TIR JOHN (PHASE 2) LANDFILL

Annual Monitoring Review January - December 2021

Enovert South Limited

Report No. 14-K6065-ENV-R009
March 2022
Revision 00

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Document Control

Document: Annual Monitoring Review January - December 2021

Project: TIR JOHN (PHASE 2) LANDFILL

Client: Enovert South Limited

Report Number: 14-K6065-ENV-R009

Document Checking:

Revision	Revision/ Review Date	Details of Issue	Authorised		
			Prepared By	Checked By	Approved By
00	March 2022	Final	Arabella Sharrock	Kathryn Wright	John Baxter
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Contents

1 Introduction

1.1 Background

This report has been prepared by Byrne Looby Partners (UK) Ltd (ByrneLooby) on behalf of Enovert South Limited. The report provides a review of the environmental monitoring carried out for the Phase 2 portion of the Tir John Landfill Site by the site operator during 2021.

Tir John Landfill Site comprises an area of approximately 36ha and is situated North of Fabian Way, Port Tennant, Swansea, at National Grid Reference SS 695 936. The Site is located approximately 3km from Swansea and ~1km from the coast. The site comprises two separate Permitted areas, an older closed landfill referred to as Phase 1 and the adjoining Phase 2. Phase 1 is in the west of the site is progressing towards definitive closure. Phases 1 and 2 are separated by a valley that incorporates a high voltage electricity transmission line and stand-off which passes through the site.

This report reviews the Phase 2 eastern portion which comprises Cells 5 to 17 and is currently accepting non-hazardous wastes for disposal in Cells 15 and 16. Disposal operations began in Cell 16 in March 2019. The Phase 1 remains the responsibility of the City and County of Swansea, although daily management has been contracted to Enovert.

The original Waste Management Licence SWW14L included permission for the development of Phase 2 as Cells 5-14. Following a change to the regulatory framework an application for a PPC Permit was made by Swansea City Waste Disposal Limited in 2004 to enable continued operations within Cells 5-14 and the development for Cells 15-17. The permit was subsequently issued as TP3935LA/A001 in 2007 after a successful appeal. Subsequent variations to the permit were made in 2007, 2012, and 2013.

Swansea City Waste Disposal Ltd applied to transfer the permit to the City and County of Swansea at which point an updated Permit was issued as EPR/LP3935EY on the 20/10/2013. There has been a subsequent transfer of the permit to Cory Environmental (Gloucestershire) Ltd and the permit was re-issued as Permit Number EPR/VP3935AT on 30/09/2015. The permit was varied in February 2018 to change the operator and Permit Holder to Enovert South Ltd, and varied again in April 2019 to make minor technical amendments and was issued as EPR/VP3935AT/V004. The most recent Variation, EPR/VP3935AT/V007, was completed in November 2021 to add 15 European Waste Catalogue (EWC) codes to the permit.

1.2 Site History

The site has been constructed within an area which was originally part of the Crymlyn Bog, a lowland fen with peat deposits that originally hosted the River Neath estuary and is believed to have been used for seasonal grazing prior to the 18th century. The north to south Glan-y-Wern canal was constructed through the fen to facilitate the development of the coal mining industry. Historically coal drift mines surrounded the site, one of which coincided with a depression that forms a spring from the valley slopes at the western boundary of the old site. There is a similar feature 150m to the north.

A coal fired power station which was constructed on the footprint of Phase 1, resulted in the generation of large quantities of Pulverised Fuel Ash (PFA) which was deposited as a platform above the Crymlyn Bog to the east of the power station platform. Construction of the PFA platform continued until the mid-1980s and is beneath the footprint of Phase 2 Cells 5 to 15.

In parallel to the later stages of PFA disposal, there was the disposal of inert waste to the east of the site area (under the footprint of Cells 16 and 17 of the Phase 2). These disposal operations gradually expanded to also include domestic and other non-hazardous wastes from 1979 until the waste management operations were formalised and regulated under the 1985 planning permission.

Landfilling operations have been undertaken at the site since 1953 in unlined cells and prior to that PFA had been deposited since 1935. There has therefore been 50 years of disposal within the permitted area prior to the construction of the first containment cell. Phase 1 was operated between 1985 and the early 1990s for the permanent disposal of municipal, degradable commercial and industrial, inert wastes, within engineered containment cells. Operations then transferred to Phase 2. However, the previously deposited inert wastes below Cells 5 to 15 were largely removed prior to cell formation and it is known that when the baling machinery was not operating in Phase 1, other wastes were deposited over the footprint of Cells 16-17 *i.e.* the current and future operational cells and remain there.

Consequently, there are wastes deposited outside of (which pre-date) the footprint of the permitted landfills' engineered containment and which lies directly above organic rich sediments.

1.3 Site Setting

The site is located within the Crymlyn Bog, a lowland peaty fen which was the former estuary of the River Clydach and the River Neath. The historically placed PFA is present below much of the waste in Phase 1 where it was pushed out into the bog and overlies the natural superficial alluvial deposits, comprising interbedded peat, clay, silt, sand and gravel layers. The Carboniferous South Wales Lower Coal Measures Formation underlies the alluvium and forms the sides of the valley to the west of the site.

Topographically the ground falls from over 80mAOD to the west of the site to ~10mAOD within the Crymlyn Bog. The local hydrogeology is controlled by springs along the western edge of the valley, which discharge into the Crymlyn Bog with an easterly and south-easterly gradient towards the coast. There is a groundwater mound located at the spring monitored at GWD023, on the valley slopes at the western boundary of the closed site, which discharges into the PFA and alluvium that underlie the site.

It is considered likely that the placement of the PFA has increased the compaction of the *in-situ* peats and the low permeability clay of the alluvium.

1.4 Site Engineering

PFA underlies the Phase 2 Cells 5 - 15, with other wastes also underlying the Cell 16 – 17 footprint (Cells 1 - 4 are part of Phase 1). Consequently, there are wastes deposited outside of (and pre-dating) the footprint of the permitted landfills' engineered containment which lies directly above organic rich sediments. As the construction of Phase 2 progressed, the engineered design also evolved.

The earliest Phase 2 cells (Cells 5 - 11) are lined with a Geosynthetic Clay Liner (GCL) with overlying 300mm stone drainage blanket. The GCL was placed directly above the PFA.

For Cells 12 - 14, a rock fill was placed above the PFA to achieve the desired elevation. This was overlain by a geotextile to separate the rock fill from a 100mm gritstone formation layer to support a 300mm Bentonite Enriched Sand (BES) artificial geological barrier. Cells 12 - 14 are then lined with GCL and leachate is collected via a 300mm quarry gritstone fines.

Cell 15 construction includes a 300mm 40-20mm gravel drainage layer, with drainage pipes above a HDPE liner. There is a leak detection layer above the 500mm BES artificial geological barrier, which was placed above a 4m formation layer constructed from imported quarry overburden. Prior to the installation of artificial geological barriers at Cell 16, a groundwater monitoring and control system was installed.

Phase 2 Cells 5, 10, 11, 13 and 14 have been permanently capped with a LLDPE geomembrane. Cells 6 - 8 have a GCL cap, whilst Cells 9 and 12 has a temporary cap. These latter cells abut Cell 15 and 16. Cell 15 was capped with GCL during 2021. Cell 16 is the current operational cell.

1.5 Site Activities

Enovert's Operating Procedures (SHE-OP-01 – Waste Acceptance and Control) ensure that wastes are assessed against the relevant permit conditions and waste acceptance procedures prior to being authorised for disposal at the landfill. Each load of waste accepted is inspected visually at the site. Contaminated land, filter cakes and restoration soils have validation samples taken and sent for laboratory analysis. Waste acceptance test results are compared against the site permit conditions to confirm waste description/basic characterisation and acceptability for disposal.

During 2021, compliance testing was undertaken on 130 samples, with only two failures of the acceptance criteria. An investigation was undertaken for the failure, with acceptance only resumed where further evaluation of the data and/ or additional testing could demonstrate the acceptance framework could be met.

The most recent Hydrogeological Risk Assessment Review was undertaken in July 2018 (TerraConsult Report 10127-R08).

1.6 Environmental Monitoring

Schedule 4 of the permit (Tables S4.2 and 4.3) requires that specific performance parameters are reported. These tables are reproduced below as Table 1 and Table 2, which provide details from the holistic site (including Phase 1 Cells 1 - 4) and is not specific to the operational site.

Table 1 – Annual Production/Treatment

Table S4.3 Performance Parameters			
Parameter	Frequency of assessment	Annual total	Unit
Potable water used	Annually	2,846	m^3/yr
Energy used (including for leachate treatment)	Annually	105.1	MWh of electricity
Non-potable water used	Annually	Nil	m^3/yr

Table 2 – Performance Parameters

Table S4.2: Annual production/treatment	
Leachate: Disposed of off-site; Disposed of to any onsite effluent treatment plant;	**Cubic metres/year** 95,990 m^3/yr
Surface water and/or Groundwater: Disposed of off site; Disposed of to any onsite effluent treatment plant	**Cubic metres/year** 103,523 m^3/yr Nil
Landfill gas: combustion in flares; combustion in gas engines; Other methods of gas utilisation	**Normalised cubic metres/year** 628,000 m^3/yr 3,046,196 m^3/yr Nil

Quantities are cumulative volumes including closed site (Phase 1) data

The remaining void space at the site has been estimated at 50,630m^3. Settlement figures for 2021 are illustrated on Drawing TJ67.

2 Monitoring Schedule

Enovert South Limited staff carried out environmental monitoring during 2021 at the locations shown on Drawing TJ66 in accordance with the site's Environmental Permit.

3 Gas Monitoring

3.1 In-Waste Gas

3.1.1 Gas Utilisation

Landfill gas must be collected from all landfills receiving biodegradable waste and the landfill gas must be treated and, to the extent possible, used[1]. Landfill gas at Tir John landfill is managed via combustion and is principally used to generate renewable energy through a Jenbacher 320 Spark Ignition Engine with a capacity of 400 – 800m^3/hr. The Landfill Directive (99/31/EC) requires that wherever landfill gas cannot be utilised, then it must be flared. In accordance with this, a back-up flare is installed for contingency during periods where the gas engines are unable to be used e.g. maintenance periods or where additional capacity is needed. The on-site flare has a capacity of 400 – 1,000m^3/hr *i.e.* approximately equivalent to the engine capacity. Landfill gas utilisation rates were at 83% during 2021.

Total gas production at the site has been estimated using the GasSim model developed in conjunction with Environment Agency. Any modelling approach has limitations and GasSim is sensitive to the quantity of degradable carbon within incoming and previously deposited waste and the moisture conditions of the landfill. The effects of the diversion of degradable organic wastes (*e.g*. food and green wastes) from landfill became apparent following the introduction of the Landfill Directive in 2002 as these waste were increasingly managed through non-landfill routes. This diversion was variable across the country due to differences between waste collection authorities and the degradable content decreased over time, consequently it is difficult to accurately model. It is considered that the biggest driver of the rate of landfill gas generation are moisture conditions within the waste, and these vary considerably both within the waste mass and over time.

Landfill by their nature are heterogenous. This along with changing environments leads to broad assumptions which, although useful, result in variations from the theoretical predictions. The limitations of modelling are further discussed within the landfill gas ICOP[2] and other literature sources[3], however it is generally accepted that the volumes are likely to be an overestimate of actual production.

Gas yields at the site averaged ~419m^3/hr during 2021 and are consistently lower than the GasSim predicted generation volumes (Figure 3.1). Nevertheless, it is apparent that there is sufficient on-site capacity to manage the landfill gas generated at Tir John landfill.

[1] Annex I of the Landfill Directive (1999/31/EC) found at https://www.legislation.gov.uk/eudr/1999/31/annex/I/2018-07-04
[2] Todeka Limited (2012) Landfill Gas: Industry Code of Practice. The Management of Landfill Gas.
[3] Gregory et al - DEFRA Review of Landfill Methane Modelling Emissions Modelling Nov 2014 Report Number 13514290381.506/A.1

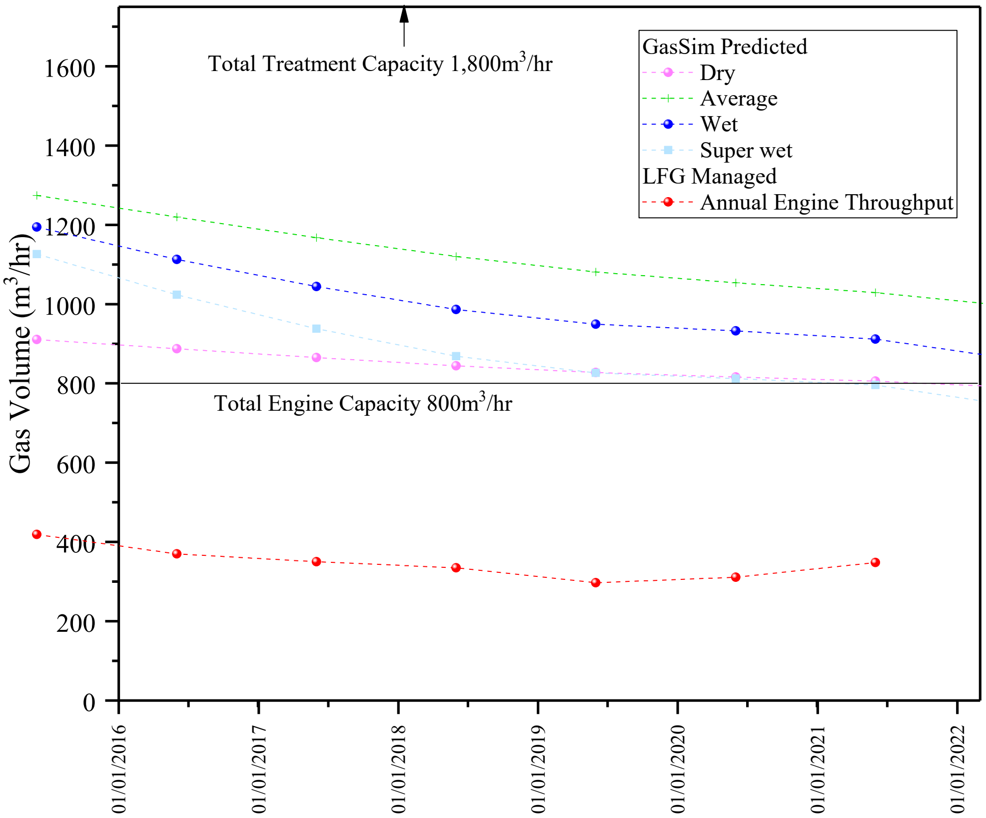

Figure 3.1 – Abstraction Yield at the Gas Management Compound

The gas quality at the compound remained relatively stable throughout 2021 and within the range ~40 - 50%v/v methane and 30%v/v carbon dioxide, with no appreciable oxygen content (Figure 3.2). Methane, carbon dioxide and oxygen are within the expected ranges for a gas management system which is being operated sustainably and where gas extraction matches production[2].

Free Nitrogen was marginally elevated during November 2021 and this was accompanied by a marginal fall in methane. However, free nitrogen fell during December and was below 20%v/v during January 2022 which is the recommended threshold for identifying excessive air ingress[2]. To optimise landfill gas abstraction, levels of free nitrogen levels should be between 7.5% and 20%. However, it is apparent that there is a fine balance between optimising the collection of landfill gas and managing migration or odour emissions, particularly within an operational landfill site like Tir John.

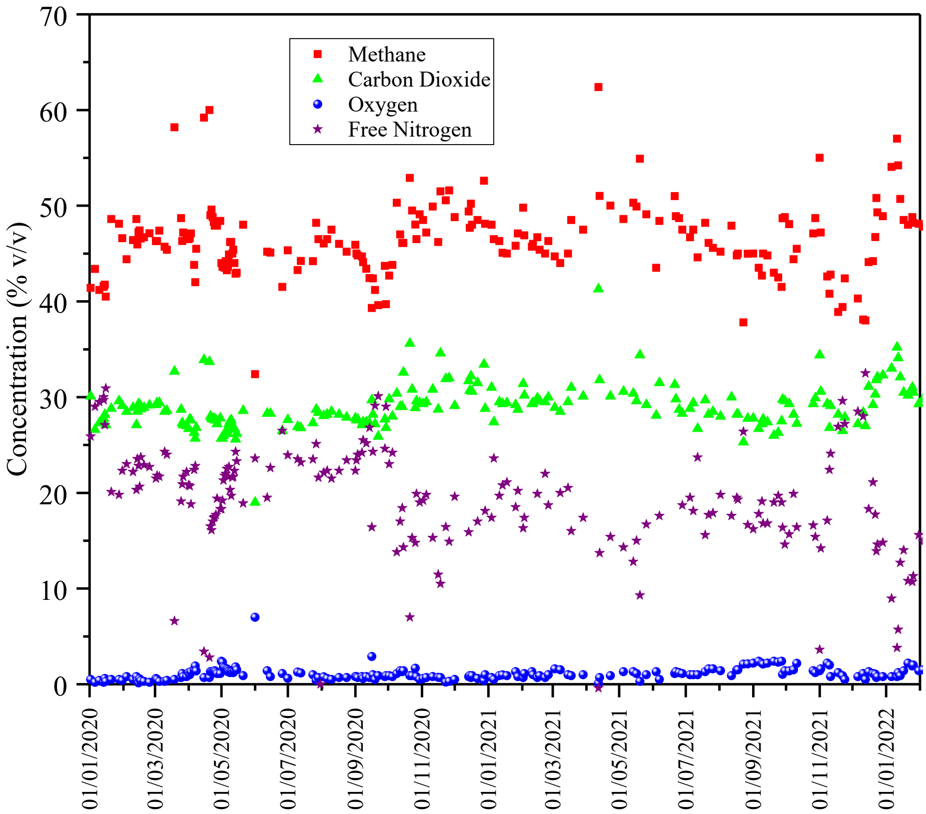

Figure 3.2 – Gas Quality at the Gas Management Compound

3.1.2 Gas Collection System

Gas quality and pressure measurements are carried out at the site whilst the system is being balanced to optimise gas collection, prevent emissions and minimise the potential for oxygen ingress into the site. The Tir John landfill gas (Figure 3.3) is typically a mixture of 40 - 65% methane with 20 - 40% carbon dioxide and negligible oxygen.

Carbon monoxide and hydrogen sulphide are both low and were reported at a maximum of 13ppm and 52ppm respectively during 2021. Occasional elevated oxygen levels in excess of 5%v/v were identified at some in-waste wells during 2021 (Appendix B). Where identified, initial investigative steps taken to reduce the elevated concentrations of oxygen are to re-balance the affected well and any surrounding wells. If required, repairs are also made to pipework and seals.

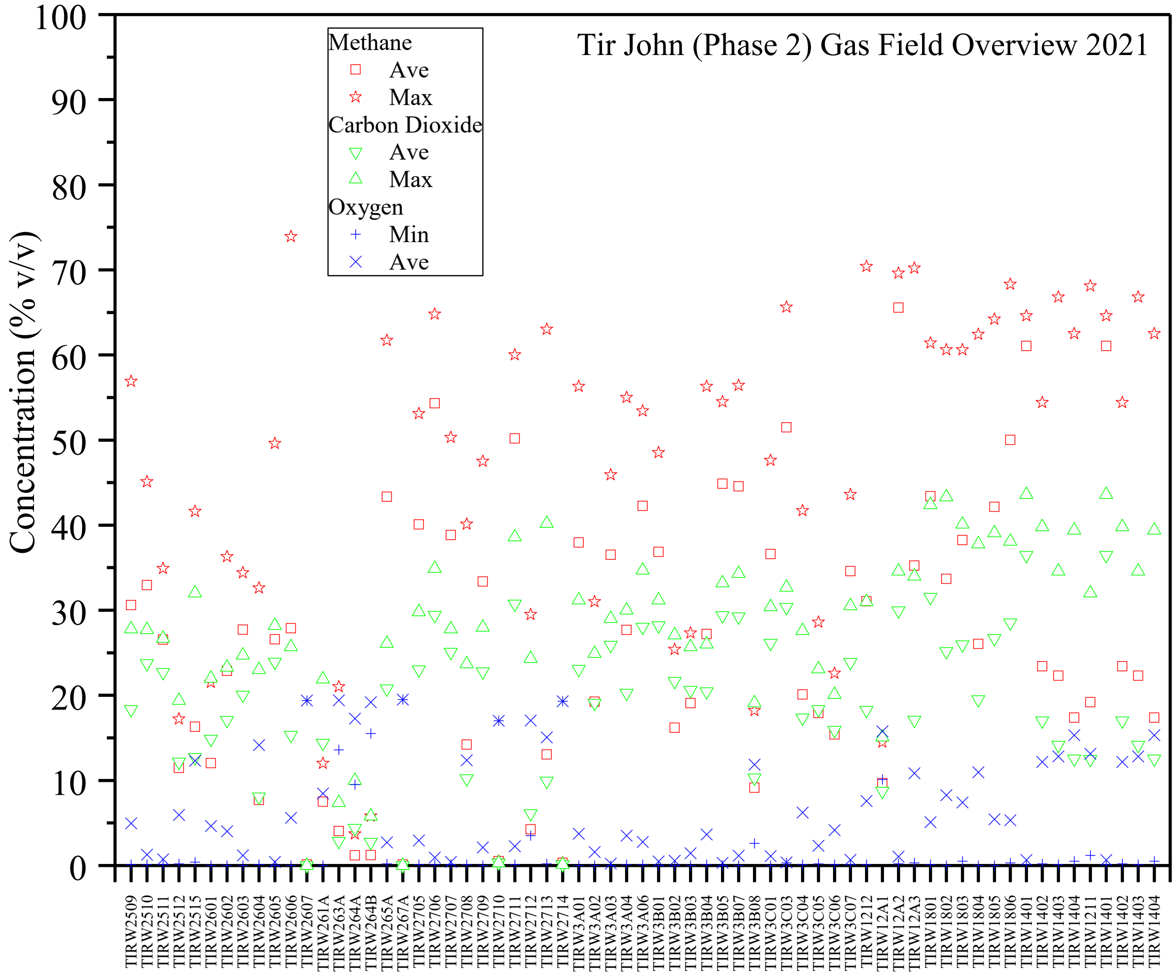

Figure 3.3 – In-Waste Landfill Gas Overview

3.2 Surface Emissions

Surface emission surveys were undertaken in December 2021. The survey was carried out to determine gas concentrations directly above the capped and temporary capped surfaces at the site. Enovert use a data logging system with GPS to allow the direct transfer of the FID route surveyed to site plans and hence identify areas of the cap which may require remediation. Discrete features, such as abstraction wells and transfer pipework were also surveyed.

The survey was carried out according to the objectives of Environment Agency guidance LFTGN07[4]. Section 2.7 of LFTGN07 states that "providing subsequent annual walkover surveys of that area demonstrate the surface concentration limits in air are less than 100 parts per million by volume (ppmv) immediately above the surface on the main zones of the cap and less than 1,000ppmv close to any discrete feature, you do not need to carry out subsequent flux box measurements to quantify emissions".

[4] Environment Agency (2010) Guidance on monitoring landfill gas surface emissions. LFTGN07 v2 2010

The survey demonstrates that there is generally good gas control at the site with low emissions (*i.e.* <10ppm) occurring across the majority of the surveyed area. Emissions in the range 100–499ppm were identified adjacent to discrete features such as leachate chambers. Given that the higher readings observed occurred adjacent to a discrete feature they are not considered to be significant and no further actions are required. All other emissions were reported below the 100ppm threshold.

3.3 Perimeter Gas

Ground gas was monitored at 11 perimeter locations surrounding the Phase 2 site in 2021. A summary of the data collected is provided within Table 3.

The site is located within the Crymlyn Bog, a lowland peaty fen that contains a biologically active soil microbial community. As a consequence of the site's location, the background soil biogeochemistry is complex and subject to a number of influences including temperature, soil saturation (including marsh areas) and seasonal or weather dependent transitions. This is further complicated by the historical placement of wastes prior to the construction of the containment cells.

Table 3 – Perimeter Ground Gas Summary 2021

Location	Methane			Carbon dioxide			Oxygen			Balance		
	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
	%v/v			%v/v			%v/v			%v/v		
TIRGP013	0.0	0.1	0.2	0.1	1.0	4.2	14.5	19.4	21.4	78.8	79.7	81.3
TIRGP014	0.0	0.0	0.2	0.2	5.6	10.6	3.2	12.9	21.3	78.4	81.7	86.2
TIRGP015	0.0	0.0	0.2	2.8	4.9	9.9	1.9	14.1	17.8	78.4	80.8	88.2
TIRGP016	0.0	0.0	0.2	4.3	7.7	10.7	6.9	10.9	17.0	78.3	81.3	84.4
TIRGP017	0.0	0.0	0.3	1.7	3.5	15.6	5.9	17.0	19.6	78.4	79.3	81.4
TIRGP018	0.0	0.1	0.3	2.2	6.2	10.9	4.7	12.5	17.7	78.0	81.3	86.2
TIRGP019	0.0	0.1	0.3	0.1	4.6	10.3	8.4	16.3	21.5	78.0	79.2	82.5
TIRGP020	0.0	0.0	0.3	0.8	5.6	10.0	6.9	11.6	18.7	79.8	82.9	86.6
TIRGP021	0.0	3.5	12.4	1.0	4.6	7.0	0.2	8.2	20.7	78.3	83.6	90.0
TIRGP022	0.0	0.0	0.3	0.1	0.2	0.6	18.8	20.5	21.6	78.5	79.3	80.6
TIRGP023	0.0	0.1	0.4	0.1	4.8	12.2	0.2	7.2	21.2	78.5	83.8	90.2

Shaded Cells indicate methane above 1%v/v

Methane is typically negligible within perimeter monitoring wells with the exception of TIRGP021 located in the south-eastern corner of the site, adjacent to Cell 6. During 2021 methane was recorded at 12.4%v/v in February, returning to negligible concentrations during summer before re-emerging in October at 9.5%v/v. The reported data is consistent with the historical dataset for this location (Figure 3.4).

Methane in TIRGP021 follows a seasonal pattern with elevated concentrations observed in the wetter winter months. A maximum annual methane concentration of 10.6%v/v was recorded in October 2019 and this was followed by a maximum annual methane concentration of 9%v/v in October 2020. The data implies that there is a seasonal influence on the ground gas at this monitoring point. These spikes with the ground gas profile may be attributable to anaerobic respiration conditions.

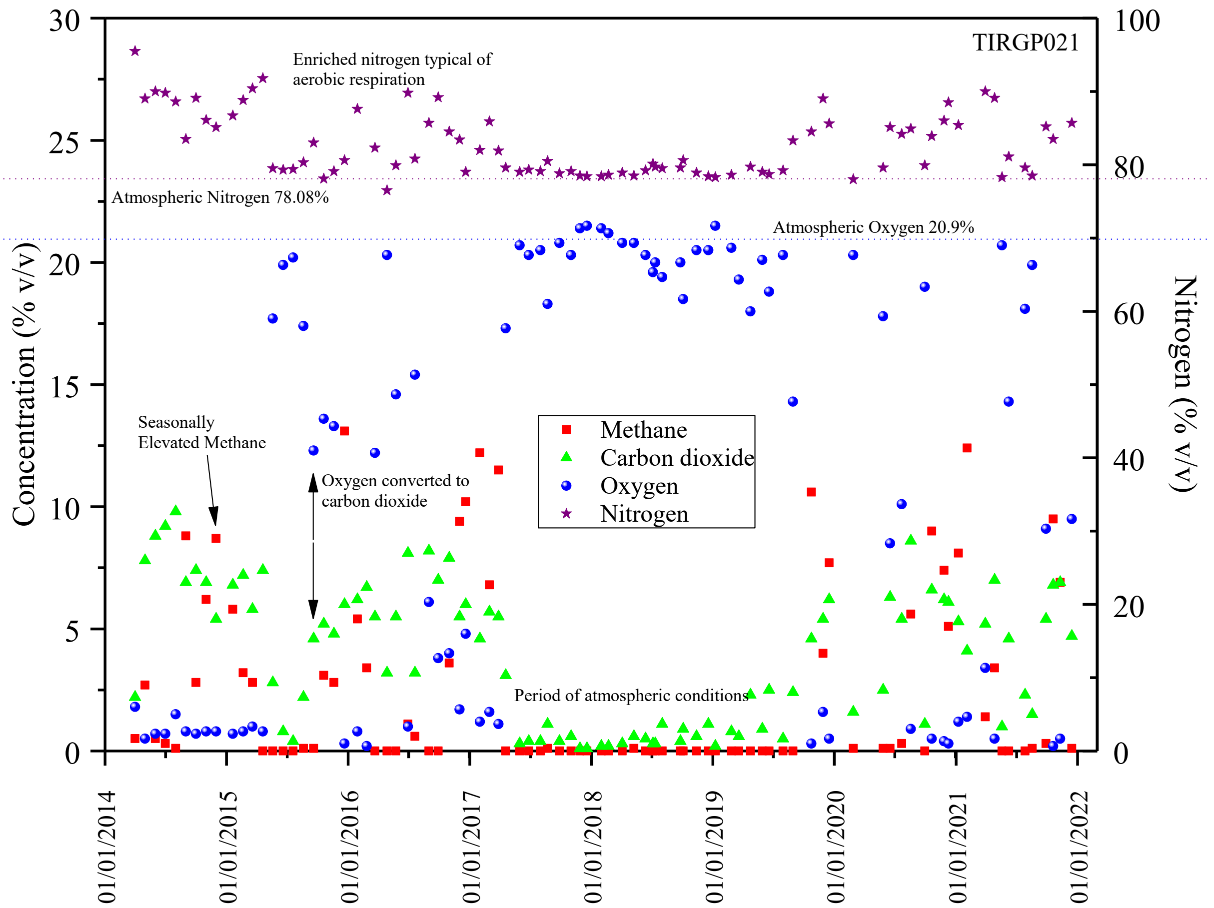

Figure 3.4 – Ground Gas Profile TIRGP021

Although there is the cyclic observation of methane and carbon dioxide at TIRGP021, the ground gas profile (Figure 3.4) demonstrates that the atmospheric gases are not purged from the ground when methane is present. The observation of nitrogen enrichment is consistent with natural processes; the most likely of which is microbial respiration resulting in a direct conversion of oxygen to carbon dioxide. In this process nitrogen is replenished from air ingress into the soil to replace the respired oxygen and hence is enriched compared to the atmosphere. It is considered likely that as methane continues to be observed during periods of seasonally higher groundwater recharge, then ground conditions were perhaps not favourable to such an *in-situ* regime during autumn 2017 and 2018, allowing the free exchange of atmospheric gases into the ground.

Methane was recorded below 1%v/v at all other monitoring points throughout 2021.

Carbon dioxide is typically in the 2.5%v/v to ~15%v/v range at the perimeter monitoring locations (Figure 3.5). The majority of perimeter monitoring locations (TIRGP013 – 020) have a ground gas profile consistent with aerobic respiration, *i.e.* nitrogen enrichment along with oxygen conversion to carbon dioxide (*e.g.* TIRGP015, Figure 3.6).

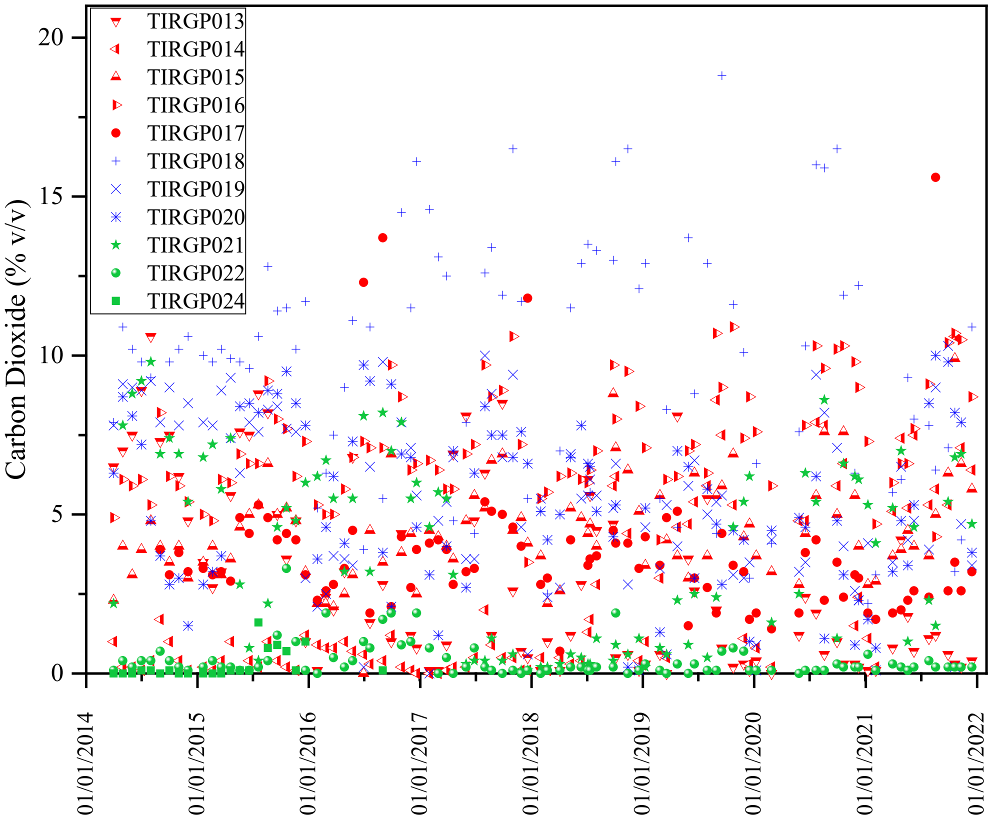

Figure 3.5 – Ground Gas Carbon Dioxide Summary

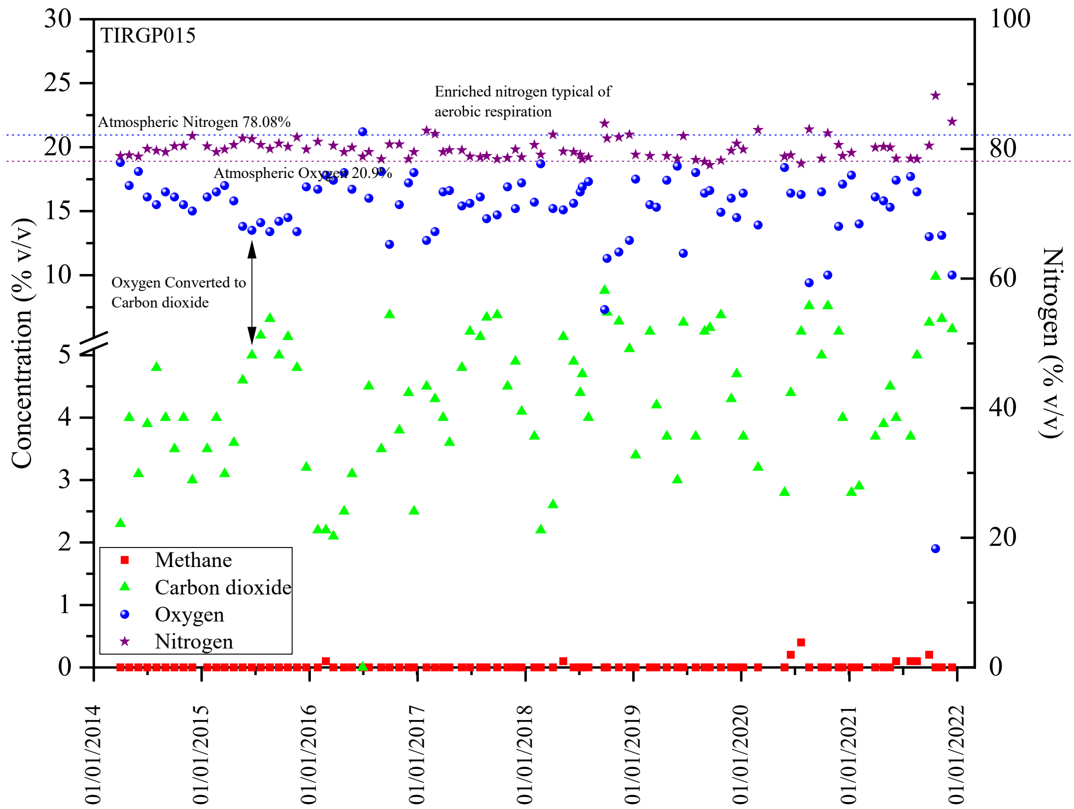

Figure 3.6 – Ground Gas Profile TIRGP015

TIRGP018 (Figure 3.7) has a generally higher baseline carbon dioxide content (at 10 - 19%v/v) than the other locations, with an average concentration of 6.2%v/v recorded in 2021. TIRGP18 and the adjacent monitoring points are installed below the base of the permitted landfill site. Therefore, the permitted Phase 2 site's landfill gas is unlikely to be a contributor to the carbon dioxide observed in these wells.

The monitoring points TIRGP013-20 along the northern section of the site were identified within the 2011 Hydrogeological risk assessment[5] to be located within or directly adjacent to historical inert wastes as well as the Crymlyn Bog. Both regimes could support the types of biological respiration resulting in the observed carbon dioxide and hence explain the monitoring programme observations. Nevertheless, the reported data at TIRGP018 is stable and there are no increasing trends in carbon dioxide or methane.

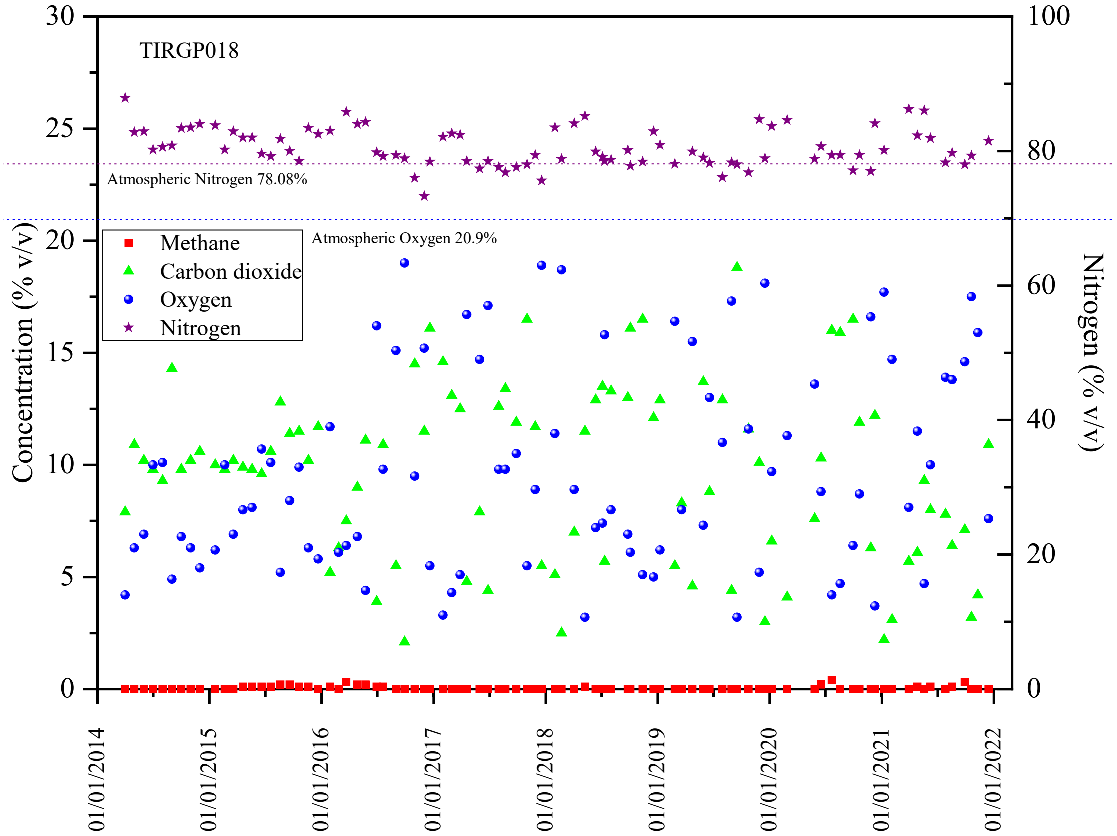

Figure 3.7 – Ground Gas Profile TIRGP018

TIRGP22 has a different ground gas profile to the other locations, more closely reflecting atmospheric conditions (Figure 3.8). TIRGP22 has historically only contained the occasional isolated carbon dioxide peaks in excess of 2%v/v, displaying a dampened seasonal trend, with otherwise negligible carbon dioxide.

[5] Drawing B1160000/OP012/Figure 4 Jacobs (2011) Tir John Landfill Hydrogeological Risk Assessment. Report B1160000/OP012/001

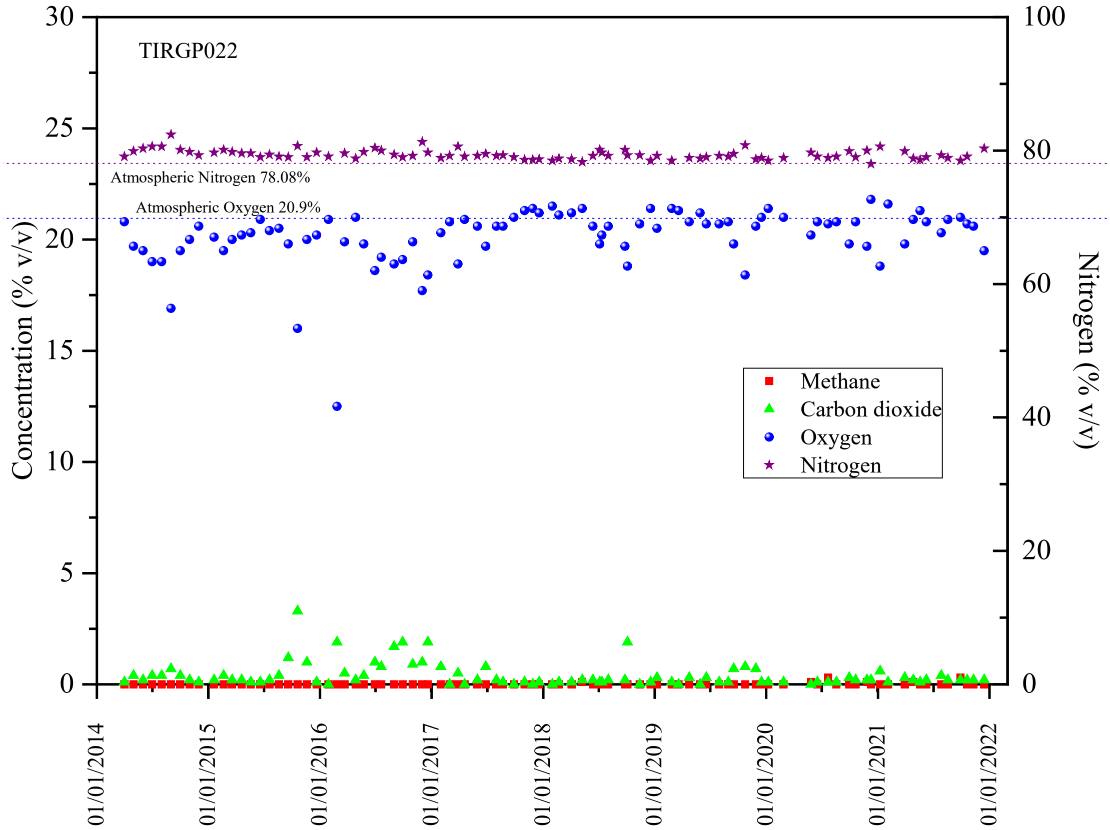

Figure 3.8 – Ground Gas Profile TIRGP022

3.4 Summary

Methane was negligible in the perimeter monitoring network during 2021 with the exception of TIRGP021, where methane re-occurred over 1%v/v. Methane has historically routinely been detected during the wetter months at TIRGP021, before depleting in late spring. Carbon dioxide in excess of 5%v/v was observed almost ubiquitously around the perimeter of the site.

The presence of neither gas is considered to be related to the permitted landfill operations. It is not known if the observed methane at TIRGP021 is as a consequence of a biogenic source influenced by changing moisture conditions resulting in marsh gas generation or derived from the coal deposits, or even historical waste disposal activities. The permitted landfill is a land raise constructed above the surrounding modified and natural topography. Consequently, the ground gas monitoring points are located physically below the base of the landfill site and more likely influenced by the Crymlyn Bog and the historical disposal activities than the current permitted landfill.

Carbon dioxide at the majority of the monitoring points was elevated with an associated depletion in oxygen and nitrogen enrichment. This is consistent with natural processes, most likely to be sub-surface microbial aerobic respiration, and concentrations are consistent with expectations for a biologically active soil, such as within a bog. Although similar processes could also occur where there is organic matter within the made ground outside of the engineered containment cells.

4 Water Environmental Monitoring

4.1 Leachate

4.1.1 Leachate Levels

A vertical abstraction system was installed during 2017-2018. Previously leachate was managed passively via a gravity drainage system. Leachate continues to be removed from the site and discharged to sewer.

During 2021, the majority of the site's leachate has been at less than 4m above the base (Figure 4.1), an environmentally insignificant level for a site benefiting from an engineered liner. There are some areas where leachate heights are in the 5 - 8m range however this is within the range modelled as part of the 2018 HRAR. Leachate levels at the majority of locations remained consistent with previous years and within the range ~10 – 17mAOD (Figure 4.2). Leachate levels in several wells appear to have stabilised during 2021 following the capping of Cell 15 undertaken in 2020, which will have resulted in reduced infiltration into the site and thus leachate generation. This is particularly evident at TIRLEW31 and TIRLEW32 (Figure 4.1).

The reported data at TIRLEW14 reflects difficulties in pumping from the well. Investigations are on-going but it is assumed that this location has become blocked.

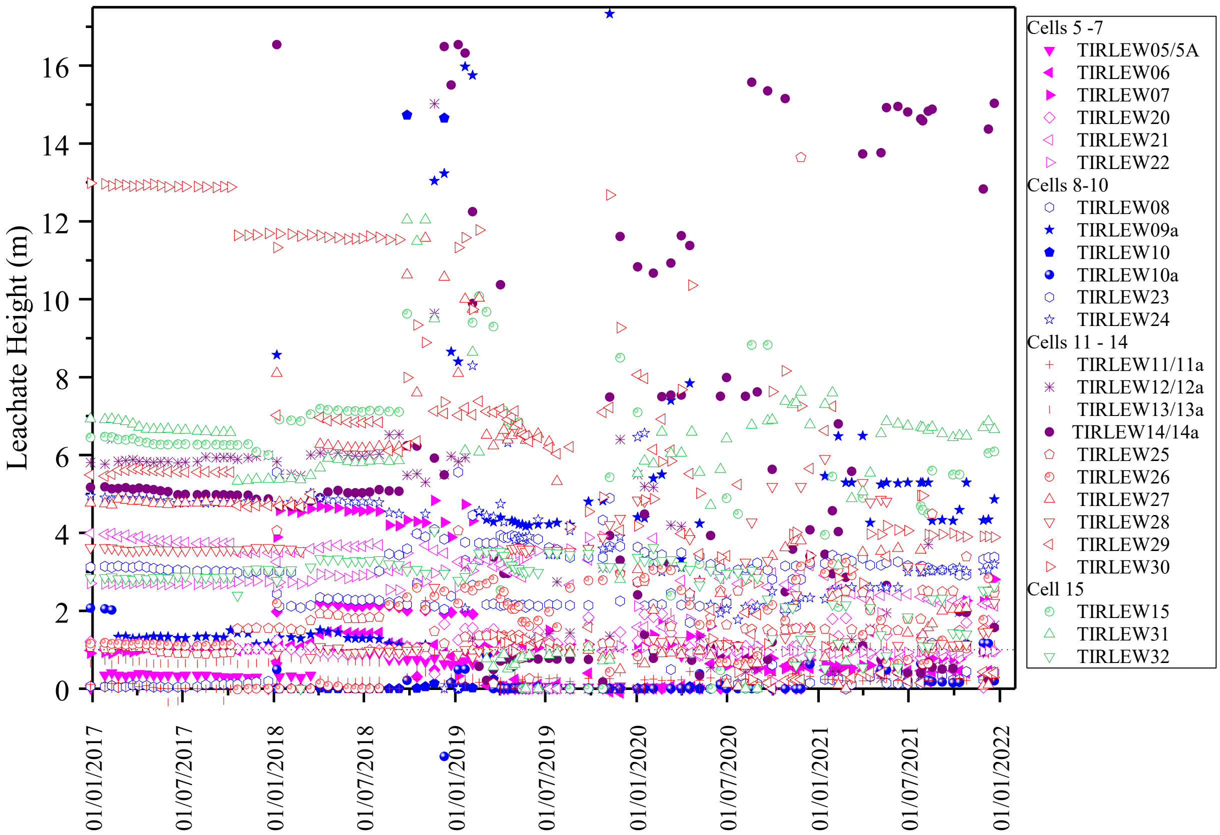

Figure 4.1 – Leachate Height

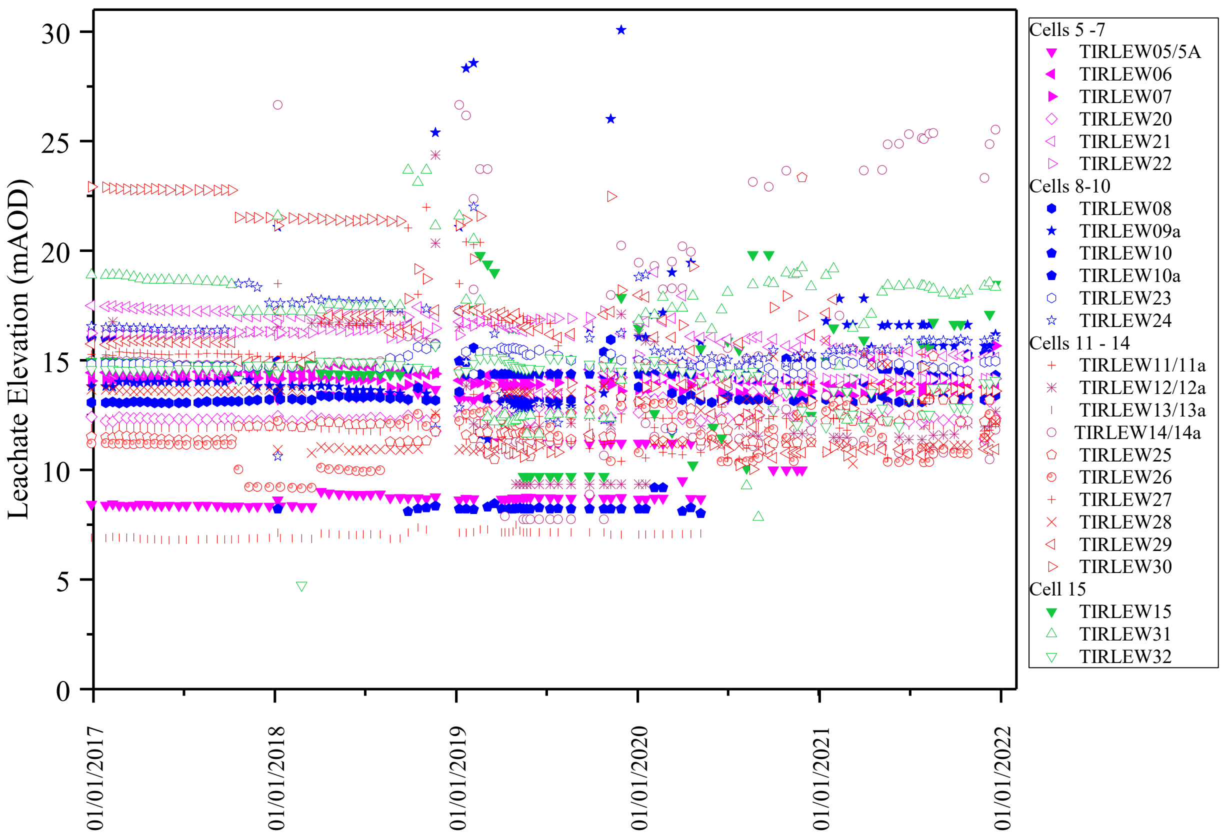

Figure 4.2 – Leachate Elevation

4.1.2 Leachate Quality

The leachate at Tir John (Phase 2) comprises of an ammoniacal-N and potassium rich sodium-bicarbonate-chloride solution with organic components. The strongest leachate (*i.e.* the highest ammoniacal-N) is present within the youngest cells, *i.e.* Cell 15 and Cell 12 which neighbours the operational area (Table 4).

Table 4 – Leachate Composition Summary 2021

Sample Point	Date	pH	EC uS/cm	NH_4-N mg/l	COD mg/l	BOD mg/l	Na mg/l	K mg/l	Cl mg/l
Cells 5-7									
LEW06	16/11/2021	7.5	3600	230	5600	310	420		310
LEW22	02/06/2021	7.8	6800	500	650	34	820	340	720
LEW22	16/11/2021	8.0	6600	410	670	8	950		690
Cells 8-10									
LEW23	02/06/2021	7.2	3900	130	420	19	680	270	580
LEW23	16/11/2021	7.1	2700	61	260	13	430		320
LEW25	02/06/2021	7.4	5600	490	430	20	700	250	570
LEW25	16/11/2021	7.2	2700	180	160	22	240		220
Cells 11,13 &14									
LEW26	02/06/2021	7.6	800	0.3	230	< 1	94	45	64
LEW26	16/11/2021	8.4	670	2.5	210	3	80		66
LEW28	02/06/2021	8.0	11000	24	1600	48	1400	490	1200
LEW28	16/11/2021	8.3	10000	1000	1300	120	1100		1100
LEW29	02/06/2021	8.0	6300	410	430	30	640	320	450
LEW29	16/11/2021	7.5	6800	560	460	22	620		670
Cells 12 & 15									
LEW12a	02/06/2021	7.8	16000	22	2000	48	1600	630	1500
LEW12a	16/11/2021	8.0	14000	1400	2000	190	2300		1800
LEW31	02/06/2021	7.9	20000	2000	4100	140	2300	53	2200
LEW31	16/11/2021	7.8	17000	1500	3400	150	2200		1900
Cell 16									
LEW16	16/11/2021	7.5	12000	1200	3500	270	1200		1200

The priority metal and metalloids are also typical of a non-hazardous leachate, in which cadmium and mercury approximate to or are below the detection limit. Zinc is variable and in the 0.002 - 0.1mg/l range. Chromium and nickel are typically in the 0.01 - 0.2mg/l range, with lead and copper typically <0.01mg/l. Arsenic ranges from 0.005 to ~0.05mg/l.

Table 5 – Leachate Priority Substances Summary 2021

Sample Point	Date	Cd	Hg	Cr	Cu	Ni	Zn	Pb	As
		ug/l	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Cells 5-7									
LEW06	16/11/2021	0.11					0.006	0.002	
LEW22	02/06/2021	0.23	<0.005	0.017	0.0026	0.041	0.004	0.004	0.044
LEW22	16/11/2021	<0.08					0.100	0.004	
Cells 8-10									
LEW23	02/06/2021	0.16	<0.005	0.011	0.0018	0.026	0.004	0.003	0.052
LEW23	16/11/2021	0.21					0.004	0.001	
LEW25	02/06/2021	<0.08	0.0086	0.011	0.0240	0.039	0.058	0.004	0.041
LEW25	16/11/2021	<0.08					0.037	0.002	
Cells 11,13 &14									
LEW26	02/06/2021	<0.08	0.0107	0.0015	0.0290	0.018	0.100	0.010	0.005
LEW26	16/11/2021	0.09					0.008	0.002	
LEW28	02/06/2021	<0.08	<0.005	0.0610	0.0100	0.150	0.052	0.009	0.043
LEW28	16/11/2021	<0.08					0.039	0.006	
LEW29	02/06/2021	0.17	0.0084	0.0081	0.0057	0.036	0.019	0.002	0.038
LEW29	16/11/2021	<0.08					0.036	0.003	
Cells 12 & 15									
LEW12a	02/06/2021	0.14	<0.5	0.0076	0.0028	0.020	0.046	0.005	0.050
LEW12a	16/11/2021	<0.08					0.018	0.004	
LEW31	02/06/2021	<0.08	<0.5	0.0042	< 0.0007	0.005	0.002	0.003	0.012
LEW31	16/11/2021	<0.08				0.001	0.004		
Cell 16									
LEW16	16/11/2021	0.14					0.089	0.002	

4.2 Groundwater

Groundwater monitoring is carried out in the bedrock, in the superficial deposits and the PFA platform beneath the waste. Groundwater monitoring was undertaken on a quarterly basis during 2021.

4.2.1 Groundwater Elevation

Groundwater elevations during 2021 were consistent with the seasonal trends observed in previous years, except for GDW14 and GDW15 where groundwater levels remain low in comparison to historical levels (Figure 4.3 and Figure 4.4).

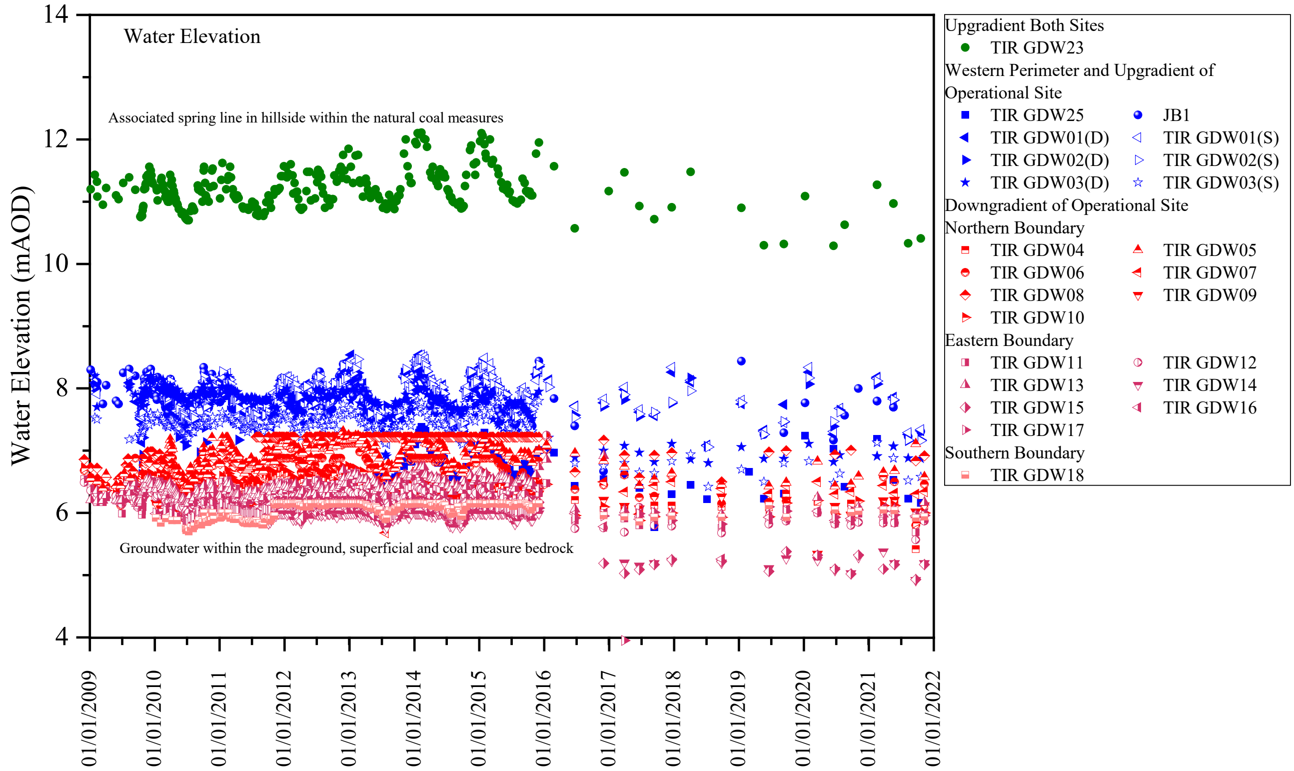

Figure 4.3 – Groundwater Elevation

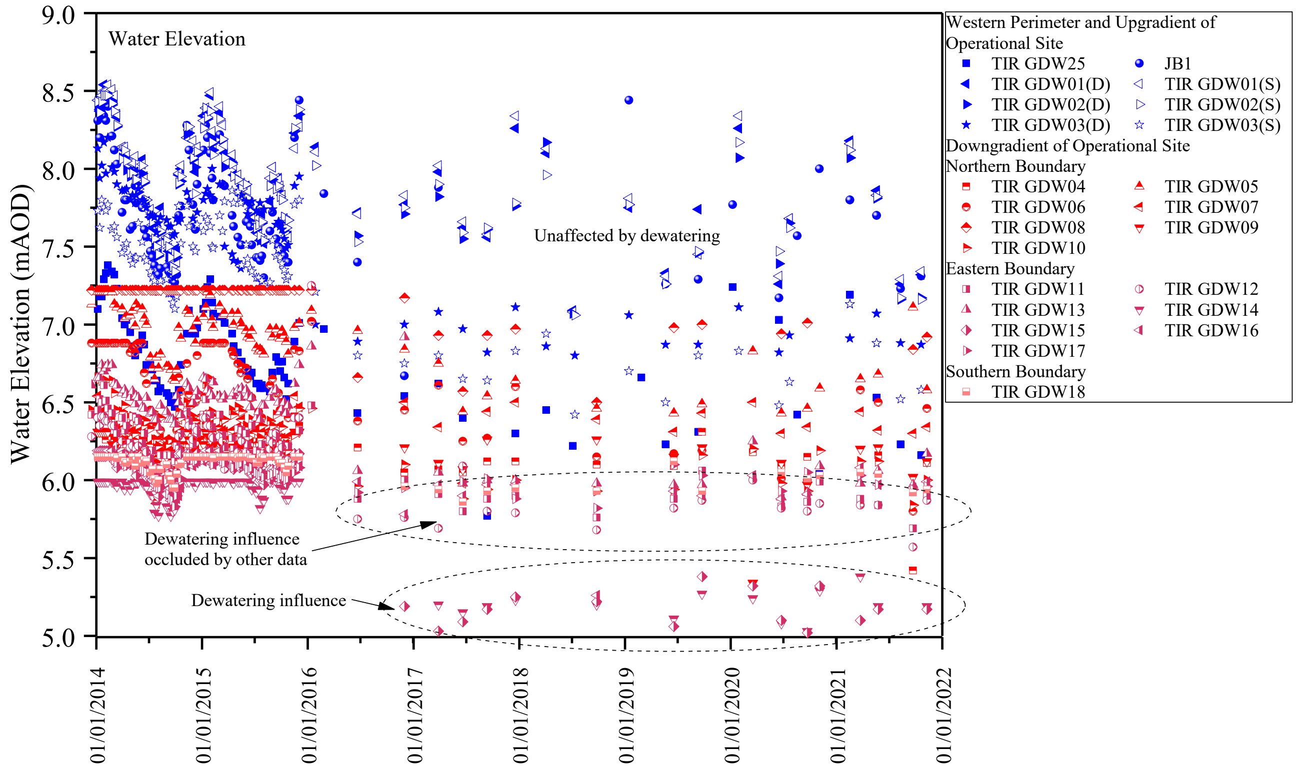

Figure 4.4 – Groundwater Elevation (2014-2021)

GDW14 and GDW15 are located at the interface of the Cell 16 extension area at the east of the site. Groundwater elevations have reduced from 5.8 - 6.2mAOD in 2015 to ~5 - 5.3mAOD in 2017 - 2021 (Figure 4.5). The likelihood is that this is a product of the management of the groundwater via controls designed to create a hydraulic barrier between the landfill and the Crymlyn Bog. This dewatering influence is also reported at a number of the adjacent wells. However, it is apparent that at GWD16 and GWD17 positioned to the south-east of the site this influence is significantly reduced.

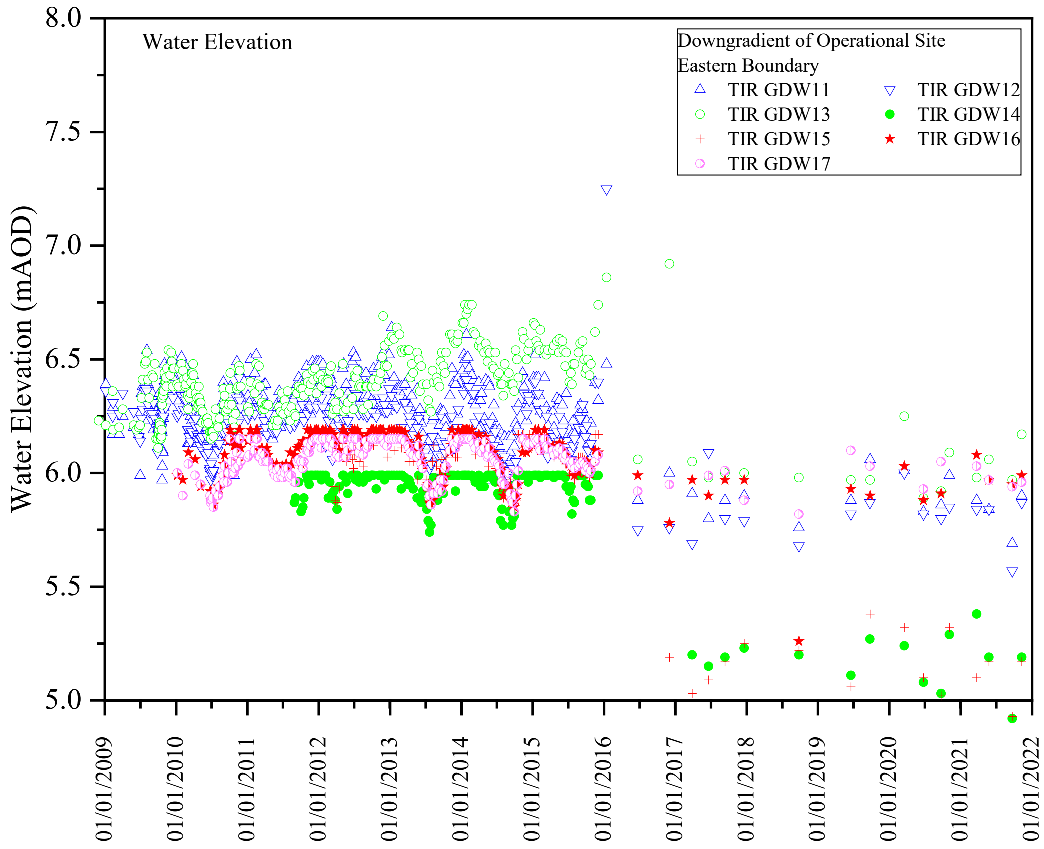

Figure 4.5 – Groundwater Elevation, Eastern Boundary

A seasonal fluctuation can be observed in the upgradient GDW23 and the locations upgradient of the Phase 2 site in the valley feature between the operational and closed phases. The seasonal trends are dampened within the deeper response zone of dual depth monitoring points, as well as on the north, east and south perimeter of the operational site as the groundwater becomes influenced by the groundwater within the bog and the PFA platform.

Groundwater recharge is dominated by springs on the valley slopes to the west of the closed Phase 1 landfill (*e.g.* GDW23) where groundwater levels are between 12.1mAOD in the winter high and 11.0mAOD in the summer low. There is then a westerly fall in groundwater height coincident with the fall of topography from the valley slopes into the superficial sediment valley fill.

4.2.2 Groundwater Quality

Monitoring is carried out for matrix substances (Table 6) and 'typical' leachate indicator substances including ammoniacal-N and chloride. The groundwater is a calcium-bicarbonate solution with secondary sulphate, sodium, potassium and chloride. Additional time series plots for each location are presented in Appendix C.

Table 6 – Groundwater Average Composition Summary 2021

Sample Location	NH_4-N			Ca	Mg	Na	K	Cl			SO_4	Alk
	Ave	Max	Limit	Ave	Ave	Ave	Ave	Ave	Max	Limit	Ave	Ave
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
GDW01(D)	2	3		89	20	58	23	49	60		30	330
GDW01(S)	2	3		82	20	59	22	49	54		31	310
GDW02(D)	8	11		180	41	45	25	39	50		171	510
GDW02(S)	18	19		340	62	198	50	178	180		269	970
GDW03(D)	11	11		38	20	21	5	27	27		1	250
GDW03(S)	22	25		120	19	29	23	31	34		73	460
GDW04	8	8	12	13	7	26	7	28	30	100	2	150
GDW05	18	23	25	93	61	200	32	28	29	100	4	890
GDW06	11	12	16	77	15	49	11	31	41	100	2	370
GDW07	18	26	15	530	58	46	18	80	85	250	642	1100
GDW08	14	15	20	130	24	64	17	23	25		1	630
GDW09	5	10	16	260	120	100	24	70	86	100	488	880
GDW10	9	9	15	170	19	40	11	31	33	100	2	580
GDW11	12	12	15	120	23	61	10	63	67	100	1	540
GDW12	8	8	12	60	64	20	38	24	25	100	1	540
GDW13	33	35		130	57	110	32	123	130		1	800
GDW14	17	19		98	36	60	30	70	81		2	580
GDW15	11	14		54	26	84	41	102	110		4	380
GDW16	1	2	4	31	13	48	7	49	58	100	3	150
GDW17	3	4	10	72	21	110	11	210	230	300	1	220
GDW18	16	18	5	140	34	67	31	74	95	300	6	580

Shaded cells indicate Permit Limit Exceedance

Ammoniacal-N has remained stable during 2021 and consistent with the historical dataset (Figure 4.6). No increasing trends have been observed.

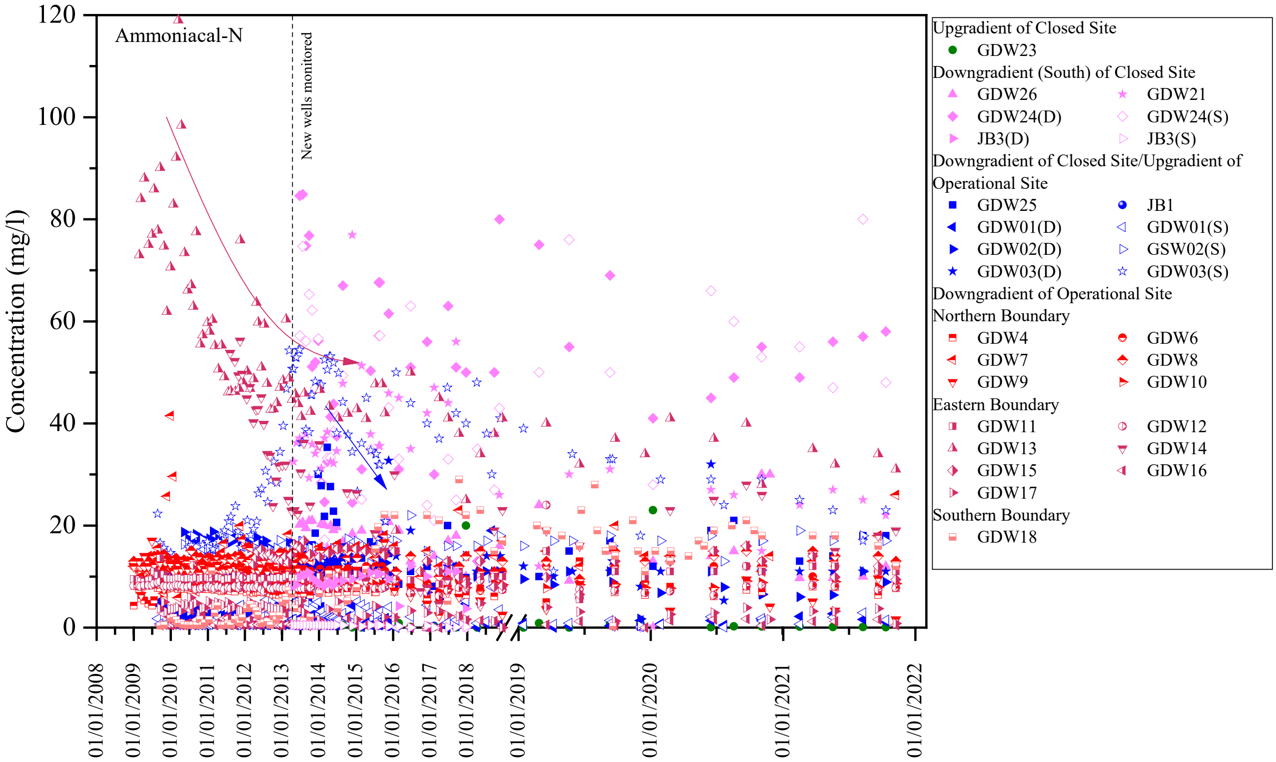

Figure 4.6 – Groundwater Ammoniacal -N

Permit limits were exceeded for ammoniacal-N at GDW07 and GDW18 during 2021 (Table 6). Ammoniacal-N limits for both monitoring points were also exceeded during the period 2016 – 2020 (Figure 4.7 and Figure 4.8) and the significance of these Permit limit exceedances were discussed in detail in the 2018 HRA Review. The same conclusions can be applied to the 2021 data.

At GDW07, ammoniacal-N approximates to the 15mg/l Permit limit and has fluctuated between 10 and 20mg/l since 2012. Time series plots (Figure 4.7) demonstrate that ammoniacal-N is usually below 16mg/l; however, each year there are 1 to 2 determinations in excess of 18mg/l. During 2021, ammoniacal-N peaked at 26mg/l, there is no correlation with elevated chloride as would be expected if leachate seepage or spillage had occurred.

It is considered at GDW07 that the observed approximation to the Permit Limit over an extended period is indicative that the Permit Limit was set too low and was based on an incomplete understanding of this background fluctuation.

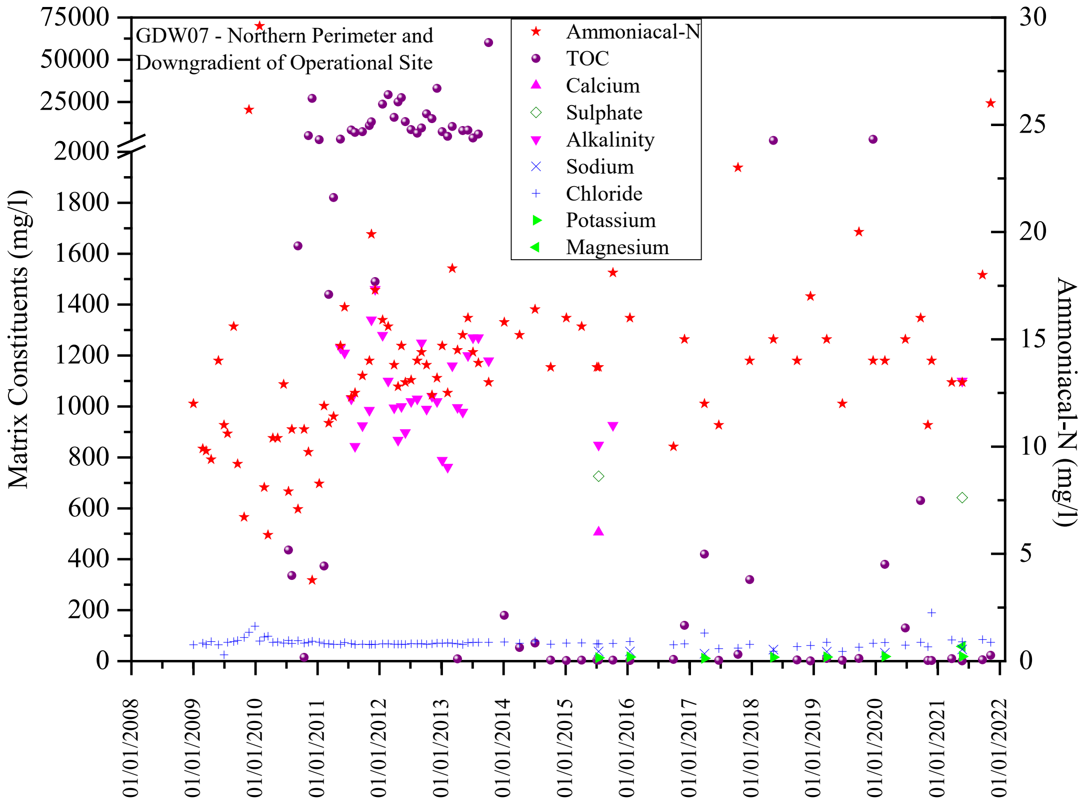

Figure 4.7 – Groundwater GDW07 Matrix Chemistry

There is an apparent step change in ammoniacal-N at GDW18 which occurred in 2015-2016 when levels increased from ~5mg/l to ~25mg/l in 2016 before stabilising at this range during the following years, with the occasional outlier (Figure 4.8). During 2021 ammoniacal-N has been in the 12-18mg/l range, consistent with that observed in 2020. Ammoniacal-N has not fluctuated as significantly compared to the 2014-2017 period where concentrations in excess of 25mg/l were observed.

The increasing trend in ammoniacal-N was associated with a depletion in chloride which has reduced from 324mg/l in 2011 to an average of 74mg/l in 2021. If the increase in ammoniacal N was caused by leachate migration a rise in both substances would be expected. The contrasting trends are more akin to that expected from recharge of the GDW18 monitoring point from waters originating in the Crymlyn Bog, rather than the Phase 2 leachates.

Irrespective of the source, there is a general inconsistency between the fluctuations in groundwater chemistry and the consistent increase in a wide range of substances that would occur for a leachate spillage or seepage event. With respect to the Phase 2 landfill site, the ongoing groundwater monitoring programme has enabled a more complete understanding of the background fluctuations in groundwater matrix chemistry. These fluctuations appear to have a greater range than was previously appreciated at the time the permit was determined and is the root cause of the persistent exceedances.

Chloride has been reported below 250mg/l at the Phase 2 site and has not exceeded the Permit Limits throughout the 2021 monitoring period (Figure 4.9).

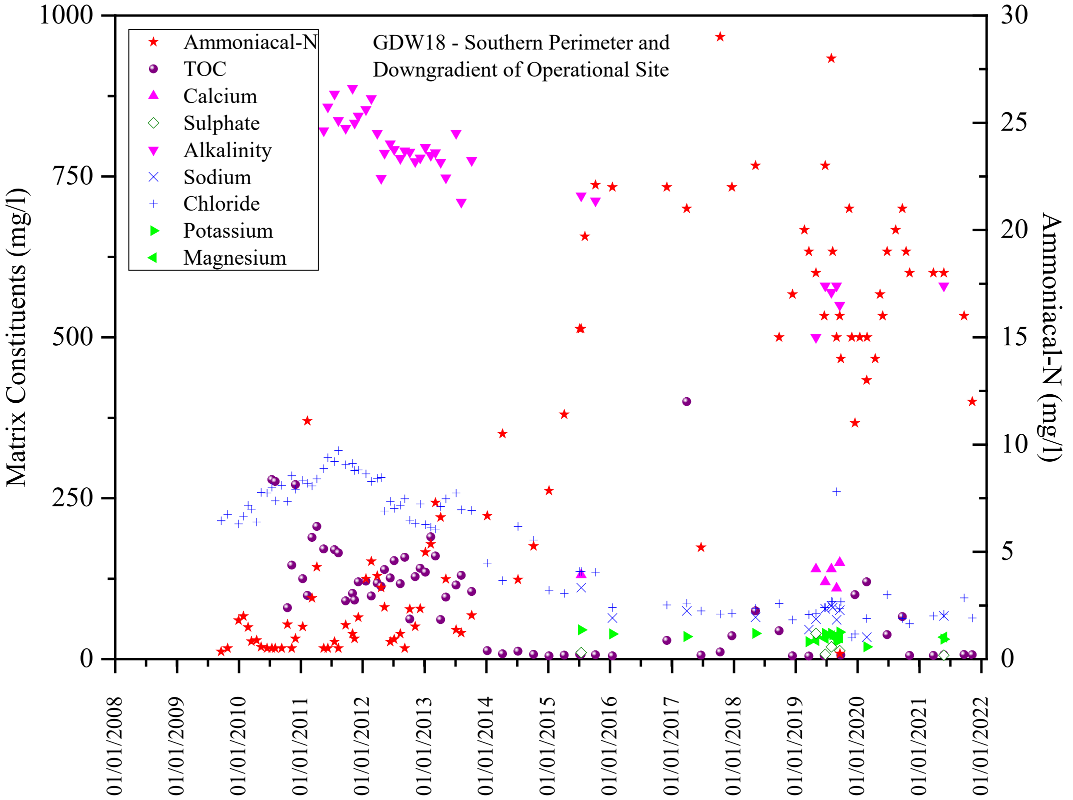

Figure 4.8 – Groundwater GDW18 Matrix Chemistry

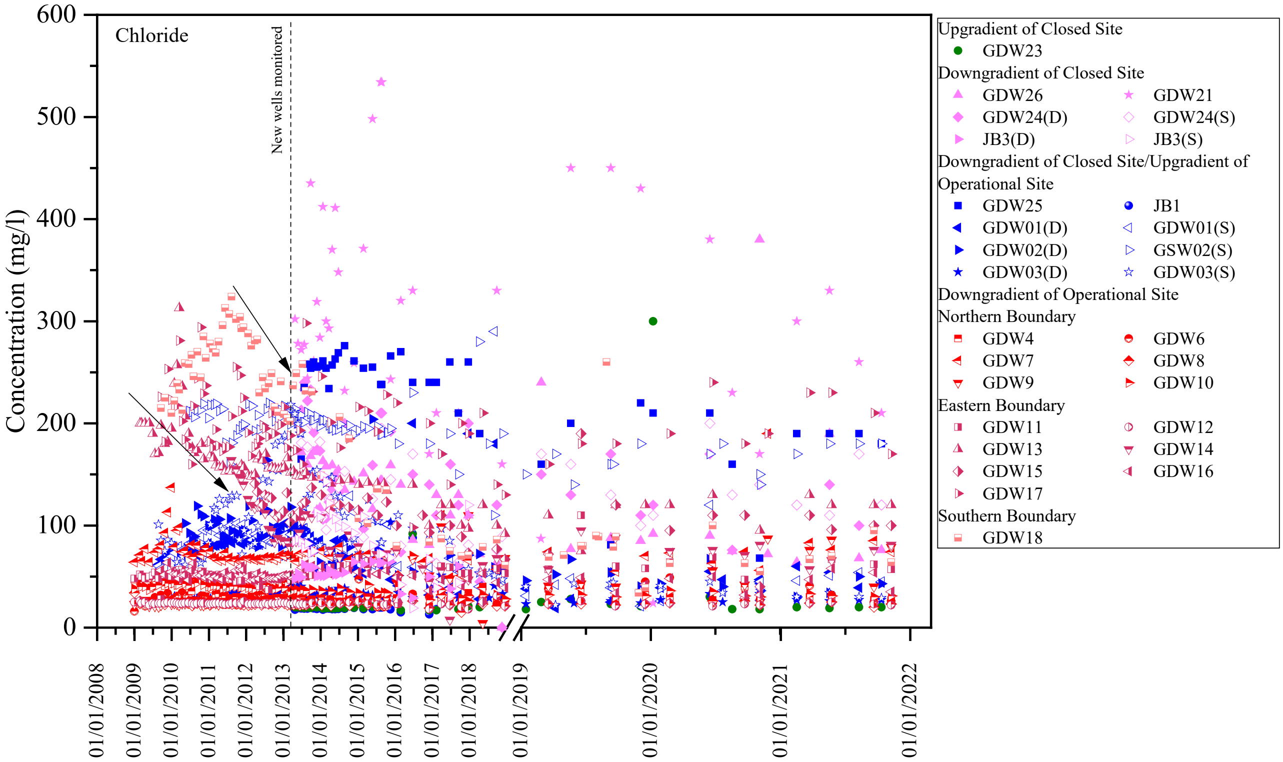

Figure 4.9 – Groundwater Chloride

The groundwater priority metals are summarised in Table 7. Mercury and cadmium (non-hazardous) are both low and below or approximating the limit of detection within the groundwater. Both substances are reported below both the DWS and EQS and are environmentally insignificant. Cadmium was consistently reported below the Permit limit of 1µg/l during 2021.

Table 7 – Groundwater Priority Metals Summary (Maximum 2021)

Sample Location	Hg	Cd	Cr	Cu	Pb	Ni	Zn	As
	µg/l							
GDW01(D)	0.015	0.10	4	2	0.5	0.9	6.8	23
GDW01(S)	0.017	0.10	4	2	0.2	0.7	8.5	20
GDW02(D)	0.008	0.04	9	3	0.2	2.9	8.6	11
GDW02(S)	0.014	0.04	14	3	0.4	2.9	11.2	5
GDW03(D)	0.013	0.02	5	2	0.2	1.5	9.1	1
GDW03(S)	0.010	0.02	5	3	0.5	1.7	8.5	3
GDW04	0.011	0.10	5	4	3.1	6.2	11.8	28
GDW05	0.011	0.05	6	2	0.2	2.6	4.9	14
GDW06	0.006	0.02	6	2	0.2	1.9	11.2	4
GDW07	0.008	0.10	12	2	0.3	12.0	3.2	3
GDW08	<0.005	<0.02	6	1	0.2	1.9	5.8	9
GDW09	<0.005	<0.02	7	1	0.3	3.5	5.9	35
GDW10	<0.005	<0.02	5	1	0.2	1.6	7.3	4
GDW11	<0.005	<0.02	7	1	0.2	1.5	7.2	6
GDW12	<0.005	<0.02	5	1	0.2	1.0	4.8	8
GDW13	<0.005	<0.02	9	3	0.3	1.4	8.5	4
GDW14	<0.005	<0.02	5	4	0.2	2.6	7.7	3
GDW15	<0.005	<0.02	6	3	0.3	2.1	6.7	2
GDW16	0.007	<0.02	4	2	0.8	1.3	5.9	3
GDW17	0.007	<0.02	6	2	0.6	2.8	5.4	4
GDW18	0.005	<0.02	5	2	0.2	2.6	3.1	24

Copper and lead were at or just above the limit of detection and below their corresponding Drinking Water Standards (DWS) of 2mg/l and 0.01mg/l respectively. Copper approximates to the EQS of 1µg/l. Given that the EQS for copper is for the bioavailable fraction (rather than the dissolved fraction which is analysed for), copper is expected to be at environmentally insignificant levels within the groundwater. Lead is also typically below the 1.2µg/l and is environmentally insignificant.

Priority non-hazardous metals chromium, nickel and zinc were similarly low to negligible within the groundwater during 2021. Zinc was reported below the 75µg/l Permit limit at all locations. In recent years, zinc has been elevated in the 0.1 – 0.3mg/l range (Figure 4.10) and this was considered to be a reflection of suspended solids within the sample, with the zinc released during the acidification/ sample preservation process. It would appear that following a change in laboratory, the analysis has improved.

Arsenic is environmentally insignificant in the groundwater and is consistently reported below the 50µg/l EQS.

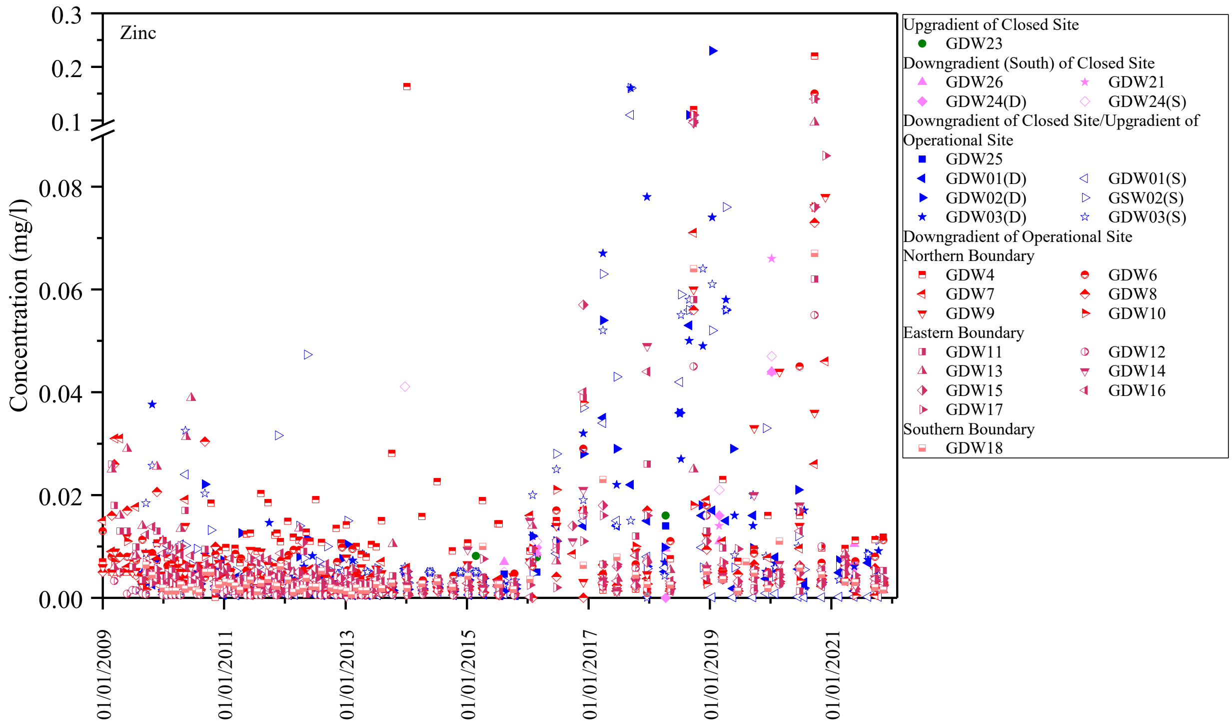

Figure 4.10 – Groundwater Zinc

4.2.3 Phosphate Substances

Groundwater phosphate is monitored in accordance with the environmental permit for both the inorganic phosphate species and as the organo-complex tributyl phosphate. Tributyl phosphate was not identified within the groundwater during 2021 and was consistently reported below the limit of detection of <0.1µg/l. This is consistent with the historical dataset for this substance. The Operator changed laboratories during 2021 and the new accredited laboratory are unable to achieve a limit of detection (LOD) of less than the Permitted limit using accredited analytical methods. Whilst the LOD is above the Permit limit of 0.02µg/l there is no indication that a significant change in the groundwater geochemistry has occurred during 2021. Tributyl phosphate is also significantly below the AA Environmental Quality Standard of 50µg/l.

Reactive phosphorus (also known as orthophosphate) was reported above the Permit limit of 0.05mg/l at several locations during 2021 with the most significant exceedances observed towards the north of the site at GDW04 - GDW07 (Table 8). Where reported, orthophosphate oscillated above and below the limit of detection throughout the year and was generally not persistently identified. Towards the end of the year, orthophosphate was generally below or just above the Permitted limit at the majority of locations.

Elevated orthophosphate was also observed on the boundary between the Phase 2 and Phase 1 site in all monitoring points (Table 8). A maximum concentration along this boundary of 0.32mg/l was observed in GDW01(S). Phosphate has been observed at this range around the site from 2015 onwards and the concentration range in phosphate is not representative of leachate spillage or a migration front.

The most likely source of groundwater phosphates is from the PFA that was placed under and around the site prior to the development of Phase 2. Consequently, it is not understood why permit limits should be set for phosphate, as an exceedance of the current permit limits in their current format does not indicate that the Phase 2 landfill has influenced the surrounding environment.

Table 8 – Groundwater Orthophosphate 2021

Sample Location	Orthophosphate (mg/l)			
	Q1	Q2	Q3	Q4
GDW01(D)	0.140	0.10	<0.062	0.086
GDW01(S)	0.320	0.09	<0.062	0.15
GDW02(D)	0.067	0.11	<0.062	<0.062
GDW02(S)	0.130	0.14	<0.062	<0.062
GDW03(D)	<0.062	0.07	<0.062	<0.062
GDW03(S)	<0.062	0.07	<0.062	<0.062
Permit Limit	**0.05**	**0.05**	**0.05**	**0.05**
GDW04	<0.062	0.42	0.27	0.16
GDW05	0.140	0.09	2.40	0.32
GDW06	<0.062	0.22	<0.062	<0.062
GDW07	<0.062	<0.062	0.61	<0.062
GDW08	<0.062	0.22	<0.062	<0.062
GDW09	<0.062	<0.062	<0.062	0.24
GDW10	<0.062	0.19	<0.062	<0.062
GDW11	<0.062	0.08	<0.062	0.20
GDW12	<0.062	0.17	<0.062	0.10
GDW13	<0.062	0.20	0.35	<0.062
GDW14	<0.062	<0.062	<0.062	<0.062
GDW15	<0.062	<0.062	<0.062	0.07
GDW16	<0.062	0.10	<0.062	0.06
GDW17	<0.062	<0.062	<0.062	0.09
GDW18	<0.062	0.07	0.08	0.08

Shaded Cells indicate permit limit exceedance

4.2.4 Organic Substances

Organic substances in the groundwater with Permit Limits include Atrazine, Benzo pyrene, Cis-1,2-dichloroethene and Dichloroprop. These substances are monitored quarterly. The organic substances were all recorded below their respective limits of detection and Permit limits throughout 2021.

4.2.5 Environmental Transects

To understand the background 'baseline' data of the Crymlyn Bog sampling, additional monitoring points have been installed along three transects perpendicular to the east and north of the Phase 2 Tir John Landfill Site. Samples are then taken at two depths of 1m (a series) and 2m (b series), over 2m (1), 4m (2), 8m (3), 16m (4), 32m (5) and 64m (6) distances from the site (Table 9). Analysis of the Environmental Monitoring Transect (the EMT series) commenced in 2014.

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Table 9 – Phase 2 Site Transect Waster Quality (March 2021)

Sample Point	pH	NH_4-N	Cl	SO_4	DOC	BOD	Ca	NO_3	NO_2	DAIN	Orthophosphate as PO4	P
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ETM2 (1a)	7.0	9.3	45	15.5	10	85	97	0.12	<0.005	9.42	<0.062	0.2
ETM2 (1b)	7.1	23.0	65	6.5	10	200	230	0.14	<0.005	23.14	<0.062	0.1
ETM2 (2a)	7.0	13.0	55	6.8	11	90	110	0.14	<0.005	13.14	0.086	0.1
ETM2 (2b)	7.2	22.0	69	2.5	10	130	120	0.15	<0.005	22.15	0.150	0.1
ETM2 (3a)	7.1	3.0	40	14.6	17	130	110	0.15	<0.005	3.15	0.077	0.1
ETM2 (3b)	6.4	8.9	120	10.3	57	140	19	2.69	<0.005	11.59	0.390	0.2
ETM2 (4a)	6.9	0.9	40	25.7	9	64	100	0.16	<0.005	1.04	<0.062	0.1
ETM2 (4b)	6.6	4.6	80	7.7	81	80	5	2.23	<0.005	6.83	<0.062	0.0
ETM2 (5a)	7.2	0.1	37	22.9	9	110	91	0.16	<0.005	0.27	<0.062	0.2
ETM2 (5b)	6.8	0.4	39	11.3	14	81	52	0.25	<0.005	0.67	0.070	0.1
ETM2 (6a)	6.8	0.4	29	5.6	8	110	57	0.18	<0.005	0.53	0.089	0.2
ETM2 (6b)	6.7	0.2	42	16.8	11	68	50	0.20	<0.005	0.38	<0.062	0.0
ETM6 (1a)	6.8	0.4	54	5.0	3	74	87	0.02	<0.005	0.44	<0.062	4.6
ETM6 (1b)	5.8	3.8	120	4.3	13	71	14	0.06	<0.005	3.86	2.200	1.8
ETM6 (2a)	6.3	0.1	60	1.6	4	81	61	0.01	<0.005	0.08	<0.062	3.2
ETM6 (2b)	6.4	53.0	120	4.3	21	78	25	0.06	<0.005	53.06	38.000	13.0
ETM6 (3a)	6.7	0.1	36	3.7	4	82	78	0.05	<0.005	0.11	0.190	4.5
ETM6 (3b)	5.6	0.1	120	2.9	20	63	9	0.14	<0.005	0.21	0.680	0.3
ETM6 (4a)	6.0	0.1	38	2.1	5	77	26	0.01	<0.005	0.06	<0.062	3.7
ETM6 (4b)	6.0	0.2	74	5.1	31	65	8	0.28	<0.005	0.48	0.064	0.1
ETM6 (5a)	6.0	0.1	50	1.5	12	72	30	0.06	<0.005	0.12	<0.062	2.2
ETM6 (5b)	5.2	0.0	130	3.5	26	73	7	0.23	<0.005	0.26	0.086	0.0
ETM6 (6a)	6.2	0.1	140	2.4	13	76	19	0.19	<0.005	0.26	0.680	2.0
ETM6 (6b)	6.5	0.0	29	5.9	10	78	37	0.11	<0.005	0.15	0.180	0.1
ETM7 (1a)	6.8	0.2	16	5.7	4	8	18	0.08	<0.005	0.25	0.160	5.9
ETM7 (1b)	7.2	1.4	15	1.2	3	9	62	0.01	<0.005	1.41	<0.062	6.9
ETM7 (2a)	6.5	0.0	15	2.2	4	7	20	0.08	<0.005	0.12	<0.062	2.7
ETM7 (2b)	7.3	0.2	17	1.1	3	7	72	0.04	<0.005	0.23	<0.062	5.1
ETM7 (3a)	6.4	0.1	15	1.8	4	7	14	0.05	<0.005	0.16	<0.062	2.7
ETM7 (3b)	7.6	0.6	52	0.5	3	8	100	0.05	<0.005	0.67	0.300	5.2
ETM7 (4a)	7.0	0.0	16	8.3	3	2	24	0.11	<0.005	0.15	<0.062	3.2
ETM7 (4b)	7.6	0.4	89	0.5	4	8	130	0.09	<0.005	0.49	0.400	5.4
ETM7 (5a)	6.9	0.5	38	1.6	4	8	45	0.08	<0.005	0.62	<0.062	3.5
ETM7 (5b)	7.4	0.3	160	0.9	4	11	160	0.15	<0.005	0.40	0.210	4.3
ETM7 (6a)	6.7	0.4	19	0.8	3	24	32	0.05	<0.005	0.46	<0.062	5.1
ETM7 (6b)	6.8	0.1	100	0.6	3	76	140	0.13	<0.005	0.18	0.086	0.4

DAIN - Dissolved available inorganic nitrogen (Sum NH_4-N, NO_3-N & NO_2-N)

The data obtained for 2021 were broadly similar to those obtained in previous years. However, there is a complex relationship with time and distance across transects adjacent to the Phase 2 site (Transects EMT2, EMT6 & EMT7). There is not a simplistic depletion of landfill indicator type substance with distance from the site. For example; ammoniacal-N can be at its highest concentration in the mid-distance or most distant monitoring points from the site. There are also no particular time series relationships or link between chloride and ammoniacal-N which would be expected for a leachate influence as displayed in Figures 4.11 – 4.16.

There are several contributing processes of which *in-situ* biological activity within the Crymlyn Bog is a key factor. Although the PFA and other historical wastes which pre-date the Phase 2 Landfill could potentially contribute nutrients and stimulate biological processes within the bog there does not appear to be a constant flux from the historical wastes into the adjacent bog. Neither is there an apparent influence from the Phase 2 leachate.

The data is indicative of a groundwater regime primarily influenced by localised conditions of each monitoring point and any relationship with the landfill and the historical operations is limited.

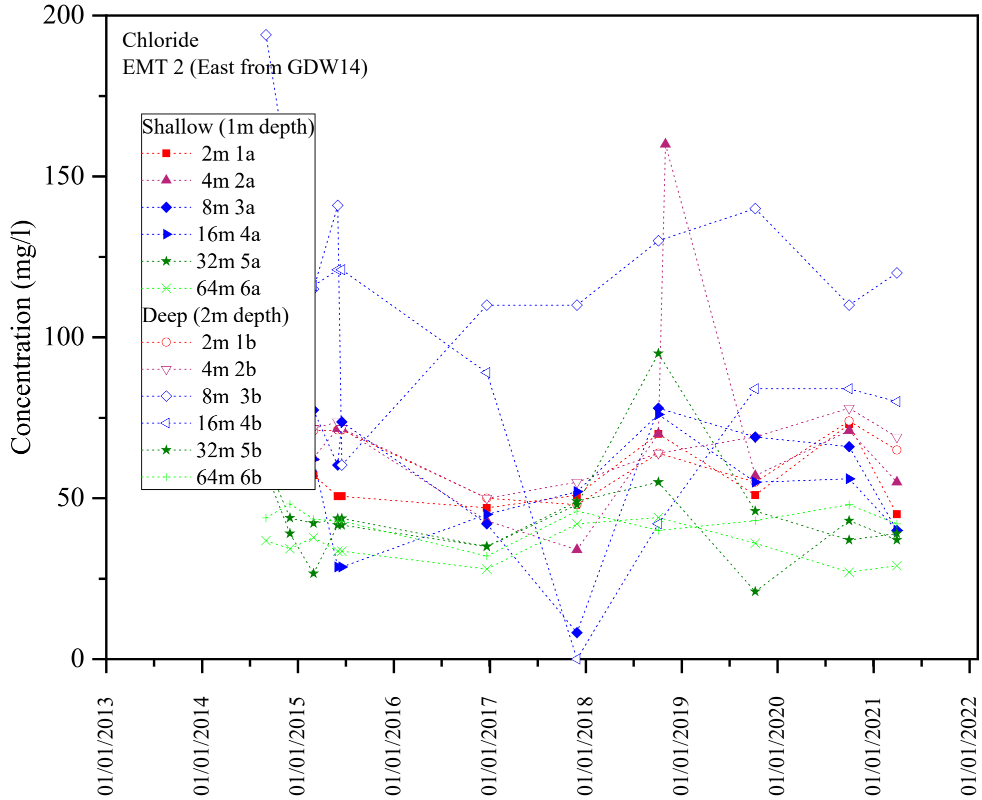

Figure 4.11 – Transect EMT2 Chloride

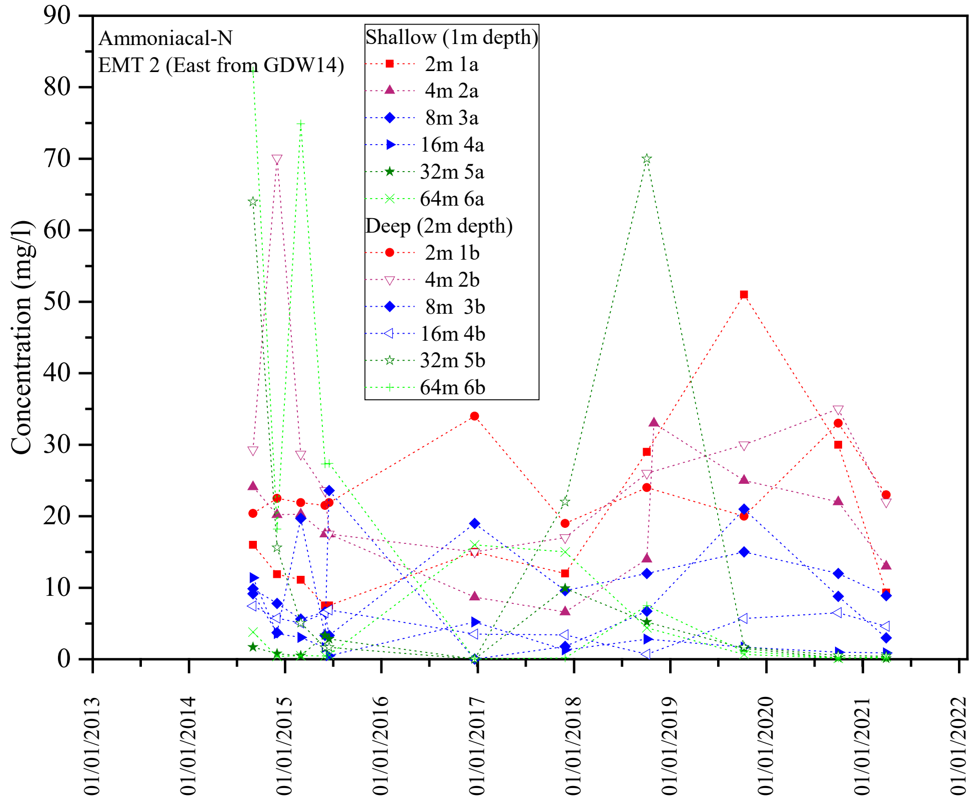

Figure 4.12 – Transect EMT2 Ammoniacal-N

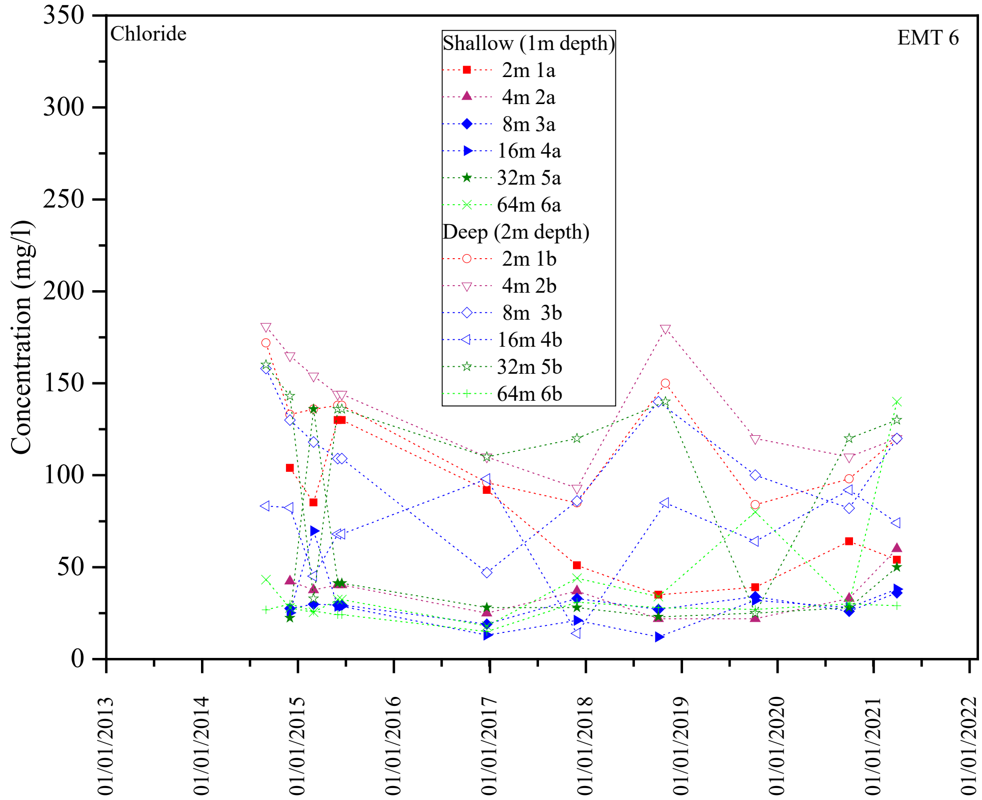

Figure 4.13 – Transect EMT6 Chloride

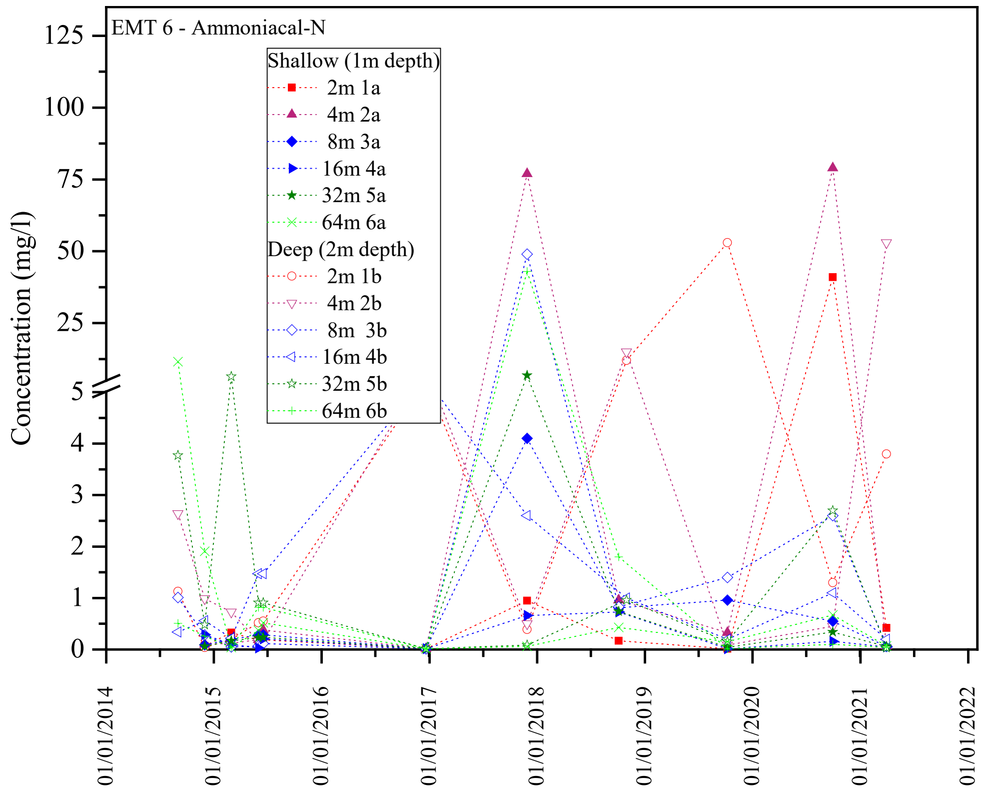

Figure 4.14 – Transect EMT6 Ammoniacal-N

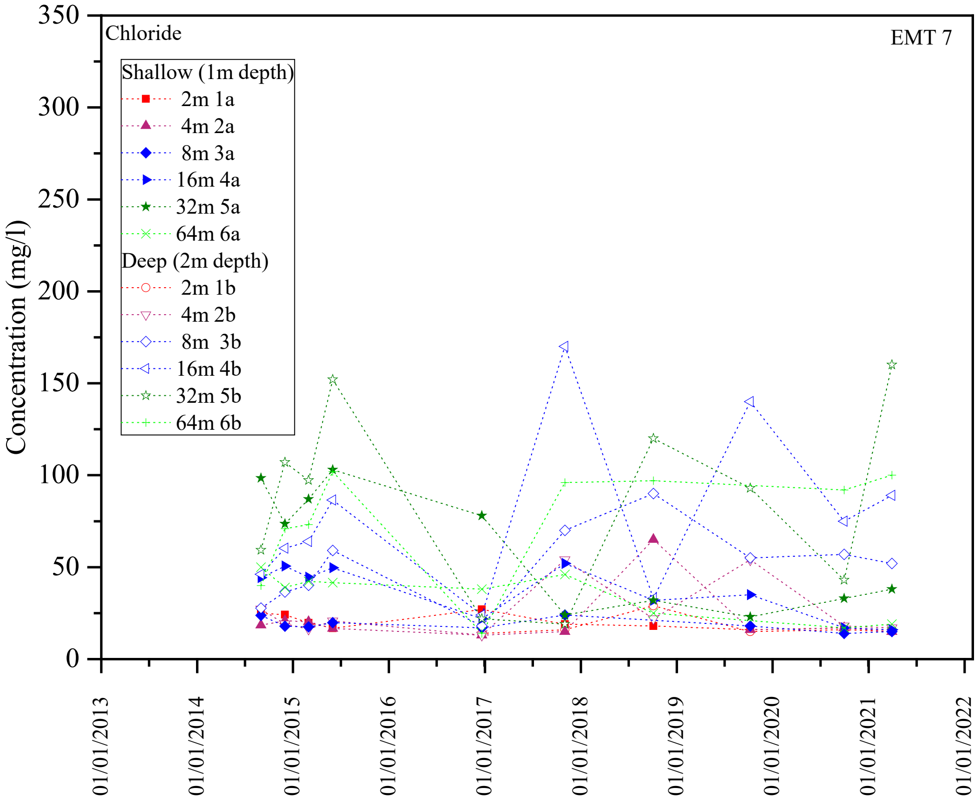

Figure 4.15 – Transect EM7 Chloride

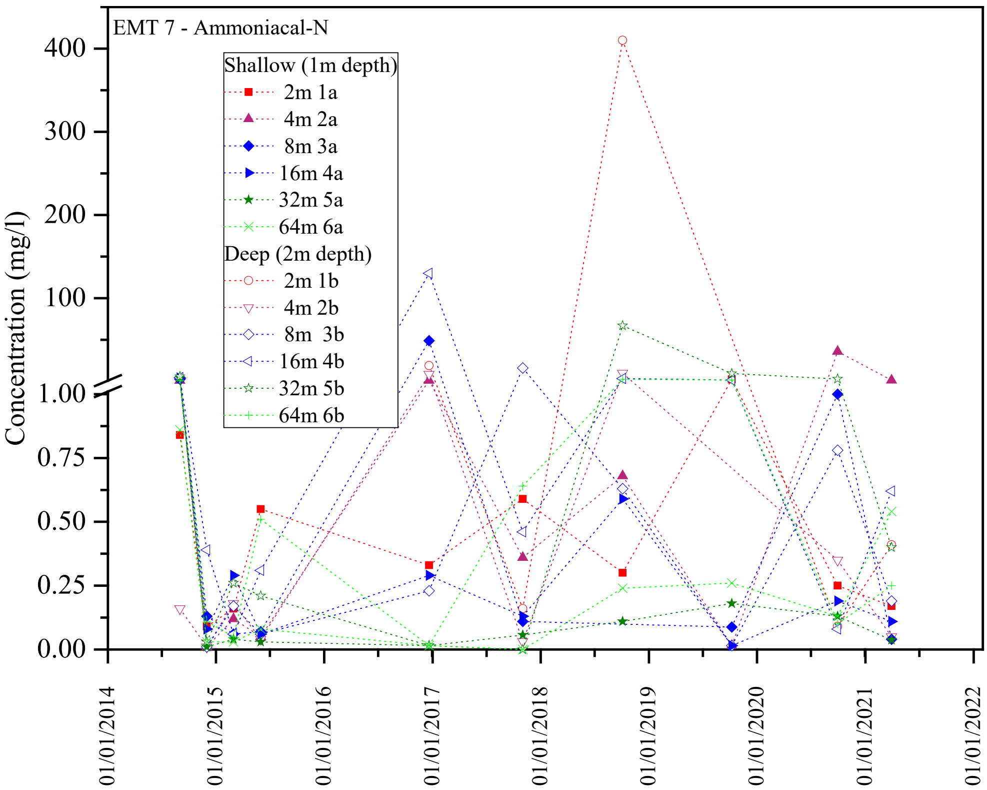

Figure 4.16 – Transect EMT7 Ammoniacal-N

4.3 Pre-Operational Measure 5 – Pore Water Monitoring

Monitoring of pore water has been undertaken at four locations around the Cell 16 perimeter since December 2018:

- IPDS, located at the south east corner of Cell 16 and the Cells 8, 9 & 16 interface
- PCS North located at the east of Cell 15 Extension Area
- PCS Mid located at the east of Cell 16 to the south of GDW13; and
- PCS South located to the southeast of Cell 16, between GDW14 and GDW15

A summary of the pore water monitoring data collected during 2021 is provided within Table 10. Groundwater quality is discussed in section 4.2.2 which confirms that ammoniacal-N and chloride at the site is variable (Table 6). Ammoniacal-N and chloride within the PFA has been reported at similar concentrations to the groundwater at the site as illustrated in (Figure 4.17 and Figure 4.18).

Table 10 – Pore Water Ammoniacal-N and Chloride

Date	IDPS		PCS Mid		PCS North		PCS South	
	NH_4-N	Cl	NH_4-N	Cl	NH_4-N	Cl	NH_4-N	Cl
08/01/2021	21.00	780	20.00	66	7.6	94	88.0	170
19/01/2021	3.90	43	3.20	18	7.7	92	8.7	21
02/02/2021	2.70	41	6.30	35	7.5	84	50.0	99
15/02/2021	12.00	63	5.90	40	8.5	87	25.0	70
02/03/2021	380.00	580	4.70	31	8.5	91	2.4	21
15/03/2021	22.00	76	4.80	30	8.1	92	4.9	29
30/03/2021	33.00	110	4.90	29	7.6	84	8.1	44
12/04/2021	47.00	150	5.10	29	6.6	87	14.0	58
20/04/2021	62.00	160	5.50	29	6.3	90	13.0	68
04/05/2021	22.00	95	5.50	31	5.3	86	20.0	73
17/05/2021	10.00	55	4.10	97	4.3	85	1.6	20
01/06/2021	1.90	57	3.10	100	4.0	84	12.0	54
15/06/2021	0.03	58	3.50	100	0.4	86	22.0	91
16/08/2021	0.42	62	2.00	150	4.4	86	23.0	79
06/09/2021	0.15	61	1.70	150	3.8	82	21.0	81
27/09/2021	0.08	37	1.10	190	3.0	71	23.0	79
11/10/2021	38.00	150	0.09	68	1.8	57	3.8	22
25/10/2021	3.50	85	0.12	47	1.4	54	6.1	28
08/11/2021	5.70	92	0.09	43	1.2	57	8.3	35

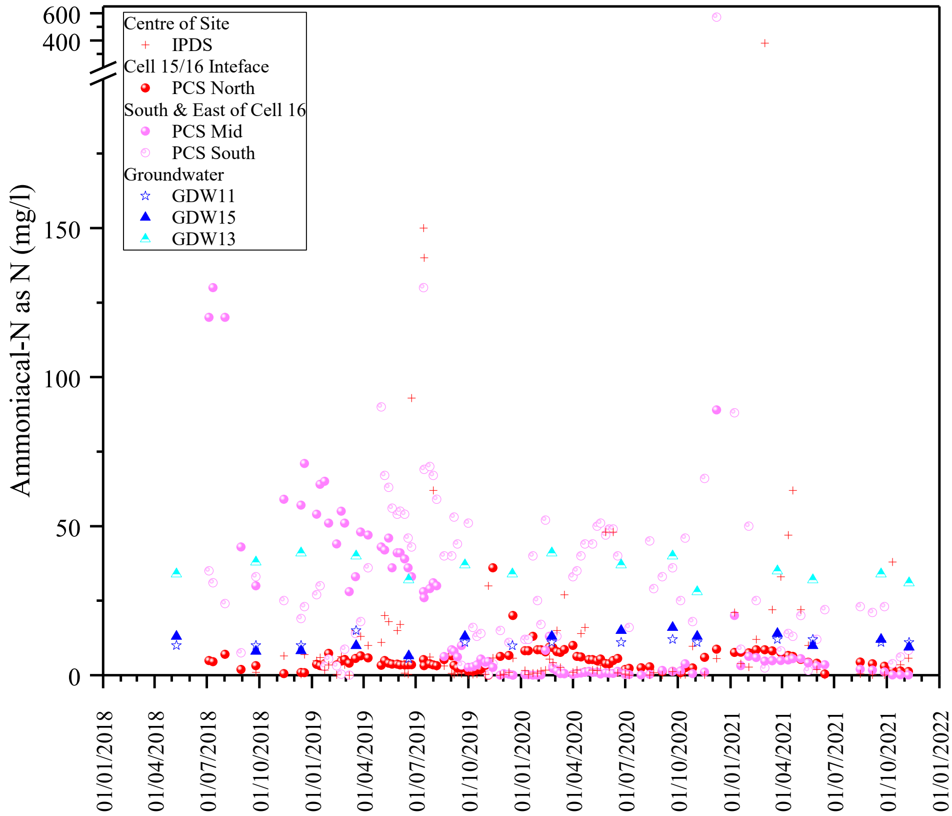

Figure 4.17 – Pore Water Ammoniacal-N

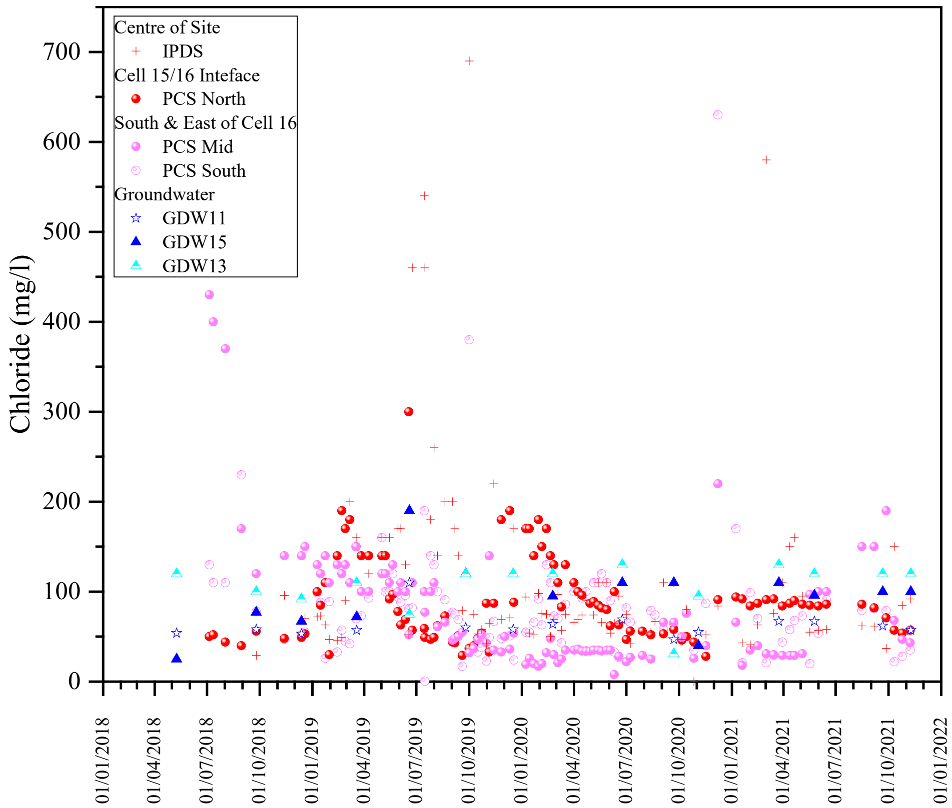

Figure 4.18 – Pore Water Chloride

It is apparent from the monitoring data collected during 2019 and 2020 that a seasonal pattern may be present at PSC South with ammoniacal-N and chloride peaking during the summer months. This is followed by a gradual decrease over the winter period (Figure 4.19). This trend was less distinctive during 2021 with ammoniacal-N and chloride reported to be relatively stable throughout the year.

Chloride in PCS South has remained consistently below the DWS of 250mg/l whilst ammoniacal-N is reported within the general range of 10 – 50mg/l and consistent with the levels reported within the adjacent groundwater monitoring boreholes. Isolated increases in ammoniacal-N and chloride were noted during 2021 at PCS South and IPDS, consistent with the historical increases during 2019.

The elevated matrix constituents observed in PCS South during December 2020 were not repeated during 2021 and it is concluded that these elevated results are most likely due to sampling or analytical error (Figure 4.19).

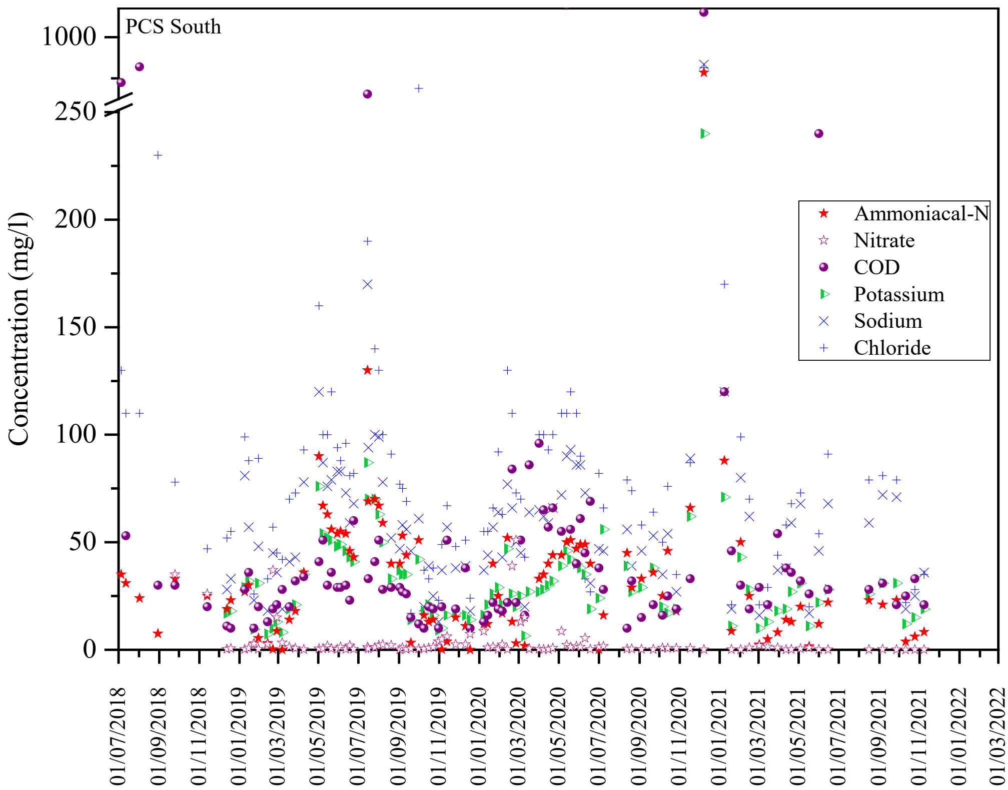

Figure 4.19 – Pore Water Matrix Chemistry PCS South

Ammoniacal-N at PCS Mid followed a decreasing trend throughout 2019 and has remained low during 2021 at 0.1 – 5mg/l (Figure 4.20). Ammoniacal-N was reported at 20mg/l on the 8th January 2021 but had returned to below 5mg/l by the 19th of January 2021. This short-term rise was not accompanied by an associated increase in chloride and is likely to be indicative of the environmental setting rather than an association with the Tir John landfill site leachate. Chloride was reported below the 25mg/l DWS throughout 2021, with a seasonal increase to 150 - 190mg/l in the summer months.

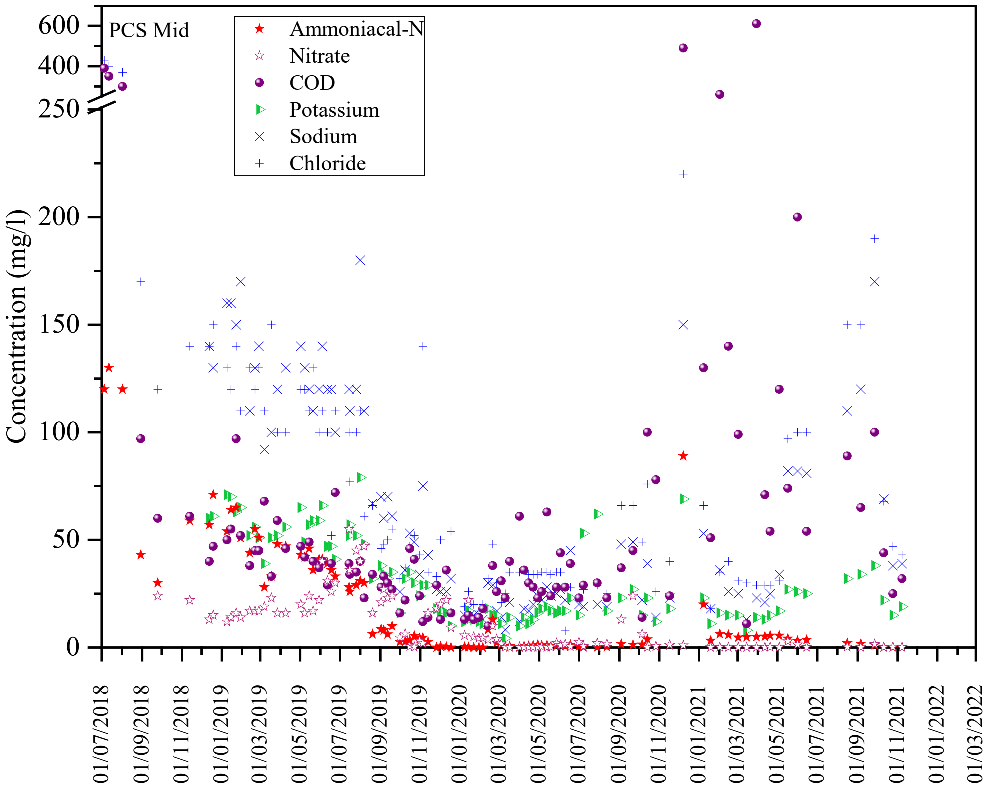

Figure 4.20 – Pore Water Matrix Chemistry PCS Mid

A cyclical pattern appeared to be emerging at PCS North (Figure 4.21) with chloride peaking during the winter months between 2018 and 2020 however this pattern was not as pronounced during 2021 with chloride concentrations showing significantly less fluctuation. Ammoniacal-N is reported at ~1 – 8.5mg/l and is consistent with the adjacent groundwater monitoring points. Chloride is consistently below the DWS of 250mg/l.

During March 2021, an outlier of 380mg/l ammoniacal-n was reported for IPCS (Figure 4.22). Whilst there was a concurrent increase in potassium, subsequent analysis identified ammoniacal-N in the 22 - 62mg/l range. A proportionate increase in chloride was not noted although chloride and sodium continue to fluctuate within a stable range. Although ammoniacal-N has also fluctuated historically at this location, the reported result is elevated in comparison to previous analysis and given the short-term nature of the increase is most likely a laboratory dilution or sampling error.

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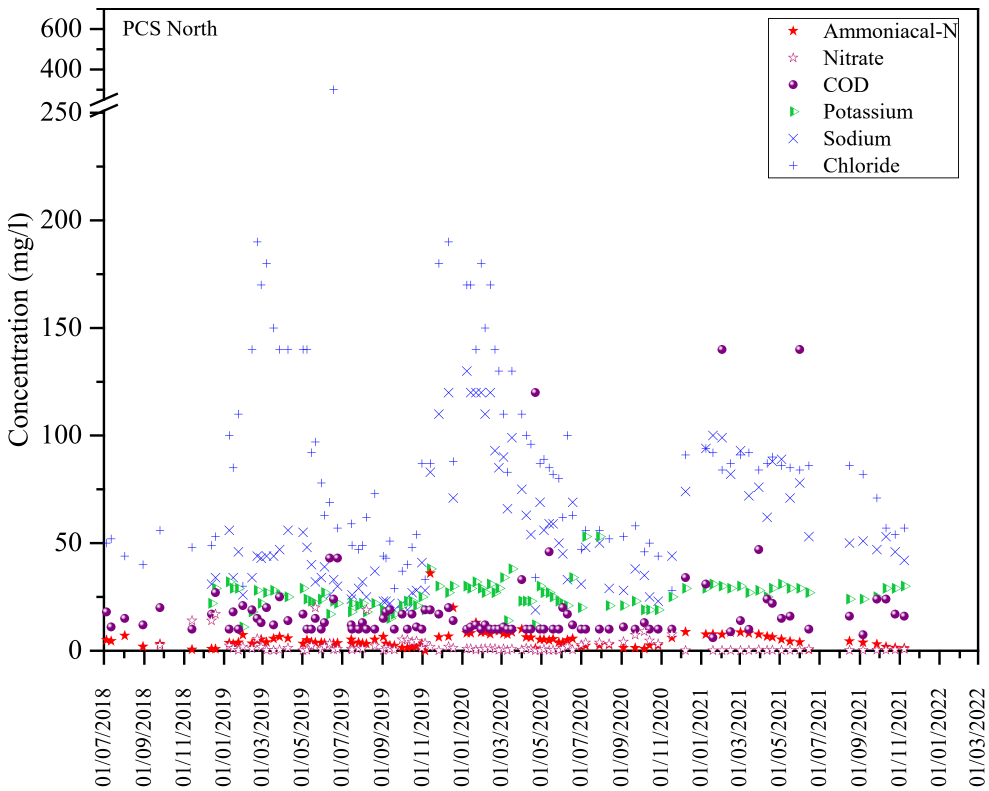

Figure 4.21 – Pore Water Matrix Chemistry PCS North

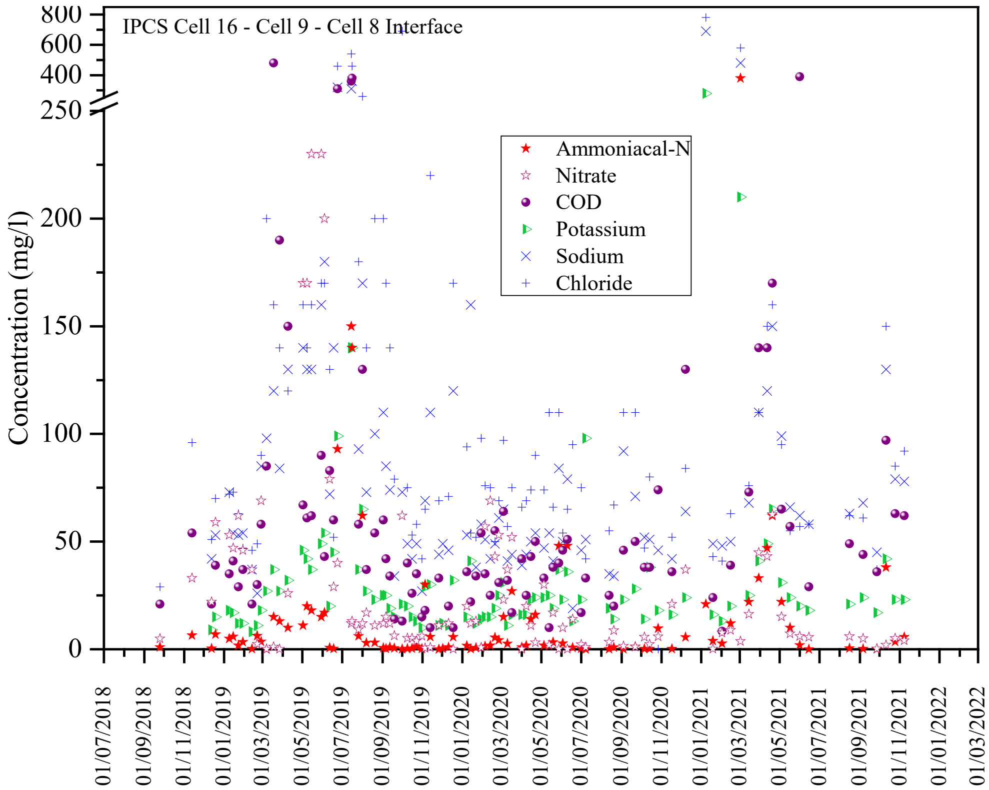

Figure 4.22 – Pore Water Matrix Chemistry IPCS

4.4 Groundwater Summary

Groundwater elevation is responsive to seasonal recharge patterns. This response is strongest in the westerly upgradient and upslope locations. The effect decreases in the deeper response zone of paired monitoring points and the downgradient perimeter boreholes as the groundwater joins the water levels of the bog and within the PFA platform.

Ammoniacal-N and chloride are present within the groundwater. Neither substance appears to be related to the Phase 2 landfill leachate. The source of these parameters is considered to be *in-situ* and will include the pre Phase 2 deposited materials including the beneath the site and the adjacent organic rich sediments. These are estuarine in origin, therefore elevated chloride and ammoniacal-N is to be expected. In addition to the estuarine sediments, groundwater is recharged via springs emanating from Coal Measures consequently redox cycling of some substances is to be expected. This results in a groundwater chemistry that can be characterised as a series of localised biogeochemical systems. There is no indication of an influence from the Phase 2 landfill on groundwater chemistry.

4.5 Surface Water

Surface water drainage is collected in perimeter interception channels and drains which transfer the surface run-off to flow attenuation lagoons. This flow attenuated surface water is then discharged from the lagoon via a low energy pumped multi-outlet trickle head system to the Crymlyn Bog to the south of the site.

During storm periods, when the surface water system and flow balancing lagoons are inundated, excess water travels via weirs into a connecting perimeter catchment channel, known as 'The Ditch' which transfers surface water to the southeast of the site. The Ditch surrounds the downgradient perimeter of the Phase 2 site and is unlined. Consequently, The Ditch is in continuity with groundwater within the Crymlyn Bog and generally acts as a seepage channel. The Ditch terminates in the south east corner of the landfill site where any remaining flow in the channel dissipates into the Crymlyn Bog.

However, surface water within the lagoon has been maintained at a low level and no storm event has ever exceeded the weir height.

Samples are collected from the surface water attenuation lagoon (SW1), from the northern perimeter of The Ditch (SW2), the Glan-y-Wern Canal in the northeast corner of the landfill (SW3) and the southern end of The Ditch (SW4). Permit limits are set for SW1 for suspended solids, BOD and ammoniacal-N (Table 11).

Chloride remained within the low range of 20 - 110mg/l for the entirety of 2021 at all monitoring points and did not exceed the drinking water standard of 250mg/l. BOD also remained low and were consistently below the Permit Limit during 2021.

Table 11 – Surface Water Quality Summary 2021

Sample Point	NH_4-N		BOD		Cl		Susp. Solids	
	mg/l							
	Ave	Max	Ave	Max	Ave	Max	Ave	Max
Permit Limit SW1	**0.5**		**20**				**40**	
SW1	0.15	1.00	2	4	20	24	17	68
SW2	3.14	5.40	3	8	32	37	11	25
SW3	1.10	6.70	2	10	27	54	8	33
SW4	17.92	31.00	3	8	69	110	11	37

Shaded cells indicate Permit Limit Exceedance

Suspended solids exceeded the permit limit once during May 2021 at 68mg/l. This is an unusual result for this location and is perhaps related to low water levels during the warmer months of the year. In any case, suspended solids reduced to below the Permit limit throughout the remainder of the year.

Ammoniacal-N was recorded below the 0.5mg/l EQS (and Permit limit) throughout 2021 except for on one occasion during March 2021 where ammoniacal-N reported at 1.0mg/l. Short-term increases in ammoniacal-N have historically been identified at this location, normally within the summer months of the year. Notably, there was no associated increase in chloride or BOD and therefore the reported ammoniacal-N is considered to be representative of background fluctuations (Figure 4.23).

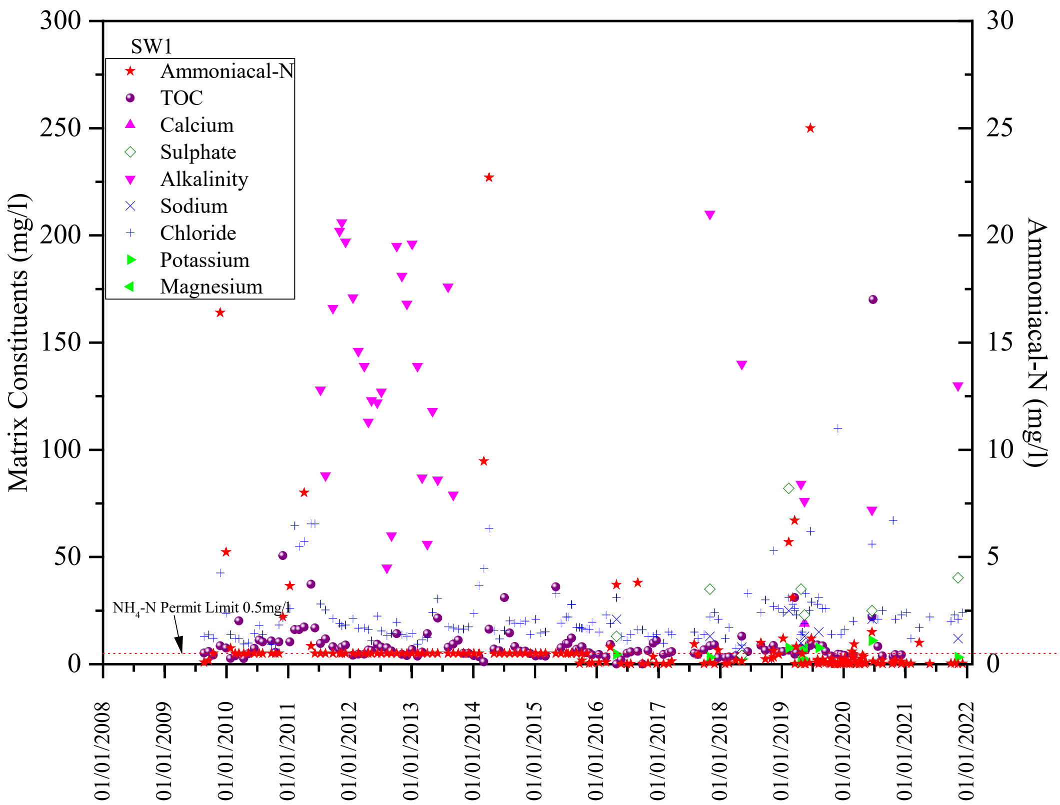

Figure 4.23 – Surface Water Matrix Chemistry SW1

The Glan-y-Wern canal (SW3, Figure 4.24) is considered as representative of an essentially static water body, which can contain stagnant water conditions and is generally isolated from the surrounding water systems, albeit that there will be some continuity with the bog pore water particularly during high recharge periods.

The Ditch (SW2 and SW4) is however more complex. Chloride remained below its DWS of 250mg/l at SW2 and SW4 and has remained stable at both points since 2016. Ammoniacal-N, however, is elevated and has historically fluctuated between <5mg/l and 47mg/l at SW4 (Figure 4.24). This trend has continued through 2021. There is a general declining trend of ammoniacal-N at the SW2 monitoring point with 2021 concentrations been recorded in the 1 - 5mg/l range. Previously ammoniacal-N has been observed in the 5 - 10mg/l range at SW2.

Ammoniacal-N variability within the Ditch is likely to be due to a greater hydraulic continuity with the anoxic conditions within the Crymlyn Bog in the downstream sampling location (SW4) compared to the upstream location (SW2).

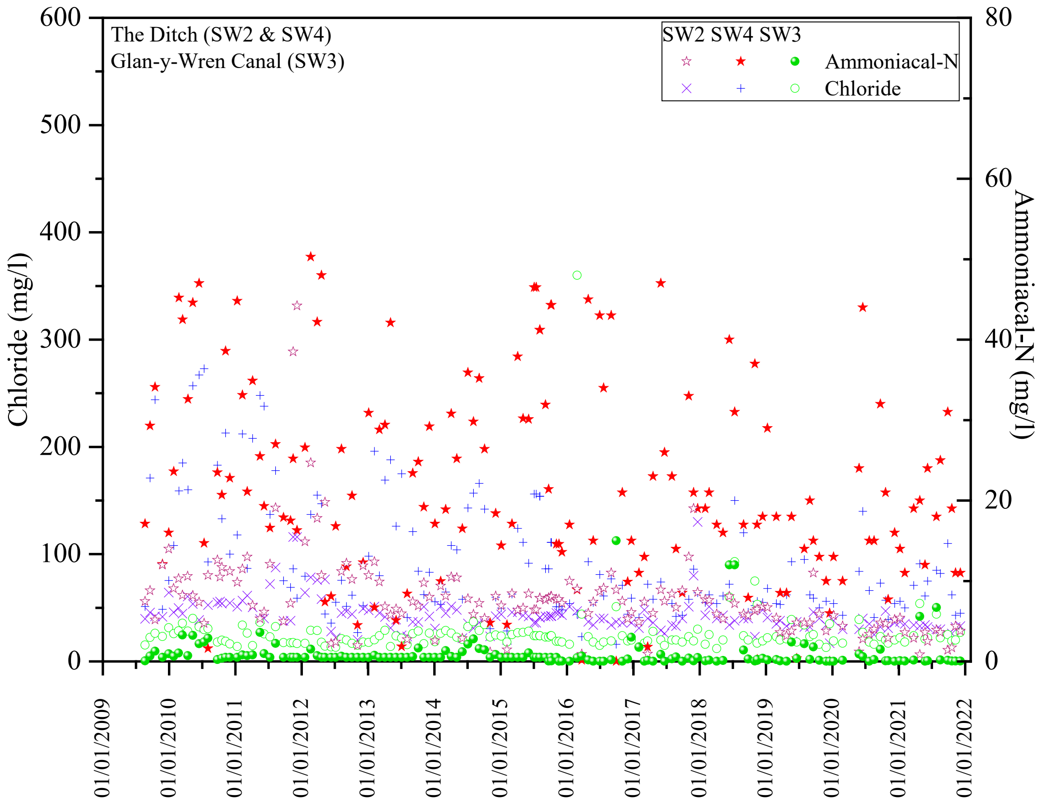

Figure 4.24 – Surface Water Matrix Chemistry SW2-4

The priority metals are at low to negligible within the surface water. Lead and chromium are reported in the 0.3 - 2µg/l range and copper and nickel at 2 – 13µg/l. Zinc was observed within the 8 – 17µg/l range during 2021 (Table 12). This is generally consistent with the ranges reported historically although zinc is marginally reduced in comparison to the 2020 dataset.

Table 12 – Surface Water Priority Metals Summary 2021

Sample Point	Date	Fe	Mn	Cr	Cu	Ni	Zn	Pb
		mg/l		µg/l				
SW1	09/11/2021	0.016	0.018	1.1	8	2	16	0.6
SW2	09/11/2021	0.009	1.400	0.9	13	5	16	0.8
SW3	09/11/2021	0.046	0.008	0.4	8	2	17	2.3
SW4	09/11/2021	0.022	0.800	0.9	5	4	8	0.3

5 Amenity

5.1 Complaints

The Operator's complaints procedure is compliant to the relevant clauses of ISO14001 and involves the capture and implementation of immediate corrective action for every complaint. There are processes that review the effectiveness of the corrective action and if necessary, further preventative action is undertaken to prevent reoccurrence of the complaint.

There were no complaints received at the site during 2021.

5.2 Weather Data

Given the close association of potential nuisance emissions to weather conditions, the weather monitoring data are summarised in Table 13.

Temperature ranges were consistent with expectations for the sites location however rainfall rates were lower than historically recorded due to an issue with the rainfall gauge at the site. The prevailing wind direction is primarily south westerly with a minor northerly component (Figure 5.1).

Table 13 – Temperature and Rainfall Summary

Month	Temperature (2021)			Rainfall					
	Min	Max	Ave	2016	2017	2018	2019	2020	2021
	°C	°C	°C	mm	mm	mm	mm	mm	mm
January	-3	6	13	49	79	144	78	105	184
February	-3	6	13	104	70	51	62	202	104
March	-2	9	21	106	113	135	99	67	53
April	0	9	20	71	28	62	68	38	15
May	1	11	23	91	15	47	28	12	156
June	6	16	25	112	74	36	73	144	29
July	12	18	30	48	13	130	35	91	73
August	8	16	24	103	65	31	140	159	5
September	6	17	29	131	143		164	40	22
October	6	14	19	54	52	17	194	205	29
November	-1	9	15	99	83	125	142	96	4
December	1	9	14	49	121	117	180	199	2
			Total	**1,016**	**854**	**895**	**1,263**	**1356**	**674**

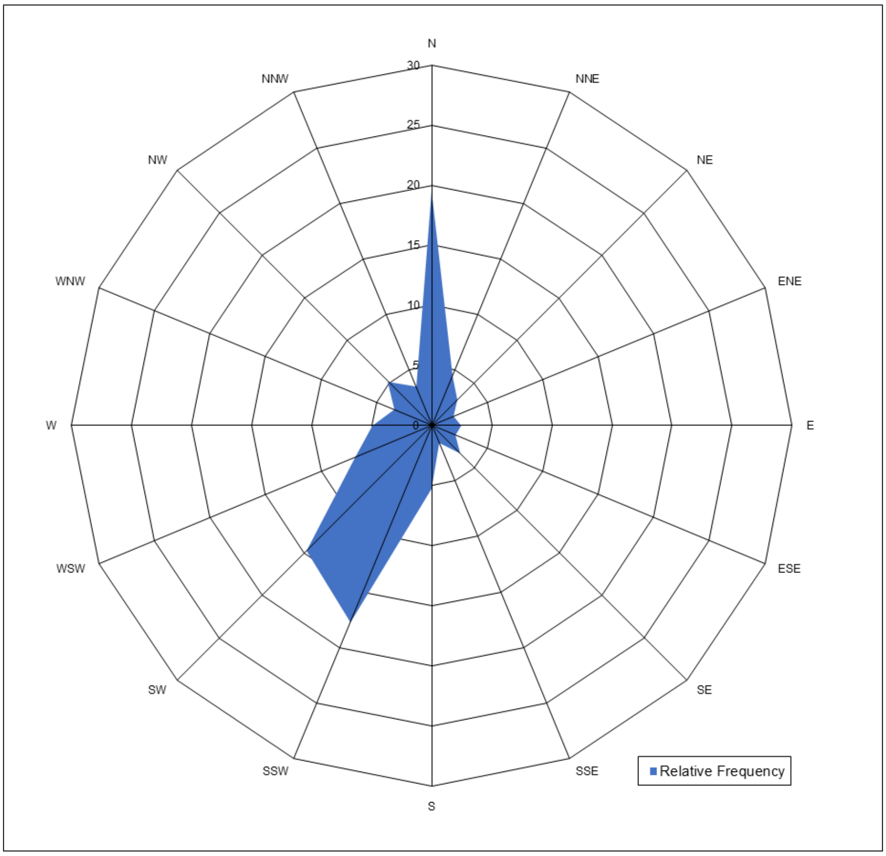

Figure 5.1 – Wind Rose Diagram 2021

6 Summary

Landfilling operations have been undertaken at the site since 1953 in unlined cells and prior to that PFA had been deposited since 1935. There has therefore been 50 years of disposal within the permitted area prior to the construction of the first containment cell. The current phase of operations commenced in the 1990s.

The site is located within a former river estuary cut into the South Wales Coal Measures, which was subsequently infilled by silts, clays, sands and peat deposits to form fenland conditions (The Crymlyn Bog).

There is no evidence of landfill gas migration from the Phase 2 of the Tir John landfill site. Similarly, there is no indication that there are ongoing leachate seepages or spillages to groundwater or surface water even though leachate is locally elevated within the site.

A Hydrogeological Risk Assessment (HRA) Review for the Tir John Phase 2 landfill was undertaken during 2018. This review demonstrated that the landfill was not causing a discernible impact on the hydrogeological system. A conclusion confirmed within this monitoring review. The HRA review also recommended a revision to the monitoring schedules to reduce the list of specific substances incorporated within the permit schedule, to a suite more appropriate to the actual leachate inventory.

The groundwater quality is poor, however the background influences dominate the groundwater chemistry. This is likely to include leaching from the PFA, biological activity within the organic rich host sediments, which is contributing to anaerobic and anoxic conditions as well as potential long term minor influences from historical wastes outside of the containment cells and groundwater recharge from the Coal Measures.

It is unlikely that the presence of waste within the engineered containment cells is exerting a discernible environmental impact.

Appendix A – Perimeter Gas Monitoring Data

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Tir John Operational Landfill Site
Perimeter Gas Summary January - December 2021

Location	Methane			Carbon dioxide			Oxygen			Balance			Carbon Monoxide			Hydrogen Sulphide			Atmospheric pressure			Relative Pressure		
	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
	%v/v			%v/v			%v/v			%v/v			ppm			ppm			mb			mb		
TIRGP013	0.0	0.1	0.2	0.1	1.0	4.2	14.5	19.4	21.4	78.8	79.7	81.3	0.0	0.0	0.0	0.0	0.3	2.0	994	1015	1031	-0.1	0.7	5.1
TIRGP014	0.0	0.0	0.2	0.2	5.6	10.6	3.2	12.9	21.3	78.4	81.7	86.2	0.0	0.0	0.0	0.0	0.2	2.0	994	1016	1032	0.0	0.2	0.3
TIRGP015	0.0	0.0	0.2	2.8	4.9	9.9	1.9	14.1	17.8	78.4	80.8	88.2	0.0	0.0	0.0	0.0	0.3	2.0	994	1016	1032	0.0	0.2	0.3
TIRGP016	0.0	0.0	0.2	4.3	7.7	10.7	6.9	10.9	17.0	78.3	81.3	84.4	0.0	0.1	1.0	0.0	0.3	2.0	994	1016	1032	-0.1	0.2	1.7
TIRGP017	0.0	0.0	0.3	1.7	3.5	15.6	5.9	17.0	19.6	78.4	79.3	81.4	0.0	0.0	0.0	0.0	0.4	2.0	994	1016	1032	-0.1	0.2	0.7
TIRGP018	0.0	0.1	0.3	2.2	6.2	10.9	4.7	12.5	17.7	78.0	81.3	86.2	0.0	0.1	1.0	0.0	0.3	2.0	994	1016	1032	-0.1	0.2	0.4
TIRGP019	0.0	0.1	0.3	0.1	4.6	10.3	8.4	16.3	21.5	78.0	79.2	82.5	0.0	0.0	0.0	0.0	0.4	2.0	994	1016	1032	0.0	0.1	0.3
TIRGP020	0.0	0.0	0.3	0.8	5.6	10.0	6.9	11.6	18.7	79.8	82.9	86.6	0.0	0.0	0.0	0.0	0.3	2.0	993	1016	1032	0.0	0.3	0.9
TIRGP021	0.0	3.5	12.4	1.0	4.6	7.0	0.2	8.2	20.7	78.3	83.6	90.0	0.0	0.0	0.0	0.0	0.7	2.0	995	1016	1032	-0.2	0.6	4.2
TIRGP022	0.0	0.0	0.3	0.1	0.2	0.6	18.8	20.5	21.6	78.5	79.3	80.6	0.0	0.0	0.0	0.0	0.4	2.0	995	1016	1031	-0.1	0.2	0.9
TIRGP023	0.0	0.1	0.4	0.1	4.8	12.2	0.2	7.2	21.2	78.5	83.8	90.2	0.0	0.4	5.0	0.0	0.8	5.0	995	1016	1032	-0.3	1.5	5.5

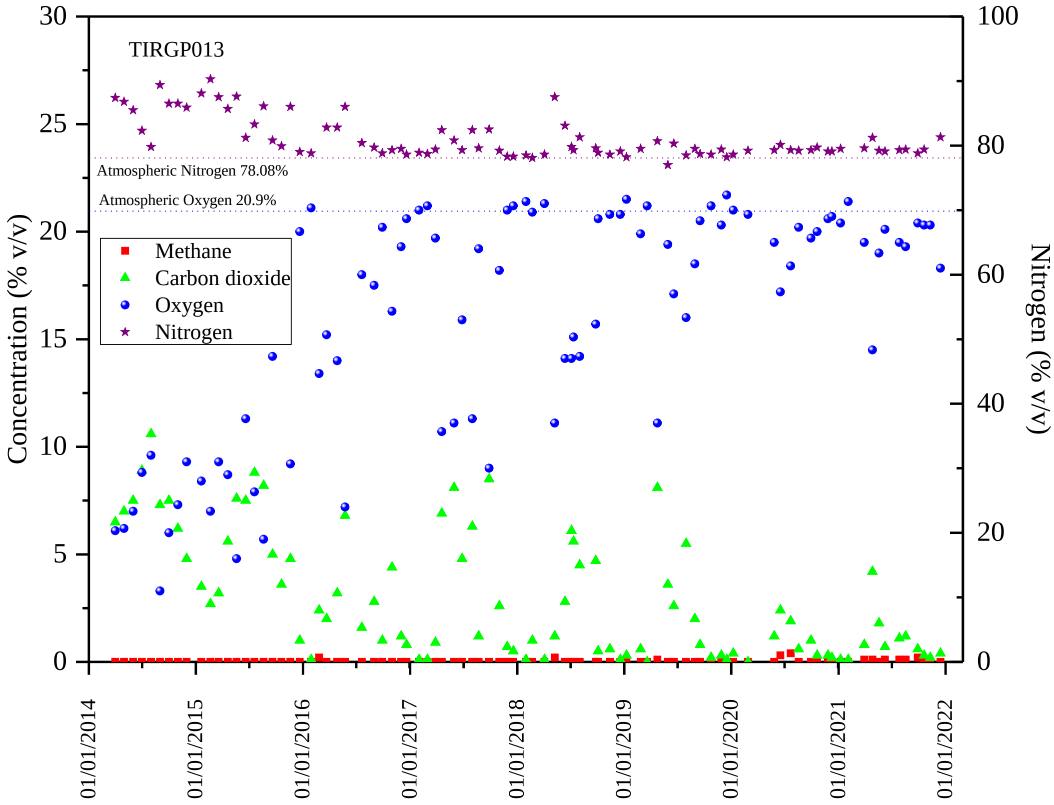

Figure A.1 – Perimeter Gas Monitoring Point TIRGP013

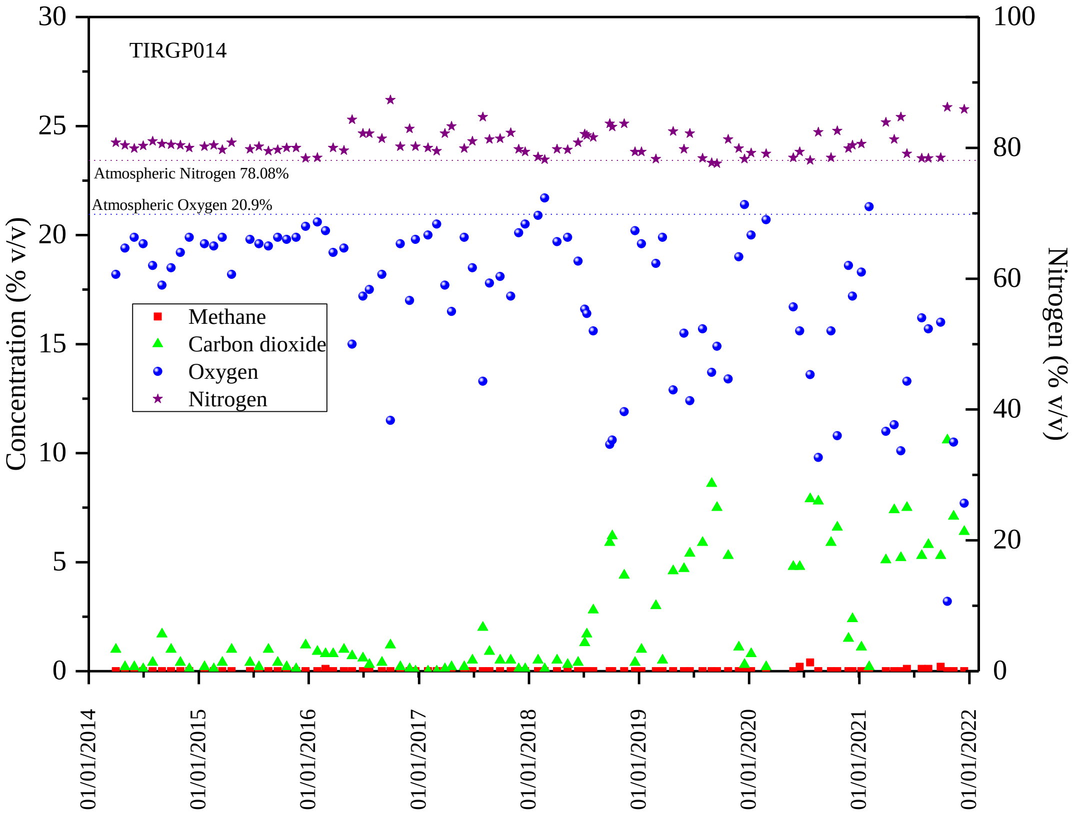

Figure A.2 – Perimeter Gas Monitoring Point TIRGP014

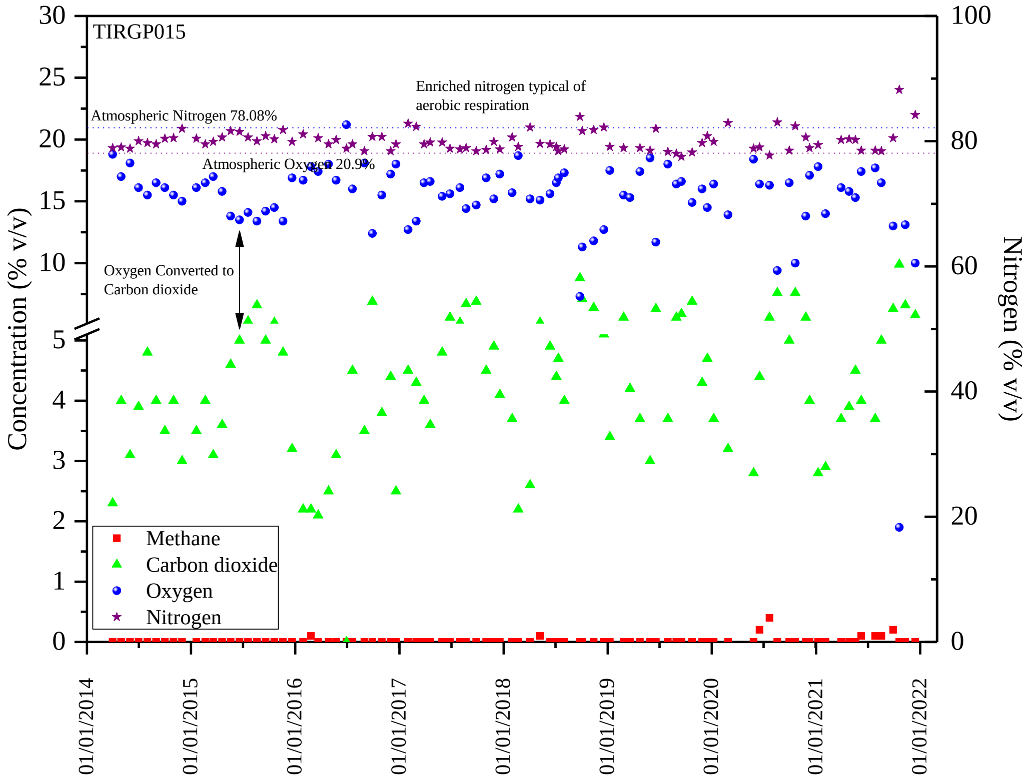

Figure A.3 – Perimeter Gas Monitoring Point TIRGP015

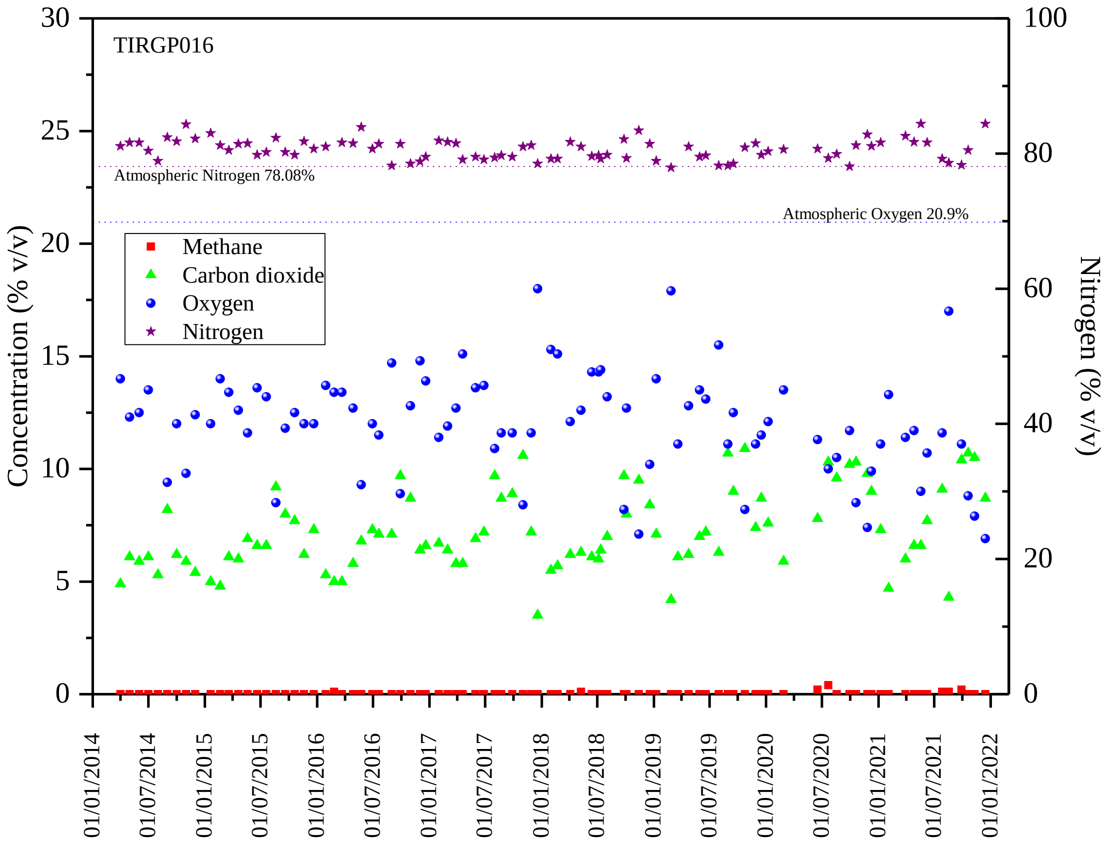

Figure A.4 – Perimeter Gas Monitoring Point TIRGP016

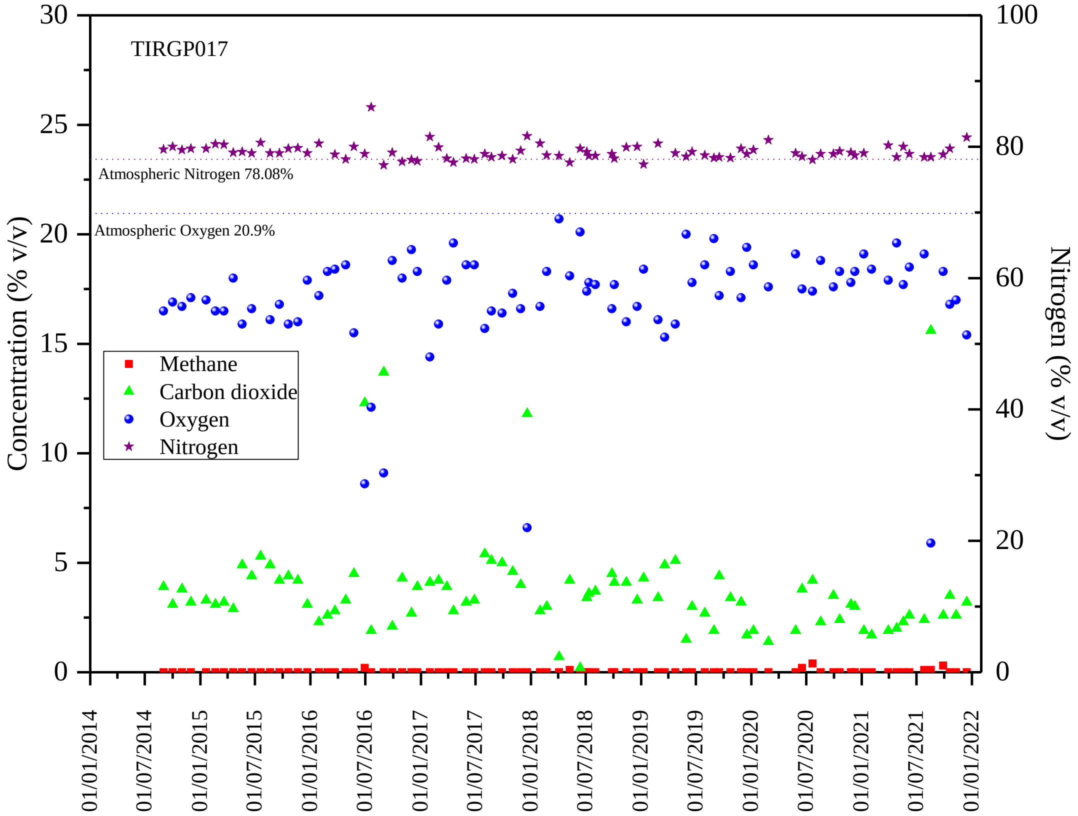

Figure A.5 – Perimeter Gas Monitoring Point TIRGP017

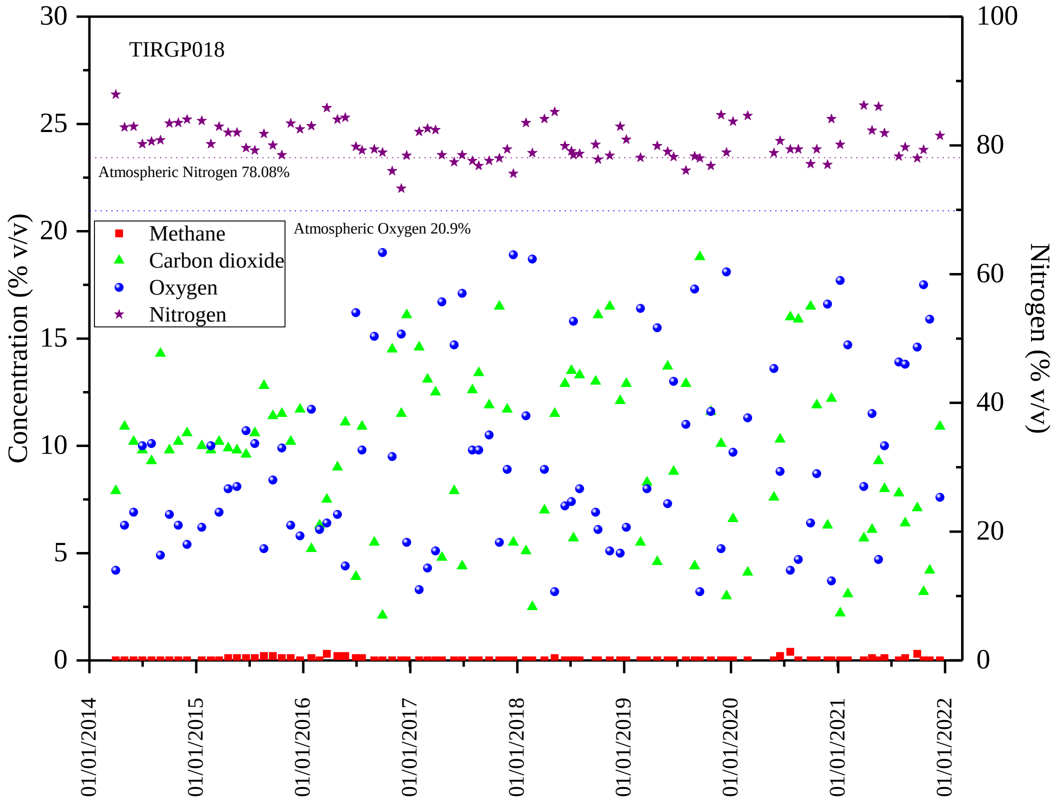

Figure A.6 – Perimeter Gas Monitoring Point TIRGP018

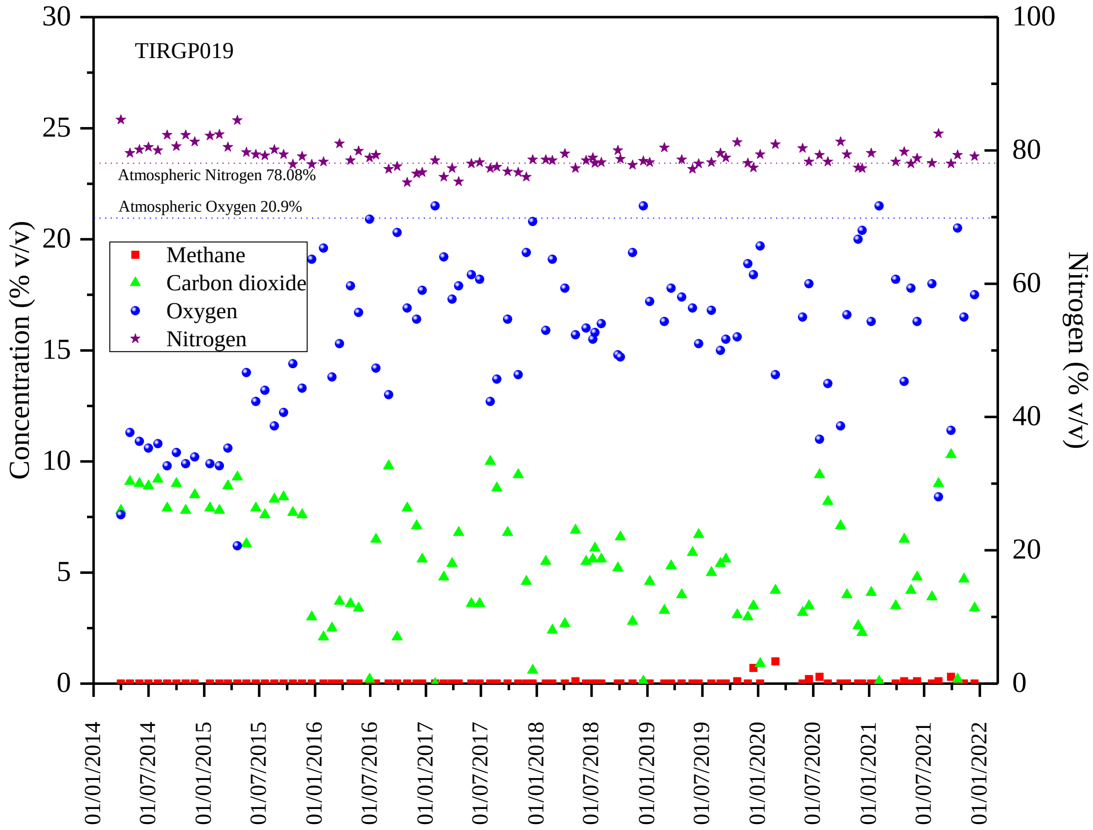

Figure A.7 – Perimeter Gas Monitoring Point TIRGP019

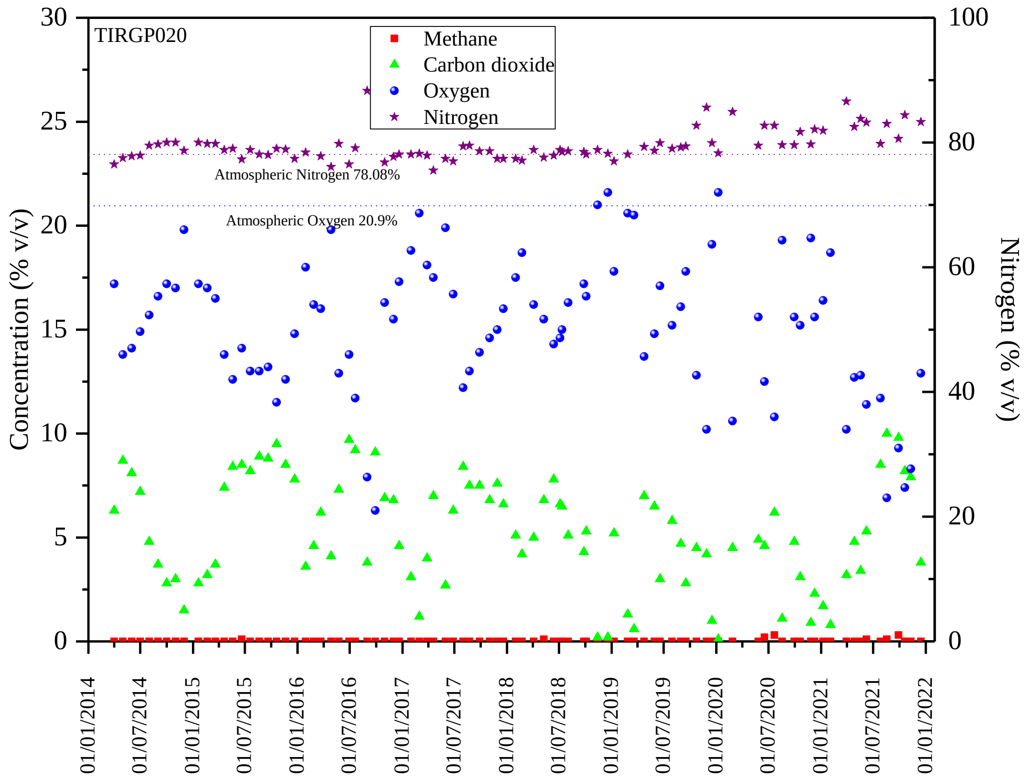

Figure A.8 – Perimeter Gas Monitoring Point TIRGP020

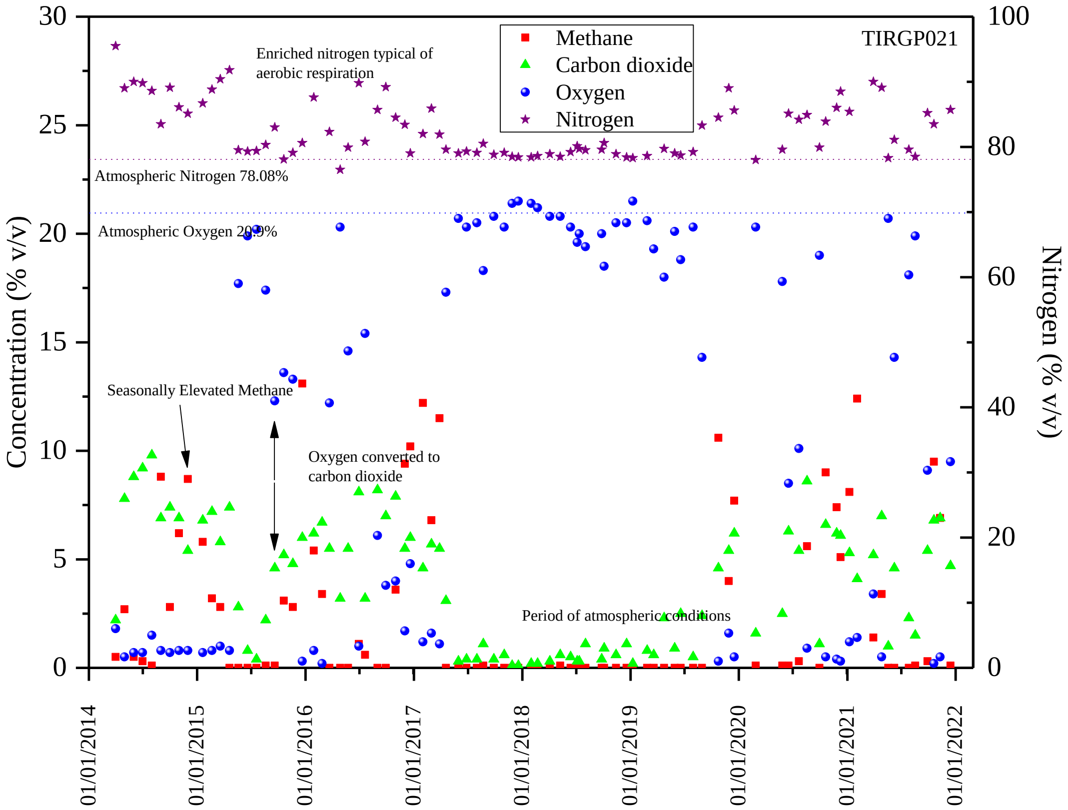

Figure A.9 – Perimeter Gas Monitoring Point TIRGP021

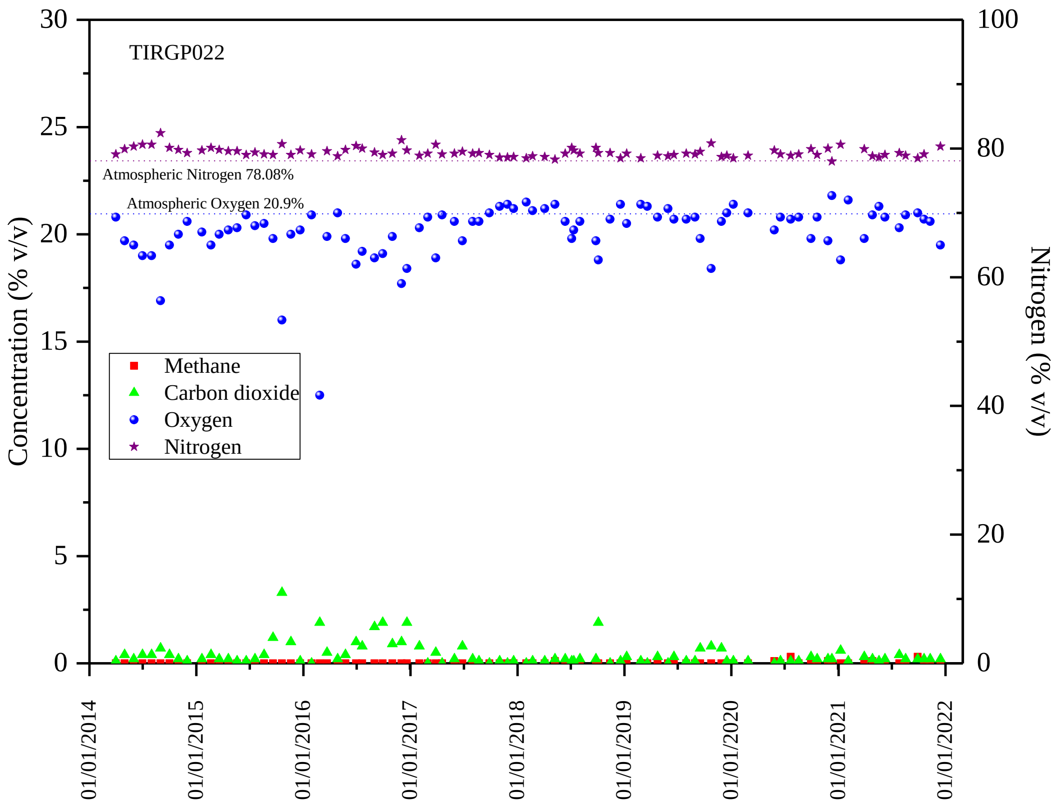

Figure A.10 – Perimeter Gas Monitoring Point TIRGP022

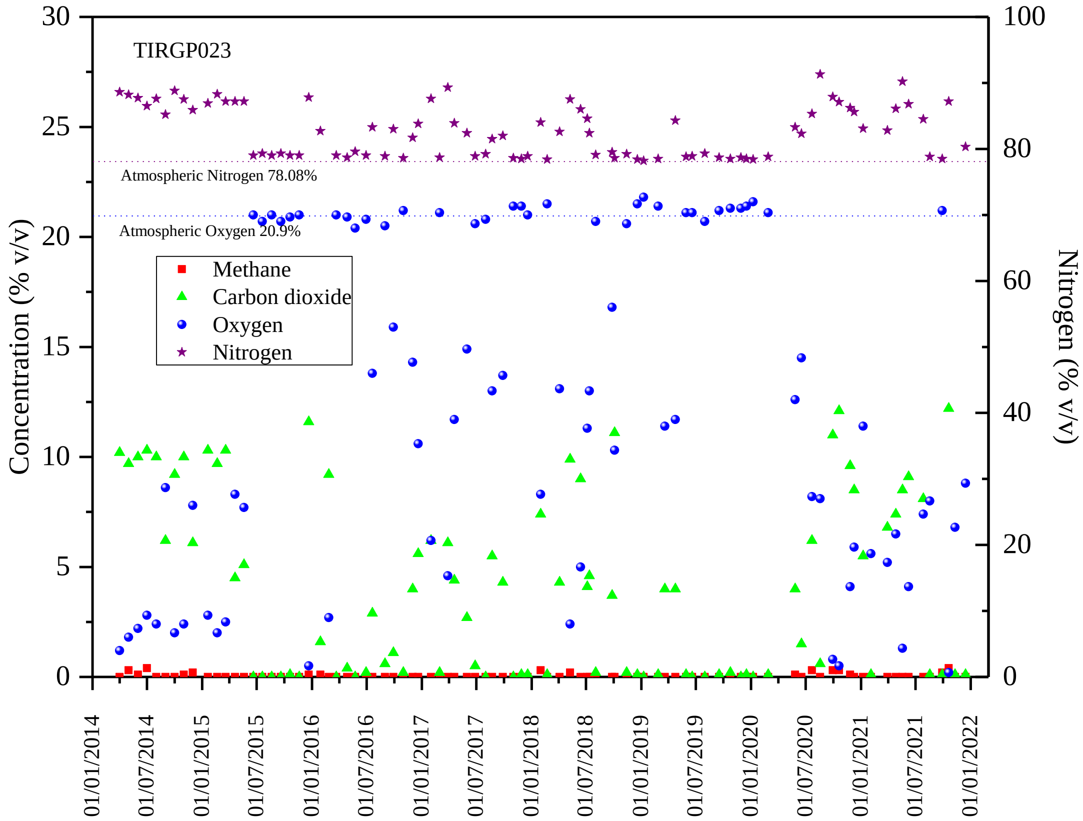

Figure A.11 – Perimeter Gas Monitoring Point TIRGP023

Appendix B – Landfill Gas Management

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Tir John Operational Landfill Site
In-Waste Gas Summary January - December 2021

Location	Methane			Carbon dioxide			Oxygen			Balance			Carbon Monoxide			Hydrogen Sulphide			Atmospheric pressure			Relative Pressure			CH4/CO2		
	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
	%v/v			%v/v			%v/v			%v/v			ppm			ppm			mb			mb					
TIRW2509	0.1	30.6	56.9	1.7	18.3	27.8	0.1	4.9	20.2	15.2	46.1	92.2	0.0	1.3	5.0	0.0	1.9	11.0	996	1011	1022	-1.7	-0.4	1.3	0.0	1.3	2.1
TIRW2510	24.2	33.0	45.1	17.2	23.8	27.7	0.1	1.3	3.7	26.9	42.0	52.8	0.0	1.4	4.0	0.0	0.6	3.0	996	1012	1022	-2.0	-0.7	0.5	1.0	1.4	1.7
TIRW2511	16.7	26.6	34.9	17.8	22.7	26.7	0.1	0.8	3.5	38.3	50.0	60.2	0.0	1.0	3.0	0.0	2.4	13.0	996	1010	1022	-1.9	-1.0	-0.4	0.9	1.2	1.5
TIRW2512	0.5	11.5	17.2	0.5	12.2	19.4	0.2	6.0	14.3	63.9	70.4	84.7	0.0	1.0	3.0	0.0	0.5	1.0	996	1006	1014	-28.2	-8.3	10.9	0.9	1.0	1.1
TIRW2515	0.1	16.3	41.6	1.3	12.7	32.0	0.4	12.3	21.4	28.5	58.7	83.4	0.0	4.0	11.0	0.0	2.7	7.0	995	1011	1023	-19.7	-2.9	0.7	0.1	4.7	35.8
TIRW2601	1.0	12.0	21.5	5.3	14.9	22.0	0.0	4.6	17.1	56.5	68.5	76.6	0.0	0.2	1.0	0.0	2.2	6.0	996	1011	1023	-5.0	-1.4	-0.1	0.2	0.7	1.0
TIRW2602	0.4	22.9	36.3	2.6	17.1	23.3	0.0	4.0	20.5	40.4	56.1	78.4	0.0	0.6	2.0	0.0	3.0	18.0	997	1012	1023	-3.2	-1.7	0.5	0.1	1.1	1.6
TIRW2603	9.6	27.7	34.4	13.6	20.0	24.7	0.0	1.2	9.2	43.4	51.1	67.6	0.0	0.8	2.0	0.0	4.2	23.0	997	1013	1023	-14.3	-5.5	0.5	0.7	1.4	1.7
TIRW2604	0.1	7.7	32.6	0.2	8.1	23.0	0.1	14.2	21.3	44.1	70.1	83.8	0.0	0.7	2.0	0.0	2.1	7.0	997	1013	1024	-1.2	-0.1	0.9	0.0	0.6	1.4
TIRW2605	13.6	26.6	49.6	20.1	23.9	28.2	0.0	0.4	3.4	23.8	49.1	63.7	0.0	1.1	2.0	0.0	2.5	10.0	997	1013	1024	-6.8	-1.5	0.2	0.6	1.1	1.9
TIRW2606	0.1	27.9	73.9	0.0	15.3	25.7	0.0	5.6	19.3	1.0	51.2	84.2	0.0	0.9	2.0	0.0	2.3	12.0	999	1012	1023	-27.5	-9.9	0.5	0.1	1.6	4.4
TIRW2607	0.1	0.1	0.1	0.0	0.0	0.0	19.4	19.4	19.4	80.5	80.5	80.5	1.0	1.0	1.0	0.0	0.0	0.0	999	999	999	0.5	0.5	0.5			
TIRW261A	0.9	7.5	12.0	7.8	14.4	21.9	0.0	8.5	15.6	64.8	69.7	75.7	1.0	1.3	2.0	0.0	2.0	3.0	997	1010	1017	-2.9	-0.8	0.7	0.1	0.5	0.9
TIRW263A	0.0	4.1	21.0	0.1	2.9	7.4	13.6	19.4	21.7	58.0	73.7	78.8	0.0	0.7	2.0	0.0	0.9	3.0	997	1013	1024	-9.3	-1.0	0.5	0.0	0.9	2.8
TIRW264A	0.0	1.2	3.7	0.1	4.4	10.0	9.5	17.3	21.4	71.9	77.2	79.8	0.0	0.8	2.0	0.0	1.1	3.0	1002	1013	1024	-29.1	-3.9	0.8	0.0	0.2	0.5
TIRW264B	0.0	1.2	5.8	0.1	2.7	5.8	15.5	19.2	22.0	73.4	76.9	78.6	0.0	0.9	3.0	0.0	0.8	3.0	997	1012	1023	-9.4	-0.1	5.0	0.0	0.3	1.1
TIRW265A	0.1	43.3	61.7	1.2	20.8	26.1	0.2	2.7	21.3	13.3	33.2	77.4	0.0	0.8	2.0	0.0	2.2	8.0	997	1013	1023	-18.2	-8.4	-3.7	0.1	1.9	2.6
TIRW267A	0.1	0.1	0.1	0.0	0.0	0.0	19.5	19.5	19.5	80.4	80.4	80.4	1.0	1.0	1.0	0.0	0.0	0.0	999	999	999	0.3	0.3	0.3			
TIRW2705	1.6	40.1	53.1	0.8	23.0	29.8	0.1	3.0	19.8	16.3	34.0	77.8	0.0	1.3	5.0	0.0	1.7	8.0	996	1011	1022	-8.1	-3.4	1.0	1.6	1.8	2.0
TIRW2706	31.0	54.3	64.8	18.7	29.4	34.9	0.1	0.9	7.2	0.1	15.3	43.1	1.0	2.8	7.0	0.0	3.8	24.0	996	1012	1022	-8.5	-4.8	1.0	1.7	1.8	1.9
TIRW2707	28.2	38.8	50.3	21.3	25.1	27.8	0.1	0.4	0.8	21.7	35.7	47.2	1.0	2.3	9.0	0.0	3.5	23.0	996	1012	1022	-1.4	-0.5	0.4	1.2	1.5	1.8
TIRW2708	0.0	14.2	40.1	0.2	10.2	23.7	0.1	12.4	22.0	36.0	63.2	79.3	0.0	2.0	7.0	0.0	3.3	25.0	996	1010	1022	-1.3	-0.1	1.2	0.0	0.8	1.7
TIRW2709	3.1	33.4	47.5	7.6	22.8	28.0	0.0	2.1	13.3	27.3	41.7	76.0	0.0	1.0	2.0	0.0	3.9	25.0	995	1011	1022	-7.0	-2.5	-0.2	0.4	1.4	1.9
TIRW2710	0.5	0.5	0.5	0.3	0.3	0.3	17.0	17.0	17.0	82.2	82.2	82.2	2.0	2.0	2.0	1.0	1.0	1.0	999	999	999	0.0	0.0	0.0	1.7	1.7	1.7
TIRW2711	0.2	50.2	60.0	0.1	30.7	38.6	0.1	2.3	19.7	4.1	16.8	80.0	0.0	4.0	9.0	0.0	3.4	14.0	996	1011	1023	-14.6	-6.1	0.6	1.4	1.8	2.6
TIRW2712	0.1	4.3	29.5	0.2	6.1	24.3	3.5	17.0	21.3	42.7	72.6	80.0	0.0	2.8	7.0	0.0	1.9	6.0	994	1011	1023	-1.1	-0.1	1.4	0.1	1.2	5.5
TIRW2713	0.0	13.1	63.0	0.1	9.9	40.2	0.2	15.1	21.5	0.0	62.3	80.4	0.0	2.7	13.0	0.0	3.5	23.0	994	1011	1023	-3.5	1.9	25.5	0.0	2.1	16.4
TIRW2714	0.3	0.3	0.3	0.1	0.1	0.1	19.3	19.3	19.3	80.3	80.3	80.3	1.0	1.0	1.0	0.0	0.0	0.0	999	999	999	0.5	0.5	0.5	3.0	3.0	3.0
TIRW3A01	0.1	38.0	56.3	0.2	23.1	31.2	0.0	3.7	19.2	13.1	35.2	83.1	0.0	1.1	3.0	0.0	4.8	36.0	996	1011	1022	-10.8	-5.2	0.1	0.1	1.4	1.9
TIRW3A02	8.2	19.2	31.0	15.4	19.1	24.9	0.0	1.6	6.7	44.1	60.1	75.5	1.0	3.3	9.0	0.0	8.7	52.0	996	1010	1022	-5.0	-2.0	-0.7	0.5	1.0	1.6
TIRW3A03	22.9	36.5	45.9	21.7	25.9	29.0	0.0	0.2	0.7	27.5	37.3	52.2	0.0	1.6	4.0	0.0	5.1	25.0	996	1011	1022	-4.5	-2.4	-0.4	0.9	1.4	2.0
TIRW3A04	0.0	27.7	55.0	1.1	20.3	30.0	0.1	3.5	21.1	20.4	48.5	77.8	0.0	1.0	4.0	0.0	1.9	7.0	996	1011	1023	-6.2	-2.3	-0.2	0.0	1.2	2.3
TIRW3A06	0.8	42.3	53.4	0.5	28.0	34.7	0.1	2.8	20.9	12.7	26.9	77.8	0.0	2.5	7.0	0.0	3.4	14.0	996	1011	1022	-16.7	-7.6	-0.6	1.4	1.5	1.7
TIRW3B01	23.1	36.9	48.5	23.4	28.2	31.2	0.0	0.5	2.0	22.6	34.4	52.6	0.0	0.9	2.0	0.0	6.4	29.0	996	1012	1022	-10.9	-4.8	-2.7	1.0	1.3	1.7
TIRW3B02	9.7	16.2	25.4	19.2	21.7	27.1	0.0	0.6	2.2	47.4	61.6	70.8	0.0	0.9	2.0	0.0	4.0	13.0	996	1013	1022	-3.7	-1.6	-0.4	0.5	0.7	1.0
TIRW3B03	12.6	19.1	27.3	13.5	20.6	25.7	0.0	1.5	8.6	46.9	58.9	65.3	0.0	0.7	2.0	0.0	1.6	5.0	996	1012	1022	-4.6	-1.3	-0.3	0.6	0.9	1.2
TIRW3B04	10.2	27.2	56.3	6.7	20.5	26.0	0.1	3.7	16.6	20.2	48.7	66.5	0.0	1.3	3.0	0.0	3.7	27.0	996	1012	1022	-29.0	-12.5	-2.2	0.6	1.3	2.4
TIRW3B05	39.0	44.9	54.5	27.4	29.4	33.2	0.0	0.3	0.8	11.9	25.5	31.7	0.0	2.0	11.0	0.0	5.6	41.0	995	1010	1022	-16.7	-12.8	-7.1	1.3	1.5	1.6
TIRW3B07	22.7	44.6	56.4	15.7	29.2	34.3	0.0	1.2	10.2	9.2	25.1	51.4	0.0	1.4	3.0	0.0	6.2	39.0	996	1011	1022	-15.9	-11.7	-4.9	1.4	1.5	1.6
TIRW3B08	0.1	9.2	18.2	1.5	10.3	19.1	2.6	11.9	21.1	60.1	68.7	77.3	0.0	0.0	0.0	0.0	0.0	0.0	1003	1013	1023	-0.9	-0.8	-0.8	0.1	0.5	1.0
TIRW3C01	22.1	36.6	47.6	19.6	26.1	30.4	0.0	1.1	6.0	21.4	36.2	54.8	0.0	1.4	3.0	0.0	6.4	42.0	995	1011	1022	-13.9	-6.5	-1.1	1.1	1.4	1.7
TIRW3C03	38.8	51.5	65.6	27.7	30.3	32.7	0.3	0.4	0.5	3.3	17.8	28.2	1.0	1.3	2.0	0.0	0.3	1.0	996	1011	1022	-14.4	-5.7	0.1	1.2	1.7	2.1
TIRW3C04	0.1	20.1	41.7	3.2	17.4	27.6	0.1	6.2	20.0	30.6	56.3	76.7	0.0	1.1	3.0	0.0	2.0	11.0	996	1011	1022	-2.0	-0.9	-0.3	0.0	1.0	1.5
TIRW3C05	5.0	17.9	28.6	13.4	18.3	23.1	0.2	2.3	5.9	50.8	61.4	78.1	0.0	0.9	2.0	0.0	1.0	5.0	996	1012	1022	-3.9	-1.1	-0.1	0.4	1.0	1.5
TIRW3C06	0.1	15.4	22.6	0.0	15.9	20.1	0.1	4.2	19.5	57.2	64.6	80.4	0.0	0.9	2.0	0.0	1.1	3.0	999	1011	1022	-2.0	-0.8	0.3	0.7	1.0	1.2
TIRW3C07	22.5	34.6	43.6	19.3	23.9	30.5	0.1	0.7	2.3	25.7	40.8	55.9	0.0	0.9	2.0	0.0	4.2	21.0	996	1011	1022	-10.8	-3.1	-0.4	1.1	1.4	1.9
TIRW1210	0.3	0.3	0.3	0.2	0.2	0.2	19.4	19.4	19.4	80.1	80.1	80.1	1.0	1.0	1.0	0.0	0.0	0.0	999	999	999	0.3	0.3	0.3	1.5	1.5	1.5
TIRW1211	0.1	19.2	68.1	0.0	12.5	32.0	1.2	13.1	20.4	0.0	55.4	80.4	0.0	1.4	5.0	0.0	1.1	3.0	999	1014	1025	-0.3	0.3	1.4	0.3	1.2	2.1
TIRW1212	0.0	31.0	70.4	0.0	18.3	31.0	0.1	7.6	21.5	1.7	43.1	78.5	0.0	1.7	6.0	0.0	1.0	4.0	997	1013	1025	-0.4	0.3	1.0	0.2	1.4	2.5
TIRW12A1	1.5	9.7	14.5	4.1	8.7	15.1	10.1	15.8	18.8	59.0	65.8	74.4	0.0	1.7	3.0	0.0	3.2	11.0	998	1014	1024	-11.5	-1.8	0.3	0.3	1.2	1.9
TIRW12A2	59.6	65.6	69.6	26.7	30.0	34.6	0.2	1.1	2.5	0.0	3.8	12.0	0.0	2.4	6.0	0.0	2.5	16.0	997	1014	1024	-31.8	-21.9	8.6	2.0	2.2	2.4
TIRW12A3	0.3	35.3	70.2	0.2	17.1	34.0	0.3	10.9	21.4	0.0	39.1	78.1	2.0	3.0	4.0	0.0	0.5	1.0	997	1004	1010	-0.7	0.3	1.3	1.5	1.8	2.1
TIRW1401	52.8	61.0	64.6	31.9	36.5	43.6	0.1	0.7	1.7	0.0	2.8	11.3	1.0	6.3	11.0	0.0	23.9	111.0	996	1013	1023	-28.6	-15.2	1.6	1.3	1.7	1.9

Location	Methane			Carbon dioxide			Oxygen			Balance			Carbon Monoxide			Hydrogen Sulphide			Atmospheric pressure			Relative Pressure			CH4/CO2		
	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
		%v/v			%v/v			%v/v			%v/v			ppm			ppm			mb			mb				
TIRW1402	0.0	23.4	54.4	0.0	17.0	39.8	0.2	12.2	21.5	6.7	47.4	80.5	0.0	3.7	11.0	0.0	5.5	18.0	999	1012	1019	-26.5	-11.2	7.9	0.0	1.3	2.3
TIRW1403	0.1	22.3	66.8	0.0	14.1	34.6	0.1	12.8	21.7	0.0	51.0	80.4	1.0	2.4	5.0	0.0	2.8	8.0	999	1013	1023	-18.3	-7.1	0.4	0.1	1.2	1.9
TIRW1404	0.2	17.4	62.5	0.7	12.5	39.4	0.5	15.3	20.8	0.0	55.4	77.3	0.0	3.8	11.0	0.0	6.5	21.0	996	1007	1019	-2.7	-0.9	0.1	0.0	1.1	1.7
TIRW1801	0.2	43.4	61.4	5.8	31.5	42.4	0.1	5.1	18.6	0.0	20.6	75.4	0.0	8.9	19.0	0.0	18.7	97.0	995	1012	1022	-15.5	-1.1	10.1	0.0	1.2	1.8
TIRW1802	0.1	33.7	60.6	0.1	25.2	43.3	0.0	8.3	21.4	0.0	33.4	78.7	1.0	5.8	11.0	0.0	7.6	22.0	996	1012	1022	-19.7	-0.7	39.8	0.1	1.2	1.6
TIRW1803	0.0	38.2	60.6	0.1	26.0	40.1	0.5	7.4	21.5	0.0	28.5	78.3	1.0	8.7	20.0	0.0	15.2	103.0	996	1013	1023	-25.3	-9.7	0.7	0.0	1.3	1.6
TIRW1804	0.1	26.0	62.4	0.1	19.5	37.8	0.0	10.9	21.2	0.0	43.6	78.5	0.0	5.3	15.0	0.0	18.1	127.0	995	1013	1023	-17.7	-3.3	1.0	0.0	1.0	2.0
TIRW1805	0.0	42.1	64.2	1.7	26.7	39.1	0.0	5.4	20.3	0.0	26.4	78.5	2.0	6.7	18.0	0.0	24.4	179.0	996	1013	1023	-16.0	-2.5	9.8	0.0	1.3	1.8
TIRW1806	0.2	50.0	68.3	3.2	28.5	38.1	0.3	5.3	19.8	0.0	16.8	76.8	0.0	4.8	8.0	0.0	13.9	60.0	996	1013	1023	-16.0	-2.6	2.9	0.1	1.5	2.5

Appendix C – Water Monitoring Data

BYRNELOOBY

Tir John Operational Landfill Site
Leachate Quality Summary January - December 2021

Sample Point	Date	pH	EC	NH_4-N	COD	BOD	Na	K	Cl	Cd	Hg	Cr	Cu	Ni	Zn	Pb	As
			uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
LEW06	16/11/2021	7.5	3600	230.0	5600	310	420		310	0.11					0.006	0.002	
LEW22	02/06/2021	7.8	6800	500.0	650	34	820	340	720	0.23	<0.005	0.017	0.0026	0.041	0.004	0.004	0.044
LEW22	16/11/2021	8.0	6600	410.0	670	8.1	950		690	<0.08					0.100	0.004	
LEW23	02/06/2021	7.2	3900	130.0	420	19	680	270	580	0.16	<0.005	0.011	0.0018	0.026	0.004	0.003	0.052
LEW23	16/11/2021	7.1	2700	61.0	260	13	430		320	0.21					0.004	0.001	
LEW25	02/06/2021	7.4	5600	490.0	430	20	700	250	570	<0.08	0.0086	0.011	0.0240	0.039	0.058	0.004	0.041
LEW25	16/11/2021	7.2	2700	180.0	160	22	240		220	<0.08					0.037	0.002	
LEW26	02/06/2021	7.6	800	0.3	230	< 1	94	45	64	<0.08	0.0107	0.0015	0.0290	0.018	0.100	0.010	0.005
LEW26	16/11/2021	8.4	670	2.5	210	3.2	80		66	0.09					0.008	0.002	
LEW28	02/06/2021	8.0	11000	24.0	1600	48	1400	490	1200	<0.08	<0.005	0.0610	0.0100	0.150	0.052	0.009	0.043
LEW28	16/11/2021	8.3	10000	1000.0	1300	120	1100		1100	<0.08					0.039	0.006	
LEW29	02/06/2021	8.0	6300	410.0	430	30	640	320	450	0.17	0.0084	0.0081	0.0057	0.036	0.019	0.002	0.038
LEW29	16/11/2021	7.5	6800	560.0	460	22	620		670	<0.08					0.036	0.003	
LEW12a	02/06/2021	7.8	16000	22.0	2000	48	1600	630	1500	0.14	<0.5	0.0076	0.0028	0.020	0.046	0.005	0.050
LEW12a	16/11/2021	8.0	14000	1400.0	2000	190	2300		1800	<0.08					0.018	0.004	
LEW31	02/06/2021	7.9	20000	2000.0	4100	140	2300	53	2200	<0.08	<0.5	0.0042	< 0.0007	0.005	0.002	0.003	0.012
LEW31	16/11/2021	7.8	17000	1500.0	3400	150	2200		1900	<0.08				0.001	0.004		
LEW16	16/11/2021	7.5	12000	1200.0	3500	270	1200		1200	0.14					0.089	0.002	

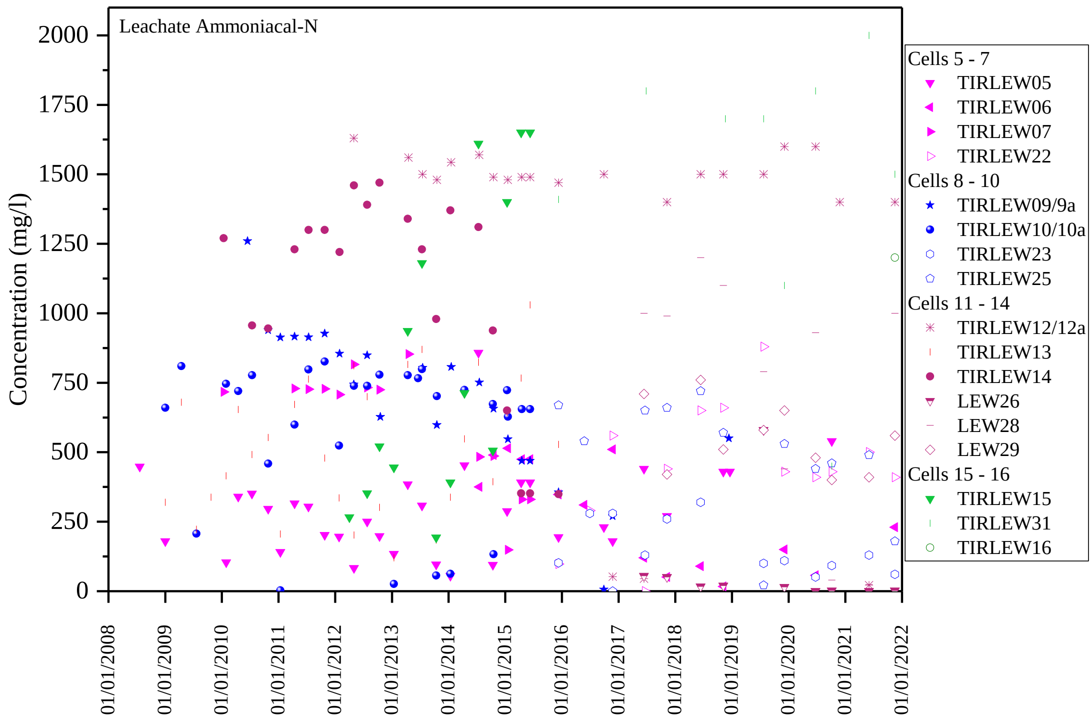


Figure B.1 – Leachate Ammoniacal-N

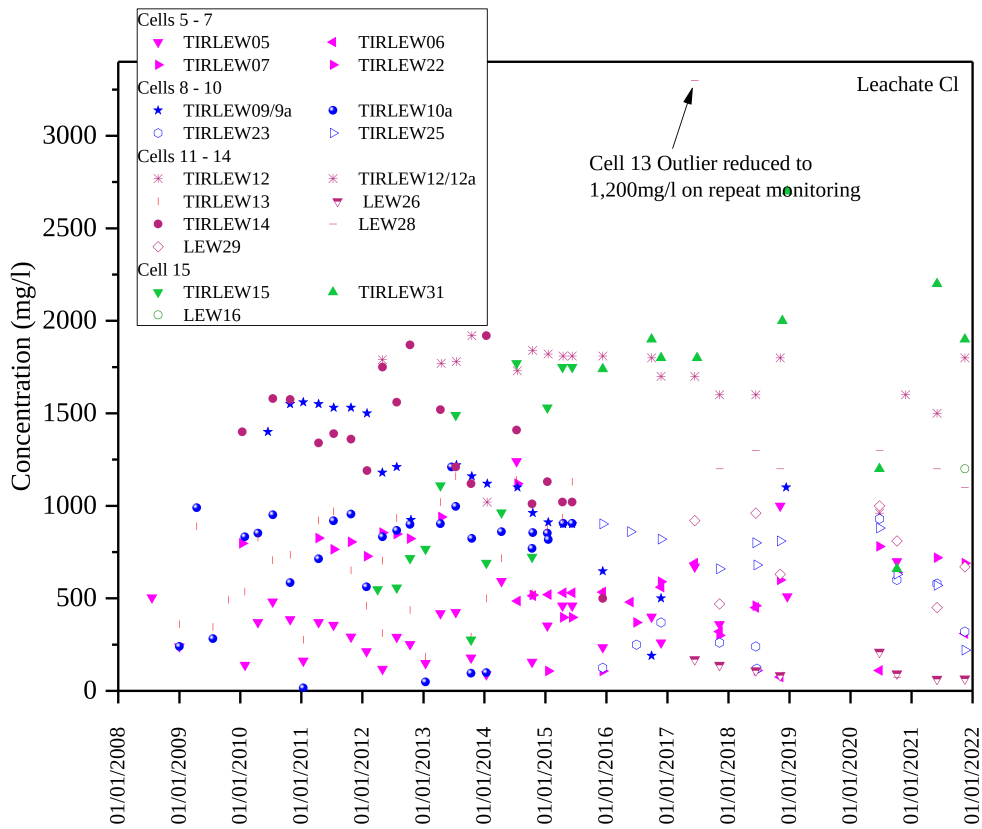


Figure B.2 – Leachate Chloride

BYRNELOOBY

Tir John Operational Landfill Site
Groundwater Quality Summary January - December 2021

Sample Point	Date	pH	EC	NH_4-N	COD	BOD	TOC	Ca	Mg	Na	K	Cl	SO_4	Alkalinity	Fe	Mn	Cd	Hg	Cr	Cu	Ni	Zn	Pb	As	MCPP
			uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l
GDW01(D)	16/02/2021	7.4	800	2.2	850	19	6			64	25	60			0.009	0.3	0.0001	< 0.0001	0.004	0.0008		0.005	0.0005	0.0099	<0.02
	19/05/2021	7.4	700	2.7	610	< 1	5	89	20	58	23	54	30	330	0.061	0.2	<0.00002	<0.000005	0.003	0.0011	0.0009	0.001	< 0.0002	0.0053	< 0.02
	10/08/2021	7.6	670	1.6	4700	11	6			49	22	39			0.013	0.5	0.00018	<0.000005	0.004	0.0015		0.007	0.0003	0.0227	< 0.02
	12/10/2021	7.6	590	1.1	4300	43	6			60	23	44			0.077	0.4	0.00012	0.0000145	0.003	0.0011		0.003	< 0.0002	0.0097	< 0.02
GDW01(S)	16/02/2021	8.5	440	0.7	800	7	3			53	21	46			0.01	0.1	0.0001	< 0.0001	0.002	0.0006		0.001	<0.0002	0.0250	<0.02
	19/05/2021	7.5	650	2.0	230	3	2	82	20	58	23	51	31	310	0.08	0.1	<0.00002	<0.000005	0.003	0.0008	0.0007	0.001	< 0.0002	0.0200	< 0.02
	10/08/2021	7.4	710	2.9	700	10	6			54	22	54			0.005	0.3	0.0001	<0.000005	0.004	0.0022		0.009	< 0.0002	0.0144	< 0.02
	12/10/2021	7.8	530	1.5	2900	25	1			69	23	45			< 0.004	0.2	0.00008	0.0000169	0.003	0.0011		0.003	< 0.0002	0.0156	< 0.02
GDW02(D)	16/02/2021	6.6	1100	6.0	95	33	2			32	28	30			0.057	2.8	0.00004	< 0.0001	0.007	0.0016		0.007	0.0002	0.0087	<0.02
	19/05/2021	6.5	980	6.4	70	41	8	180	41	42	26	34	171	510	0.82	4.1	0.00004	<0.000005	0.007	0.0016	0.0029	0.004	< 0.0002	0.0105	< 0.02
	10/08/2021	6.6	970	11.0	59	19	5			48	21	50			0.021	4.2	<0.00002	<0.000005	0.009	0.0029		0.009	< 0.0002	0.0014	< 0.02
	12/10/2021	6.5	980	8.9	290	20	13			58	26	43			0.4	3.7	<0.00002	0.0000084	0.009	0.0009		0.004	< 0.0002	0.0044	< 0.02
GDW02(S)	16/02/2021	6.8	2300	19.0	700	40	3			180	49	170			0.2	0.9	0.00004	< 0.0001	0.014	0.0026		0.006	0.0004	0.0037	<0.02
	19/05/2021	7.0	1900	17.0	460	17	6	340	62	180	51	180	269	970	1.1	0.9	<0.00002	0.0000095	0.008	0.0029	0.0029	0.003	< 0.0002	0.0054	< 0.02
	10/08/2021	6.9	1900	18.0	240	21	6			190	47	180			0.048	0.8	<0.00002	<0.000005	0.007	0.0024		0.008	< 0.0002	0.0020	< 0.02
	12/10/2021	6.9	1500	17.0	520	6	5			240	52	180			0.2	0.8	<0.00002	0.0000137	0.012	0.0015		0.011	< 0.0002	0.0017	< 0.02
GDW03(D)	16/02/2021	6.3	500	11.0	150	10	4			22	4	27			0.12	0.9	<0.00002	< 0.0001	0.005	0.0005		0.004	<0.0002	0.0006	<0.02
	19/05/2021	6.3	460	11.0	140	11	10	38	20	20	4	26	1	250	0.14	0.8	<0.00002	0.0000107	0.004	0.0007	0.0015	0.006	< 0.0002	0.0010	< 0.02
	10/08/2021	6.4	500	11.0	190	3	14			20	4	27			0.047	0.7	<0.00002	<0.000005	0.005	0.0019		0.007	< 0.0002	0.0007	< 0.02
	12/10/2021	6.3	550	11.0	130	33	10			22	6	27			35	0.6	<0.00002	0.0000129	0.005	0.0014		0.009	< 0.0002	0.0006	< 0.02
GDW03(S)	16/02/2021	7.2	830	25.0	81	6	4			33	22	30			0.25	1.6	<0.00002	< 0.0001	0.005	0.0013		0.004	<0.0002	0.0014	<0.02
	19/05/2021	7.4	820	23.0	190	2	4	120	19	33	25	34	73	460	0.047	1.7	<0.00002	<0.000005	0.003	0.0011	0.0017	0.003	< 0.0002	0.0013	< 0.02
	10/08/2021	7.4	740	17.0	120	5	5			23	20	30			0.015	1.3	<0.00002	<0.000005	0.005	0.0030		0.009	0.0005	0.0025	< 0.02
	12/10/2021	7.4	810	23.0	14	< 1	5			27	24	29			0.044	2.1	<0.00002	0.0000103	0.004	0.0019		0.004	< 0.0002	0.0018	< 0.02
GDW04	24/03/2021	6.1		8.0			24					30					0.0001		0.005	0.0043		0.010	0.0009	0.0130	<0.02
	25/05/2021	6.0		7.9			8		7	26	7	29	2	150		0.2		0.0000108	0.004	0.0043	0.0062	0.011	0.0031	0.0253	< 0.02
	21/09/2021	5.5		6.4			36					27							0.001	0.0028		0.011	0.0017	0.0203	< 0.02
	09/11/2021	5.7		7.7			40					27							0.004	0.0023		0.012	0.0016	0.0275	< 0.02
GDW05	24/03/2021	7.2		11.0			11					29					0.00005		0.006	0.0015		0.004	<0.0002	0.0050	<0.02
	25/05/2021	7.2		19.0			3		61	200	32	29	4	890		0.3		0.0000111	0.006	0.0023	0.0026	0.002	< 0.0002	0.0043	< 0.02
	21/09/2021	7.2		23.0			20					27							0.001	< 0.0005		0.003	< 0.0002	0.0132	< 0.02
	09/11/2021	7.1		20.0			16					27							0.003	0.0012		0.005	< 0.0002	0.0141	< 0.02
GDW06	24/03/2021	6.5		10.0			7					41					<0.00002		0.006	0.0022		0.008	<0.0002	0.0006	<0.02
	25/05/2021	6.4		12.0			3		15	49	11	32	2	370		0.5	5.6E-06		0.004	0.0024	0.0019	0.007	< 0.0002	0.0014	< 0.02
	21/09/2021	6.3		11.0			8					25							< 0.0002	0.0007		0.008	< 0.0002	0.0017	< 0.02
	09/11/2021	6.3		12.0			18					26							0.003	0.0006		0.011	< 0.0002	0.0044	< 0.02
GDW07	24/03/2021	6.8		13.0			10					83					0.0001		0.012	0.0016		0.003	0.0003	0.0042	<0.02
	25/05/2021	7.0		13.0			1		58	46	18	76	642	1100		0.7	7.9E-06	0.0000079	0.005	0.0005	0.012	0.003	< 0.0002	0.0025	< 0.02
	21/09/2021	6.8		18.0			5					85							0.000	< 0.0005		< 0.0005	< 0.0002	0.0008	< 0.02
	09/11/2021	6.8		26.0			23					74							0.004	0.0007		0.003	< 0.0002	0.0010	< 0.02
GDW08	24/03/2021	7.2		15.0			18					24					<0.00002		0.006	0.0011		0.004	<0.0002	0.0014	<0.02
	25/05/2021	7.2		14.0			14		24	64	17	25	1	630		0.9		<0.000005	0.003	0.0006	0.0019	0.002	< 0.0002	0.0021	< 0.02
	21/09/2021	6.9		14.0			8					20							< 0.0002	< 0.0005		0.006	< 0.0002	0.0090	< 0.02
	09/11/2021	6.9		13.0			20					23							0.002	< 0.0005		0.003	< 0.0002	0.0013	< 0.02
GDW09	24/03/2021	6.9		5.1			6					76					<0.00002		0.007	0.0010		0.006	0.0003	0.0064	<0.02
	25/05/2021	6.9		3.3			0		120	100	24	86	488	880		0.7		<0.000005	0.005	0.0007	0.0035	0.003	< 0.0002	0.0348	< 0.02
	21/09/2021	6.7		9.6			3					40							< 0.0002	< 0.0005		0.002	< 0.0002	0.0152	< 0.02
	09/11/2021	7.0		1.6			5					79							0.002	< 0.0005		0.003	< 0.0002	0.0118	< 0.02
GDW10	24/03/2021	7.1		9.3			8					33					<0.00002		0.005	0.0012		0.007	<0.0002	0.0024	<0.02
	25/05/2021	7.0		9.0			9		19	40	11	31	2	580		0.5		<0.000005	0.004	0.0007	0.0016	< 0.0005	0.0002	0.0035	< 0.02
	21/09/2021	7.1		7.9			6					30							< 0.0002	< 0.0005		0.003	< 0.0002	0.0028	< 0.02
	09/11/2021	7.1		8.6			16					31							0.004	0.0005		0.003	< 0.0002	0.0019	< 0.02
GDW11	24/03/2021	6.7		12.0			5					67					<0.00002		0.007	0.0011		0.007	<0.0002	0.0019	<0.02
	25/05/2021	6.9		12.0			12		23	61	10	67	1	540		1.0		<0.000005	0.002	0.0006	0.0015	0.002	< 0.0002	0.0008	< 0.02
	21/09/2021	6.7		11.0			7					62							< 0.0002	< 0.0005		0.002	< 0.0002	0.0059	< 0.02
	09/11/2021	6.8		11.0			9					57							0.003	0.0009		0.005	< 0.0002	0.0009	< 0.02
GDW12	24/03/2021	7.3		8.3			6					24					<0.00002		0.005	0.0011		0.005	<0.0002	0.0044	<0.02
	25/05/2021	7.4		8.1			10		64	20	38	25	1	540		0.5		<0.000005	0.002	0.0008	0.001	0.002	< 0.0002	0.0064	< 0.02
	21/09/2021	7.4		7.4			6					23							< 0.0002	0.0009		0.004	< 0.0002	0.0080	< 0.02

Sample Point	Date	pH	EC	NH_4-N	COD	BOD	TOC	Ca	Mg	Na	K	Cl	SO_4	Alkalinity	Fe	Mn	Cd	Hg	Cr	Cu	Ni	Zn	Pb	As	MCPP
			uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l
	09/11/2021	7.3		7.8			14					22							0.002	< 0.0005		0.002	< 0.0002	0.0063	< 0.02
GDW13	24/03/2021	6.8		35.0			10					130					<0.00002		0.009	0.0025		0.009	0.0003	0.0005	<0.02
	25/05/2021	6.8		32.0			12		57	110	32	120	1	800		1.6		<0.000005	0.004	0.0013	0.0014	0.002	< 0.0002	0.0006	< 0.02
	21/09/2021	6.8		34.0			6					120							< 0.0002	< 0.0005		0.003	< 0.0002	0.0041	< 0.02
	09/11/2021	6.8		31.0			8					120							0.005	0.0016		0.002	< 0.0002	0.0017	< 0.02
GDW14	24/03/2021	7.0		14.0			7					57					<0.00002		0.005	0.0023		0.008	<0.0002	0.0018	<0.02
	25/05/2021	7.1		15.0			8		36	60	30	66	2	580		0.9		<0.000005	0.002	0.0035	0.0026	0.003	< 0.0002	0.0017	< 0.02
	21/09/2021	7.0		18.0			10					76							0.000	0.0013		0.004	< 0.0002	0.0018	< 0.02
	09/11/2021	7.0		19.0			21					81							0.005	0.0025		0.003	< 0.0002	0.0029	< 0.02
GDW15	24/03/2021	6.5		14.0			25					110					<0.00002		0.005	0.0026		0.007	0.0002	0.0013	<0.02
	25/05/2021	6.5		9.9			25		26	84	41	96	4	380		0.6		<0.000005	0.006	0.0023	0.0021	0.003	0.0003	0.0012	< 0.02
	21/09/2021	6.4		12.0			26					100							0.000	0.0016		0.003	0.0002	0.0017	< 0.02
	09/11/2021	6.4		9.4			31					100							0.004	0.0024		0.002	< 0.0002	0.0012	< 0.02
GDW16	24/03/2021	6.0		1.2			12					47					<0.00002		0.004	0.0016		0.006	0.0007	0.0023	<0.02
	25/05/2021	5.9		1.2			7		13	48	7	58	3	150		0.3		0.0000067	0.002	0.0011	0.0013	0.003	0.0007	0.0017	< 0.02
	21/09/2021	6.0		1.6			18					54							0.000	0.0010		0.004	0.0008	0.0025	< 0.02
	09/11/2021	6.1		0.5			6					35							0.001	0.0008		0.003	< 0.0002	0.0011	< 0.02
GDW17	24/03/2021	6.1		3.2			2					230					<0.00002		0.006	0.0018		0.005	0.0002	0.0060	<0.02
	25/05/2021	6.1		3.2			11		21	110	11	230	1	220		1.0		0.0000065	0.003	0.0012	0.0028	0.004	< 0.0002	0.0027	< 0.02
	21/09/2021	6.0		3.7			17					210							< 0.0002	0.0007		0.005	0.0006	0.0044	< 0.02
	09/11/2021	6.4		0.8			16					170							0.002	0.0006		0.004	< 0.0002	0.0023	< 0.02
GDW18	24/03/2021	7.1		18.0			5					67					<0.00002		0.005	0.0013		0.003	0.0002	0.0350	<0.02
	25/05/2021	7.2		18.0			7		34	67	31	70	6	580		0.9		0.0000051	0.004	0.0011	0.0026	0.003	< 0.0002	0.0242	< 0.02
	21/09/2021	7.1		16.0			7					95							0.000	0.0024		0.002	< 0.0002	0.0056	< 0.02
	09/11/2021	7.2		12.0			7					64							0.002	< 0.0005		0.002	< 0.0002	0.0124	< 0.02

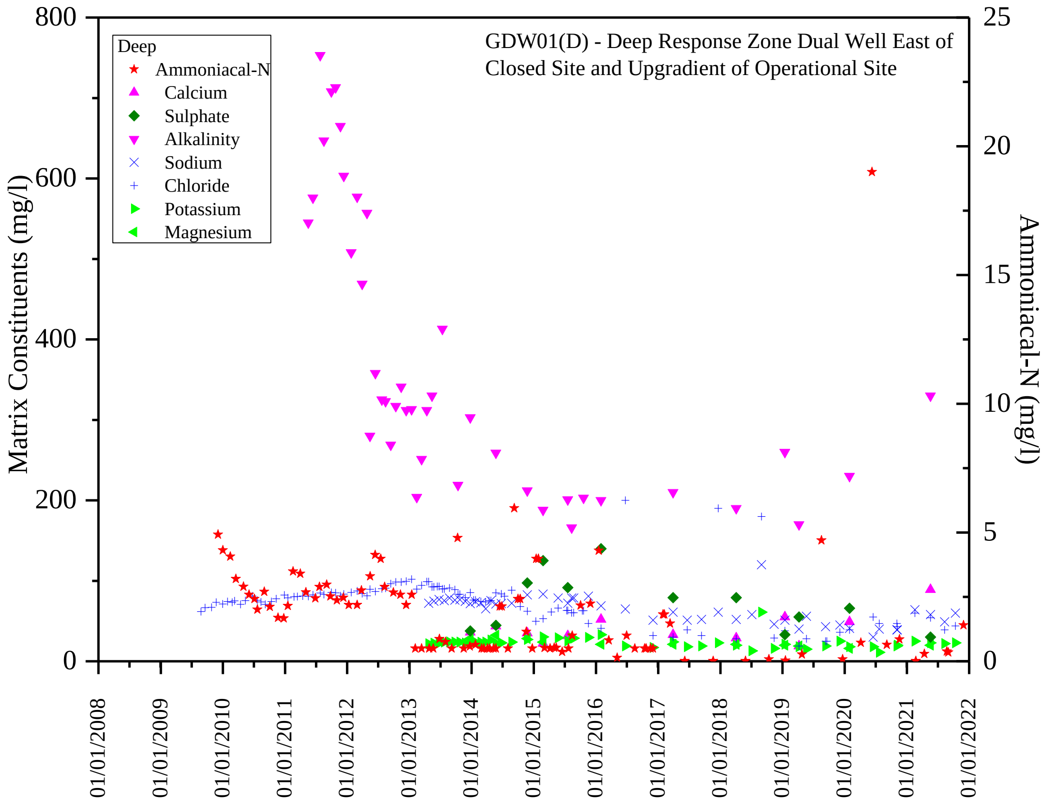


Figure C.1 – Groundwater Monitoring Point GDW01D

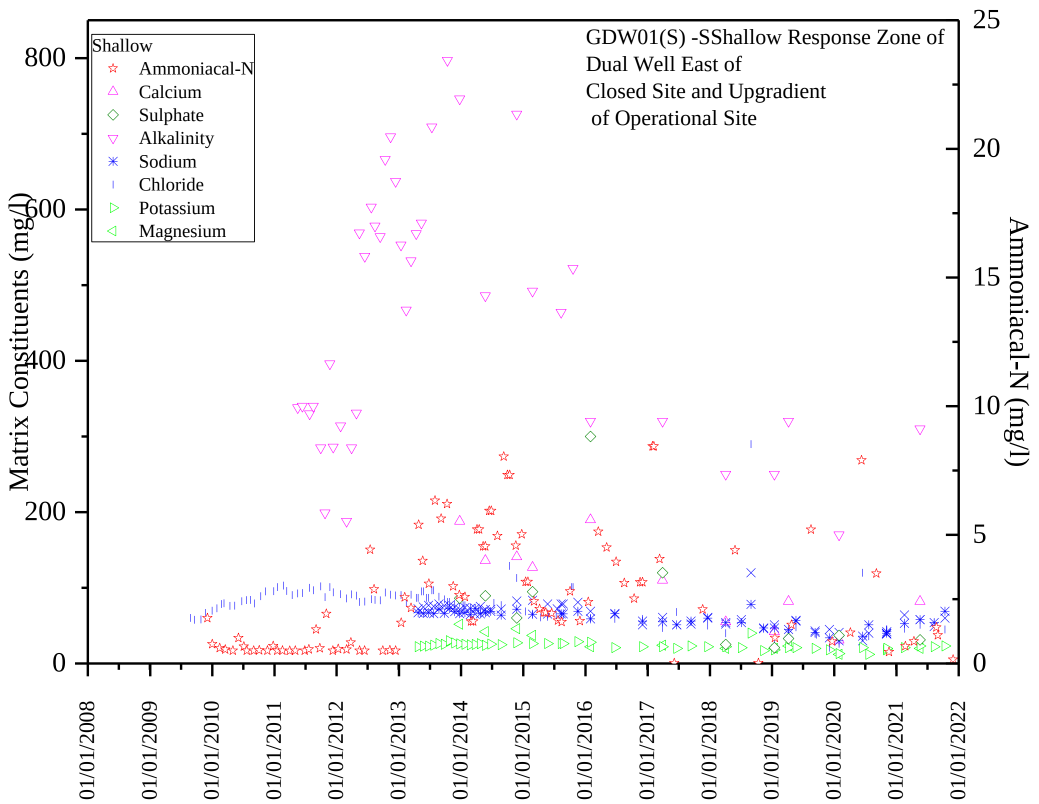


Figure C.2 – Groundwater Monitoring Point GDW01S

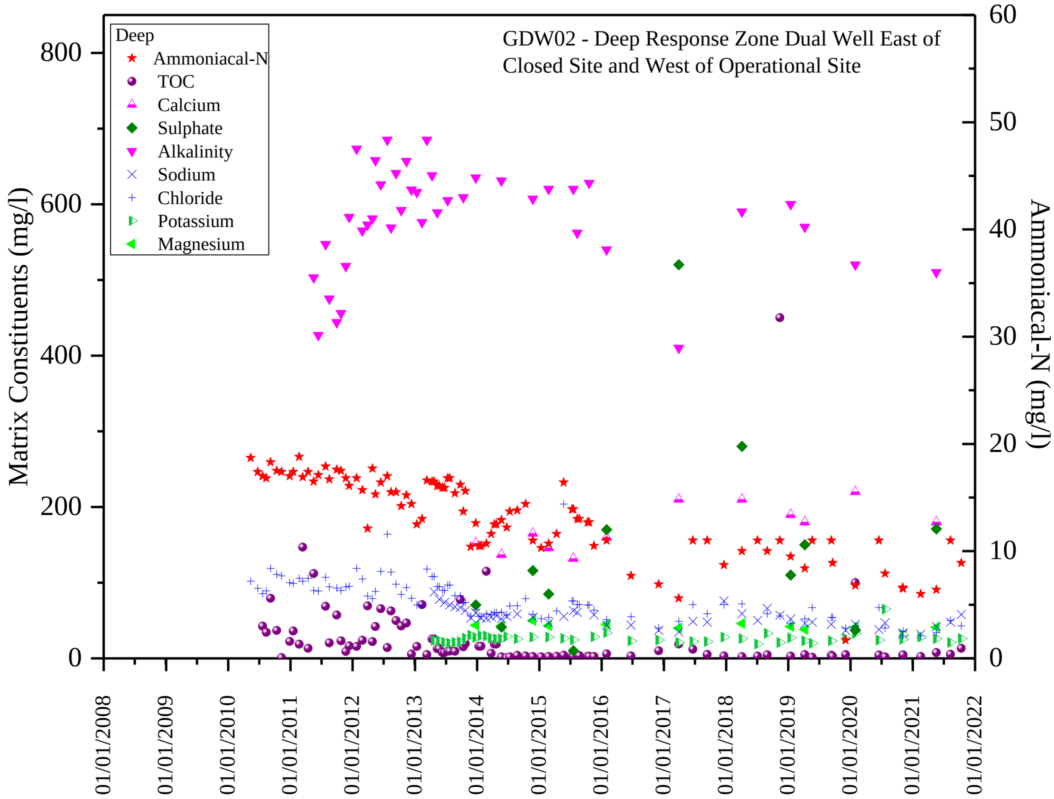


Figure C.3 – Groundwater Monitoring Point GDW02D

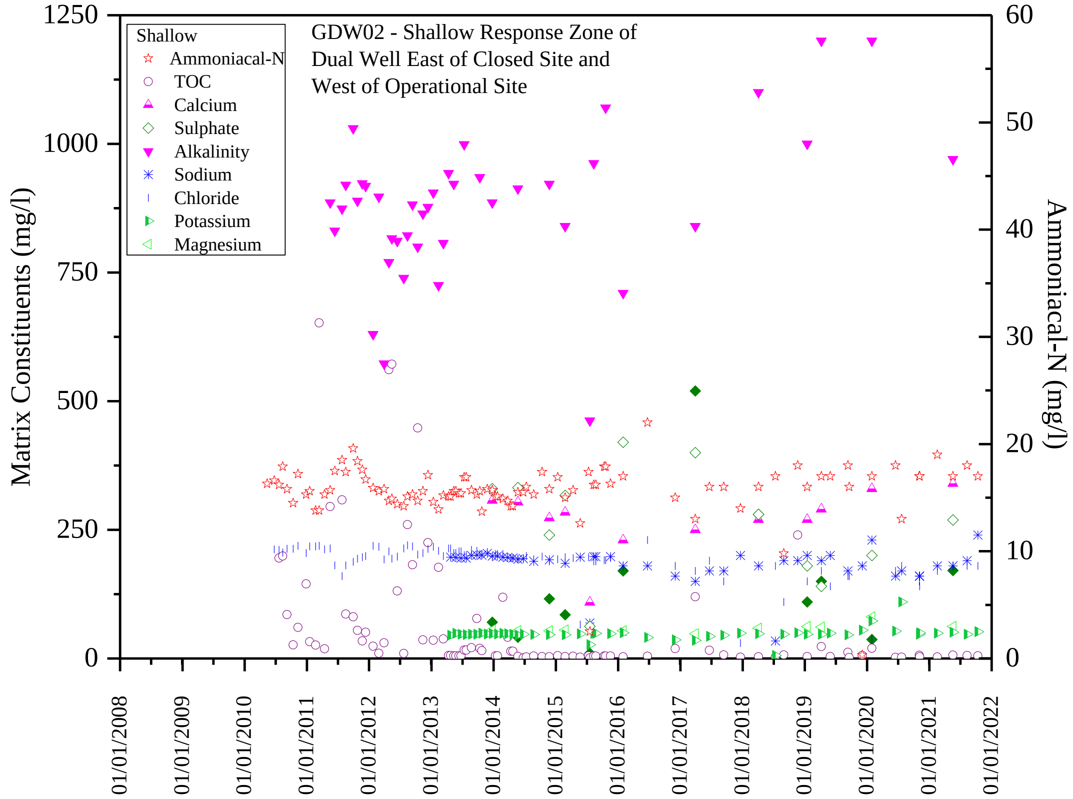


Figure C.4 – Groundwater Monitoring Point GDW02S

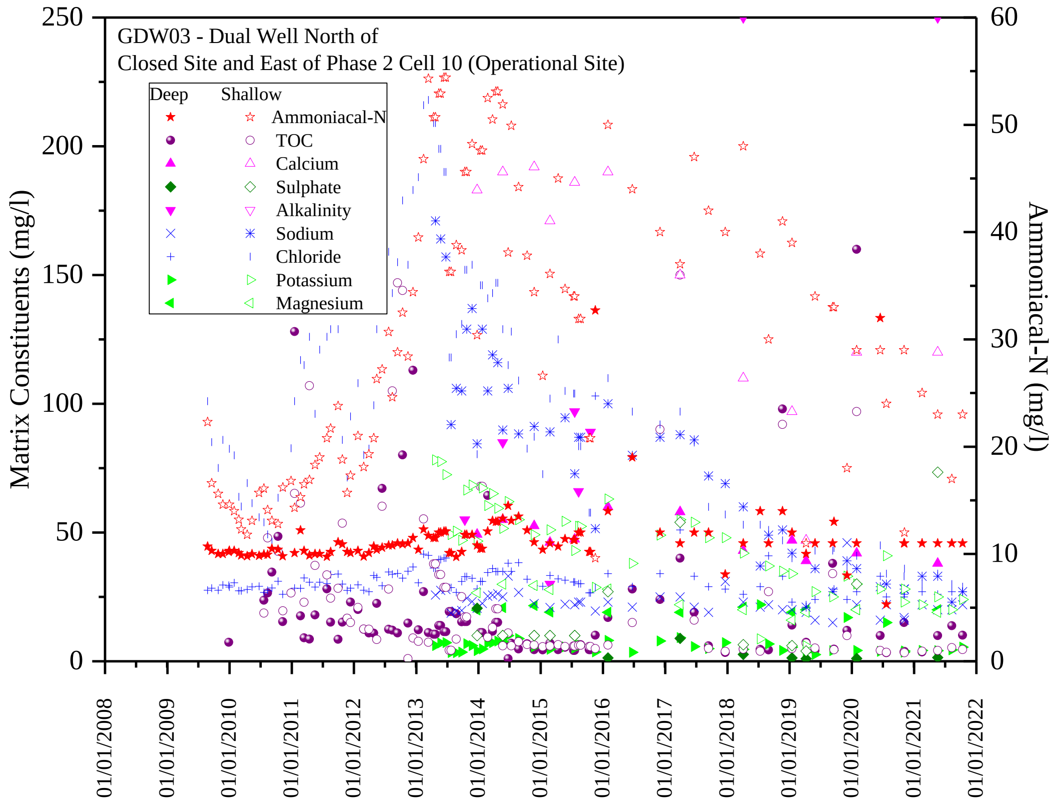


Figure C.5 – Groundwater Monitoring Point GDW03

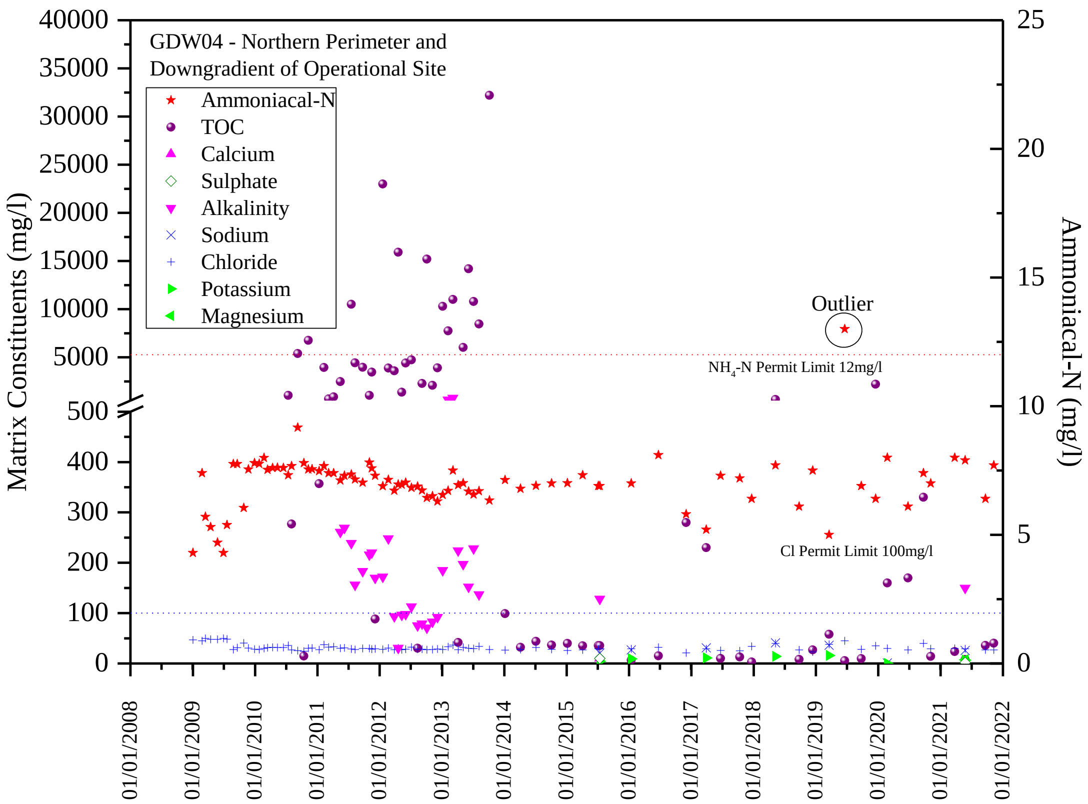


Figure C.6 – Groundwater Monitoring Point GDW04

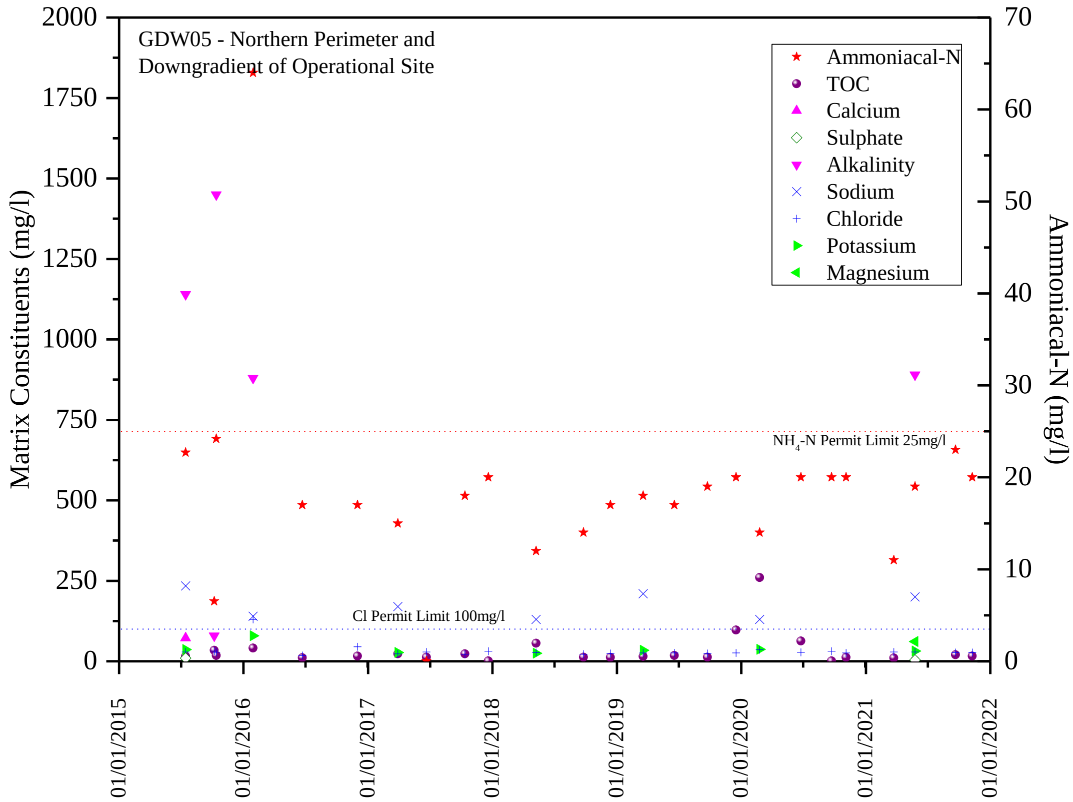


Figure C.7 – Groundwater Monitoring Point GDW05

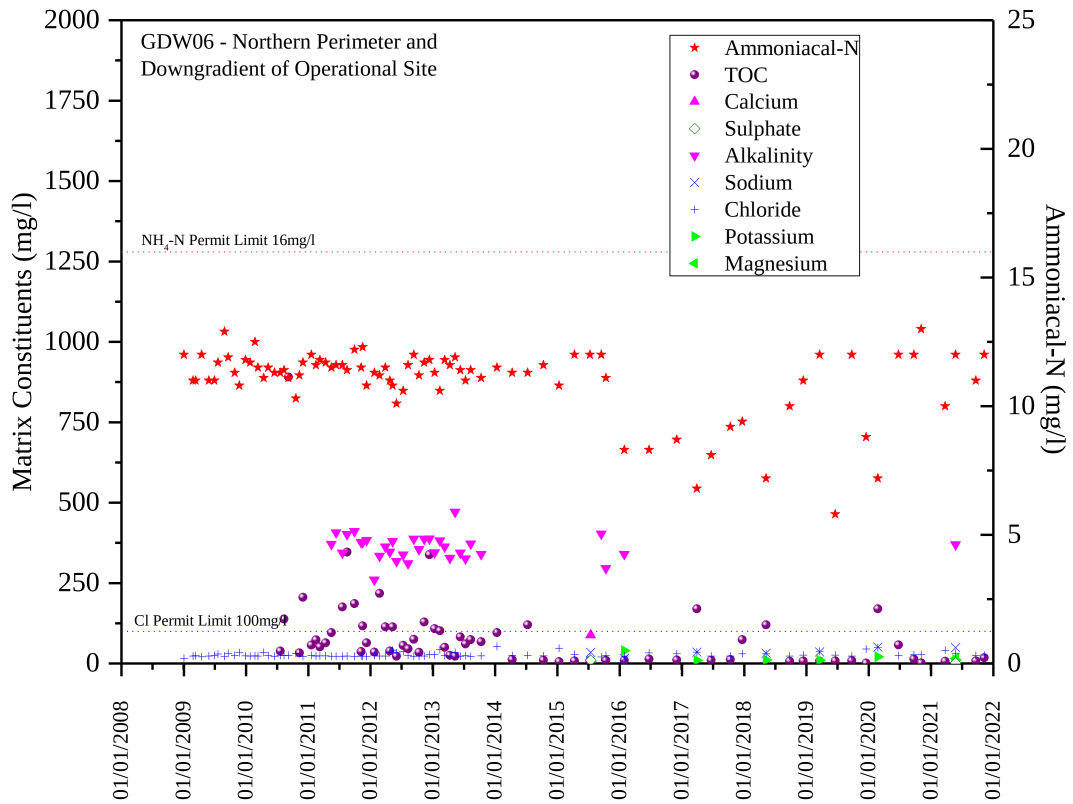


Figure C.8 – Groundwater Monitoring Point GDW06

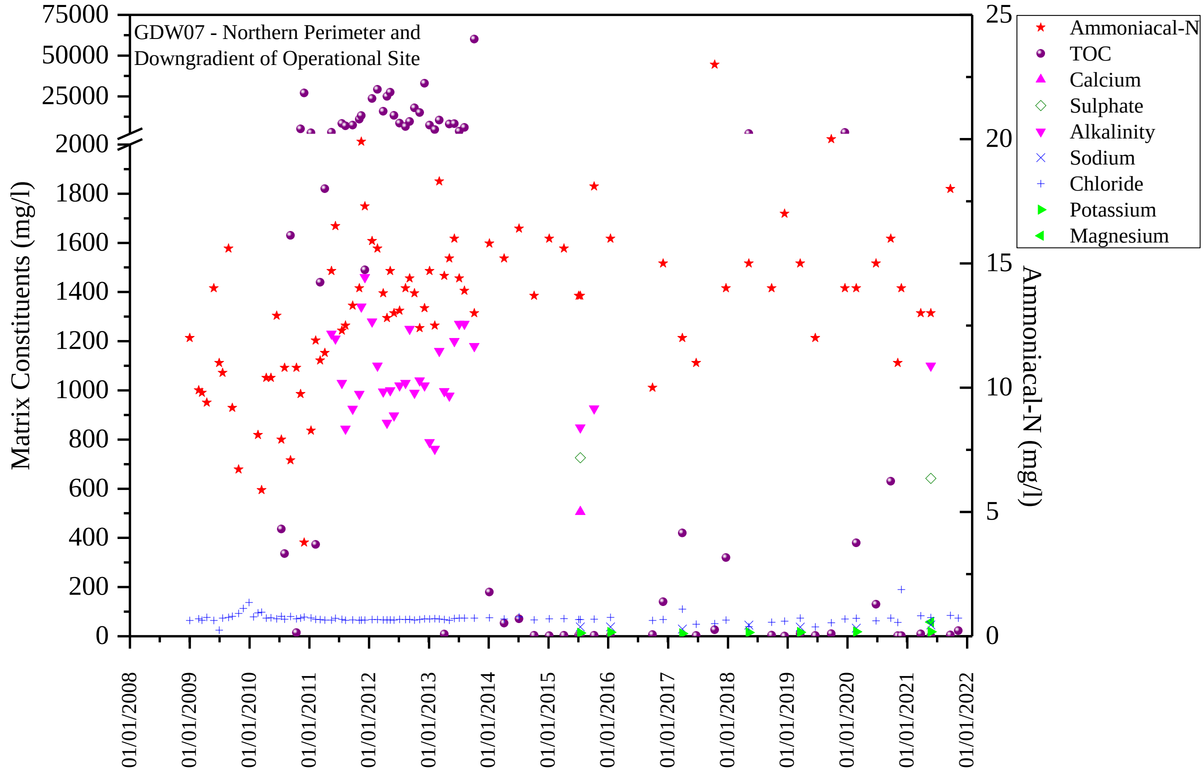


Figure C.9 – Groundwater Monitoring Point GDW07

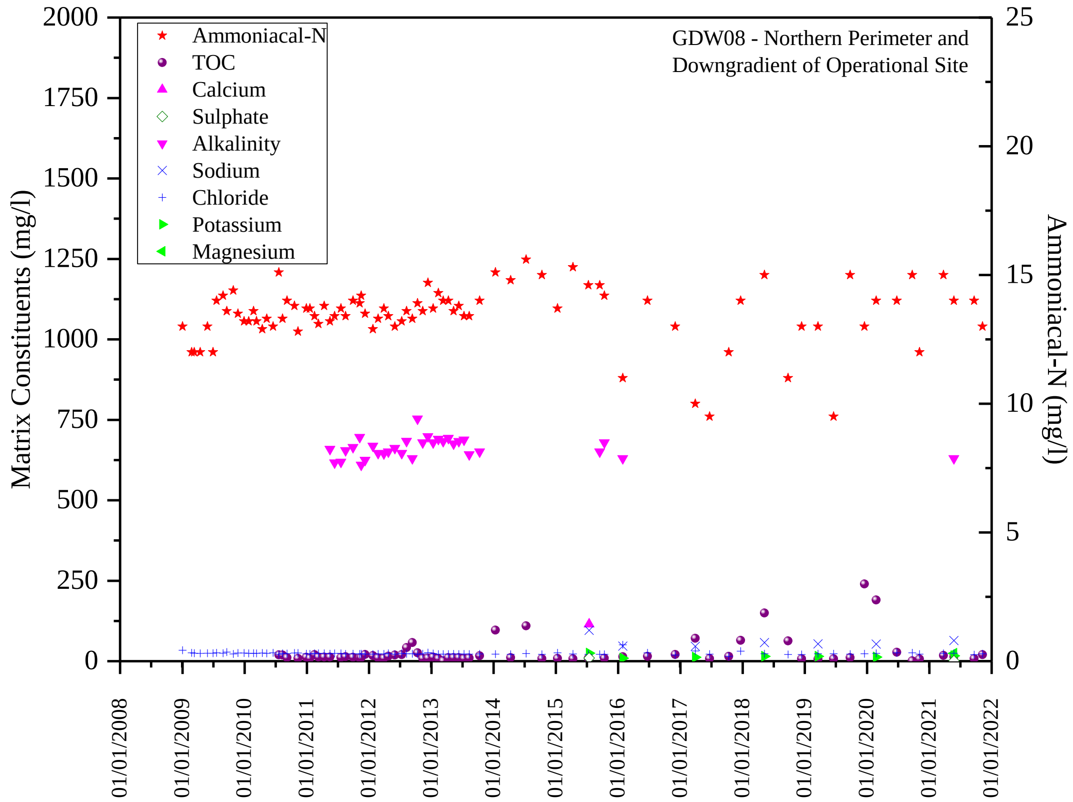


Figure C.10 – Groundwater Monitoring Point GDW08

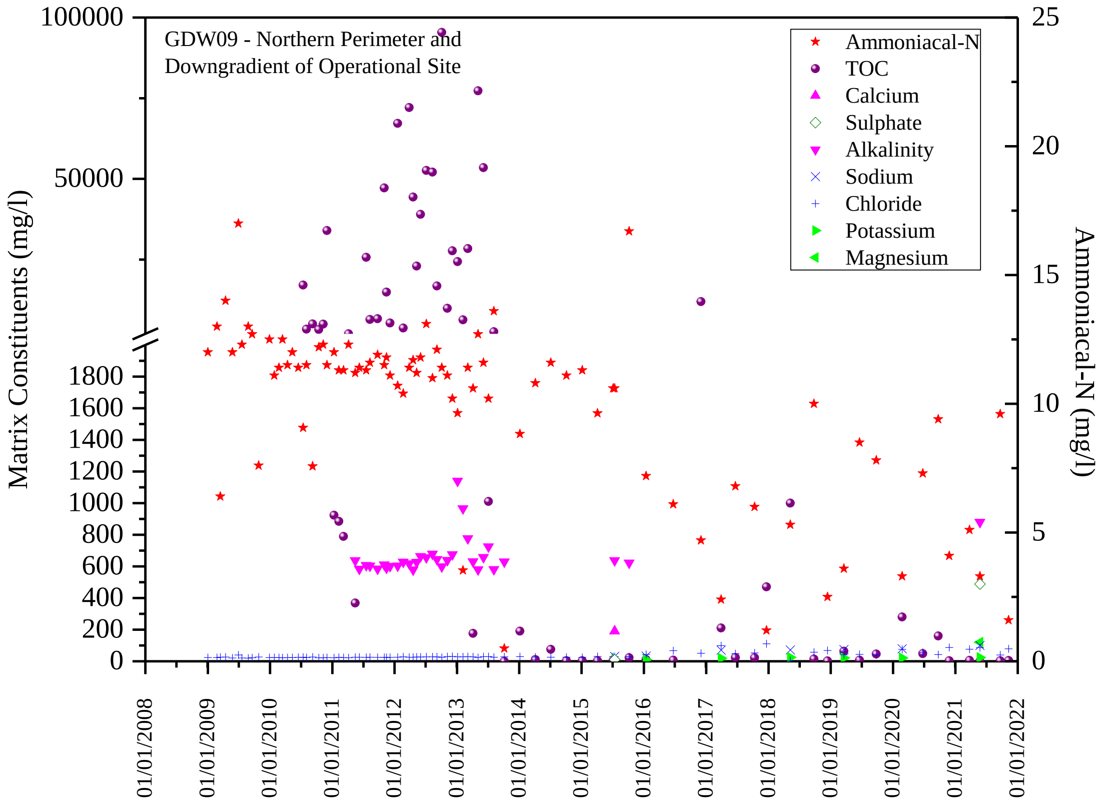


Figure C.11 – Groundwater Monitoring Point GDW09

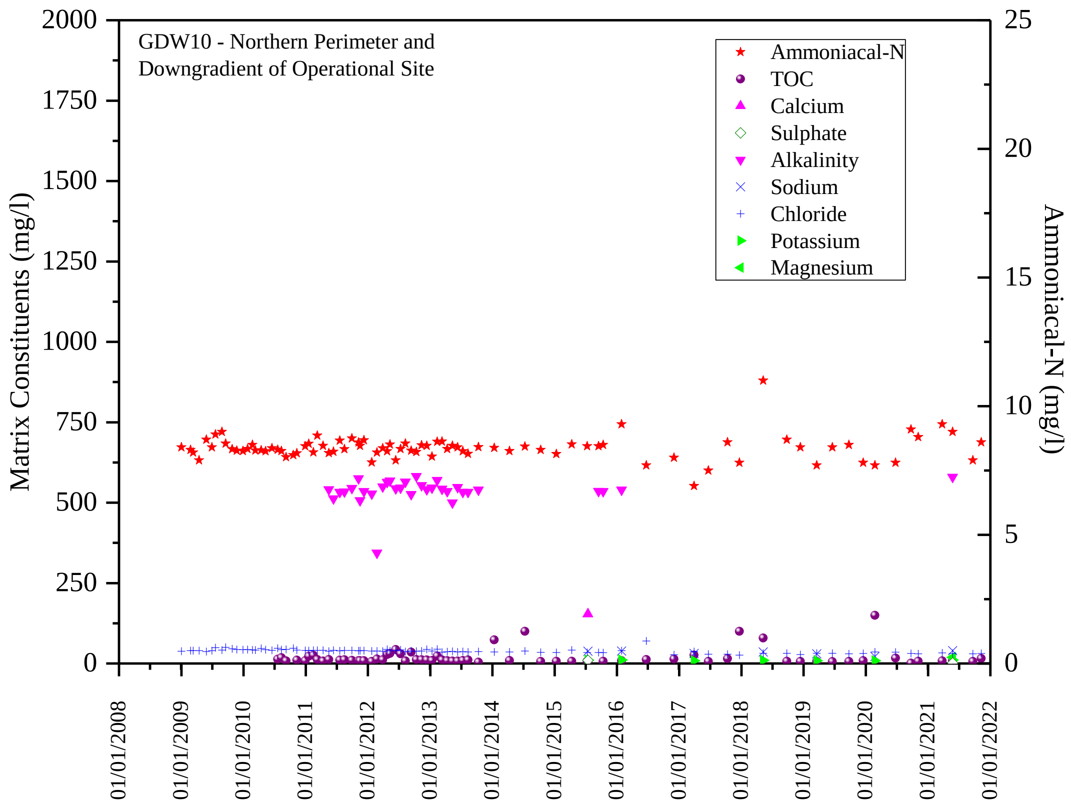


Figure C.12 – Groundwater Monitoring Point GDW10

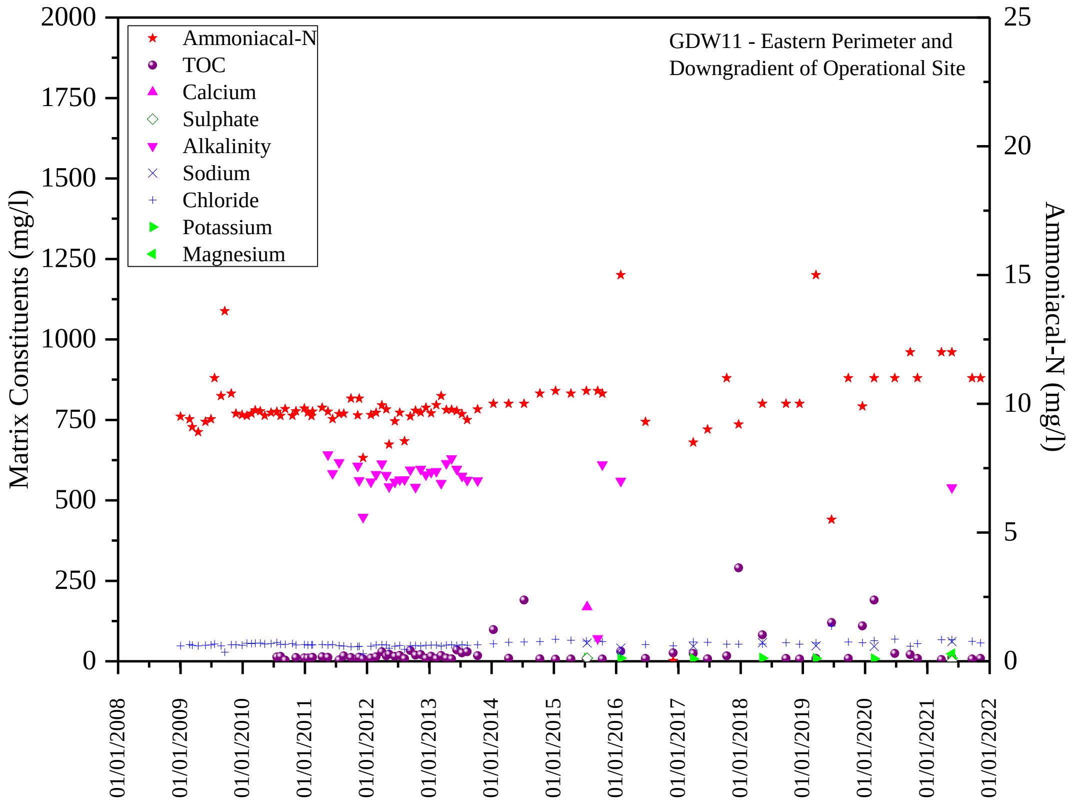


Figure C.13 – Groundwater Monitoring Point GDW11

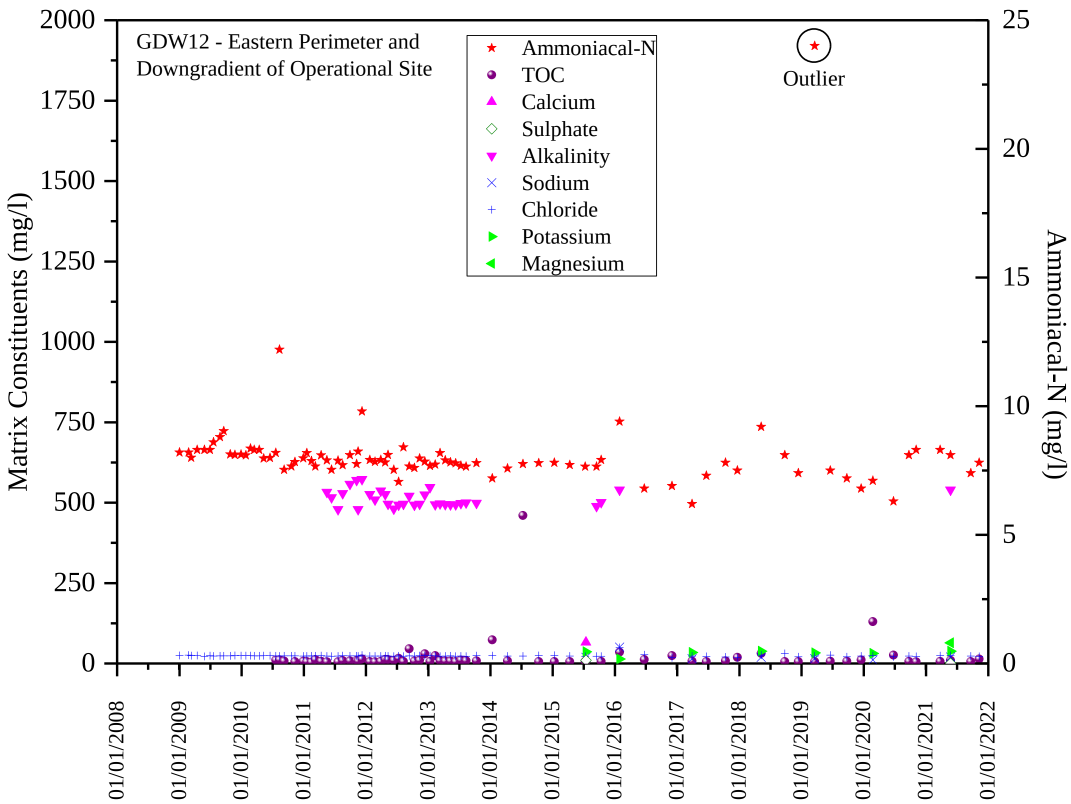


Figure C.14 – Groundwater Monitoring Point GDW12

BYRNELOOBY

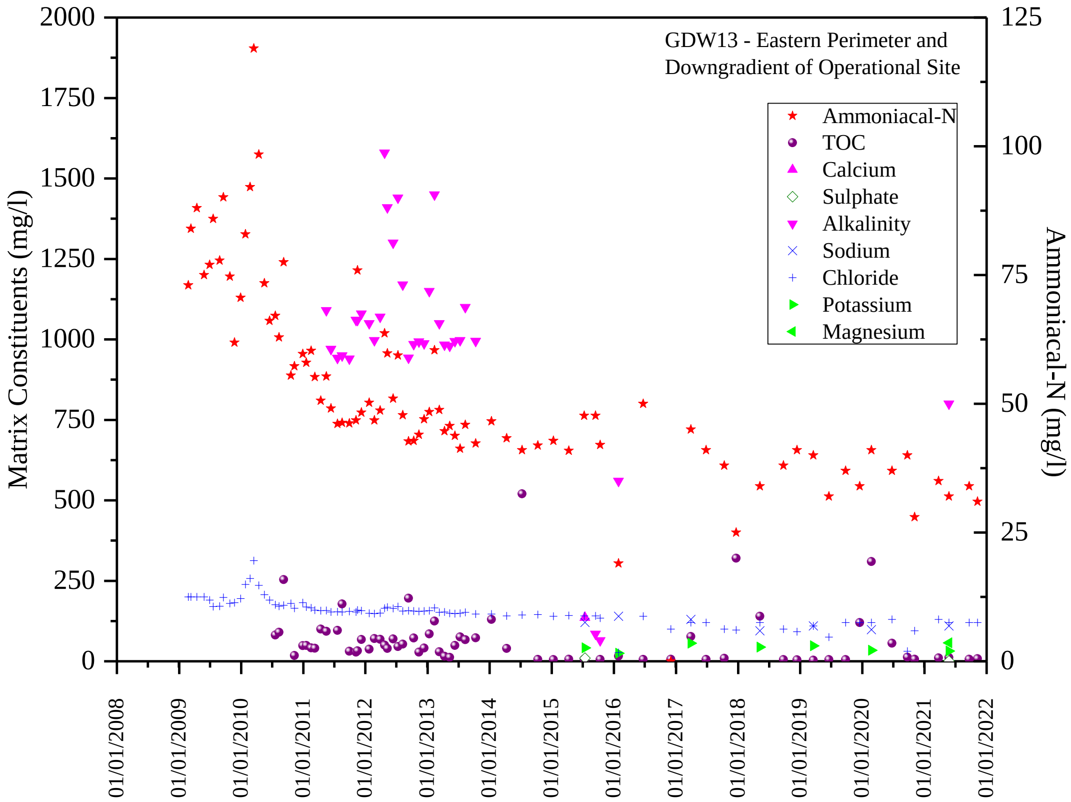


Figure C.15 – Groundwater Monitoring Point GDW13

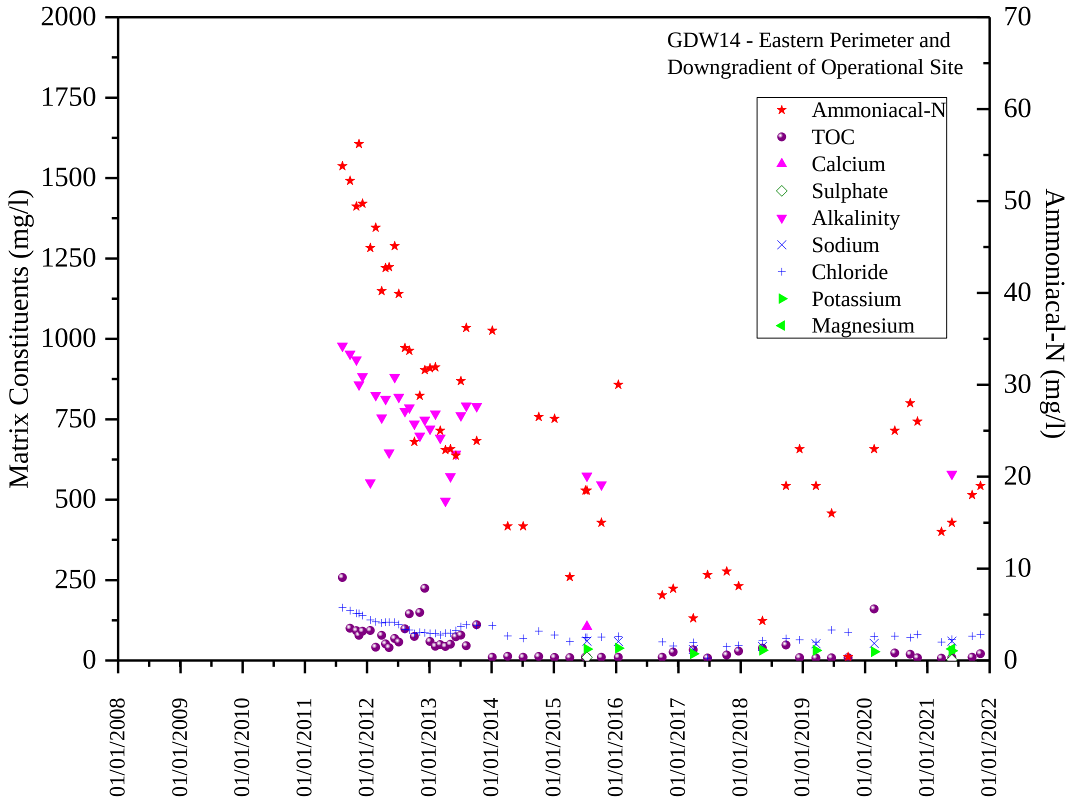


Figure C.16 – Groundwater Monitoring Point GDW14

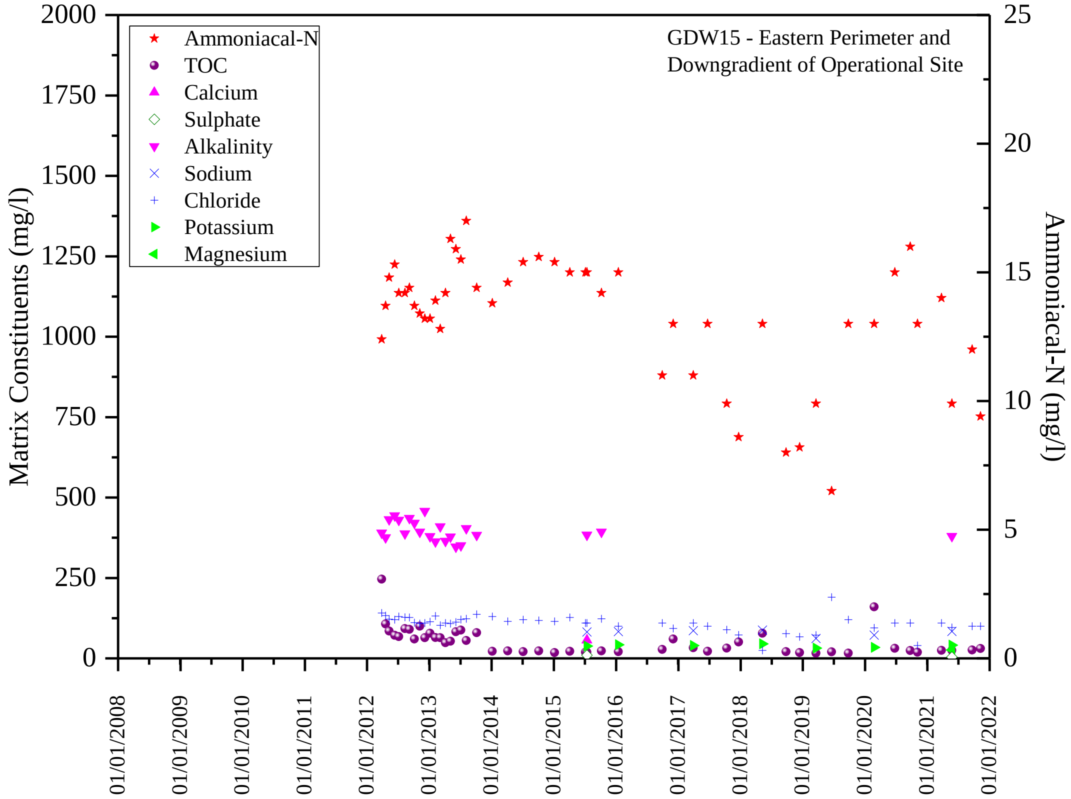


Figure C.17 – Groundwater Monitoring Point GDW15

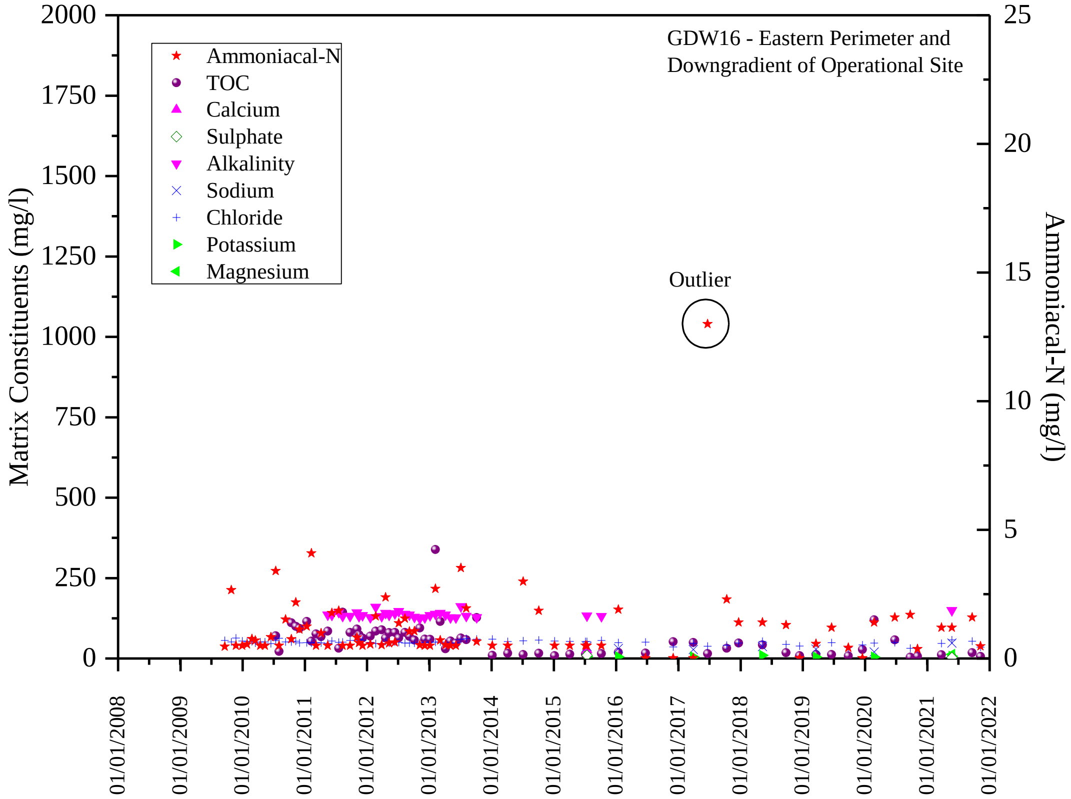


Figure C.18 – Groundwater Monitoring Point GDW16

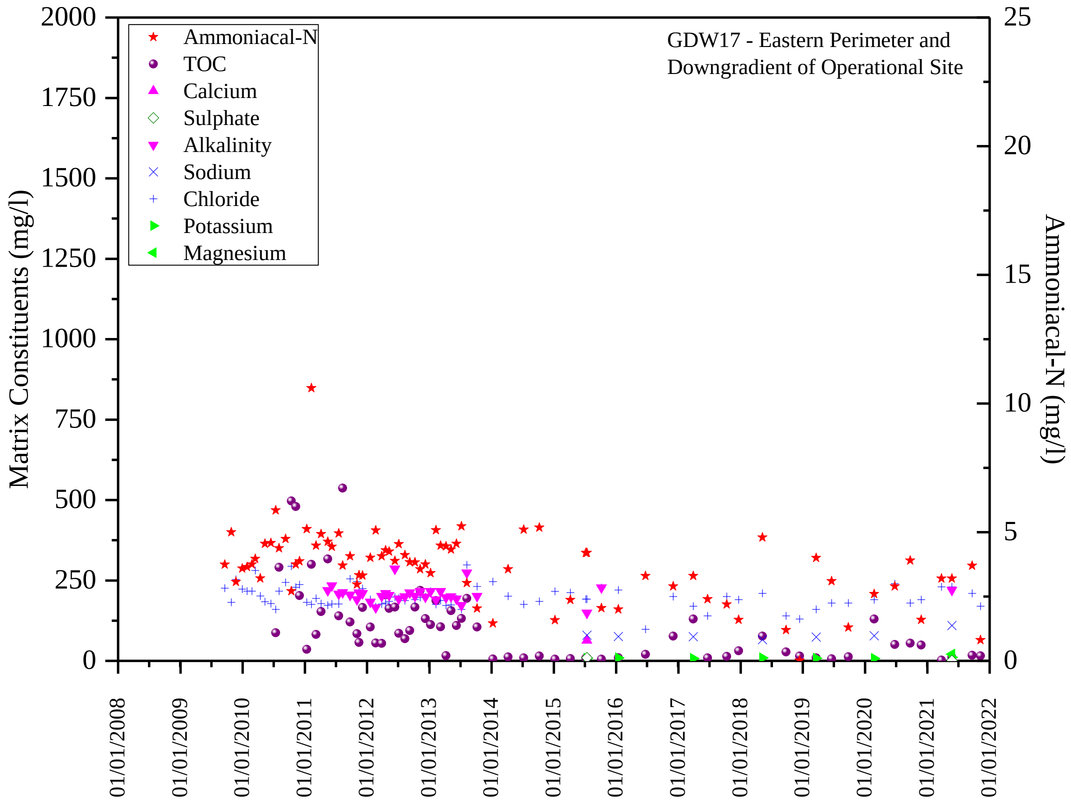


Figure C.19 – Groundwater Monitoring Point GDW17

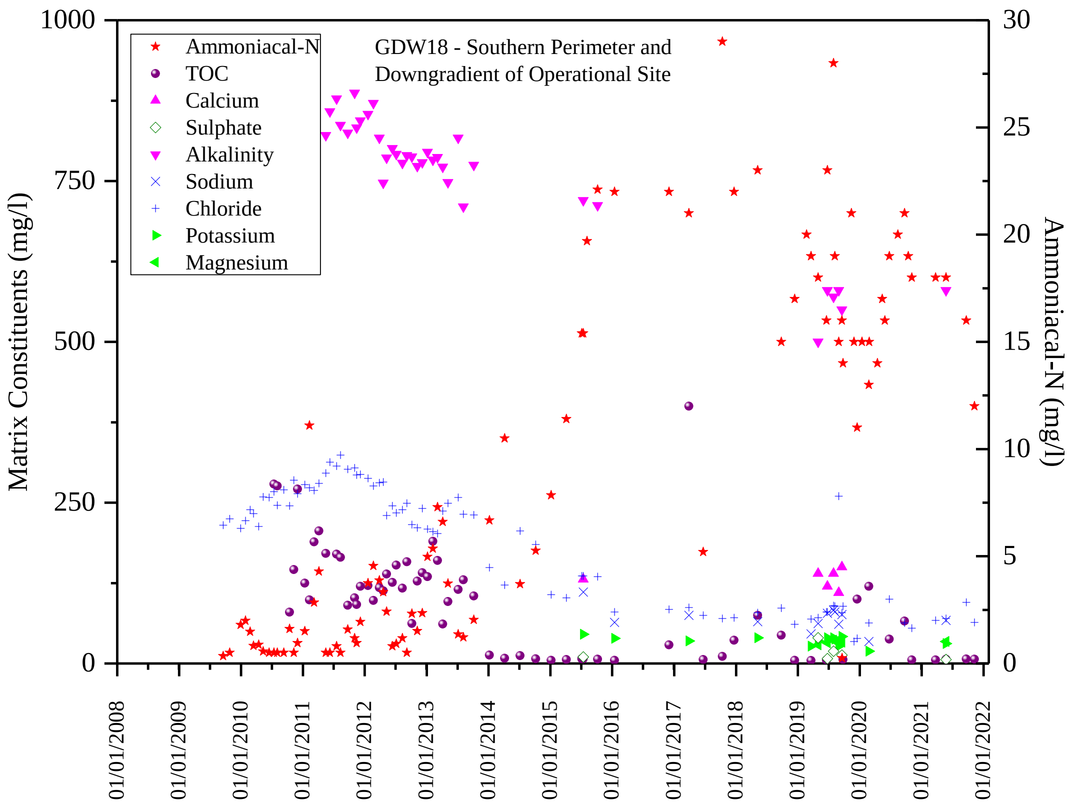


Figure C.20 – Groundwater Monitoring Point GDW18

Tir John Landfill Site
Surface Water Quality Summary January - December 2021

Sample Point	Date	pH	NH_4-N	BOD	COD	Na	K	Cl	SO_4	Alk	Fe	Mn	Cr	Cu	Ni	Zn	Pb	Susp. Solids
			mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
SW1	08/01/2021	8.1	0.04	3	5			24										6
	03/02/2021	8.4	0.02	1	6			12										4
	24/03/2021	7.3	1.00	4	26			17										9
	26/05/2021	7.8	< 0.015	1	16			22										68
	28/09/2021	8.0	0.04	< 1	24			20										2
	20/10/2021	8.0	0.04	< 1	8			23										26
	09/11/2021	7.9	0.02	< 1	10	12	3	21	40	130	0.016	0.018	0.0011	0.008	0.002	0.016	0.0006	4
	06/12/2021	8.1	0.03	< 1	15			24										18
SW2	08/01/2021	7.3	5.40	6	6			37										6
	03/02/2021	8.2	3.60	8	10			35										7
	24/03/2021	7.2	2.90	5	8			34										18
	27/04/2021	7.3	0.86	6	15			33										13
	25/05/2021	7.3	3.60	4	9			34										12
	08/06/2021	7.3	2.50	1	14			32										5
	27/07/2021	7.7	3.90	5	19			30										25
	18/08/2021	7.5	3.60	< 1	16			30										< 2
	28/09/2021	7.6	1.40	3	23			25										14
	20/10/2021	7.5	1.70	1	19			26										6
	09/11/2021	7.3	4.40	< 1	12	25	16	32	64	370	0.009	1.400	0.0009	0.013	0.005	0.016	0.0008	10
	06/12/2021	7.3	3.80	< 1	14			33										12
SW3	08/01/2021	7.3	0.08	<1	10			22										<2
	03/02/2021	7.8	0.04	4	10			18										<2
	24/03/2021	7.2	0.17	1	10			24										4
	27/04/2021	7.5	5.60	7	15			54										11
	25/05/2021	7.3	< 0.015	< 1	8			21										< 2
	08/06/2021	7.1	0.09	< 1	15			22										< 2
	27/07/2021	7.6	6.70	10	20			44										19
	18/08/2021	7.2	0.18	< 1	15			22										< 2
	28/09/2021	7.3	0.15	< 1	22			25										2
	20/10/2021	7.3	0.05	< 1	23			19										< 2
	09/11/2021	7.4	0.04	< 1	30	14	4	20	24	84	0.046	0.008	0.0004	0.008	0.002	0.017	0.0023	18
	06/12/2021	7.4	0.04	< 1	33			27										33
SW4	08/01/2021	7.4	14.00	<1	17			56										5
	03/02/2021	8.1	11.00	5	17			50										23
	24/03/2021	7.4	19.00	4	21			71										13
	27/04/2021	7.5	20.00	8	30			91										37
	25/05/2021	7.6	12.00	6	7			61										6
	08/06/2021	7.7	24.00	2	29			75										3
	27/07/2021	8.0	18.00	3	30			85										5
	18/08/2021	7.9	25.00	2	31			82										< 2
	28/09/2021	7.9	31.00	< 1	33			110										7
	20/10/2021	7.6	19.00	4	21			62										13
	09/11/2021	7.6	11.00	< 1	13	46	20	43	38	450	0.022	0.800	0.0009	0.005	0.004	0.008	0.0003	11
	06/12/2021	7.8	11.00	4	28			45										10

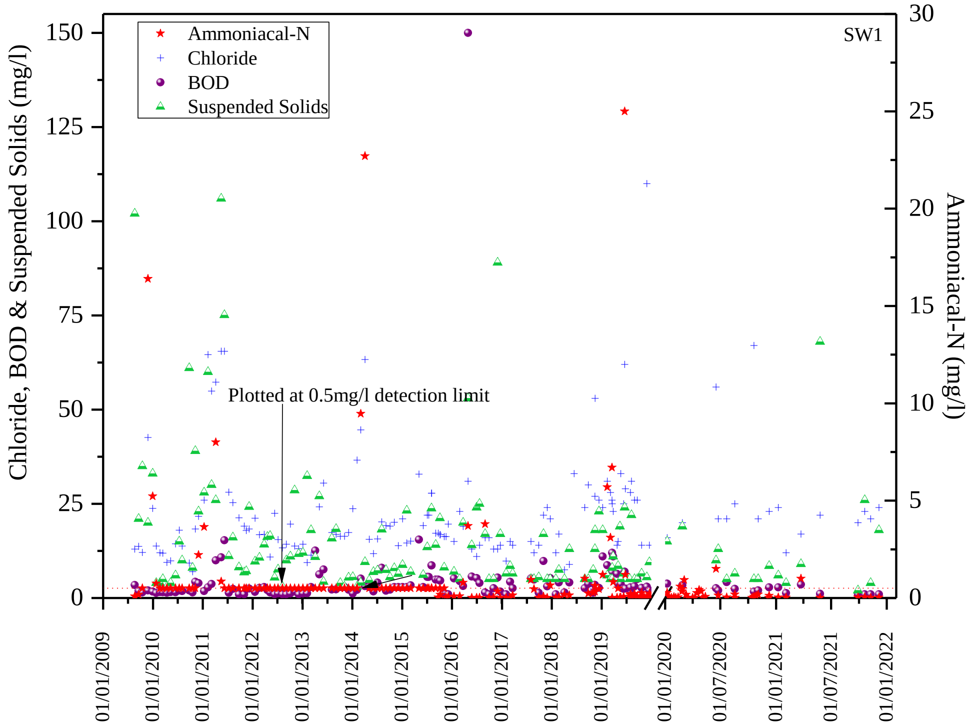


Figure C.21– Surface Water Monitoring Point SW1

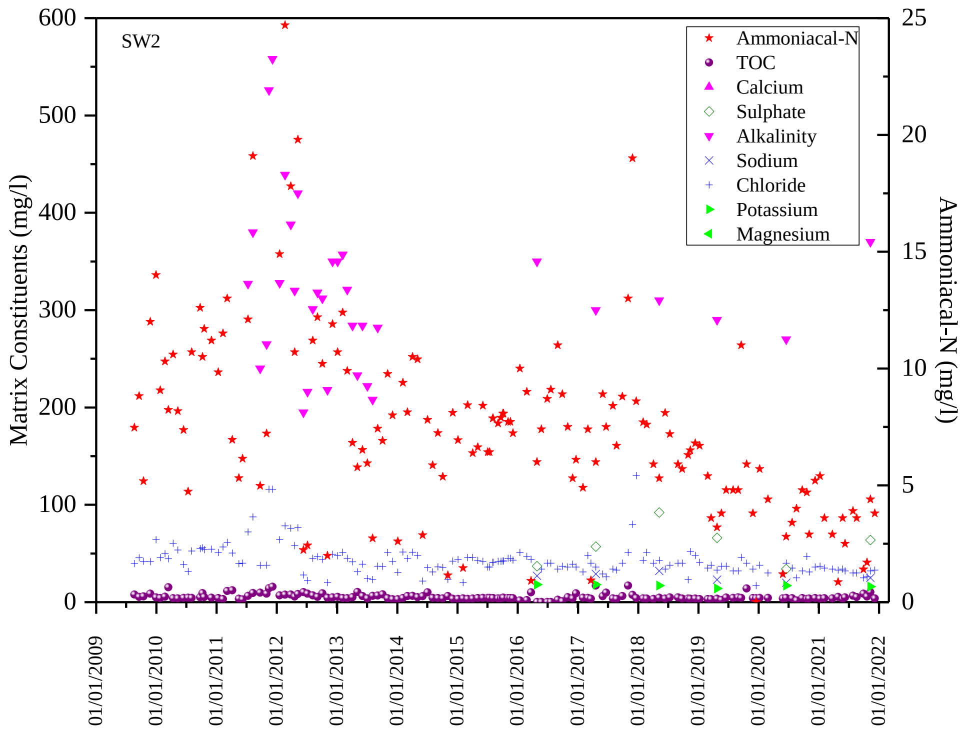


Figure C.22 – Surface Water Monitoring Point SW2

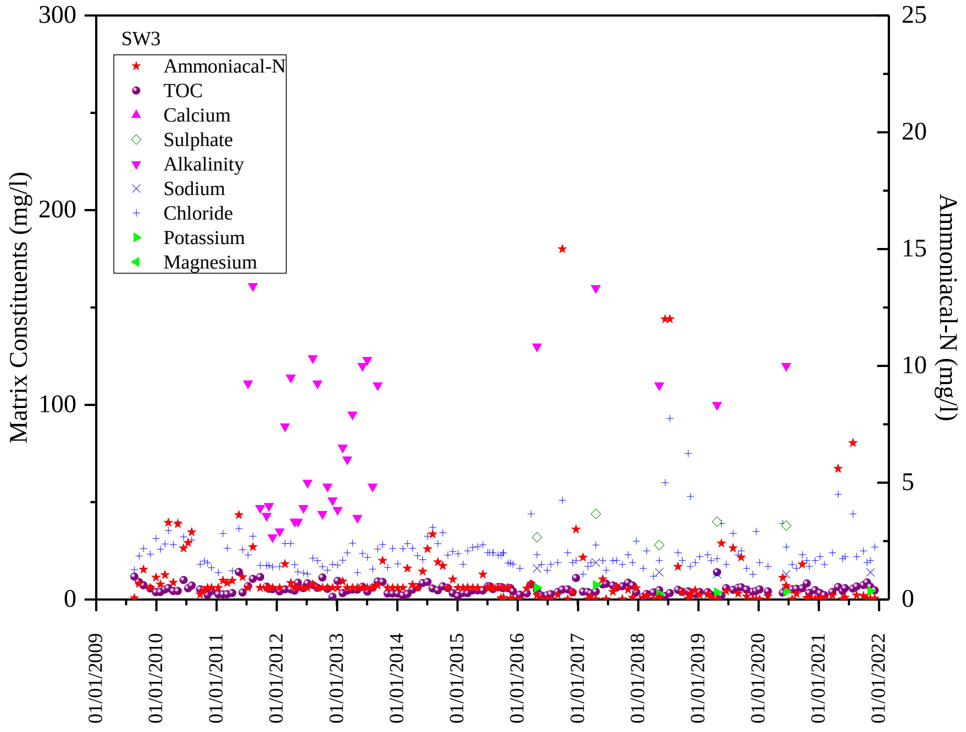


Figure C.23 – Surface Water Monitoring Point SW3

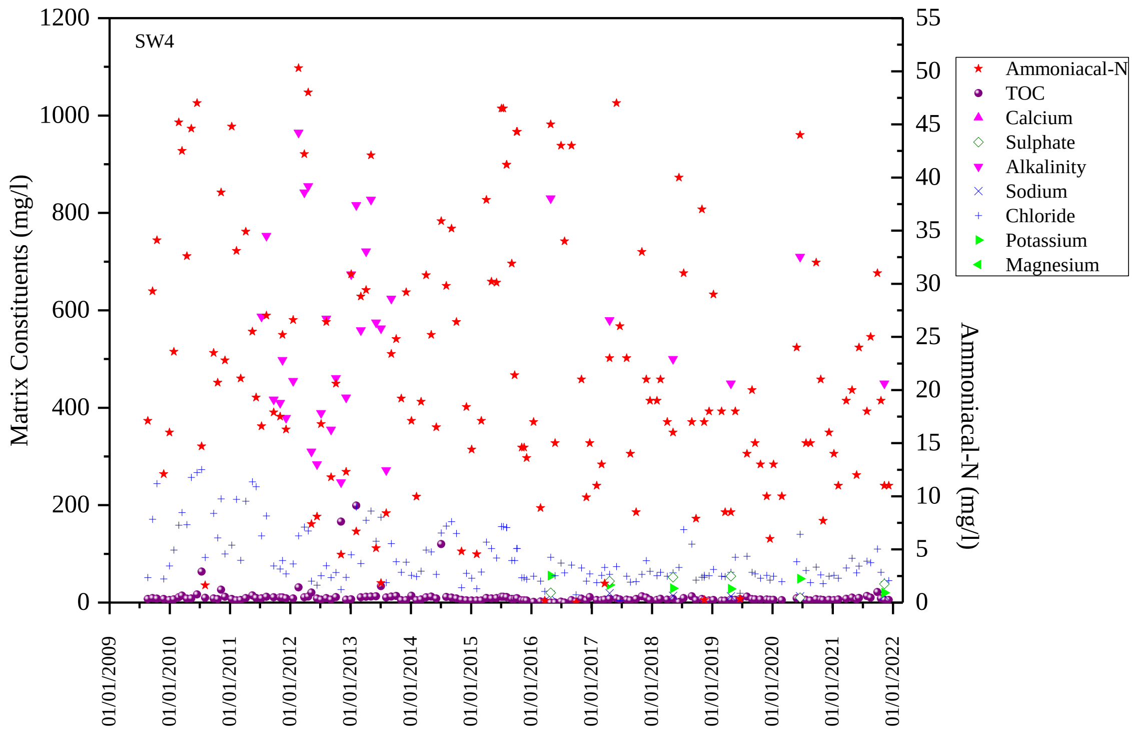
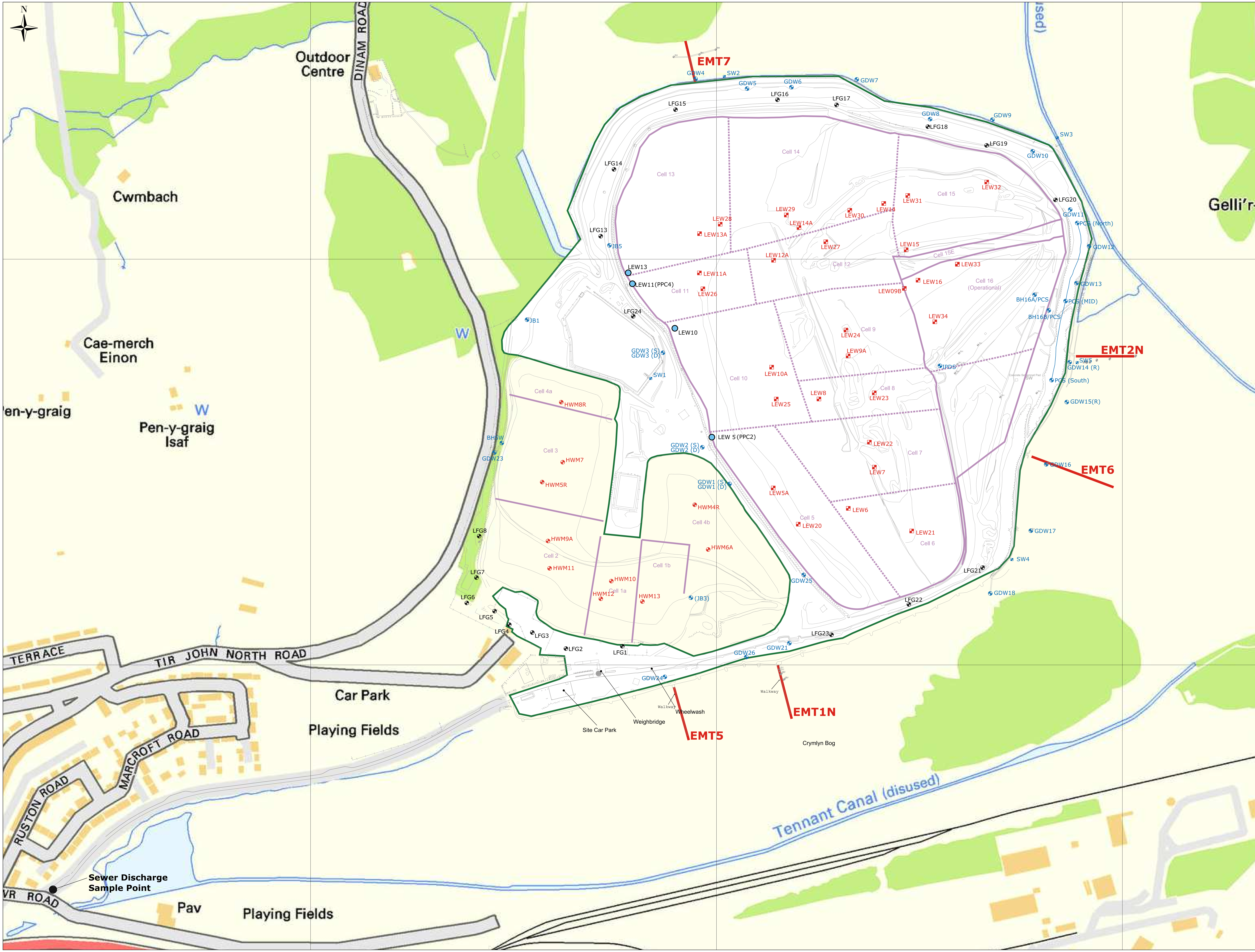


Figure C.24 – Surface Water Monitoring Point SW4

Drawings



Key

- Permit Boundary
- Leachate extraction sump
- Leachate monitoring well
- Surface water monitoring point
- Ground water monitoring borehole
- Gas monitoring borehole
- Drainage sump
- ( ) Not in use

Enovert

Units 3-5 Greyfriars Business Park,
Frank Foley Way, Stafford, ST16 2ST
Tel: 01785 251555

Site: **TIR JOHN**

Title: **Environmental Monitoring Locations**

Drawn:	Date:	Scale @A1:
TJG	18-1-22	1:2000

Drawing number: **TJ66**

TIR JOHN
FID Survey Dated 15-12-21

Key

- Permit Boundary
- Settlement Calculation Location
- 5m contour line
- 1m contour line

Tir John Settlement Dec 20 to Feb 22								
			Dec-20	Feb-22				
Point	E	N	10/02/2020	11/02/2022	Basal	**Settlement**	Depth of Waste	**Settlement**
	(m)	(m)	(mAOD)	(mAOD)	(mAOD)	**(m)**	(m)	**(%)**
1	269161.6	193897.6	38.661	38.286	10.983	0.375	27.678	1.4%
2	269131.8	193977.9	37.543	37.31	10.367	0.233	27.176	0.9%
3	269225.9	194055.8	32.783	32.574	10.507	0.209	22.276	0.9%

Enovert

Units 3-5 Greyfriars Business Park,
Frank Foley Way, Stafford,
ST16 2ST
Tel: 01785 251555

Revision: Details:

Site: **TIR JOHN**

Title: **Site Survey**

Drawn	Date:	Scale @A4:
TJG	23-2-22	1:5000

Drawing number **TJ67**

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