



**REVIEW OF ENVIRONMENTAL MONITORING
RESULTS AT THE
NANT-Y-GWYDDON LANDFILL SITE DURING THE
PERIOD JAN 17 – DEC 17**

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Executive Summary

Amgen Rhondda Ltd. has carried out a review of the results of environmental monitoring activities undertaken at the Nant-y-Gwyddon landfill site, during 2017.

The submission to the Environment Agency (EA) of a periodic review of environmental monitoring results is required under Section 7.4 of the site Waste Management Licence. It is outlined in this document that such a review should include:

- a) An analysis and review of the environmental monitoring results recorded for the site under these conditions, with an interpretation of the trend of the results against background and trigger level and reference standards;*
- b) A review of a risk assessment for the site, taking account of the findings under (a).*

The purpose of this report is to review the environmental performance of the Nant-y-Gwyddon Landfill over the previous 12 months and to fulfil the above requirement of Section 7.4 of the site licence.

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**REVIEW OF ENVIRONMENTAL PERFORMANCE
of
NANT-Y-GWYDDON LANDFILL SITE, GELLI, RHONDDA.**

1. INTRODUCTION

1.1 Terms of Reference and Context

As the site licence holder for the Nant-y-Gwyddon Landfill Site (Gelli, Rhondda Cynon Taff), Amgen Rhondda Ltd. (ARL) has continued Environmental Monitoring at the site in accordance with the site licence (Environmental Permit) and working plan documents.

This document provides an analysis and review of the environmental monitoring results recorded during the period Jan-17 to Dec-17, with an interpretation of the trends of the results against site specific trigger levels and other relevant reference standards.

An updated Hydrogeological Risk Assessment (HRA) was completed in June 2007 for the site, as part of the assessment process for definitive closure. This was approved in March 2008, permitting the site to enter into 'definitive closure' in accordance with the Landfill Regulation (England and Wales) 2002. The HRA provides a model for ground conditions at the site and has been used to interpret the results of monitoring carried out by ARL staff.

1.2 Scope

This document uses this description of the site's HRA to interpret the results of monitoring implemented and recorded at the Nant-y-Gwyddon Landfill Site by ARL. It covers the following items:

- Leachate Compositions
- Surface Water Quality
- Groundwater Level and Quality
- Landfill Gas Monitoring

2. SITE DESCRIPTION

2.1 Site Location and Surroundings

The Nant-y-Gwyddon site is located at Ordnance Survey National Grid Reference (NGR) SS 980 940, in an elevated position above the Rhondda Fawr valley, as shown on the Site Location Plan (Dwg. No. ARL2018/ENV/01/001).

The landfill site has been established in what was a naturally developed depression at the head of the valley formed by the Nant-y-Gwyddon stream. The base of the site is at an approximate elevation of 320 mAOD, whereas the elevation of the upper surface of the current landform is approximately 350 mAOD.

North of the landfill site, Myndd-y-Gelli descends steeply towards the small village of Gelli. The Hen Dr'er ring and platform cairns are located just outside the vicinity of the landfill in this direction. These are listed Bronze Age Ancient Monuments.

In an easterly direction, Llwynypia Mountain consists of gently sloping rough grazing land passing, down slope, into the natural woodland of the Glyn-Cornal nature reserve and Craig-Pont-Rhondda, both of which are designated SSSI (Special Site of Scientific Interest).

The elevated land to the south and west of the landfill is predominantly Forestry Commission plantation. However, these forested areas also extend down the south-facing slopes of Clydach Vale.

Clydach Vale (Grid Reference 2980 1930) is the closest built-up area to the site; the Clydach Vale Rugby Club being the closest property, less than 1000 m away from the southern margin of the landfill site.

Tip No. 232 is situated adjacent to the site entrance, at the top of the site access road. This was, along with the smaller No. 233 tip, constructed from waste produced by the Gelli Colliery. However, all of the latter and part of the former have now been removed, having been used for site preparation and ongoing operational purposes (i.e. daily cover, landfill cap engineering).

2.2 Site Management and Engineering

The Nant-y-Gwyddon Landfill Site was designed and operated as a containment Landfill and consists of a management infrastructure for the control and disposal of contaminated water (leachate) and landfill gas.

Waste disposal operations at Nant-y-Gwyddon were split into Phase 1, now containing approximately 1.25 million tonnes of landfill waste and Phase 2. Despite the construction of an engineered barrier system (basal liner) over the 3 hectare area of Phase 2, no waste has been deposited within this phase, due to the early closure of the site in March 2002.

The landfill site boundary comprises an area of approximately 24 ha which can be described as follows:

- **Phase 1 Landfill** – Containing approximately 1.25 million m³ of waste in an area of approximately 9 ha. This area has now been fully remediated with the construction of an engineered geocomposite capping layer and drainage measures.
- **Phase 2** – The 3.5 ha area historically referred to as Phase 2, previously consisted of an engineered barrier system (basal liner) and leachate storage facility. These have now been removed and the restored area now consists of gently sloping grassland and a small surface water lagoon and associated drainage.
- **Site Offices, Weighbridge, Car Park and Landfill Gas Compound** – These are located adjacent to the site entrance. Further information related to the landfill gas compound is provided below.

Leachate Management

Landfill waste deposited in the Phase 1 area is contained by the presence of a basal engineered barrier (basal liner) and leachate drainage system.

As detailed in the Site's Working Plan Document this consists of the following:

- 300 mm graded colliery spoil, with leachate collector drains (in no fines granular surrounds and geotextile wrap), placed on
- 2.5 mm HDPE Geomembrane, placed on
- 300 mm graded colliery spoil with sub liner drainage (as above), placed on
- Compacted colliery spoil sub-grade, placed on
- Excavated and re-compacted ground.

The completed phase 1 area is now fully capped with an engineered (permanent) landfill cap. Since its completion in September 2005 this has been shown to be successful in acting as a barrier to infiltration and thus significantly reducing the volume of leachate produced at the site.

The permanent cap covers the entire area of the landfill and is tied into the basal liner at the margins of the landfill, thus completing containment engineering. The cap consists of the following elements as reference in the approved validation report for the works:

- 750 mm restoration soils, placed upon
- 300 mm colliery spoil protection layer (nominal particle size 20 mm), placed upon
- 6 mm non-woven Geosynthetic drainage layer and subsurface collector drains, placed upon
- 1 mm LLDPE Geomembrane fully welded and tested, placed upon
- 6 mm non-woven Geosynthetic drainage layer and subsurface collector drains, placed upon
- 200 mm cap foundation layer (nominal particle size 20 mm), placed on
- graded / regularised landfill surface.

In addition to the above the following active leachate extraction measures are present at the site:

- 7 no. pneumatic pumps (AP3 type) installed within extraction wells situated in the landfill area.
- A fixed pumping station, situated at the base of the landfill western flank (an area previously referred to as Jones's Bund).

Leachate collected from the site's basal drainage and active pumping systems are piped to a large concrete holding tank located in the eastern area of the site. From this location leachate is discharged untreated to the foul sewer network via a dedicated 1.5 km underground pipeline.

This discharge is done in accordance with a Consent to Discharge (No. AN00117), as provided and regulated by the water authority (Dwr Cymru / Welsh Water).

Landfill Gas Management

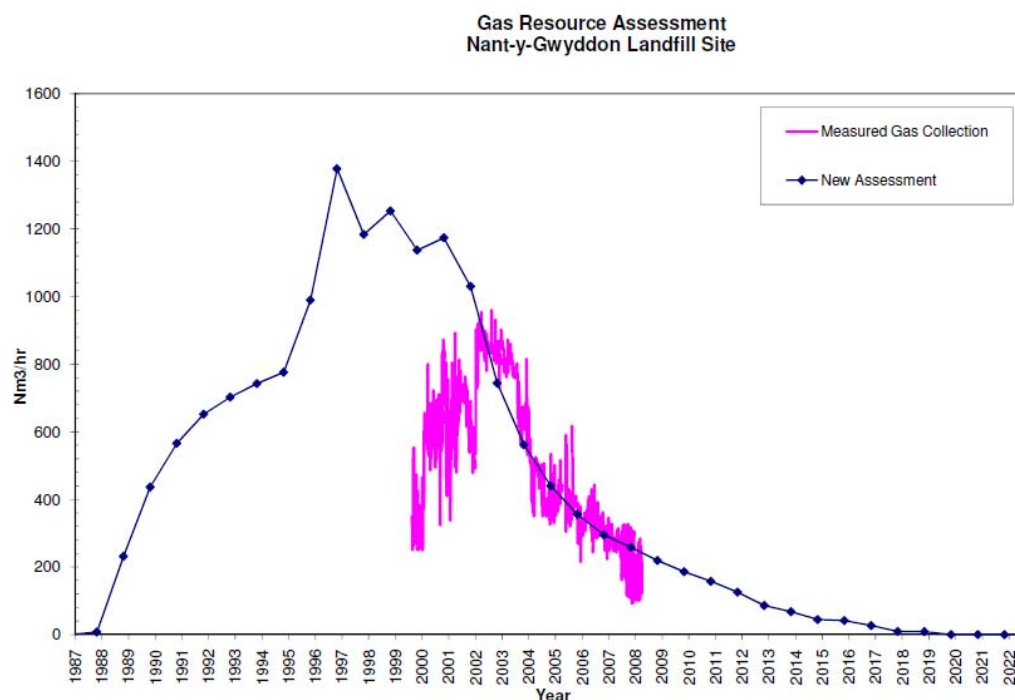
Landfill gas (LFG) production at Nant-y-Gwyddon is controlled using an active gas extraction and flaring / power generation system.

This consists of the following elements:

- Geo-synthetic gas drainage layer and pipe-work (underneath the plastic cap).
- 40 no. vertical landfill gas extraction wells
- Collection pipe-work connected to 4 no. control manifolds and dewatering knockout pots.
- Gas extraction plant (200 m³/hr capacity) and high temperature enclosed landfill gas flare.
- Micro-Generating Turbine (rated 60 kW/hr).

At the time of writing (Aug-18) the gas management system at Nant-y-Gwyddon is capturing and treating around 75 m³/hr of landfill gas. This is consistent with the theoretical prediction for gas generation at the site as documented in the 'Gas Resource Assessment for Nant-y-Gwyddon Landfill Site, Renewable Power Systems, December 2008. Figure 2.1 (below) is taken from the RPS report and provides an overview of the predicted generation of landfill gas over the next 5 years and beyond.

Figure 2.1: Gas Resource Assessment produced by RPS in 2008.



3. LEACHATE, GROUNDWATER AND SURFACE WATER.

3.1 Leachate, Groundwater and Surface Water Analysis Suites.

The Nant-y-Gwyddon Landfill Site – Working Plan (Amgen Rhondda Ltd., August 2001, updated 2008) outlined the manner in which leachate, groundwater and surface water samples are obtained from the site along with a suggested suite of chemical analysis for each of these groups.

Laboratory analysis for a range of water chemistry determinands are required on a monthly, quarterly and annual frequency depending on their presence within leachate contamination, and general association with wastes deposited at the site, and their relative cost of analysis, along with the logistics involved in accurately quantifying their presence.

Analysis of water sampled obtained from the site are undertaken by an independent laboratory services company. Throughout 2017 ARL has continued to employ the analytical services of the National laboratory Service [NLS].

Tables 10, 11 and 12 from the working plan detail the analysis required for leachate, groundwater and surface water monitoring. These have been reproduced in appendix B of this document for reference. The timetable via which ARL implemented these analysis suites on leachate, groundwater and surface water is illustrated in Table 1 below.

Table 3.1: ARL's implementation of the required chemical analysis suites for leachate, groundwater and surface water monitoring at Nant-y-Gwyddon during the period Jan 17 – Dec 17.

2017 – Leachate Analysis												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Analysis Suite	Mon	Qtr	Mon	Mon	Qtr	Mon	Ann	Mon	Mon	Mon	Qtr	Mon
Date of Monitoring	10.01	07.02	01.03	05.04	10.05	14.06	11.07	15.08	06.09	10.10	07.11	05.12
2017 – Groundwater Analysis												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Analysis Suite	Mon	Qtr	Mon	Mon	Qtr	Mon	Ann	Mon	Mon	Mon	Qtr	Mon
Date of Monitoring	25.01	21.02	22.03	26.04	24.05	28.06	25.07	22.08	19.09	25.10	22.11	13.12
2017 – Surface Water Analysis												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Analysis Suite	Mon	Qtr	Mon	Mon	Qtr	Mon	Ann	Mon	Mon	Mon	Qtr	Mon
Date of Monitoring	10.01	07.02	01.03	05.04	10.05	14.06	11.07	15.08	06.09	10.10	07.11	05.12

Note:

Mon - Monthly Analysis Suite
 Qtr - Quarterly Analysis Suite
 Ann - Annual Analysis Suite

3.2 Leachate

ARL carries out monthly monitoring of leachate level and contamination concentrations at the Nant-y-Gwyddon Landfill Site. Two sampling locations are provided for leachate to be collected directly from the landfill waste and a third, external to the waste, for the monitoring of leachate quality prior to disposal.

Leachate Level Monitoring

Leachate level monitoring is carried out monthly, involving dip measurement, undertaken by a suitably qualified landfill technician. The location of the 2 monitoring points currently used is illustrated in Drawing No. ARL2018/ENV/01/003 and a description provided below:

- **L5a (leachate inspection manhole L5a)** – L5a is a leachate inspection chamber located within the landfill immediately adjacent to the Inert Bund retaining the eastern margin of the waste. This chamber is linked directly to the basal drainage system, at a location considered to be the lowest point in the landfill. Leachate collected by the basal drainage system flows to this point under the influence of gravity - prior to exiting the landfill via an underground pipeline.

Over the last two years only a small flow of leachate has been noticeable at this location.

- **LPS1 (Leachate Pumping Station, Western Flank)** – As part of the remediation works a leachate extraction sump was constructed in the area previously referred to as Jones Bund. Historically this area was subject to significant leachate build-up, sourced by run-off from the, as then uncapped Phase 1 landfill area and the un-tipped Phase 2 area. This installation extends to the base of the landfill and can be used to interpret the head of water present within the waste at this location.

The results of leachate level monitoring carried out throughout 2017 are provided in Table 3.2 (overleaf). Results from 2016 are also illustrated in order to demonstrate any longer term trends.

Table 3.2: Result of Leachate Level Monitoring carried out at the Nant-y-Gwyddon Landfill Site, Jan 16 – Dec 17.

Date	L5a		LPS1	
	Depth of Installation (m bgl)	Water Head (m)	Depth of Installation (m bgl)	Water Head (m)
Jan-16	20	0 (dry)	6.50	0.83
Feb-16	20	0 (dry)	6.50	0.89
Mar-16	20	0 (dry)	6.50	0.75
Apr-16	20	0 (dry)	6.50	0.89
May-16	20	0 (dry)	6.50	0.86
Jun-16	20	0 (dry)	6.50	0.79
Jul-16	20	0 (dry)	6.50	0.80
Aug-16	20	0 (dry)	6.50	0.73
Sep-16	20	0 (dry)	6.50	0.81
Oct-16	20	0 (dry)	6.50	0.71
Nov-16	20	0 (dry)	6.50	0.90
Dec-16	20	0 (dry)	6.50	0.80
Jan-17	20	0 (dry)	6.50	0.72
Feb-17	20	0 (dry)	6.50	0.89
Mar-17	20	0 (dry)	6.50	0.89
Apr-17	20	0 (dry)	6.50	0.77
May-17	20	0 (dry)	6.50	0.86
Jun-17	20	0 (dry)	6.50	0.78
Jul-17	20	0 (dry)	6.50	0.69
Aug-17	20	0 (dry)	6.50	0.87
Sep-17	20	0 (dry)	6.50	0.87
Oct-17	20	0 (dry)	6.50	0.79
Nov-17	20	0 (dry)	6.50	0.71
Dec-17	20	0 (dry)	6.50	0.73

L5a

Monthly monitoring of Leachate Inspection Chamber L5a has shown it to be consistently dry over the previous 12 months. This observation has been confirmed by visual inspection of the installation. A very small basal flow is observed within the drainage channel and this is freely escaping the landfill (under gravity) into the external leachate management pipe-work.

This gives good indication that there is little or no head of leachate acting on the basal lining system in this area of the landfill. L5a is connected to a network of drains that cover a large area of the Phase 1 landfill.

LPS1

Leachate levels in this area of the landfill are shown to have been less than 1m throughout 2017, averaging 0.80 m and thus are compliant with the statutory requirements for the site.

Leachate Quality Monitoring

Leachate monitoring and sampling is undertaken at 3 locations at the site. The location of these monitoring points is illustrated in Drawing No. ARL2018/ENV/01/003 and a description provided below:

- **L5a (leachate inspection manhole L5a)** – Leachate sampled at this location is sourced directly from the waste. It is thought to be the most representative monitoring location for leachate generated directly within the waste mass. On visual inspection there is a small basal flow of leachate draining under gravity, but this cannot be sampled using the existing sample methodology.

In order to gain some meaningful data from this location an alternative sample point has been constructed at a location approximately 100 m down-gradient of the landfill site. This consists of an inspection chamber which has been modified to allow ARL's Technical Staff to gain access (for sampling) to the basal flow identified within the L5a Leachate Chamber.

- **LPS 1 (Leachate Pumping Station, Western Flank)** – Leachate sampled at this location is sourced directly from the waste. Previously leachate samples were taken from the leachate attenuation lagoons (LL01). However, this has ceased due to the removal of this infrastructure during restoration works undertaken in 2006.
- **L5 (leachate holding tank)** – Prior to disposal (to foul sewer), leachate from the landfill is stored within the leachate holding tank. This regulates the discharge of leachate (trade effluent) to the foul sewer at a maximum rate of 6 l/s.

Table 3.3 (overleaf) provides a comparison of the results of leachate monitoring at the Nant-y-Gwyddon Landfill Site during the period Jan-15 to Dec-17.

Table 3.3: Annual average concentration of the principal leachate contaminants monitored by Amgen Rhondda Ltd at the Nant-y-Gwyddon landfill site during the period Jan 15 - Dec 17, compared with those national averages reported in DoE Research Report No. CWM 072/94 (DoE 1995).

Determinant	DoE (1995)	L5a			L5			LPS1		
		2015	2016	2017	2015	2016	2017	2015	2016	2017
Alkalinity	5,376	218	341	318	322	292	291	160	312	262
NH ₄ as N	889	10.4	1.0	1.1	0.3	20.7	19.4	6.2	32.4	20.5
Conductivity	11,502	684	1188	860	1014	916	917	422	908	696
BOD	374	1.4	1.0	<1.0	0.5	2.6	3.7	<1.0	2.5	1.7
COD	2,307	38.9	40.8	16.0	31.8	64.8	64.3	16.1	47.6	24.8
Cadmium	0.015	N/D	N/D	N/D	N/D	<0.001	N/D	N/D	N/D	<0.001
Chloride	2,074	56.7	115.8	48.6	81.3	83.9	92.2	18.6	74.5	53.1
Chromium	0.09	<0.001	<0.001	0.001	<0.001	0.003	0.003	<0.001	0.002	0.002
Iron	27.4	0.2	0.1	0.1	0.3	3.5	1.7	0.3	1.2	2.9
Lead	0.2	N/D	N/D	N/D	N/D	0.002	N/D	N/D	N/D	0.002
pH	7.52	8.0	8.0	8.0	8.0	8.0	8.0	7.3	7.3	7.2
Potassium	854	16.0	30.2	23.9	23.4	22.1	58.4	11.3	37.0	29.1
Sodium	1,480	29	56	41	33	42	120	9.1	70	53
Sulphate	67	28.1	53.5	58.7	53.3	31.5	50.0	32.4	57.2	41.9
TOC	733	9.4	10.2	5.7	8.5	11.8	13.6	3.2	11.8	26.8
TON	0.86 – 1.0345	7.2	18.3	11.9	10.7	9.0	13.7	0.4	0.3	0.6

Note: All values in mg/l except Conductivity (uS/cm³).

N/D – Not Detected in any samples analysed.

Leachate sampled at the Nant-y-Gwyddon Landfill site over the previous three years is shown to be weak in nature (dilute) when compared to the national averages reported in DoE Research Report No. CWM 072/94 (DoE 1995). Of particular interest are the low levels of Ammoniacal Nitrogen (NH₄ as N), Chloride and Electrical Conductivity. Annual averages for these parameters are significantly below the national average presented above. Taking this into consideration, along with the overall volume of leachate still being collected at the site, suggests that the site's leachate management system continues to intercept groundwater beneath the site.

There does not appear to be any trend in the strength of leachate samples at the site. Concentrations of the principal leachate contaminants have remained relatively consistent over the referenced monitoring period.

3.3 Surface Water

Background

The Site is located near the watershed separating the Rhondda Fawr and Clydach valleys. Therefore, no part of the Site is within the EA's Indicative Floodplain for the Rhondda Fawr.

(see <http://www.environment-agency.gov.uk/maps/info/floodmaps/>).

This part of the Rhondda valley receives a high annual rainfall (the long-term average annual total precipitation for the Site is over 1500 mm), most of which leaves the surface water catchment, via a network of tributary rivers and streams, in the Avon Rhondda Fawr (which typically exhibits a high intensity-short duration response to rainfall events).

The Nant-y-Gwyddon stream (a small tributary of the Afon Rhondda Fawr) is fed by clean surface water drainage from within the area of the licensed landfill.

It has been shown that a large proportion of the groundwater passing beneath the Nant-y-Gwyddon site enters into the Nant-y-Gwyddon stream via a number of springs located on the valley side. These are typically associated with the outcrop location of the No. 1 Rhondda and No. 1 Rhondda Rider coal seams – the main aquaclude retaining groundwater beneath the site.

Under the EA's General Quality Assessment (GQA) Scheme, the water quality of the Afon Rhondda Fawr, in common with all surface water features designated as "Main River" across all of England and Wales, is regularly monitored and annual targets for improvement set (where necessary).

Previously, the adjacent reach of the Afon Rhondda Fawr has been generally classified as Grade A (the highest possible rating). It is fair to note that, since this classification has been the same at points both upstream and downstream of its confluence with the Nant-y-Gwyddon stream, the impact of the latter is clearly insignificant, in terms of both quantity and quality.

Surface Water Monitoring

ARL currently monitor the quality of surface water at seven locations on and around the Nant-y-Gwyddon Landfill Site. The location of these points is illustrated in Drawing No. ARL2018/ENV/01/004 (Appendix A) and a description provided below:

Surface water monitoring points **SW1**, **SW5**, **SW6**, and **SW8** are within the immediate vicinity of the landfill site and located along the Nant-y-Gwyddon stream:

- **SW5** (settlement lagoon in Phase 2 area) – Previously the monitoring location SW 5 referred to the water sampled from the site fire lagoon. The fire lagoon was removed during the 2005 / 2006 remediation work and the monitoring point has now been relocated to the settlement lagoon situated in the restored Phase 2 area.
- **SW6** (upper Nant-y-Gwyddon stream) - The majority of the surface water collected from the area surrounding the landfill is discharged into the stream at this point. Site drainage discharge at this location is covered by a Consent to Discharge Surface Water (EA Ref: AN0308201) as regulated by the Environment Agency.

- **SW8** (middle Nant-y-Gwyddon) – This monitoring point is located half way down the Nant-y-Gwyddon watercourse. It is aimed at identifying any potential impact from groundwater issues evident upstream of this location.
- **SW1** (lower Nant-y-Gwyddon) - Flow rates are increased due to groundwater input from streams at, or above, this point.

In addition, there are three more distant surface water monitoring points (**SW2**, **SW3**, and **SW4**), which are located as follows:

- **SW4** (Glyncornel Nature Reserve Lake) – Located just upstream of the lake in a small spring. Tracer tests have shown that 80% of the groundwater passing below the landfill emerges on the lower slopes of the Rhondda Fawr Valley, some of which feed into this lake.
- **SW2** (Nant-y-Clydach Fach) – This stream flows in a south-easterly direction through the Clydach Vale Country Park and is also fed by groundwater thought to originate beneath the site.
- **SW3** (Cwm Cae Dafydd Tributary) – This tributary originates on the south-western margin of the landfill site boundary, flows south through the village of Cwm Clydach, and into the Nant Clydach (a major tributary of the Rhondda Avon Fawr).

Surface Water Quality

Annual averages have been calculated for the main surface water quality determinands monitored at the site by Amgen during the period January 2015 to December 2017. This analysis has been summarised, below, in Tables 3.4, 3.5 and 3.6 for 2015, 2016 and 2017 respectively. The identity and value of the chosen EAL is indicated for each determinand, with any exceedances highlighted in **bold** type.

Table 3.4: Annual Averages for Surface Water Quality Determinands monitored at Nant-y-Gwyddon in 2015.

Water Quality Determinand	Units	EAL		Surface Water Monitoring Point						
				SW1	SW2	SW3	SW4	SW5	SW6	SW8
Alkalinity (as CaCO ₃)	mg/l	-	-	81	9	8	52	78	Dry	166
Ammonia (NH ₄ as N)	mg/l	DWS	0.5	<0.03	<0.03	<0.03	<0.03	<0.03	Dry	<0.03
BOD	mg/l			<1.0	<1.0	N/D	N/D	1.8	Dry	N/D
Cadmium	mg/l	DWS	0.005	N/D	N/D	N/D	N/D	N/D	Dry	N/D
Calcium	mg/l	DWS	250	19.5	3.2	14.5	13.7	16.5	Dry	20.9
Chloride	mg/l	DWS	250	7.8	9.4	9.6	8.7	6.5	Dry	7.5
Chromium	mg/l	DWS	0.05	N/D	N/D	N/D	<0.0005	N/D	Dry	N/D
COD	mg/l	-	-	<10	<10	<10	N/D	16.3	Dry	<10
Copper	mg/l	DWS	2	<0.001	<0.001	<0.001	<0.001	0.001	Dry	0.002
EC @ 20°C	µS/cm	DWS	1500	248	61	157	168	181	Dry	378
Iron	mg/l	EQS	1	0.01	0.05	0.04	0.01	0.08	Dry	0.01
Lead	mg/l	DWS	0.01	N/D	N/D	N/D	N/D	N/D	Dry	N/D
Magnesium	mg/l	DWS	50	18.3	1.7	8.6	9.3	9.7	Dry	21.3
Nickel	mg/l	DWS	0.02	<0.001	0.002	0.002	N/D	<0.001	Dry	<0.001
Nitrate (as NO ₃)	mg/l	DWS	50	N/D	N/D	N/D	N/D	N/D	Dry	N/D
Nitrite (as NO ₂)	mg/l	DWS	0.1	N/D	N/D	N/D	N/D	<0.004	Dry	N/D
pH	-	DWS	5.5-9.5	8.1	7.1	7.5	7.9	8.3	Dry	7.9
Potassium	mg/l			7.3	0.7	2.2	1.9	5.0	Dry	9.5
Sodium	mg/l	DWS	200	8.3	5.4	6.2	6.8	6.6	Dry	12.5
Sulphate	mg/l	DWS	250	47	N/D	27	23	14	Dry	54
TOC	mg/l	-	-	1.1	1.8	<0.7	<0.7	3.8	Dry	1.5
Zinc	mg/l	DWS	5	<0.005	0.010	<0.005	N/D	N/D	Dry	<0.005

N/D - Substance not detected above minimum reporting value.

Table 3.5: Annual Averages for Surface Water Quality Determinands monitored at Nant-y-Gwyddon in 2016.

Water Quality Determinand	Units	EAL		Surface Water Monitoring Point						
				SW1	SW2	SW3	SW4	SW5	SW6	SW8
Alkalinity (as CaCO ₃)	mg/l	-	-	80	4	49	52	72	Dry	103
Ammonia (NH ₄ as N)	mg/l	DWS	0.5	<0.03	<0.03	<0.03	<0.03	<0.03	Dry	<0.03
BOD	mg/l			<1.0	<1.0	N/D	<1.0	3.3	Dry	<1.0
Cadmium	mg/l	DWS	0.005	N/D	N/D	N/D	N/D	N/D	Dry	N/D
Calcium	mg/l	DWS	250	18.9	3.8	14.8	13.8	18.7	Dry	19.4
Chloride	mg/l	DWS	250	8.4	10.2	10.1	9.2	6.9	Dry	8.0
Chromium	mg/l	DWS	0.05	N/D	<0.0005	N/D	N/D	N/D	Dry	N/D
COD	mg/l	-	-	<10	<10	N/D	N/D	14.9	Dry	<10
Copper	mg/l	DWS	2	N/D	0.001	0.001	N/D	N/D	Dry	N/D
EC @ 20°C	µS/cm	DWS	1500	253	65	168	169	171	Dry	273
Iron	mg/l	EQS	1	N/D	<0.03	0.02	N/D	0.16	Dry	N/D
Lead	mg/l	DWS	0.01	N/D	N/D	N/D	N/D	N/D	Dry	N/D
Magnesium	mg/l	DWS	50	18.0	1.7	9.4	9.2	12.4	Dry	20.1
Nickel	mg/l	DWS	0.02	N/D	0.001	0.002	N/D	<0.001	Dry	N/D
Nitrate (as NO ₃)	mg/l	DWS	50	N/D	N/D	N/D	N/D	N/D	Dry	N/D
Nitrite (as NO ₂)	mg/l	DWS	0.1	N/D	N/D	N/D	N/D	N/D	Dry	N/D
pH	-	DWS	5.5-9.5	8.2	7.0	7.8	7.9	8.2	Dry	8.0
Potassium	mg/l			6.9	0.7	2.3	1.9	6.4	Dry	8.3
Sodium	mg/l	DWS	200	7.9	5.3	5.5	6.2	6.9	Dry	10.8
Sulphate	mg/l	DWS	250	44	N/D	28	22	15	Dry	42
TOC	mg/l	-	-	0.8	0.9	7.8	<0.7	3.5	Dry	1.0
Zinc	mg/l	DWS	5	0.014	0.015	0.008	N/D	N/D	Dry	N/D

N/D - Substance not detected above minimum reporting value.

Table 3.6: Annual Averages for Surface Water Quality Determinands monitored at Nant-y-Gwyddon in 2017.

Water Quality Determinand	Units	EAL		Surface Water Monitoring Point						
				SW1	SW2	SW3	SW4	SW5	SW6	SW8
Alkalinity (as CaCO ₃)	mg/l	-	-	87	14	46	57	86	Dry	99
Ammonia (NH ₄ as N)	mg/l	DWS	0.5	<0.03	<0.03	<0.03	<0.03	<0.03	Dry	<0.03
BOD	mg/l			<1.0	<1.0	<1.0	<1.0	2.2	Dry	<1.0
Cadmium	mg/l	DWS	0.005	N/D	N/D	N/D	N/D	N/D	Dry	N/D
Calcium	mg/l	DWS	250	22.2	N/D	16.6	15.9	16.0	Dry	13.0
Chloride	mg/l	DWS	250	7.5	8.7	9.1	8.3	4.7	Dry	6.8
Chromium	mg/l	DWS	0.05	N/D	N/D	N/D	N/D	N/D	Dry	N/D
COD	mg/l	-	-	<10	<10	<10	<10	20.2	Dry	<10
Copper	mg/l	DWS	2	N/D	0.002	<0.001	N/D	<0.001	Dry	0.001
EC @ 20°C	µS/cm	DWS	1500	264	81	168	184	185	Dry	255
Iron	mg/l	EQS	1	0.02	0.06	0.06	N/D	0.12	Dry	0.08
Lead	mg/l	DWS	0.01	N/D	N/D	N/D	N/D	N/D	Dry	N/D
Magnesium	mg/l	DWS	50	20.2	6.4	9.9	8.3	13.6	Dry	10.3
Nickel	mg/l	DWS	0.02	N/D	0.001	0.002	N/D	N/D	Dry	<0.001
Nitrate (as NO ₃)	mg/l	DWS	50	N/D	<0.8	N/D	N/D	N/D	Dry	N/D
Nitrite (as NO ₂)	mg/l	DWS	0.1	N/D	<0.004	N/D	N/D	N/D	Dry	N/D
pH	-	DWS	5.5-9.5	8.2	7.0	7.8	7.9	7.9	Dry	7.8
Potassium	mg/l			8.5	3.2	2.6	2.2	6.1	Dry	4.7
Sodium	mg/l	DWS	200	8.3	6.1	5.8	6.9	5.6	Dry	6.6
Sulphate	mg/l	DWS	250	54	9	30	27	5	Dry	17
TOC	mg/l	-	-	1.2	1.4	0.9	<0.7	4.5	Dry	2.0
Zinc	mg/l	DWS	5	N/D	<0.005	<0.005	<0.005	<0.005	Dry	<0.005

N/D - Substance not detected above minimum reporting value.

Summary of Surface Water Monitoring Results

Surface water sampled within the four main watercourses surrounding the Nant-y-Gwyddon site is considered to be of a good quality. Table 3.6 (previous) presents annual average concentrations, calculated for 22 key Water quality determinands and compares them to water quality thresholds (e.g. Drinking Water Standard – DWS).

Of the 22 water quality determinands presented, it can be seen that there was no exceedances of any water quality standard, when considering the annual averages calculated for 2017. This was also the case for annual averages calculated for surface water monitoring results recorded during the 2016 and 2015 calendar year. The consistency of these observations indicated that surface water monitored on and around the Nant-y-Gwyddon Landfill Site continue to be of good quality.

Further analysis is provided below:

General Water Quality Determinands

Throughout 2017, it is noted that concentrations of ammoniacal nitrogen (ammonia NH_4 as N) were very low, averaging less than <0.03 mg/l at each of the 6 surface water monitoring locations. Of the 70 water samples analysed for NH_4 as N, only 2 (3%) returned a positive result above the minimum reporting value of 0.03 mg/l NH_4 as N. The maximum value recorded during 2017 was 0.10 mg/l, recorded at SW 2 in May-17. It is noted that this maximum reading is below the drinking water standard (0.5 mg/l) for this water quality determinant.

Other relevant observations are as follows:

- Chloride concentrations are consistently low, averaging between 5-10 mg/l for each of the surface water monitoring locations (compared to the UK Drinking Water Standard of 250 mg/l).
- Measurements of Electrical Conductivity (EC) taken at each of the 7 monitoring location were low, averaging between 80 – 265 $\mu\text{S}/\text{cm}^3$ throughout 2017. This is well within the UK-DWS of 1500 $\mu\text{S}/\text{cm}^3$.
- Of the 22 surface water samples analysed for Nitrite during 2017, only a single positive result was reported. This constitutes less than 5% of samples and the reported value 0.009 mg/l (SW 2, May-17) is well below the UK Drinking Water standard for this determinant.
- Nitrate concentrations in the streams surrounding the Nant-y-Gwyddon Landfill Site were consistently low in all samples monitored in 2017. Of the 22 surface water samples analysed for Nitrate during 2017, a single positive result was recorded (i.e. reported to contain Nitrate above the MRV of 0.8 mg/l). This positive detection was recorded at SW 2 in May-17. At the time of measurement, the level of Nitrate was found to be 0.74 mg/l. This value is below the UK Drinking Water Standard for this determinand, (currently set a 50mg/l).

List I Substances

Surface Water samples taken from the site and the surrounding area during 2017 have been subject to a number of independent analyses, for a range of chemical substances considered to be harmful to human health and the environment (Dangerous Substances). This analysis has been undertaken on a quarterly and annual basis and the results reviewed by ARL Staff. The main substances of concern when considering the potential impact of landfill leachate on the water environment are considered to be as follows:

- Benzene
- Cadmium
- Mercury

1,2 Dichloroethane is further substance that was previously detected in leachate samples at the Nant-y-Gwyddon Landfill Site and has therefore been analysed on a frequent basis. The following paragraphs provide a summary of the results of the above substances recorded in surface water samples taken on and around the Nant-y-Gwyddon Landfill Site during the period Jan-17 to Dec-17:

- Throughout 2017 a total of 4 surface water samples were analysed for the presence of Benzene. There was no indication of Benzene in any of the 4 samples (above the MRV of 0.1 µg/l).
- A total of 22 surface water samples taken at Nant-y-Gwyddon in 2017 were analysed for the presence of Cadmium. There was no positive detection of Cadmium in any of the samples (at or above the MRV of 0.0001 mg/l).
- A total of 4 surface water samples taken at Nant-y-Gwyddon in 2017 were analysed for the presence of Mercury. There was no positive detection of Mercury in any of the samples (at or above the MRV of 0.00001 mg/l).
- Of the 22 surface water samples analysed for 1,2 Dichloroethane throughout 2017, no positive values were reported. This gives a good indication that this substance was not present above the Minimum Reporting Value (MRV) of 0.0001 mg/l.

Summary

Amgen Rhondda Ltd. has continued monitoring the quality of surface water on and around the Nant-y-Gwyddon landfill in accordance with the site's environmental permission. Throughout 2017, a total of 70 samples were taken from 5 'off-site' and 1 'on-site' monitoring location. The quality of water sampled on each of these occasions was within the UK Drinking Water Standards listed in table 3.6.

It is concluded that the surface water on and around the Nant-y-Gwyddon Landfill Site is of good quality. There is no indication that the landfill is having a determinable impact on the surface water environment surrounding the site.

3.4 GROUNDWATER

Background

The area of land on which the Nant-y-Gwyddon Landfill Site is located is designated as being underlain by a Minor Aquifer (as per the EA's Policy and Practice for the Protection of Groundwater (1998)), and is covered by soils with a low leaching potential.

Based on the information available on the EA's website, it has been determined that the Site is not within the source protection zone (SPZ) or any abstraction license for public water supply. However, there is a licensed abstraction within 1 km of the Site, held by Welsh Water (Dwr Cymru), which relates to two points on the Nant Cesig stream, less than 1200 metres to the north-west of the perimeter of the landfill. Although these points are not currently used for supply, the licenses remain in force and, as such, they are afforded all the statutory protection that such a licence entails.

The local Environmental Health Department has confirmed that there are no known private (domestic) water supplies for individual properties, or groups of properties, within the vicinity of the Site, except for that at Bwllfa Farm (NGR SS 9704 9415).

The Hydrogeological conceptual site model derived for Nant-y-Gwyddon, identifies two groundwater bodies beneath the landfill site that could be at risk from any fugitive emissions of leachate from the Site. These have been identified as follows:

- The Upper Aquifer – Previous investigation have indicated seasonal groundwater retained above a siltstone / mudstone aquaclude located approximately 25 to 30m above the No.1 RR coal seam.
- The Main Aquifer – Groundwater retained above the No.1 RR coal seam (and associated argillaceous horizons), between 28 and 35 metres below the base of the landfill. Various springs located at the level of the outcrop of the No.1 RR coal seam (eastern slope of Myndd-y-Gelli / Llywnypia Mountain) are thought to represent the discharge points for this aquifer, issuing into various sensitive receptors.

Groundwater Monitoring

The Nant-y-Gwyddon site is equipped with a total of 20 groundwater monitoring boreholes, 10 of which are down-gradient of the landfill, 7 up-gradient and 3 of which are considered to be perpendicular to groundwater flow. Monitoring is carried out on a monthly frequency for both level and water quality. Independent laboratory analysis is undertaken in accordance with those schedules listed in Appendix B.

The location of each of these groundwater monitoring points is illustrated in Drawing No. ARL2018/ENV/01/005 and an overview of their specification provided in Table 3.7 (overleaf).

Table 3.7: Specification of 20 groundwater monitoring boreholes situated at the Nant-y-Gwyddon Landfill Site.

Aquifer	BH ID	Location	Co-Ordinates			Installation Depth mbgl	2016	2017
			East	North	Ave Water mAOD		Ave Water mAOD	Ave Water mAOD
Upper Aquifer	NG 105	Up-gradient	297719	193376	336.06	15.0	338.5	339.3
	NG 106		297659	193831	338.4	14.4	339.1	339.3
	NG 107		297660	193896	337.55	8.4	337.9	337.8
	BH 1		297743	193905	Dry	21.0	Dry	Dry
	BH 3		297866	193794	Dry	9.5	Dry	Dry
	BH 4	Adjacent	297800	194132	Dry	8.8	Dry	Dry
	BH 9		298045	193802	Dry	21.2	Dry	Dry
	BH 10		297931	193765	312.91	43.0	313.2	313.2
	NG 104	Down-gradient	298146	193946	324.94	15.0	324.5	324.0
Main Aquifer	GW 94	Up-gradient	297674	194008	327.37	29.1	331.7	331.2
	BH 2		297779	193877	300.3	45.0	N/R	N/R
	NG 101	Down-gradient	298030	194230	289.09	34.5	290.2	289.1
	BH 5		297944	194157	292.97	34.8	N/R	N/R
	GW 96		298507	193729	262.58	68.2	270.1	269.5
	GW 97		298785	193978	N/R	53.8	Dry	Dry
	NG 110		298383	194156	264.95	17.9	N/R	N/R
	BH 6		298146	194107	282.29	28.2	282.6	284.3
	BH 7		298142	194027	318.4	40.0	Dry	Dry
	BH 8		298170	193889	Dry	61.8	Dry	Dry
Lower Aquifer	NG 111	Down-gradient	298375	194156	Dry	51.2	Dry	Dry

Trigger Levels

As part of the process of completing 'Definitive Closure' for the Nant-y-Gwyddon Landfill Site, a series of site specific Trigger Levels for groundwater quality were agreed with the Environment Agency. This was completed in March 2008 in accordance with the EA's Technical Guidance Document LFTGN01.

This document states:

'Generally, trigger levels should be set for the same substances that are considered in the risk assessment, particularly where those substances are present in the highest concentrations in leachate and are most mobile in the sub-surface.'

'As a general rule, trigger levels should be set for at least three, but no more than ten substances'.

Table 3.8 (below) illustrates the agreed trigger levels and their associated compliance points in groundwater situated around the landfill. In addition to this, control levels are used as check points, so that any deterioration in groundwater quality, towards the trigger level, can be identified at an early stage.

Table 3.8: Summary of Trigger and Control Levels currently in place at the Nant-y-Gwyddon Landfill Site, along with the relevant compliance points.

Water Quality Determinand	Units	Trigger Level	Control Level 1	Control Level 2	Compliance Point
List I:					
Benzene	ug/l	0.1	n/a	n/a	Groundwater Monitoring Boreholes: GW 5, GW6, NG 101 and GW 97
Cadmium	ug/l	0.5	n/a	n/a	
Mercury	ug/l	0.1	n/a	n/a	
List II:					
Ammonia (NH ₃ as N)	mg/l	0.50	0.24	0.33	Groundwater Monitoring Boreholes: GW 5, GW6, NG 101, GW 96, GW 97 and NG 110
Chloride	mg/l	50	17	28	
Nickel	mg/l	0.050	0.017	0.028	
Zinc	mg/l	0.043	0.024	0.030	

Table 3.9 (below) provides a summary of results of groundwater monitoring, against the agreed control and trigger levels for the Nant-y-Gwyddon Landfill Site.

Table 3.9: Summary of groundwater monitoring results recorded at the Nant-y-Gwyddon Landfill Site during the period Jan 17 – Dec 17, compared with the approved Trigger and Control levels for the site.

		List 1			List II			
		Benzene	Cadmium	Mercury	Ammonium (NH4 as N)	Chloride	Nickel	Zinc
GW 5	Samples	0	0	0	0	0	0	0
	Control 1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Control 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Trigger Level	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GW 6	Samples	3	3	1	9	9	3	3
	Control 1	N/A	N/A	N/A	0	1	0	0
	Control 2	N/A	N/A	N/A	0	0	0	0
	Trigger Level	0	0	0	0	0	0	0
NG 101	Samples	4	4	1	12	12	4	4
	Control 1	N/A	N/A	N/A	0	0	0	1
	Control 2	N/A	N/A	N/A	0	0	0	1
	Trigger Level	0	0	0	0	0	0	0
GW 97	Samples	0	0	0	0	0	0	0
	Control 1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Control 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Trigger Level	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GW 96	Samples	4	4	0	12	12	4	4
	Control 1	N/A	N/A	N/A	0	0	0	1
	Control 2	N/A	N/A	N/A	0	0	0	1
	Trigger Level	0	0	N/A	0	0	0	1
NG 110	Samples	0	0	0	0	0	0	0
	Control 1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Control 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Trigger Level	N/A	N/A	N/A	N/A	N/A	N/A	N/A

List I Substance – Benzene

Of the 11 groundwater samples taken from down-gradient boreholes GW5, GW6, NG101, GW97, NG110 and GW 96, Benzene was not detected any of the samples sent for analysis. Therefore no exceedances of the Benzene trigger level occurred at the Nant-y-Gwyddon Landfill during the 12 month period Jan-17 to Dec-17.

List I Substance – Cadmium

Of the 11 groundwater samples taken from down-gradient boreholes GW5, GW6, NG101, GW97, NG110 and GW 96, Cadmium was not detected any of the samples sent for analysis (at or above MRV of 0.0005mg/l). Therefore no exceedances of the Cadmium trigger level occurred at the Nant-y-Gwyddon Landfill during the 12 month period Jan-17 to Dec-17.

List I Substance – Mercury

Due to availability of samples during the annual round of monitoring a single Mercury analysis was recorded from down-gradient monitoring boreholes, GW 5, GW 6, NG 101 and GW 97, during the period Jan-17 to Dec-17. This analysis did not yield a positive result above the minimum reporting value of <0.01 ug/l.

List II Substance – Ammonia (NH₃ as N)

Laboratory analysis for Ammonia sampled in groundwater is reported as ammoniacal nitrogen (NH₄ as N). In order to provide a comparison with the agreed trigger level Ammonia (NH₃ as N), reported values have been converted between the two using the following formula:

$$\text{NH}_4^+(\text{mg/l}) \times 7/11 = \text{N mg L}$$

Of the 33 groundwater samples taken from down-gradient boreholes GW5, GW6, NG101, GW97, NG110 and GW 96, there was no exceedances of any control or trigger levels, when considering the analysis reported for Ammonia. This observation provide a good indication that leachate present within the landfill site is not having a demonstrable impact on groundwater quality at the site.

List II Substance – Chloride

Of the 33 groundwater samples taken from down-gradient boreholes GW5, GW6, NG101, GW97, NG110 and GW 96, there was no exceedances of the trigger levels (i.e. 50 mg/l), when considering the analysis reported for chloride. The maximum value reporting for groundwater samples taken down-gradient of the landfill was during the referenced monitoring period was 18.5 mg/l (within down-gradient borehole GW 6, sampled in Feb-17). This Chloride result is above the control level (Control Level 2) set at the site. No significance is attributed to this observation, subsequent tests reported a return to low levels of Chloride in samples taken from GW 6 (i.e. in the region of 5 – 15 mg/l).

These observations further support the above statement, that leachate present within the landfill at Nant-y-Gwyddon is not having a demonstrable impact on groundwater at the site.

List II Substance – Nickel

Of the 12 groundwater samples taken from down-gradient boreholes GW5, GW6, NG101, GW97, NG110 and GW 96, there was no exceedances of the trigger levels (i.e. 0.05 mg/l), when considering the analysis reported for nickel. Furthermore there was no exceedances of either control level 1 or 2 (i.e. 0.017mg/l and 0.028 mg/l, respectively).

List II Substance – Zinc

Of the 12 groundwater samples taken from down-gradient boreholes GW5, GW6, NG101, GW97, NG110 and GW 96 during the reporting period, there was a single exceedance of the agreed trigger level of 0.043 mg/l for Zinc. The value recorded for GW 96 in Nov-17 was 0.044 mg/l. Subsequent rounds of monitoring did no yield similar results. Zinc levels recorded within GW 8 during Feb-18, May-18 and Jul-18 were 0.008 mg/l, 0.011 mg/l and <0.005 mg/l, respectively.

4. LANDFILL GAS.

4.1 Overview.

ARL currently uses 18 ground monitoring borehole installations for the purpose of detecting any potential migration of landfill gas (LFG) from the base of the Nant-y-Gwyddon landfill. The location of these installations (labelled GMBH 1 – GMBH 8 & NYG 1 – NYG 10) in relation to the landfill is illustrated on Drawing No. ARL2018/ENV/01/006.

Each of these installations are monitored monthly by trained Amgen staff, using a handheld gas analyser, for the following parameters:

- Methane (CH₄)
- Carbon Dioxide (CO₂)
- Oxygen (O₂)
- Carbon Monoxide (CO)
- Hydrogen Sulphide (H₂S)
- Temperature
- Relative Pressure
- Atmospheric Pressure
- Installation Depth
- Depth to Water

The purpose of this monitoring is to detect whether any of the gas being produced by the landfill waste is migrating laterally towards off-site receptors.

4.2 Risk Assessment

Source

The source term with respect to landfill gas production at the Nant-y-Gwyddon Landfill Site is landfill waste. Landfill gas is produced by the microbial breakdown of biodegradable waste. Landfill Gas contains a high proportion of methane (typically between 35% - 60% by Volume) and carbon dioxide (typically 16% - 57% by Volume); in addition to a number of trace components that may arise depending on the waste type deposited.

Pathway

If gas pressures within the landfill are high, then there is the potential for landfill gas to migrate towards the margins of the landfill where it could enter into the sub-surface. Depending on ground conditions, landfill gas has potential to migrate significant distances, towards on-site and off-site receptors.

The presence of an active gas extraction system at Nant-y-Gwyddon acts to minimise the risk of gas pressures building up within the landfill. This minimises the potential for sub-surface lateral emissions by creating a preferential pathway for any gas generated. In addition to this, the presence of the engineered containment system further reduces the likelihood of landfill gas escaping into the ground in significant quantities.

Receptor

The nearest residential properties to the landfill are located around 400 – 500 m south of the landfill site boundary in the village of Clydach Vale. The village of Gelli is located in excess of 500 m from the Northern boundary of the site. Both these villages are situated at a lower elevation to the site and are considered to be very low risk, when assessing potential sub-surface gas migration from the site.

4.3 Monitoring Results

Table 4.1 (page 26), provides a summary of the results of ARL's monthly LFG monitoring carried out at the site by ARL staff using the agreed methodology.

The results of sub-surface landfill gas monitoring carried out at Nant-y-Gwyddon throughout 2017 did not record the presence of elevated concentration of methane in any of the 120 samples taken. Elevated carbon dioxide and slightly reduced oxygen concentration have been recorded on occasions at each of the 10 functional ground monitoring installations used at the site. This is considered to represent background concentrations of these substances in the soil gas (sub surface gas samples) present at the site.

Annual average Methane (CH₄) concentrations calculated for the results of monitoring undertaken during 2017 are shown to be 0.0% CH₄ by Vol for each of the ground monitoring boreholes sampled. This indicates that there has been no detection of landfill gas migration at the site over the previous 12 months of monitoring.

Ground monitoring installation GMBH 5 recorded the highest concentration of carbon dioxide (4.6% CO₂ by Vol) in Feb-17. This was accompanied by a reduced Oxygen reading of 18.1%. The presence of carbon dioxide detected within this installation has not been attributed to landfill gas migration due to the absence of methane in the sample. Furthermore, there is no indication of elevated gas pressure within the monitoring installation. Monitoring of the relative pressure within the installation was low averaging 0 mbar over the 12 month period Jan-17 to Dec-17.

Considering the results of sub-surface landfill gas monitoring undertaken by Amgen staff at the Nant-y-Gwyddon Landfill Site throughout the period Jan-17 to Dec-17, there is no evidence to suggest that landfill gas is migrating into the ground strata surrounding the site.

Measures currently employed at the site to control landfill gas migration are shown to be protective of the environment and human health.

Table 4.1: Summary of sub-surface landfill gas monitoring undertaken by ARL at the Nant-y-Gwyddon Landfill during the period Jan 17 – Dec 17.

Determinant	GMBH 1			GMBH 2			GMBH 3a			GMBH 3b			GMBH 5			GMBH 6		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
CH ₄ (%)	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	0.0	0.1	0.1	0.0	0.1	0.1
CO ₂ (%)	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	0.0	4.6	0.8	0.0	1.3	0.6
O ₂ (%)	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	18.1	22.0	20.5	19.0	21.9	20.6
CO (PPM)	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	0	0	0	0	0	0
H ₂ S (PPM)	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	0	0	0	0	0	0
Peak CH ₄ (%)	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	0.0	0.2	0.1	0.0	0.2	0.1
LEL (%)	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	0	2	1	0	2	1
Pressure (mb)	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	0.0	0.0	0.0	0.0	0.0	0.0
Temp (°C)	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
Determinant	N/R			N/R			N/R			N/R			N/R			N/R		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
CH ₄ (%)	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.2	0.1	N/R	N/R	N/R	N/R	N/R	N/R	0.0	0.2	0.1
CO ₂ (%)	0.0	3.5	0.7	0.0	1.2	0.3	0.0	1.5	0.6	N/R	N/R	N/R	N/R	N/R	N/R	0.1	1.3	0.4
O ₂ (%)	15.1	22.1	20.4	19.3	21.8	20.9	19.5	21.6	20.4	N/R	N/R	N/R	N/R	N/R	N/R	19.7	21.8	20.7
CO (PPM)	0	0	0	0	0	0	0	0	0	N/R	N/R	N/R	N/R	N/R	N/R	0	2	0
H ₂ S (PPM)	0	0	0	0	0	0	0	0	0	N/R	N/R	N/R	N/R	N/R	N/R	0	0	0
Peak CH ₄ (%)	0.0	0.2	0.1	0.0	0.1	0.1	0.0	0.2	0.1	N/R	N/R	N/R	N/R	N/R	N/R	0.0	0.3	0.1
LEL (%)	0	2	1	0	2	1	0	4	2	N/R	N/R	N/R	N/R	N/R	N/R	0	4	2
Pressure (mb)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/R	N/R	N/R	N/R	N/R	N/R	-0.2	0.0	0.0
Temp (°C)	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
Determinant	NYG 5			NYG 6			NYG 7			NYG 8			NYG 9			NYG 10		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
CH ₄ (%)	N/R	N/R	N/R	0.0	0.1	0.1	0.0	0.2	0.1	0.0	0.2	0.1	N/R	N/R	N/R	0.0	0.2	0.1
CO ₂ (%)	N/R	N/R	N/R	0.0	0.7	0.2	0.0	0.2	0.1	0.0	0.5	0.1	N/R	N/R	N/R	0.0	0.2	0.1
O ₂ (%)	N/R	N/R	N/R	19.5	21.9	21.0	19.7	21.6	20.9	16.8	21.5	20.4	N/R	N/R	N/R	19.9	21.8	20.8
CO (PPM)	N/R	N/R	N/R	0	0	0	0	0	0	0	0	0	N/R	N/R	N/R	0	0	0
H ₂ S (PPM)	N/R	N/R	N/R	0	0	0	0	0	0	0	0	0	N/R	N/R	N/R	0	0	0
Peak CH ₄ (%)	N/R	N/R	N/R	0.0	0.1	0.1	0.0	0.2	0.1	0.0	0.2	0.1	N/R	N/R	N/R	0.0	0.2	0.1
LEL (%)	N/R	N/R	N/R	0	2	1	0	4	2	0	4	2	N/R	N/R	N/R	0	4	2
Pressure (mb)	N/R	N/R	N/R	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/R	N/R	N/R	0.0	0.0	0.0
Temp (°C)	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R

5. CONCLUSIONS

5.1 Overview

Amgen Rhondda Ltd. (ARL) have carried out environmental monitoring of leachate, groundwater, surface water and landfill gas at the Nant-y-Gwyddon landfill site throughout 2017, as specified in the site licence (Environmental Permit) and working plan.

The information collected during these exercises has been reviewed in sections 3 and 4 of this document and form part of the continual reporting of site activities to Natural Resources Wales (formerly EA Wales).

5.2 Landfill Leachate Levels and Contamination

Throughout 2017, ARL have taken monthly dip measurement of leachate levels within the landfill at Nant-y-Gwyddon. These have been taken from 2 locations situated within the waste, both of which extend to the base of the landfill.

Results show that leachate levels within the landfill at Nant-y-Gwyddon have been maintained below 1m throughout 2017 as required by the site's permit conditions.

ARL utilise 3 locations at the Nant-y-Gwyddon landfill site for the purpose of monitoring the concentrations of contaminants present within the landfill leachate (including 1 located directly in the waste cell). During this reporting period (Jan-17 to Dec-17), ARL carried out the required suite of laboratory analysis on 34 leachate samples collected from these locations.

Section 3.2 provides a comparison of ARL's analysis of contaminant concentrations in leachate sampled at Nant-y-Gwyddon with published average data for leachate in similar type UK landfill (see Table 3.3). It is shown that leachate currently being produced at the Nant-y-Gwyddon Landfill Site is relatively dilute when compared to national averages, as reported in DoE Research Report No. CWM 072/94 (DoE 1995). It has also been shown that there is no obvious trend in concentrations of leachate contamination present at the site during the same period. Each of the contaminants analysed remained fairly consistent in concentration (see Table 3.3 and Appendix D for reference).

5.3 Surface Water Quality

Throughout the period Jan-17 to Dec-17 ARL have carried out the required surface water monitoring at 7 locations on and around the Nant-y-Gwyddon landfill site. The results of a series of laboratory analysis carried out on 70 surface water samples collected at the site are presented, along with a comparison of associated EAL's.

Throughout 2017, surface water sampled on and around the Nant-y-Gwyddon Landfill Site has been shown to be of a good quality. There was no indication of leachate contamination in any samples taken in any of the 4 watercourses surrounding the site, with concentrations of ammoniacal nitrogen (NH_4 as N) very low in each of the 70 samples analysed.

When compared with the results of surface water monitoring undertaken in 2015 and 2016, it has been shown that the high quality of water document during previous years has been maintained throughout 2017.

5.4 Groundwater Quality

The Nant-y-Gwyddon site is equipped with a total of 20 groundwater monitoring boreholes, 10 of which are down-gradient of the landfill, 7 up-gradient and 3 of which are considered to be perpendicular to groundwater flow. During the period Jan-17 to Dec-17, ARL carried out the agreed suite of laboratory analysis on 96 groundwater samples obtained from these monitoring installations.

The results of Groundwater monitoring undertaken by ARL at the Nant-y-Gwyddon Landfill Site during the period Jan-17 to Dec-17 have been reviewed as part of the ongoing stewardship of the Nant-y-Gwyddon Landfill Site. Results have been compared against site specific trigger and control levels in order to determine the environmental performance of the landfill.

Table 3.9 (section 3.4) provides a summary of results of groundwater monitoring, against the agreed control and trigger levels for the Nant-y-Gwyddon Landfill Site. It can be seen that there was a single exceedance of the trigger level for Zinc. This was recorded at the down-gradient monitoring borehole GW 96 in Nov-17. Further testing was undertaken from within this borehole in Feb-18 and May-18. Levels of Zinc at this time had returned to those values typically observed in groundwater at the site (i.e. in the region of 0 to 20 ug/l). No significance has been attributed to this observation.

5.5 Sub-surface Landfill Gas Monitoring

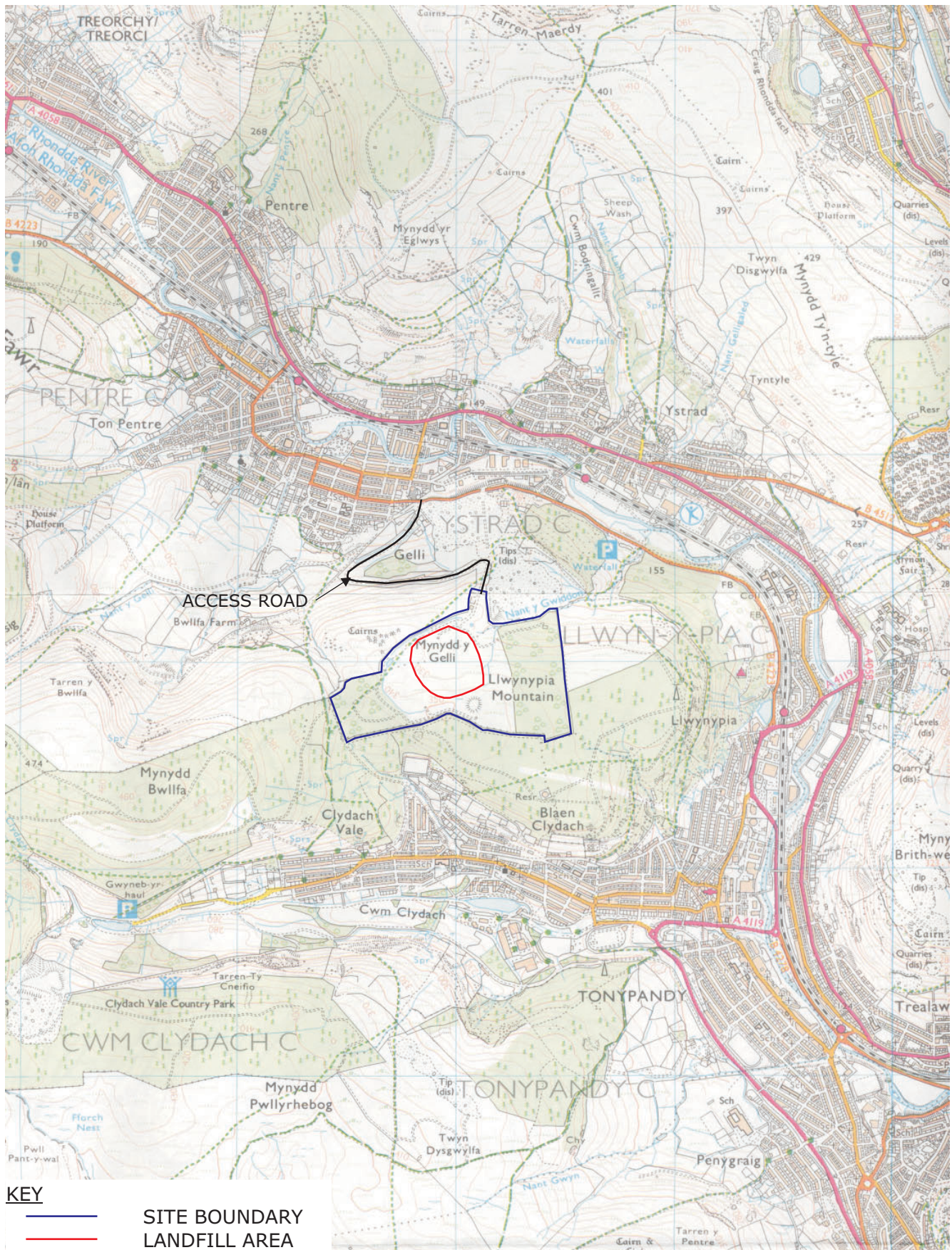
Throughout 2017, ARL staff have undertaken monthly monitoring of landfill gas in 18 sub-surface boreholes located around the Nant-y-Gwyddon Landfill Site. Results show that there is no evidence to suggest that landfill gas is escaping from the base of the site. Current measures in place to control landfill gas migration are shown to be protective of the environment and human health.

6. RECOMMENDATIONS

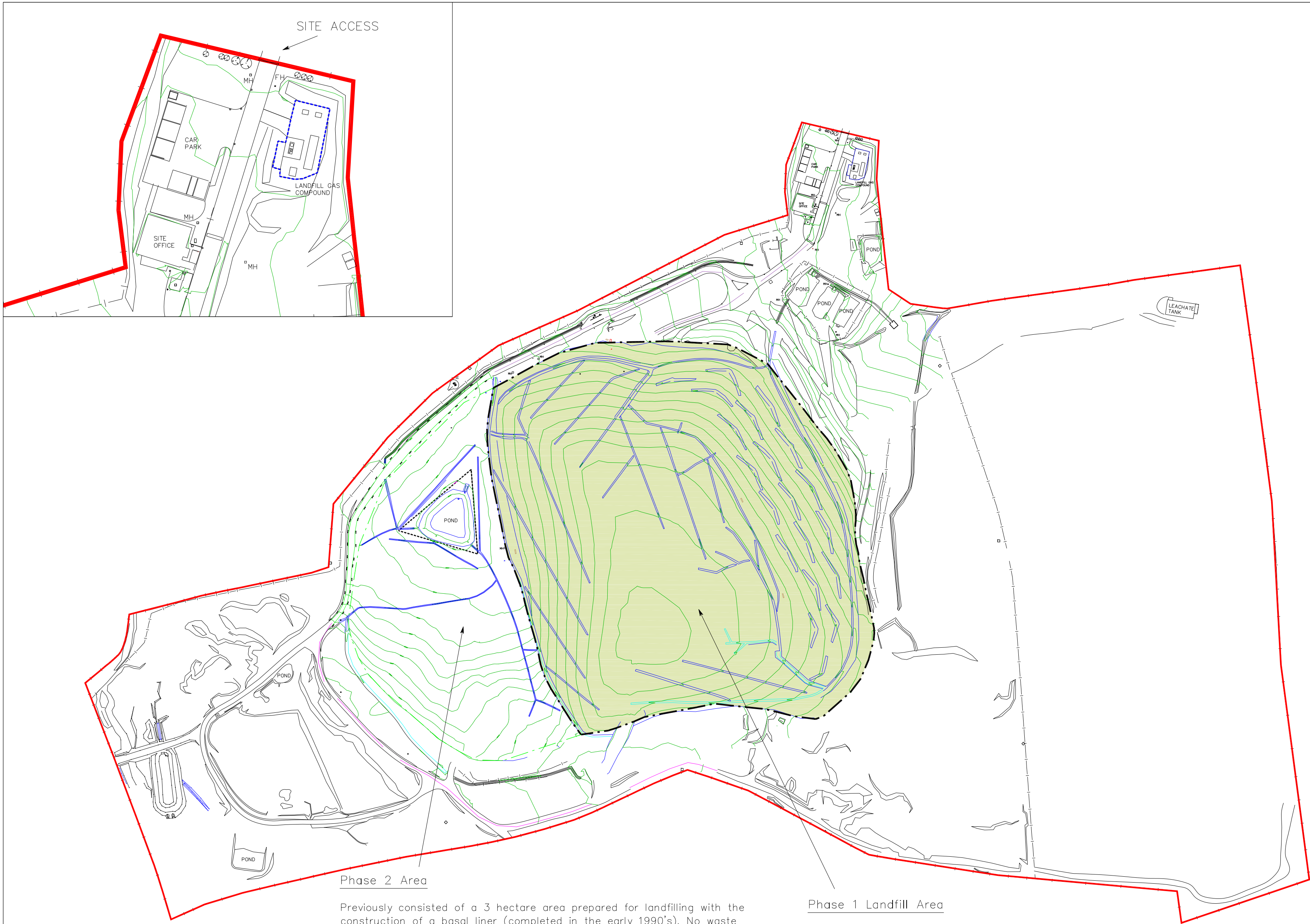
Continue to obtain and review samples of water and soil gas on and around the Nant-y-Gwyddon Landfill Site in accordance with the approved Working Plan for the site.

APPENDIX A

Drawings



AMGEN RHONDDA NANT-Y-GWYDDON LANDFILL SITE NANT-Y-GWYDDON ROAD GELLI MID-GLAMORGAN CF41 7TL		PROJECT REVIEW OF ENVIRONMENTAL MONITORING RESULTS FOR NANT-Y-GWYDDON LANDFILL SITE 2017		DRAWING TITLE LOCATION PLAN (DRG NO. ARL2018/01/001)	
SCALE 1:25,000	DATE 29/04/2018	DRAWN L.F.	APPROVED	REPRODUCED FROM ORDNANCE SURVEY 1:50,000 MAP OF 1991 WITH THE PERMISSION OF THE CONTROLLER OF HER MAJESTY'S STATIONERY OFFICE, CROWN COPYRIGHT, LICENCE NUMBER AL50604A.	



Phase 2 Area

Previously consisted of a 3 hectare area prepared for landfilling with the construction of a basal liner (completed in the early 1990's). No waste was ever deposited within this area.

Subsequently, the current site operator (Amgen) constructed 3 (14,000 m3 capacity) leachate holding lagoons (completed in Dec 2001) for the control of leachate.

Both the basal liner and leachate lagoons have now been removed and the area restored with a shallow surface water lagoon.

Phase 1 Landfill Area

The Phase 1 landfill covers an area of approximately 9.5 hectares and was operated during the period November 1987 – March 2002. It contains approximately 1.25 million tonnes of Household, Commercial and Non-Hazardous Industrial Waste.

Now fully remediated and restored with the construction of an engineered landfill cap and surface water drainage infrastructure (completed September 2005).

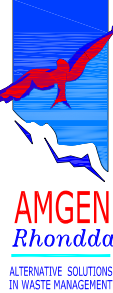
NOTES:

KEY:

WML BOUNDARY

AREA OF LANDFILL WASTE

REV.	DESCRIPTION	DATE



AMGEN
Rhondda
ALTERNATIVE SOLUTIONS
IN WASTE MANAGEMENT

AMGEN RHONDDA LTD.
BRYN PICA
LLWYDCOED
ABERDARE
CF44 0BX

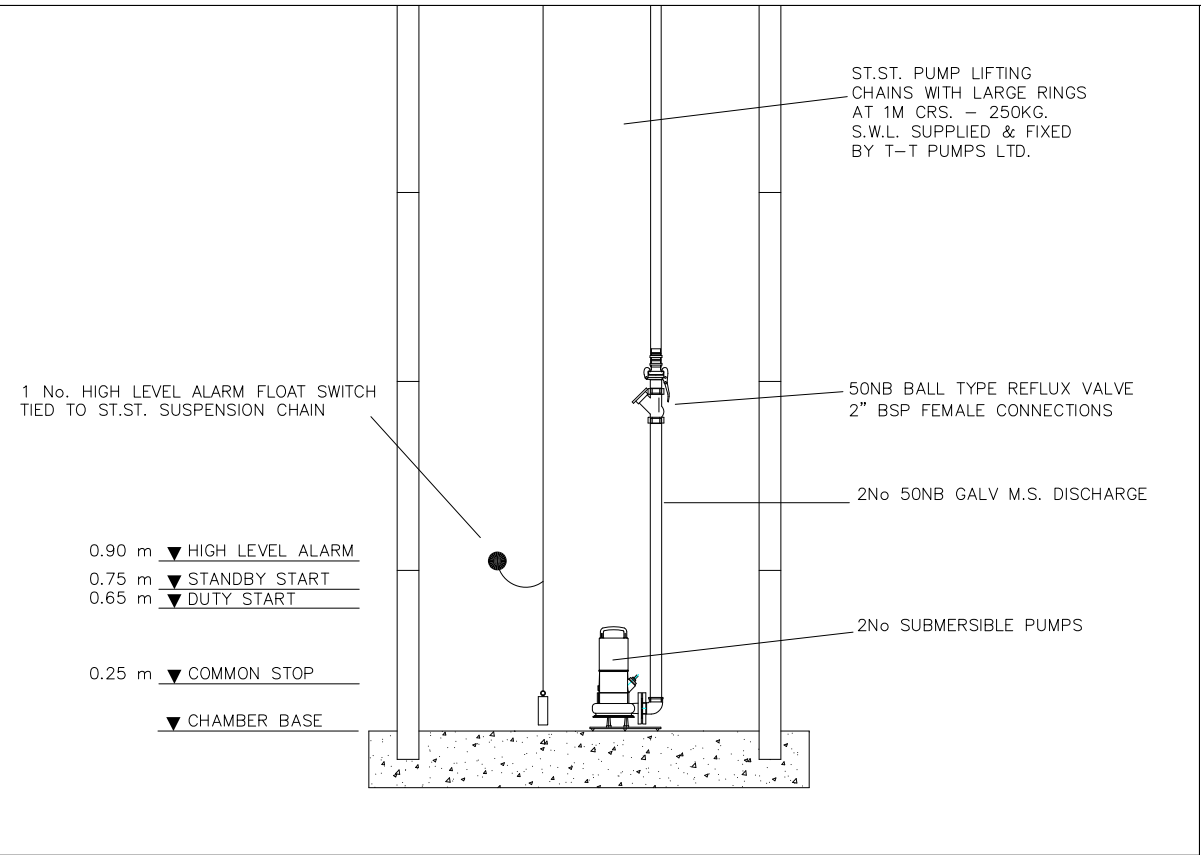
TEL: 01685 870770
FAX: 01685 874684

JOB TITLE
NANT-Y-GWYDDON
ENVIRONMENTAL REVIEW
2017

DRAWING TITLE
GENERAL LAYOUT

DRAWN	DATE	STATUS
		FOR COMMENT ☐
		FOR APPROVAL ☐
		DRAFT ☐
		FINAL ☒

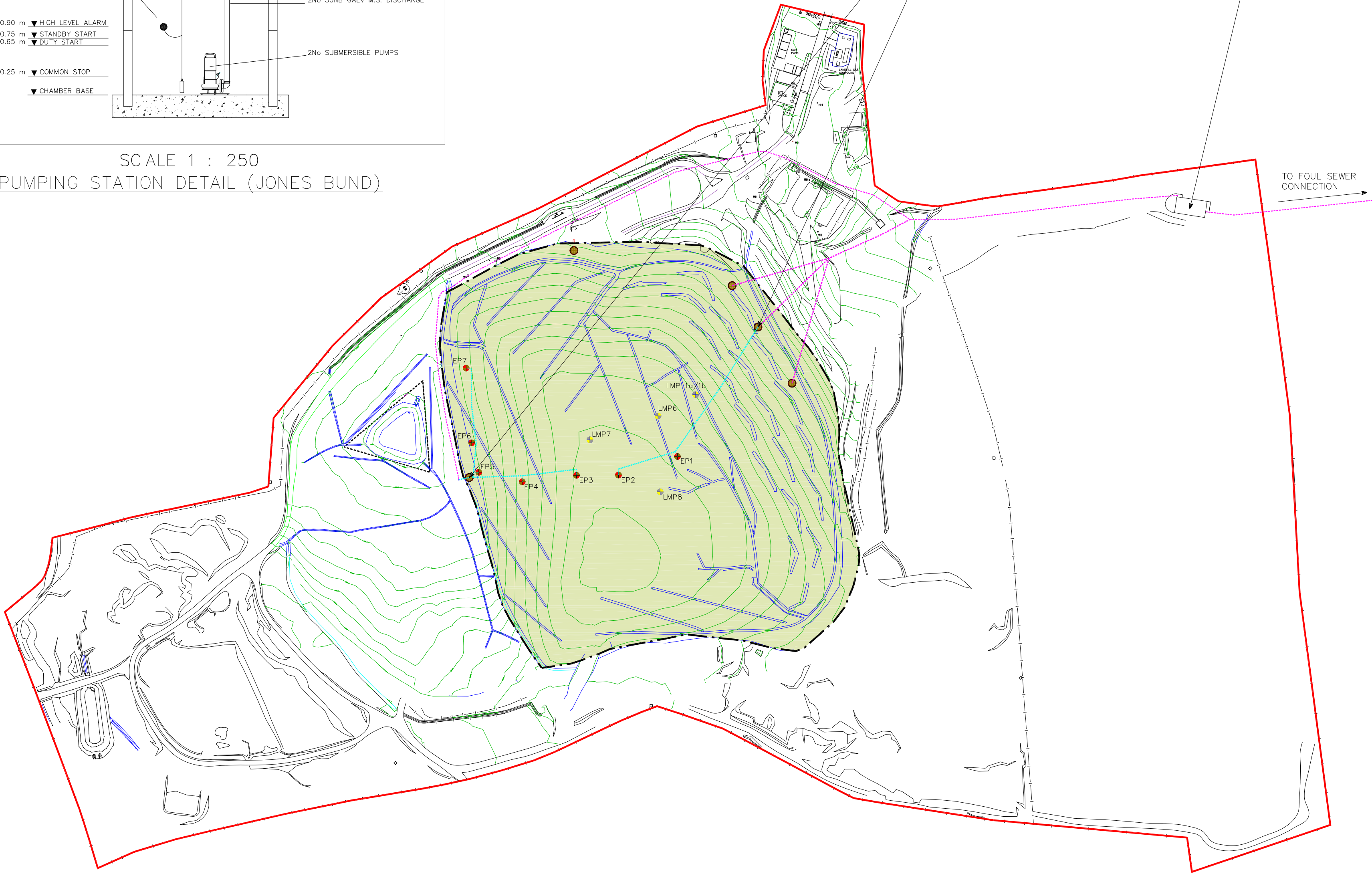
SCALE	SHEET	DRAWING NO.	REVISION
1: 2500	A2	ARL2018/ENV/01/002	—



SCALE 1 : 250
PUMPING STATION DETAIL (JONES BUND)

LEACHATE CONTAMINATION MONITORING POINTS:

- LPS1 (LEACHATE PUMPING STATION JONES BUND)
- L5a (INSPECTION MANHOLE)
- L5 (LEACHATE HOLDING TANK)



NOTES:

KEY:

- WML BOUNDARY
- AREA OF LANDFILL WASTE
- LEACHATE DISCHARGE PIPEWORK (SURFACE)
- LEACHATE DISCHARGE PIPELINE (UNDERGROUND)
- LEACHATE INSPECTION CHAMBER /SUMP
- LEACHATE EXTRACTION POINT
- LEACHATE MONITORING PIEZOMETER

REV.	DESCRIPTION	DATE



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BRYN PICA
LLWYDCOED
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JOB TITLE

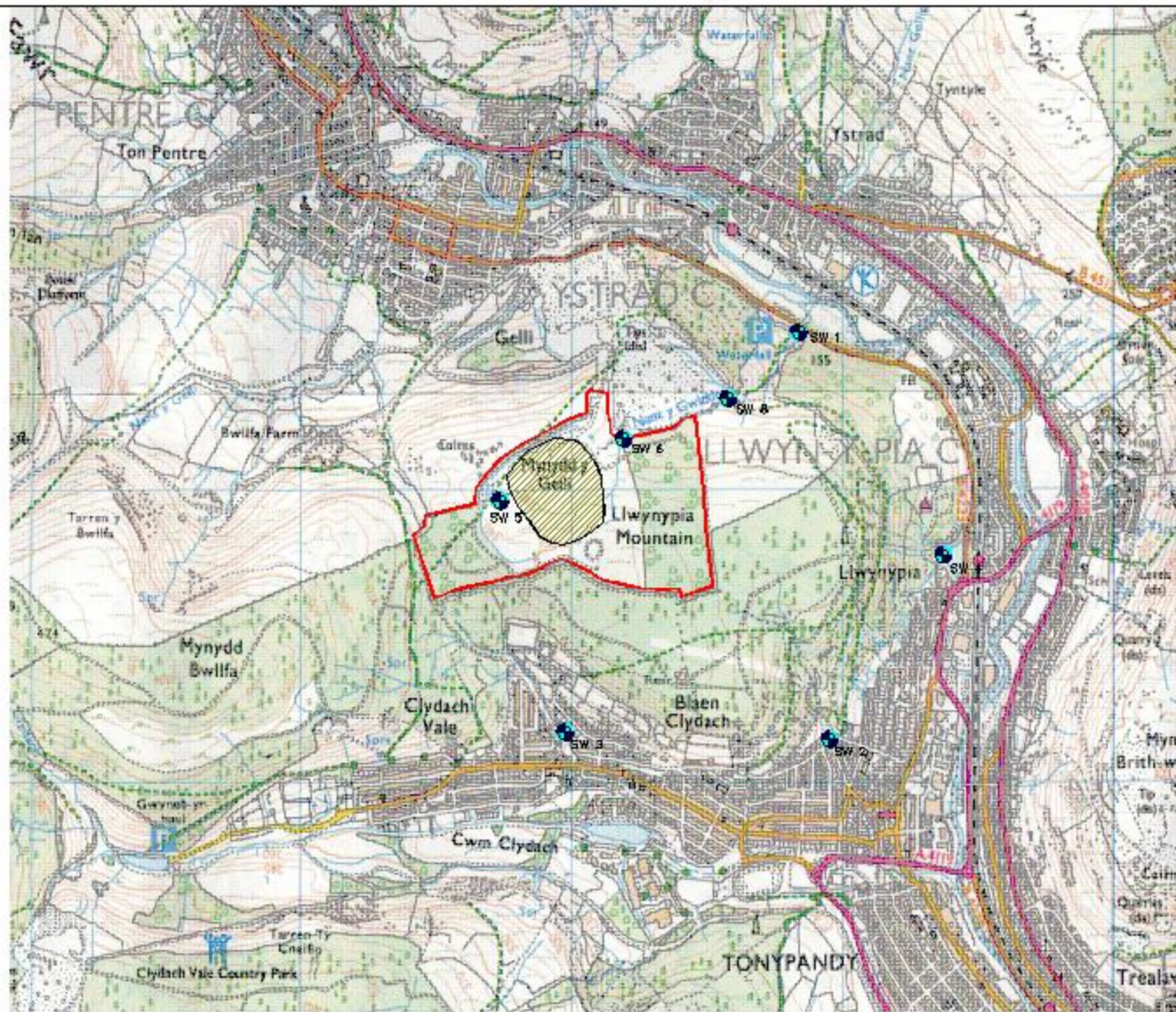
NANT-Y-GWYDDON
ENVIRONMENTAL REVIEW
2017

DRAWING TITLE

LEACHATE MANAGEMENT
AND MONITORING

DRAWN	DATE	STATUS
LF	28/08/18	FOR COMMENT ☐ FOR APPROVAL ☐ DRAFT ☐ FINAL ☒

SCALE	SHEET	DRAWING NO.	REVISION
1: 2500	A2	ARL2018/ENV/01/003	-



REV

REV

-  MAIN RAILWAY
-  AREA OF LANDFILL WASTE
-  SURFACE WATER MONITORING POINT

REV	DESCRIPTION	DATE

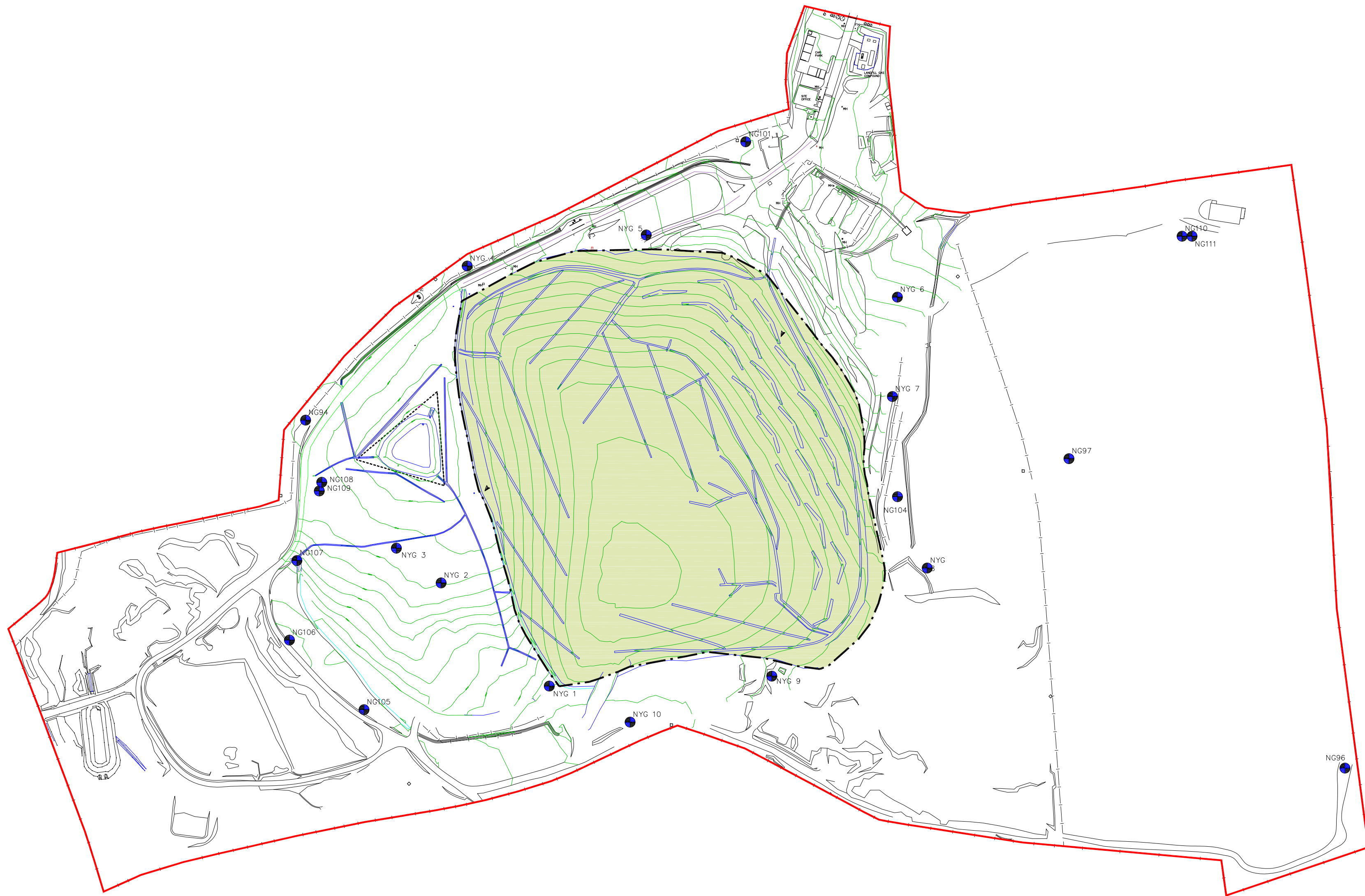


ANGLIA RAILWAYS LTD
30th FLOOR
LONDON
EC4A 3DF
TEL: 020 7467 0770
FAX: 020 7467 0744

**NANT-Y-GWYDDON
ENVIRONMENTAL REVIEW
2010**

**SURFACE WATER
MONITORING POINTS**

DATE	REV	BY	CHKD	DATE
20/08/10	AZ	ARL2010/000/11/004	-	-



NOTES:

KEY:

-  WML BOUNDARY
-  AREA OF LANDFILL WASTE
-  GROUNDWATER MONITORING POINT

REV.	DESCRIPTION	DATE



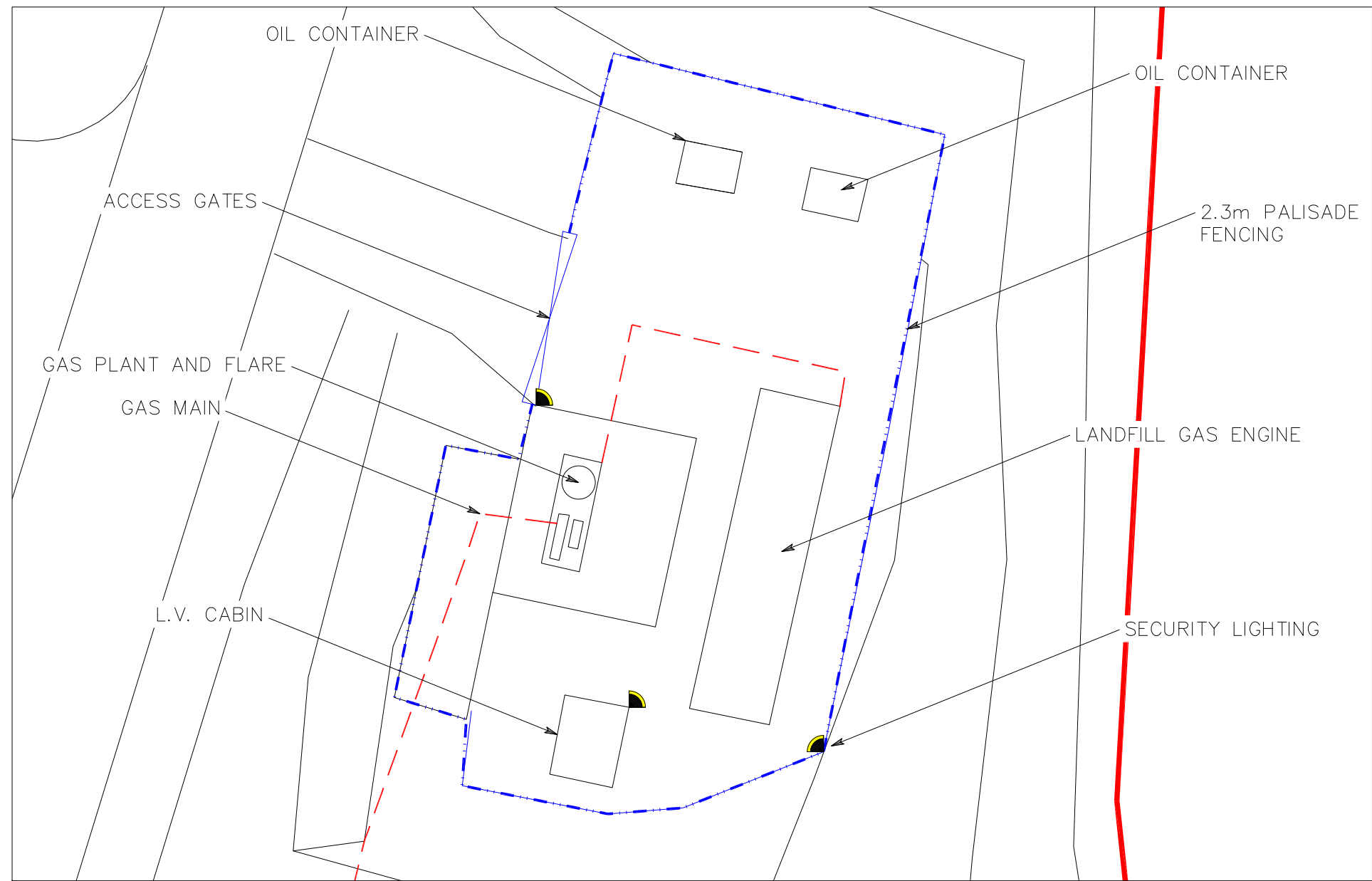
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JOB TITLE
NANT-Y-GWYDDON
ENVIRONMENTAL REVIEW
2017

DRAWING TITLE
GROUNDWATER MONITORING

			STATUS
			FOR COMMENT
APPROVED		DATE	FOR APPROVAL
LF		28/08/18	DRAFT
			FINAL

SCALE	SHEET	DRAWING NO.	REVISION
1: 2500	A2	ARL2018/ENV/01/005	—



SCALE 1 : 200

GENERAL LAYOUT OF LANDFILL GAS
POWER GENERATION COMPOUND



NOTES

KEY:

- WML BOUNDARY
- PHASE 1 LANDFILL AREA
- GAS MAIN
- GAS LINE (UNDERGROUND)
- GAS LINE (SURFACE)
- GAS EXTRACTION WELL WITH MONITORING POINT
- SUBSURFACE LANDFILL GAS MONITORING BOREHOLE
- LEACHATE INSPECTION CHAMBER
- LANDFILL GAS CONTROL MANIFOLD AND DEWATERING KNOCKOUT POT

REV.	DESCRIPTION	DATE



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JOB TITLE

NANT-Y-GWYDDON
ENVIRONMENTAL REVIEW
2017

DRAWING TITLE

LANDFILL GAS MANAGEMENT
AND MONITORING

APPROVED	DATE	STATUS
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SCALE	SHEET	DRAWING NO.	REVISION
1:1500	A1	ARL2018/ENV/01/006	—

Monitoring Suites from Site Working Plan

Table 10: Leachate monitoring and sampling determinands:

Parameter	Monthly Suite	Quarterly Suite	Annual Suite	Lower Detection Limit mg/l	Action Threshold
1,2-Dichloroethane		✓	✓	0.002	
Acetone			✓	0.1	
Acrylonitrile			✓	0.1	
Alkalinity	✓	✓	✓	10	
Ammoniacal Nitrogen	✓	✓	✓	0.3	
Arsenic			✓	0.0005	
Benzene		✓	✓	0.002	
BOD	✓	✓	✓	1.3	
Cadmium		✓	✓	0.0002	
Calcium		✓	✓	0.01	
Chloride	✓	✓	✓	20	
Chromium		✓	✓	0.01	
COD	✓	✓	✓	17	
Conductivity	✓	✓	✓		
Copper		✓	✓	0.01	
Anionic Detergents and Surfactants			✓	0.2	
Dimethoxymethane			✓	0.1	
Dimethylethanolamine			✓	0.01	
Dissolved Oxygen				0.5	
Formaldehyde			✓	0.1	
Iron		✓	✓	0.01	
Lead		✓	✓		
Magnesium		✓	✓	0.0005	
Manganese			✓	0.001	
Mercury			✓	0.0005	
Methanol			✓		
Nickel		✓	✓	0.01	
Nitrate		✓	✓	0.4	
Nitrite		✓	✓	0.008	
pH	✓	✓	✓	n/a	
Phenol		✓	✓	0.11	
Phosphate		✓	✓	0.1	
Potassium		✓	✓	0.0005	
Propan-1-ol			✓	0.1	
Propan-2-ol			✓	0.1	
Propylamine			✓	0.01	
Sodium		✓	✓	0.0005	
Sulphate		✓	✓	0.1	
Sulphide		✓	✓	0.2	
Suspended Solids	✓	✓	✓	2	
Styrene		✓	✓	0.002	
Temperature	✓	✓	✓		
TOC	✓	✓	✓	2	
Toluene			✓	0.002	
Total Oxidised Nitrogen		✓	✓	0.4	
Trichloroethane		✓	✓	0.002	
Trichloroethylene		✓	✓	0.002	
Trimethylamine			✓	0.01	
Water/leachate level / piezometric head	✓	✓	✓	n/a	
Xylene		✓	✓	0.002	
Zinc		✓	✓	0.05	

Table 11a: Groundwater monitoring and sampling determinands:

Parameter	Monthly Suite	Quarterly Suite	Annual Suite
1,2-Dichloroethane		X	X
Acetone		X	X
Acrylonitrile		X	X
Alkalinity	X	X	X
Ammoniacal Nitrogen (ammonium as N)	X	X	X
Arsenic		X	X
Benzene		X	X
BOD	X	X	X
Cadmium		X	X
Calcium		X	X
Chloride	X	X	X
Chromium		X	X
COD	X	X	X
Conductivity	X	X	X
Copper		X	X
Anionic Detergents and Surfactants			X
Dimethoxymethane			X
Dimethylethanolamine			X
Dissolved Oxygen			
Formaldehyde			X
Iron		X	X
Lead		X	X
Magnesium		X	X
Manganese			X
Mercury			X
Methanol			X
Nickel		X	X
Nitrate	X	X	X
Nitrite	X	X	X
pH	X	X	X
Phenol		X	X
Phosphate		X	X
Potassium		X	X
Propan-1-ol			X
Propan-2-ol			X
Propylamine			X
Sodium		X	X
Sulphate		X	X
Sulphide		X	X
Suspended Solids	X	X	X
Styrene		X	X
Temperature	X	X	X
TOC	X	X	X
Toluene		X	X
Total Oxidised Nitrogen		X	X
Trichloroethane		X	X
Trichloroethylene		X	X
Trimethylamine			X
Water/leachate level / piezometric head	x	X	X
Xylene		X	X
Zinc		X	X

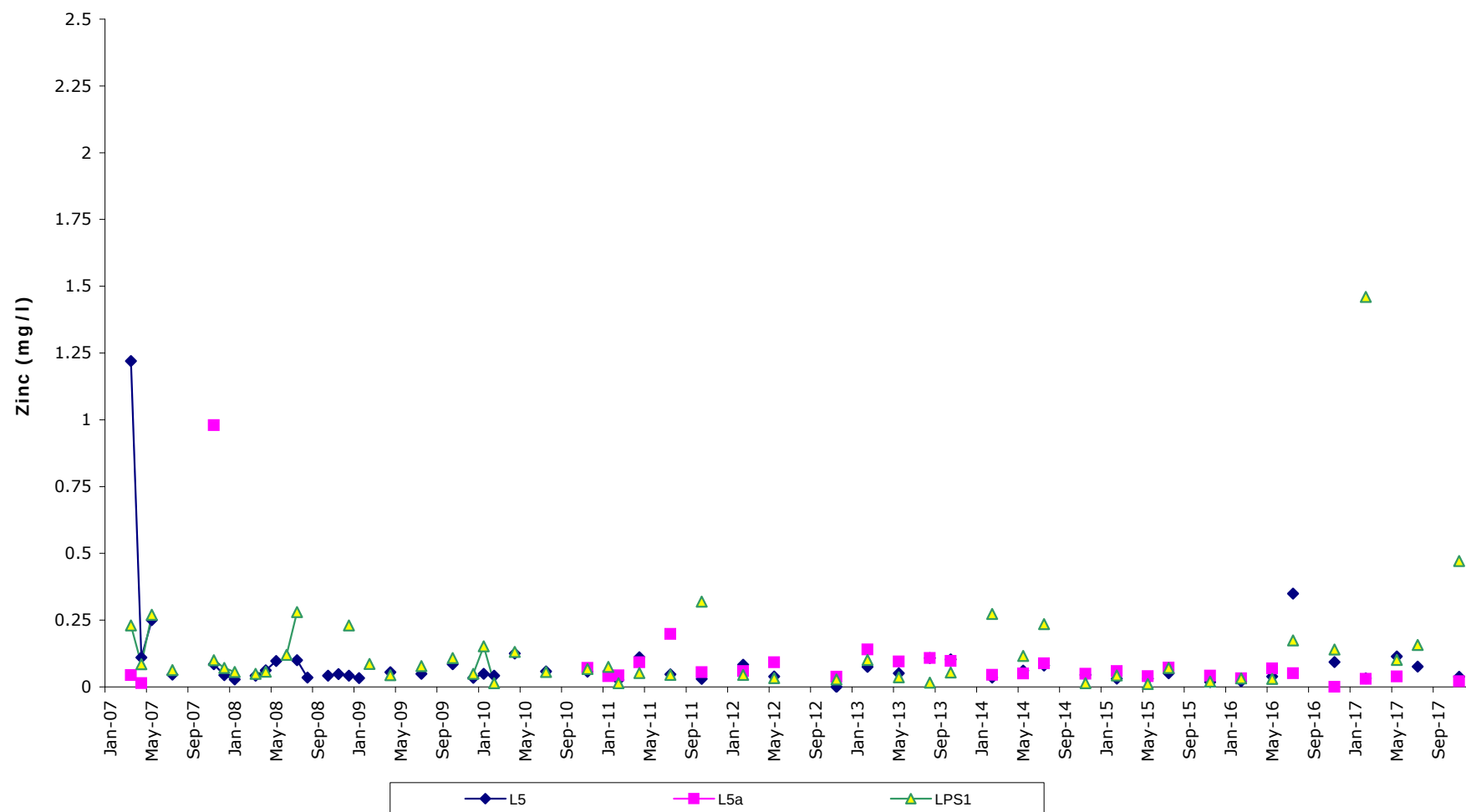
Table 12: Surface water monitoring and sampling determinands:

Parameter	Monthly Suite	Quarterly Suite	Annual Suite	Lower Detection Limit mg/l	Action Threshold
1,2-Dichloroethane		✓	✓	0.002	
Acetone			✓	0.1	
Acrylonitrile			✓	0.1	
Alkalinity	✓	✓	✓	10	
Ammoniacal Nitrogen	✓	✓	✓	0.3	
Arsenic			✓	0.0005	
Benzene			✓	0.002	
BOD	✓	✓	✓	1.3	
Cadmium		✓	✓	0.0002	
Calcium		✓	✓	0.01	
Chloride	✓	✓	✓	20	
Chromium		✓	✓	0.01	
COD	✓	✓	✓	17	
Conductivity	✓	✓	✓	100 µS	
Copper		✓	✓	0.01	
Anionic Detergents and Surfactants			✓	0.2	
Dimethoxymethane	-		✓	0.1	
Dimethylethanolamine	-		✓	0.01	
Dissolved Oxygen	✓	✓	✓	0.5	
Formaldehyde			✓	0.1	
Iron		✓	✓	0.01	
Lead		✓	✓		
Magnesium		✓	✓	0.0005	
Manganese			✓	0.001	
Mercury			✓	0.0005	
Methanol	-		✓		
Nickel		✓	✓	0.01	
Nitrate		✓	✓	0.4	
Nitrite		✓	✓	0.008	
pH	✓	✓	✓	n/a	
Phenol	-		✓	0.11	
Phosphate	-	✓	✓	0.1	
Potassium		✓	✓	0.0005	
Propan-1-ol	-		✓	0.1	
Propan-2-ol	-		✓	0.1	
Propylamine	-		✓	0.01	
Sodium		✓	✓	0.0005	
Sulphate		✓	✓	0.1	
Sulphide		✓	✓	0.2	
Suspended Solids	✓	✓	✓	2	
Styrene	-		✓	0.002	
Temperature	✓	✓	✓	0.1 C	
TOC	✓	✓	✓	2	
Toluene	-		✓	0.002	
Total Oxidised Nitrogen			✓	0.4	
Trichloroethane	-		✓	0.002	
Trichloroethylene	-		✓	0.002	
Trimethylamine	-		✓	0.01	
Water/leachate level / piezometric head				n/a	
Xylene	-		✓	0.002	
Zinc		✓	✓	0.05	

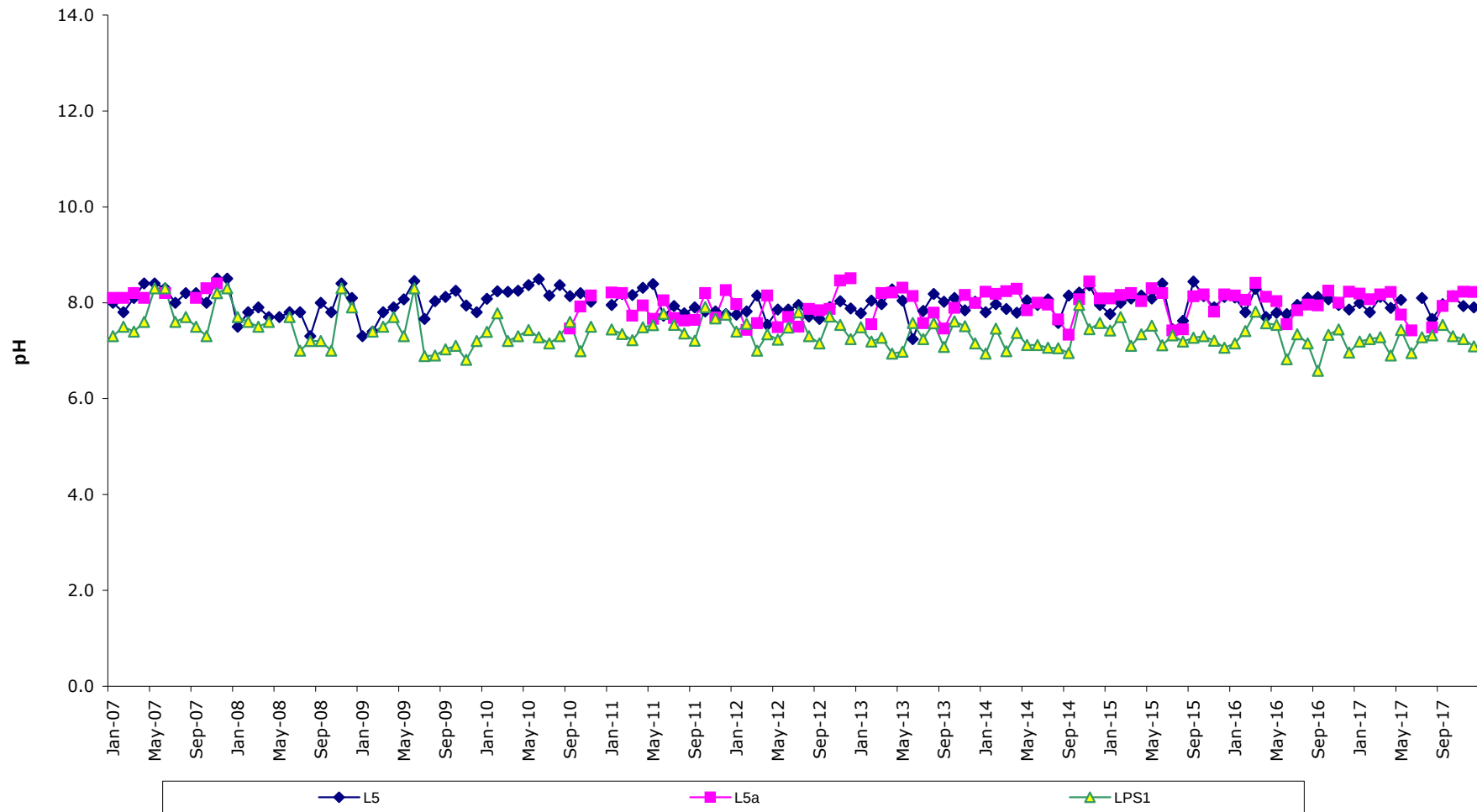
APPENDIX C

**Time Series Plots Illustrating the Results of ARL's Lab Analysis of
Leachate Sampled at the Nant-y-Gwyddon Landfill Site During the Period
Jan 07 – Dec 17.**

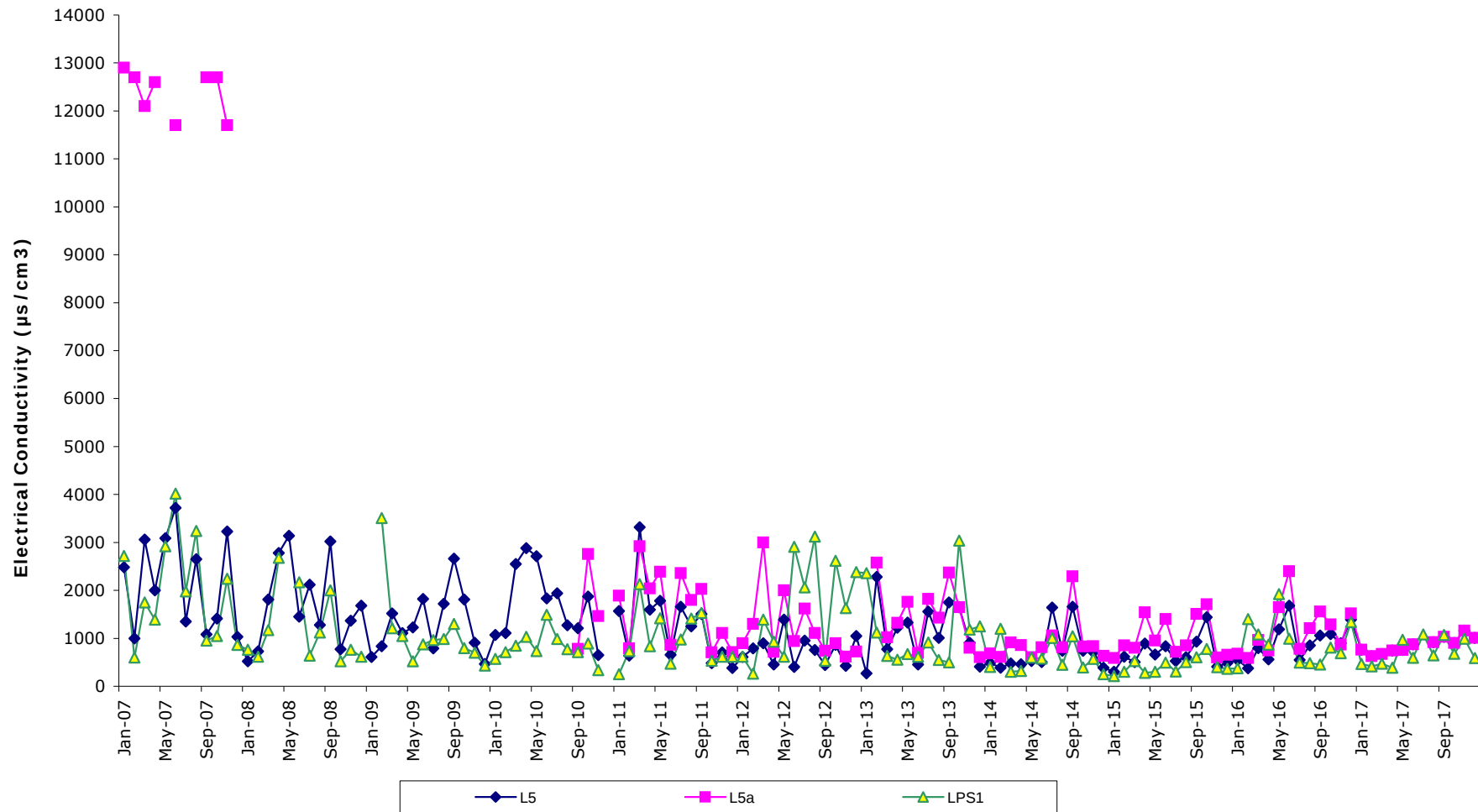
Lab analysis of Zinc in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



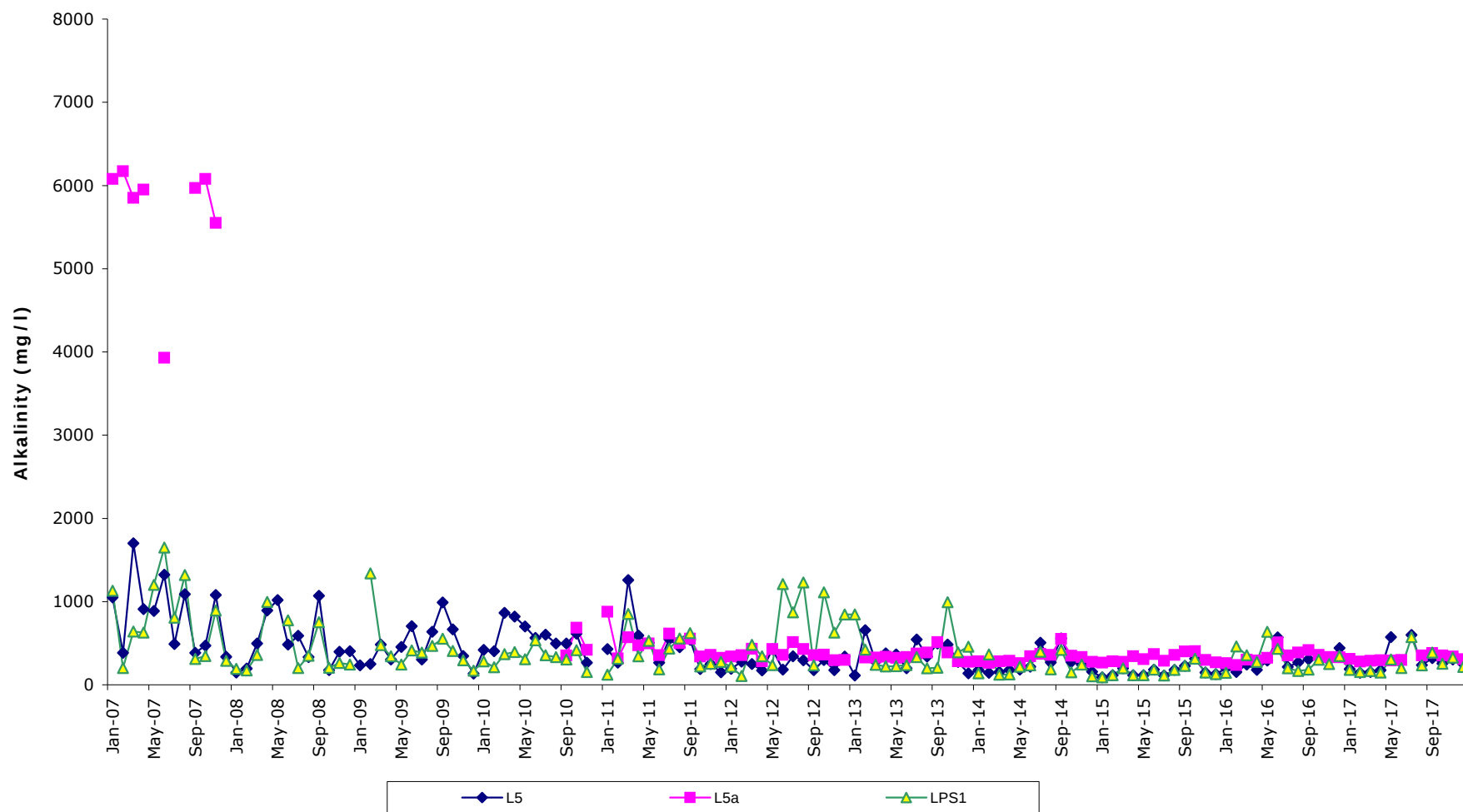
Lab analysis of pH levels in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill
Site during the period Jan 2007 - Dec 2017.



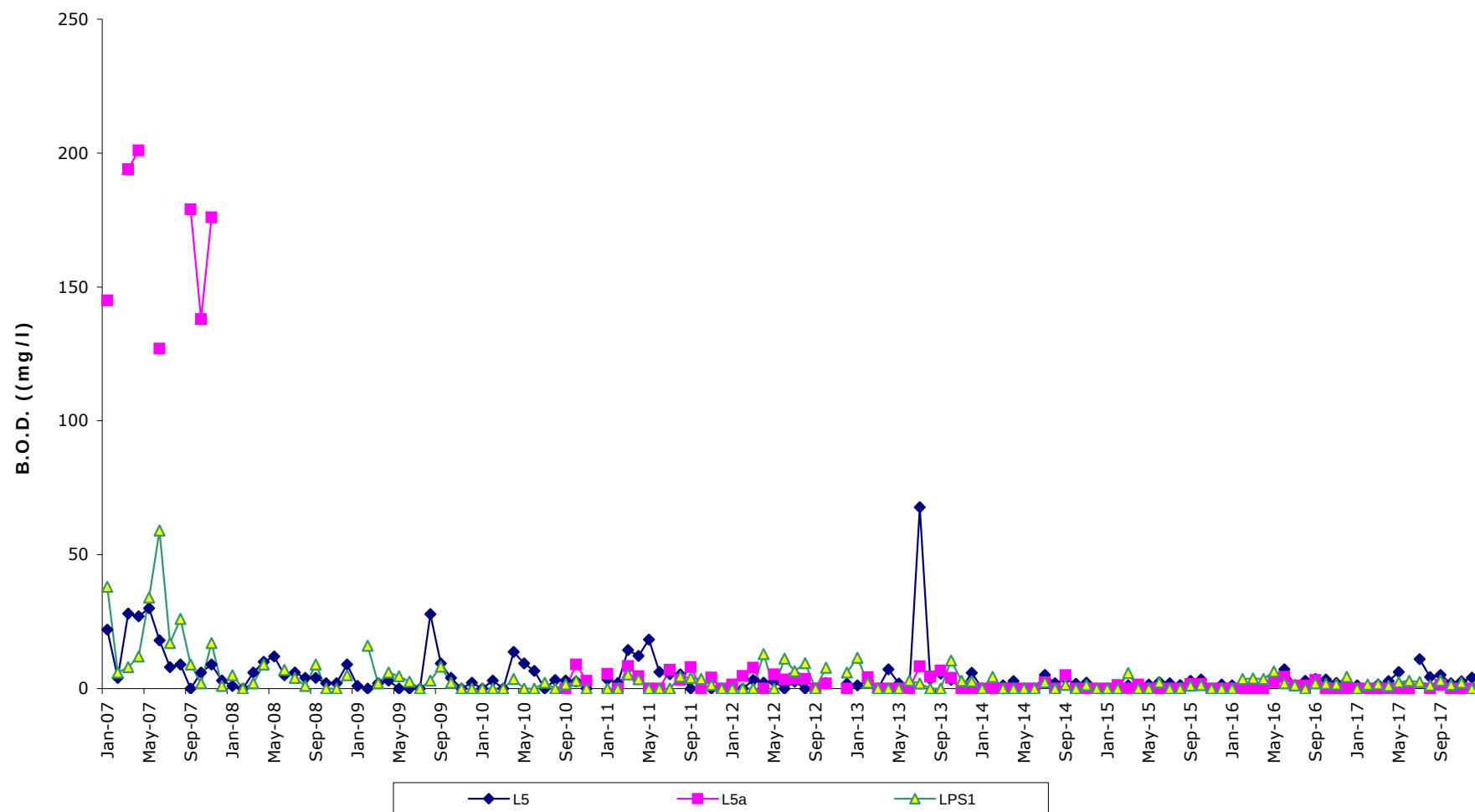
Lab analysis of Electrical Conductivity levels in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



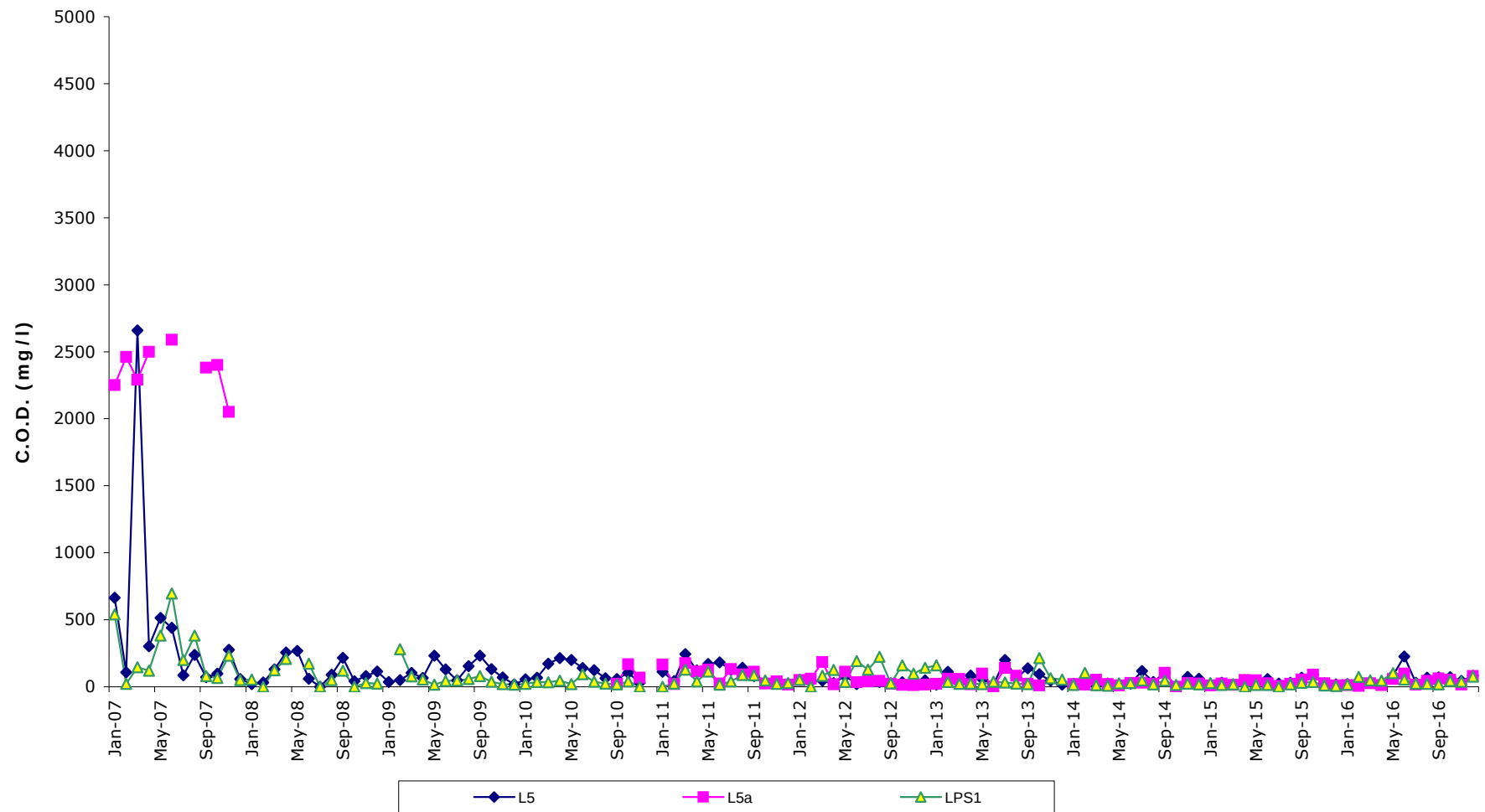
**Lab analysis of Alkalinity levels in leachate sampled by Amgen Rhondda Ltd at the Nant-y-Gwyddon
Landfill Site during the period Jan 2007- Dec 2017.**



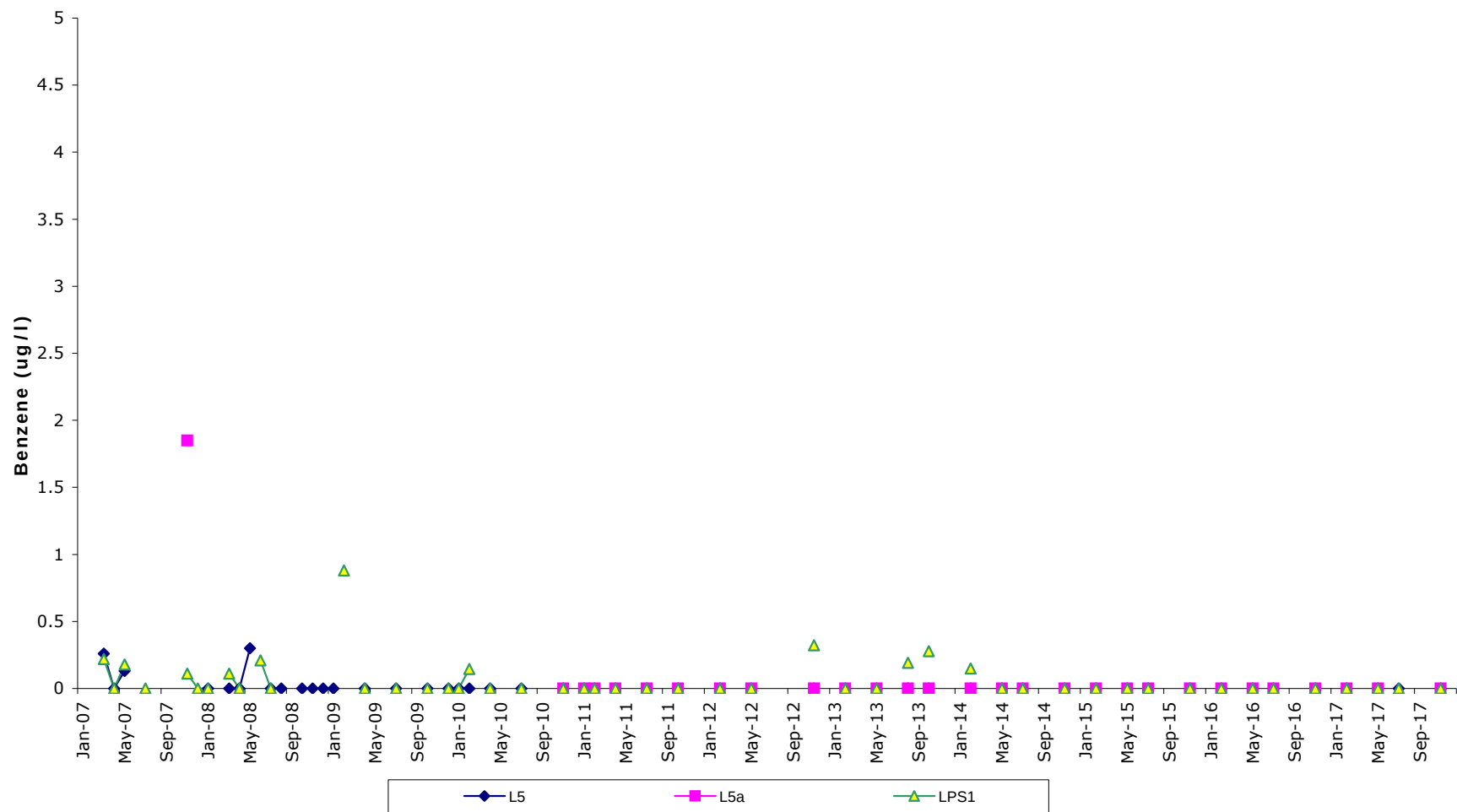
Lab analysis of B.O.D. in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill
Site during the period Jan 2007- Dec 2017.



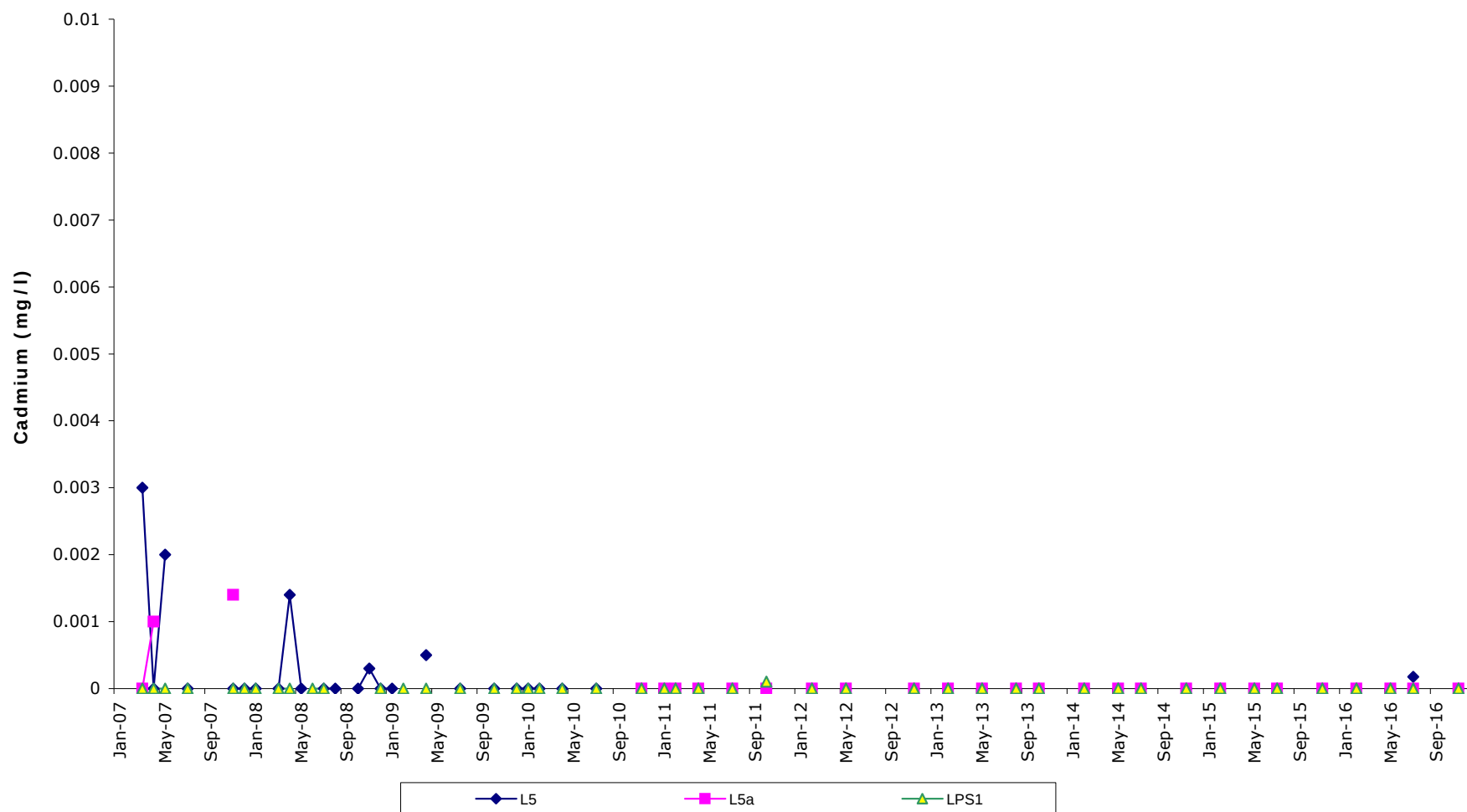
Lab analysis of C.O.D. in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill
Site during the period Jan 2007 - Dec 2017.



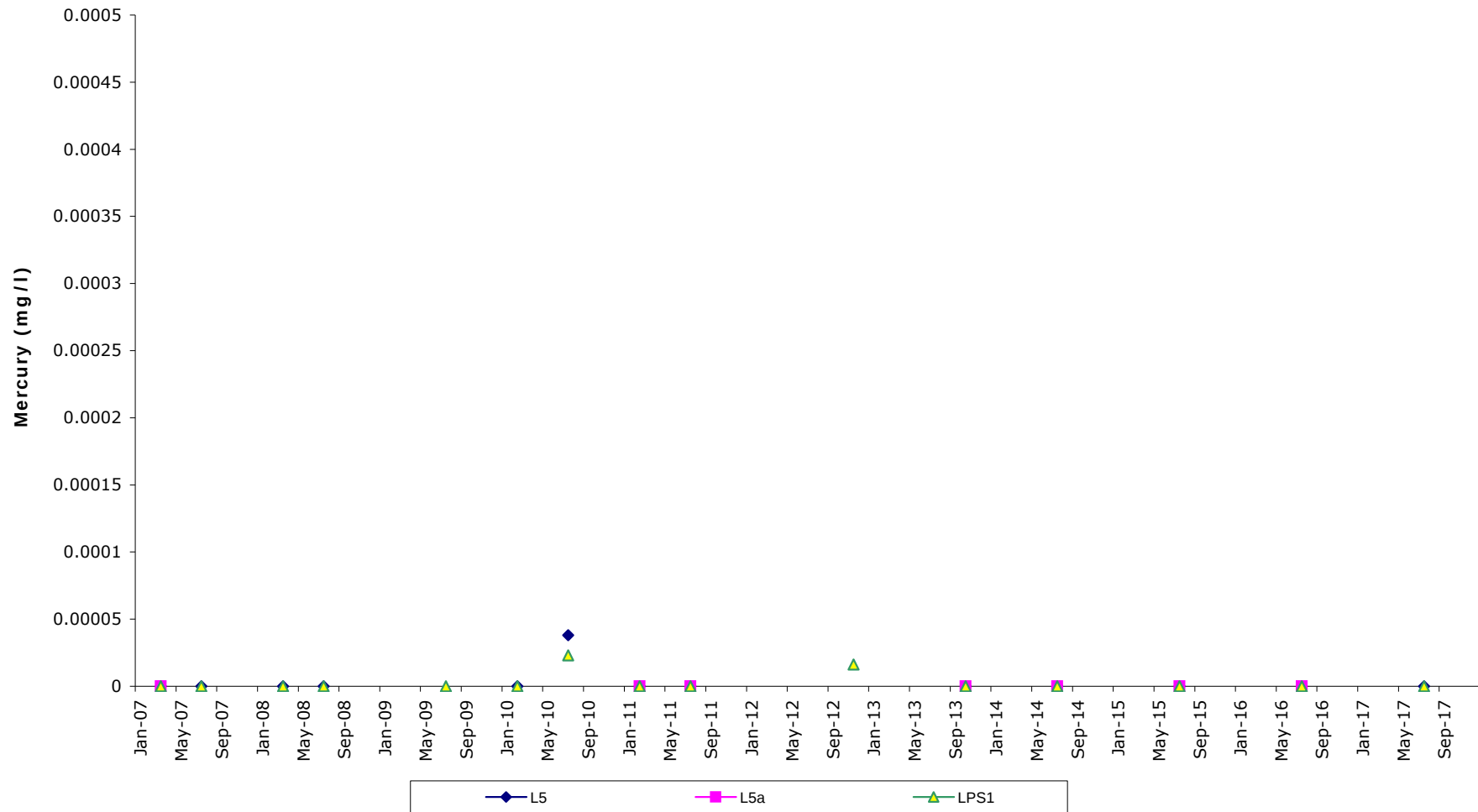
Lab analysis of Benzene in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill
Site during the period Jan 2007 - Dec 2017.



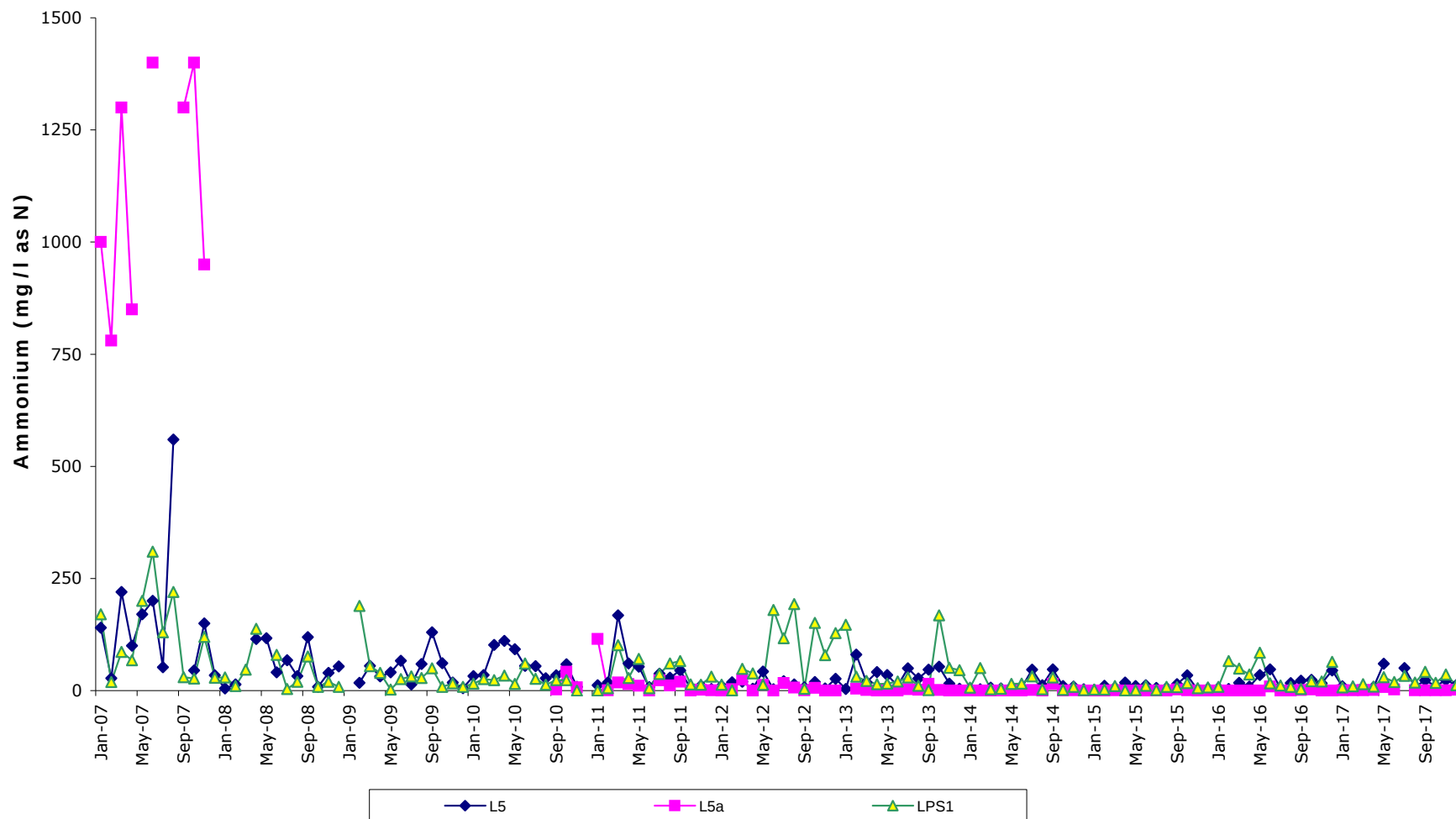
Lab analysis of Cadmium in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill
Site during the period Jan 2007 - Dec 2017.



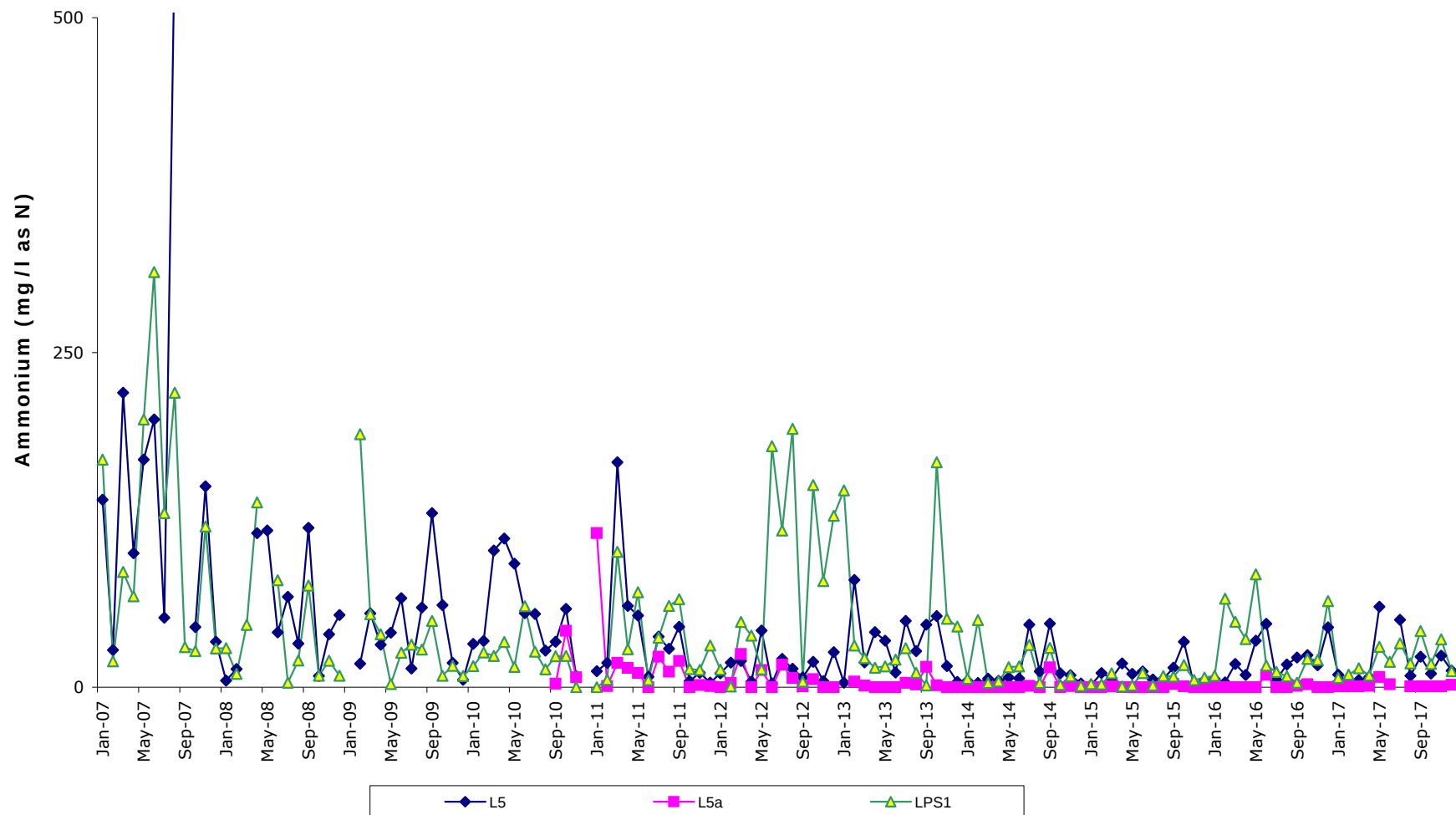
Lab analysis of Mercury in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



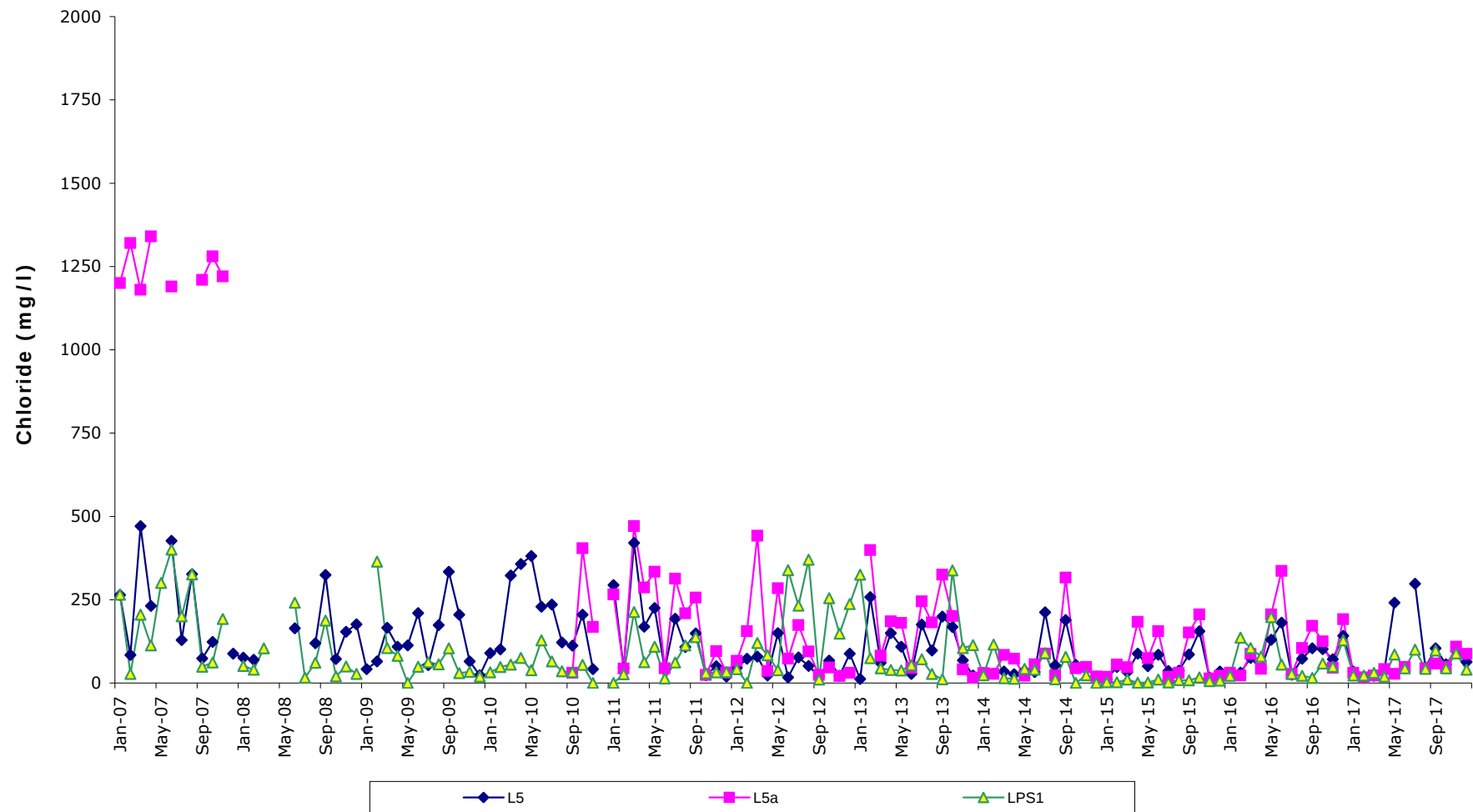
Lab analysis of Ammonium (as N) in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017 (Scale 0 - 1500 mg/l).



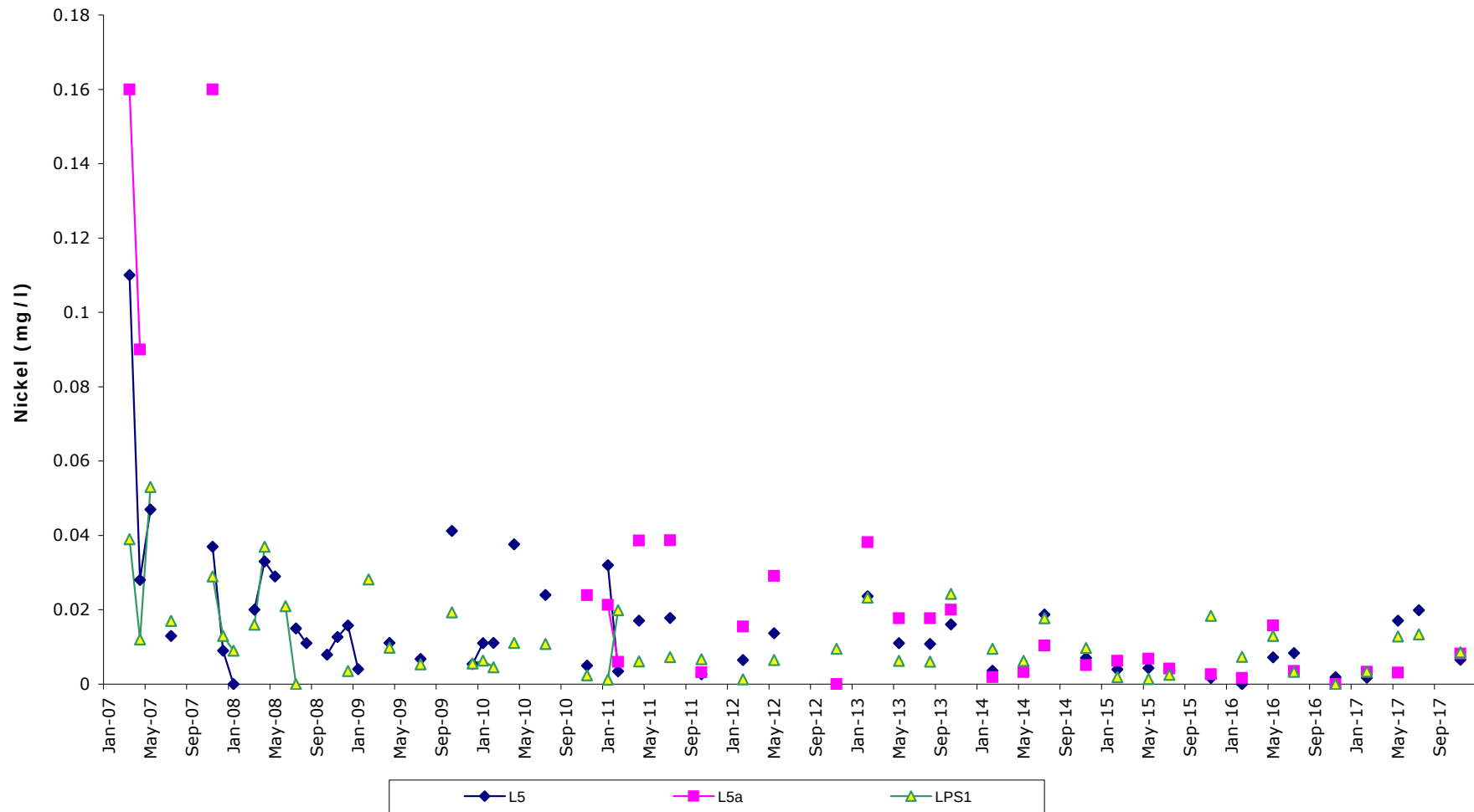
Lab analysis of Ammonium (as N) in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017 (Scale 0 - 500 mg/l).



Lab analysis of Chloride in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



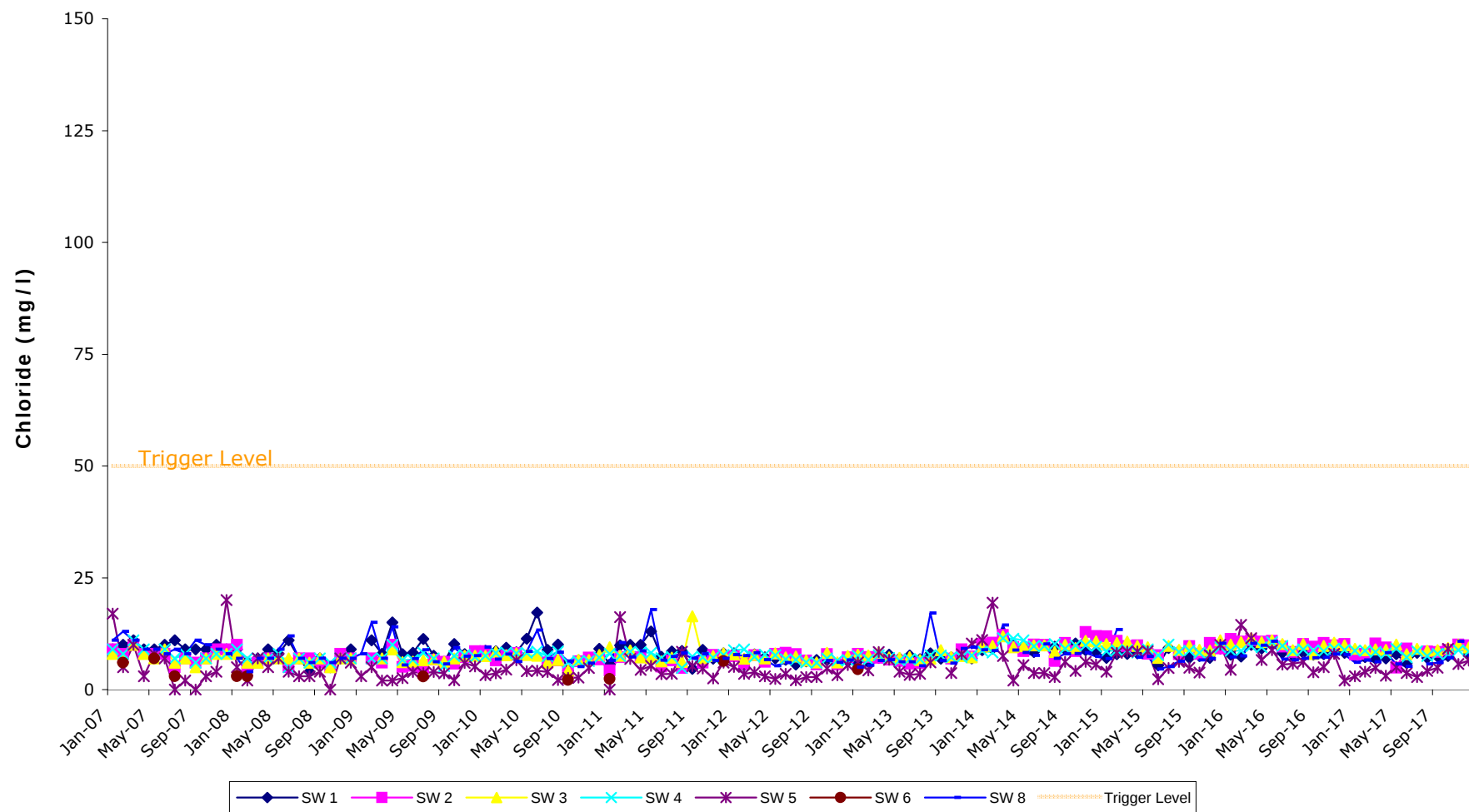
Lab analysis of Nickel in leachate sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill
Site during the period Jan 2007 - Dec 2017.



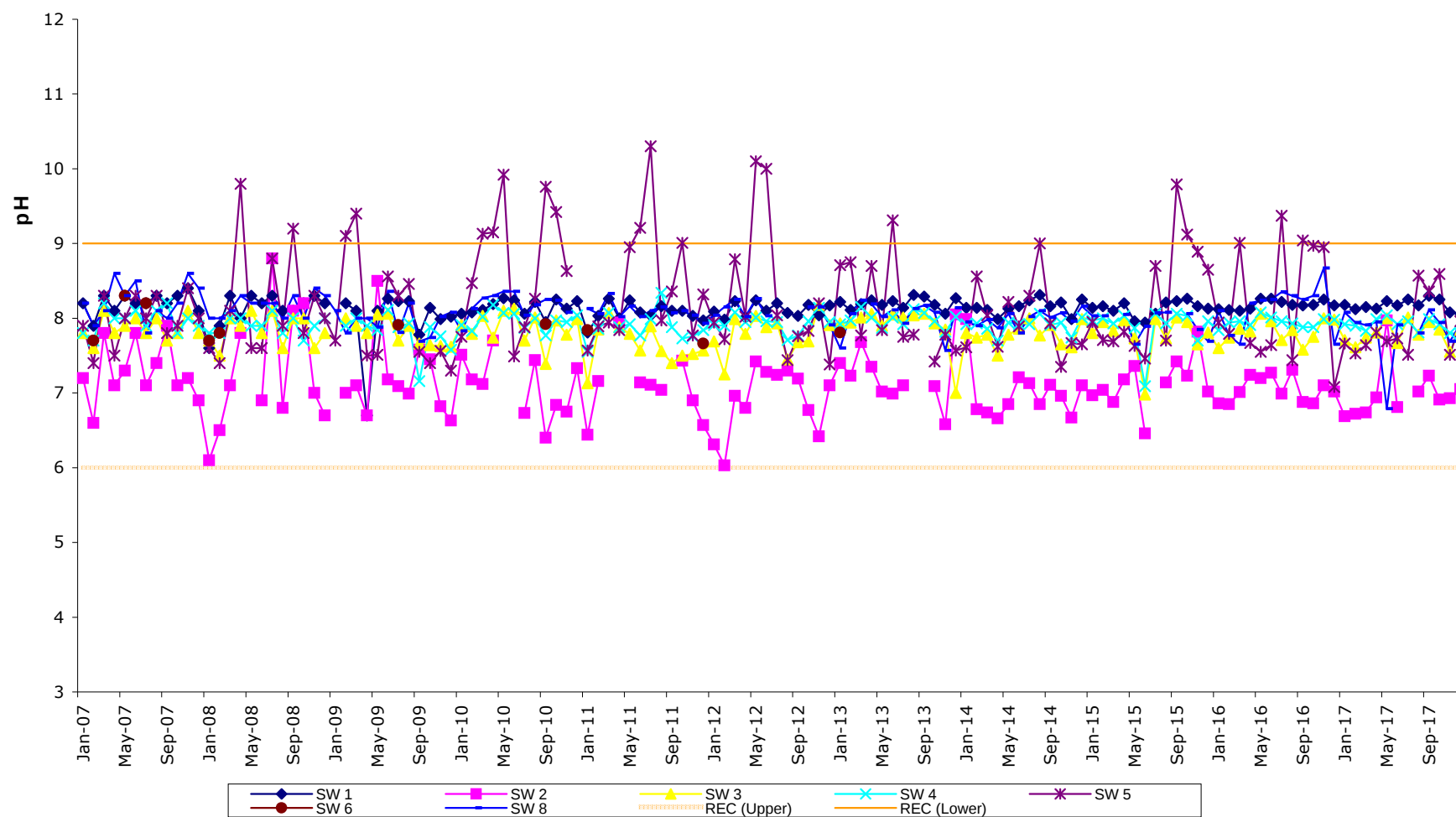
APPENDIX D

**Time Series Plots Illustrating the Results of ARL's Lab Analysis of
Surface Water Sampled at the Nant-y-Gwyddon Landfill Site During the
Period Jan 07 – Dec 17.**

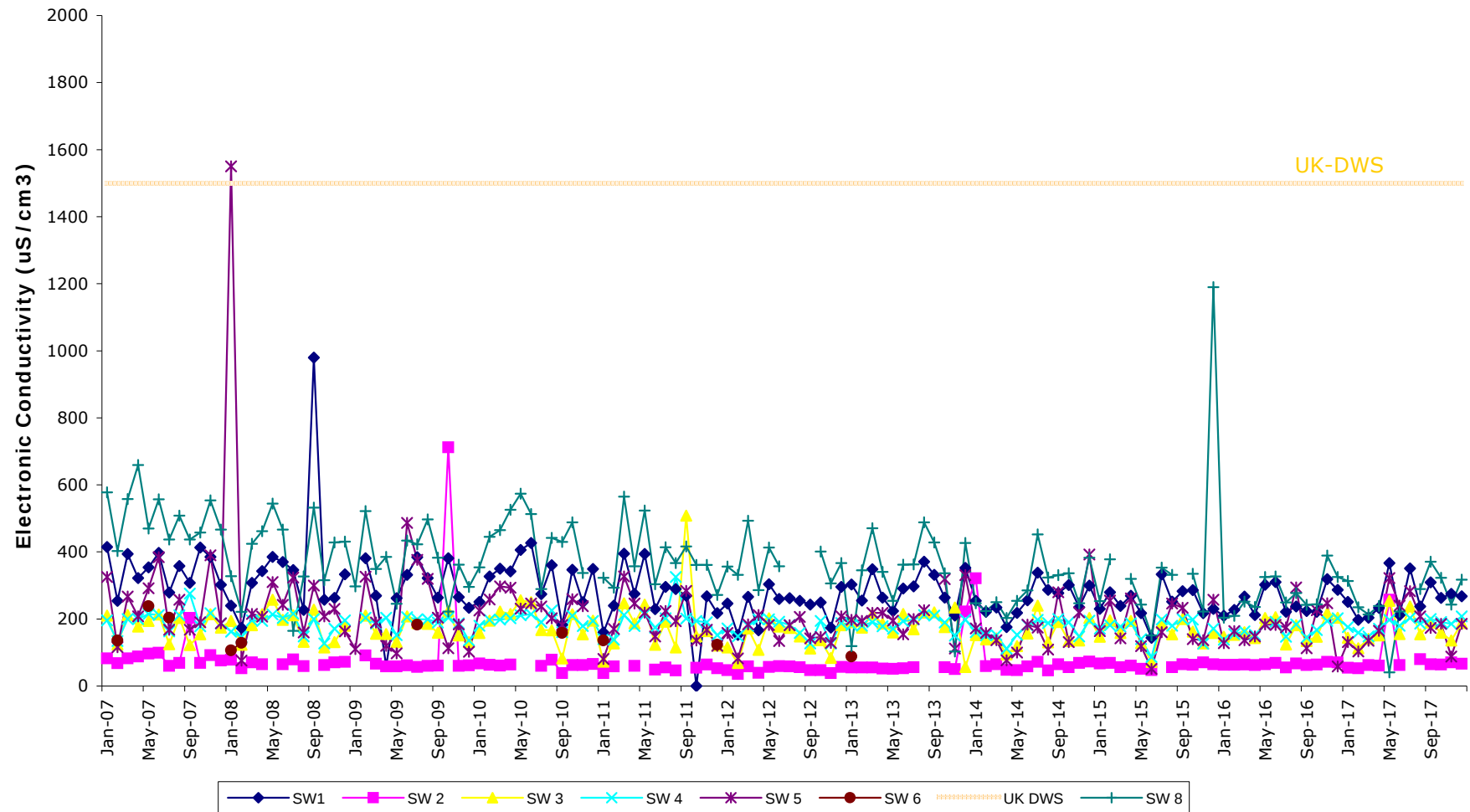
Lab analysis of Chloride concentrations in surface water sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



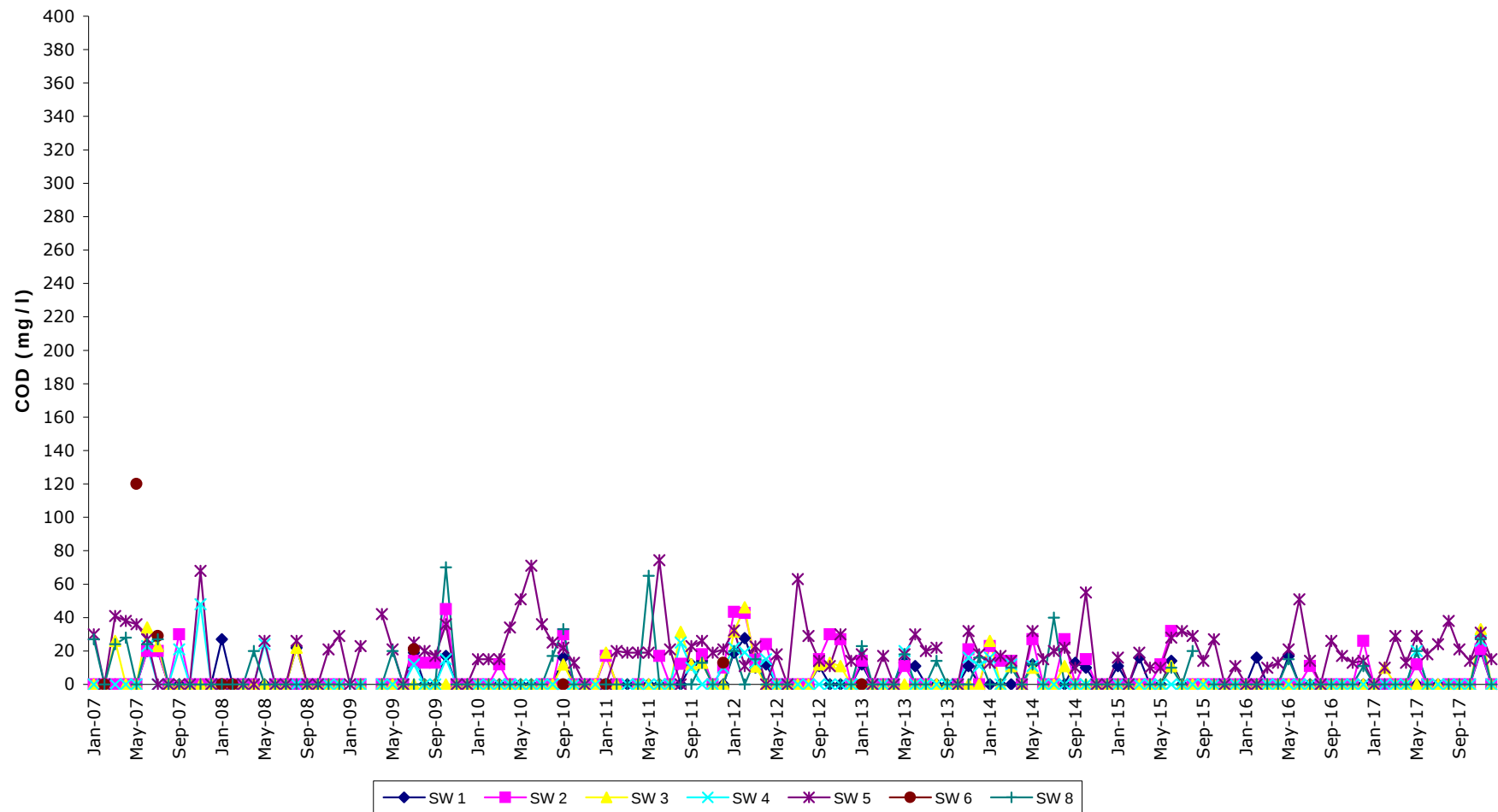
**Lab analysis of pH values in surface water sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon
Landfill Site during the period Jan 2007 - Dec 2017.**



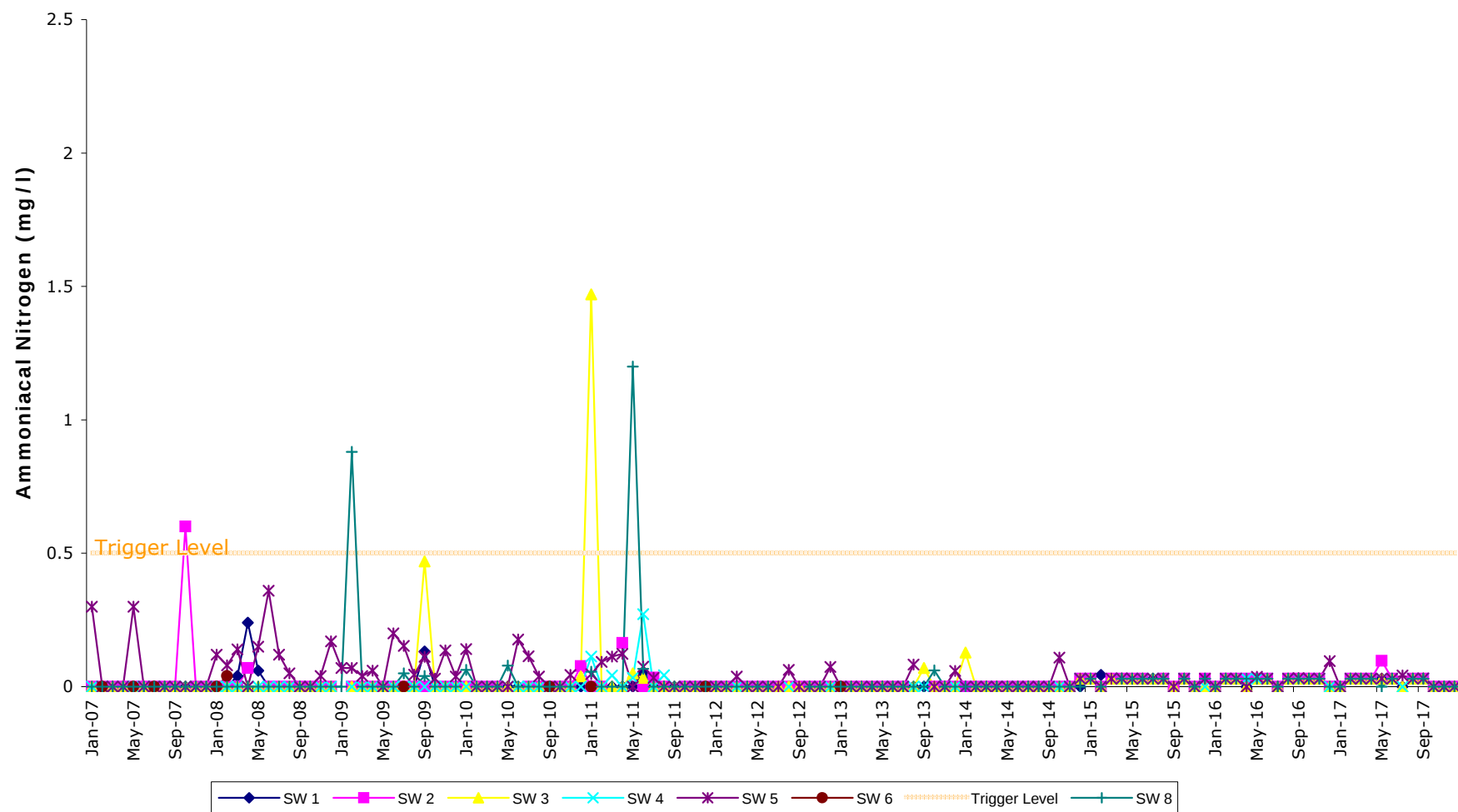
Lab analysis of Electronic Conductivity levels in surface water sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



Lab analysis of Chemical Oxygen Demand (COD) concentrations in surface water sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.

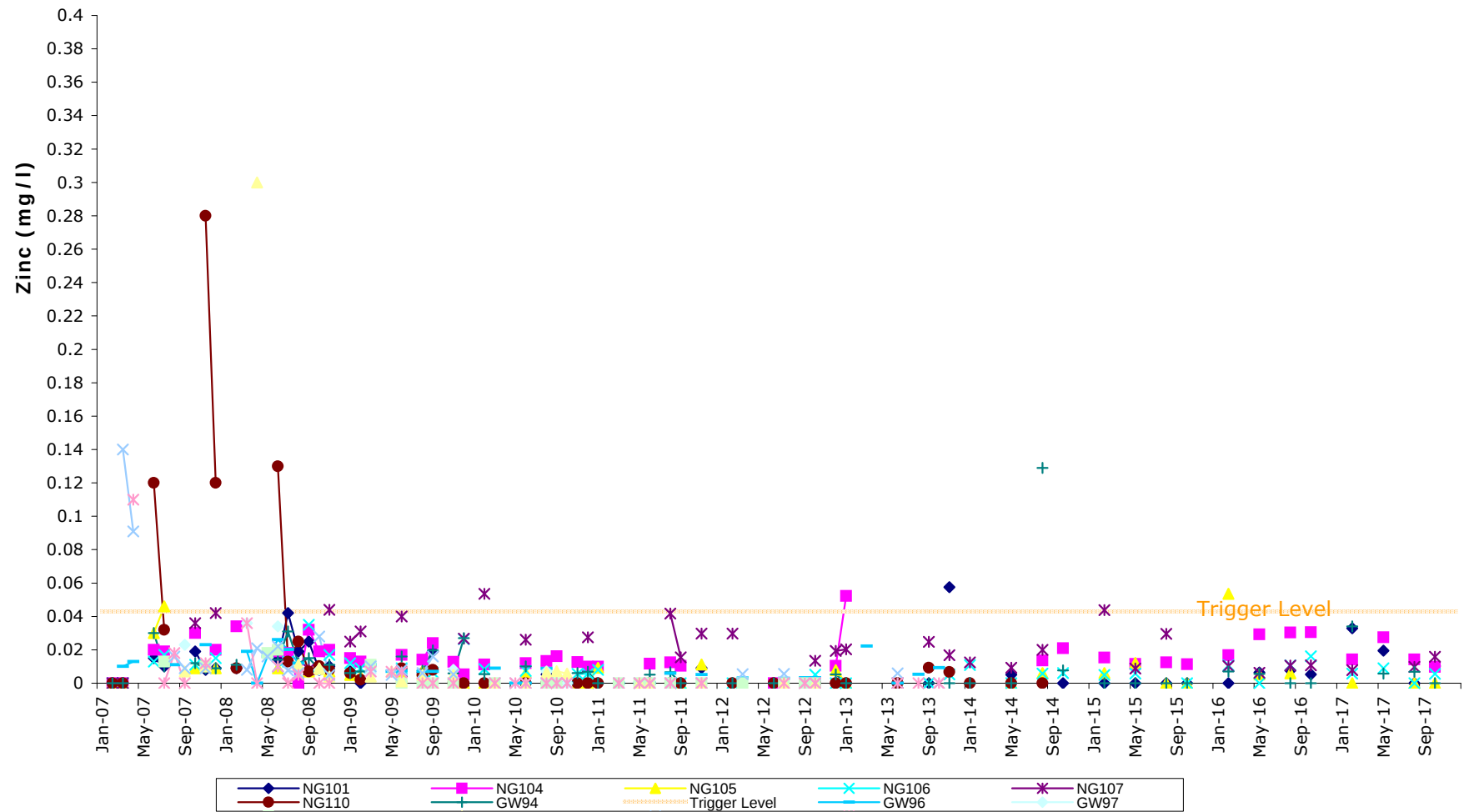


Lab analysis of Ammoniacal Nitrogen levels in surface water sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.

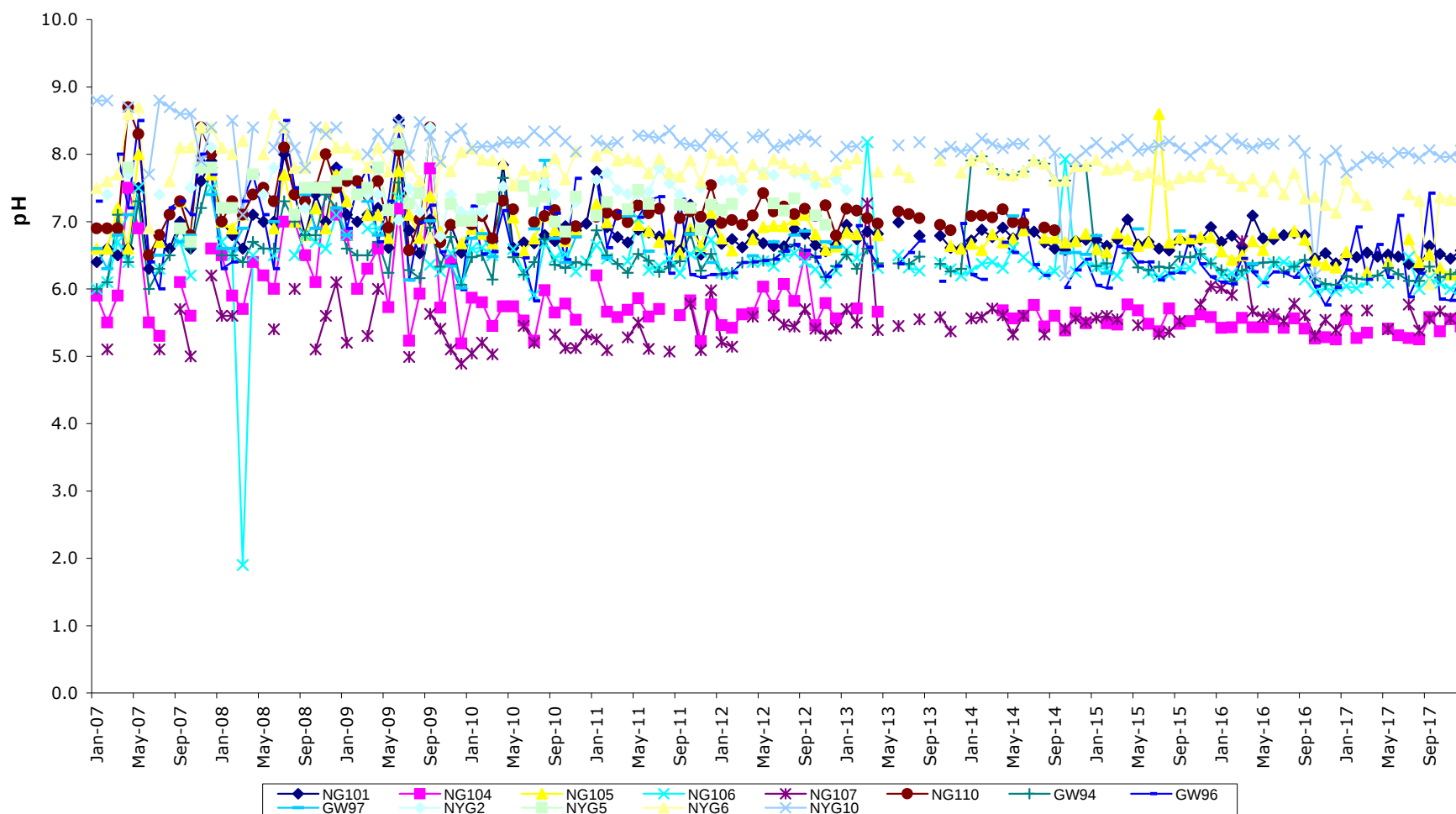


**Time Series Plots Illustrating the Results of ARL's Lab Analysis of
Groundwater Sampled at the Nant-y-Gwyddon Landfill Site During the
Period Jan 07 – Dec 17.**

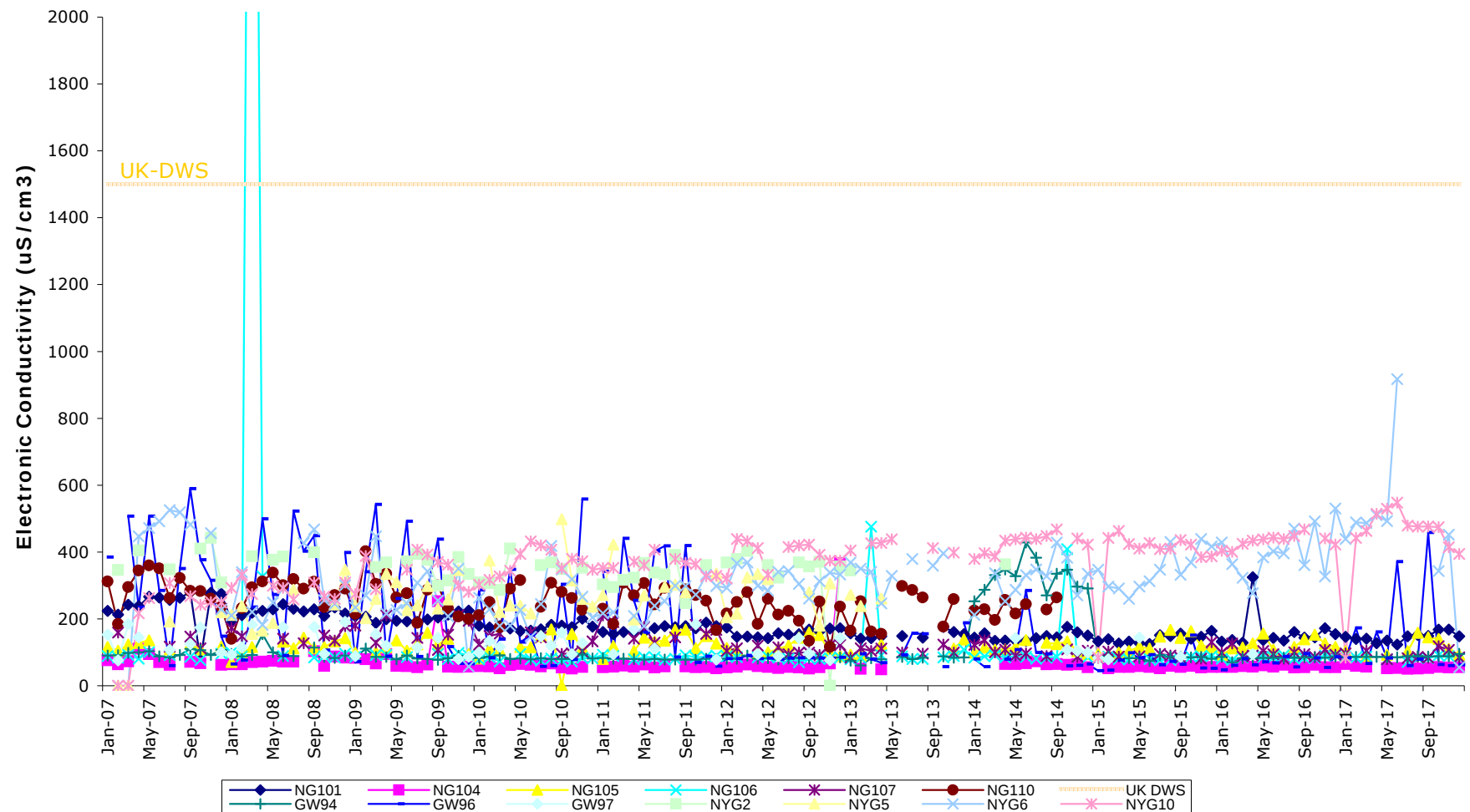
Lab analysis of Zinc levels in groundwater sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



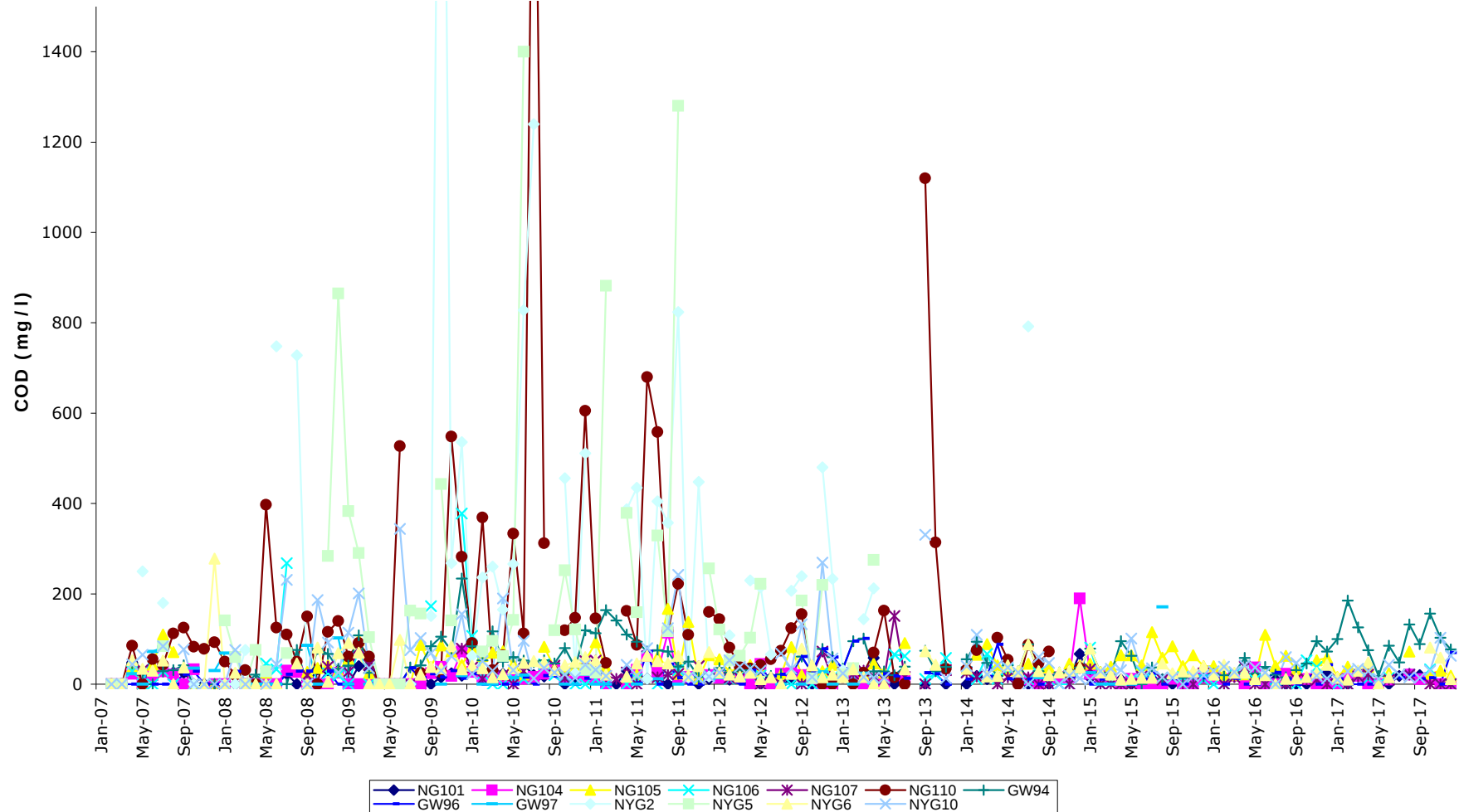
**Lab analysis of pH values in groundwater sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon
Landfill Site during the period Jan 2007 - Dec 2017.**



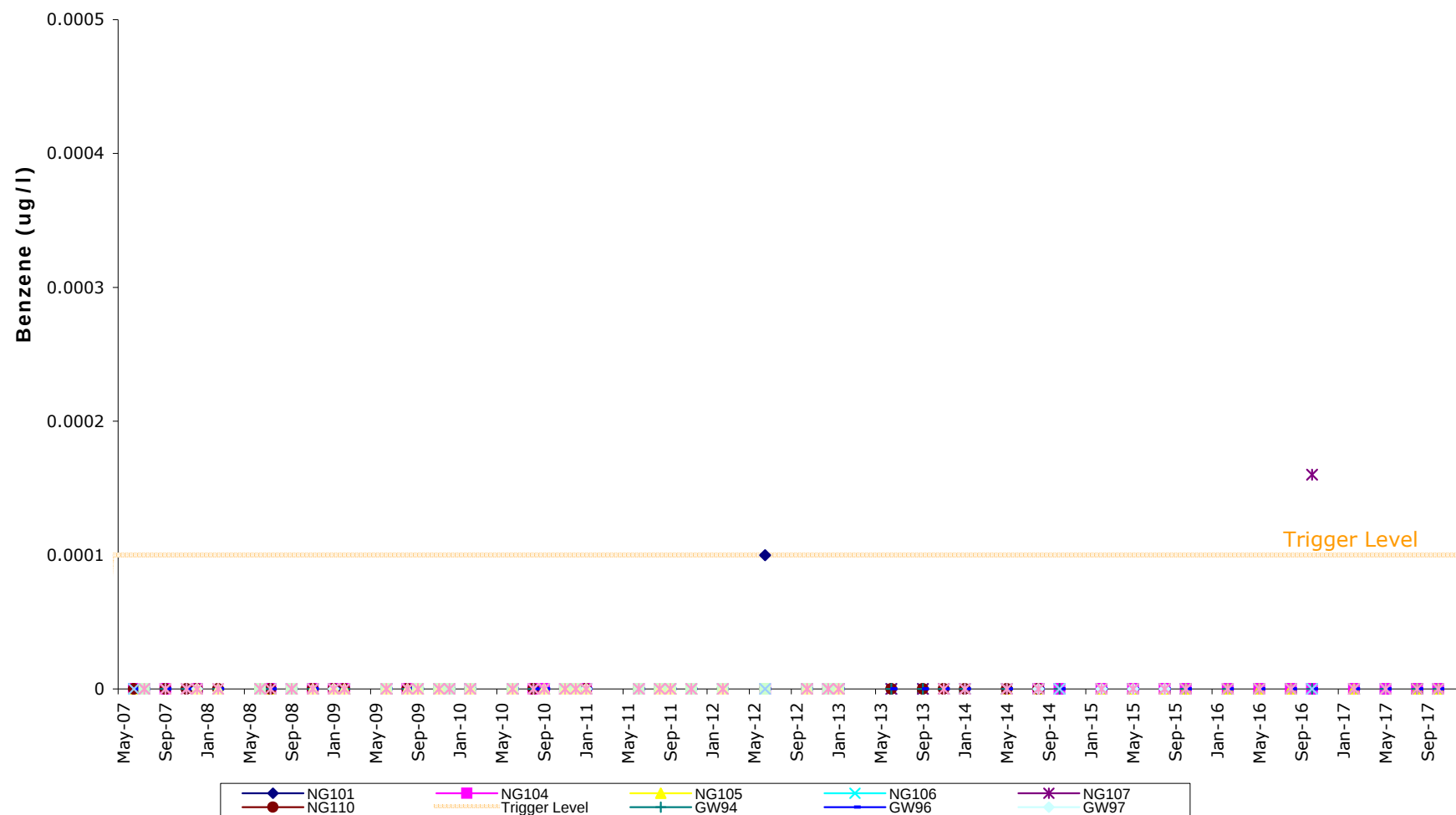
Lab analysis of Electronic Conductivity levels in groundwater sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



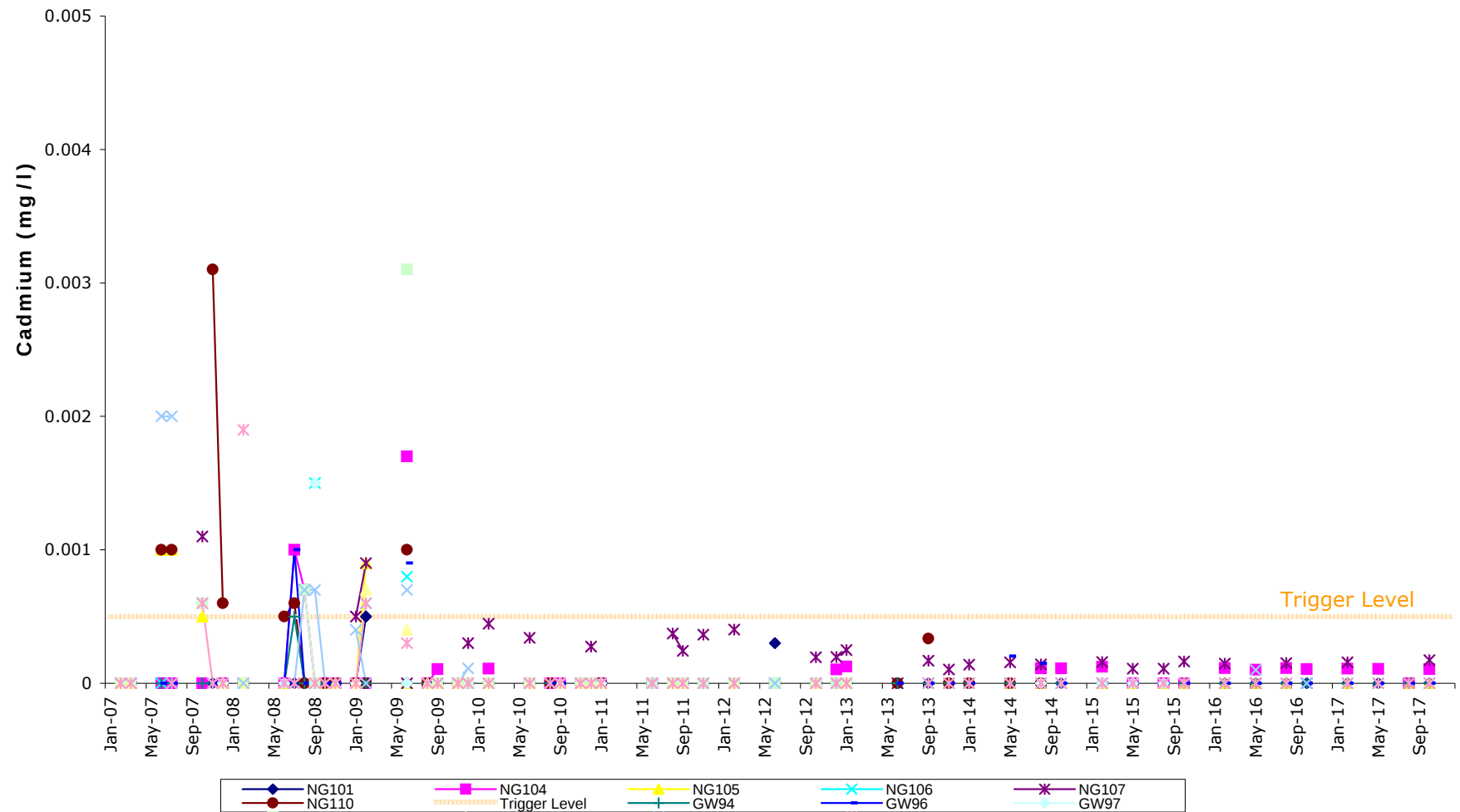
Lab analysis of Chemical Oxygen Demand (COD) concentrations in groundwater sampled at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017 (Scale 0-1500 mg/l).



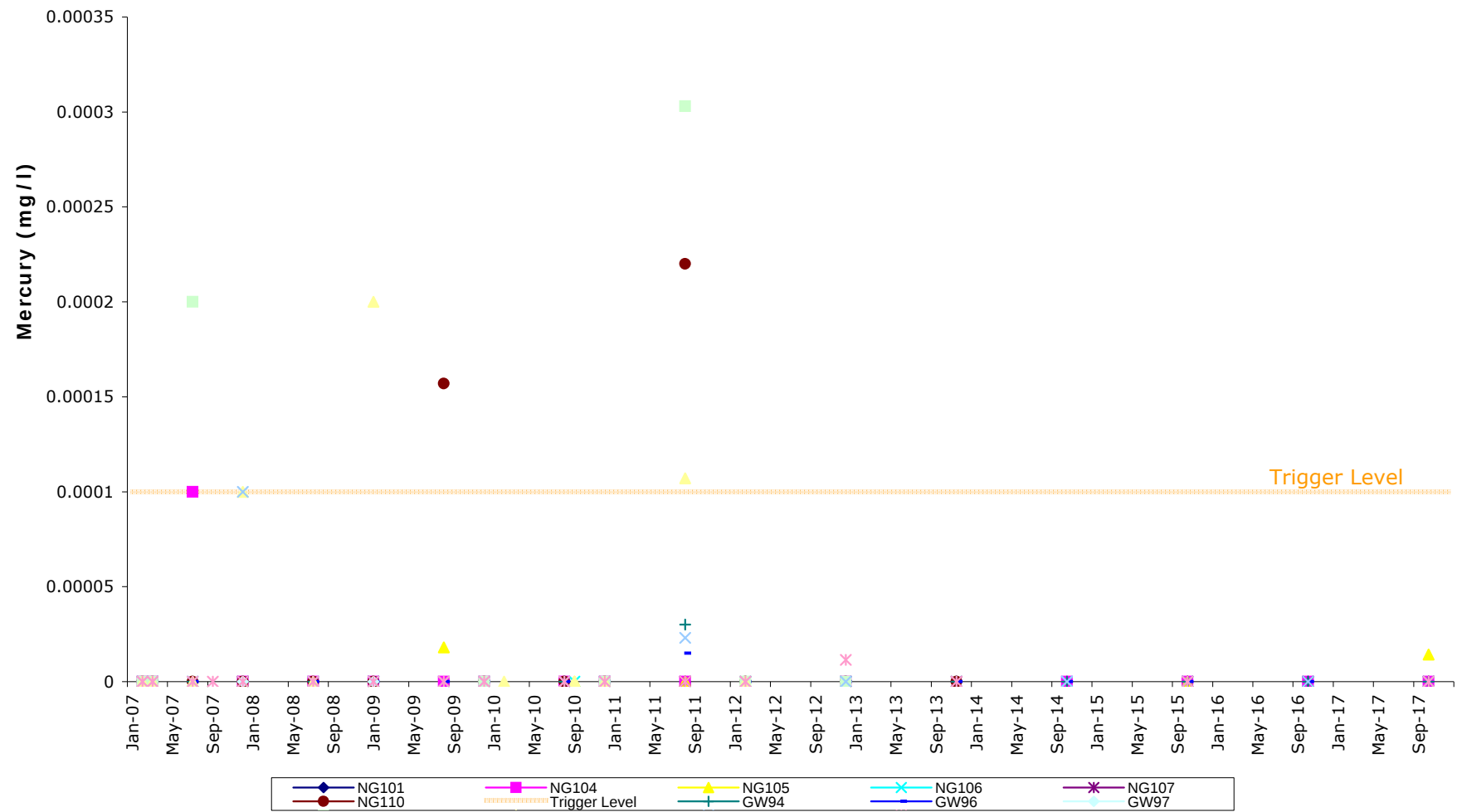
Lab analysis of Benzene levels in groundwater sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



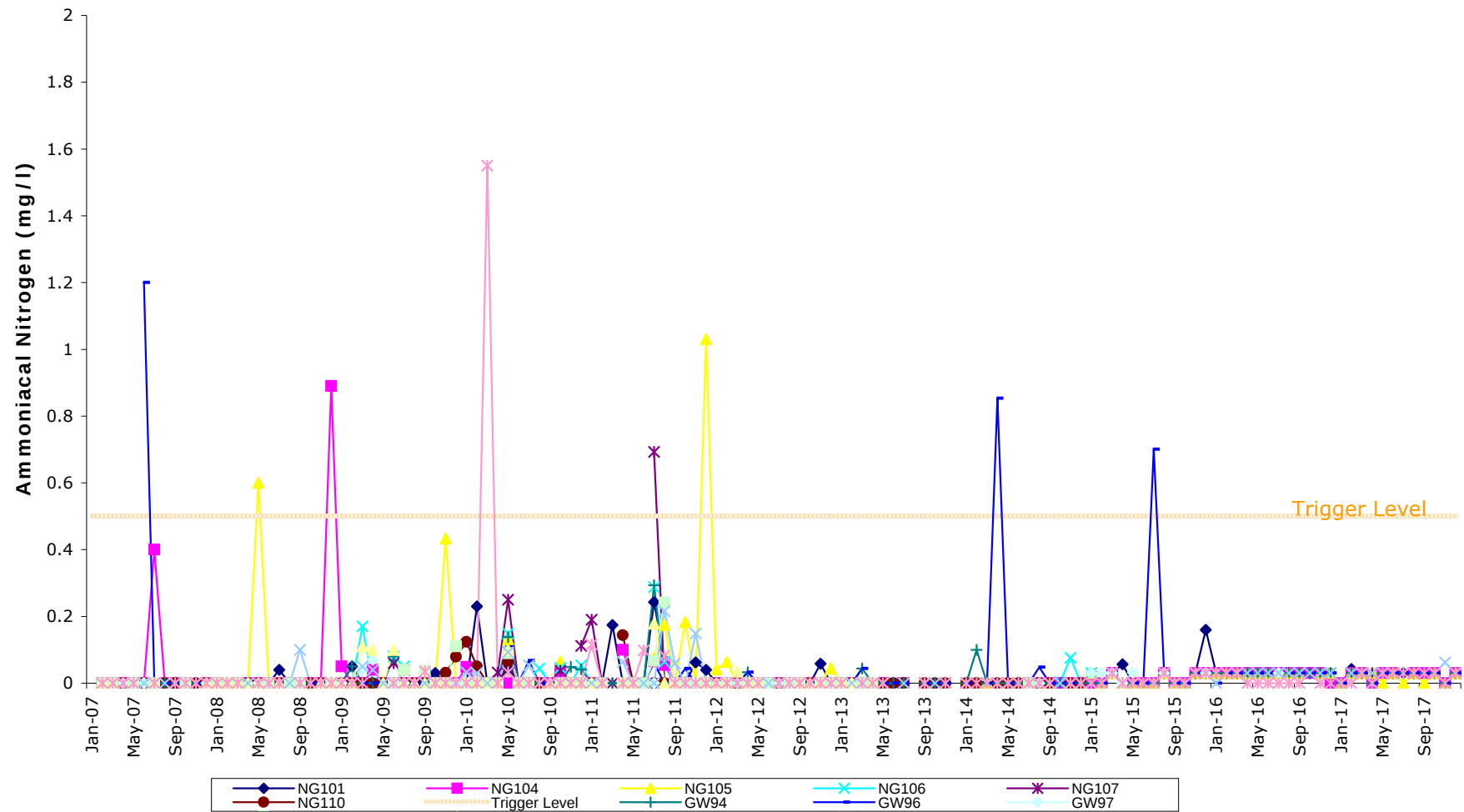
Lab analysis of Cadmium levels in groundwater sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



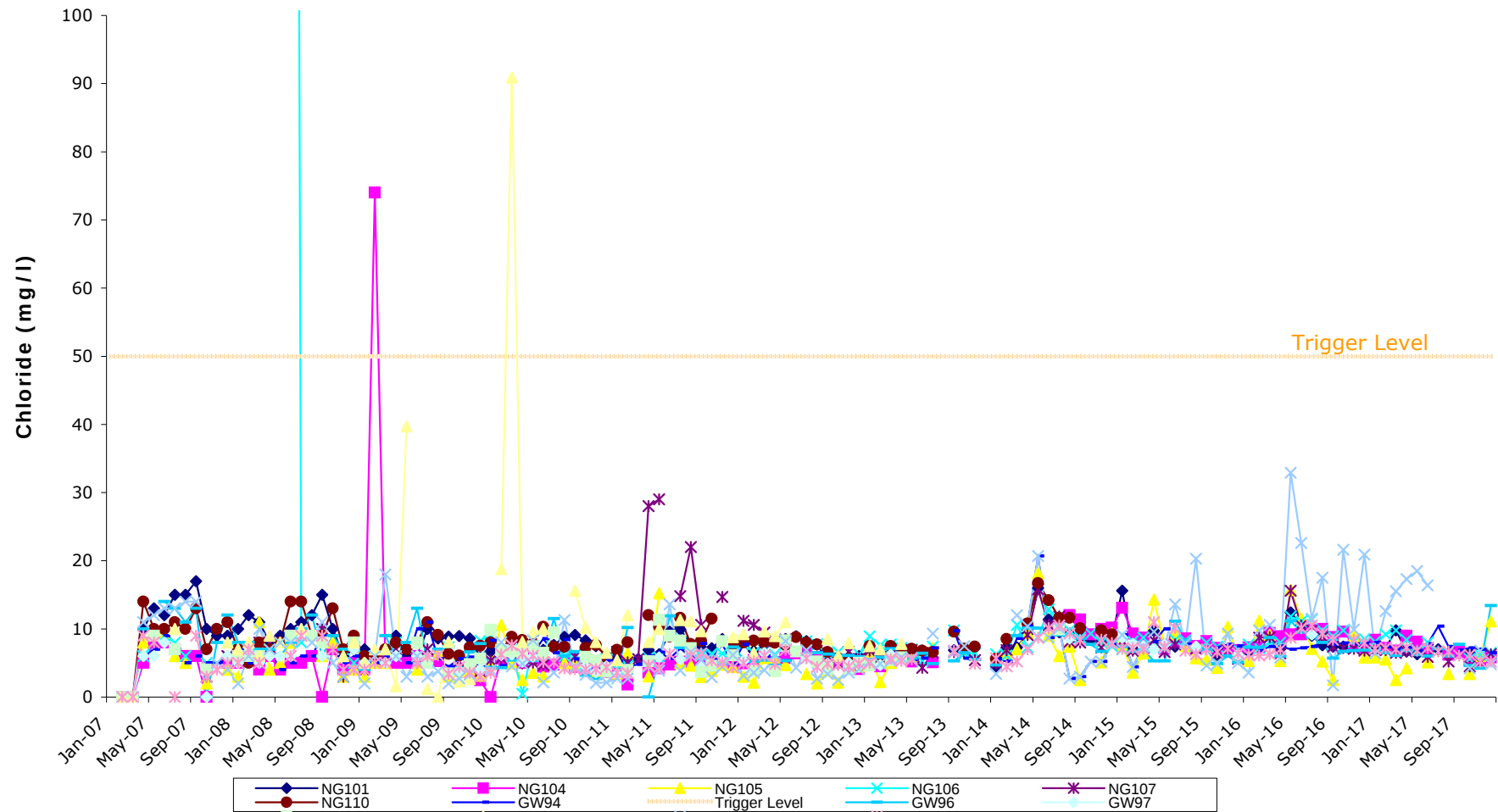
Lab analysis of Mercury levels in groundwater sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



Lab analysis of Ammoniacal Nitrogen levels in groundwater sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



Lab analysis of Chloride concentrations in groundwater sampled by Amgen Rhondda Ltd at the Nant-Y Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.



Lab analysis of Nickel levels in groundwater sampled by Amgen Rhondda Ltd at the Nant-Y-Gwyddon Landfill Site during the period Jan 2007 - Dec 2017.

