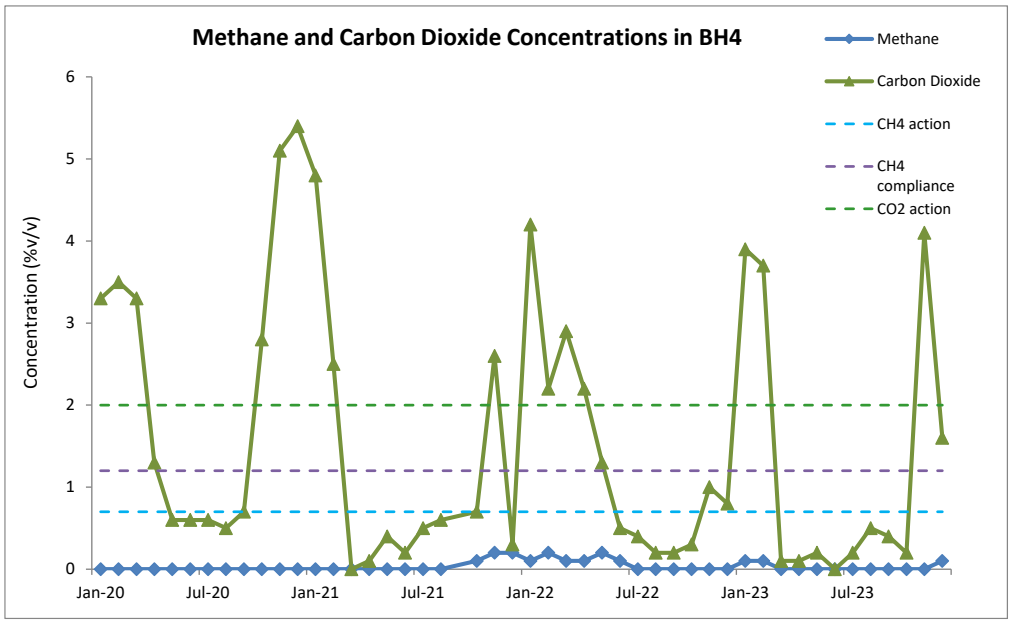
b) Western boundary boreholes

A review of the gas conditions in the western boundary boreholes is provided below. BH8 recorded elevated methane and carbon dioxide in September that exceeded the compliance level for methane (and the action level for carbon dioxide).

Unless noted the carbon monoxide concentrations were at or below 1ppm throughout 2023.

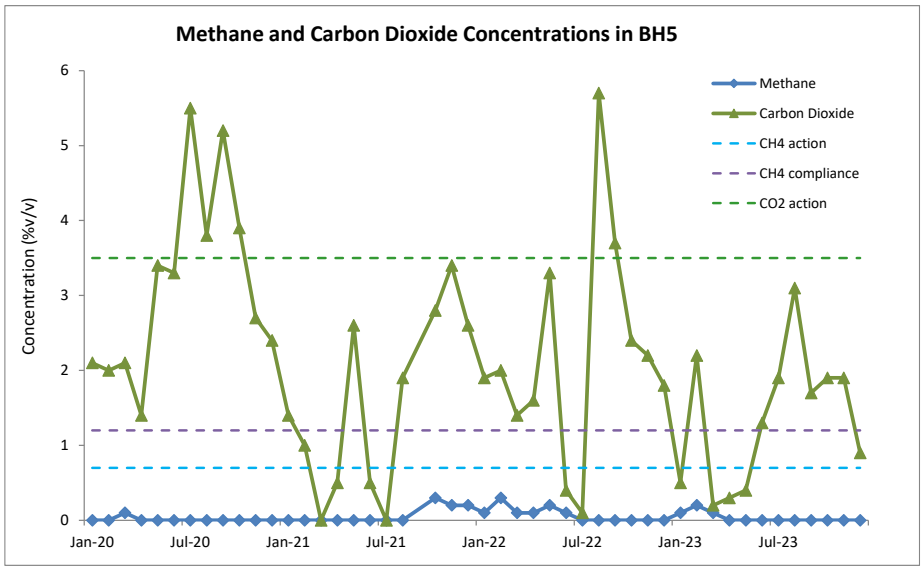
Borehole BH4

No elevated methane recorded in BH4 in 2023 with the highest at 0.1%. Elevated carbon dioxide at above the action level of 2.0% in January, February and November has been recorded. The elevated carbon dioxide continues to show a potential seasonal pattern of higher concentrations during the winter months. Other than this seasonal elevated carbon dioxide no adverse trends noted in the gas conditions at this location.



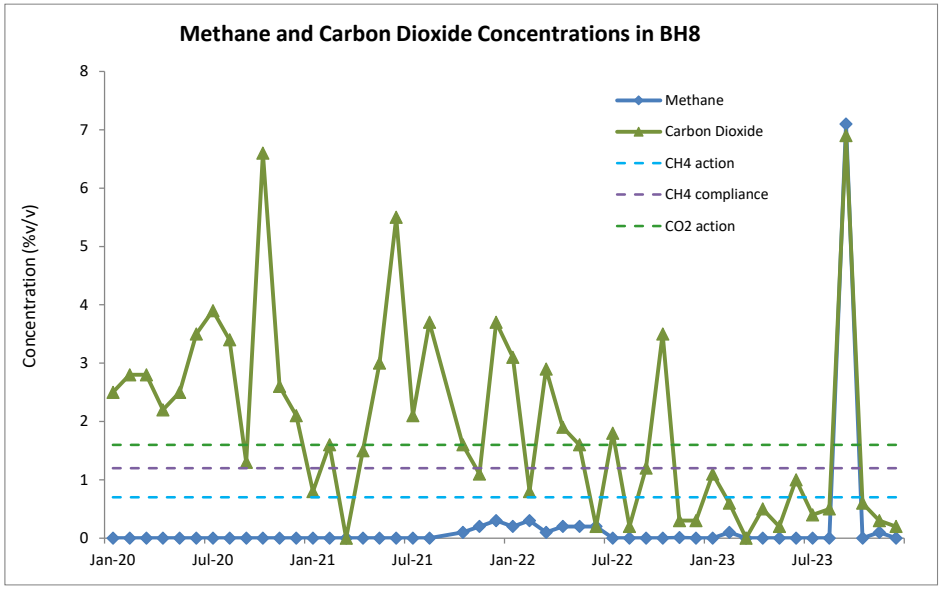
Borehole BH5

No methane detection at above 0.2% throughout 2023 and all readings from April at 0%. The carbon dioxide concentration continues to fluctuate considerably, although all 2023 readings are below the action level of 3.5%. Overall, the 2023 data continues to show a fluctuating pattern but no adverse trends.



Borehole BH8

A spike of methane at 7.1% and carbon dioxide at 6.9% during September 2023. There was no other methane detection above 0.1% and no other exceedance of the carbon dioxide action level of 1.6% during 2023. This methane spike is the first recorded for many years and appears to suggest a spike of landfill gas within the location represented by this borehole. As all subsequent readings were back to typical low concentrations then this appears to be only a transitory landfill gas migration event.

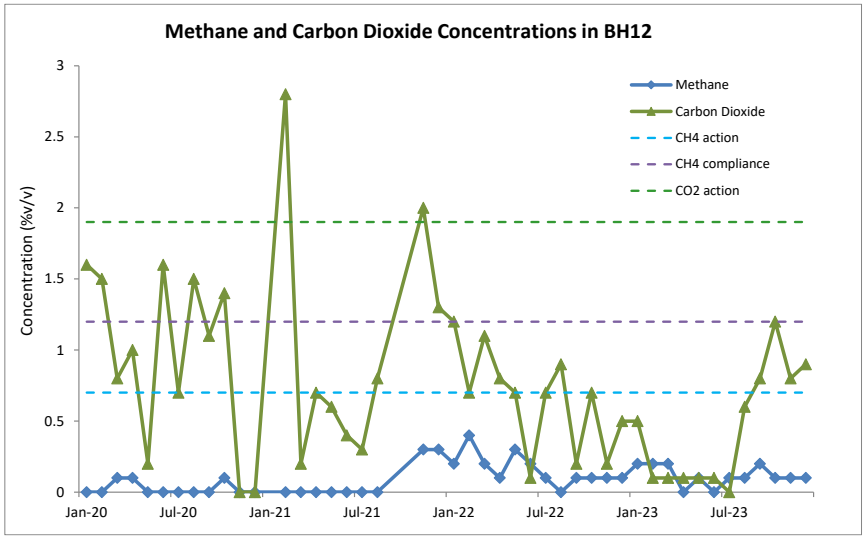


c) Southern boundary boreholes

A review of the gas conditions in the southern boundary boreholes is provided below, although none of the locations recorded any exceedances of a permitted action or compliance level for methane. All carbon monoxide concentrations were at or below 2ppm throughout 2023.

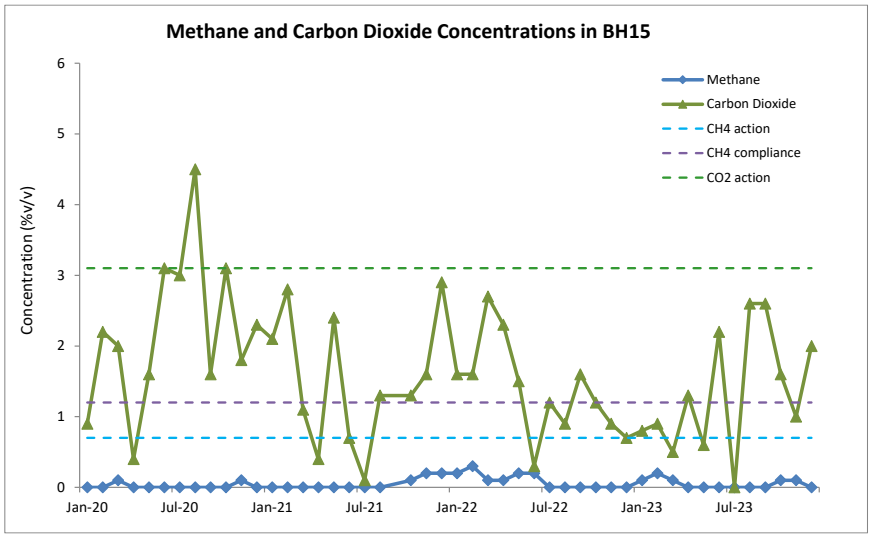
Borehole BH12

The elevated spike of methane recorded in 2019 has not been repeated since with the 2023 readings at 0.2% of lower. The carbon dioxide concentrations continue to fluctuate although no results approach the action level of 1.9%. No adverse trends in gas conditions noted at this location.



Borehole BH15

No methane detection at above 0.2% throughout 2023. The carbon dioxide concentrations continue to fluctuate, although remained below the action level of 3.1% (highest of 2.6%. No adverse trends in gas conditions noted at this location.



d) Eastern boundary boreholes

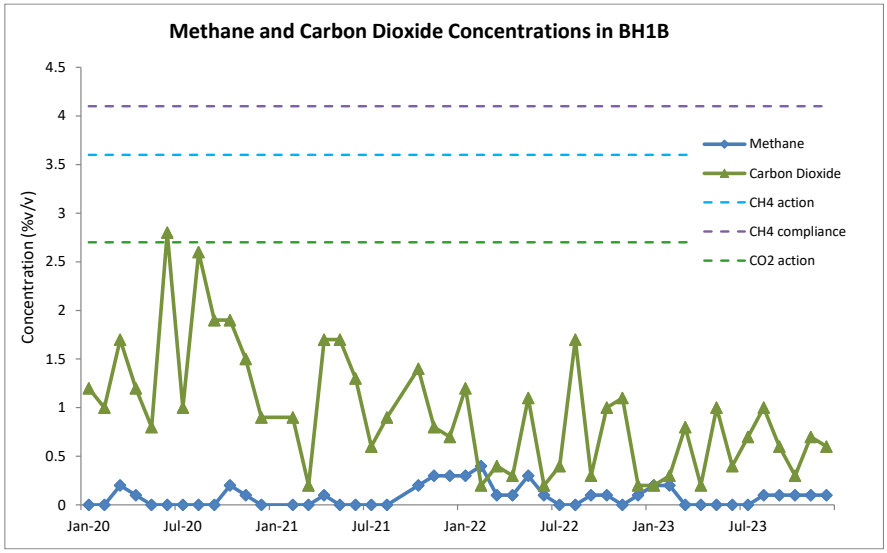
A review of the gas conditions in the eastern boundary boreholes is provided below, although none of the locations recorded any exceedances of a permitted action or compliance level for methane. The action levels for carbon dioxide were also not exceeded during 2023.

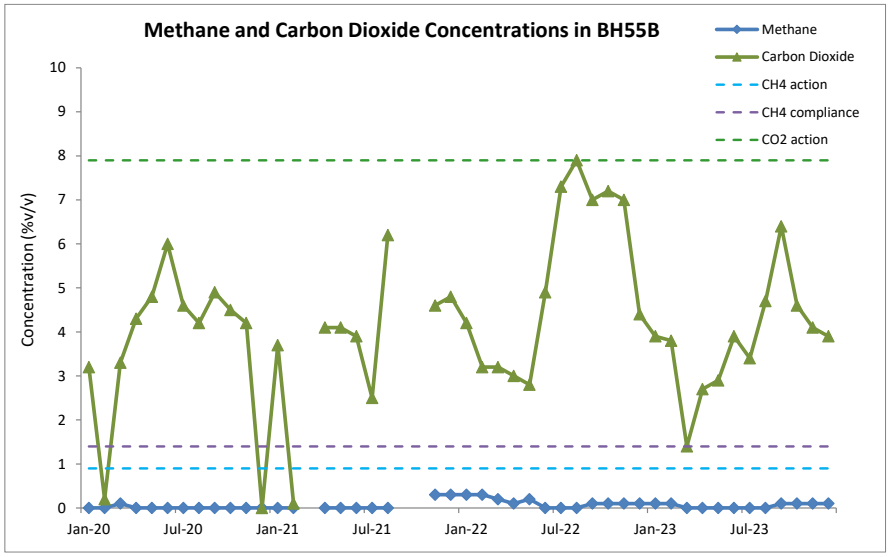
The locations BH40B, BH43B and BH45B recorded some detection of carbon monoxide as described below, although the remaining locations were all at or below 2ppm throughout 2023.

Boreholes BH1B and BH55B

Occasional trace presence of methane detected in BH1B (up to 0.2%) and BH55B (up to 0.1%) and no adverse trend noted for the methane in these boreholes.

The carbon dioxide fluctuates in both locations, although remains below the action levels relevant to each borehole. For BH1B the mean carbon dioxide concentration appears to be falling over recent years. For BH55B, the readings between March and September showed an increasing trend, although results have decreased since.





Note: for BH1B, the 2017 annual report recalculated the action and compliance levels for methane: action level of 1.3% and compliance level of 1.8% *(compared to those previous calculated at 3.6% and 4.1% respectively)*. The methane remained below these respective levels, and it continues to be recommended that the recalculated levels would be more appropriate for ongoing monitoring for this location and should be added into the next review of the Landfill Aftercare Plan.

Boreholes BH40B, BH43B and BH45B

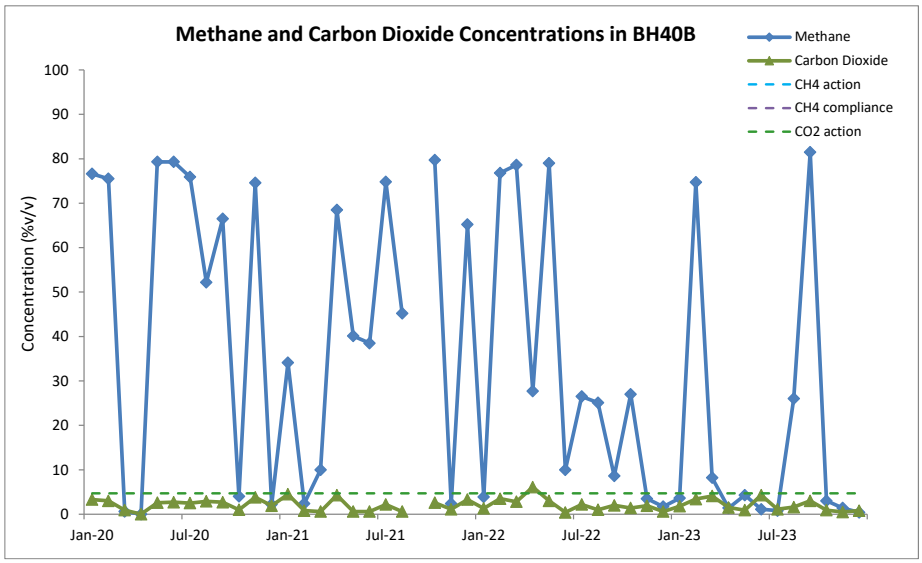
Elevated methane continues to be recorded in the boreholes BH40B, BH43B and BH45B as has been the case over previous years. These boreholes appear to show a continuing fluctuating pattern as was recorded in 2022.

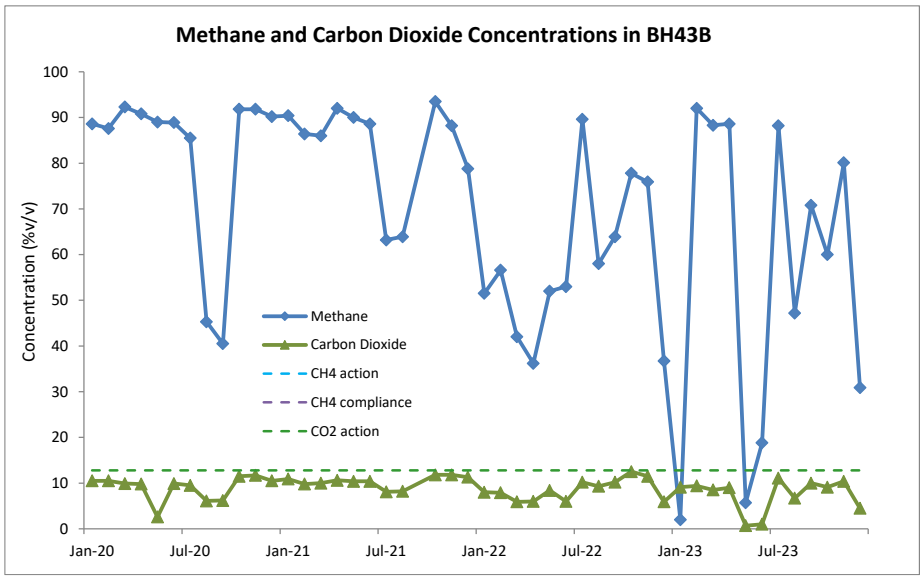
Elevated concentrations of methane have consistently been observed in these boreholes and this is in line with historic data. A risk assessment last completed in 2013 has previously been undertaken which indicated the elevated concentrations did not pose a risk to human health. It is believed that the landfill gas measured in these wells is from waste buried beneath the surface outside the landfill boundary and therefore outside the influence of the on-site gas control infrastructure. Due to the elevated methane and unstable gas conditions, no action levels or compliance limits for methane have been set on these wells.

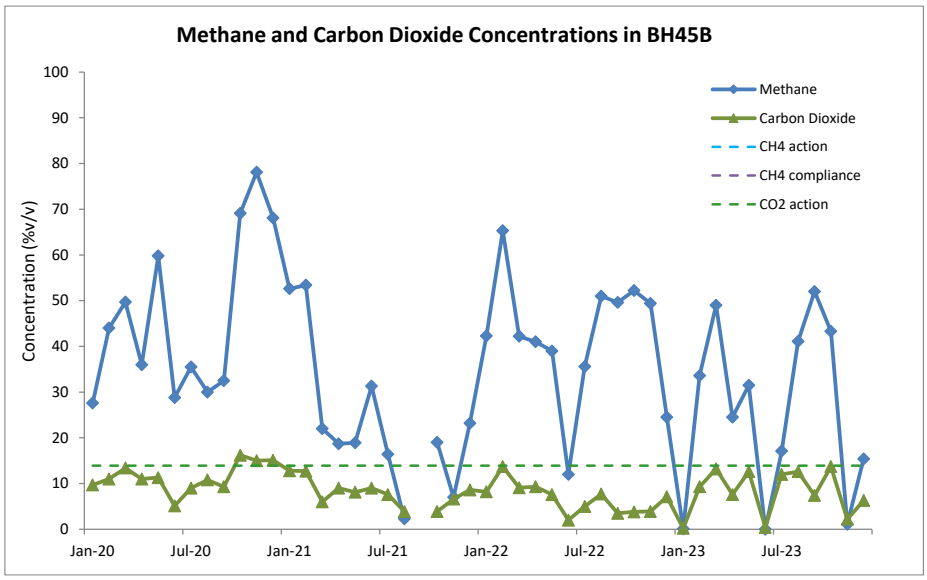
Each of these boreholes records relatively consistent and low carbon dioxide concentrations and (when elevated methane detected) a depleted oxygen gas regime. The elevated methane but lower carbon dioxide would suggest there is some carbon dioxide removal mechanism within the sub-surface.

Although no compliance or actions levels are set for methane, the boreholes have carbon dioxide action levels due to the relatively consistent carbon dioxide data. For 2023 there were no exceedance of the carbon dioxide action levels in any of these three boreholes.

Carbon monoxide is recorded in BH40B and BH43B at up to 26ppm and 21ppm respectively. Although not elevated these are the highest concentrations recorded across the site.



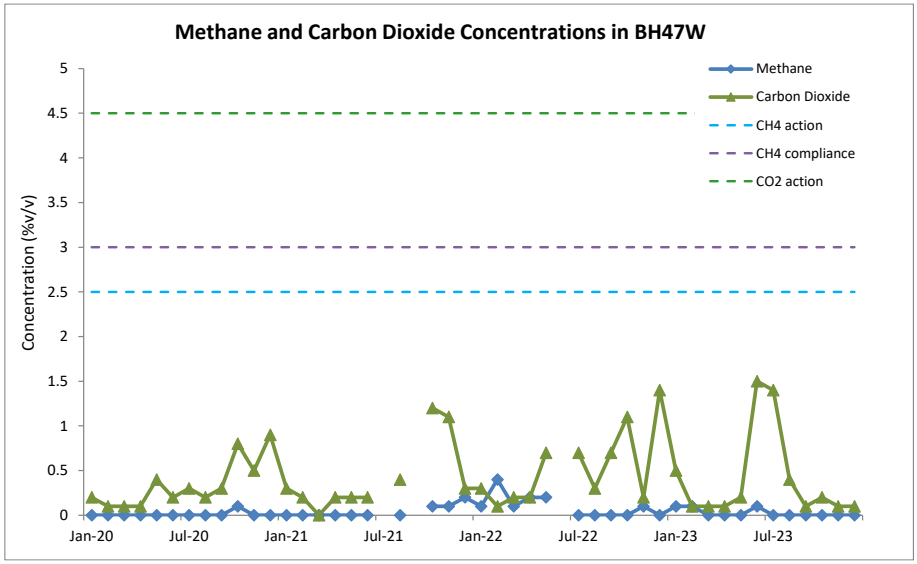

Methane and Carbon Dioxide Concentrations in BH43B
Concentration (%v/v)
100
90
80
70
60
50
40
30
20
10
0
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Methane
Carbon Dioxide
CH4 action
CH4 compliance
CO2 action

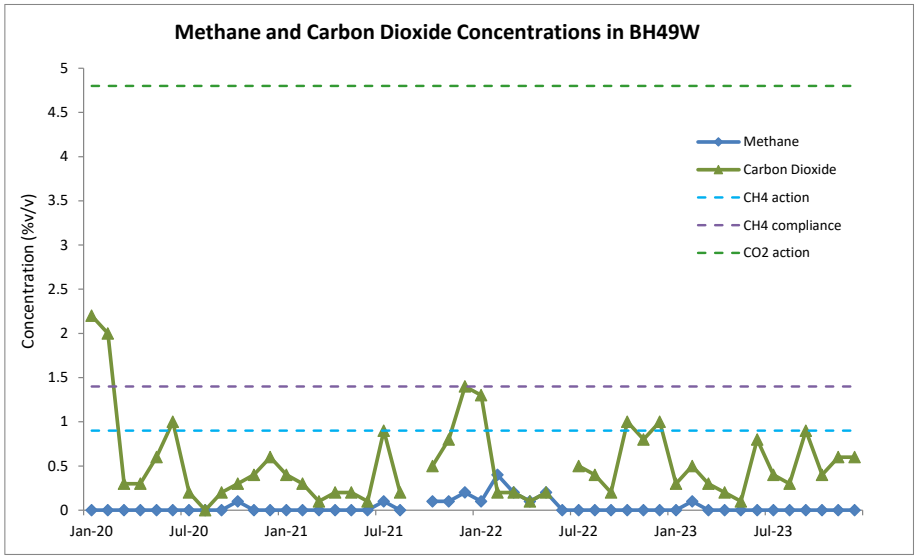

Methane and Carbon Dioxide Concentrations in BH45B
Concentration (%v/v)
100
90
80
70
60
50
40
30
20
10
0
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Jan-23
Jul-23
Methane
Carbon Dioxide
CH4 action
CH4 compliance
CO2 action

Boreholes BH47W and BH49W

No methane detected at greater than 0.1% in either of these two boreholes during 2023.

Both locations continue to record a slightly fluctuating carbon dioxide pattern with highest readings of 1.5% (BH47W) and 0.9% (BH49W) which remain well below the action levels at 4.5% and 4.8% respectively. No adverse trend in carbon dioxide is observed based on the 2023 data.





5.4.2 In-Waste Landfill Gas Monitoring

Any data collected from the in-waste landfill gas wells during 2023 has not been provided for compilation of this annual report. Therefore, this report does not include any review of the in-waste gas data.

Appendix F includes the data collected on the following:

1. Annual Performance Report
2. Weekly, Monthly and Six-Monthly Monitoring Data
3. Annual Emissions Testing
4. Annual Trace Gas Analysis
5. Quarterly Engine Emissions
6. C&P - Surface Emissions Survey (results described in section 5.4.3)

5.4.3 Surface Emissions Monitoring

In accordance with the requirements in Table 3.7 of the permit and agreement with NRW, the annual surface emissions monitoring was undertaken, although this was during January 2024 rather than the calendar year 2023 (the monitoring was undertaken on 10, 11 and 12 January 2024). This was in the form of a surface emissions survey undertaken by Enitial.

Enitial stated the following within the desk study element of planning the survey:

> *'The areas that would be subject to Surface Emissions Monitoring included the entire landfill site and were taken from the previous survey undertaken by Enitial in 2023. The survey plan was updated for 2024 detailing the proposed survey areas with a survey route based on survey transects spaced at 10m intervals as detailed in the Enitial Emissions Mapping Surveys on Landfill Sites Method Statement 2024. In addition, all infrastructure as identified from the information provided by C&P and during the previous survey was also included on the survey plan.'*

A TDL Laser Methane Detector instrument was used to undertake the survey which detects methane from 0ppm to 100% with a resolution of 1ppm. A Mobile Data Collector utilising a Differential GPS receiver was connected to the TDL providing continuous GPS and time stamped data logging.

The survey was undertaken as per the predetermined survey plan. During the survey, the surface was scanned at a distance not exceeding 5cm above the surface whilst a steady walking pace was maintained. In the event of excessive vegetation and / or other obstruction preventing surface scanning at <5cm, the TDL500 probe was held as close to the surface as possible. It is to be noted that some locations of the survey were inaccessible due to areas of dense vegetation, particularly on the southern and western slopes.

Landfill gas and leachate extraction / monitoring infrastructure was included in the survey. In surveying such features, all potential emission points of the feature were monitored. The data logging parameter was set to reflect if the surface or an

infrastructure location was being surveyed to allow this data to be filtered out and assessed separately at the reporting stage.

The full report is provided in Appendix F.

Weather conditions encountered were predominantly sunny on the 10th and 11th January with a 'light frost' first thing in the morning and ground conditions described as 'wet' in the afternoon recording. The wind speed was up to 17mph on the 10th and up to 8mph on the 11th.

On the 12th the weather conditions described as low-level cloud with sunny intervals with initial light frost and then wet ground conditions. A wind speed measured at up to 4mph.

Landfill surface emissions survey results

The reports from previous years averaged out readings for each 10m-by-10m grid and did not record many significant surface emission features. The readings from January 2023 and again for this monitoring in January 2024 do not include such averaging and record more frequent elevated single and multiple results.

A total of 29,187 methane concentration readings were recorded during the survey of the landfill surface of which 99.6% were <100ppm and within the assessment criteria of:

- Through capped surfaces: 100ppm Methane
- Through point source features: 1,000ppm Methane

Table 3.3 of the report summarises the 5 discrete locations where concentrations were recorded ≥100ppm. This table is provided on page 8 of the report and reproduced below.

Table 3.3 Surface locations above Assessment Criteria

Data Ref	Reference	Easting	Northing	Peak Concentration (ppm)	Comment
10/01-01438	Surface 1	273692	195730	342	Isolated area of surface
10/01-10268	Surface 2	273639	195908	3,072	Isolated area of surface
11/01-12851	Surface 3	273137	195580	2,341	Areas of surface on slope
11/01-13055	Surface 4	273151	195593	171	Isolated area of surface on slope
12/01-00503	Surface 5	273155	195455	172	Areas of surface along base of slope

To contextualise these surface emissions a comparison to the monitoring in January 2023 can be made:

- In 2024: 5 readings across the surface that were >100ppm of methane
- In 2023: 11 readings across the surface that were >100ppm of methane

The comparison between the methane contour plots shows that the higher readings from 2024 were in similar locations to some of those in 2023:

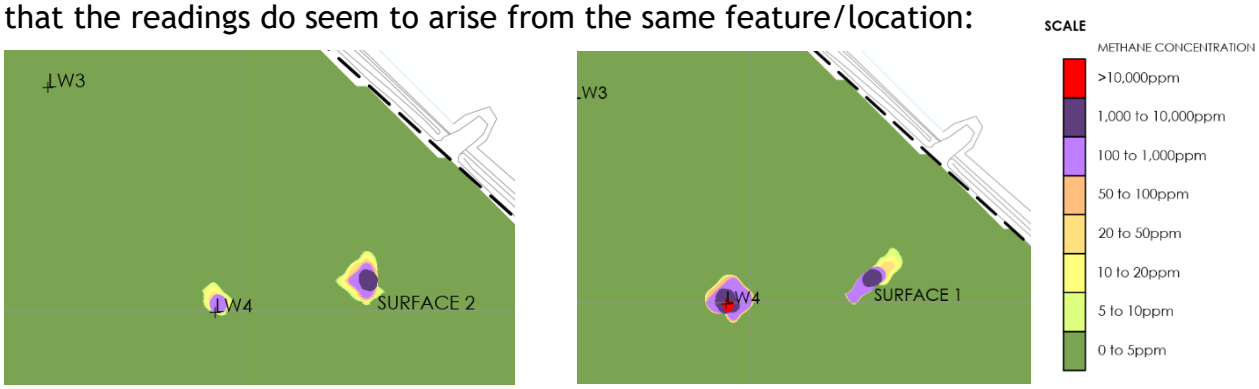
- In 2024 - 2 of the higher readings are along the southwestern slope (compared with 5 in 2023).

- In 2024 - the same location west of LW4 has been the most significant readings in both years. These were 'Surface 1' in 2023 with a highest reading of 4196ppm and 'Surface 2' in 2024 with the highest reading of 3072ppm. These were the highest readings measured at the site in each year.
- The next highest readings were 'Surface 3' in 2024 at 2341ppm and then next highest reading at 342ppm. For 2023 there were 5 readings above 1000ppm and a further 4 above the 342ppm (recorded as third highest in 2024).

Overall - there is some elevated methane surface emissions along the southwestern slope of the landfill and to the west of LW4, but the readings in 2024 show an improvement compared to those measured in 2023.

The photograph taken of the area to the west of LW4 does not specifically indicate a discrete feature, although some browning (dieback) of the vegetation might be suggested.

The methane contour plots from January 2023 and January 2024 of this area show that the readings do seem to arise from the same feature/location:



January 2024 January 2023

The LFTGN07 guidance states that if a walkover survey demonstrates the cap is not consistent and there are discrete features emitting substantial amounts of landfill gas, remedial action is required as soon as practically possible. Large surface fissures in landfill capping do not comply with current best practice for site restoration. Irrespective of the gas concentration close to these features, it should be assumed some remedial action will be necessary.

Therefore, it is recommended that an action plan is considered and implemented to remediate the discrete locations of the surface recording elevated methane – and especially the area to the west of LW4.

To understand the issues better and to formulate the appropriate level of remediation that may be required it is first suggested to organise a surface emissions survey earlier in 2024 (late summer would be recommended) to ensure that the surface emissions monitoring is undertaken in a different season to the recent years. In recent years the surface emissions survey has been completed in the winter or later autumn with typically wet ground conditions.

However, the actions should initially consider visual inspections of the area to the west of LW4 and determining whether there are any obvious surface cracks or fissures or evidence of vegetation stress (photographical evidence should be obtained). Subsequent remediation measures should then be considered and implemented following the 2024 surface emissions survey.

Note – the aftercare plan for the site does not specifically consider actions for discrete surface emissions features.

Overall, the average surface emissions from across the site are not elevated, but there are limited discrete features of elevated methane emissions through the cap. The feature to the west of LW4 was determined in both the 2022 and 2023 surface emissions surveys (completed in January 2023 and 2024 respectively).

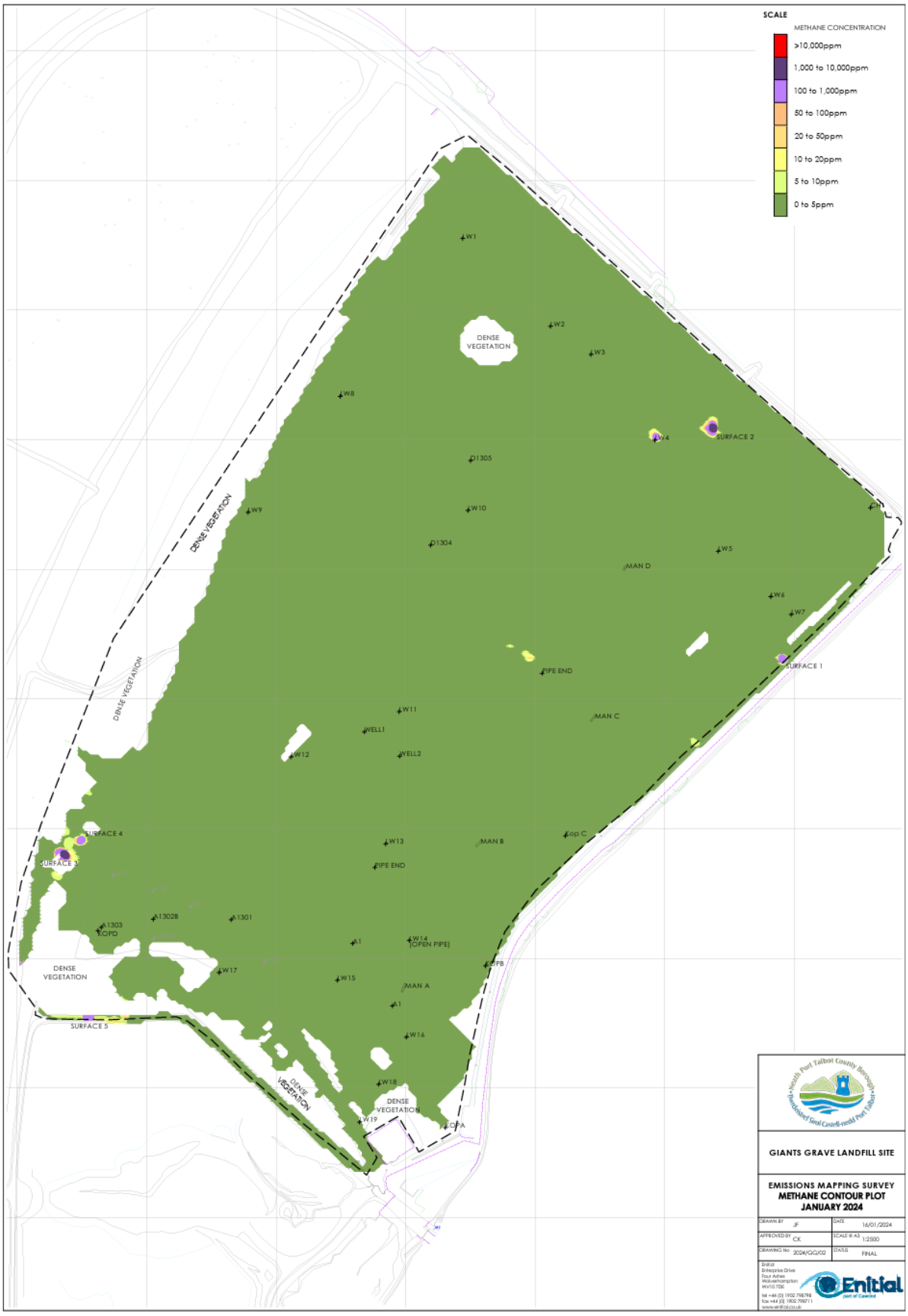
Infrastructure surface emissions survey results

A total of 39 infrastructure locations were monitored during this survey. There were no locations where concentrations were recorded ≥1,000ppm.

To contextualise these infrastructure surface emissions a comparison to the monitoring in January 2023 can be made:

- In 2024: no specific infrastructure readings >1000ppm**
- In 2023: 3 specific infrastructure locations (LW1, LW2 and LW4) that >1000ppm

**Note that LW14 has been referred to as an open well (photograph below) and this should be repaired/remediated (even though there were no elevated methane from this location on the date of measurement).



Methane contour plot - January 2024

5.5 Summary and Recommendations for the Perimeter Gas Monitoring Programme

There are no recommendations for change in the perimeter gas monitoring programme with respect to the frequency and parameters monitored.

There was one breach of a methane compliance level during 2023 – for BH8 in September. The methane was recorded at 7.1% compared to the compliance level of 1.2%. No other methane readings in BH8 exceeded 0.2%. The carbon dioxide in the same month was also elevated at 6.9% and exceeded the action level of 1.6%. This methane and carbon dioxide spike is the first recorded for many years and appears to suggest a spike of landfill gas within the location represented by this borehole. As all subsequent readings were back to typical low concentrations then this appears to be only a transitory landfill gas migration event.

Other than BH8 the methane concentrations were low across the boreholes except for BH40B, BH43B and BH45B which were at their expected elevated levels. There were no action level exceedances for methane during 2023 in any boreholes other than BH8.

In addition to BH8, the action level for carbon dioxide was exceeded in only one other location (BH4 on three occasions in January, February and November).

- Note – the aftercare action level of 8.4% for BH3W was not exceeded during 2023, although the 2017 recalculated action level of 3.1% would have been exceeded on one occasion during 2023 (January).

Other than the spike of methane and carbon dioxide in BH8 in September, no borehole showed any significant adverse or unusual trend in gas quality.

It is recommended that the revised action levels and compliance limits for borehole BH1B are more appropriate for ongoing monitoring and to determine any significant change in gas quality. These revised concentrations ought to be included in the next revision of the Landfill Aftercare Plan.

For the surface emissions survey in 2023 (undertaken early 2024) there were fewer surface areas recording elevated methane emissions compared with 2022 and no discrete features (compared with three in 2022). However, there was one location to the west of LW4 that has now shown some of the highest emissions of methane in both 2022 and 2023.

Recommended actions have been considered in section 5.4.3.

Appendices

Appendix A Leachate Monitoring Data

Appendix B Groundwater Monitoring Data

Appendix C Surface Water Monitoring Data

Appendix D Perimeter Gas Monitoring Data

Appendix E Borehole location plan

Appendix F Landfill Gas

Appendix A - Leachate Monitoring Data

A1 - Leachate Level Monitoring Data

Monitoring location		Borehole Levels	Borehole Depth	Difference
		mbTOC	mbTOC	m
LW1	Jan-23	4.98	4.98	0
	Feb-23	4.98	4.98	0
	Mar-23	4.98	4.98	0
LW1	Apr-23	4.95	4.98	0.03
	May-23	dry	4.98	dry
	Jun-23			
LW1	Jul-23			
	Aug-23			
	Sep-23			
LW1	Oct-23			
	Nov-23			
	Dec-23			
LW3	Jan-23	6.64	7.64	1
	Feb-23	6.36	7.64	1.28
	Mar-23	6.08	7.64	1.56
LW3	Apr-23	6.17	7.64	1.47
	May-23	6.47	7.64	1.17
	Jun-23			
LW3	Jul-23			
	Aug-23			
	Sep-23			
LW3	Oct-23			
	Nov-23			
	Dec-23			
LW5	Jan-23	5.81	7.05	1.24
	Feb-23	6.25	7.05	0.8
	Mar-23	5.42	7.05	**1.63**
LW5	Apr-23	5.91	7.05	1.14
	May-23	6.32	7.05	0.73
	Jun-23	6.66	7.05	0.39
LW5	Jul-23	6.66	7.05	0.39
	Aug-23	6.2	7.05	0.85
	Sep-23	5.87	7.05	1.18
LW5	Oct-23	5.47	7.05	1.58
	Nov-23	5.6	7.05	1.45
	Dec-23	5.62	7.05	1.43
LW8	Jan-23	5.94	5.94	0
	Feb-23	5.94	5.94	0
	Mar-23	4.8	5.94	**1.14**
LW8	Apr-23	dry	5.94	dry
	May-23	dry	5.94	dry
	Jun-23	dry	5.94	dry
LW8	Jul-23	dry	5.94	dry
	Aug-23	5.94	5.94	0
	Sep-23	dry	5.94	dry
LW8	Oct-23	5.3	5.94	0.64
	Nov-23	5.95	5.94	dry
	Dec-23	4.98	5.94	0.96
LW9	Jan-23	7.05	7.05	0
	Feb-23	7.05	7.05	0
	Mar-23	6.98	7.05	0.07
LW9	Apr-23	dry	7.05	dry
	May-23	dry	7.05	dry
	Jun-23			
LW9	Jul-23			
	Aug-23			
	Sep-23			
LW9	Oct-23			
	Nov-23			
	Dec-23			

Monitoring location		Borehole Levels	Borehole Depth	Difference
		mbTOC	mbTOC	m
LW15	Jan-23	10.71	12.23	1.52
	Feb-23	10.93	12.23	1.3
	Mar-23	10.58	12.23	1.65
LW15	Apr-23	dry	10.56	dry
	May-23	dry	10.56	dry
	Jun-23	dry	10.56	dry
LW15	Jul-23	10.56	10.56	0
	Aug-23	dry	10.56	dry
	Sep-23	dry	10.56	dry
LW15	Oct-23	9.5	10.56	1.06
	Nov-23	10.39	10.56	0.17
	Dec-23	10.46	10.56	0.1
LW16	Jan-23	7.64	9.06	1.42
	Feb-23	7.98	9.06	1.08
	Mar-23	7.59	9.06	1.47
LW16	Apr-23	7.79	9.06	1.27
	May-23	8.02	9.06	1.04
	Jun-23			
LW16	Jul-23			
	Aug-23			
	Sep-23			
LW16	Oct-23			
	Nov-23			
	Dec-23			
LW17	Jan-23	14.56	14.56	0
	Feb-23	14.56	14.56	0
	Mar-23	14.56	14.56	0
LW17b	Apr-23	11.84	14.56	**2.72**
	May-23	12.16	14.56	**2.4**
	Jun-23	12.3	14.56	**2.26**
LW17b	Jul-23	12.3	14.56	**2.26**
	Aug-23	8.95	14.56	**5.61**
	Sep-23	12.03	14.56	**2.53**
LW17b	Oct-23	dry	14.56	dry
	Nov-23	11.64	14.56	**2.92**
	Dec-23	11.64	14.56	**2.92**
LW18	Jan-23	8.6	10.17	1.57
	Feb-23	8.82	10.06	1.24
	Mar-23	8.36	10.06	1.7
LW18	Apr-23	8.67	10.05	1.38
	May-23	8.96	10.05	1.09
	Jun-23			
LW18	Jul-23			
	Aug-23			
	Sep-23			
LW18	Oct-23			
	Nov-23			
	Dec-23			
A1301	Jan-23	16.98	19.69	2.71
	Feb-23	17.26	19.69	2.43
	Mar-23	17.08	19.69	2.61
A1301	Apr-23	17	19.69	2.69
	May-23	17.3	19.69	2.39
	Jun-23			
A1301	Jul-23			
	Aug-23			
	Sep-23			
A1301	Oct-23			
	Nov-23			
	Dec-23			

Monitoring location		Borehole Levels	Borehole Depth	Difference
		mbTOC	mbTOC	m
A1302	Jan-23	15.47	18.09	2.62
	Feb-23	15.63	18.09	2.46
	Mar-23	15.49	18.09	2.6
A1302	Apr-23	15.4	18.09	2.69
	May-23	15.6	18.09	2.49
	Jun-23	15.8	18.09	2.29
A1302	Jul-23	15.8	18.09	2.29
	Aug-23	15.6	18.09	2.49
	Sep-23	15.35	18.09	2.74
A1302	Oct-23	16	18.09	2.09
	Nov-23	15.3	18.09	2.79
	Dec-23	15.32	18.09	2.77
A1303	Jan-23	10.03	11.13	1.1
	Feb-23	9.97	11.13	1.16
	Mar-23	9.02	11.46	2.44
A1303	Apr-23	9.49	11.53	2.04
	May-23	9.08	11.53	2.45
	Jun-23			
A1303	Jul-23			
	Aug-23			
	Sep-23			
A1303	Oct-23			
	Nov-23			
	Dec-23			

Monitoring location		Borehole Levels	Borehole Depth	Difference
		mbTOC	mbTOC	m
A1304	Jan-23	11.58	14	2.42
	Feb-23		14	
	Mar-23	11.64	14	2.36
A1304	Apr-23	11.47	14	2.53
	May-23	11.87	14	2.13
	Jun-23			
A1304	Jul-23			
	Aug-23			
	Sep-23			
A1304	Oct-23			
	Nov-23			
	Dec-23			
A1305CV	Jan-23	10.48	13.18	2.7
	Feb-23	10.6	13.18	2.58
	Mar-23	10.53	13.18	2.65
A1305CV	Apr-23	10.5	13.18	2.68
	May-23	10.69	13.18	2.49
	Jun-23	10.72	13.18	2.46
A1305CV	Jul-23	10.7	13.18	2.48
	Aug-23	10.78	13.18	2.4
	Sep-23	10.29	13.18	**2.89**
A1305CV	Oct-23	10.27	13.18	**2.91**
	Nov-23	10.27	13.18	**2.91**
	Dec-23	10.36	13.18	**2.82**

Black shading is for data not required to be monitored. Grey boxes are for data not required for that month. Blank spaces indicate monitoring not undertaken or a questionable result including:

- The leachate level in A1302 in February was measured at 6.91m which is significantly different to readings before and afterwards and appears to be incorrect. This reading has not been included in the above data.

Leachate Levels (m above base of well) in 2023

Leachate Levels (m above base of well)													Leachate compliance level (from September 2020 onwards)
Leachate well	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	
LW5	1.24	0.8	**1.63**	1.14	0.73	0.39	0.39	0.85	1.18	1.58	1.45	1.43	1.6
LW8	0	0	**1.14**	0	0	0	0	0	0	0.64	0	0.96	1
LW15	1.52	1.3	1.65	0	0	0	0	0	0	1.06	0.17	0.1	2.1
LW17b	0	0	0	**2.72**	**2.4**	**2.26**	**2.26**	**5.61**	**2.53**	0	**2.92**	**2.92**	1
A1302	2.62	2.46	2.6	2.69	2.49	2.29	2.29	2.49	2.74	2.09	2.79	2.77	3
A1305	2.7	2.58	2.65	2.68	2.49	2.46	2.48	2.4	**2.89**	**2.91**	**2.91**	**2.82**	2.8

Empty cells signifies unable to be monitored

Some wells recorded as 'dry' on the monitoring records - these have been consider zero in the above table

Red text indicates exceedence of the well specific leachate level threshold (From September 2020)

A2 - Leachate Quality Monitoring - Quarterly Data

This data represents the quarterly data which consists of pH, ammoniacal nitrogen and nitrate, for example.

Monitoring location		pH	Temperature	Conductivity	Dissolved oxygen	Chloride	Ammoniacal nitrogen	Potassium
		-	°C	µS	mg/l	mg/l	mg/l	mg/l
LW3	Jan-23	7.1	19.4	1100	8.3	29	45	26
	Feb-23							
	Mar-23							
LW3	Apr-23	6.9	13.9	800	8.5	10	3.8	11
	May-23							
	Jun-23							
LW3	Jul-23	6.9		1800	<1	65	71	39
	Aug-23							
	Sep-23							
LW3	Oct-23	6.8	18.9	810	6.9	9.6	0.59	10
	Nov-23							
	Dec-23							
LW5	Jan-23	6.9	19.6	670	6.1	13	5.1	12
	Feb-23							
	Mar-23							
LW5	Apr-23	7	13.2	800	8.5	8.5	4	11
	May-23							
	Jun-23							
LW5	Jul-23	u/s		u/s	u/s	9.8	5.6	14
	Aug-23							
	Sep-23							
LW5	Oct-23	6.8	18	890	8.6	9.8	2.6	12
	Nov-23							
	Dec-23							
LW8	Jan-23	Dry - no leachate to sample						
	Feb-23							
	Mar-23							
LW8	Apr-23	Dry - no leachate to sample						
	May-23							
	Jun-23							
LW8	Jul-23	Dry - no leachate to sample						
	Aug-23							
	Sep-23							
LW8	Oct-23	7.2	19.7	1100	5.5	20	13	21
	Nov-23							
	Dec-23							
LW9	Jan-23		20.1	Dry - no leachate to sample				
	Feb-23							
	Mar-23							
LW9	Apr-23	Dry - no leachate to sample						
	May-23							
	Jun-23							
LW9	Jul-23	u/s		u/s	u/s	10	0.05	10
	Aug-23							
	Sep-23							
LW9	Oct-23	7.3	n/a	780	i/s	13	1.5	8.3
	Nov-23							
	Dec-23							
LW15	Jan-23	7.3	24	2500	4.9	160	140	150
	Feb-23							
	Mar-23							
LW15	Apr-23	Dry - no leachate to sample						
	May-23							
	Jun-23							
LW15	Jul-23	u/s		u/s	u/s	330	250	99
	Aug-23							
	Sep-23							
LW15	Oct-23	7.2	20.9	3000	7.1	170	160	130
	Nov-23							
	Dec-23							
LW16	Jan-23	7.2	23.5	4600	7.5	380	290	320
	Feb-23							
	Mar-23							
LW16	Apr-23	7.3	17.8	5700	6	540	#0.23	360
	May-23							
	Jun-23							
LW16	Jul-23							
	Aug-23							
	Sep-23							
LW16	Oct-23	7.3	16.9	5300	4.6	490	350	290
	Nov-23							
	Dec-23							

Monitoring location		pH	Temperature	Conductivity	Dissolved oxygen	Chloride	Ammoniacal nitrogen	Potassium
		-	°C	µS	mg/l	mg/l	mg/l	mg/l
LW17	Jan-23	Dry - no leachate to sample						
	Feb-23							
	Mar-23							
LW17b	Apr-23	Unable to retrieve a sample						
	May-23							
	Jun-23							
LW17b	Jul-23	Unable to retrieve a sample						
	Aug-23							
	Sep-23							
LW17b	Oct-23	Unable to retrieve a sample						
	Nov-23							
	Dec-23							
LW18	Jan-23	6.9		870	9.5	11	14	13
	Feb-23							
	Mar-23							
LW18	Apr-23	7		970	8.3	13	6	11
	May-23							
	Jun-23							
LW18	Jul-23							
	Aug-23							
	Sep-23							
LW18	Oct-23	6.7		1000	4.9	12	11	10
	Nov-23							
	Dec-23							
A1301	Jan-23	7.1	20.1	3900	9.3	290	200	200
	Feb-23							
	Mar-23							
A1301	Apr-23	7.5	28.7	6300	8.7	640	360	300
	May-23							
	Jun-23							
A1301	Jul-23							
	Aug-23							
	Sep-23							
A1301	Oct-23	7.7	27	7800	6.6	860	540	340
	Nov-23							
	Dec-23							
A1302	Jan-23	7.2	19.8	2700	8.1	130	150	120
	Feb-23							
	Mar-23							
A1302	Apr-23	7.3	22.2	2600	8.7	110	150	74
	May-23							
	Jun-23							
A1302	Jul-23							
	Aug-23							
	Sep-23							
A1302	Oct-23	7.1	24.8	2900	6.5	120	190	87
	Nov-23							
	Dec-23							
A1303	Jan-23	7.3	23.5	5600	6.4	400	420	220
	Feb-23							
	Mar-23							
A1303	Apr-23	7.1	16.8	3200	3.1	220	210	130
	May-23							
	Jun-23							
A1303	Jul-23							
	Aug-23							
	Sep-23							
A1303	Oct-23	7.2	18.3	2100	6.3	120	120	71
	Nov-23							
	Dec-23							
A1304	Jan-23	6.8	19.5	2100	5.2	120	160	92
	Feb-23							
	Mar-23							
A1304	Apr-23	7.6	16.6	2400	6.7	130	150	100
	May-23							
	Jun-23							
A1304	Jul-23							
	Aug-23							
	Sep-23							
A1304	Oct-23	7	16.8	2000	6.3	85	120	70
	Nov-23							
	Dec-23							

Monitoring location		pH	Temperature	Conductivity	Dissolved oxygen	Chloride	Ammoniacal nitrogen	Potassium
		-	°C	µS	mg/l	mg/l	mg/l	mg/l
A1305CV	Jan-23	7.2	18.7	4800	<1	400	230	250
	Feb-23							
	Mar-23							
A1305CV	Apr-23	7.4	17.8	5400	1.1	540	300	250
	May-23							
	Jun-23							
A1305CV	Jul-23	7.3		4500	4.6	410	300	220
	Aug-23							
	Sep-23							
A1305CV	Oct-23	7.2	17.2	4300	4.4	310	280	160
	Nov-23							
	Dec-23							

Grey spaces indicate months where no site readings or laboratory analysis required.
Blanks indicate location not sampled.

'U/S' means unsuitable sample for the analysis requested. 'I/S' means insufficient sample.

A3 - Leachate Quality Monitoring - Annual Data

This analysis was not undertaken in October 2023

A4 - Leachate Quality Monitoring - Discharge Flap Valve

Parameter	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Ammoniacal Nitrogen	15	0.38	0.089	6	0.083	0.084	1.7	0.034	0.062	3.1	8.9	9.6
As (dissolved)	3.53	1.66	1.44	2.58	4.26	8.43	2.53	6.83	6.83	3.38	2.59	1.81
Cd (dissolved)	0.06	0.07	0.07	0.06	0.04	0.04	0.05	<0.02	0.05	0.04	0.04	0.1
Cr (dissolved)	0.8	0.4	0.6	0.7	0.7	1.9	1	0.5	1	0.5	1.3	0.7
Cu (dissolved)	3.3	4.7	3.7	3.1	3.8	8	7.5	5	5.2	2.9	2.3	7.5
Iron	0.018	0.008	0.035	0.017	0.01	0.023	0.055	0.008	0.025	0.016	0.021	0.028
Pb (dissolved)	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	0.8	<0.2	<0.2	<0.2
Ni (dissolved)	5.7	1.5	2.1	3.4	4.5	7	7.4	4.2	4.7	2.3	3.7	2.9
Zn (dissolved)	7.5	7.4	10	7.1	8	6.9	7.1	5.4	7.1	4.8	5.8	17

Appendix B - Groundwater Monitoring Data

B1 - Groundwater Level Monitoring Data

Groundwater levels (mAOD)													
Borehole	Well Base (mAOD)	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Northern Boundary													
BH3W	-1.4	3.45	3.32	3.56	3.25	3.04	2.64	2.9	3.1	3.34	3.48	3.52	3.58
BH5B	-3.91	2.87	2.85	3.15	2.74	2.55	2.17	2.34	2.5	2.62	2.92	2.95	3.02
BH7B	-4.39	2.36	2.14	2.51	2.24	1.94	1.45	1.37	1.89	2.21	2.32	2.33	2.5
BH9B	-3.06	2.48	2.31	2.71	2.39	2.12	1.61	1.97	2.24	2.3	2.46	2.5	2.64
Eastern Boundary													
BH1B	-2.76	0.5	1.62	2.08	1.65	1.38	1.05	1.2	1.14	1.76	1.76	0.63	1.9
BH40B	-0.55	2.21	2.15	2.8	2.07	1.65	1.79	1.92	2.07	2.32	2.47	2.44	2.59
BH43B	-1.56	2.92	3	3.57	3.11	2.77	2.5	1.58	2.75	3.13	3.27	3.27	3.27
BH45B	-3.08	3.03	2.39	2.66	2.15	1.8	1.43	0.64	1.99	2.26	2.36	2.37	2.4
Western Extension													
BH4	0.31	2.62	2.7	2.65	2.63	2.47	1.56	1.84	2.27	2.29	2.51	2.65	2.7
BH5	-0.51	2.53	2.85	2.5	2.32	2.07	1.31	1.57	2.02	2.18	2.36	2.67	2.5
BH6	-0.42	2.09	2.01	2.2	2.06	1.63	0.97	1.38	1.27	1.92	1.93	2.35	2.33
BH7	-1.58	1.42	1.42	Flooded	1.42	0.27	0.69	0.53	0.85	0.59	Flooded	0.67	1.22
BH8	-0.82	2.16	0.87	Flooded	1.94	1.47	1.77	2.63	1.97	2.03	2.39	2.07	2.28
Southern Extension													
BH12	0.43	1.12	0.98	0.54	1.04	0.74	0.48	0.43	1.4	1.34	1.54	1.76	2.61
BH15	0.5	2.36	2.36	2.91	2.14	1.62	2.34	1.61	2.19	2.4	2.36	2.54	2.88

B2 - Groundwater Quality Monitoring - Monthly Data

Monitoring location		Borehole Levels	Borehole Depth	Difference	pH	Temperature	Conductivity	Chloride	Ammoniacal nitrogen	Potassium
		mbTOC	mbTOC	m	-	°C	µS	mg/l	mg/l	mg/l
BH4	Jan-23	0.49	2.8	2.31						
	Feb-23	0.41	2.8	2.39						
	Mar-23	0.46	2.8	2.34						
BH4	Apr-23	0.48	2.8	2.32						
	May-23	0.64	2.8	2.16						
	Jun-23	1.55	2.8	1.25						
BH4	Jul-23	1.27	2.8	1.53						
	Aug-23	0.84	2.8	1.96						
	Sep-23	0.82	2.8	1.98						
BH4	Oct-23	0.6	2.8	2.2						
	Nov-23	0.46	2.8	2.34						
	Dec-23	0.41	2.8	2.39						
BH5	Jan-23	0.32	3.36	3.04	7.3		870	23	0.023	i/s
	Feb-23	0	3.36	3.36	8.1	9.9	570	31	<0.015	12
	Mar-23	0.35	3.36	3.01	7.4	11.1	500	16	0.028	6.1
BH5	Apr-23	0.53	3.36	2.83	7.4	12.8	900	24	0.043	11
	May-23	0.78	3.36	2.58	7.3	15.5	920	33	0.038	9.4
	Jun-23	1.54	3.36	1.82	7.2	14.4	1000	27	0.031	10
BH5	Jul-23	1.28	3.36	2.08	u/s	13.9	u/s	22	0.084	8.3
	Aug-23	0.83	3.36	2.53	7.4	12.1	660	24	<0.015	8.7
	Sep-23	0.67	3.36	2.69	7.4	15.9	680	28	0.024	8.8
BH5	Oct-23	0.49	3.36	2.87	7.4	15.8	720	30	<0.015	7.9
	Nov-23	0.18	3.36	3.18	8.1	11.8	660	20	<0.015	6.2
	Dec-23	0.35	3.36	3.01	7.3	12.3	630	17	0.017	6.3
BH6	Jan-23	0.54	3.05	2.51						
	Feb-23	0.62	3.05	2.43						
	Mar-23	0.43	3.05	2.62						
BH6	Apr-23	0.57	3.05	2.48						
	May-23	1	3.05	2.05						
	Jun-23	1.66	3.05	1.39						
BH6	Jul-23	1.25	3.05	1.8						
	Aug-23	1.36	3.05	1.69						
	Sep-23	0.71	3.05	2.34						
BH6	Oct-23	0.7	3.05	2.35						
	Nov-23	0.28	3.05	2.77						
	Dec-23	0.3	3.05	2.75						
BH7	Jan-23	0	3	3						
	Feb-23	0	3	3						
	Mar-23	Flooded								
BH7	Apr-23	0	3	3						
	May-23	1.15	3	1.85						
	Jun-23	0.73	3	2.27						
BH7	Jul-23	0.89	3	2.11						
	Aug-23	0.57	3	2.43						
	Sep-23	0.83	3	2.17						
BH7	Oct-23	Flooded	3	flooded						
	Nov-23	0.75	3	2.25						
	Dec-23	0.2	3	2.8						
BH8	Jan-23	0.71	3.69	2.98	8.2		610	67	0.017	4.5
	Feb-23	2	3.69	1.69	7.6	11.2	1400	150	3	12
	Mar-23	Flooded			7.4	12.8	660	44	0.047	11
BH8	Apr-23	0.93	3.69	2.76	7.9	14.3	830	41	0.025	9.9
	May-23	1.4	3.69	2.29	7.4	18.8	2700	170	15	21
	Jun-23	1.1	3.69	2.59	7.4	19.8	3200	610	22	84
BH8	Jul-23	0.24	3.69	3.45	u/s	19.5	u/s	660	35	86
	Aug-23	0.9	3.69	2.79	7.3	14.1	3400	570	12	99
	Sep-23	0.84	3.69	2.85	7.6	15.2	3300	720	24	110
BH8	Oct-23	0.48	3.69	3.21	7.4	15.5	1500	520	20	22
	Nov-23	0.8	3.69	2.89	8.2	12.1	1200	130	2.3	12
	Dec-23	0.59	3.69	3.1	7.4	12.9	630	30	<0.015	3.5
BH12	Jan-23	3.09	3.78	0.69	7.5		220	15	<0.015	4.4
	Feb-23	3.23	3.78	0.55	7.3	11.1	1200	120	2	22
	Mar-23	3.67	3.78	0.11	7.4	13.2	180	8.6	0.031	2.9
BH12	Apr-23	3.17	3.78	0.61	7.7	15.8	250	9.7	0.56	11
	May-23	3.47	3.78	0.31	Insufficient groundwater for sampling					
	Jun-23	3.73	3.78	0.05	Insufficient groundwater for sampling					
BH12	Jul-23		3.78		u/s	15	u/s	110	<0.015	30
	Aug-23	2.81	3.78	0.97	7.3	15.6	320	17	0.15	7.3
	Sep-23	2.87	3.78	0.91	7.6	15.9	380	11	0.03	8.1
BH12	Oct-23	2.67	3.78	1.11	7.4	16.2	870	7.3	0.23	8.3
	Nov-23	2.45	3.78	1.33	8.2	12.6	280	6.2	0.055	5.5
	Dec-23	1.6	3.78	2.18	7	12.5	730	16	<0.015	16

Monitoring location		Borehole Levels	Borehole Depth	Difference	pH	Temperature	Conductivity	Chloride	Ammoniacal nitrogen	Potassium
		mbTOC	mbTOC	m	-	°C	µS	mg/l	mg/l	mg/l
BH15	Jan-23	2	3.86	1.86	7.1		1600	43	<0.015	35
	Feb-23	2	3.86	1.86	7.1	12.4	1300	52	0.13	40
	Mar-23	1.45	3.86	2.41	7	11.5	910	29	<0.015	25
BH15	Apr-23	2.22	3.86	1.64	7	12.4	1400	34	0.029	38
	May-23	2.74	3.86	1.12	7.1	13.1	1900	81	0.13	42
	Jun-23	2.02	3.86	1.84	7.2	14.5	1200	29	0.028	37
BH15	Jul-23	2.75	3.86	1.11	u/s	14.3	u/s	24	0.12	30
	Aug-23	2.17	3.86	1.69	7.2	12	1500	33	0.024	52
	Sep-23	1.96	3.86	1.9	7.2	15.8	1400	37	0.039	37
BH15	Oct-23	2	3.86	1.86	6.9	15.1	1000	29	0.028	28
	Nov-23	1.82	3.86	2.04	8	12.3	740	15	<0.015	18
	Dec-23	1.48	3.86	2.38	Water levels monitored a week prior to groundwater sampling - but location flooded at the time of sampling					
BH9B	Jan-23	4.76	10.3	5.54	7.1		13000	2800	0.89	140
	Feb-23	4.93	10.3	5.37	7.1	11.8	9600	5000	1.2	110
	Mar-23	4.53	10.3	5.77	7	13.4	11000	5000	2.8	120
BH9B	Apr-23	4.85	10.3	5.45	7.2	16.5	15000	3800	0.8	130
	May-23	5.12	10.3	5.18	7.1	21.8	14000	4600	0.74	110
	Jun-23	5.63	10.3	4.67	7.1	17	11000	4100	0.9	110
BH9B	Jul-23	5.27	10.3	5.03	u/s	16.4	u/s	3700	0.38	150
	Aug-23	5	10.3	5.3	7.3	16	9900	4100	0.054	120
	Sep-23	4.94	10.3	5.36	7.1	16.4	11000	4600	2	160
BH9B	Oct-23	4.78	10.3	5.52	7	14.2	14000	5300	0.85	130
	Nov-23	4.74	10.3	5.56	8.1	11.2	9300	3600	0.77	110
	Dec-23	4.6	10.3	5.7	7.1	13.1	14000	4200	0.67	91
BH7B	Jan-23	4.53	11.28	6.75						
	Feb-23	4.75	11.28	6.53						
	Mar-23	4.38	11.28	6.9						
BH7B	Apr-23	4.67	11.3	6.63						
	May-23	4.97	11.3	6.33						
	Jun-23	5.44	11.28	5.84						
BH7B	Jul-23	5.52	11.28	5.76						
	Aug-23	5	11.28	6.28						
	Sep-23	4.68	11.28	6.6						
BH7B	Oct-23	4.57	11.28	6.71						
	Nov-23	4.56	11.28	6.72						
	Dec-23	4.39	11.28	6.89						
BH5B	Jan-23	4.45	11.23	6.78						
	Feb-23	4.47	11.23	6.76						
	Mar-23	4.17	11.23	7.06						
BH5B	Apr-23	4.59	11.24	6.65						
	May-23	4.78	11.24	6.46						
	Jun-23	5.15	11.23	6.08						
BH5B	Jul-23	4.98	11.23	6.25						
	Aug-23	4.82	11.23	6.41						
	Sep-23	4.7	11.23	6.53						
BH5B	Oct-23	4.4	11.23	6.83						
	Nov-23	4.37	11.23	6.86						
	Dec-23	4.3	11.23	6.93						
BH3W	Jan-23	2.99	7.84	4.85						
	Feb-23	3.12	7.84	4.72						
	Mar-23	2.88	7.84	4.96						
BH3W	Apr-23	3.19	7.84	4.65						
	May-23	3.4	7.84	4.44						
	Jun-23	3.8	7.84	4.04						
BH3W	Jul-23	3.54	7.84	4.3						
	Aug-23	3.34	7.84	4.5						
	Sep-23	3.1	7.84	4.74						
BH3W	Oct-23	2.96	7.84	4.88						
	Nov-23	2.92	7.84	4.92						
	Dec-23	2.86	7.84	4.98						
BH1B	Jan-23	4.64	7.9	3.26	7.7		1100	220	0.062	11
	Feb-23	3.52	7.9	4.38	7.6	11.9	190	13	<0.015	4.9
	Mar-23	3.06	7.9	4.84	7.8	14.5	3100	420	1.1	26
BH1B	Apr-23	3.49	7.9	4.41	8	15.2	3200	350	1.9	30
	May-23	3.76	7.9	4.14	7.8	18.8	3300	450	0.078	25
	Jun-23	4.09	7.9	3.81	7.7	16.9	3100	140	1.6	24
BH1B	Jul-23	3.94	7.9	3.96	u/s	16.5	u/s	56	0.024	3.3
	Aug-23	4	7.9	3.9	7.4	15	390	180	0.023	4.5
	Sep-23	3.38	7.9	4.52	7.8	17	2900	450	0.17	28
BH1B	Oct-23	3.38	7.9	4.52	8.1	15.3	3300	570	0.65	30
	Nov-23	4.51	7.9	3.39	8.5	13.7	2600	330	0.3	22
	Dec-23	3.24	7.9	4.66	7.9	13.2	3200	370	0.98	28

Monitoring location		Borehole Levels	Borehole Depth	Difference	pH	Temperature	Conductivity	Chloride	Ammoniacal nitrogen	Potassium
		mbTOC	mbTOC	m	-	°C	µS	mg/l	mg/l	mg/l
BH45B	Jan-23	3.3	9.41	6.11	7.1		1800	93	86	85
	Feb-23	3.94	9.41	5.47	7	11.9	1900	400	88	71
	Mar-23	3.67	9.41	5.74	7.1	14.1	1700	110	67	59
BH45B	Apr-23	4.18	9.41	5.23	7.1	14.5	2200	130	96	82
	May-23	4.53	9.41	4.88	7	17.2	2300	150	120	62
	Jun-23	4.9	9.41	4.51	7.4	16	2300	130	92	69
BH45B	Jul-23	5.69	9.41	3.72	u/s	15.4	u/s	430	75	84
	Aug-23	4.34	9.41	5.07	7.2	13.9	2100	140	82	78
	Sep-23	4.07	9.41	5.34	7	16.3	2300	190	120	75
BH45B	Oct-23	3.97	9.41	5.44	7	14.1	2700	170	130	87
	Nov-23	3.96	9.41	5.45	7.3	11.8	2400	270	120	99
	Dec-23	3.93	9.41	5.48	7.3	11.8	230	11	0.021	6
BH43B	Jan-23	4.45	8.93	4.48	7.1		1900	96	71	72
	Feb-23	4.37	8.93	4.56	7	12.3	1800	100	65	54
	Mar-23	3.8	8.93	5.13	7.1	14.6	1900	130	85	52
BH43B	Apr-23	4.26	8.93	4.67	7.2	14	1900	110	61	54
	May-23	4.6	8.93	4.33	7.1	18.6	1300	59	26	33
	Jun-23	4.87	8.93	4.06	7.3	15.9	1600	95	54	72
BH43B	Jul-23	5.79	8.93	3.14	u/s	15.9	u/s	90	50	50
	Aug-23	4.62	8.93	4.31	7.1	14.1	1700	78	58	68
	Sep-23	4.24	8.93	4.69	7	16.5	1600	120	72	56
BH43B	Oct-23	4.1	8.93	4.83	7.3	15.1	2000	130	83	54
	Nov-23	4.1	8.93	4.83	7.5	12	1800	110	73	75
	Dec-23	4.1	8.93	4.83	7.1	13.6	1900	100	68	58
BH40B	Jan-23	4.14	6.9	2.76						
	Feb-23	4.2	6.9	2.7						
	Mar-23	3.55	6.9	3.35						
BH40B	Apr-23	4.14	6.76	2.62						
	May-23	4.56	6.76	2.2						
	Jun-23	4.56	6.9	2.34						
BH40B	Jul-23	4.43	6.9	2.47						
	Aug-23	4.28	6.9	2.62						
	Sep-23									
BH40B	Oct-23	3.88	6.9	3.02						
	Nov-23	3.91	6.9	2.99						
	Dec-23	3.76	6.9	3.14						

Number in orange font indicate exceedance of a Control level
Number in red font indicate exceedance of a Trigger level

Black shading is for data not required to be monitored. Grey boxes are for data not required for that month. Blank spaces indicate monitoring not undertaken.

'U/S' means unsuitable sample for the analysis requested. 'I/S' means insufficient sample.

B3 - Groundwater Quality Monitoring - Six-Monthly Data

April 2023

Determinand	Units	Monitoring location							
		BH5	BH8	BH12	BH15	BH9B	BH1B	BH43B	BH45B
Alkalinity expressed as CaCO3	mg/l	490	420	130	570	630	1400	1000	1200
As (Dissolved)	µg/l	0.64	2.42	7.69	2.94	0.7	5.54	3.54	0.81
Biochemical Oxygen Demand	mg/l	1.7	1.4	2	1.1	1.4	10	20	5.6
Cd (Dissolved)	µg/l	0.07	0.09	0.03	0.1	0.07	<0.02	0.06	0.02
Calcium	mg/l	160	170	38	220	180	14	140	180
Chemical Oxygen Demand	mg/l	19	89	150	22	110	310	170	88
Cr (Dissolved)	µg/l	<0.2	<0.2	<0.2	0.3	<0.2	4	0.6	0.9
Cu (Dissolved)	µg/l	4.3	7.4	7.1	15	4.2	2.8	4.7	1.5
Iron	mg/l	0.012	0.012	0.041	0.006	0.038	5.2	0.11	0.089
Pb (Dissolved)	µg/l	<0.2	<0.2	<0.2	<0.2	<0.2	3.3	<0.2	<0.2
Magnesium	mg/l	21	25	19	71	340	23	79	71
Mn (Dissolved)	µg/l	410	1.9	48	28	1600	210	2600	820
Mercury	µg/l	<0.005	0.0051	<0.005	<0.005	<0.005	0.0121	<0.005	<0.005
Ni (Dissolved)	µg/l	4.3	3.4	2.3	6.5	4	2.1	7.3	5.3
Sodium	mg/l	59	88	68	100	2000	1000	160	190
Sulphate	mg/l	53.2	116	3.74	362	770	10.2	2.21	2.51
Total Organic Carbon	mg/l	5.1	7.94	4.52	7.06	10	108	20.1	22.2
Zn (Dissolved)	µg/l	6.9	4.4	5.4	31	8.1	8.1	17	5.4

October 2023

Determinand	Units	Monitoring location							
		BH5	BH8	BH12	BH15	BH9B	BH1B	BH43B	BH45B
Alkalinity expressed as CaCO3	mg/l	380	1200	270	470	730	1500	1100	1400
As (Dissolved)	µg/l	1.26	12.9	1.45	4.1	0.63	7.14	6.97	0.87
Biochemical Oxygen Demand	mg/l	<1.0	14	4	1.4	1.1	4.6	6.7	4.8
Cd (Dissolved)	µg/l	<0.02	0.24	0.02	0.13	0.02	<0.02	<0.02	<0.02
Calcium	mg/l	110	180	45	130	180	13	120	180
Chemical Oxygen Demand	mg/l	11	100	21	18	84	340	230	170
Cr (Dissolved)	µg/l	0.5	0.8	1	0.4	0.2	4.9	0.7	0.9
Cu (Dissolved)	µg/l	10	18	13	26	3.3	5	1.1	2.2
Iron	mg/l	0.04	0.024	0.018	0.017	0.029	5.1	0.085	0.04
Pb (Dissolved)	µg/l	<0.2	<0.2	0.5	<0.2	<0.2	7.5	<0.2	<0.2
Magnesium	mg/l	14	60	7.8	38	350	23	65	71
Mn (Dissolved)	µg/l	2.2	25	1.2	12	1900	250	2100	930
Mercury	µg/l	<0.005	<0.005	<0.005	<0.005	<0.005	0.0058	<0.005	<0.005
Ni (Dissolved)	µg/l	1.1	6.9	2.6	5.4	1.2	3.3	5.5	6.1
Sodium	mg/l	83	200	7.9	52	3300	920	130	170
Sulphate	mg/l	43.3	72.6	7.66	86.1	684	12.6	2.04	3.07
Total Organic Carbon	mg/l	11.3	8.21	11.9	5.96	23.9	92.2	39.9	21.9
Zn (Dissolved)	µg/l	7.3	9.3	19	50	3.6	11	13	3.6

B4 - Groundwater Quality Monitoring - Two Yearly Data

October 2023

Determinand	Units	Monitoring location							
		BH5	BH8	BH12	BH15	BH9B	BH1B	BH43B	BH45B
2-methylphenol	ug/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
4-Methylphenol	ug/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Phenol	ug/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sb (Dissolved)	ug/l	0.5	0.5	0.6	1.1	<0.4	0.8	<0.4	<0.4
Ba (Dissolved)	ug/l	29	44	84	26	29	19	22	320
Benzo(a)Pyrene	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	ug/l	130	490	63	380	1400	1900	740	1100
Co (Dissolved)	ug/l	<0.2	2	<0.2	<0.2	0.2	1.7	3.1	2.9
Cyanide(Total)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10
Fluoride	ug/l	300	890	280	560	550	1800	500	360
Mo (Dissolved)	ug/l	1.4	0.8	0.89	2.2	1.1	0.9	0.33	0.2
Naphthalene	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite as N	ug/l	<1.0	860	52	<1.0	19	U/S	35	80
Mecoprop	ug/l	<0.02	1.1	<0.02	<0.02	<0.02	<0.02	0.5	1.5
Phosphate as P	ug/l	<20	200	<20	60	64	5100	<20	<20
Phosphorus (Total)	ug/l	31	3600	51	260	770	5200	610	1800
Se (Dissolved)	ug/l	0.9	3.5	<0.6	1.1	29	12	2.1	2.4
Uranium	ug/l	2.2	1.3	<1.0	3.2	<1.0	<1.0	<1.0	<1.0
V (Dissolved)	ug/l	0.7	5.8	0.4	2.1	0.6	13	0.6	0.4
TPH (C5-C6 aliphatic)	ug/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TPH (C6-C8 aliphatic)	ug/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TPH (C8-C10 aliphatic)	ug/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TPH DW(C10-C12 aliphatic)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10
TPH DW(C12-C16 aliphatic)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10
TPH DW(C16-C21 aliphatic)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10
TPH DW(C21-C35 aliphatic)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10
TPH (Aliphatic) total	ug/l	<10	<10	<10	<10	<10	<10	<10	<10
TPH (C6-C7 aromatic)	ug/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TPH (C7-C8 aromatic)	ug/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TPH (C8-C10 aromatic)	ug/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TPH DW(C10-C12 aromatic)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10
TPH DW(C12-C16 aromatic)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10
TPH DW(C16-C21 aromatic)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10
TPH DW(C21-C35 aromatic)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10
TPH (Aromatic) total	ug/l	<10	<10	<10	<10	<10	<10	<10	<10
Benzene	ug/l	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
EthylBenzene	ug/l	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
M/P Xylene	ug/l	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Methyl tert-Butyl Ether	ug/l	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
O Xylene	ug/l	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Toluene	ug/l	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Appendix C - Surface Water Monitoring Data

Canal North - 2023 - Surface Water Quality Monitoring													
Parameter	**Unit**	**Jan-23**	**Feb-23**	**Mar-23**	**Apr-23**	**May-23**	**Jun-23**	**Jul-23**	**Aug-23**	**Sep-23**	**Oct-23**	**Nov-23**	**Dec-23**
pH	-	7.4	7.2	7.1	7	7.2	7.1	u/s	6.5	6.4	7.3	7.6	7.1
Electrical conductivity	µs/cm	230	220	170	220	220	390	u/s	240	190	190	210	180
Ammonical Nitrogen as N	mg/l	0.077	0.086	0.035	0.24	0.25	0.13	0.66	**3.5**	0.44	0.079	0.056	0.037
BOD	mg/l	1.2	2.3	1.1	8.2	6.9	3.4	u/s	61	3.2	2.2	1.6	1.3
COD	mg/l	10	19	10	41	18	47	340	3900	180	12	16	10
Nickel	µg/l	3	1	2.2	1.2	1.8	0.8	7.5	5.9	3.6	1.9	1.5	1.7
Nitrate as NO_3	mg/l	0.53	0.47	0.37	0.16	0.09	0.18	0.59	0.13	0.37	0.26	0.57	0.44
Phenol	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	10.2	<0.5	<0.5	<0.5	<0.5
Total Suspended Solids	mg/l	3	130	2	150	5	33	1400	210	340	54	6	27

Number in orange font indicate exceedance of a Control level
Number in red font indicate exceedance of a Trigger level

Blank space - not determined
'u/s' means unsuitable sample for the analysis.

Canal South - 2023 - Surface Water Quality Monitoring													
Parameter	**Unit**	**Jan-23**	**Feb-23**	**Mar-23**	**Apr-23**	**May-23**	**Jun-23**	**Jul-23**	**Aug-23**	**Sep-23**	**Oct-23**	**Nov-23**	**Dec-23**
pH	-	7.1	7.3	7.1	7.4	6.8	7.5	u/s	6.8	6.8	7.1	7.7	6.9
Electrical conductivity	µs/cm	270	210	180	210	220	400	u/s	210	190	200	220	190
Ammonical Nitrogen as N	mg/l	**0.85**	0.1	**0.36**	**0.5**	0.12	0.17	0.29	0.12	**0.33**	0.24	0.22	0.22
BOD	mg/l	1	<1	3.2	1.5	5.2	<1	u/s	20	48	1.5	1.5	2.1
COD	mg/l	10	9.6	16	13	15	27	18	28	67	7.6	6.8	5.7
Nickel	µg/l	2.1	1.7	1.5	1.9	1.9	5	1.5	1.4	1.8	7.6	4.7	2.2
Nitrate as NO_3	mg/l	0.7	0.46	2.19	0.13	0.18	0.15	0.07	0.06	0.11	0.24	0.83	0.63
Phenol	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	23.3	<0.5	<0.5	<0.5	<0.5
Total Suspended Solids	mg/l	19	<2	610	17	<2	40	11	24	180	4	4	<2

Number in orange font indicate exceedance of a Control level
Number in red font indicate exceedance of a Trigger level

Blank space - not determined
'u/s' means unsuitable sample for the analysis.

River North - 2023 - Surface Water Quality Monitoring													
Parameter	**Unit**	**Jan-23**	**Feb-23**	**Mar-23**	**Apr-23**	**May-23**	**Jun-23**	**Jul-23**	**Aug-23**	**Sep-23**	**Oct-23**	**Nov-23**	**Dec-23**
pH	-	8	7.9	7.9	7.8	7.5	7.9	u/s	7.8	7.8	8	8	8.1
Electrical conductivity	µs/cm	1800	10000	480	21000	20000	35000	u/s	52000	8800	2700	21000	140
Ammonical Nitrogen as N	mg/l	**0.53**	0.054	0.037	0.074	0.22	0.088	0.2	u/s	0.062	0.039	0.035	0.04
BOD	mg/l	7	4.2	1.7	2	3.8	<1	u/s	9.6	1.5	1.2	1.3	9.7
COD	mg/l	890	150	15	210	340	1000	23	1600	140	15	1100	110
Nickel	µg/l	1.5	1.6	3.3	1.6	2	1.1	2.4	i/s	4.8	2.8	1	1.4
Nitrate as NO_3	mg/l	0.24	0.38	0.55	0.41	0.1	0.1	0.31	0.05	0.37	0.58	0.37	0.15
Phenol	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Suspended Solids	mg/l	26000	1200	2200	340	2600	50	16	200	240	31	530	450

Number in orange font indicate exceedance of a Control level
Number in red font indicate exceedance of a Trigger level

Blank space - not determined
'u/s' means unsuitable sample for the analysis.

River South - 2023 - Surface Water Quality Monitoring													
Parameter	**Unit**	**Jan-23**	**Feb-23**	**Mar-23**	**Apr-23**	**May-23**	**Jun-23**	**Jul-23**	**Aug-23**	**Sep-23**	**Oct-23**	**Nov-23**	**Dec-23**
pH	-	8	7.7	7.7	7.8	7.6	7.8	u/s	7.5	7.7	7.8	8	7.7
Electrical conductivity	µs/cm	570	32000	570	40000	34000	47000	u/s	51000	13000	10000	40000	200
Ammonical Nitrogen as N	mg/l	**0.38**	0.11	0.2	0.1	0.19	0.082	<0.015	<0.015	0.094	0.04	0.13	0.041
BOD	mg/l	4.9	4.6	1	1.7	8.9	1.5	u/s	2.5	1.4	1.1	1.8	1.7
COD	mg/l	120	690	15	940	1100	1100	25	5200	220	19	1200	33
Nickel	µg/l	1.3	1.3	1.9	1.5	1.1	i/s	2.5	0.9	2.7	1.9	1	2.3
Nitrate as NO_3	mg/l	1.19	0.14	0.68	0.16	0.09	i/s	0.38	0.11	0.14	0.46	0.41	0.16
Phenol	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Suspended Solids	mg/l	940	690	29	520	1300	65	20	280	490	13	760	60

Number in orange font indicate exceedance of a Control level
Number in red font indicate exceedance of a Trigger level

Blank space - not determined
'u/s' means unsuitable sample for the analysis.

Appendix D - Perimeter Gas Monitoring Data

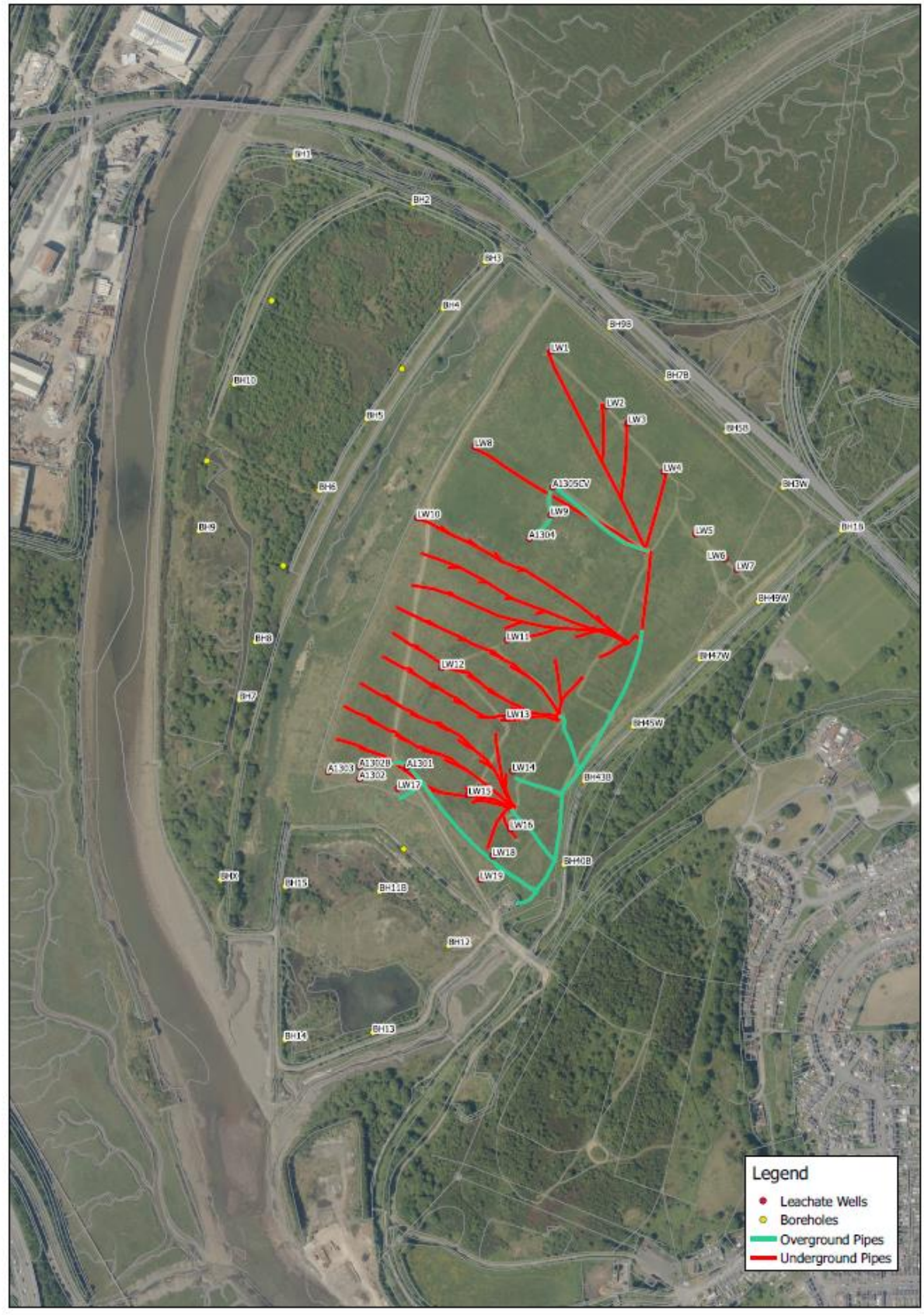
Monitoring location	Month	Methane	Carbon dioxide	Oxygen	Carbon monoxide	Atmosheric pressure	Differential pressure
		%	%	%	ppm	mbar	mbar
BH4	Jan-23	0.1	3.9	19.3	0	1033	0.03
	Feb-23	0.1	3.7	18.5	0	1015	-0.02
	Mar-23	0	0.1	21.5	0	998	0
BH4	Apr-23	0	0.1	21.1	0	1029	0
	May-23	0	0.2	20.9	0	1031	-0.02
	Jun-23	0	0	20.4	1	1017	0.02
BH4	Jul-23	0	0.2	20.7	0	1018	0.04
	Aug-23	0	0.5	19.7	0	1006	-0.09
	Sep-23	0	0.4	19.9	0	1019	0
BH4	Oct-23	0	0.2	20.8	0	990	0.03
	Nov-23	0	4.1	18.2	0	1026	0
	Dec-23	0.1	1.6	20.2	0	1008	-0.02
BH5	Jan-23	0.1	0.5	20.7	0	1033	0.03
	Feb-23	0.2	2.2	20.1	0	1.15	0
	Mar-23	0.1	0.2	21.6	0	998	0.02
BH5	Apr-23	0	0.3	21.5	0	1029	0.02
	May-23	0	0.4	20.7	0	1031	-0.03
	Jun-23	0	1.3	19.7	0	1017	-0.02
BH5	Jul-23	0	1.9	17.2	0	1018	-0.02
	Aug-23	0	3.1	15.3	1	1006	-0.09
	Sep-23	0	1.7	19.6	0	1019	0
BH5	Oct-23	0	1.9	19.2	0	990	0.02
	Nov-23	0	1.9	19.7	0	1026	0
	Dec-23	0	0.9	20.4	0	1008	0.02
BH8	Jan-23	0	1.1	21	0	1033	0.02
	Feb-23	0.1	0.6	20.3	0	1014	0
	Mar-23	flooded					
BH8	Apr-23	0	0.5	21.5	0	1029	0.03
	May-23	0	0.2	21.2	0	1031	0
	Jun-23	0	1	20.1	0	1017	0.02
BH8	Jul-23	0	0.4	20.7	0	1018	0.02
	Aug-23	0	0.5	20.4	1	1006	0
	Sep-23	7.1	6.9	12.3	0	1019	-0.02
BH8	Oct-23	0	0.6	20.2	0	990	-0.02
	Nov-23	0.1	0.3	20.2	0	1026	0.02
	Dec-23	0	0.2	15.8	0	1008	0.02
BH12	Jan-23	0.2	0.5	20.1	0	1033	0.02
	Feb-23	0.2	0.1	21.3	0	1014	-0.03
	Mar-23	0.2	0.1	21.4	0	998	0
BH12	Apr-23	0	0.1	21.4	0	1029	0
	May-23	0.1	0.1	21	0	1030	-0.02
	Jun-23	0	0.1	20.5	0	1016	0
BH12	Jul-23	0.1	0	20.9	2	1018	0.07
	Aug-23	0.1	0.6	20.2	1	1006	0.02
	Sep-23	0.2	0.8	20.4	0	1018	-0.06
BH12	Oct-23	0.1	1.2	20	0	990	0.09
	Nov-23	0.1	0.8	20	0	1026	0.03
	Dec-23	0.1	0.9	19.9	0	1008	0
BH15	Jan-23	0.1	0.8	21	0	1033	-0.03
	Feb-23	0.2	0.9	19.9	0	1014	0
	Mar-23	0.1	0.5	21	0	998	0
BH15	Apr-23	0	1.3	19.3	0	1029	0.05
	May-23	0	0.6	19.7	0	1030	-0.03
	Jun-23	0	2.2	18.7	0	1016	0.03
BH15	Jul-23	0	0	18.6	2	1018	0.05
	Aug-23	0	2.6	17.6	1	1006	0.02
	Sep-23	0	2.6	17.5	0	1018	-0.09
BH15	Oct-23	0.1	1.6	19.2	0	990	0.02
	Nov-23	0.1	1	19.9	0	1026	0.02
	Dec-23	0	2	19.2	0	1008	0.02

Monitoring location	Month	Methane	Carbon dioxide	Oxygen	Carbon monoxide	Atmosheric pressure	Differential pressure
		%	%	%	ppm	mbar	mbar
BH9B	Jan-23	0.1	0	21.6	0	1033	0
	Feb-23	0.1	0.1	19.9	0	1015	0.02
	Mar-23	0	0.1	21.4	0	998	0
BH9B	Apr-23	0	0.1	21.7	0	1028	0.05
	May-23	0	0.1	21.6	1	1030	0
	Jun-23	0	0.2	20.8	1	1017	-0.03
BH9B	Jul-23	0	0.1	21	0	1018	-0.09
	Aug-23	0	0.1	20.3	1	1006	0
	Sep-23	0	0.1	19.8	0	1019	-0.02
BH9B	Oct-23	0	0.1	20.8	0	990	0
	Nov-23	0	0.1	20.6	0	1026	0.03
	Dec-23	0	0.1	20.6	0	1008	0.02
BH7B	Jan-23	0	0.3	21.5	0	1033	0
	Feb-23	0.1	0.5	20.3	0	1015	-0.02
	Mar-23	0	0.2	21.5	0	998	-0.09
BH7B	Apr-23	0	0.1	20.8	0	1028	-0.02
	May-23	0	0.1	21.2	1	1030	-0.02
	Jun-23	0	0.2	20.4	1	1017	-0.02
BH7B	Jul-23	0	0.1	21.2	0	1018	-0.03
	Aug-23	0	0.4	20.2	1	1006	0.02
	Sep-23	0	0.1	20.4	1	1019	0
BH7B	Oct-23	0	0.7	20.7	0	990	0.02
	Nov-23	0	0.4	20.4	0	1026	0.02
	Dec-23	0	0.2	20.5	0	1008	-0.03
BH5B	Jan-23	0.1	0.2	21.9	0	1033	0
	Feb-23	0.1	0.2	20.9	0	1015	0
	Mar-23	0	0.1	21.6	0	998	0
BH5B	Apr-23	0	0.1	21.1	1	1028	-0.02
	May-23	0	0.1	21.3	1	1030	-0.02
	Jun-23	0	0.1	20.8	1	1017	0
BH5B	Jul-23	0	0.1	21.4	0	1018	0.02
	Aug-23	0	0.1	20.7	1	1006	0.02
	Sep-23	0	0.1	20.6	1	1019	-0.02
BH5B	Oct-23	0	0.1	20	0	990	0
	Nov-23	0	0.1	21	0	1026	0
	Dec-23	0	0.1	20.8	0	1008	-0.02
BH3W	Jan-23	0.1	3.2	19.7	0	1033	0.03
	Feb-23	0.1	2	18.1	0	1015	0
	Mar-23	0	0.7	20.3	0	997	0
BH3W	Apr-23	0	0.4	21.1	0	1028	0
	May-23	0	0.8	20.6	1	1030	0.02
	Jun-23	0	0	21.1	1	1017	-0.02
BH3W	Jul-23	0	0.5	21	0	1018	-0.02
	Aug-23	0	2	17.6	1	1006	0.02
	Sep-23	0	0.9	19.3	1	1019	0
BH3W	Oct-23	0	0.6	20.2	0	990	0
	Nov-23	0	2.9	15.4	0	1026	0
	Dec-23	0	0.5	20.4	0	1008	0
BH1B	Jan-23	0.2	0.2	20.6	0	1026	0.03
	Feb-23	0.2	0.3	21.4	0	1018	0
	Mar-23	0	0.8	20.4	0	997	-0.02
BH1B	Apr-23	0	0.2	21.1	0	1028	0.02
	May-23	0	1	20	0	1030	0
	Jun-23	0	0.4	20.6	1	1017	0.02
BH1B	Jul-23	0	0.7	21	0	1019	0.03
	Aug-23	0.1	1	19.8	0	1010	0.03
	Sep-23	0.1	0.6	19	0	1003	-0.05
BH1B	Oct-23	0.1	0.3	21	0	990	0
	Nov-23	0.1	0.7	20.3	0	1027	0
	Dec-23	0.1	0.6	20.4	0	1036	0

Monitoring location	Month	Methane	Carbon dioxide	Oxygen	Carbon monoxide	Atmosheric pressure	Differential pressure
		%	%	%	ppm	mbar	mbar
BH49W	Jan-23	0	0.3	21.8	0	1033	0
	Feb-23	0.1	0.5	20.9	0	1015	0
	Mar-23	0	0.3	21	0	997	0
BH49W	Apr-23	0	0.2	21.2	1	1028	0.02
	May-23	0	0.1	21.6	1	1030	0.02
	Jun-23	0	0.8	20.3	1	1017	0.03
BH49W	Jul-23	0	0.4	21.4	0	1018	-0.03
	Aug-23	0	0.3	20.6	1	1006	0.02
	Sep-23	0	0.9	20	1	1019	0.03
BH49W	Oct-23	0	0.4	20.4	0	990	0
	Nov-23	0	0.6	20.4	0	1026	0.03
	Dec-23	0	0.6	20.5	0	1008	0
BH47W	Jan-23	0.1	0.5	21.9	0	1033	-0.02
	Feb-23	0.1	0.1	21.2	2	1015	0
	Mar-23	0	0.1	21.2	0	997	-0.02
BH47W	Apr-23	0	0.1	21.4	0	1028	0.02
	May-23	0	0.2	21.4	1	1030	0
	Jun-23	0.1	1.5	19.9	0	1017	0.02
BH47W	Jul-23	0	1.4	19.8	0	1018	-0.05
	Aug-23	0	0.4	20.3	1	1006	0
	Sep-23	0	0.1	20.4	1	1019	0.03
BH47W	Oct-23	0	0.2	20.8	0	990	0.02
	Nov-23	0	0.1	21.1	0	1026	-0.05
	Dec-23	0	0.1	21.2	0	1008	0.03
BH55B	Jan-23	0.1	3.9	17.2	0	1026	0
	Feb-23	0.1	3.8	17.4	0	1015	0
	Mar-23	0	1.4	20	0	997	0
BH55B	Apr-23	0	2.7	17.8	1	1027	0
	May-23	0	2.9	12.5	0	1030	-0.02
	Jun-23	0	3.9	17	0	1017	0
BH55B	Jul-23	0	3.4	17.5	0	1019	-0.03
	Aug-23	0	4.7	16.2	0	1010	-0.03
	Sep-23	0.1	6.4	16.7	0	1016	-0.02
BH55B	Oct-23	0.1	4.6	16	0	1004	0
	Nov-23	0.1	4.1	17.6	0	1008	-0.07
	Dec-23	0.1	3.9	16.5	0	1036	0
BH45B	Jan-23	0.1	0.2	20.6	0	1026	0
	Feb-23	33.6	9.3	7.2	2	1018	0
	Mar-23	49	13.2	1.9	7	997	0
BH45B	Apr-23	24.5	7.6	9.5	2	1028	0.02
	May-23	31.5	12.6	12.5	2	1030	-0.03
	Jun-23	0	0.4	20.6	1	1017	0
BH45B	Jul-23	17.1	12	7.1	0	1019	0.03
	Aug-23	41.1	12.6	2.4	0	1010	0.02
	Sep-23	52	7.4	0.3	5	1003	0
BH45B	Oct-23	43.3	13.7	1.6	6	988	0.02
	Nov-23	1.1	2.2	17.9	0	1027	0
	Dec-23	15.4	6.3	10.4	2	1036	0
BH43B	Jan-23	2	9.1	1.3	2	1026	0
	Feb-23	92	9.4	0.4	2	1018	0
	Mar-23	88.3	8.5	0.8	3	997	0
BH43B	Apr-23	88.6	9	8	5	1028	-0.02
	May-23	5.7	0.7	19.5	0	1030	-0.02
	Jun-23	18.8	1	16.2	3	1017	0.02
BH43B	Jul-23	88.2	11.1	1.2	21	1019	0.03
	Aug-23	47.2	6.7	8.8	4	1010	-0.03
	Sep-23	70.8	10	2.6	3	1003	-0.02
BH43B	Oct-23	60	9.1	14.9	1	988	-0.02
	Nov-23	80.1	10.4	10.1	2	1027	0
	Dec-23	30.9	4.5	13.4	0	1036	0.01

Monitoring location	Month	Methane	Carbon dioxide	Oxygen	Carbon monoxide	Atmosheric pressure	Differential pressure
		%	%	%	ppm	mbar	mbar
BH40B	Jan-23	3.6	1.8	18	0	1026	0.02
	Feb-23	74.7	3.4	0.6	17	1016	0
	Mar-23	8.2	4.1	12.1	0	998	-0.02
BH40B	Apr-23	1.4	1.5	18.1	0	1028	-0.02
	May-23	4.3	0.9	13	1	1030	0
	Jun-23	1.1	4.3	15.9	2	1017	-0.02
BH40B	Jul-23	0.8	1.1	19.9	3	1019	0.02
	Aug-23	26	1.6	10	26	1010	0.03
	Sep-23	81.5	3	3.7	15	1003	-0.07
BH40B	Oct-23	3	0.9	19.1	0	988	0.03
	Nov-23	1.4	0.5	20.5	0	1027	0
	Dec-23	0.4	0.8	18.7	0	1036	0.02

Appendix E – Sampling point location plan



Appendix F – Landfill Gas

The following appendix is available as a separate document to this annual report.

This separate document has the following contents:

1. Annual Performance Report
2. Weekly, Monthly and Six-Monthly Monitoring Data
3. Annual Emissions Testing
4. Annual Trace Gas Analysis
5. Quarterly Engine Emissions
6. C&P - Surface Emissions Survey

File name:
'Giants Grave SEM - Report January 2024 v2'

Report title
Surface Emissions Monitoring Report
Giants Grave Landfill Site
Neath Port Talbot Borough Council
January 2024