Ffridd Rasus Landfill

Areas 1 & 3

EPR/GP3330BY

GWYNEDD COUNCIL VARIATION PROPOSAL

June 2022

- Ffridd Rasus Landfill Areas 1 & 3 EPR/GP3330BY

BACKGROUND

The Ffridd Rasus Site is approximately 3 km to the north of Harlech, at National Grid Reference (NGR) SH 577 338. The site comprises Areas 1, 2 & 3. (Appendix A – Site Plan)

- Area 1 contains the main site infrastructure, covering approximately 1.5 ha and comprises the Household Waste Recycling Centre (HWRS), weighbridge and Waste Transfer Station, regulated under Environmental Permit YB3897TF.
- Area 2 is an unlined landfill, covering approximately 9 ha, in its aftercare phase. Area 2 was developed as a land raise and accepted pulverised domestic, commercial and non-hazardous industrial waste from 1981 up until closure in 2007. Regulated under EPR/PP3294FZ.
- Area 3 is an engineered landfill that has been capped and restored. Waste was accepted between 2007 and early 2014, predominantly in the form of municipal waste. It has been developed with engineered containment and leachate management facilities. Area 3 lies adjacent to and west of Area 2. Regulated under EPR/ GP3330BY.

CURRENT GROUNDWATER COMPLIANACE LIMITS

Drilling of the groundwater monitoring boreholes confirms the site overlies extensive windblown sand deposits; of a homogenous nature. The sands extend to depths of approximately 70m, overlying silt and mudstone. Locally there are no special groundwater receptors down gradient of the site. In addition, there are no licenced or private groundwater or surfacewater abstractions within 3km of the site. Groundwater is found at shallow depths, flowing in a westward direction towards the coast. The local geology is classified as a secondary aquifer.

Details of the monitoring requirements are outlined in the EP, *Schedule 3 – Emissions and Monitoring*. Currently the groundwater is monitored on a quarterly basis at several borehole locations (*Table S3.9 in EP*). Groundwater compliance limits have been set in ten of the groundwater boreholes. In all 10 boreholes, BH 19A, B & C, BH 20A&B, BH 21A&B, BH29, BH 30 and BH31 compliance limits have been set for chloride and ammoniacal nitrogen on a quarterly basis and cadmium and naphthalene on a 6-monthly basis.

The original compliance levels for the 10 boreholes were agreed by the NRW and incorporated in the 01/04/16 permit.

According to condition 4.2.1 (b) in the permit, a yearly review / revision of the compliance limits is required.

4.2 Reporting

4.2.1(a) A report or reports on the performance of the activities over the previous year shall be submitted to Natural Resources Wales by 31 January (or other date agreed in writing by Natural Resources Wales) each year. The reports shall include as a minimum :

(b) a review and where appropriate, revision of the groundwater compliance limits set in Table S3.4 shall be carried out as part of the annual monitoring report.

With the exception of the Annual Environmental Report (AER) for 2021, all other AER include a comprehensive assessment of the compliance levels and, where required, revision proposals.

In December 2017, NRW agreed to the changes proposed by Amec Foster Wheeler on behalf of Gwynedd Council in their report, *Ffridd Rasus Landfill: Review of Ground Water Compliance Limits, June 2017*. A copy of both the report and NRW response are included in Appendix B.

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Table 1 summarises the original compliance limits as set out in *Table S3.4 of the EP, 2016*. The revisions agreed in December 2017 are shown in italics.

Table 1.

(Table S3.4) Trigger levels for emissions into groundwater and monitoring requirements						
Borehole	Quarterly				6-monthly	
	Chloride (mg/l)		Ammoniacal nitrogen (mg/l)		Cadmium (ug/l)	Naphthalene (ug/l)
	2016 Permit	*2017 revision*	2016 Permit	*2017 revision*		
BH 19A	Suspended	/	3.6	*0.7*	3	2
BH 19B	Suspended	/	1.5	*0.7*	3	2
BH 19C	Suspended	/	3	*2*	3	2
BH 20A	450	/	85	*70*	3	2
BH 20B	400	/	259	*235*	3	2
BH 21A	320	*482*	150	*50*	3	2
BH 21B	250	*200*	80	*60*	3	2
BH 29	19.8	/	19.8	*6*	3	2
BH 30	340	/	190	/	3	2
BH 31	130	/	100	*80*	3	2

Following recent discussions with a Lead Regulatory Officer within NRW, a suspension to section 4.2.1 (b) was permitted. As part of this permit variation, Gwynedd Council, in agreement with NRW, propose to remove item *4.2.1(a)* from the permit and incorporate the review of the compliance limit as part of the sites 6 yearly HRA, item 3.1.7 of the permit.

During its gradual migration, a plume of leachate-contaminated groundwater emanating from the unlined Area 2 landfill, migrating beneath the engineered Area 3, is encountered in boreholes located along the western boundary and southern boundary of Area 3, downgradient of Area 2. Ammoniacal nitrogen levels have exceeded the permitted compliance levels at groundwater monitoring boreholes BH19B, BH19C and BH 20A, whilst chloride levels exceed compliance levels in boreholes BH 20B, BH 21A, BH 21B and BH 29 (tabulated in Appendix C).

Under the permit conditions any exceedances of the compliance levels are reported as a Schedule 6 notification. In 2020, following successive breaches and subsequent notifications, NRW issued Gwynedd Council with a temporary suspension from NRW's Compliance Classification Scheme (CCS) for Cd, Cl and NH4 in boreholes 21A, 21B, BH20A, BH19B and BH 19C. NRW correspondence is shown in Appendix D.

NRW will resume scoring at these 5 boreholes from 01 April 2022 onwards.

PROPOSED GROUNDWATER COMPLIANACE LIMITS

Following discussions with a Lead Regulatory Officer at NRW, Gwynedd Council intend proposing new compliance limits at the site.

The following items have been taken into consideration: -

- Both permits for Area 2 and Area 3 will be varied separately. However, the proposed changes undertaken in these variations will unify the groundwater compliance levels between both EPs.

- The groundwater receptor within the sand aquifer for both Area 2 and Area 3 is the same body of water. Gwynedd Council propose that one compliance limit for chloride and one compliance limit

for ammoniacal nitrogen be agreed in both permits. Proposed compliance limits are shown in Table 3.

- Extensive groundwater monitoring borehole data exists prior to the engineering of Area 3, dating back to 2004. Since the engineering and placement of waste in Area 3, monitoring has been carried out in accordance with the Environmental Permit, GP3330BY.

- The variation proposes that multiple sample depth boreholes (BH 18A and B, BH19A, B & C, BH20A & B and BH21A & B), will in the future be sampled at one location per borehole. Sampling will be confined to the deeper wells, namely, BH 18A, BH 19A, BH20A and BH 21A and be taken at varying depths within a three-meter zone, continuing to provide data on the sinking contamination plume originating in the unlined landfill in A2.

Table 2. Proposed sampling locations at multilevel boreholes

Borehole	Borehole depth / (screened section) M bgl
BH 18A	10 (6-9)
BH 19A	18 (14-17)
BH 20A	16 (12-15)
BH 21A	15 (11-14)

- The data and contents of the most recent HRA report (2015) and Woods October 2017 Review of Groundwater Compliance Limits and Surface Water Investigation (Appendix E and B), continues to support the movement of the contamination plume both in a westward and downwards direction within the groundwater.

- Remedial management of the pollution plume from the unlined Area 2 landfill cannot be undertaken by any means. The pollution plume from Area 2 is a historical event, having occurred due to the dilute and disperse nature of the old un-engineered landfill.

- Waste within the Area 2 landfill was deposited at the site between 1981 – 2007. Capping of the site was completed in 2008. Waste in Area 2 has been decomposing for a period of between 15 and 37 years. Measurements of groundwater quality down gradient of Area 2, along the western boarder has seen an improvement in water quality over the last 10 years. Boreholes further west down gradient of the engineered landfill, Area 3, are noting a similar trend; with water quality improving in most boreholes.

- It is a very unlikely scenario that leakage into the local groundwater will occur from the engineered landfill in Area 3. The unlined landfill in Area 2 provides the source of the groundwater contamination. The cells within Area 3 were designed in accordance with landfill regulations. Furthermore, the leachate head within the cells are kept to below the maximum permitted requirement of 1.50m and remain very constant, with minimal pumping for off-site disposal.

- A comprehensive Annual Environmental Report for the site is written and issued to NRW by Gwynedd Council's Consultants, WOODs.

- Ffridd Rasus Landfill Areas 1 & 3 EPR/GP3330BY

Table 2. Proposed groundwater compliance limits

	6-month frequency		Annually	
	Chloride (mg/l)	Ammoniacal nitrogen (mg/l)	Cadmium (ug/l)	Naphthalene (ug/l)
BH 19A	500	150	5.5	2
BH 20A	500	150	5.5	2
BH 21A	500	150	5.5	2
BH 29	500	150	5.5	2
BH30	500	150	5.5	2
BH 31	500	150	5.5	2

- Monitoring will no longer take place in BH19B & C, BH 20B, BH 21B
- Data plots for Ammoniacal nitrogen and Chlorine are shown in Appendix C.
- Any exceedances to the new proposed compliance limits for Chloride and Ammoniacal nitrogen will be reported on a 6-monthly basis.
- The compliance level for Cadmium will increase from the current compliance limit 3ug/l to 5.5ug, as is current in the Area 2 permit, EPR/PP3294FZ. The frequency of reporting will reduce from 6-months to Annually.
- The compliance level for naphthalene will remain at 2ug, as is current in the permit. The frequency of reporting will reduce from 6-monthly to Annually.

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ADDITIONAL PERMIT ITEMS REQUIRING VARIATION

Permit	Amendment
4.2 Reporting	Remove item 4.2.1 (b) from the permit ***4.2 Reporting*** *4.2.1(a) A report or reports on the performance of the activities over the previous year shall be submitted to Natural Resources Wales by 31 January (or other date agreed in writing by Natural Resources Wales) each year. The reports shall include as a minimum :* *(b) a review and where appropriate, revision of the groundwater compliance limits set in Table S3.4 shall be carried out as part of the annual monitoring report.* Include within the 6-yearly review of the HRA.
Table S3.1	**Leachate level limits and monitoring frequency** Reduce the level monitoring of the leachate wells in Area 3 from quarterly to 6-monthly in line with the current requirements of Area 2 permit.
Table S3.2	**Point source emission to air – emission limits and monitoring requirements.** Landfill gas flare. No change proposed. Continue to monitor annually.
Table S3.3	**Point source emission to water (other than sewer) – emission limits and monitoring requirements.** No change proposed. Continue to monitor every 6-months.
Table S3.4	**Trigger levels for emissions into groundwater and monitoring requirements** See notes above and Table 2 – proposed groundwater compliance limits.
Table S3.5	**Landfill gas in external monitoring boreholes – limits and monitoring requirements** No change proposed. Continue to monitor every 6-months.

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<table>
<tr><td>Table S3.6</td><td>Landfill gas from capped surfaces – limits and monitoring requirements

No change proposed. Continue to monitor annually.</td></tr>
<tr><td>Table S3.7</td><td>Landfill gas – other monitoring requirements

<u>In waste monitoring boreholes</u>
No change proposed. Continue to monitor every 6-months.

<u>Input to LFG Utilisation Compound</u>
No change proposed. Continue to monitor annually.</td></tr>
<tr><td>Table S3.8</td><td>Leachate – other monitoring requirements

Reduce the level monitoring of the leachate wells in Area 3 from quarterly to 6-monthly in line with the current requirements of Area 2 permit.

No change proposed to the 6-monthly and annual monitoring.</td></tr>
<tr><td>Table S3.9</td><td>Groundwater – Other monitoring requirements

Reduce to the following frequency

<table><tr><td>Monitoring point</td><td>Parameter</td></tr><tr><td rowspan="2">BH1, BH15, BH18A, BH19A, BH 20A, BH 21A, BH23, BH 24, BH 27-BH36 and NRA3</td><td><u>6 - monthly</u>
Water level, pH, Cl, EC, NH4-N, DO, Ca, Mg, K, Na, Cd, Alk, TOC, SO4, TON</td></tr><tr><td><u>Annually</u>
Cr, Cu, Fe, Pb, Mn, Ni, Zn, phenol and naphthalene</td></tr></table></td></tr>
</table>

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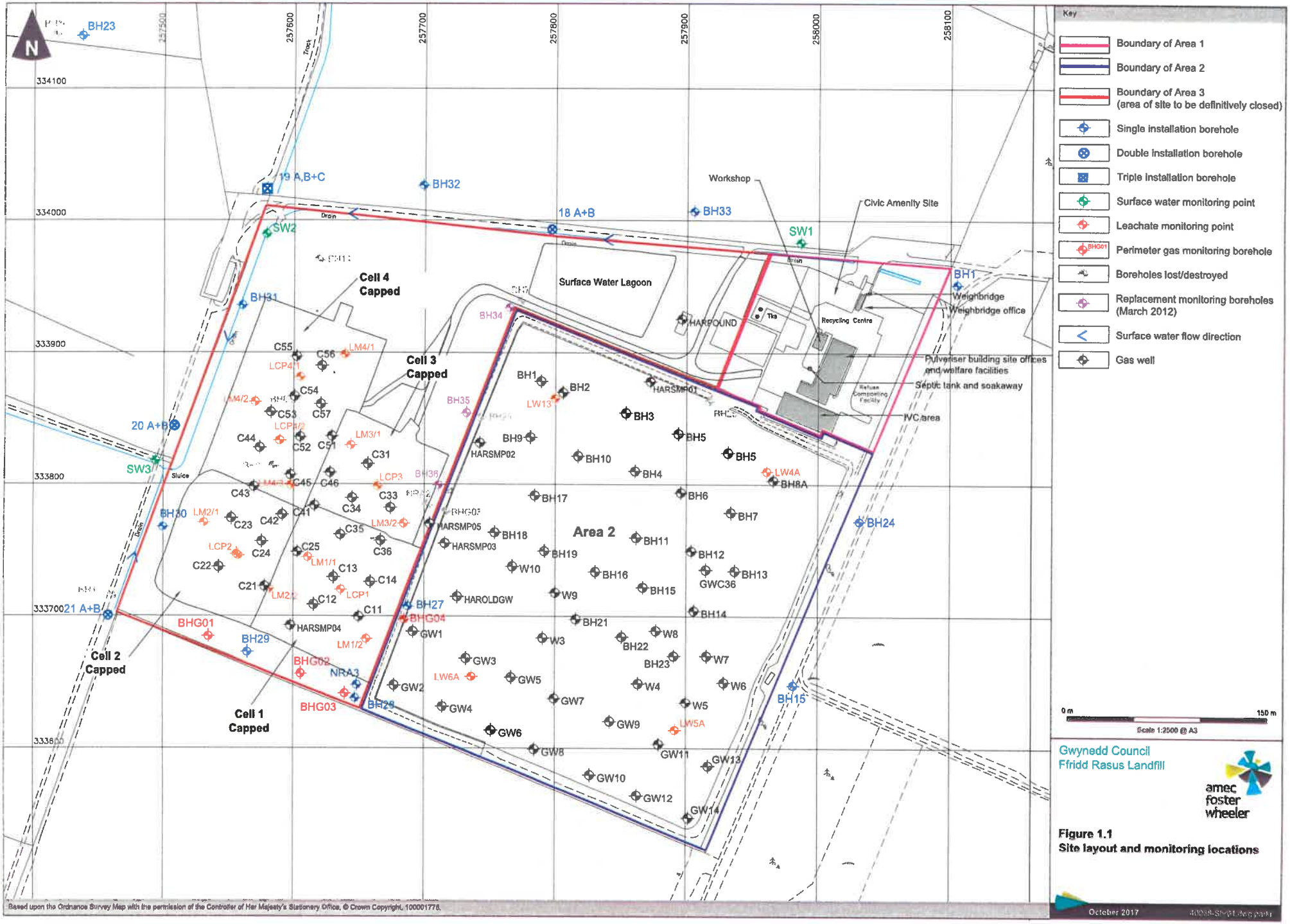
APPENDIX A

SITE PLAN


Key
Boundary of Area 1
Boundary of Area 2
Boundary of Area 3 (area of site to be definitively closed)
Single installation borehole
Double installation borehole
Triple installation borehole
Surface water monitoring point
Leachate monitoring point
Perimeter gas monitoring borehole
Boreholes lost/destroyed
Replacement monitoring boreholes (March 2012)
Surface water flow direction
Gas well
Cell 1 Capped
Cell 2 Capped
Cell 3 Capped
Cell 4 Capped
Area 2
Surface Water Lagoon
Workshop
Civic Amenity Site
Recycling Centre
Weighbridge
Weighbridge office
Pulveriser building site offices and welfare facilities
Septic tank and soakaway
HVC area
Refuse Composting Facility
0 m
150 m
Scale 1:2500 @ A3
Gwynedd Council
Ffridd Rasus Landfill
amec foster wheeler
Figure 1.1
Site layout and monitoring locations
October 2017
Based upon the Ordnance Survey Map with the permission of the Controller of Her Majesty's Stationery Office. © Crown Copyright, 100001778.

- Ffridd Rasus Landfill Areas 1 & 3 EPR/GP3330BY

APPENDIX B

AMEC FOSTER WHEELER

Ffridd Rasus Landfill :

Review of Groundwater Compliance Limits and Surface Water Investigation

November 2017 (Doc Ref: 40068n003i2)

NATURAL RESOURCES WALES RESPONSE

Ffridd Rasus Landfill:
Review of Groundwater Compliance Limits and Surface Water Investigation

1. Purpose of this Note

This note has been prepared by Amec Foster Wheeler Environment & Infrastructure UK Limited on behalf of Gwynedd Council in response to the Natural Resources Wales (NRW) comments dated 15 August 2017 to the proposed groundwater compliance limits for Areas 1 and 3[1] and the surface water investigations[2] at Ffridd Rasus Landfill ('the site').

2. Groundwater Compliance Limits

2.1 Background

Review of groundwater quality data as part of the 2016 Annual Environmental Report (AER)[3] for the site indicated that the leachate plume derived from the unlined Area 2 continues to have an impact on groundwater quality downgradient of Areas 2 and 3. Following capping of Area 2 in 2005-2008 groundwater quality has improved at the downgradient edge of Area 2. However, groundwater quality at the downgradient edge of Area 3 has deteriorated (as elevated chloride and ammoniacal-nitrogen concentrations) since the compliance limits were derived in 2006. As a result the concentrations for certain substances exceeded the 2006 compliance limits at a number of boreholes in the first quarter of 2016. This is likely to be because the highest concentrations in the Area 2 leachate plume have migrated downgradient beneath Area 3 and because recharge to the aquifer has reduced as a result of engineering of Area 2 and Area 3.

New compliance limits for Areas 1 and 3 came into force on 1 April 2016 as part of the EP for definitive closure. A further update of the compliance limits was undertaken in June 2017[1] as requested in NRW's compliance assessment report (CAR) number NRW0031272. NRW's letter dated 15 August 2017 requested revision of some of the proposed chloride and ammoniacal-nitrogen compliance limits as indicated in Tables 2.1 and 2.2 below.

[1] Amec Foster Wheeler, 2017. Ffridd Rasus Landfill. Review of Groundwater Compliance Limits. Report ref 28587N1019i2.
[2] Amec Foster Wheeler, 2017. Ffridd Rasus Landfill. Review of Ammoniacal-Nitrogen Sources in Groundwater. Report ref 28587n1017i2.
[3] Amec Foster Wheeler, 2016. Ffridd Rasus Landfill. Annual Environmental Report for January to December 2016. Report ref 28587rr1012i2.

Table 2.1 Groundwater Compliance Limits for Chloride

Borehole	EP (ref GP3330BY) Compliance Limit for Areas 1 & 3 (Definitive Closure)	EP (ref PP3294FJ) Compliance Limit for Area 2 and Civic Amenity	Proposed Revised Compliance Limits (June 2017)	NRW comments (August 2017)
BH19A	a)	250	**55**	Revision needed
BH19B	a)	34	**450**	Revision needed
BH19C	a)	34	**450**	Revision needed
BH20A	450	504	450 (no change)	Accepted
BH20B	400	504	400 (no change)	Accepted
BH21A	320	387	**600**	Revision needed
BH21B	250	215	**250** (no change)	Reduction advised
BH29	19.8	-	**25**	Revision needed
BH30	340	504	340 (no change)	Accepted
BH31	130	179	**150**	Revision needed

Notes: a) Suspended pending the results of additional annual monitoring.
Compliance limits in bold have not been accepted by NRW.

Table 2.2 Groundwater Compliance Limits for Ammoniacal-Nitrogen

Borehole	EP (ref GP3330BY) Compliance Limit for Areas 1 & 3 (Definitive Closure)	EP (ref PP3294FJ) Compliance Limit for Area 2 and Civic Amenity	Proposed Revised Compliance Limits (June 2017)	NRW comments (August 2017)
BH19A	3.6	2	**3.6**	Revision needed
BH19B	1.5	1	**3**	Revision needed
BH19C	3	2	3	Accepted
BH20A	85	70	5	Accepted
BH20B	259	259	**230** (no change)	Reduction advised
BH21A	150	80	**266**	Revision needed
BH21B	80	80	**69.7** (no change)	Reduction advised
BH29	19.8	-	6	Accepted
BH30	190	200	**266**	Revision needed
BH31	100	100	**100** (no change)	Reduction advised

Notes: Compliance limits in bold have not been accepted by NRW.

2.2 Review of Groundwater Compliance Limits

The latest update[1] of the compliance limits used groundwater quality data up to April 2017. More recent chloride and ammoniacal-nitrogen data up to July 2017 have been collected and are reviewed in Table 2.3.

Updated water quality plots for chloride and ammoniacal-nitrogen concentrations are provided in Appendix A. Monitoring locations are shown in Figure 1.1.

The data show that:

- The leachate plume associated with historical leakage from the unlined Area 2 continues to have an impact on groundwater quality (as elevated chloride and ammoniacal-nitrogen concentrations) downgradient of Areas 2 and 3;
- The historical release and movement of the leachate plume from Area 2 within the underlying sand aquifer to the boreholes at the downgradient (western) edge of Area 3 is complex and is affected by:
  - Hydraulic conductivity and gradient of the underlying sand aquifer;
  - Retardation of leachate contaminants within the sand aquifer;
  - Capping of Area 2 in 2005-2008, which reduced leachate generation and leakage in this area;
  - Engineering of Area 3 during 2007 to 2014, which reduced recharge to the aquifer; and
  - Sinking of the plume within the sand aquifer with distance from the source, which may result in different concentrations in paired deep/shallow borehole installations.
- The improvement in groundwater quality at the downgradient edge of Area 2 since 2012 is consistent with capping of Area 2 in 2005-2008, which has led to reduced leakage and therefore increased dilution in groundwater. This is apparent in the downward trend in chloride and ammoniacal-nitrogen concentrations at boreholes BH27, BH35 and BH36;
- The breakthrough of chloride and ammoniacal-nitrogen concentrations at the downgradient edge of Area 3 is consistent with travel times from the edge of Area 2 (where infilling started 36 years ago) to the edge of Area 3 of approximately 6 to 10 years for chloride (unretarded) and 21 to 37 years for ammoniacal-nitrogen (retarded; sorption coefficient of 0.4 ml/g from EA, 2003[4]);
- The stable or declining chloride and ammoniacal-nitrogen concentrations at most boreholes at the downgradient edge of Area 3 is consistent with the reduced leakage following the capping of Area 2 in 2005-2008;
- Chloride concentrations at the paired boreholes BH20A/B and BH21A/B is consistent with sinking of the leachate plume with distance from the source: chloride breakthrough first at the shallower installations (BH20B and BH21B), followed by breakthrough at the deeper installations (BH20A and BH21A) as concentrations start to stabilise/drop at the shallower installations. Chloride concentrations in 2017 at the downgradient edge of Area 3 are higher at the deeper installations (concentrations versus depth plot in Appendix B);
- The recent increase above the compliance limit in chloride concentrations at BH21A (deeper installation at the downgradient edge of Area 3) could be due to:
  - Leakage from Area 3. However this is unlikely as Area 3 comprises a Landfill Regulations-compliant composite liner on the base and sides consisting of a 2 mm HDPE geomembrane and a 0.5 m thick artificially established geological barrier of bentonite enhanced sands (BES) with a maximum permeability of 5×10^{-10} m/s. In addition leachate levels have been managed below the EP compliance limit of 1.5 m above base. This is supported by previous LandSim modelling[5] which did not predict discernible breakthrough of chloride at the edge of Area 3 (0.8 mg/l in 2112 as 95th percentile) for leachate heads of up to 2 m;
  - Impact of leachate plume migration from Area 2 at depth. This appears to be the most likely cause as it is consistent with higher chloride concentrations observed at the deeper

[4] Environment Agency, 2003. Review of ammonium attenuation in soil and groundwater.
[5] Amec Foster Wheeler, 2016. Ffridd Rasus Landfill. Hydrogeological Risk Assessment Review. Report ref 28587rr954i2.

installations downgradient edge of Area 3 in 2017 (Appendix B). This may be due to sinking of the leachate plume with distance from the source.

The EP compliance limits for Areas 1 and 3 for chloride and ammoniacal-nitrogen have been reviewed and where necessary revised in Table 2.3 to take into account NRW's comments and more recent monitoring data as discussed above. A summary of the proposed compliance limits and control levels for Areas 1 and 3 are listed in Table 2.4. The compliance limits should be reviewed annually as part of the AERs (or more often if required) and reduced as appropriate to reflect dispersion and attenuation of the leachate plume from Area 2.

Table 2.3 Review of Groundwater Data and EP Groundwater Compliance Limits for Areas 1 and 3

Borehole	Chloride	Ammoniacal-nitrogen
BH19A	Compliance limits suspended pending the results of additional monitoring as required under EP condition 4.2.1 (b). Current elevated concentrations are not directly linked to the Area 2 landfilling activity, but are a result of a separate pollution incident from site capping (which resulted in the release of a saline slug). Monitoring to be continued and compliance limits derived once there is no impact from the saline slug.	**Data review:** historical concentrations show variability and a number of elevated spikes. Since 2013 concentrations dropped but with some variability with a number of elevated spikes. Concentrations have been below 0.5 mg/l since 2015. **Proposed compliance limit**: reduce compliance limit from 3.6 to 0.7 mg/l and set control level of 0.6 mg/l (review annually as part of AERs).
BH19B	Same as BH19A	**Data review:** historical concentrations show variability and a number of elevated spikes. The elevated spikes have become less frequent and have been below 0.6 mg/l since mid-2013. **Proposed compliance limit**: reduce compliance limit from 1.5 mg/l to 0.7 mg/l and set control level of 0.6 mg/l (review annually as part of AERs).
BH19C	Same as BH19A	**Proposed compliance limit accepted by NRW (15/08/17)**
BH20A	**Proposed compliance limit accepted by NRW (15/08/17)** It is noted that the latest data (471 mg/l in July 2017) shows a small exceedance of the compliance limit (440 mg/l). This is likely to be associated with data variability and will be reviewed as part of the 2017 AER.	**Proposed compliance limit accepted by NRW (15/08/17)**
BH20B	**Proposed compliance limit accepted by NRW (15/08/17)** It is noted that the latest data (473 mg/l in July 2017) shows a small exceedance of the compliance limit (450 mg/l). This is likely to be associated with data variability and will be reviewed as part of the 2017 AER.	**Data review:** concentrations show considerable variability since 2012 ranging between 21 and 235 mg/l. Concentrations dropped during 2016 to about 65 mg/l before increasing to 170 mg/l in 2017. **Proposed compliance limit**: reduce the EP compliance limit from 259 to 235 mg/l (limit remains high given the historical elevated and recently variable concentrations) (review annually as part of AERs).
BH21A	**Data review:** as discussed above the recent increase above the compliance limit may be due to: leakage from Area 3 (unlikely) or impact of leachate plume migration from Area 2 at depth (more likely). Concentrations appear to have peaked in May 2017 (482 mg/l). **Proposed compliance limit**: increase temporarily compliance limit to 482 mg/l, continue monitoring and review as part of the 2017 AER.	**Data review:** concentrations are lower than the historically in 2011/2012 and show variability with several periods of increasing and then decreasing concentrations but with an overall downward trend. Concentrations have recently dropped below 20 mg/l. Additional data is required to confirm the recent drop in concentrations. **Proposed compliance limit**: reduce EP compliance limit for from 150 mg/l to 50 mg/l allowing for the observed variability in concentrations (review annually as part of AERs).

Borehole	Chloride	Ammoniacal-nitrogen
BH21B	**Data review:** concentrations have shown a downward trend since 2004 and have been below the compliance limit (250 mg/l) since 2006 except for two spikes. More recently concentrations have dropped below 200 mg/l except for a small number of spikes. **Proposed compliance limit**: reduce compliance limit from 250 to 200 mg/l to reflect the improvement in groundwater quality (review annually as part of AERs).	**Data review:** concentrations are lower than the historical elevated concentrations in 2011/2012. Concentrations show variability with several periods of increasing and then decreasing concentrations but with an overall downward trend. More recently concentrations have dropped below 40 mg/l. Additional data is required to confirm the recent drop in concentrations. **Proposed compliance limit**: reduce EP compliance limit for from 80 mg/l to 60 mg/l allowing for the observed variability in concentrations (review annually as part of AERs).
BH29	**Data review:** downward trend between 2012 and 2014. Concentrations have remained below the compliance limit (19.8 mg/l) since end of 2014 except for one elevated spike. **Proposed compliance limit:** no change (review annually as part of AERs).	**Proposed compliance limit accepted by NRW (15/08/17)**
BH30	**Proposed compliance limit accepted by NRW (15/08/17)**	**Data review** concentrations show a downward trend since 2010 with a recent increase peaking marginally above the compliance limit (190 mg/l). **Proposed compliance limit**: no change (review annually as part of AERs).
BH31	**Data review:** since the end of 2009 concentrations vary between 41 and 138 mg/l and only exceeded the compliance limit (130 mg/l) on a small number of occasions. **Proposed compliance limit**: no change (review annually as part of AERs).	**Data review:** concentrations have ranged historically between 50 and 100 mg/l with the highest concentrations observed in 2012/2013. Since 2013 concentrations have remained below 80 mg/l dropping recently (2016/early 2017) to 54 mg/l. Additional data is required to confirm the recent drop in concentrations. **Proposed compliance limit**: reduce EP compliance limit for from 100 mg/l to 80 mg/l allowing for the observed variability in concentrations (review annually as part of AERs).

For consistency with the EP for Area 2 the compliance limits in Table 2.4 are also proposed for Area 2. As part of the EP Variation for Area 2 it is proposed that the compliance limits would be incorporated via a similar condition to condition 3.1.6 of Areas 1 and 3 EP which states "*The compliance limits for emissions into groundwater for the parameters and monitoring points set out in schedule 3 table S3.4 (or as otherwise agreed in writing in accordance with annual monitoring report to be carried out in accordance with condition 4.2.1 (b)) shall not be exceeded*".

Table 2.4 Proposed Groundwater Control Levels and Compliance Limits for Areas 1 and 3

Borehole	Ammoniacal Nitrogen (mg/l)		Chloride (mg/l)	
	Control Level	Compliance Limit	Control Level	Compliance Limit
BH19A	**0.6**	**0.7**	**a)**	**a)**
BH19B	**0.6**	**0.7**	**a)**	**a)**
BH19C	1.8	2	**a)**	**a)**
BH20A	60	70	440	450
BH20B	**211**	**235**	390	400
BH21A	**45**	**50**	**434 b)**	**482 b)**
BH21B	**54**	**60**	**180**	**200**
BH29	5.4	6	**17.8**	**19.8**
BH30	**171**	**190**	325	340
BH31	**72**	**80**	**117**	**130**

Note: Compliance limits to be reviewed annually as part of the AERs.
Proposed revised compliance limits shown in bold. All other compliance limits have been accepted by NRW (15/08/17).
a) Compliance limits suspended pending the results of additional monitoring as required under EP condition 4.2.1. Monitoring to be continued and compliance limits derived once there is no impact from the saline slug.
b) Temporary compliance limit pending further monitoring and review in the 2017 AER

3. Surface Water Investigation

3.1 Background

Investigations have been undertaken previously[2] to identify possible sources of increasing ammonium concentrations during 2016 in the ditch downgradient of the site at location SW3 (ditch exiting downstream boundary of Area 3, which represents the main surface water discharge from the site). Possible ammonium sources include:

- Groundwater baseflow contaminated with leachate. Previous AERs showed that a leachate plume derived from the unlined Area 2 landfill is having an impact on groundwater quality (elevated chloride and ammoniacal-nitrogen) downgradient of the site;
- Surface water runoff from adjacent agricultural land contaminated with nitrogen following sludge spraying/muck spreading. Sludge spraying/muck spreading has been reported on a number of occasions during 2016; and
- Surface water runoff contaminated with nitrogen from livestock (cows), feeding troughs and cow sheds located close to the ditch at SW3.

These investigations included review of groundwater monitoring data; sampling of additional locations and analysis for a wider suite in the ditch samples in March 2017. However, the data available for the assessment was insufficient to conclusively determine whether the source of ammonium at SW3 is agricultural or landfill. Additional works were recommended to improve the understanding of ammonium sources in the ditch:

- Monthly monitoring for 6 months of water quality in the ditch at SW2, SW3, locations near BH20A, BH30 and BH31 and one location downstream of SW3 for ammoniacal-nitrogen, chloride, nitrate and phosphorous (dissolved);
- Record the periods of sludge spraying/muck spreading and presence of livestock in the agricultural land adjacent to the ditch; and
- Review the data collected above and assess ammonia sources at SW3.

NRW's letter dated 15 August 2017 requested review of the data collected and re-assessment of potential sources of ammonium at SW3.

3.2 Investigation Works

Surface Water Sampling

Monthly monitoring for 6 months of water quality along the ditch flowing in the downstream boundary of Area 3 for ammoniacal-nitrogen, chloride, nitrate and phosphorous (dissolved) has been undertaken in April to September 2017. The monitoring locations include (from up to downstream): SW2, location near BH31, location near BH20A/B, SW3 and 10 m downstream of SW3.

The surface water quality data are summarised in Table 3.1 and presented graphically for ammoniacal-nitrogen, chloride and nitrate in Appendix C.

Table 3.1 Surface Water Quality Data for Ditch (March to September 2017)

Location	Ammoniacal Nitrogen (mg/l)			Chloride (mg/l)			Nitrate as N (mg/l)			Phosphorus, Filtered as P (mg/l)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
SW2	<0.41	0.543	1.24	10.8	30.03	41.6	<0.7	0.83	1.6	<0.12		<0.12
Ditch near BH31	0.69	1.252	1.8	9.6	34.3	47.3	<0.7	0.9	1.5	<0.12		<0.12
Ditch near BH20A/B	<0.41	1.816	4.24	11.2	32.1	48.3	<0.7	1.31	2.4	<0.12		<0.12
SW3	1.33	18.16	28.7	16.5	56.51	70.4	<0.7	1.11	2.1	<0.12		<0.12
Ditch 10m downstream of SW3	0.78	12.07	28.7	14.4	48.7	82.4	<0.7	0.95	2.2	<0.12		<0.12

Notes: Monthly monitoring data. Includes data of preliminary investigation undertaken in March 2017.

The water quality data for the ditch show that:

- Ammoniacal-nitrogen concentrations at SW3 continued to be elevated (up to 28.7 mg/l) but dropped to 1.33 mg/l in September. Chloride concentrations at SW3 over the same period were within historical range and were relatively low (less than 75 mg/l) and showed no trend;
- Ammoniacal-nitrogen and chloride concentrations at SW2 continue to be within historical range and show no upward trend;
- Ammoniacal-nitrogen and chloride concentrations increased along the ditch from up to downstream locations as follows: SW2, locations near BH31 and BH20A/B and SW3. This increase is more significant for ammonia than for chloride; and
- Nitrogen in the ditch is mostly in the form of ammonium indicating reducing conditions. Nitrate concentrations were low at all location (<3mg/l) and dropped to below detection limit (<0.7 mg/l) at all locations from June 2017 onwards.

Compost and Livestock Observations

Photographs of the ditch taken during April and September 2017 (Appendix D) show considerable compost stockpiles near the ditch. These have reduced over time as the compost was moved to other fields. Livestock (cows) were observed next to the ditch near SW2. Low flow or stagnant water conditions were observed in the ditch.

Groundwater Sampling

Groundwater level and quality continued to be monitored monthly at the boreholes near the southern and northern ditches which flow into SW3 (BH19A/B/C, BH20A/B, BH30 and BH31). The data are provided graphically in Appendix E and show that:

- Groundwater depth near the drain typically ranged between 0.3 and 1.3 m bgl at BH21A/B, 0.6 and 1.2 m bgl at BH20A/B and 1 to 2 m bgl at BH19A/B/C and BH30 and BH31. This suggests that groundwater may occasionally provide baseflow to the ditch near BH21A/B and BH20A/B during winter level peaks (assumed above 0.5 m bgl);
- 2014 and 2016 winter groundwater levels near the ditch were higher than in earlier years;
- Groundwater at the downgradient boundary of Area 3 (BH20A/B, BH21A/B, BH30 and BH31) is impacted by a leachate plume associated with historical leakage from the unlined Area 2 (See discussion in Section 2). Within the plume, chloride and ammoniacal-nitrogen concentrations remain elevated (100 to 450 mg/l and 20 to 180 mg/l respectively) but are stable or declining at

most boreholes at the downgradient edge of Area 3. Water quality plots are presented in Appendix A.

3.3 Assessment of Potential Ammonium Sources

Leachate

Shallow groundwater potentially contributes leachate-contaminated baseflow to the ditch. This is unlikely to be the source of the recent increase in ammoniacal-nitrogen concentrations at SW3 because:

- The leachate plume is characterised by elevated concentrations of both ammoniacal nitrogen and chloride but the ditch water showed increases in ammoniacal nitrogen but not chloride. The absence of elevated chloride means that the ditch water is unlike leachate;
- Higher groundwater levels should result in increased baseflow and hence increased concentrations in the ditch. However, it appears that higher groundwater levels result in decreases in ammoniacal-nitrogen concentrations at SW3; and
- If the source were leachate, groundwater monitoring should show increasing concentrations in a leachate plume heading towards and entering the ditch. However, monitoring data show stable or decreasing ammoniacal-nitrogen concentrations in groundwater near the ditch.

Other Sources

The recent site investigations show that other, more likely, sources of ammonium at SW3 include:

- Surface water runoff contaminated with nitrogen from the large compost stockpiles identified near the ditch;
- Surface water runoff contaminated with nitrogen from livestock (cows) near the ditch; and
- Low flow/stagnant water conditions in the ditch. Organic matter in the ditch is likely to have created reducing conditions whereby nitrogen is mostly in the form of ammonium. The sediment may also be a source of ammonium. Samples obtained under these stagnant conditions may reflect water quality in equilibrium with sediments in the ditch.

3.4 Summary and Recommendations

Further investigations have been undertaken to identify possible sources of the increase in ammoniacal-nitrogen concentrations observed during 2016/2017 in the ditch downgradient of the site at location SW3. These included review of groundwater monitoring data and sampling of additional locations and for a wider suite in the ditch. The data collected suggest that the source of the increase in ammoniacal nitrogen is not landfill leachate. Potential sources include compost stockpiles/spreading and livestock (cows) in the adjacent farmland and outside the site's EP boundary and/or natural low flow/stagnant water conditions in the ditch.

4. Close

This note is provided as a response to NRW's letter dated 15 August 2017 and we trust it fully answers your queries. If however you require any further information, please do not hesitate to contact us.

Author

Ana Braid

Reviewer

Ben Fretwell

Copyright and non-disclosure notice

Third party disclaimer

Management systems

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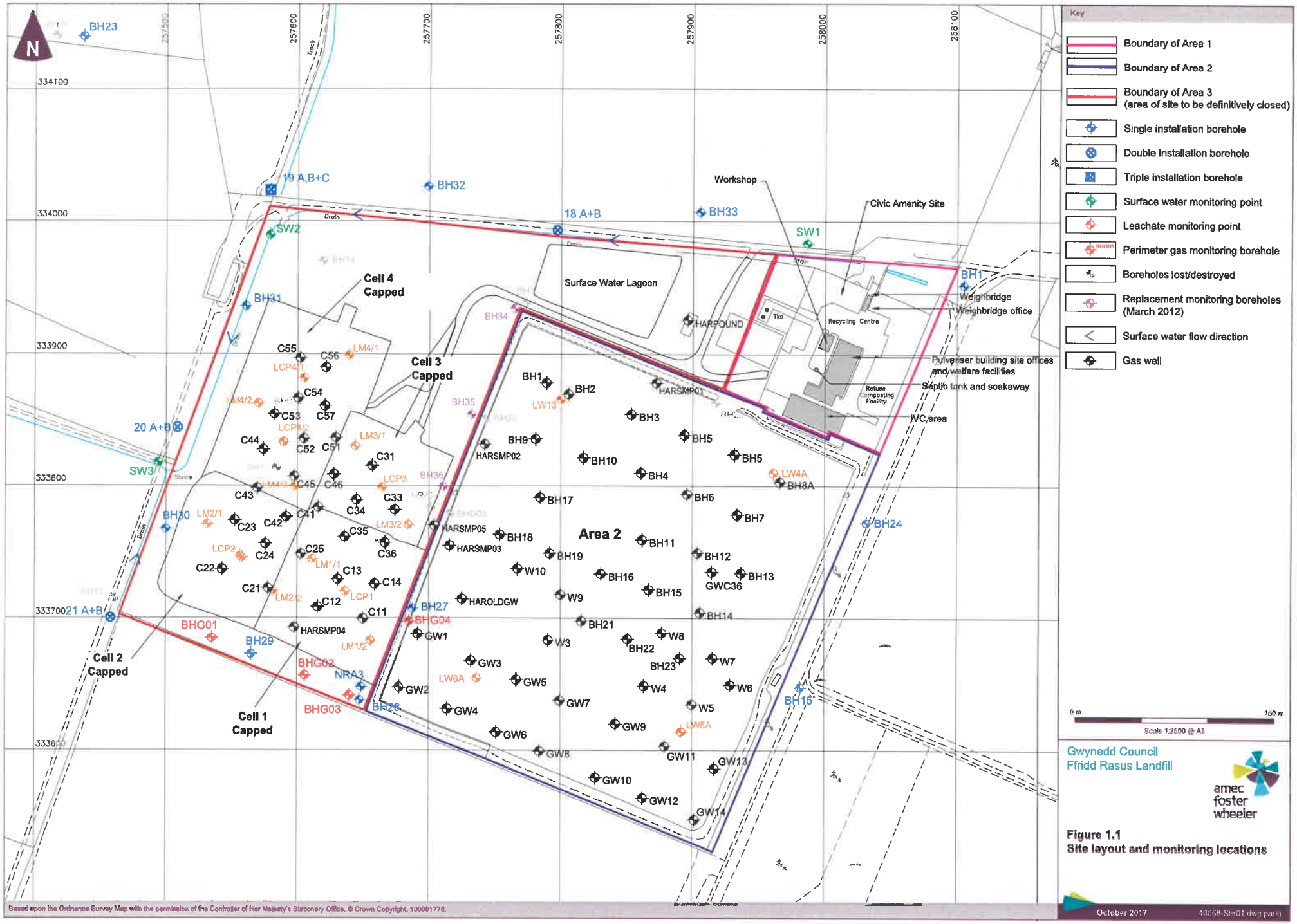
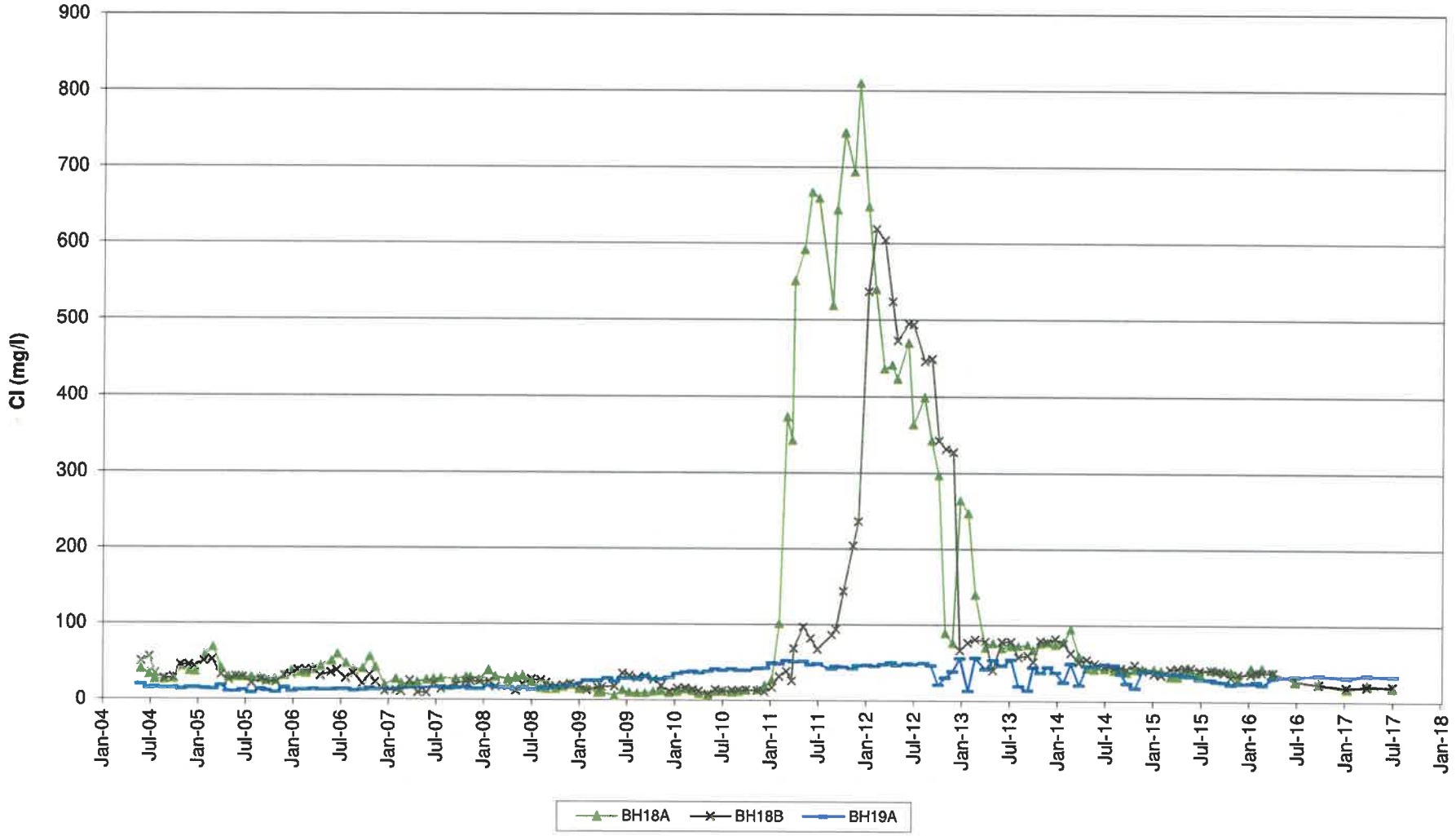
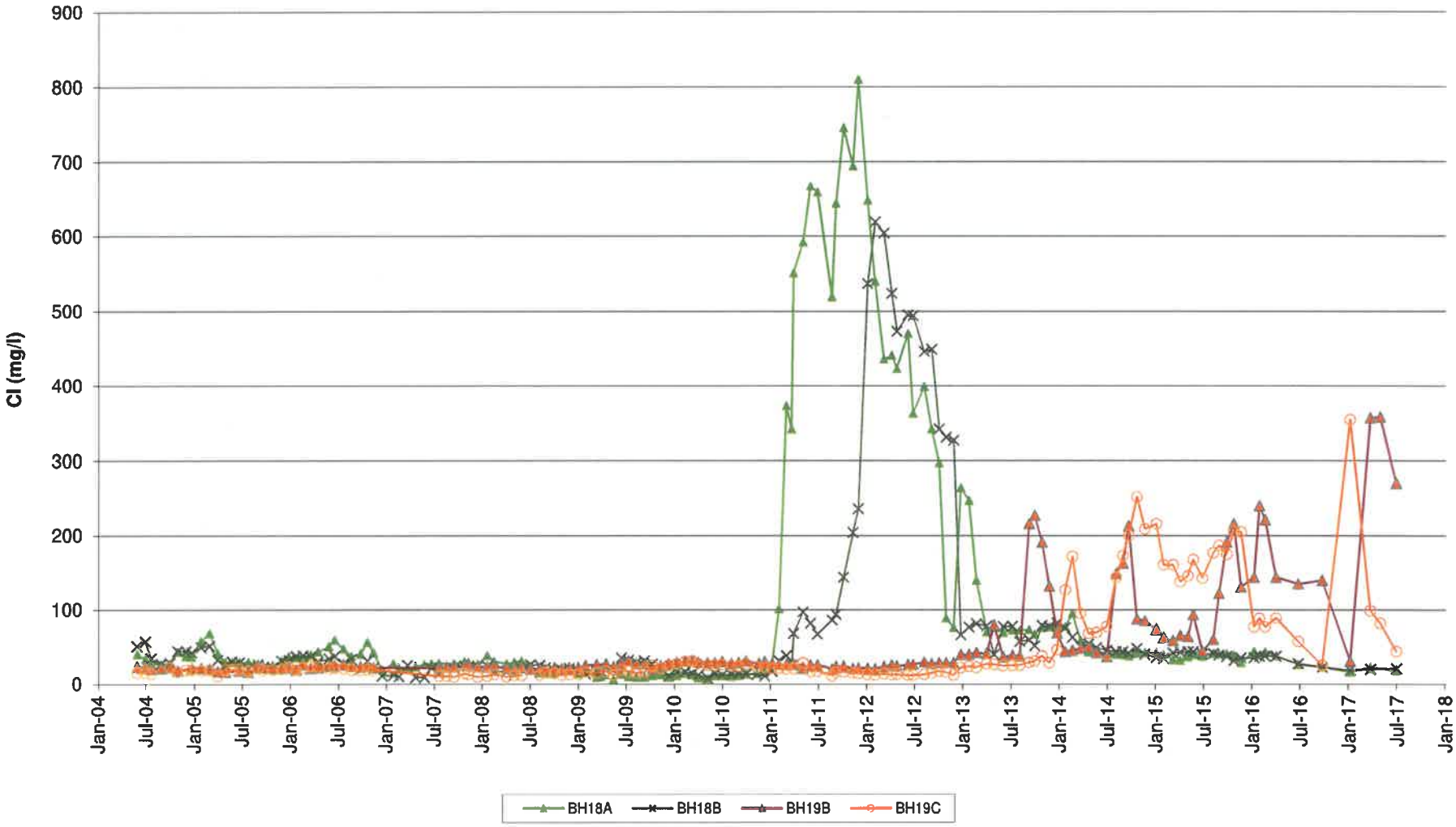

N
Key
Boundary of Area 1
Boundary of Area 2
Boundary of Area 3 (area of site to be definitively closed)
Single installation borehole
Double installation borehole
Triple installation borehole
Surface water monitoring point
Leachate monitoring point
Perimeter gas monitoring borehole
Boreholes lost/destroyed
Replacement monitoring boreholes (March 2012)
Surface water flow direction
Gas well
Cell 1 Capped
Cell 2 Capped
Cell 3 Capped
Cell 4 Capped
Area 2
Surface Water Lagoon
Workshop
Civic Amenity Site
Recycling Centre
Weighbridge
Weighbridge office
Pulveriser building site offices and welfare facilities
Septic tank and soakaway
IVC area
Refuse Composting Facility
HARPOUND
Tks
Drain
Track
334100
334000
333900
333800
333700
333600
257500
257600
257700
257800
257900
258000
258100
0 m
150 m
Scale 1:2500 @ A3
Gwynedd Council
Ffridd Rasus Landfill
amec foster wheeler
Figure 1.1
Site layout and monitoring locations
October 2017
40068-Sht01.dwg par4j
Based upon the Ordnance Survey Map with the permission of the Controller of Her Majesty's Stationery Office. © Crown Copyright, 100001776.

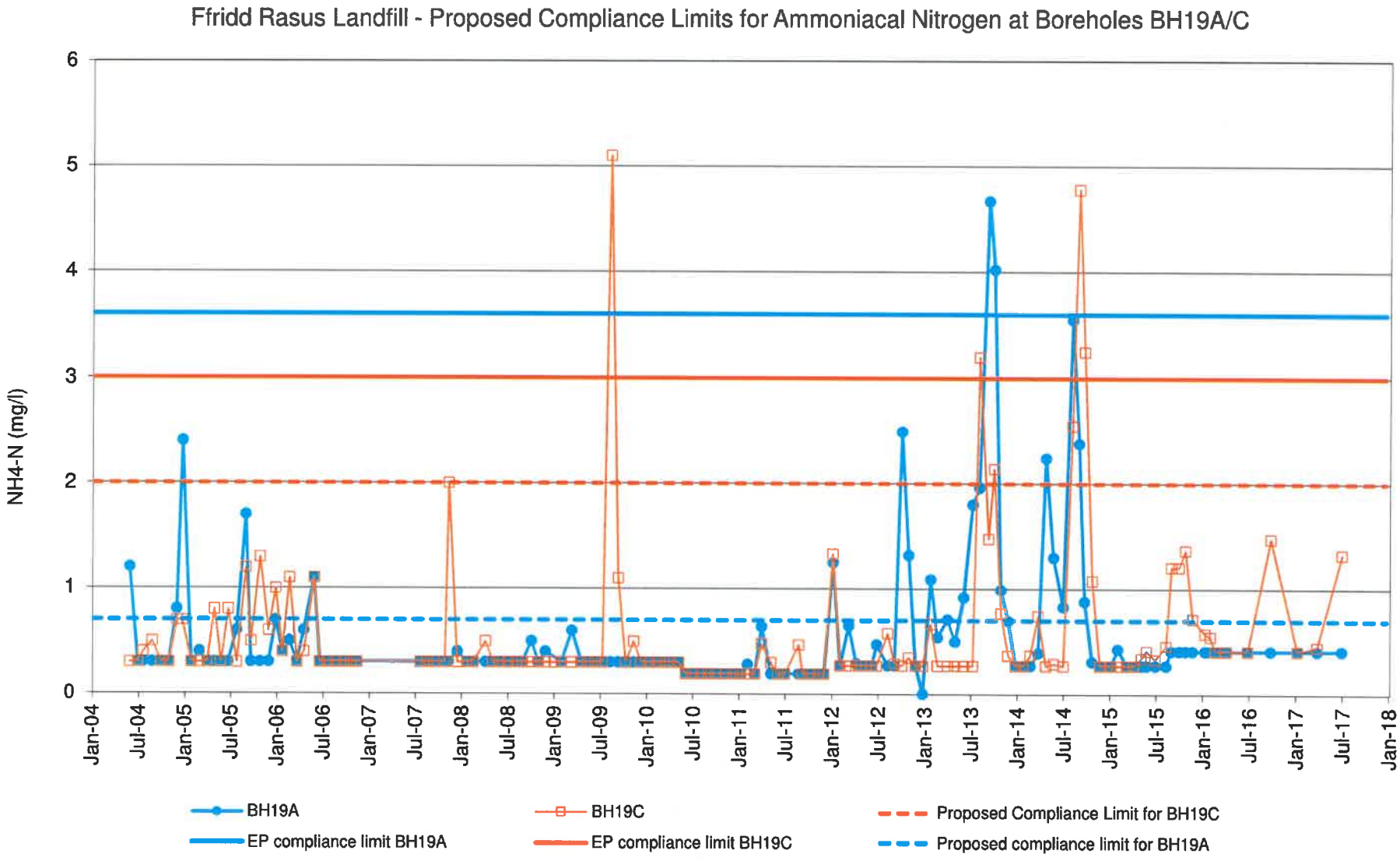
Appendix A
Proposed Groundwater Compliance Limits

Ffridd Rasus Landfill - Groundwater Quality (Chloride at Boreholes BH18A, BH18B and BH19A)

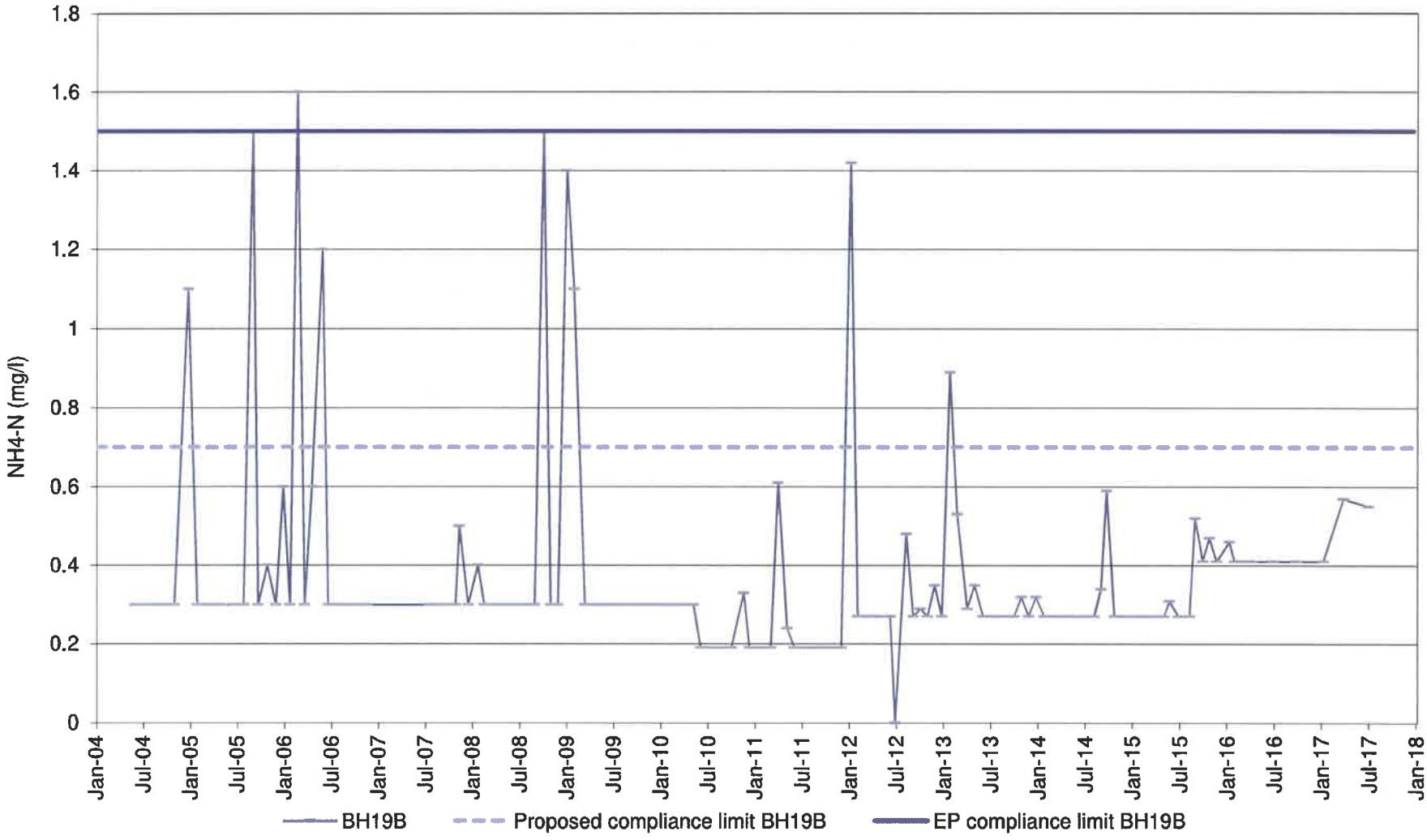


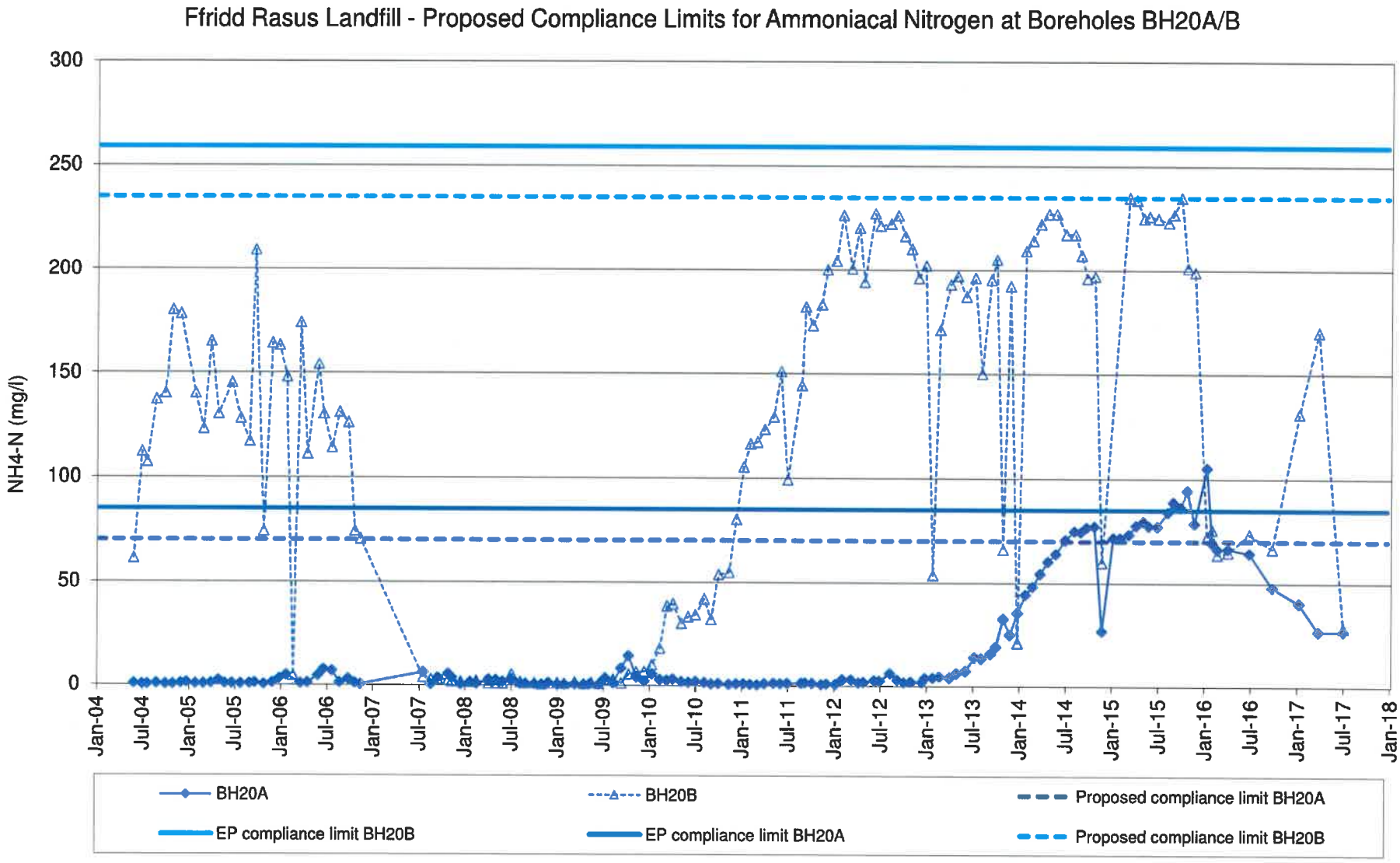
Ffridd Rasus Landfill - - Groundwater Quality (Chloride at Boreholes BH18A, BH18B, BH19B and BH19C)



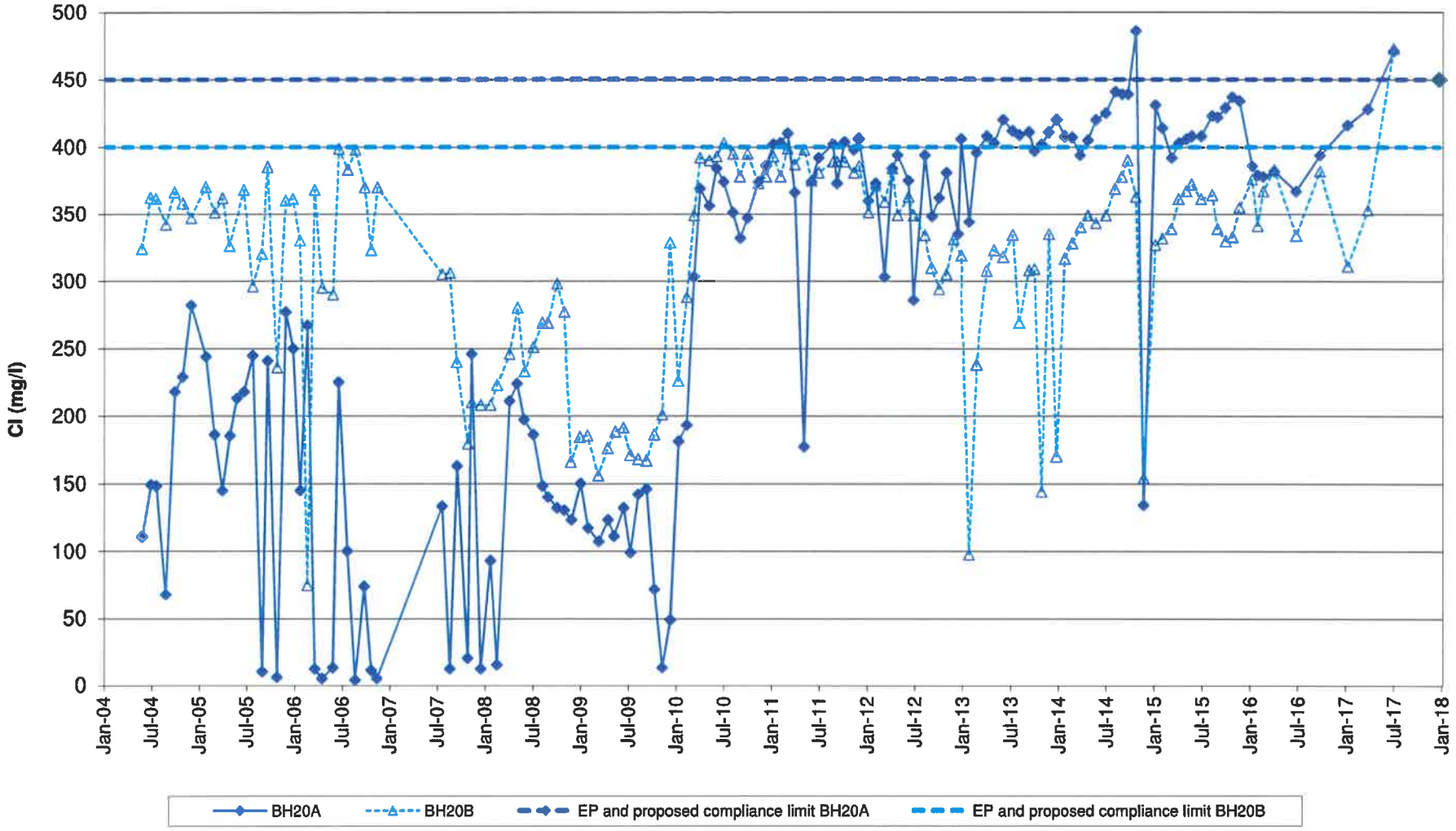

Ffridd Rasus Landfill - Proposed Compliance Limits for Ammoniacal Nitrogen at Boreholes BH19A/C
NH4-N (mg/l)
0
1
2
3
4
5
6
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
BH19A
BH19C
Proposed Compliance Limit for BH19C
EP compliance limit BH19A
EP compliance limit BH19C
Proposed compliance limit for BH19A

Ffridd Rasus Landfill - Proposed Compliance Limits for Ammoniacal Nitrogen at Boreholes BH19B

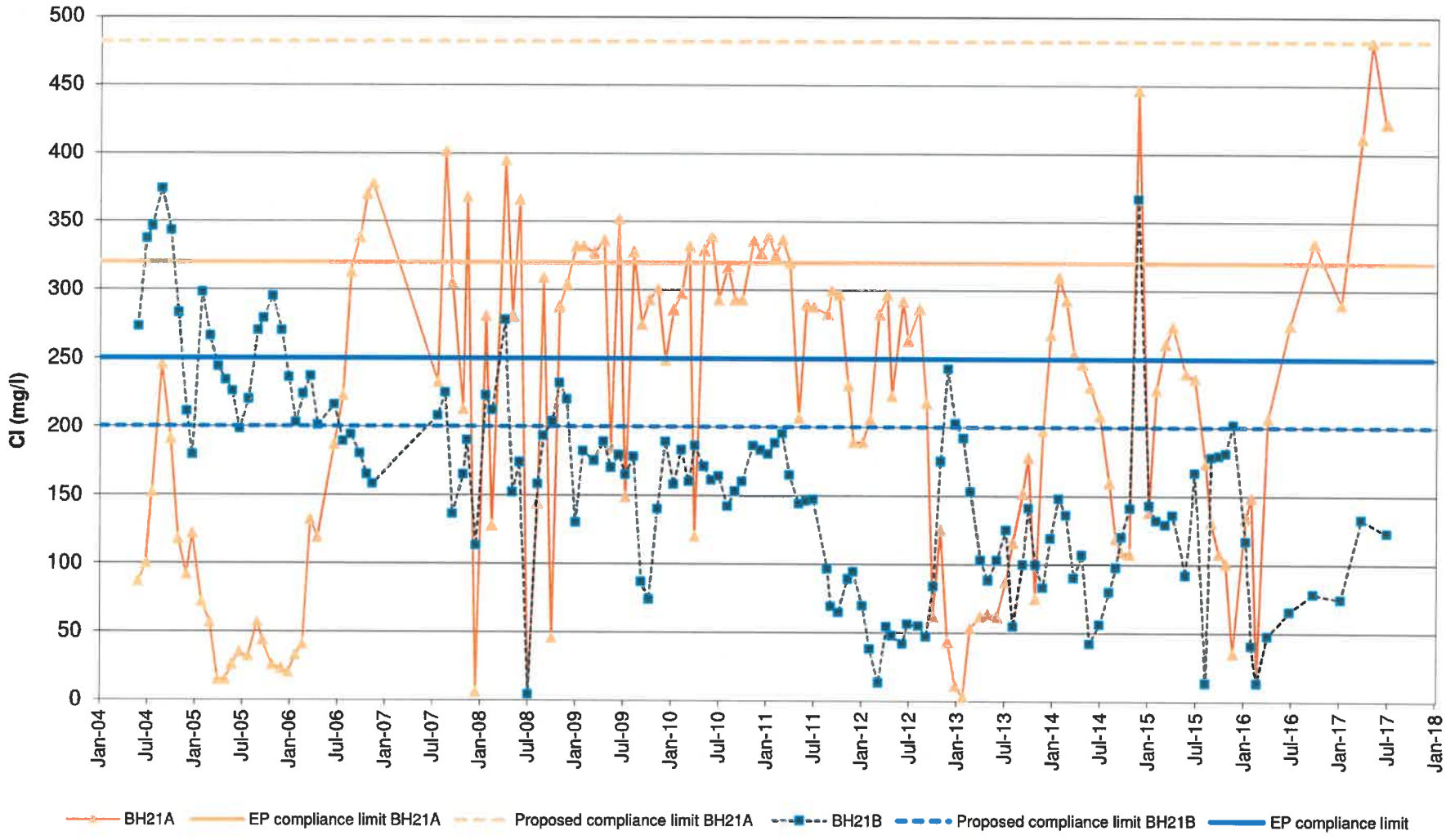



Ffridd Rasus Landfill - Proposed Compliance Limits for Ammoniacal Nitrogen at Boreholes BH20A/B
NH4-N (mg/l)
300
250
200
150
100
50
0
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
BH20A
BH20B
Proposed compliance limit BH20A
EP compliance limit BH20B
EP compliance limit BH20A
Proposed compliance limit BH20B

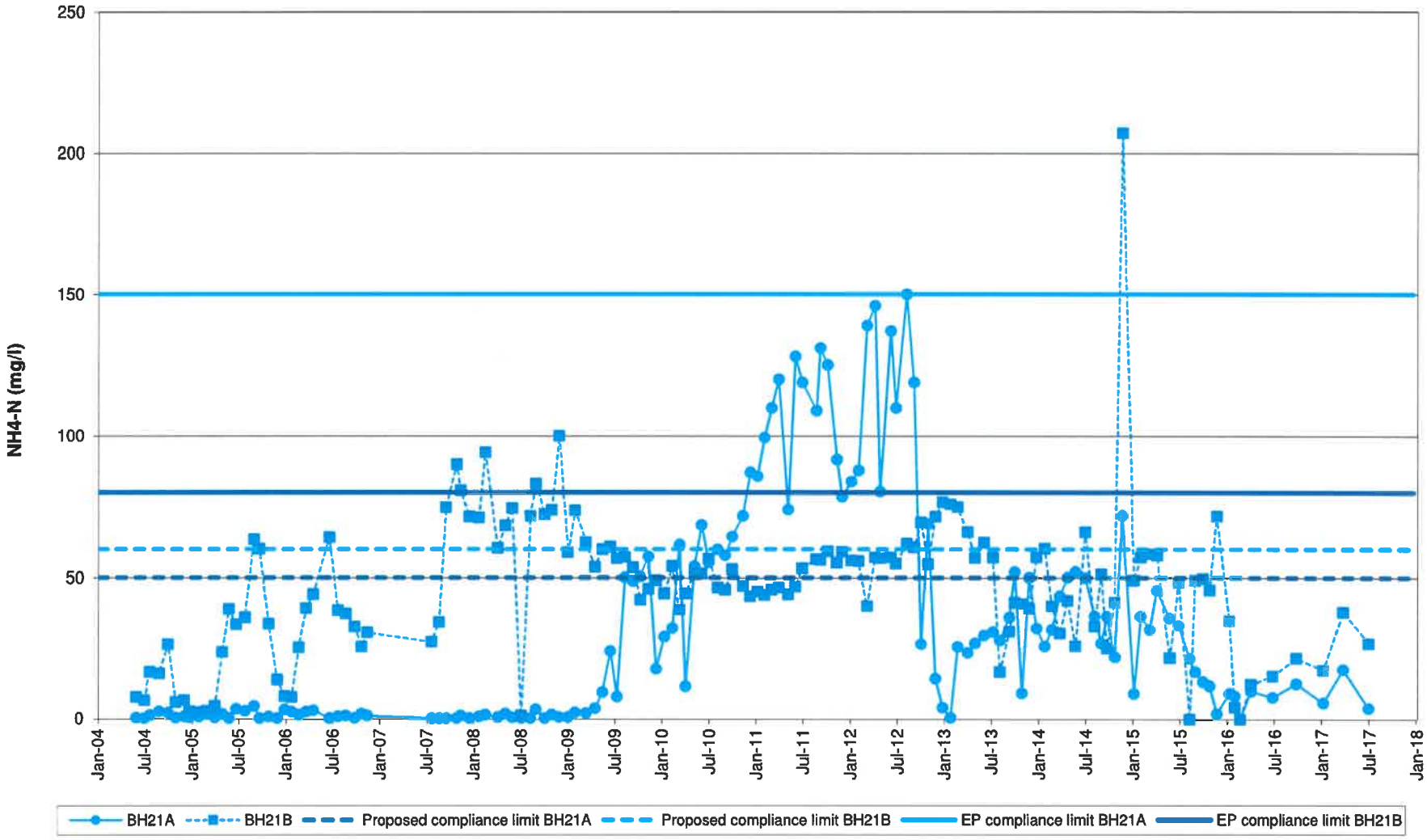
Ffridd Rasus Landfill - Proposed Compliance Limits for Chloride at Boreholes BH20A/B



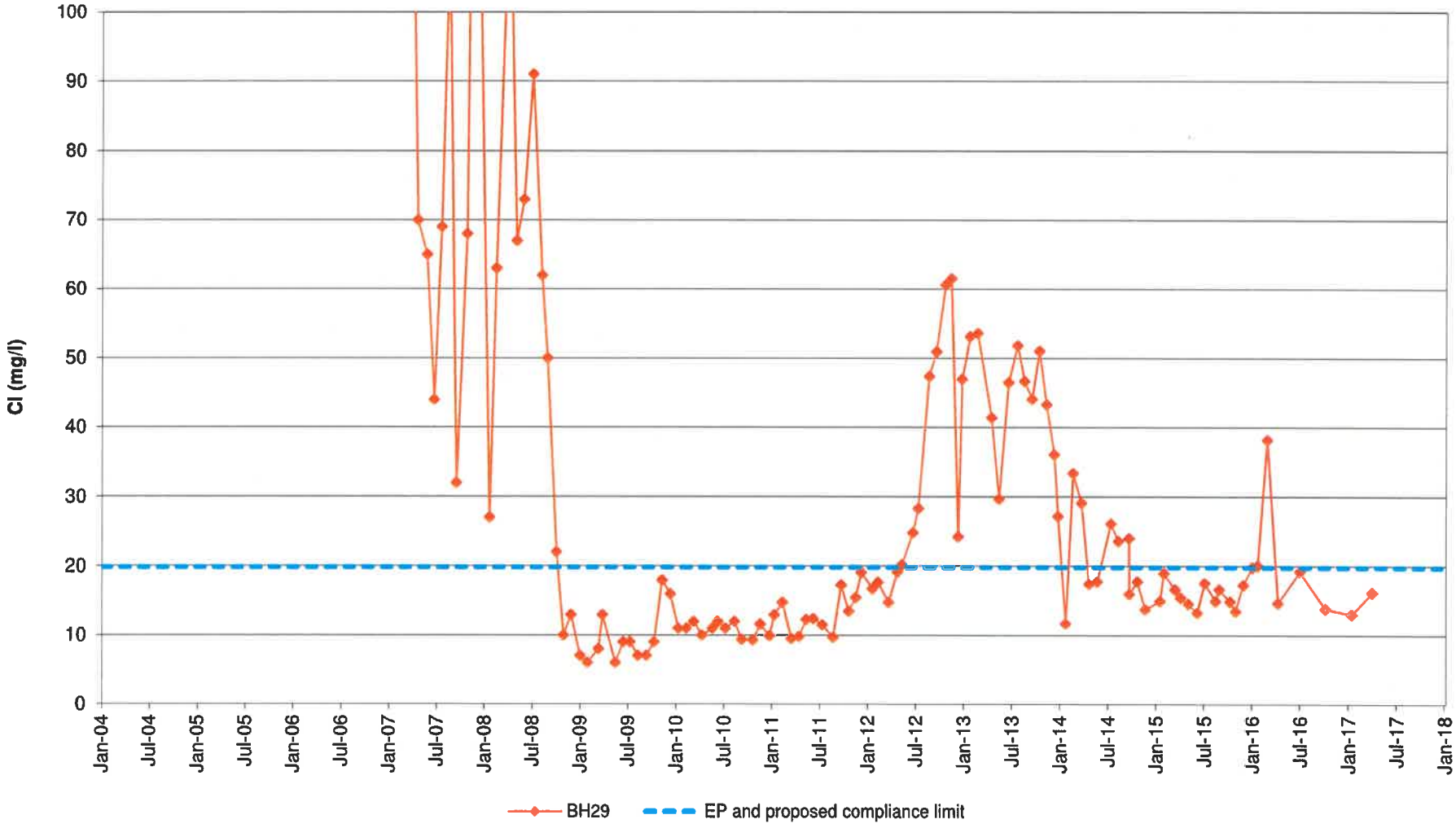
Ffridd Rasus Landfill - Proposed Compliance Limits for Chloride at Boreholes BH21B



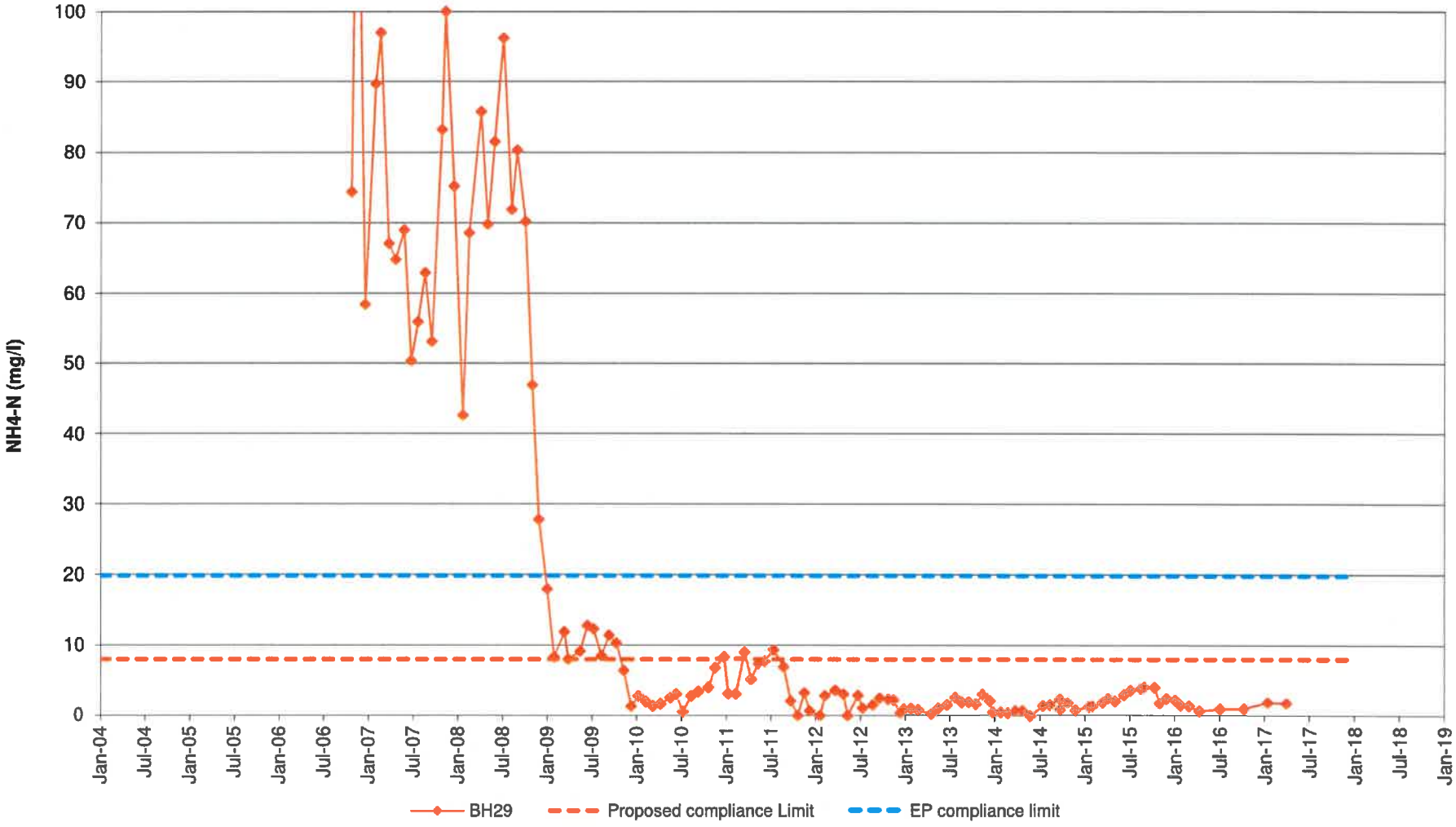
Ffridd Rasus Landfill - Proposed Compliance Limits for Ammoniacal Nitrogen at Boreholes BH21A/B



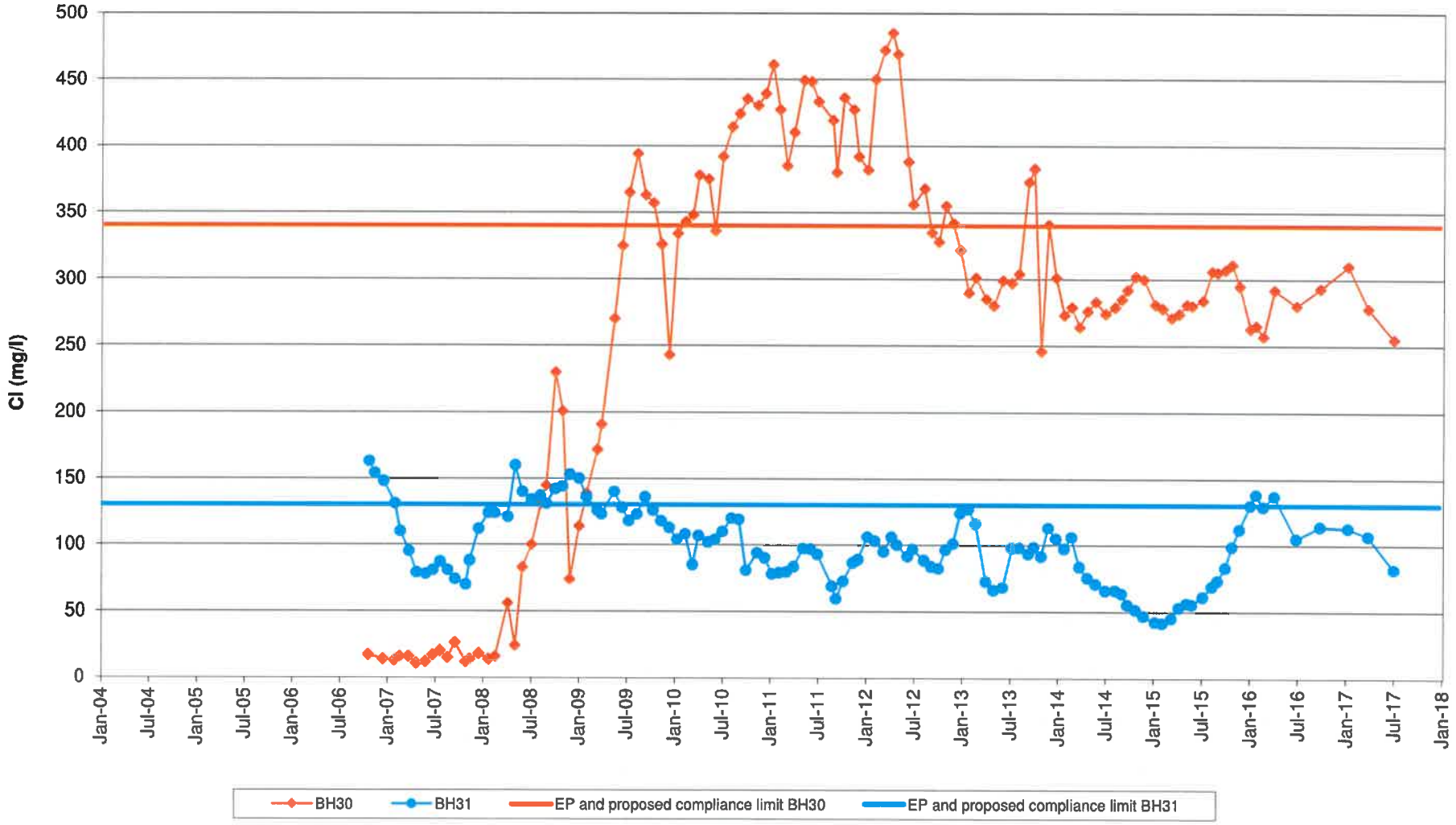
Ffridd Rasus Landfill - Proposed Compliance Limits for Chloride at Borehole BH29



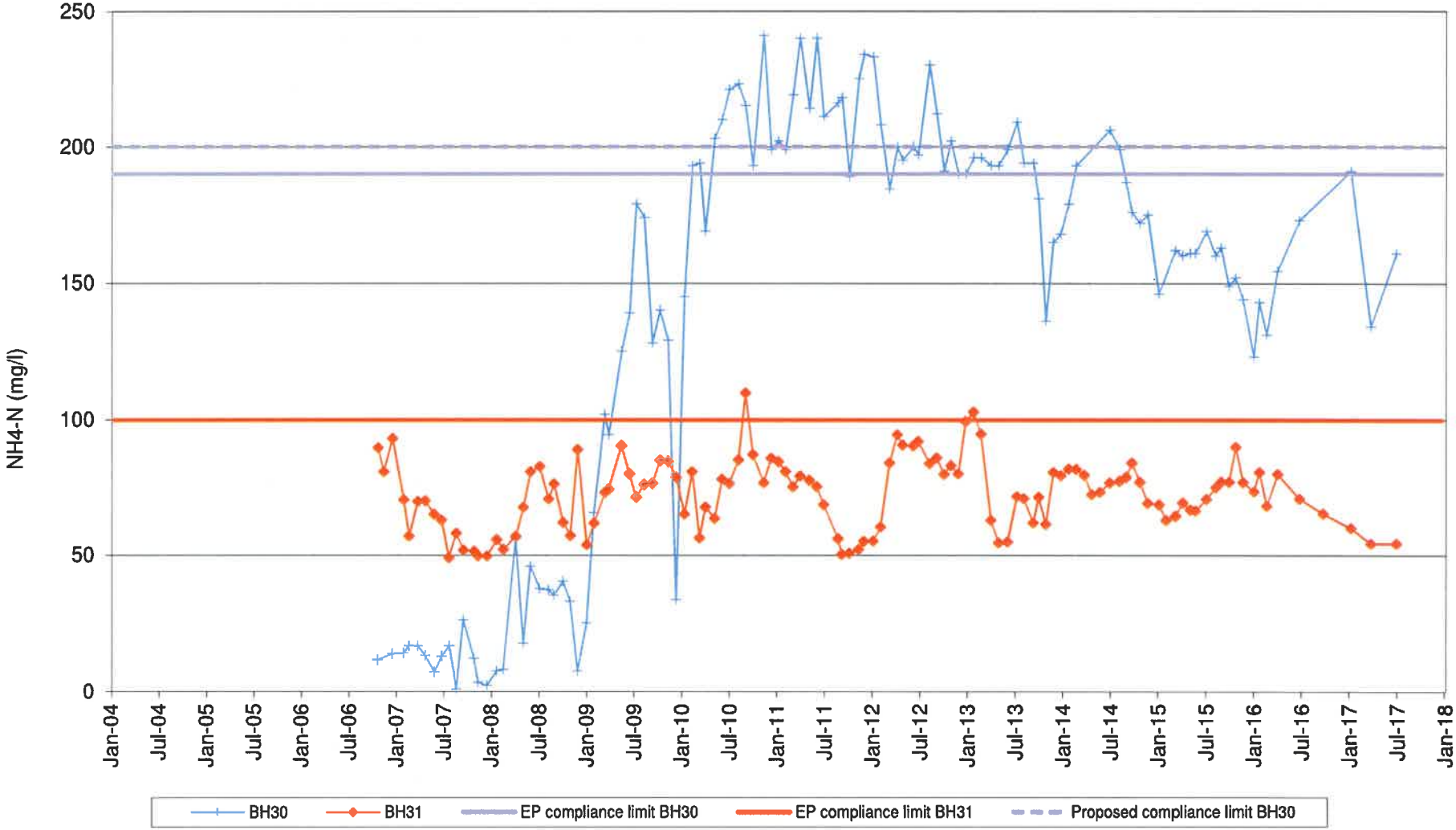
Ffridd Rasus Landfill - Proposed Compliance Limits for Ammoniacal-Nitrogen at Borehole BH29



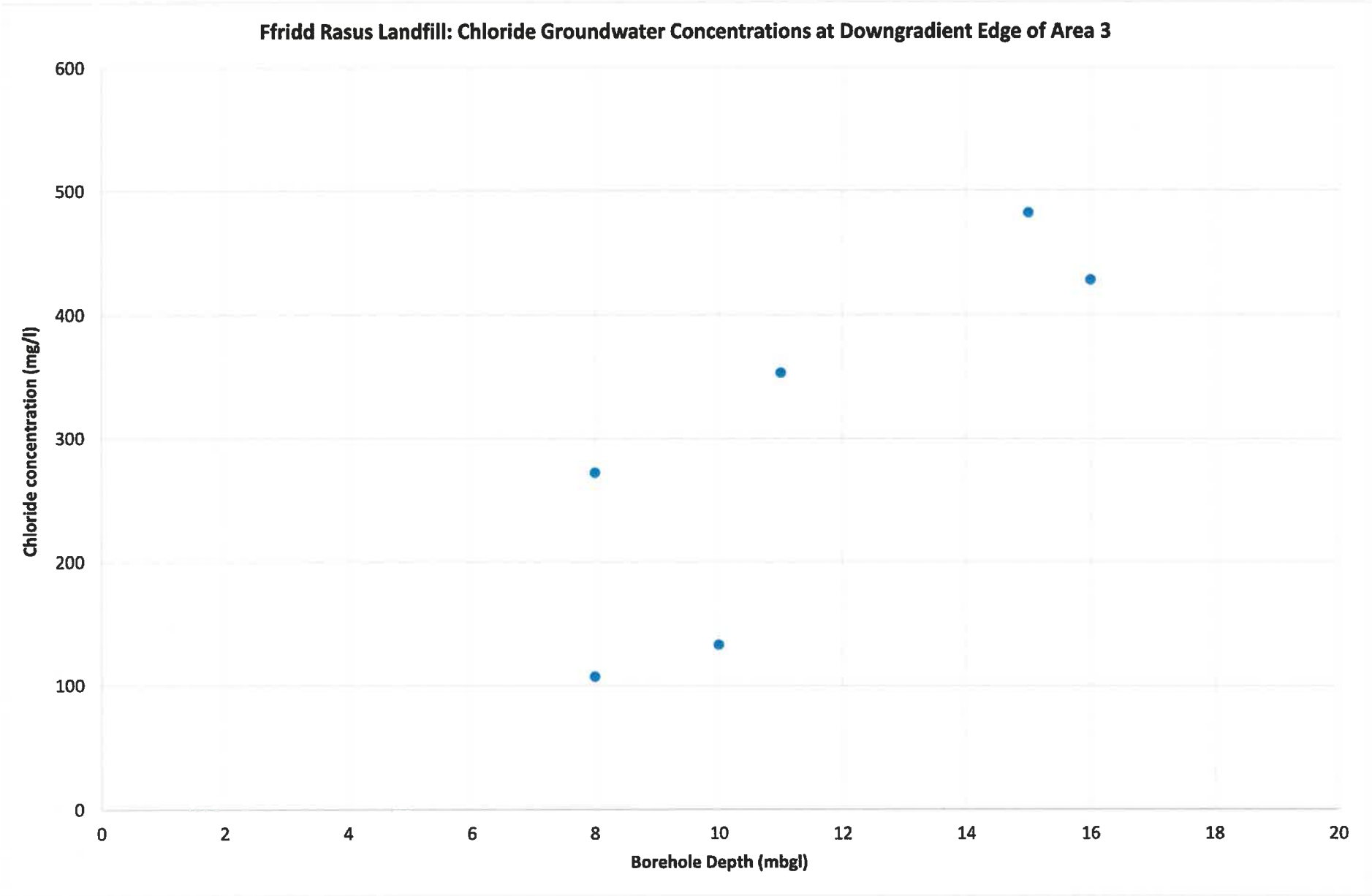
Ffridd Rasus Landfill - Proposed Compliance Limits for Chloride at Boreholes BH30 & BH31



Ffridd Rasus Landfill - Proposed Compliance Limits for Ammoniacal Nitrogen at Boreholes BH30 & BH31

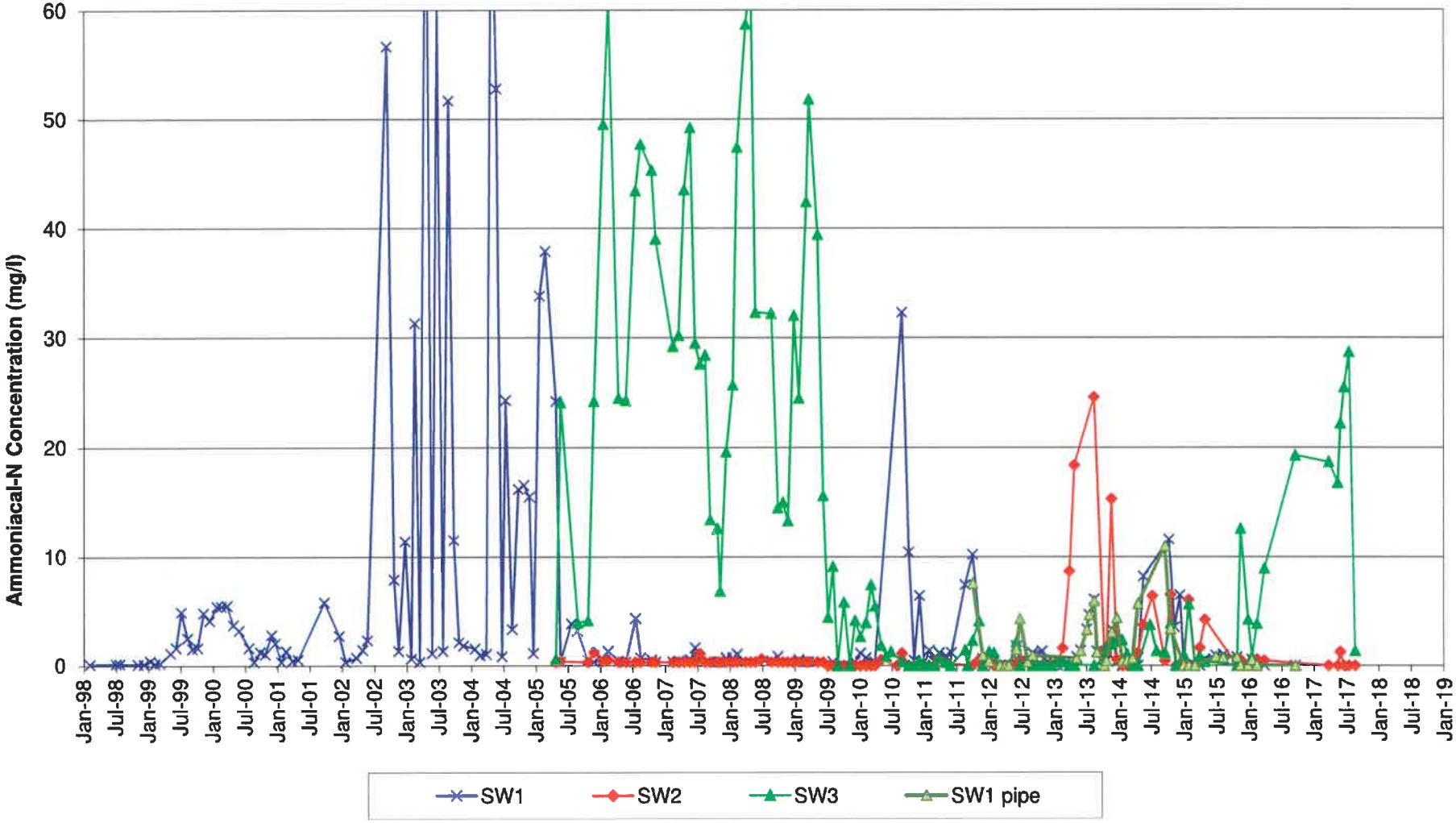


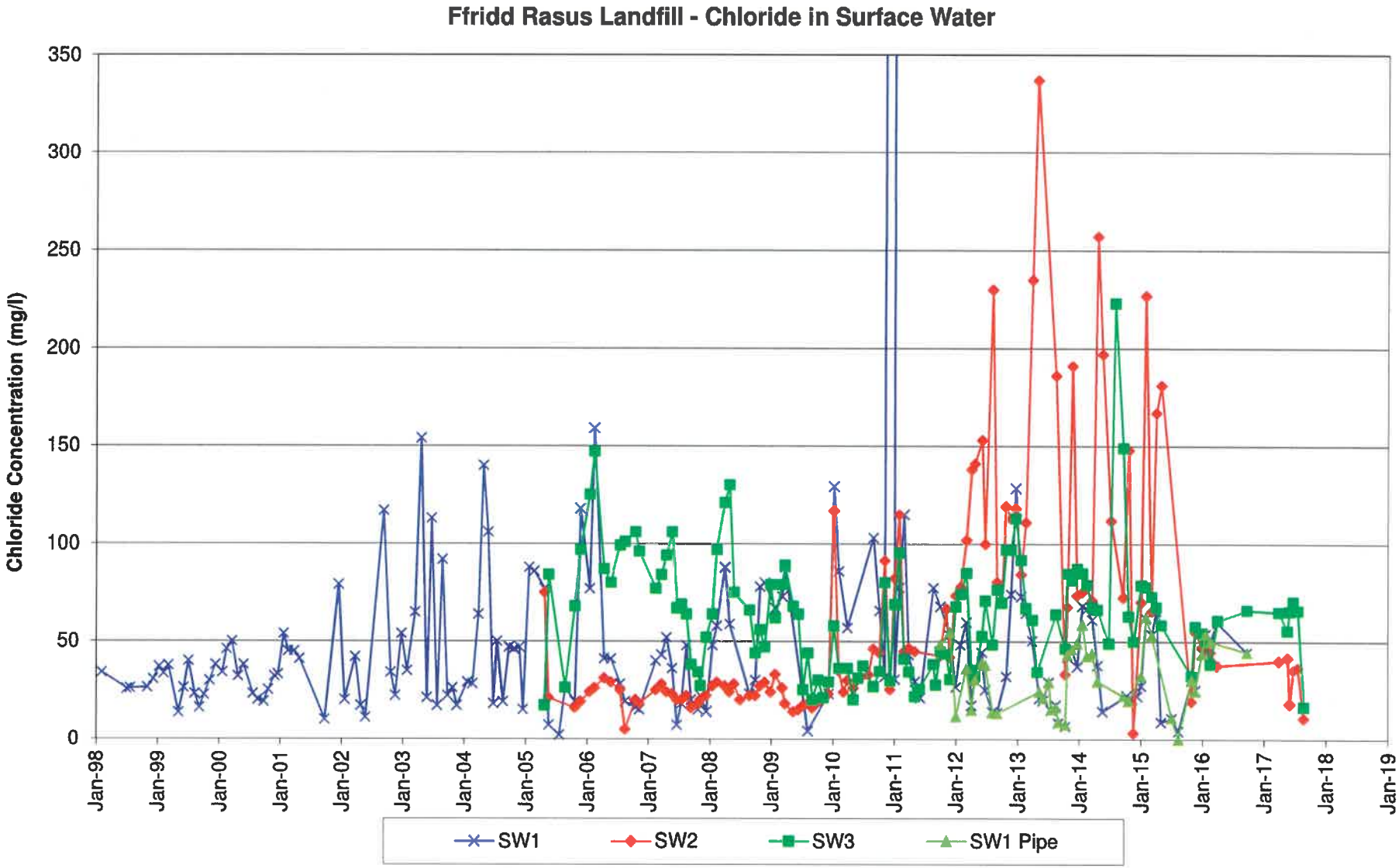
Appendix B
Chloride Concentrations at Shallow and Deep Boreholes

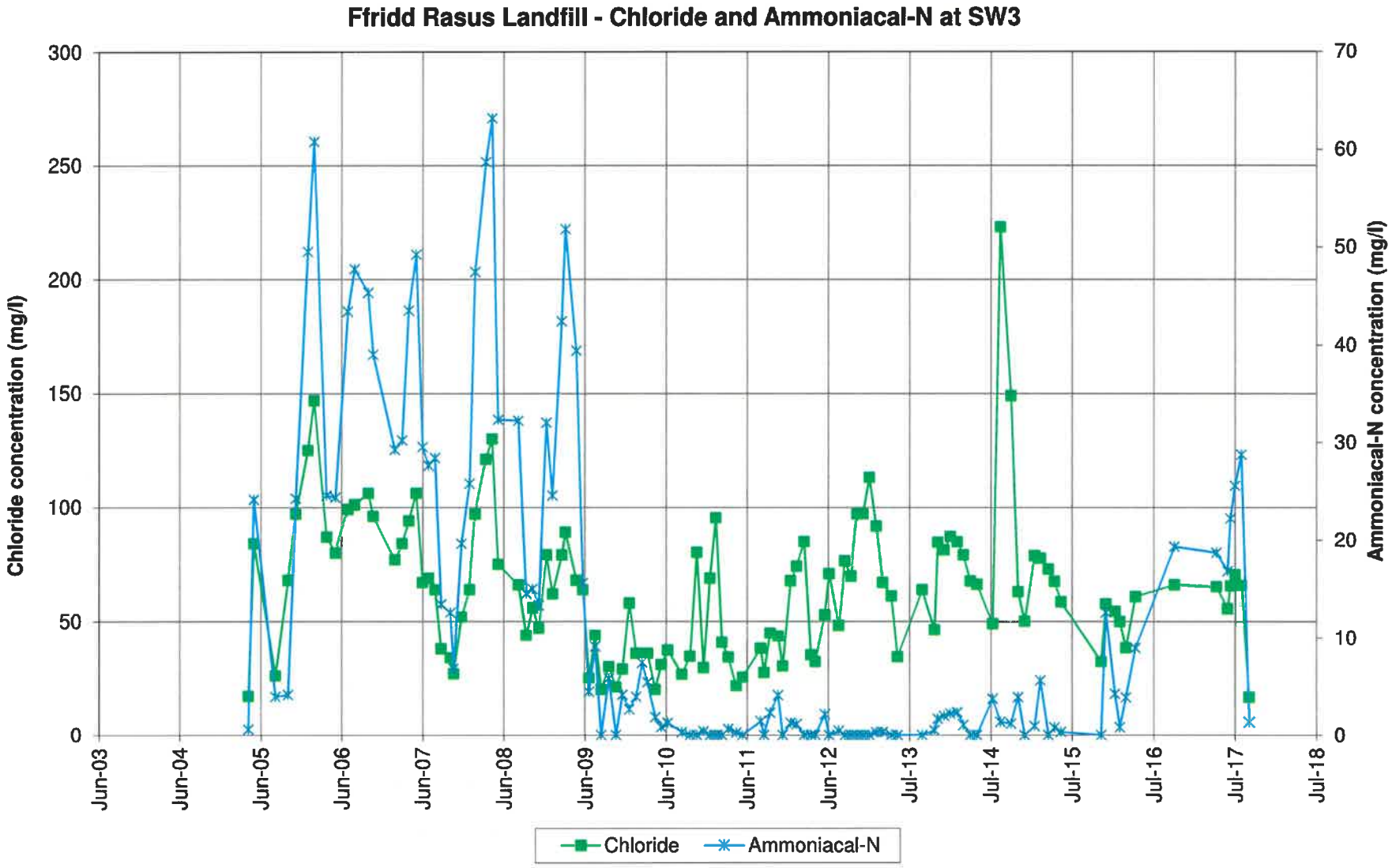

Ffridd Rasus Landfill: Chloride Groundwater Concentrations at Downgradient Edge of Area 3
Chloride concentration (mg/l)
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
18
20
Borehole Depth (mbgl)

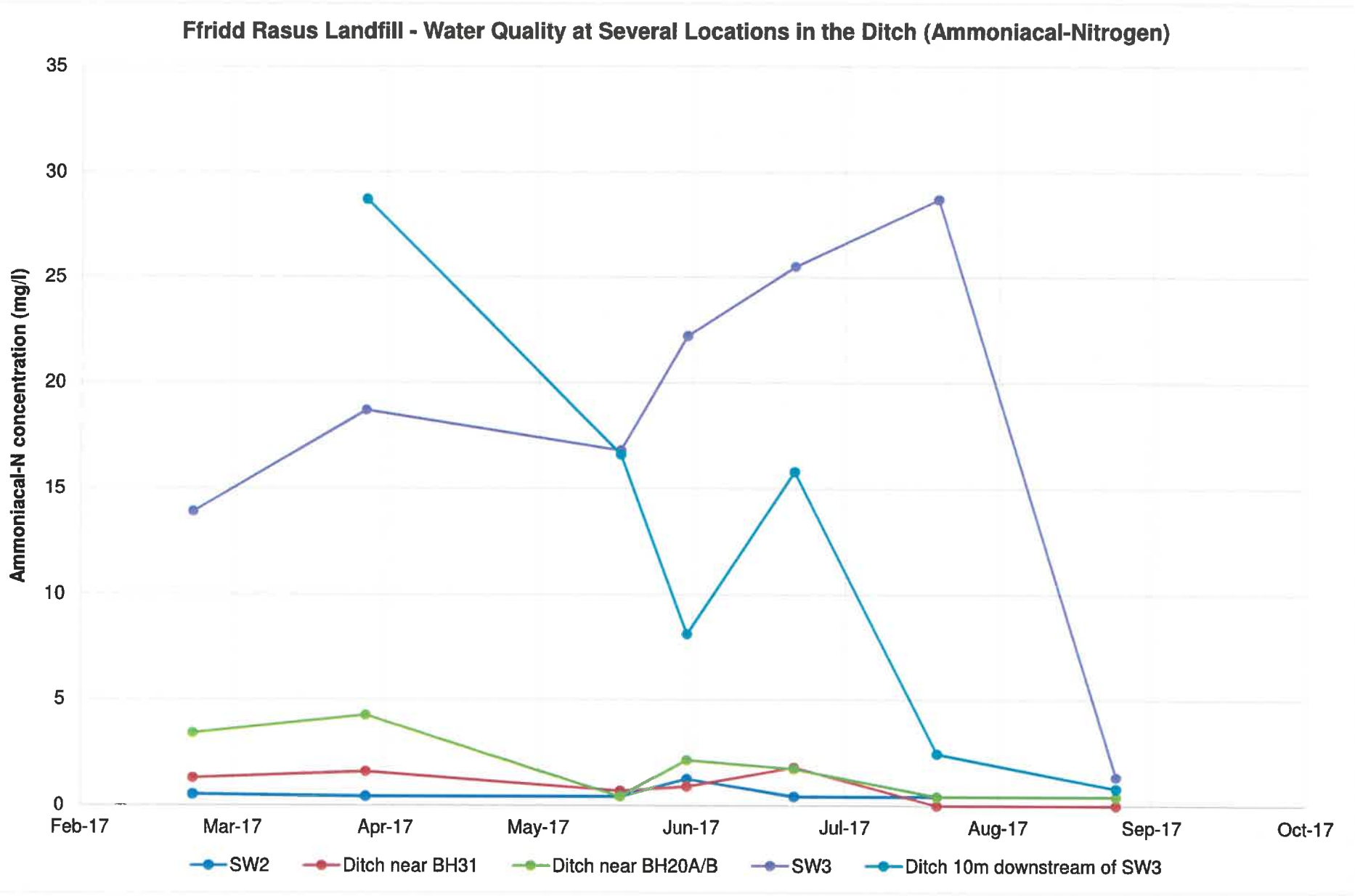
Appendix C
Surface Water Investigation: Water Quality Plots

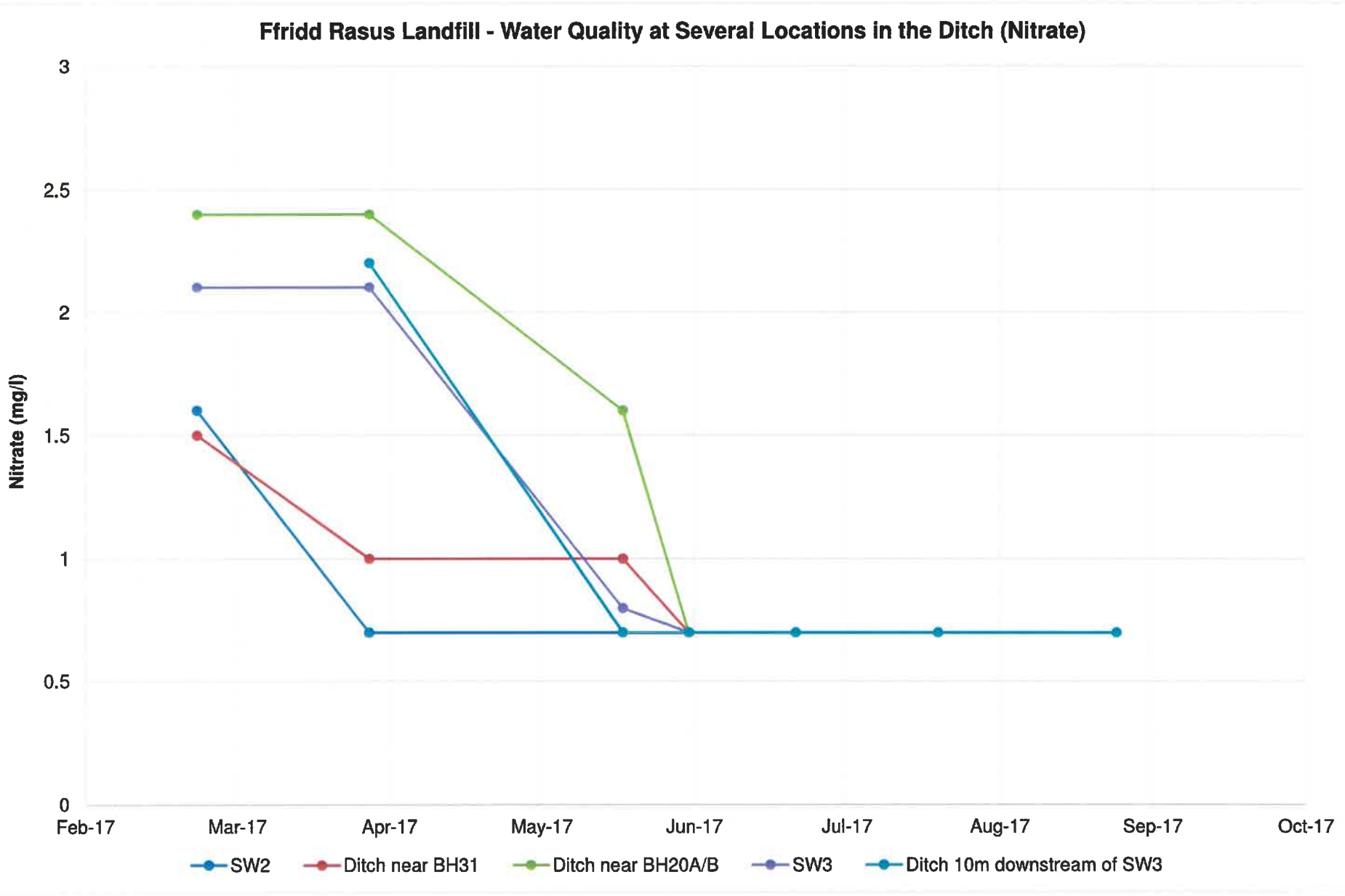
Ffridd Rasus Landfill - Ammoniacal-Nitrogen in Surface Water

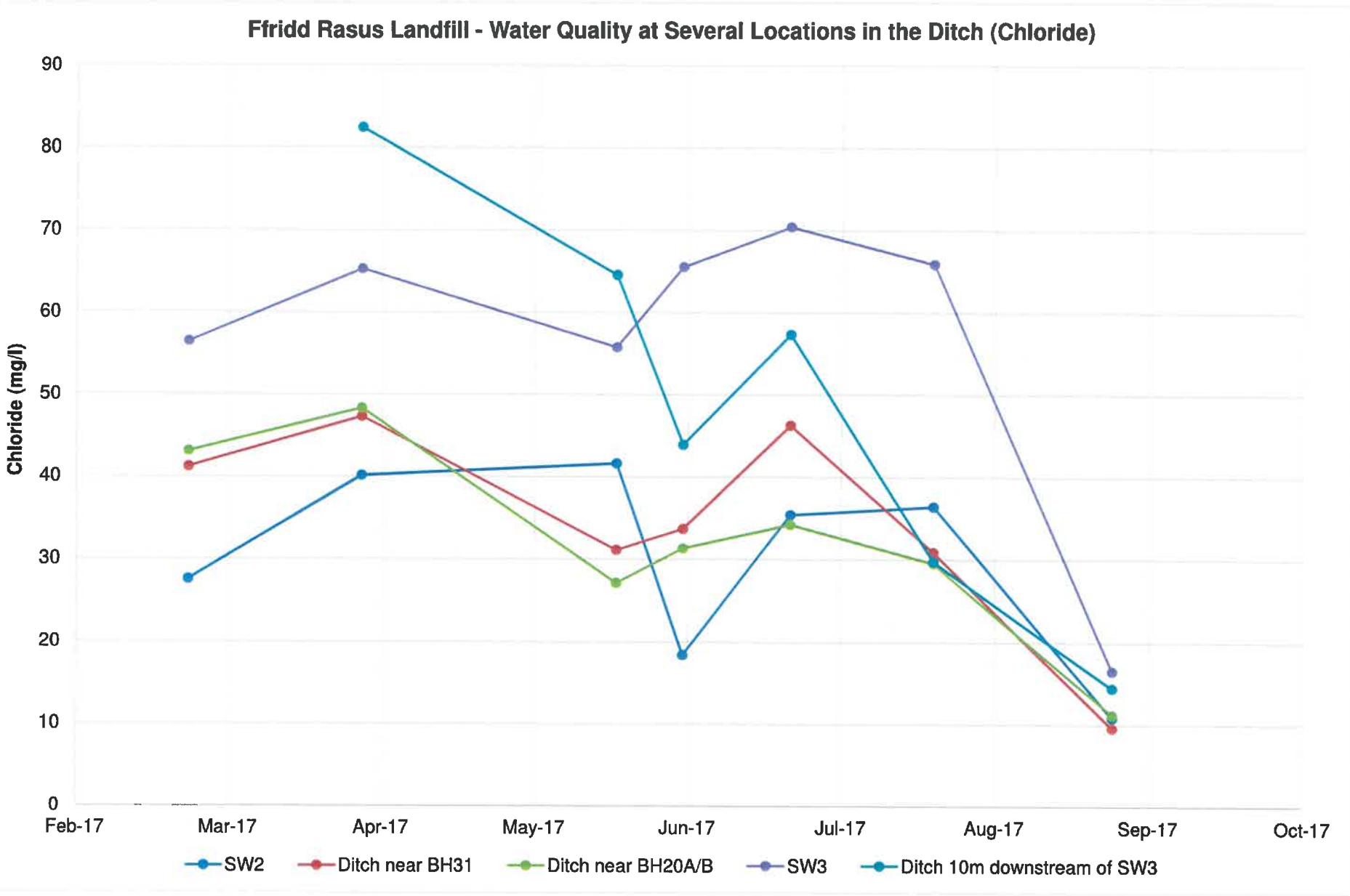



Ffridd Rasus Landfill - Chloride in Surface Water
Chloride Concentration (mg/l)
350
300
250
200
150
100
50
0
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
SW1
SW2
SW3
SW1 Pipe


Ffridd Rasus Landfill - Chloride and Ammoniacal-N at SW3
Chloride concentration (mg/l)
Ammoniacal-N concentration (mg/l)
300
250
200
150
100
50
0
70
60
50
40
30
20
10
0
Jun-03
Jun-04
Jun-05
Jun-06
Jun-07
Jun-08
Jun-09
Jun-10
Jun-11
Jun-12
Jul-13
Jul-14
Jul-15
Jul-16
Jul-17
Jul-18
Chloride
Ammoniacal-N


Ffridd Rasus Landfill - Water Quality at Several Locations in the Ditch (Ammoniacal-Nitrogen)
Ammoniacal-N concentration (mg/l)
35
30
25
20
15
10
5
0
Feb-17
Mar-17
Apr-17
May-17
Jun-17
Jul-17
Aug-17
Sep-17
Oct-17
SW2
Ditch near BH31
Ditch near BH20A/B
SW3
Ditch 10m downstream of SW3


Ffridd Rasus Landfill - Water Quality at Several Locations in the Ditch (Nitrate)
Nitrate (mg/l)
3
2.5
2
1.5
1
0.5
0
Feb-17
Mar-17
Apr-17
May-17
Jun-17
Jul-17
Aug-17
Sep-17
Oct-17
SW2
Ditch near BH31
Ditch near BH20A/B
SW3
Ditch 10m downstream of SW3


Ffridd Rasus Landfill - Water Quality at Several Locations in the Ditch (Chloride)
Chloride (mg/l)
90
80
70
60
50
40
30
20
10
0
Feb-17
Mar-17
Apr-17
May-17
Jun-17
Jul-17
Aug-17
Sep-17
Oct-17
SW2
Ditch near BH31
Ditch near BH20A/B
SW3
Ditch 10m downstream of SW3

Appendix D
Surface Water Investigation: Photographs

Photo 1: Compost stockpile present in field opposite to BH30 in April 2017. Approximately one fourth of the compost volume still remains in September 2017 at this location.

Photo 2: Stagnant water in ditch upstream of BH19/SW2 (April 2017)

Photo 3: Cow next to ditch near SW2 (April 2017)

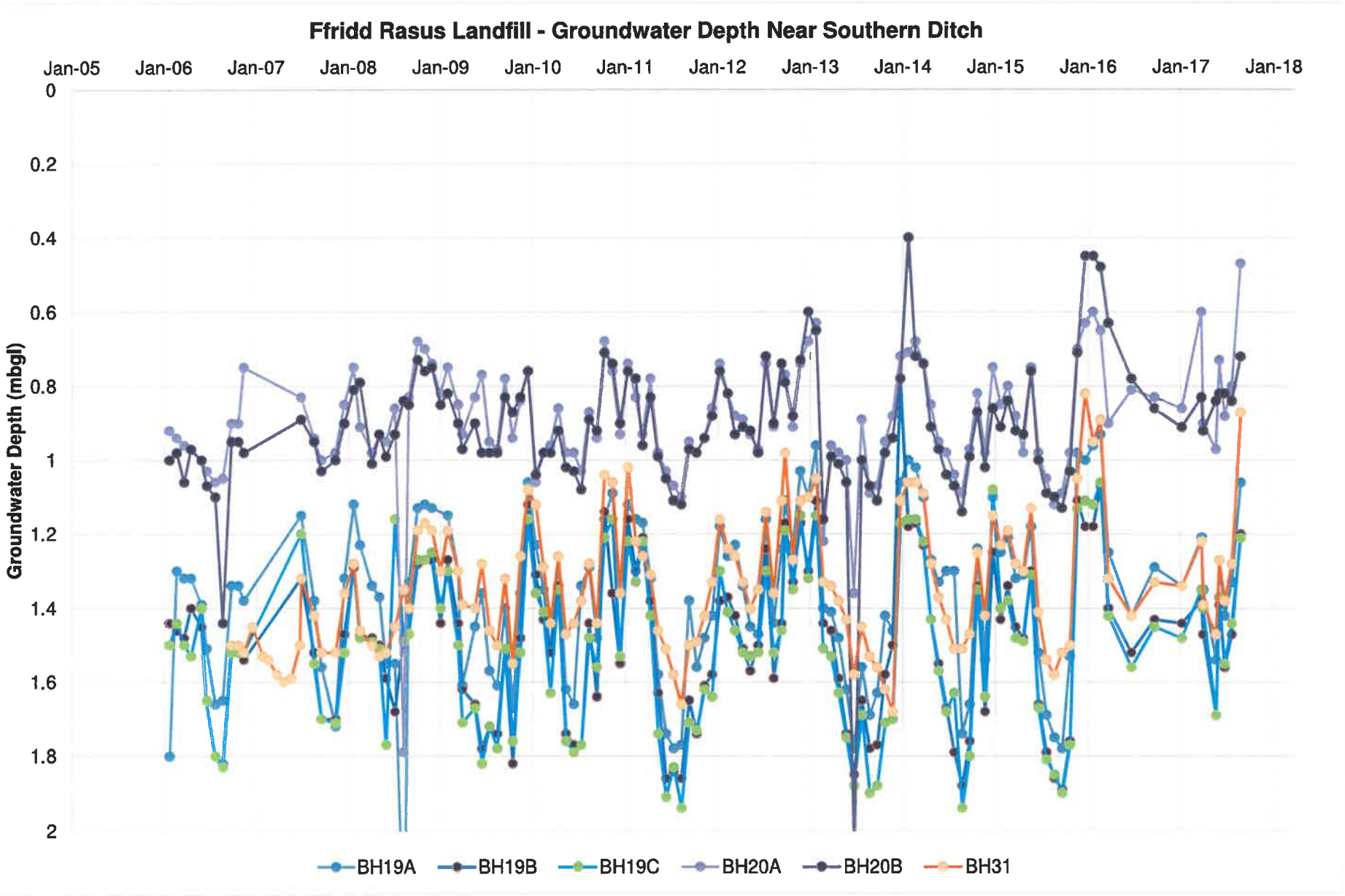
Photo 4: View of ditch upstream of BH19/SW2 (and downstream of Photos 2 and 3) with stagnant water/low flow (April 2017)

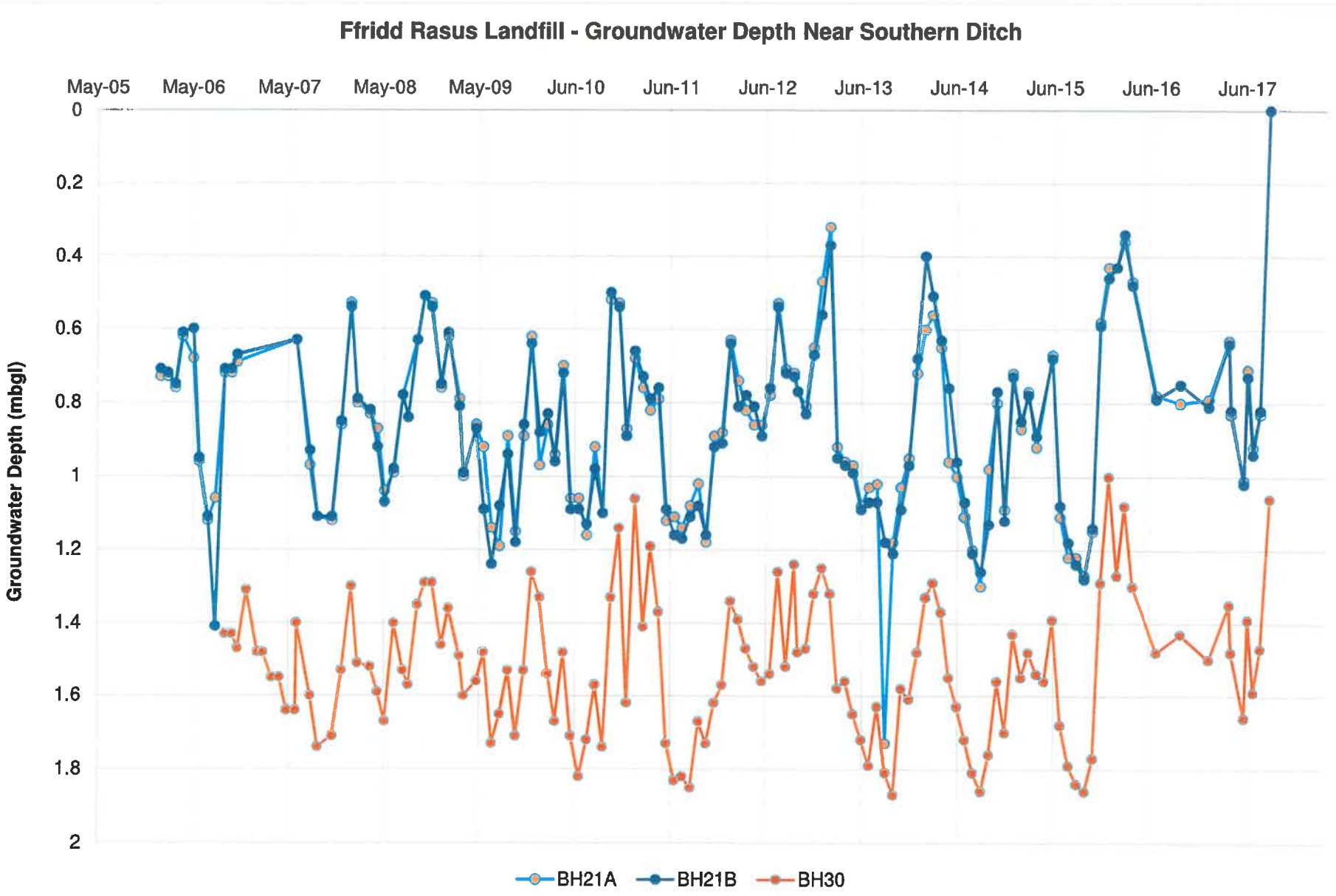
Photo 5: View of vegetation in the ditch near SW2. Compost pile in the background has been moved from the original location shown in Photo 1 in April 2017. The stockpile has been at this location for approximately 2 months.

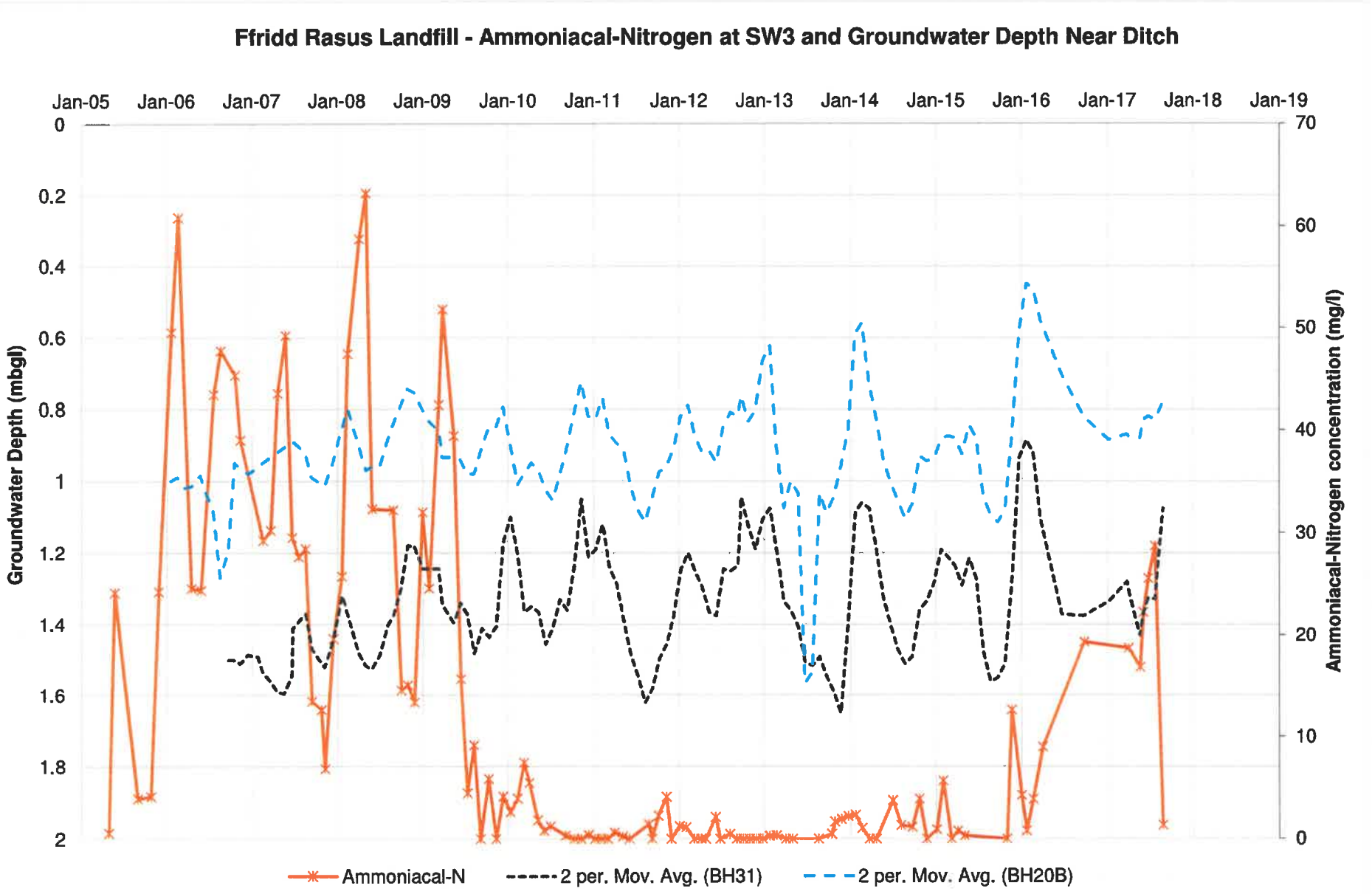
Photo 6: View of the ditch near SW2 with standing water (April 2017)

Photo 7: Tank opposite to BH31 (content/use unknown)

Appendix E
Groundwater Levels near the Ditch


Ffridd Rasus Landfill - Groundwater Depth Near Southern Ditch
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Groundwater Depth (mbgl)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
BH19A
BH19B
BH19C
BH20A
BH20B
BH31


Ffridd Rasus Landfill - Groundwater Depth Near Southern Ditch
May-05
May-06
May-07
May-08
May-09
Jun-10
Jun-11
Jun-12
Jun-13
Jun-14
Jun-15
Jun-16
Jun-17
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Groundwater Depth (mbgl)
BH21A
BH21B
BH30


Ffridd Rasus Landfill - Ammoniacal-Nitrogen at SW3 and Groundwater Depth Near Ditch
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Groundwater Depth (mbgl)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Ammoniacal-Nitrogen concentration (mg/l)
70
60
50
40
30
20
10
0
Ammoniacal-N
2 per. Mov. Avg. (BH31)
2 per. Mov. Avg. (BH20B)

Susan Jane Francis (PAB)

From: Ross, Stuart <Stuart.Ross@cyfoethnaturiolcymru.gov.uk>
Sent: 06 December 2017 12:02
To: Francis Susan Jane (PAB)
Cc: Edwards Steven (PAB); Bradford, Julie
Subject: Ffridd Rasus

Susan,

I am writing further to the receipt of the '*Review of Groundwater Compliance limits and surface water investigation (Amec, November 2017)*', as per your e-mail of 23/11/17.

The report was submitted to our Geoscience Team for review and we agree to accept (as allowed by the permit) the compliance limits for chloride and ammoniacal nitrogen proposed in Table 2.4 of the report. However, this is the basis that the next Annual Environmental Report (AER) is due in January 2018 and compliance limits are reviewed again.

At some of the compliance boreholes there has been variability in the concentrations of chloride and ammoniacal nitrogen data during 2016 and first half of 2017 but there appears to be an overall downward trend as the plume from Area 2 migrates beneath the site. We expect to see compliance limits reduce further at most of the compliance boreholes when the full dataset from 2017 is reviewed. We do have a concern over the use of temporary compliance limit at BH21A (meaning an increase to 482mg/l from the current permit value of 300mg/l) and request that copies of the borehole construction logs for all the compliance boreholes can be provided with the AER for us to look into this in more detail.

We note that these limits are also proposed by Amec for Area 2 (as previously recommended by us) to ensure consistency between the different permits – changes to the Area 2 permit are likely to require a variation and this is something we can discuss when the AER is submitted / compliance limits are reviewed again.

If you would like to discuss anything further then please get in touch.

Regards,

Stuart Ross, AIEMA
Regulatory Officer, Industry Regulation Team
Swyddog Rheoliadol, Tim Rheoliad Diwydiant
Cyfoeth Naturiol Cymru / Natural Resources Wales

03000 653 915
www.naturalresourceswales.gov.uk / www.cyfoethnaturiolcymru.gov.uk

Ffridd Rasus Proposed Permit Variation/Consolidation and Revised Groundwater Trigger Levels For Areas 2 and 3.

Meeting Summary and Decision-options Rationale

Permit consolidation Proposal - Gwynedd:

1) *Consolidate the A2 & A3 permits*
   The aim is to consolidate both permits and bring the unlined area 2 into line with the conditions in the lined and capped area 3.

2) *Remove the restoration permit condition of the landfill (A2) as this has been completed as this adds to the yearly costs of the permit subsistence (tier 3 bespoke permit) in the consolidated permit.*
   Area 2 introductory note states this is a Tier 3 bespoke permit for:
   -Civic Amenity Site
   -Closed Landfill Site
   -Restoration of Landfill

   NRW Comments:
   The Area 2 permit is a joint permit for a CA site and the closed landfill site. Can the site be consolidated with Area 3 EPR whilst containing the CA site in Area 1? **This needs to be clarified with permitting as a direct enquiry if this is the route Gwynedd intend to take.**
   The landfill restoration condition is required to be removed as this has been completed and adds cost to the permit. **This will need to be part of the variation application to permitting.**
   The overall aim of any consolidation is to justify the contamination caused by area 2 which is causing breaches in area 3. This has been proven in the extensive Wood/Amec Foster Wheeler reports due to the presence of naphthalene and other determinands reflecting contamination from Area 2 and not leakage from Area 3. The question remains as to whether the current Area 3 GW boreholes; 21 A&B 20 A&B and 19 A,B &C are reflective of contamination from area 2. **If this is the case then permit variation for determinand levels and frequency must be addressed via the permit variation route. Whether the route taken is one of consolidation or individual permit variation is a decision for the applicant to make in consultation with permitting as above.**

Trigger/Assessment Levels in Groundwater Boreholes

3) The proposal to remove the trigger levels from Area 2 permit and use the triggers specified in Area 3 Permit seems a sensible way forward, but the inter landfill boreholes should still be monitored annually to ensure data is retained tracking pollution from the unlined site. The other key aspect will be the influence of Area

2 pollution and where action levels will need to be set. This must be addressed with reference to point 1 above
The trigger levels are variable across both sets of boreholes. There are major discrepancies between boreholes representing the same source in a contiguous sand aquifer. To address these anomalies the trigger levels should be aligned on a risk basis and should be set consistent with the evidence and reflective of actions which would be undertaken should a breach of liner in area 3 occur. The leakage from Area 2 is uncontained but capped and dilute and disperse is the only historical option. New trigger levels should be agreed, which are consistent across the site and reflective of the risk assessment. To this end a final meeting between Gwynedd and NRW should establish the parameters for Gwynedd to submit draft final trigger levels and monitoring frequencies on a risk assessment basis. What action (if any) would the trigger levels trigger and given the residual nature of pollution from the dilute and disperse site (Area 2), are there any actions that can be taken to mitigate this. Limit values should be set on this basis and I agree that limits for Area 3 should represent the effects of the plume from area 2 in the knowledge that little can be done to remediate historical pollution of this nature.

4) One trigger for ammoniacal nitrogen and chloride. Currently the levels vary depending on the depth of the slotted section in the borehole. This is meant to represent plume gradient but in the context of risk assessment appears to be an academic argument, ie;

   - BH 19A, 19B and 19C
   - BH 20A and 20B

   Multiple differential triggers potentially do not reflect the risk assessment and the variability in the readings across the site. Trigger levels should be re-set in line with risk and previous results assuming that no further action can be taken on the breach of trigger levels which are different orders of magnitude between and within individual boreholes. Consideration should be given to reducing the leachate head within Area 3 to test effect on determinands hydraulically downgradient, but the site is within its compliance limits for leachate head and this is therefore an operator decision.

   Readings for Napthalene are generally expressed as < which is not an exact reading. There have been specific compliant readings in December 2018. Please contact the lab for an explanation of this anomaly as a breach should be specific where possible.

5) Reduce Area 3 monitoring from 3 monthly to 6 monthly. (as is current in Area 2 permit)
   - Groundwater dips
   - Groundwater sampling
   - Leachate dips

Agreed.

6) Flare Monitoring. Continue to monitor according to Area 2 & Area 3 permit requirements
   - Yearly flare emissions

   Agreed

7) Amend in Area 3 permit the need for yearly trigger level reviews.

Wood are reviewing trigger levels for Area 3 every year which is a permit requirement this should be discontinued.

8) Gwynedd council to submit a proposal to review the additional requirements for reporting trigger levels annually if they exist. See above for final trigger/assessment level agreement

   Include a review in the 6 yearly HRA. Allowing for 12 data sets (6-month monitoring) to review the trigger levels. A yearly review appears to be too frequent, with the proposed levels not yet being agreed between CG and NRW.

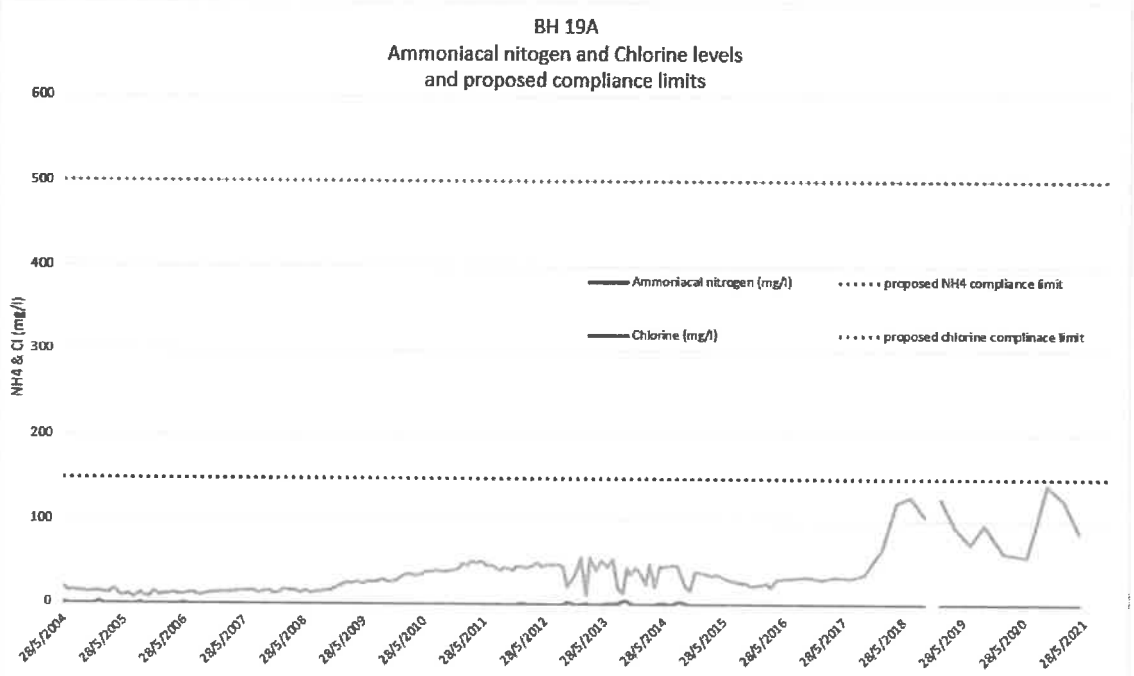
- Ffridd Rasus Landfill Areas 1 & 3 EPR/GP3330BY

APPENDIX C

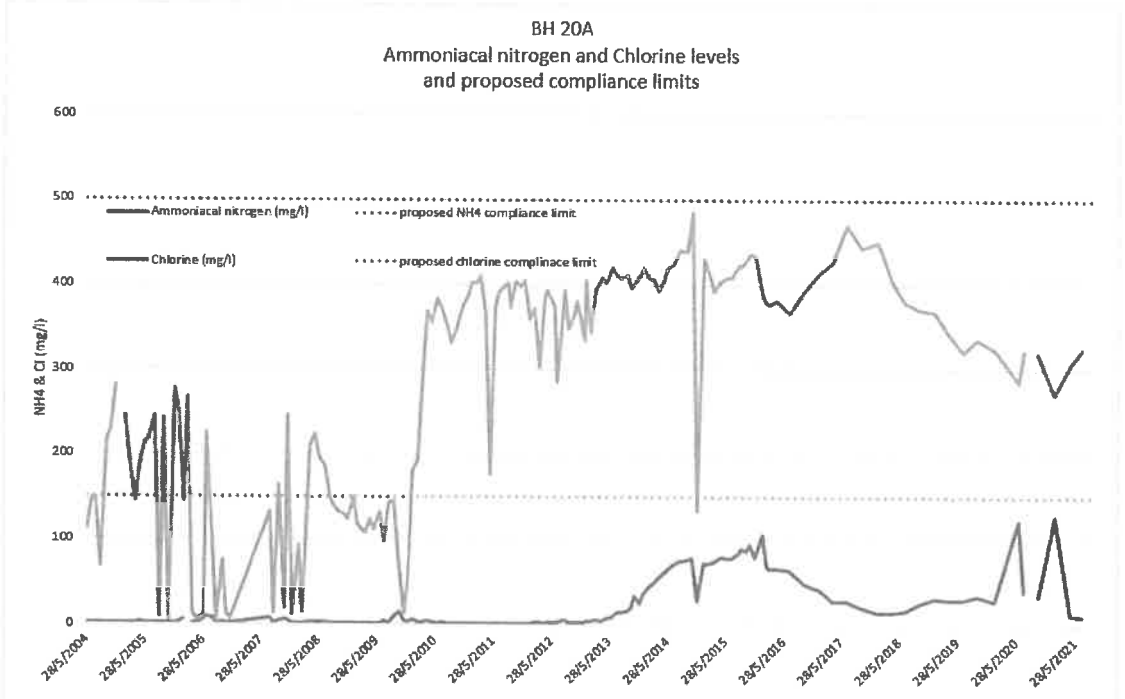
Ammoniacal nitrogen and Chloride levels

- Ffridd Rasus Landfill Areas 1 & 3 EPR/GP3330BY

BH 19A – Ammoniacal Nitrogen and Chlorine levels

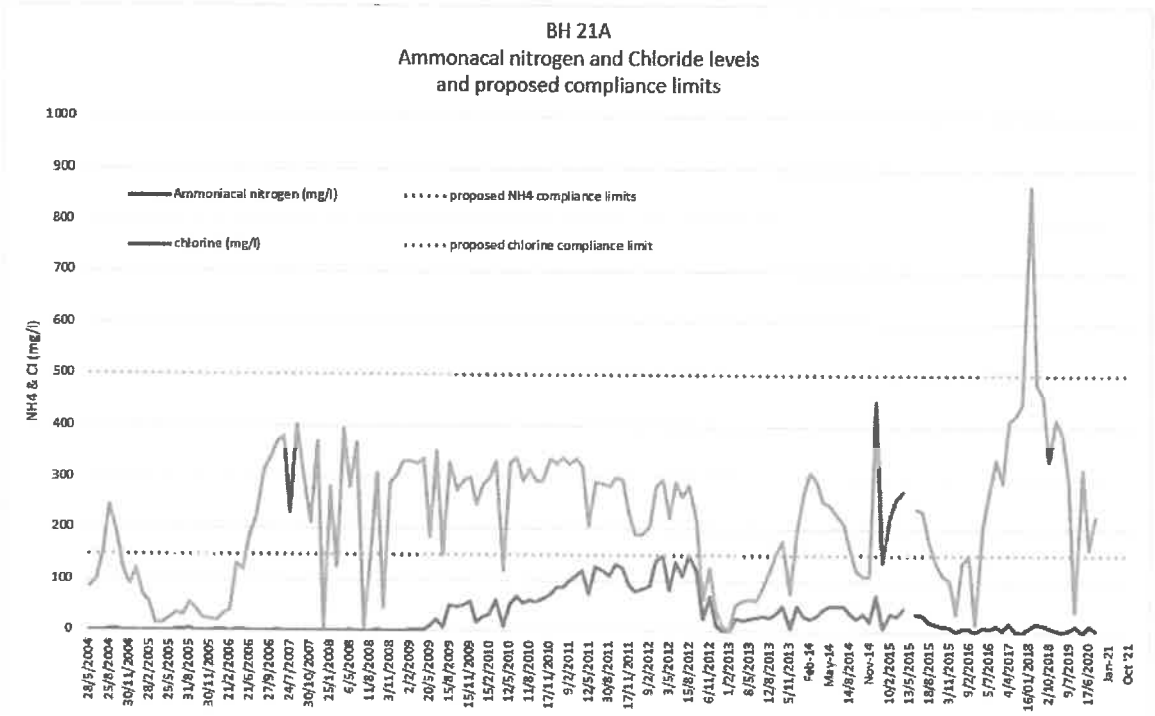


BH 20A – Ammoniacal Nitrogen and Chlorine levels

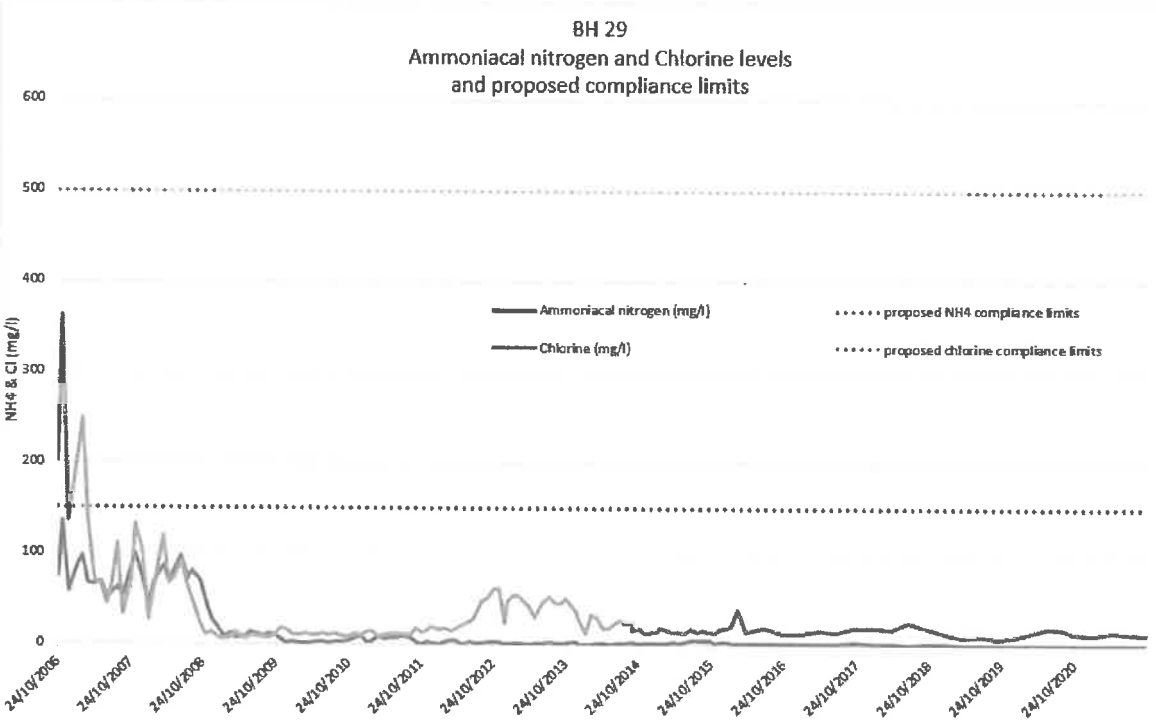


- Ffridd Rasus Landfill Areas 1 & 3 EPR/GP3330BY

BH 21A - Ammoniacal Nitrogen and Chlorine levels

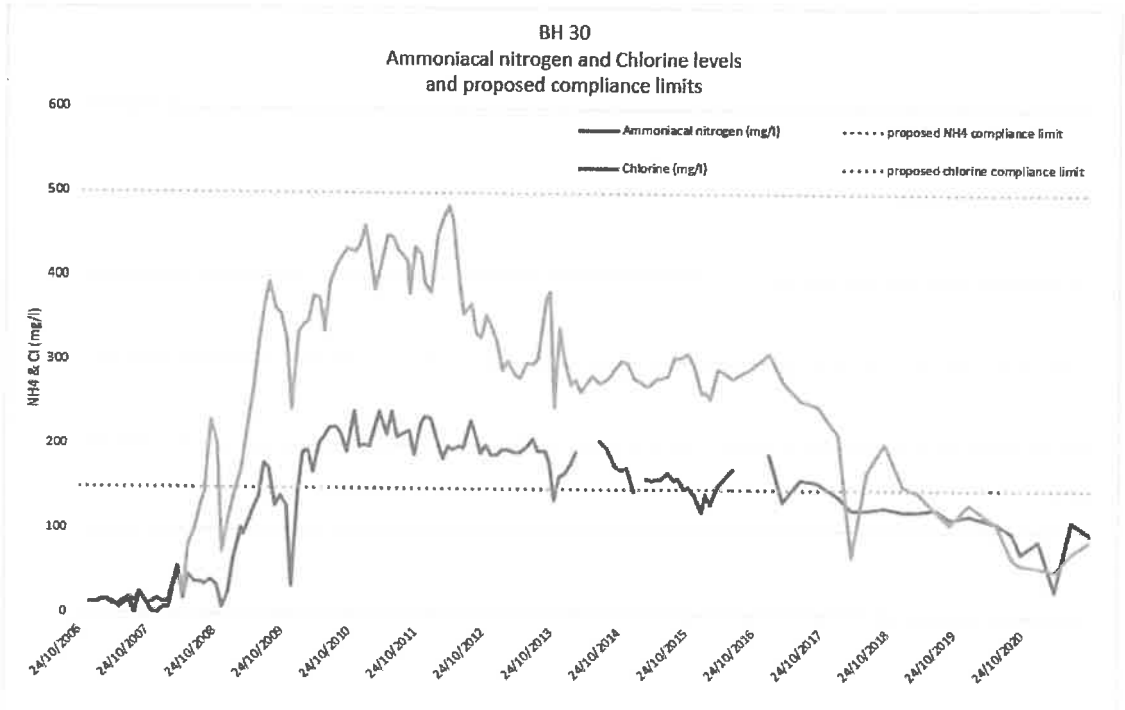


BH 29 - Ammoniacal Nitrogen and Chlorine levels

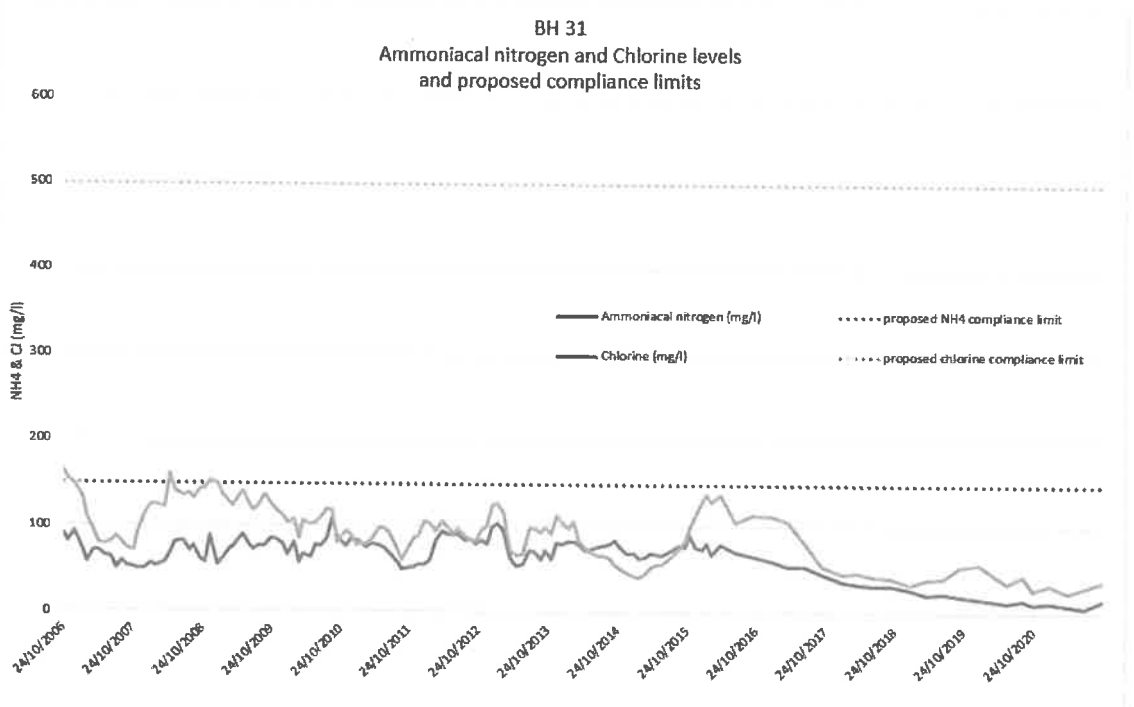


- Ffridd Rasus Landfill Areas 1 & 3 EPR/GP3330BY

BH 30 - Ammoniacal Nitrogen and Chlorine levels



BH31 - Ammoniacal Nitrogen and Chlorine levels



- Ffridd Rasus Landfill Areas 1 & 3 EPR/GP3330BY

APPENDIX D

NRW temporary suspension

Susan Jane Francis (PAB)

From: Roberts, Anthony <Anthony.Roberts@cyfoethnaturiolcymru.gov.uk>
Sent: 24 February 2022 11:03
To: Edwards Steven (PAB); Francis Susan Jane (PAB); si.howard@woodplc.com
Cc: Bradford, Julie; Wilby, David
Subject: Ffridd Rasus AER 2021 and GW Trigger Limits - Re-instatement of Limit Breaches for Boreholes

Importance: High

Dear Steve and Sue,

I have reviewed the AER for Ffridd Rasus (submitted in accordance with condition 4.2 of the sites environmental permit) and last year's data regarding the groundwater monitoring boreholes at Ffridd Rasus Landfill. The AER has been reviewed and other than the following conclusions is hereby accepted by NRW and will be placed on the public register.

The following statement from the AER updates the state of the pollution plume:

Surface water quality data for 2021 at SW1 and SW2 indicate no impact of leachate from the site. Data from SW3 continues to show low chloride concentrations with ammoniacal nitrogen levels below the detection limit.

Groundwater quality at the downgradient edge of area 2 continues to improve and chloride and ammoniacal nitrogen concentrations are stable or declining at most boreholes at the downgradient edge of Area 3.

Ammoniacal nitrogen concentrations for BH 20A, 20B, 21A and 21B have historically been generally higher than measured in other boreholes.

In 2021 comparison of the monitoring data against compliance limits in Area 2 and Area 3 show no exceedance of compliance limits for ammoniacal nitrogen and chloride apart from a single marginal exceedance in borehole 20B of ammoniacal nitrogen. 151mg/l vs permit limit of 150mg/l. This is within margin of error for sampling and therefore will not be scored as a permit breach

Trigger level exceedances from the following boreholes were suspended from CCS scoring in 2020 for the reasons given below:

	Cd	Cl	NH4
BH 21A			
BH 21B			
BH 20A			
BH 19B			
BH 19C			

Please note that due to the HRA conclusion (Wood 2017) , scoring of breaches in the above tabulated boreholes, for the determinands therein were suspended in January 2020, pending further investigation. In the light of the latest HRA update and a clearer understanding of the

pollution plume from Area 2 and its effects on Area 3 monitoring, scoring for breaches at these boreholes will resume from 01st April 2022.

I look forward to our meeting on the 21st March where we will review these issues along with any other permit variation issues in scope.

If you have any questions, please do not hesitate to contact me.

Best wishes

Tony

Tony Roberts
Cyfoeth Naturiol Cymru / Natural Resources Wales
Senior Officer/SMNR and SynBiogas Programme Project Manager
Waste and Industry Regulation Team, Maes Y Fynnon,
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- Ffridd Rasus Landfill Areas 1 & 3 EPR/GP3330BY

APPENDIX E

HRA report

Susan Jane Francis (PAB)

From: Roberts, Anthony <Anthony.Roberts@cyfoethnaturiolcymru.gov.uk>
Sent: 22 February 2022 09:03
To: Edwards Steven (PAB); Francis Susan Jane (PAB)
Cc: Bradford, Julie
Subject: Ffridd Rasus Variation - Trigger Levels and HRA etc.

Categories: Red Category

Hi Steve and Sue,

I have just changed the time of our proposed meeting re the above to the 21st of March as I am on leave during the proposed time. I am in work until Wednesday of next week so we could go for a date between now and then if that would suit better?

The revised trigger levels for GW and the impact of the HRA pointing to contaminated historic GW affecting the boreholes in the newer phase 3 monitoring boreholes is the key issue. For this reason, I have not been scoring the breaches. This needs to be resolved ASAP and I hope we can agree a way forward on the 21st.

Please note that in your permit:

Annual review of HRA as required by condition 4.2.1 (b) Every 12 months 1 January

This was enacted to characterise the nature of the GW plume which I now feel has been achieved. Guidance and EPR states the review should be conducted every 6 years. Now we have a definite conclusion about the origing of the GW pollution plume affecting phase 3, I feel that a reversion to the 6-year cycle is appropriate.

If you have any queries, please let me know.

Best wishes

Tony

Tony Roberts
Cyfoeth Naturiol Cymru / Natural Resources Wales
Senior Officer/SMNR and SynBiogas Programme Project Manager
Waste and Industry Regulation Team, Maes Y Fynnon,
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Gwynedd Council

Ffridd Rasus Landfill- Areas 1 and 3

Hydrogeological Risk Assessment Review – Final Report

4 June 2015

Amec Foster Wheeler Environment
& Infrastructure UK Limited

Report for

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Gwynedd Council
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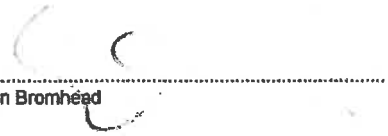

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Document revisions

No.	Details	Date
1	Draft for Client Comment	01/06/2015
2	Final Report	04/06/2015

Executive Summary

This report provides a review of the 2009 hydrogeological risk assessment (HRA)/2011 LandSim update for Areas 1 and 3 of the Ffridd Rasus Landfill (the site) using monitoring data up to March 2015 in accordance with the site's Environmental Permit (EP) requirement for four yearly reviews of the HRA (now revised to six-yearly reviews by the Environmental Permitting Regulations 2010).

The site, which comprises Areas 1, 2 and 3, is located approximately 3 km to the north of Harlech, at National Grid Reference (NGR) SH 577 338. Area 1 comprises the main elements of the site infrastructure, Area 2 is an unlined landfill in its aftercare phase and Area 3 is an engineered landfill now capped and restored.

A HRA was carried out for Areas 1 and 3 of the site by Amec Foster Wheeler in 2004 in support of an EP application. Areas 1 and 3 were issued with an EP in 2005 and subsequent variations. In 2009, Amec Foster Wheeler updated the 2004 HRA in accordance with the EP requirements. In 2011 Amec Foster Wheeler provided a LandSim model update of the 2009 HRA taking into account an increase in leachate strength as requested by Natural Resources Wales (NRW).

Leachate levels in Area 3 have remained below the EP compliance limit of 1.5 m above cell base since the 2009 HRA except for an isolated occurrence in November 2009. Leachate strength (as chloride and ammoniacal-nitrogen) is stabilising in Cells 1 and 2 and shows an upward trend in the more recent Cells 3 and 4.

Surface runoff is discharged to the site's surface water infiltration lagoon with a small component of flow discharging in the drainage ditch to the north of the site. Chloride and ammoniacal-nitrogen concentrations at the perimeter ditch location SW2 exceed the range measured previously. Possible reasons for the increased levels are under investigation. The elevated ammoniacal-nitrogen concentrations recorded during 2005-2008 at the perimeter ditch location SW3 have reduced to below 1 mg/l in 2009. No increase in chloride was recorded suggesting a non-landfill source of ammoniacal-nitrogen at this location.

The geology at the site comprises wind-blown, unconsolidated sands (Secondary A aquifer). The total thickness of these deposits is greater than 20 m. The geology encountered in boreholes drilled at the site in 2012 was comparable to the geology noted from previous investigations and adds confidence to the site's conceptual model developed in the previous HRAs. Groundwater in the Blown Sand deposits flows to the west towards the coast.

Review of monitoring data since the 2009 HRA indicates that a plume of leachate contaminated groundwater derived from Area 2 continues to have an impact on groundwater quality downgradient of Areas 2 and 3. Following capping of Area 2 in 2005-2008 groundwater quality is improving at the downgradient edge of Area 2. However, groundwater quality has deteriorated at the downgradient edge of Area 3 as the leachate plume moves downgradient and because recharge to the aquifer has reduced as a result of engineering of Area 3. However, quality now appears to be stable and even improving at some boreholes. The deterioration in groundwater quality since the compliance limits were derived in 2006 means that these are now exceeded at a number of boreholes. Proposals for revised compliance limits are presented on the basis of data collected since the 2009 HRA. It is noted that any potential impact from Area 3 on groundwater would not be discernible over the currently elevated chloride and ammoniacal-nitrogen concentrations at the downgradient edge of Area 3.

The conceptual model for Area 3 is qualitatively unchanged from the 2009 HRA/2011 LandSim update but it is considered appropriate to reassess the risks to groundwater to take into account the increase in leachate strength (as ammoniacal-nitrogen, chloride, cadmium and mecoprop).

The risks to groundwater from Area 3 have been re-assessed using LandSim v 2.5.17. The modelling results for the EP leachate limit of 1.5 m above cell base indicate that there is no breakthrough of the hazardous substances cadmium or naphthalene above their minimum reporting value (MRV) at the base of the unsaturated sand deposits and no breakthrough above drinking water standard (DWS) of the non-hazardous substances chloride, ammoniacal-nitrogen and zinc. Mecoprop is not predicted to impact on groundwater when modelled as either a hazardous substance or non-hazardous pollutant. There is,

therefore, no predicted impact on groundwater quality at the downgradient edge of Area 3. A sensitivity run with an increased leachate head of 2 m above cell base (reflecting potential temporary loss of leachate level control) indicates no additional unacceptable risk to groundwater from Area 3.

There is therefore no predicted risk to the receptors to the west of the site, comprising the Blown Sand deposits aquifer and the Morfa Harlech Site of Special Scientific Interest (SSSI) and Natural Nature Reserve (NNR), as a consequence of the operation of Area 3.

Contents

1. Introduction

1.1 Background

Ffridd Rasus Landfill ("the site") is located approximately 3 km to the north of Harlech, at National Grid Reference (NGR) SH 577 338 (Figure 1.1). The site includes Areas 1, 2 and 3. Area 1 comprises the main elements of the site infrastructure, Area 2 is an unlined landfill in its aftercare phase and Area 3 is an engineered landfill, which has been capped.

The site is operated by Gwynedd Council.

A hydrogeological risk assessment (HRA) was carried out for Areas 1 and 3 of the site by Amec Foster Wheeler in 2004 (hereafter referred to 2004 HRA) in support of an Environmental Permit (EP) application. Areas 1 and 3 were issued with an EP (ref GP3330BY dated 31 October 2005) and a subsequent variation (ref: Variation No QP3134LYV004 dated 21 March 2013). Area 2 is regulated under EP ref PP3294FJ/V008. In 2009, Amec Foster Wheeler updated the 2004 HRA in accordance with the EP requirement for four yearly reviews (now revised to six-yearly reviews by the Environmental Permitting Regulations 2010). In 2011 Amec Foster Wheeler provided an update of the LandSim model from the 2009 HRA to take into account an increase in leachate strength (as ammoniacal nitrogen, chloride, zinc and mecoprop) as requested by Natural Resources Wales (NRW). The next review of the site's HRA is due in 2015.

1.2 Purpose of this Report

Amec Foster Wheeler has been appointed by Gwynedd Council to carry out a review of the 2009 HRA/2011 LandSim update for Areas 1 and 3 of the site in accordance with the EP requirements. This report provides the HRA review which is being used to support the closure application for Area 3 of the landfill.

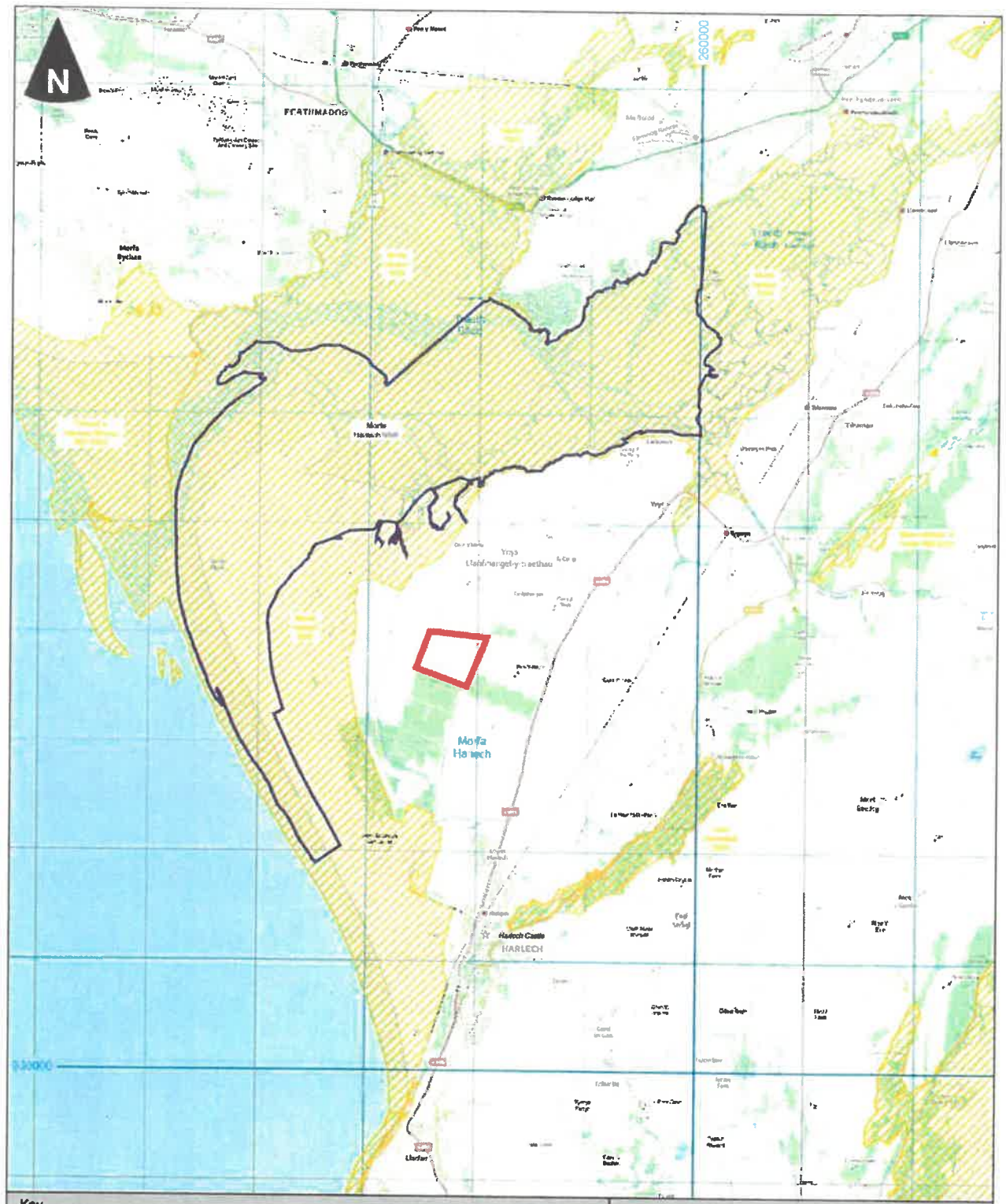
1.3 Sources of Information

Key sources of information used in the preparation of this report are:

- Amec Foster Wheeler, 2004. PPC Application for Ffridd Rasus Landfill Site – Areas 1 and 3 - Hydrogeological Risk Assessment. Entec ref. 04602rr541i1.
- Amec Foster Wheeler 2009. Ffridd Rasus Landfill Areas 1 and 3 – Hydrogeological Risk Assessment Review. Report ref 22258rr104i2;
- Amec Foster Wheeler 2011. Ffridd Rasus Landfill – LandSim Model Update. Report ref. 28587N317i2.
- Amec Foster Wheeler 2011. Ffridd Rasus Landfill – Review of Groundwater Quality Control and Trigger Levels. Report ref. 28587N129i1.

1.4 Layout of this Report

Following this introduction, the conceptual hydrogeological model for the site developed in the 2009 HRA is updated using monitoring data up to March 2015. The quantitative re-assessment of the risks to groundwater is presented in Section 3. Section 4 reviews the adequacy of the monitoring network and Section 5 presents the conclusions. Data and calculations are summarised in the text and, where appropriate, more detailed information and charts are provided in the Appendices to this report.



Key

Site location

Site of Special Scientific Interest (SSSI)

National Nature Reserve (NNR)

0 km 3 km

Scale 1:50,000 @ A4

Ffridd Rasus
Areas 1 and 3 - Hydrogeological Risk Assessment Review

amec foster wheeler

Figure 1.1
Site location

May 2015

28587-Shr333 dwg parkj

2. Review of Conceptual Hydrogeological Model

2.1 Introduction

This section of the report provides an update of the conceptual hydrogeological understanding of Areas 1 and 3 of the site developed in the 2009 HRA Review and 2011 LandSim model update through incorporation of monitoring data up to March 2015. Where appropriate, the details in this section are drawn from the previous HRA's.

2.2 Site History and Design

The site is divided into 3 areas (Areas 1, 2 and 3). Waste disposal at the site commenced in 1981 in Area 2.

Area 1 comprises the main elements of the site infrastructure. It covers approximately 1.5 ha and comprises: the Household Waste Recycling Centre (HWRC); a disused In-Vessel-Composting (IVC) facility; the weighbridge and site control office; the former waste pulveriser building and associated reception hall (since closure of the landfill on 6 January 2014 now operating as a waste transfer station); and the workshop. Area 1 has not been subject to waste disposal.

Area 2 was used for the disposal of pulverised domestic, commercial and non-hazardous industrial waste from 1981 until 2007, when it was closed. Area 2 was developed as a land raise that covered an area of approximately 9 ha. It was operated on the principle of "dilute and disperse" and has no engineered containment. Area 2 was capped in two stages, 1.7 ha in August 2005 to July 2006 and 7.5 ha in July 2007 to June 2008.

Area 3 is also a land raise and lies adjacent to and west of Area 2. It has been developed with engineered containment and leachate management facilities. The periods of filling and capping in Area 3 were as follows:

- Cells 1 and 2: were filled between 2007 and 2011. Capping was completed in June 2011;
- Cell 3: was filled between January 2011 and June 2012. Capping was completed in February 2013; and
- Cell 4A and Cell 4B were filled between June 2012 and January 2014 and capped in February to March 2014.

The engineered system in Area 3 cells comprises a Landfill Regulations-compliant composite liner on the base and sides consisting of a 2 mm HDPE geomembrane (artificial sealing layer) and a 0.5 m thick artificially established geological barrier of bentonite enhanced sands (BES) with a maximum permeability of 5×10^{-10} m/s. The HDPE geomembrane is protected by a geotextile, above which lies a 300 mm leachate drainage layer comprising 20-40 mm stone. The cells were capped with a 1 mm Linear Low Density Polyethylene (LLDPE) double textured geomembrane overlain by a Geosynthetic Drainage Layer (GDL) and 750 mm of restoration soils. The site layout is shown on Figure 2.2.

2.3 Updated Geology

The geology at the site was described in detail in the 2004 HRA and is summarised in Table 2.1. Three combined gas/groundwater boreholes have been drilled since the 2009 HRA, BH34, BH35 and BH36, as replacements for boreholes BH7, BH26 and NRA2, respectively, which were lost during development of Area 3. These boreholes are located at the upgradient edge of Area 3/downgradient edge of Area 2 (Figure 2.1). The logs for the new boreholes (Appendix A) confirm the geological sequence at the site and add confidence to the site conceptual models developed in previous HRAs.

Table 2.1 Geological Succession Beneath the Ffridd Rasus Landfill Site (from 2004 HRA)

Formation	Description	Top Elevation (m bgl)
Quaternary Blown Sand	Unconsolidated fine to medium grained, rounded to subrounded quartz sand with occasional white shell fragments and abundant dark grey rounded lithic fragments. Typically changes to grey in colour at depths below 2.5 m. Deposit density increases with depth with occasional thixotropic horizons	>20 (the deepest borehole drilled on site to date).
Cambrian Gamlan Formation	Interbedded grey and purple siltstone and mudstone	70-100

2.4 Leachate Levels

EP Compliance Levels

Table S4.1 of the EP sets out a compliance limit for leachate levels of 1.5 m above the base of each cell in Area 3.

Leachate Management

Leachate extraction is carried out in Area 3 to manage leachate levels. The extracted leachate is stored on-site in the leachate collection tank prior to removal off-site by tanker for disposal. The leachate volume exported off-site was 4,339 m^3 in 2010, 3,892 m^3 in 2011, 7,729 m^3 in 2012, 13,791m^3 in 2013 and 7,369 m^3 in 2014.

Leachate Level Data

Leachate levels are monitored weekly in Area 3 which exceeds the requirements of the EP for monthly monitoring. Leachate wells LM1/1, LM1/2, LM2/1, LM2/2, LM3/1, LM3/2 were connected to the gas extraction system in August 2013 and are no longer monitored. Leachate levels have been monitored at the cell sumps LCP1, LCP2, LCP3, LCP4/2 and LCP4/B since August 2013.

Time-series plots of leachate levels for the period June 2009 to March 2015 are presented in Appendix B. Locations and details of the leachate monitoring wells/sumps are provided on Figure 2.1 together with the leachate levels across the site in March 2015. The 2009 HRA considered data up to March 2009. The more recent data show variability in leachate levels but no exceedance of the EP limit of 1.5 m above cell base except for an isolated occurrence (2.2 m at LCP1 and 1.81 m at LM1/2) in November 2009 in Cell 1. This suggests that the leachate extraction system is effective and that the on-site leachate storage capacity is sufficient to ensure leachate level compliance in Area 3.

Leachate Quality

Leachate quality is monitored monthly in Area 3 in accordance with the EP. Up to 2013, leachate samples were generally taken from the leachate collection tank, with the cell source identified. From January 2013 onwards, samples of leachate have been collected individually from each of the four cells. The monitoring locations are shown on Figure 2.1. Concentrations of ammoniacal-nitrogen and chloride (typical landfill leachate indicators) in leachate with time since August 2007 are presented in Appendix C. The 2009 HRA considered leachate quality monitoring data up to March 2009. The more recent data (April 2009 to March 2015) are summarised in Table 2.2 and show that:

- Leachate composition continues to be within the range of compositions seen at other landfill sites receiving domestic and industrial wastes (as indicated by LandSim model default concentrations);

- Chloride and ammoniacal-nitrogen concentrations show an upward trend in Cells 1 and 2 until 2010 and 2012, respectively, before levelling off at 1000-1750 mg/l and 750-1500 mg/l, respectively.
- Chloride and ammoniacal-nitrogen concentrations in Cells 3 and 4A show an upward trend since January 2014;

An extended analytical suite for hazardous substances in leachate from Area 3 was carried in June 2009, June 2011, July 2012, July 2013 and June 2014. The results are summarised in Appendix C. The majority of determinands were below the laboratory detection limits (<0.001 to <400 µg/l). Substances recorded above the detection limits in the leachate included pesticides (in particular mecoprop), extractable hydrocarbon bands (in particular EC10-EC16 and EC24-EC40), toluene, and low concentrations of other aromatic compounds (e.g. 2,4,6-trichlorophenol), mercury and cyanide.

Table 2.2 Selected Leachate Quality Data for Ffridd Rasus Landfill

Substance	Concentrations April 2009-March 2015 (mg/l)					LandSim Defaults (mg/l)		
	No	No>dl	Min	Mean	Max	Min	Mean	Max
NH4-N	147	147	11.7	1153	2230	4	723	3640
Cl	144	144	184	1534	2550	37	2270	7760
Zn	44	34	<0.018	0.167	0.565	0.00225	0.165	208
Cd	53	38	<0.0006	0.0032	0.0597	0.0019	0.0101	0.105
Mecoprop	39	39	0.0013	0.04	0.0837	-	-	-

Notes: No- total number of samples; No>dl- number of samples above detection limit.

2.5 Surface Water Quality Update

EP Water Emission Limits

There are no emission limits for surface water set in the site's EP, other than the avoidance of visible oil and grease at emission points SW1 and SW3 (Figure 2.1).

Surface Water Quality Data

Surface runoff is discharged to the site's surface water infiltration lagoon with a small component of flow discharging in the drainage ditch to the north of the site (Figure 2.1). Surface water monitoring is a requirement of the EP at monitoring locations SW1, SW2 and SW3. SW1 is located in the vicinity of the site's permitted discharge of hardstanding runoff from Area 1 and SW2 and SW3 are located in the ditch on the western boundary (downstream) of Area 3, as shown on Figure 2.1. The ditch connects into a surface water drain to the west of the site, which flows north into the estuary to the north of the site. As a consequence of hydrocarbon contamination identified at SW1 in late 2010, when diesel and/or motor oils/lubricants entered the drain due to failure of the oil/water interceptor samples are also collected from the pipe which discharges to the drain near this point. The pipe discharges surface water runoff from hardstanding around the site buildings in Area 1 after it has passed through the oil/water interceptor which was replaced in 2012.

Time series plots for ammoniacal-nitrogen and chloride (typical leachate indicators) are provided in Appendix D. The 2009 HRA reviewed data up to March 2009. The more recent data (April 2009-March 2015) are summarised in Table 2.3 for ammoniacal-nitrogen and chloride and show:

- Monitoring location SW1: Concentrations of ammoniacal-nitrogen were below 1 mg/l during 2009 and then show variability with various spikes (6.08-32.3 mg/l). Concentrations of chloride are variable and generally range between 4 and 130 mg/l excluding a spike in December 2010 (3130 mg/l). In general, concentrations remained within historical data limits and show no upward trend. Similar concentrations were measured at the adjacent pipe discharge. Following the occurrence of hydrocarbon contamination near SW1 in late 2010. Remedial works to the oil/water interceptor were carried out in October 2010 to prevent the flushing out of oils and fats into the ditch during periods of heavy rainfall and no contamination has been recorded since;
- Monitoring location SW2: Concentrations of ammoniacal-nitrogen were generally below 1 mg/l until early 2013 followed by variable concentrations with various spikes (6.04-24.6 mg/l). Chloride concentrations were below 50 mg/l until 2011 then increased to about 100 mg/l during 2012 and have since showed significant variability with spikes of up to 337 mg/l. There are a number of possible explanations for the increased concentrations, which are under investigation including:
  - Former storage of compost taken from the IVC facility which ceased operation in 2013 (some site-derived compost has been applied to the Cell 4 final capped soil profile);
  - Sludge spraying and muck spreading on adjacent agricultural land;
  - Saline groundwater baseflow contribution to the perimeter ditch during periods of high groundwater levels: groundwater quality in the northern part of the site (cross-gradient to the landfill) has been affected, particularly during 2011 to 2013, by the passage of a saline "slug" associated with runoff and infiltration from the marine dredgings used as part of the engineered cap to Area 2 (discussed in Section 2.7). The elevated chloride peaks recorded since 2012 are likely to reflect baseflow of saline groundwater. The occasional ammoniacal-nitrogen peaks during 2013-2014 may be associated with desorption of ammoniacal-nitrogen from the sand aquifer by potassium (ion exchange) associated with the saline "slug";
- Monitoring location SW3: The elevated concentrations of ammoniacal-nitrogen during 2005-2008 decreased to below 1 mg/l between mid-2009 and 2010. Chloride concentrations show variability but generally remain between 25 and 100 mg/l with no upward trend. The temporarily elevated ammoniacal-nitrogen concentrations were not coupled with elevated chloride concentrations suggesting a non-landfill source.

Table 2.3 Selected Surface Water Quality Data for Ffridd Rasus Landfill

Location	Ammoniacal-Nitrogen (mg/l)			Chloride (mg/l)		
	Min	Mean	Max	Min	Mean	Max
SW1	<0.27 (a)	3.4 (a)	32 (a)	4 (b)	101 (b)	3130 (b)
SW1 Pipe	<0.27	2.8	11	7.5	32	63
SW2	<0.27 (c)	3.9 (c)	25 (c)	3.1 (d)	87 (d)	337 (d)
SW3	<0.27 (e)	5 (e)	52 (e)	20 (f)	60 (f)	223 (f)

Note: Data for the period April 2009 - March 2015.
a) Includes various spikes (6.08-32.3 mg/l). Excluding these spikes min-mean-max are <0.27-1.13-4.64 mg/l.
b) Includes spike (3130 mg/l in December 2010). Excluding this spike min-mean-max are 4-46-129 mg/l.
c) Includes various spikes since early 2013 (6.04-24.6 mg/l). Excluding these spikes min-mean-max are <0.27-0.80-3.71 mg/l.
d) Includes various spikes since 2012 (153-337 mg/l). Excluding these spikes min-mean-max are 3.1-64-148 mg/l.
e) Includes temporarily elevated concentrations during 2005-2008 which decreased to <1 mg/l since 2009. Excluding these elevated concentrations pre-2009 min-mean-max are <0.27-2.2-7.4 mg/l.
f) Includes spike (223 mg/l in August 2014). Excluding this spike min-mean-max is 20-56-113 mg/l.

In summary, chloride and ammoniacal-nitrogen concentrations at the perimeter ditch location SW2 exceed the range measured previously. Possible reasons for the increased levels are under investigation. The elevated ammoniacal-nitrogen concentrations recorded during 2005-2008 at the perimeter ditch location SW3 have reduced to below 1 mg/l in 2009. No increase in chloride was recorded suggesting a non-landfill source of ammoniacal-nitrogen at this location.

2.6 Groundwater Level Update

There is an extensive monitoring network at the site that provides groundwater level data with records dating back 15 years. The boreholes are monitored monthly in accordance with the EP. Monitoring data for the period February 2000 to March 2015 are plotted as hydrographs in Appendix E. These have been split into three groups for ease of presentation as follows:

- Older boreholes with a long record – boreholes drilled prior to 2004;
- Boreholes drilled during 2004; and
- Recent boreholes drilled in 2006 and 2012.

The 2009 HRA considered data up to March 2009. Borehole details and groundwater level data for March 2015 are presented in Table 2.4. The data show that:

- There is seasonal variation in the groundwater levels with higher levels recorded in winter compared to summer;
- There is a general downward trend in groundwater levels and increase in thickness of the unsaturated sand underlying the site at some locations. This is most likely associated with reduced recharge to the sand aquifer due to periods of lower rainfall, the progressive engineering of Area 3 with a low permeability liner and the capping of Area 2; and
- The highest water levels were recorded on the eastern side of Area 2 at boreholes BH1 and BH15 and the lowest on the western side at boreholes BH20A/B, BH23, BH30 and BH31, indicating a westwards flow direction towards the coast. This is consistent with the findings of the previous HRAs. Groundwater level contour plots have been constructed for March 2015 data using the software Surfer vs12 and are shown on Figure 2.1.

Table 2.4 Groundwater Level Data for Ffridd Rasus Landfill

Borehole	Date of Installation	Borehole Datum	Borehole Depth	Groundwater Level March 2015	
		m AOD	m bgl	m bgl	m AOD
BH1	1992	7.88	5	1.74	6.14
BH15	Apr-99	8.15	5	1.78	6.37
BH18A	May-04	6.72	10	1.72	5.00
BH18B	May-04	6.75	10	1.12	5.63
BH19A	May-04	5.82	18	1.21	4.61
BH19B	May-04	5.95	12	1.34	4.61
BH19C	May-04	5.92	8	1.38	4.54
BH20A	May-04	5.07	16	0.80	4.27
BH20B	May-04	5.07	11	0.84	4.23
BH21A	May-04	5.19	15	0.77	4.42
BH21B	May-04	5.20	10	0.78	4.42
BH23	May-04	4.47	11.5	1.10	3.37
BH24	May-04	7.36	13	1.69	5.67
BH27	Oct-06	9.81	13	4.89	4.92
BH28	Oct-06	7.35	8	2.25	5.10
BH29	Oct-06	6.01	8	1.38	4.63
BH30	Oct-06	5.60	8	1.48	4.12
BH31	Oct-06	5.49	8	1.19	4.30
BH32	Oct-06	6.36	8	1.75	4.61
BH33	Oct-06	7.22	8	1.76	5.46
NRA3	Unknown	6.78	4.9	1.75	5.03
BH34	February 2012	6.85	8.70	1.12	5.73
BH35	February 2012	6.95	8.70	1.26	5.69
BH36	February 2012	7.60	8.50	1.99	5.61

2.7 Groundwater Quality Update

EP Compliance Limits

The groundwater compliance limits for Areas 1 and 3 are summarised in Table 2.5. These limits were derived in accordance with Improvement Condition Table S1.3(3) of the EP and are based on monitoring data up to December 2005 (Amec Foster Wheeler, 2006). The elevated compliance limits at some boreholes reflect the impact on groundwater quality from the closed Area 2 of the site, which lies to upgradient of Area 3.

Table 2.5 Groundwater Compliance Limits for Areas 1 and 3

Borehole	Ammoniacal Nitrogen (mg/l)	Cadmium (µg/l)	Chloride (mg/l)
BH19A	3.6	5.5	29
BH19B	3	5.5	28
BH19C	3	5.5	30
BH20A	5	5.5	310
BH20B	230	5.5	424
BH21A	5.1	5.5	270
BH21B	69.7	5.5	411

Groundwater Quality Data

Groundwater quality at the site is monitored at a number of locations with records dating back 15 years. On the basis of an overall groundwater flow direction to the west the boreholes have been grouped as upgradient, lateral and downgradient of the site (Table 2.6). Time-series plots for the compliance substances ammoniacal-nitrogen, chloride and cadmium from February 1998 to March 2015 are provided in Appendix F. The 2009 HRA reviewed data up to March 2009. A summary of more recent data (April 2009 to March 2015) is provided Table 2.6 and in the discussion below.

- Baseline: Boreholes upgradient of Areas 2 and 3 (BH1, BH15 and BH24):
  - Ammoniacal-nitrogen concentrations have remained below detection limit (0.19 mg/l and 0.27 mg/l) with the exception of peaks, which were generally below 4 mg/l and a more sustained period of above-detection concentrations at BH24 between 2010 and 2012. Chloride concentrations continue to be low (<50 mg/l) although an upward trend is noted in boreholes BH1 and BH24 since 2009. Cadmium concentrations have generally remained below the detection limit (0.3 µg/l and 0.6 µg/l).
- Boreholes downgradient of Area 2 and upgradient of Area 3 (BH27, BH34 to BH36 and NRA3):
  - Concentrations of ammoniacal nitrogen and chloride continue to be above baseline at boreholes BH27, BH35 and BH36, which are located on the downgradient boundary of Area 2. Ammoniacal nitrogen and chloride concentrations at borehole BH27 appear to have peaked at about 300 mg/l and 550 mg/l previously and show a downward trend since 2010. This represents the downgradient migration of a leachate plume from Area 2.
  - Ammoniacal nitrogen concentrations in boreholes BH34 to BH36 continue to be lower than those at borehole BH27 but to show increasing concentrations southwards towards borehole BH27. This is likely to reflect the local movement of groundwater towards borehole BH27;

- Concentrations of ammoniacal nitrogen and chloride on the edge (NRA3 and BH34), continue to be lower than in the centre (BH27, BH35 and BH36) of the downgradient boundary of Area 2; and
- Cadmium concentrations at borehole NRA3 remained below detection limit (0.3 µg/l and 0.6 µg/l). Concentrations at other boreholes show a peak in 2012 followed by a downward trend.

- Boreholes Lateral to the Groundwater Flow Direction (BH18A/B, BH28, BH29, BH32 and BH33)
  - Ammoniacal-nitrogen and chloride concentrations at boreholes BH28 (to the south) and BH32 and BH33 (to the north) continue to be low and consistent with baseline water quality;
  - Chloride at boreholes BH18A and BH18B in the north increased from baseline concentrations to 810 mg/l and 619 mg/l, respectively, in 2012 before falling again to baseline. The elevated chloride concentrations are associated with leaching from marine dredgings used as part of the engineered cap of Area 2. The marine dredgings produced a saline runoff during wet periods that discharged to the surface water infiltration lagoon. Infiltration from the lagoon resulted in an impact on groundwater quality, which was measured in the nearby boreholes BH18A and BH18B. Over time this effect is diminishing as the "saline slug" migrates downgradient. Ammoniacal-nitrogen concentrations continue to be low and consistent with baseline water quality;
  - Chloride and ammoniacal-nitrogen at borehole BH29 (south of Area 3) showed a declining trend during 2006-2008 (Cl) and 2006-2011 (NH4-N) from concentrations of up to 360 mg/l and 130 mg/l, respectively, to baseline levels. This decline may be due to local changes in groundwater flow direction. Groundwater levels indicate a gradient from the impacted areas at BH27 during 2006-2009. However, as groundwater levels at BH27 fell due to lower recharge following engineering of Area 3 the direction of groundwater flow has swung westwards and there is little gradient from BH27 to BH29;
  - Cadmium concentrations continue to show variability with a number of peaks above detection limit (0.3 µg/l and 0.6 µg/l) but no upward trend.
- Boreholes Downgradient of Areas 2 and 3 (BH19A/B/C, BH20A/B, BH21A/B, BH23, BH29, BH30 and BH31):
  - Ammoniacal-nitrogen and cadmium concentrations remain within baseline water quality at boreholes BH19A/B/C and BH23. Chloride concentrations remain within baseline at BH23 but show an upward trend at BH19A/B/C since 2013. The compliance limits for ammoniacal-nitrogen and cadmium at these boreholes were not exceeded except for isolated ammoniacal-nitrogen peaks at BH19A/B/C. However chloride concentrations at BH19A/B/C show sustained exceedances of the compliance limits since 2009 and may be related to the downgradient migration of a saline slug detected in BH18A/B in 2011-2012;
  - Boreholes BH20A/B, BH21A/B, BH29, BH30 and BH31 are contaminated to some extent by the leachate plume from Area 2 and showed previously rising trends in both chloride and ammoniacal-nitrogen concentrations and sustained exceedances of the compliance limits. Concentrations now appear to have stabilised at boreholes BH20A/B and are declining in boreholes BH21A/B and BH30 whilst borehole BH31 shows falling chloride concentrations and stable ammoniacal-nitrogen concentrations.
  - Cadmium concentrations have remained below the compliance limit (5.5 µg/l).

An extended analytical suite for hazardous substances in groundwater downgradient of Areas 2 and 3 was carried in May/June 2013. Most substances were below the laboratory detection limits (<0.001 for pesticides to <1000 µg/l for 4-nitrophenol, bis(2-ethylhexyl)phthalate and pentachlorophenol). The substances detected were present at very low concentrations and in a small number of samples (mecoprop <0.04-3.04 µg/l in 4 out of 7 samples and hydrocarbons: naphthalene <0.01-0.07 µg/l in 1 out of 7 samples, toluene <1-3 µg/l in 1 out of 7 samples, EC6- EC40 <20-97 µg/l in 6 out of 7 samples, EC10- EC16 <10-81 µg/l in 3 out of 7 samples and EC24-EC40 <20-97 µg/l in 4 out of 7 samples).

Figure 2.3 shows variations in groundwater quality across the site in March 2015. The highest ammoniacal-nitrogen and chloride concentrations were recorded at boreholes BH27 (downgradient of Area 2) and BH20A/B and BH30 (downgradient of Areas 2 and 3). The elevated concentrations at the downgradient edge of Area 2 have declined from their peak and concentrations downgradient of Areas 2 and 3 have increased above baseline and the compliance limits but are now stable or declining. These observed impacts are considered most likely to represent the passage of a plume of leachate contaminated groundwater derived from Area 2 of the site beneath Area 3. In the long term, contaminant concentrations can be expected to continue to decline as the leachate plume moves away from the site. However, at downgradient locations, concentrations will first rise as the plume migrates through them before declining once the peak has passed. As the plume migrates to the west, peak concentrations in downgradient boundary of Area 3 will be lower than in those near the source (Area 2) due to the effects of attenuation (dispersion and retardation) and degradation. It is noted that any potential impact from Area 3 would not be discernible over the currently-elevated chloride and ammoniacal-nitrogen concentrations at the downgradient edge of Area 3.

Table 2.6 Groundwater Quality Data for Ffridd Rasus Landfill

Borehole	Ammoniacal Nitrogen (mg/l)			Chloride (mg/l)			Cadmium (µg/l)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Upgradient of Areas 2 and 3 (Baseline)									
BH1	<0.27	1.76	12	15.5	26	57	<0.6	0.83	1.1
BH15	<0.27	0.53	1.2	3.9	11	24	<0.6	0.75	1.6
BH24	<0.27	1.23	5.7	14	25	32	<0.6	0.70	1.0
Downgradient of Area 2 and Upgradient of Area 3									
BH27	147	209	442	253	413	2250	<0.6	1.96	5.3
BH34	<0.27	0.96	1.9	13.7	117	449	<0.6	1.71	2.4
BH35	1.2	26	57	38.9	104	235	<0.6	1.84	5.3
BH36	11.4	122	172	44.2	217	376	<0.6	1.09	1.9
NRA3	<0.27	5.6	21	10	22	48	<0.6	0.43	0.7
Lateral to Groundwater Flow									
BH18A	<0.27	1.44	9.32	6	185	810	<0.6	0.77	1.9
BH18B	<0.27	1.02	7.79	8	120	619	<0.6	0.82	1.8
BH28	<0.27	0.53	3.3	9	30.71	84.5	<0.6	0.72	1.6
BH29	<0.27	3.46-	12.8	6	22.53	61.5	<0.6	1.19	4.4
BH32	<0.27	0.46	0.8	12	24.19	41.8	<0.6	0.65	1.3
BH33	<0.27	0.42	0.8	8.2	13.32	21	<0.6	0.72	1.2
Downgradient of Areas 2 and 3									
BH19A	<0.27	1.24	4.67	12.6	39	56	<0.6	1.11	2.7
BH19B	<0.27	0.41	1.42	20	49	227	<0.6	1.20	3.6
BH19C	<0.27	1.23	5.1	11.4	47	252	<0.6	0.83	2.4
BH20A	<0.27	16	77	134	340	486	<0.6	1.66	4.5
BH20B	<0.27	132	235	98	320	403	<0.6	1.10	1.8
BH21A	0.49	559	150	3.2	227	447	<0.6	0.85	2.3
BH21B	16.7	53	207	13	128	367	<0.6	1.56	2.7
BH23	<0.27	3.32	41	13	20	222	<0.6	1.26	2.7
BH29	<0.27	3.46	12.8	6	22.5	61	<0.6	1.19	4.4
BH30	34	188	241	191	350	485	<0.6	1.28	3.9
BH31	50	76	110	41	93	140	<0.6	1.08	2.2

Note: Data for period April 2009 to March 2015

2.8 Groundwater and Surface Water Abstractions Update

NRW and Gwynedd Council have confirmed that there are no licensed or private groundwater and surface water abstractions and within 3 km of the site.

2.9 Conceptual Model

The conceptual model for Area 3 of the site developed in the 2009 HRA/2011 LandSim update has been updated using monitoring data up to March 2015 (summarised in Sections 2.3 to 2.8) and is summarised in Table 2.7 and illustrated in Figure 2.4.

Table 2.7 Updated Hydrogeological Conceptual Model for Area 3 of Ffridd Rasus Landfill

Source	Potential Pathways	Potential Receptors
Landfill leachate	Leachate leakage through the engineered composite liner into the underlying unsaturated Blown Sand deposits. Vertical migration through the unsaturated Blown Sand deposits to the underlying water table. Lateral migration within groundwater flow westwards towards the coast. Lateral migration westwards within surface water in the drainage ditches around the site boundary	Groundwater within the Blown Sand deposits aquifer below the site. Surface water in the drainage ditches around the site boundary. Morfa Harlech SSSI/NNR.

Source

The source at the site is landfill leachate, which typically comprises a complex range of contaminants. The validity of the leachate level and quality parameters modelled in the 2009 HRA/2011 LandSim update is assessed in Table 2.8 using more recent monitoring data (2009-2015).

- Leachate levels remain below the maximum level modelled previously (1.5 m above cell base) except for an isolated occurrence (2.2 m at LCP1 and 1.81 m at LM1/2) in November 2009 in Cell 1;
- Ammoniacal-nitrogen, chloride, cadmium and mecoprop concentrations exceed the range modelled previously by a factor of up to 2;
- Zinc concentrations remain within the range modelled previously. It is noted that concentrations are below the water quality standard;
- Naphthalene (equivalent carbon number C11.7) was modelled in the 2011 LandSim update, at the request of NRW, as representative of the hydrocarbon band EC10-EC16. Naphthalene has not been recorded above detection limit since 2011. Hydrocarbon band EC10-EC16 leachate concentrations since 2011 (0.269-1.07 mg/l) remain below the concentrations reported in the 2011 LandSim update (0.353-1.55 mg/l);
- The majority of hazardous organic substances in leachate remain below the laboratory detection limits (<0.001 to <400 µg/l). Substances recorded above detection limit include pesticides (modelled as mecoprop) and hydrocarbon bands (modelled as naphthalene) with the remaining substances only recorded at low concentrations and in a small number of samples (Appendix C). The hazardous organic substances modelled previously therefore remain valid.

Table 2.8 Comparison of Leachate Composition Modelled in 2009 HRA/2011 LandSim Update with Leachate Monitoring Data for 2009-2011

Parameter Modelled	Parameter Range Modelled in 2009 HRA/2011 LandSim Update			Parameter Range April 2009-March 2015			Water Quality Standard
	Min	Mean	Max	Min	Mean	Max	
Ammoniacal-N (mg/l)	154	968	1250	11.7	1153	2230	0.39 (DWS)
Chloride (mg/l)	487	1420	1760	184	1534	2550	250 (DWS)
Zinc (mg/l)	0.101	0.274	0.565	<0.018	0.167	0.565	5 (DWS)
Cadmium (mg/l)[a]	0.0007	0.00236	0.010	<0.0006	0.0032	0.0597	0.0001 (MRV)
Mecoprop (mg/l)	0.0106	0.031	0.0456	0.0013	0.040	0.0837	0.00004 (MRV)
Naphthalene (mg/l)[b]	0.005	-	0.05	<0.008	-	<0.02	0.0024 (EQS)
EC10-EC16 (mg/l)	Modelled as naphthalene			0.269	0.690	1.07	-
Leachate (m above base)	0.5	1.0	1.5	0.01	0.8	2.2[c]	-

Notes:
a) Cadmium concentrations are those modelled in the 2009 HRA as it was not remodelled in the 2011 LandSim update (concentrations during January 2010 -September 2011 were within the range modelled in the 2009 HRA)
b) At the request of NRW, an additional hazardous substance (naphthalene) was selected and modelled in the 2011 LandSim update.
c) Includes isolated peak (2.2 m at LCP1 and 1.81 m at LM1/2) recorded in November 2009 in Cell 1. Excluding this isolated peak leachate levels have remained below 1.5 m above cell base.
DWS- drinking water standard. MRV- minimum reporting value. EQS- environment quality standard

Pathways

The potential pathways for leachate contaminants from the landfill modelled in the 2009 HRA include:

- Leachate leakage through the engineered composite liner into the underlying unsaturated Blown Sand deposits;
- Vertical migration through the unsaturated zone to the underlying water table. It comprises fine/medium, Blown Sand deposits with an organic carbon content of approximately 0.1%;
- Lateral migration within groundwater flow westwards towards the coast (see Figure 1.1 for setting of the site in relation to the coast); and
- Lateral migration westwards within surface water in the drainage ditches around the site boundary.

There have been no relevant alterations to the operation, construction or management of the site proposed in the 2009 HRA. On this basis, it is concluded that the pathways modelled previously remain valid for Area 3.

Receptors

The key receptors considered in the 2009 HRA were as follows:

- Groundwater within the Blown Sand deposits aquifer beneath the site (Secondary A aquifer);
- Surface waters in the drainage ditches around the site boundary which discharge into the estuary to the north of the site; and

- The Morfa Harlech Site of Special Scientific Interest (SSSI) and National Nature Reserve (NNR) which lies approximately 0.5 km to the west, downgradient of the site (Figure 1.1). The SSSI/NNR consists of sand dune habitat (1063 ha in extent) and the associated petalwort (*Petalophyllum ralfsii*), a liverwort.

This assessment considers the likely effect of the site on groundwater within the Blown Sand deposits aquifer in proximity to the landfill. Appropriate protection of groundwater near to the site will therefore protect against any potential effects on the Morfa Harlech SSSI/NNR farther from the site.

There are no licensed or private groundwater and surface water abstractions within 3 km of the site.

The receptors modelled in the 2009 HRA are still considered to be appropriate and additional receptors have not been included in the updated conceptual model.

Summary

The site conceptual model is qualitatively unchanged from the 2009 HRA/2011 LandSim update but it is considered appropriate to reassess the risks to groundwater to take into account the increase in leachate strength (as ammoniacal-nitrogen, chloride, cadmium and mecoprop).

3. Hydrogeological Risk Assessment Update

3.1 The Nature of the Hydrogeological Risk Assessment

Guidance for HRAs for landfills is given in EA (2010). This guidance takes into account the requirements of the Groundwater Directive and the Landfill Directive, as implemented by the Environmental Permitting Regulations 2010 (as amended).

Having developed a conceptual model for the site (Section 2.9), the guidance requires that a risk assessment be undertaken. The level of detail in a risk assessment should be proportionate to the nature and complexity of the risk being addressed, with the three tiers being Risk Screening, Simple Risk Assessment and Complex Risk Assessment. The more sensitive the environmental setting, the greater the level of confidence required. A Complex Risk Assessment is considered appropriate for Ffridd Rasus Landfill as the site is underlain by a Secondary A aquifer (Blown Sand deposits) aquifer with a sensitive downgradient receptor (Morfa Harlech SSSI/NNR).

This section re-assesses the risks to groundwater quality from the site on the basis of the updated site conceptual model presented in Section 2.9.

3.2 Numerical Modelling Approach

Modelling Approach and Software

The 2009 HRA/ 2011 LandSim update assessed the risks to groundwater from the site using the EA's preferred landfill modelling package LandSim v2.5.17. The risks to groundwater from the increase in leachate strength have been reassessed using the same model.

Model Parameterisation

Tables 3.1 and 3.2 list the input parameters and sources of information for the LandSim model. These are a combination of site specific data and literature values as discussed in the previous HRAs. Parameters revised as part of this review are noted in Tables 3.1 and 3.2. It is noted that mecoprop is in the process of being downgraded to a non-hazardous pollutant (JAGDAG, 2013) and therefore has been modelled as a non-hazardous pollutant. However, as a precautionary approach, the model results for mecoprop are also presented as if it were a hazardous substance. Although the concentrations of naphthalene and zinc in leachate have not increased since the 2009 HRA/2011 LandSim update it is considered appropriate to re-model these substances due to changes in other model parameters.

Table 3.1 LandSim Input Parameters: Leachate Source Term

Description		Concentration			Kd (l/kg)	Koc (l/kg)	Half Life (yrs)	Justification
	Unit	Min	Mean	Max				
Ammoniacal-N	mg/l	*15*	*1200*	*2300*	0.5-2	-	10^9	Conc- rounded up from Table 2.8 Kd – LandSim default Half life – no degradation assumed
Chloride	mg/l	*200*	*1600*	*2600*	0	-	10^9	Conc- rounded up from Table 2.8 Kd & ☑ – conservative substance so no sorption or biodegradation.
Mecoprop	mg/l	*0.0015*	*0.040*	*0.08*	-	*0-50-5700*	3	Conc- rounded up from Table 2.8 Koc – EA (2004). Kd calculated by LandSim. Half life – conservative value based on the literature
Naphthalene	mg/l	0.005	-	0.05	-	1288	8	Conc- 2009 LandSim update Koc – ConSim manual. Kd calculated by LandSim. Half life – conservative value based on the literature
Zinc	mg/l	*0.02*	*0.2*	*0.6*	1-600	-	10^9	Conc- rounded up from Table 2.8 Kd – LandSim default Half life – no degradation
Cadmium	mg/l	*0.0006*	*0.0032*	*0.06*	*1.6-1500*	-	10^9	Conc- rounded up from Table 2.8 Kd – LandSim default Half life – no degradation
Leachate Head Above Liner	m	0.5	1	1.5	-		-	EP Compliance Level

Notes: Parameters in italic indicate change from 2009/2011 LandSim model.
Where two input values are given this indicates that a uniform distribution was used for probabilistic modelling; where three input values are presented then a triangular distribution was used. Where the range of values was more than 2 orders of magnitude a log uniform or log-triangular distribution was used.
LandSim default kappa values used where available (ammoniacal-nitrogen, chloride, and cadmium). Kappa value for mecoprop was assumed to be the same as that for chloride.

Table 3.2 LandSim Input Parameters: Infiltration, Site Geometry, Engineered Barrier and Unsaturated and Aquifer Pathways

Description	Distribution				Justification
	Unit	Min	Mean	Max	
Infiltration					
Infiltration Uncapped	mm/yr	*500*	*650*	*800*	Effective rainfall from EA (2008)
Infiltration Capped	mm/yr		*50 (mean) 5 (standard deviation)*		LandSim default. Normal distribution assumed with a 10% standard deviation from mean.
Site Geometry					
Top area	Ha	*3.60*			Site plans
Base area	Ha	*2.52*			Site plans
Head of leachate when surface water breakout occurs	m	-	2	-	2009 HRA (measured from cell base contours and ground level)
Waste thickness	m	*3*	*8*	*11*	Measured from cell base contours and topographic survey levels
Waste porosity	-	*0.50*	-	*0.55*	Powrie & Beaven (1999)
Waste Dry density	kg/l	*0.4*	-	*0.5*	Powrie & Beaven (1999)
Waste field capacity	-	*0.40*	-	*0.45*	Powrie & Beaven (1999)
Engineered Barrier System					
Type	Composite				
Geomembrane liner					
Defect type with CQA system					
Pin holes		0	-	25	2009 HRA (LandSim default)
Holes		0	-	5	2009 HRA (LandSim default)
Tears		0	0.1	2	2009 HRA (LandSim default)
Offset of FML degradation	years		150		2009 HRA (LandSim default)
Time for area of defects to double*	years		100		2009 HRA (LandSim default)
Mineral Liner (BES)					
Hydraulic Conductivity	m/s	*5.2×10^{-11}*	*1.7×10^{-10}*	*5.0×10^{-10}*	CQA data

Notes: Parameters in italic indicate change from 2009/2011 LandSim model.
Where two input values are given this indicates that a uniform distribution was used for probabilistic modelling; where three input values are presented then a triangular distribution was used. Where the range of values was more than 2 orders of magnitude a log uniform or log-triangular distribution was used.

Description	Distribution				Justification
	Unit	Min.	Mean	Max.	
Mineral Liner (BES)					
Thickness	m		0.5		2009 HRA (site design)
Moisture Content	%	*5*	*8*	*10*	CQA data
Longitudinal Dispersivity	m		0.05		2009 HRA (10% pathway length)
Density	kg/l	*2.0*		*2.2*	CQA data
Organic carbon content	-	0.0001	-	0.001	2009 HRA (assumed)
Unsaturated Pathway (Blown Sand deposits)					
Flow Model	Porous medium				
Pathway length	m	*0.3*	*1.5*	*2.4*	Estimated from groundwater levels in the vicinity of the site for the period April 2009 to March 2015 and pit base levels.
Matrix Hydraulic conductivity	m/s	1.15×10^{-4}	1.50×10^{-4}	2.08×10^{-4}	2009 HRA (calculated from PSD data)
Moisture Content	-	0.1	0.15	0.2	2009 HRA (site measurements)
Density	kg/l	1.5	-	1.8	Typical value for sands (Consim)
Organic carbon content	-	0.0001	-	0.001	2009 HRA (site measurements)
Longitudinal Dispersivity	m	*0.03*	*0.15*	*0.24*	10% of pathway length (LandSim default)
Aquifer Pathway (Blown Sand deposits)					
Mixing zone thickness	m	10	-	15	2009 HRA (estimated from field data)
Hydraulic gradient	-	*0.006*	*0.009*	*0.01*	Measured from groundwater levels across the site (2009-2015).
Hydraulic conductivity	m/s	1.15×10^{-4}	1.50×10^{-4}	2.08×10^{-4}	2009 HRA (calculated from PSD data)
Porosity	-	0.20	0.25	0.35	2009 HRA (estimated from LandSim manual)
Density	kg/l	1.5	-	1.8	Typical value for sands (Consim)
Organic carbon content	-	0.0001	-	0.001	2009 HRA (site measurements)
Longitudinal Dispersivity	m	10% of pathway length			LandSim default
Transverse Dispersivity	m	10% of longitudinal dispersivity			LandSim default

Notes: Parameters in italic indicate change from 2009/2011 LandSim model.
Where two input values are given this indicates that a uniform distribution was used for probabilistic modelling; where three input values are presented then a triangular distribution was used. Where the range of values was more than 2 orders of magnitude a log uniform or log-triangular distribution was used.

Aerobic biodegradation of mecoprop in topsoil has been relatively widely studied, with mecoprop half-lives typically being between 10 and 100 days (0.03 to 0.3 years) in well-drained, acclimated soils. The literature

indicates that there is a very rapid decrease in degradation rate with increasing depth through the soil profile as anaerobic conditions prevail (EA, 2004 and Buss et al., 2006). Aerobic degradation of naphthalene has also been reported with typical half-lives of 100-300 days (0.3-0.8 years) in shallow sand/gravel aquifers (EA, 2002). Monitoring data indicates baseline dissolved oxygen (DO) in the Blown Sand deposits of 7 mg/l reducing to 3-5 mg/l downgradient of Area 2 as a result of redox processes within the leachate plume. Preliminary model runs, undertaken without biodegradation of mecoprop and naphthalene, showed times to peak concentration at the base of the unsaturated Blown Sand deposits in excess of 60 years (95th percentile) and 170-350 years (50th percentile). Within these timescales the leachate plume is likely to have migrated away from Area 3 and aerobic conditions are likely to prevail in the Blown Sand deposits. On this basis, mecoprop and naphthalene aerobic biodegradation in the Blown Sand deposits has been modelled using conservative half-lives of 3 years and 8 years, respectively (10 times the upper half-live value reported in the references above).

Sensitivity analysis

Sensitivity analysis is implicit in the selection of appropriate values for the parameters used in the risk assessment and the use of ranges of values. Where possible values have been checked for internal consistency. Where a choice of parameters was available, then more conservative values were selected. In addition to this implicit sensitivity analysis, an explicit analysis of the leachate levels has been undertaken.

The model base run considered the EP compliance leachate limit (1.5 m above base of cell) as the maximum leachate head. A maximum leachate head of 2 m above base of cell has been modelled as part of the sensitivity analysis in order to assess any increased risk to the receptors in the event that leachate level control is unable to maintain levels below 1.5 m above base.

3.3 Emissions to Groundwater

Emissions to Groundwater: Hazardous Substances

Table 3.3 shows the predicted concentrations of the hazardous substances cadmium, mecoprop and naphthalene at the base of the unsaturated Blown Sand deposits underlying the site prior to dilution in groundwater. The model results are reported for the 50th percentile (most likely) and 95th percentile (pessimistic assessment) predictions for both the base run and sensitivity run and show that:

- For the EP leachate limit of 1.5 m above base (base run) cadmium, naphthalene and mecoprop are not predicted to breakthrough at the base of the unsaturated Blown Sand deposits above their minimum reporting value (MRV);
- For a maximum leachate level of 2 m above base (sensitivity run) the predicted breakthrough concentrations at the base of the unsaturated zone are slightly higher than for the EP limit but remain below their MRV.

Table 3.3 LandSim Results for Base and Sensitivity Run: Hazardous Substances

Substance	Max Conc at Base of Unsaturated Blown Sand deposits in mg/l [travel time through unsaturated zone in years]		Water Quality Standard (mg/l)[a]	Baseline/ Downgradient of Areas2&3 (mg/l)[b]
	50th Percentile	95th Percentile		
Run 1 (Base Run)				
Cadmium	NB	NB	$1x10^{-4}$	<0.6-0.8-1.6/ <0.6-1.2-4.5
Mecoprop	NB	$3.1x10^{-5}$ [43]	$4x10^{-5}$	No baseline data/ $<4x10^{-5}$-0.0017-0.003
Naphthalene	NB	$2.9x10^{-4}$ [52]	$2.4x10^{-3}$	$<1x10^{-5}$-$<1x10^{-4}$/ $<1x10^{-5}$-$1.1x10^{-4}$-$2.6x10^{-4}$
Run 2 (Sensitivity Run)				
Cadmium	NB	$4.9x10^{-7}$ [20000]	$1x10^{-4}$	<0.6-0.8-1.6/ <0.6-1.2-4.5
Mecoprop	NB	$5.0x10^{-5}$ [94]	$4x10^{-5}$	No baseline data/ $<4x10^{-5}$-0.0017-0.003
Naphthalene	NB	$2.7x10^{-4}$ [52]	$2.4x10^{-3}$	$<1x10^{-5}$-$<1x10^{-4}$/ $<1x10^{-5}$-$1.1x10^{-4}$-$2.6x10^{-4}$

Note:
a) Water quality standard is minimum reporting value (MRV) for cadmium and mecoprop and environmental quality standard (EQS) for naphthalene.
b) Data for April 2009 to March 2015 shown as min-mean-max

Emissions to Groundwater: Non-Hazardous Pollutants

Table 3.4 shows the predicted concentrations of the non-hazardous pollutants ammoniacal-nitrogen, chloride and zinc and the candidate non-hazardous pollutant mecoprop in the Blown Sand deposits at the downgradient boundary of the site. Predictions are shown for the 50th percentile (most likely) and 95th percentile (pessimistic assessment) for both the base run and sensitivity run and show that:

- For the EP leachate limit of 1.5 m above base (base run) chloride, ammoniacal-nitrogen, zinc and mecoprop groundwater concentrations at the downgradient edge of the site are not predicted to exceed their drinking water standards (DWS) or baseline concentrations;
- For an increased leachate level of 2 m above base (sensitivity run) the predicted groundwater concentrations at the downgradient edge of the site are slightly higher than for the EP limit but remain below their DWS and baseline concentrations.

Table 3.4 LandSim Results for Base and Sensitivity Run: Non-Hazardous Substances

Substance	Max Groundwater Conc at Downgradient Site Boundary in mg/l [travel time to downgradient site boundary]		DWS (mg/l)	Baseline/ Downgradient (mg/l)[a]
	50th Percentile	95th Percentile		
Run 1 (Base Run)				
Ammoniacal-N	0.02 [510]	0.30 [315]	0.39	<0.27-1.2-12/ <0.27-94-241
Chloride	0.13 [141]	0.80 [105]	250	4-21-57/ 3-149-486
Zinc	NB	NB	5	<0.018-0.099-0.033/ <0.018-0.083-0.32
Mecoprop	NB	$5.6x10^{-9}$ [160]	$1x10^{-4}$	No baseline data/ $<4x10^{-5}$-0.0017-0.003
Run 2 (Sensitivity Run)				
Ammoniacal-N	0.03 [420]	0.36 [255]	0.39	<0.27-1.2-12/ <0.27-94-241
Chloride	0.17 [90]	0.83 [30]	250	4-21-57/ 3-149-486
Zinc	NB	NB	5	<0.018-0.099-0.033/ <0.018-0.083-0.32
Mecoprop	NB	$1.0x10^{-6}$ [170]	$1x10^{-4}$	No baseline data/ $<4x10^{-5}$-0.0017-0.003

Note: a) Data for April 2009 to March 2015 shown as min-mean-max

3.4 Summary

The site conceptual model is qualitatively unchanged from the 2009 HRA/2011 LandSim update but it has been considered appropriate to reassess the risks to groundwater taking into account an increase in leachate strength (as ammoniacal-nitrogen, chloride, cadmium and mecoprop). Similar to the previous HRAs, the risks to groundwater have been re-assessed using the EA's preferred landfill modelling package LandSim v 2.5.17.

The modelling results for the EP leachate limit of 1.5 m above cell base indicate that there is no breakthrough of the hazardous substances cadmium or naphthalene above their MRV at the base of the unsaturated Blown Sand deposits and no breakthrough above DWS of the non-hazardous substances chloride, ammoniacal-nitrogen and zinc. Mecoprop is not predicted to impact on groundwater when modelled as either a hazardous substance or non-hazardous pollutant. There is, therefore, no predicted impact on groundwater quality from the Area 3 wastes at the downgradient edge of Area 3. It is noted that any potential impact from Area 3 would not be discernible over the currently-elevated chloride and ammoniacal-nitrogen concentrations at the downgradient edge of Area 3.

A sensitivity run with an increased leachate head of 2 m above cell base (reflecting potential temporary loss of leachate level control) indicates no additional unacceptable risk to groundwater.

There is therefore no risk to the receptors to the west of the site, comprising the Blown Sand deposits aquifer and the Morfa Harlech SSSI/NNR, as a consequence of the operation of Area 3 at Ffridd Rasus.

4. Requisite Surveillance

4.1 The Risk Based Monitoring Scheme

Under the Environmental Permitting Regulations, appropriate monitoring, or requisite surveillance, of a permitted site must be undertaken, typically consisting of leachate, groundwater and surface water monitoring. An appropriate level of monitoring is required to establish that site management requirements are being met and to provide warning of adverse impacts.

In addition to the monitoring locations and schedules, there are typically requirements for the establishment of control levels and compliance limits for groundwater and surface water quality (for surface water discharges) and leachate levels. These levels are used to ensure that the landfill is performing in line with its design (control levels) and as an indicator for potential impact from leachate and requirement for remedial actions (compliance limits).

4.2 Leachate Monitoring

Monitoring Regime

Leachate monitoring is currently undertaken at one location per cell. Leachate levels are monitored weekly and leachate samples are analysed on a monthly basis for key determinands, with quarterly and annual extended analytical suites including additional metals and organic contaminants as identified in Table 4.1. This level of monitoring is consistent with, and exceeds for leachate level monitoring, the requirements of the EP. It is proposed to reduce leachate monitoring from weekly to quarterly for levels and from monthly to quarterly for quality on the basis that:

- Leachate levels have not exceeded the EP limit of 1.5 m above cell base except for an isolated occurrence (2.2 m at LCP1 and 1.81 m at LM1/2) in November 2009 in Cell 1;
- Filling and capping of the site was complete in March 2014 and this reduced the rate of leachate generation. It is therefore expected that leachate management will continue to maintain levels below the EP compliance limit;
- Leachate quality data for the two key indicators chloride and ammoniacal nitrogen, show that concentrations have stabilised in Cells 1 and 2 but show a rising trend in Cells 3 and 4 as would be expected due to having the most recently deposited waste;
- The majority of hazardous substances from the annual extended suite were found at concentrations below the laboratory detection limits (Appendix C); and
- The HRA modelling presented in Section 3 predicts no future impact on groundwater quality and the Morfa Harlech SSSI/NNR from Area 3.

Table 4.1 Leachate Monitoring Regime for Areas 1 and 3: Current and Proposed

Monitoring Location	Frequency	Parameters
Current		
LCP1, LCP2, LCP3, LCP4/2 and LCP4/B	Weekly	Level
	Monthly	As weekly plus Temperature, pH, EC, NH4 and Cl.
	Quarterly	As monthly plus Ca, Mg, K, Na, Alkalinity, TOC, SO4, TON, phenol, COD, BOD and Cd.
	Annually	As quarterly plus Cr, Cu, Fe, Pb, Mn, Ni, Zn and hazardous substances screen.
Proposed		
LCP1, LCP2, LCP3, LCP4/2 and LCP4/B	Quarterly	Level, Temperature, pH, EC, NH4 and Cl.
	Six Monthly	As quarterly plus Ca, Mg, K, Na, Alkalinity, TOC, SO4, TON, phenol, COD, BOD and Cd.
	Annually	As six monthly plus: Cr, Cu, Fe, Pb, Mn, Ni, Zn and hazardous substances screen.

Note: Leachate levels should be measured to Ordnance Datum, and since leachate wells may move within the waste body over time, each datum point should be surveyed on a periodic basis.

Compliance Leachate Limit

The HRA modelling presented in Section 3 has shown no impact from Area 3 on groundwater quality for the EP compliance leachate limit of 1.5 m above cell base. In addition, a sensitivity analysis modelling a maximum leachate level of 2 m above base representing temporary loss of leachate level control also showed no impact on groundwater quality. On this basis no changes are proposed to the EP limit.

4.3 Groundwater Monitoring

Monitoring Regime

Guidance published by the EA identifies a minimum requirement for three groundwater monitoring boreholes per groundwater system for a landfill site, comprising one up gradient and two down gradient (EA, 2003).

There is an extensive monitoring network at Ffridd Rasus of upgradient, lateral and downgradient boreholes that provide groundwater data for the site (Figure 2.1) as follows:

- Upgradient of Areas 2 and 3: BH1, BH15 and BH24;
- Upgradient of Area 3 and downgradient of Area 2: BH27, BH34, BH35, BH36 and NRA3;
- Lateral to groundwater flow: BH18A/B, BH28, BH29, BH32 and BH33; and
- Downgradient of Areas 2 and 3: BH19A/B/C, BH20A/B, BH21A/B, BH23, BH30 and BH31.

The number of monitoring boreholes meets the EA guidance (EA, 2003) requirements and so additional groundwater quality monitoring boreholes are not recommended.

The current groundwater monitoring regime is shown in Table 4.2 and is consistent with the EP requirements. It is proposed to reduce groundwater monitoring from monthly to quarterly on the basis of:

- Groundwater level monitoring data up to March 2015 for the Blown Sand deposits aquifer show typical seasonal variations within a 6-7 month period which would continue to be captured in the proposed quarterly monitoring; and
- The HRA modelling presented in Section 3 predicts no future impact on groundwater quality and the Morfa Harlech SSSI/NNR from Area 3.

Table 4.2 Groundwater Monitoring Regime for Areas 1 and 3: Current and Proposed

Monitoring Location	Frequency	Measurement/ Determinand
Current		
BH1, BH15, BH18A, BH18B, BH19A, BH19B, BH19C, BH20A, BH20B, BH21A, BH21B, BH23, BH24, BH27-BH36 and NRA3	Monthly	Level, Temperature, pH, Cl, EC, NH_4-N, DO
	Quarterly	As monthly plus: Ca, Mg, K, Na, Cd, Alk, TOC, SO_4, TON and phenol.
	Annually	As quarterly plus: Cr, Cu, Fe, Pb, Mn, Ni, Zn.
	Once every 4 years	As annually plus hazardous substances screen
Proposed		
BH1, BH15, BH18A, BH18B, BH19A, BH19B, BH19C, BH20A, BH20B, BH21A, BH21B, BH23, BH24, BH27-BH36 and NRA3	Quarterly	Level, Temperature, pH, Cl, EC, NH4-N, DO, Cd, naphthalene
	Six Monthly	As quarterly plus: Ca, Mg, K, Na, Alk, TOC, SO4, TON and phenol.
	Annually	As six-monthly plus: Cr, Cu, Fe, Pb, Mn, Ni, Zn
	Once every 4 years	As annually plus hazardous substances detected in leachate

Groundwater Control Levels and Compliance Limits

Control levels are intended to draw attention to any adverse or unanticipated trends in groundwater quality monitoring data or groundwater impacts. They are intended to provide an early warning system. They should allow for natural variations in groundwater quality and allow sufficient time for any necessary actions to be taken prior to compliance limits being exceeded. Compliance limits are specific compliance or regulatory standards.

The current compliance limits for Areas 1 and 3 were derived using monitoring data up to December 2005 (Amec Foster Wheeler, 2006). Review of more recent data indicates that a leachate plume derived from Area 2 continues to have an impact on groundwater quality downgradient of Areas 2 and 3. Following capping of Area 2 in 2005-2008 groundwater quality is improving at the downgradient edge of Area 2. However, groundwater quality has deteriorated at the downgradient edge of Area 3 as the leachate plume moves downgradient and because recharge to the aquifer has reduced as a result of engineering of Area 3. Groundwater quality appears to have stabilised or even declined at some boreholes. The deterioration in groundwater quality as a result of the migration of the leachate plume since the compliance limits were derived in 2006 means that these are now exceeded at a number of boreholes. It is noted that any potential impact from Area 3 would not be discernible over the currently-elevated chloride and ammoniacal-nitrogen concentrations at the downgradient edge of Area 3. The compliance limits have been revised using more recent data in Table 4.3.

Chloride and Ammoniacal-Nitrogen

Following an upward trend in concentrations at boreholes BH19A, BH20A/B, BH21A/B, BH29, BH30 and BH31 concentrations now appear to have stabilised at boreholes BH20A/B and are declining at boreholes BH21A/B, BH30 and BH31. Concentrations at boreholes BH19A/ C still show an upward trend. Table 4.4 compares the maximum concentrations recorded at the edge of Area 2 at BH27 with those measured about 200 m downgradient of Area 2 (at the edge of Area 3). This indicates that concentrations decrease along the flow path as a result of dispersion/dilution of chloride and dispersion/dilution/retardation/biodegradation of ammoniacal-nitrogen. However at some locations (e.g. BH30) there is only a small reduction in chloride concentrations suggesting that dilution/dispersion is limited. The proposed compliance limits are illustrated in Appendix G and were derived as follows:

- Boreholes showing a downward trend in concentrations: compliance limit has been set as the peak concentration recorded at that borehole and the control limit as 90% of the compliance limit;
- Boreholes showing stable concentrations: compliance limit has been set as the peak concentration recorded at that borehole plus 10% and the control limit as 90% of the compliance limit;
- Boreholes showing an upward trend in concentrations: compliance limit has been set as the peak concentration recorded at BH27 (maximum concentration near the source) and the control limit as 90% of the compliance limit.

As there is uncertainty on the overall rate at which groundwater quality will improve the proposed compliance limits and control levels should be reviewed as part of the 2016 Annual Monitoring Report.

Cadmium

Concentrations have remained below the compliance limit of 5.5 µg/l and show no upward trend. On this basis the compliance limit remain appropriate.

Naphthalene

Naphthalene has not been detected in groundwater (<0.01 to <0.04 µg/l) except for one occasion (0.073 µg/l at borehole BH30) which was below EQS (2.4 µg/l). On this basis the EQS of 2.4 µg/l is proposed as a compliance limit.

Table 4.3 Proposed Groundwater Control Levels and Compliance Limits for Areas 1 and 3

Borehole	Ammoniacal Nitrogen (mg/l)		Chloride (mg/l)		Cadmium (µg/l)		Naphthalene (µg/l)
	Control Level	Compliance Limit	Control Level	Compliance Limit	Control Level	Compliance Limit	Compliance Limit
BH19A	5.0	5.5	50	55	5.0	5.5	2.4
BH19B	1.4	1.5	495	550	5.0	5.5	2.4
BH19C	5.0	5.5	495	550	5.0	5.5	2.4
BH20A	79	85	437	485	5.0	5.5	2.4
BH20B	228	259	399	443	5.0	5.5	2.4
BH21A	135	150	315	350	5.0	5.5	2.4
BH21B	72	80	315	350	5.0	5.5	2.4
BH30	216	240	405	450	5.0	5.5	2.4

Borehole	Ammoniacal Nitrogen (mg/l)		Chloride (mg/l)		Cadmium (µg/l)		Naphthalene (µg/l)
	Control Level	Compliance Limit	Control Level	Compliance Limit	Control Level	Compliance Limit	Compliance Limit
BH31	99	110	135	150	5.0	5.5	2.4

Table 4.4 Calculation of Chloride and Ammoniacal-Nitrogen Compliance Limits for Areas 1 and 3

Monitoring Location	Peak Groundwater Concentration Cl (mg/l)	Peak Groundwater Concentration NH4-N (mg/l)	Proposed Compliance Limit Cl (mg/l)	Proposed Compliance Limit NH4-N (mg/l)
Area 2 Downgradient Boundary				
BH27	550 (declining)	300 (declining)	-	-
Downgradient of Areas 2 & 3 (200 m downgradient of Area 2 Boundary)				
BH19A	50 (stable)	<5 (variable but no upward trend)	55	5.5
BH19B	200 (increasing)	<1.5 (stable)	550	1.5
BH19C	250 (increasing)	<5 (variable but no upward trend)	550	5.5
BH20A	441 (stable)	77 (stable)	485	85
BH20B	403 (stable)	235 (stable)	443	259
BH21A	350 (declining)	150 (declining)	350	150
BH21B	350 (declining)	80 (declining)	350	80
BH30	450 (declining)	240 (declining)	450	240
BH31	150 (declining)	110 (stable)	150	110

4.4 Surface Water Monitoring

Monitoring Regime

Surface water quality is currently monitored on a monthly basis at four locations SW1 and SW1 pipe (Area 1 discharge), SW2 (drain) and SW3 (site discharge near sluice) in accordance with the requirements of the EP. In addition visual observations of the state of the water at locations SW1 and SW3 are also undertaken on a weekly basis (Table 4.5). It is proposed to reduce the monitoring frequency to quarterly on the basis of:

- Monitoring data up to March 2015 show no impact from Areas 1 and 3, and
- Chloride and ammoniacal nitrogen concentrations at SW2 exceed historical data and there are a number of possible explanations which are under investigation including former storage of compost taken from the IVC maturation slab and muck/sludge spreading on adjacent agricultural land; and
- The HRA modelling presented in Section 3 predicts no future impact on groundwater quality from Area 3 and therefore no impact on receptors receiving groundwater baseflow.

Table 4.5 Surface Water Monitoring Regime for Areas 1 and 3: Current and Proposed

Monitoring Location	Frequency	Measurement/Determinand
Current		
SW1 and SW3	Weekly	Visible oil and grease.
SW1, SW1pipe, SW2 and SW3	Monthly	Cl, COD, DO, EC, NH4, pH and Temperature.
Proposed		
SW1 and SW3	Quarterly	Visible oil and grease.
SW1, SW1pipe, SW2 and SW3	Quarterly	Cl, COD, DO, EC, NH_4, pH and Temperature.

Surface Water Emission Limits

Surface water runoff from hardstanding in Area 1 is discharged into a drain which runs along the northern border of the site. No emission limits have been set in the EP other than the avoidance of visible oil and grease at emission points SW1 and SW3. No changes are proposed.

5. Conclusions

This report provides an update to the 2009 HRA/2011 LandSim update for Area 3 using monitoring data up to March 2015 in accordance with the EP requirement for four yearly reviews of the HRA (now revised to six-yearly reviews by the Environmental Permitting Regulations 2010). The site conceptual model developed in the previous HRAs is qualitatively unchanged but it is considered appropriate to re-assess the risks to groundwater posed by the increase in leachate strength (as ammoniacal-nitrogen, chloride, cadmium and mecoprop).

Similar to the previous HRAs the risks to groundwater from Area 3 were re-assessed using LandSim. The results for the EP leachate limit of 1.5 m above cell base indicate that there is no breakthrough of the hazardous substances cadmium or naphthalene above their MRV at the base of the unsaturated Blown Sand deposits and no breakthrough above DWS of the non-hazardous substances chloride, ammoniacal-nitrogen and zinc. Mecoprop is not predicted to impact on groundwater when modelled as either a hazardous substance or non-hazardous pollutant.

A sensitivity run with an increased leachate head of 2 m above cell base (reflecting potential temporary loss of leachate level control) indicates no additional unacceptable risk to groundwater from Area 3.

Area 3 will continue to operate a comprehensive risk-based programme of leachate, surface water and groundwater monitoring and the implementation of compliance limits. A reduction in the monitoring frequency is proposed on the basis that the site is now closed and capped and no future risks are predicted. The deterioration in groundwater quality as a result of the migration of the leachate plume from Area 2 since the current groundwater compliance limits were derived in 2006 means that these are now exceeded at a number of boreholes. Proposals for revised compliance limits are presented on the basis of data collected since the 2009 HRA. It is noted that any potential impact from Area 3 would not be discernible over the currently-elevated chloride and ammoniacal-nitrogen concentrations at the downgradient edge of Area 3.

Chloride and ammoniacal-nitrogen concentrations at the perimeter ditch location SW2 exceed the range measured previously. Possible reasons for the increased levels are under investigation. The elevated ammoniacal-nitrogen concentrations recorded during 2005-2008 at the perimeter ditch location SW3 have reduced to below 1 mg/l in 2009. No increase in chloride was recorded suggesting a non-landfill source of ammoniacal-nitrogen at this location. No future risks are predicted from Areas 1 and 3 on receptors receiving groundwater baseflow.

Areas 1 and 3 are therefore considered to comply with the relevant requirements of the Environmental Permitting Regulations 2010.

6. References

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Amec Foster Wheeler 2009. Ffridd Rasus Landfill Areas 1 and 3 – Hydrogeological Risk Assessment Review. Report ref 22258rr104i2;

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Buss, S.R., Thrasher, J., Morgan, P. and Smith, J.W.N. 2006. A review of mecoprop attenuation in the subsurface. Quarterly Journal of Engineering Geology and Hydrogeology. Vol.39, pp. 283-292.

Environment Agency, 2002. The Effects of Contaminant Concentration on the Potential for Natural Attenuation. R&D Technical Report P2-228/TR.

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Joint Agencies Groundwater Directive Advisory Group (JAGDAG), 2013. Consolidated Response Report for Substance Determinations.

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Appendix A
Borehole Logs

Monitoring Well Construction Record	Monitoring Well Reference Number
Site Name: Ffridd Rasus Area 2 / Area 3 Landfill	**BH34**
WML Number: NOW-24-L / GP3330BY	
Site Operator: Gwynedd Council	Sheet 1 of 1
No. of Monitoring Points in Borehole: 1	
Area Reference: Area 2 / Area 3 boundary	

Monitoring Point Information
Monitoring Point Type: Single installation
Monitoring Point Use: Combined groundwater/gas monitoring
Strata: Unconsolidated sands over Gamlan Formation (siltstone/mudstone)
Response Zone: 0.7 m bgl - 8.7 m bgl

Construction Record
BH Ref: BH34
Hole Diameter (mm): 100
Hole Depth (m bgl): 8.7
Date Completed: 28/2/12
Contractor: Environmental Sampling Ltd
Supervisor: Simon Howard (AMEC) / Sue Francis (Gwynedd Council)
Construction Method: Sonic drilling with hollow rods and plastic lost head. Pipework then installed through hollow rods as they were withdrawn.

Ground Survey at Time of Construction
Surveyor: DMS (elevation) AMEC (XY estimates using available drawings)
Ground Elevation (m AOD): 6.42
Easting (m): 257765.11
Northing (m): 333934.37
Datum Point Description: Ordnance Datum
Height of Datum (m agl): 0.0
Datum Elevation (m AOD): 0.0

Lining Completion Record
Lining Material: HDPE
Lining Diameter (mm): 63 (external) 50 (internal)
Depth to Base of Lining (m bgl): 8.7
Top of Lining above Ground Level (m agl): 0.3
Screen Description and Size: 1mm slotted with 50 micron geosock
Top of Screen (m bgl): 0.7
Base of Screen (m bgl): 8.7
Screen Length (m): 8.0
Annular Filter Description and Size: planned to be 6mm washed gravel but was 'bridging' between drill pipe and HDPE pipework, so no gravel added - in-situ sand allowed to collapse back in up against the pipework, which was carefully fitted with a geosock to prevent the ingress of fines into the well.
Top of Filter (m bgl): 0.6
Base of Filter (m bgl): 8.7
Filter Length (m): 8.1
Annular Seal Description: Bentonite granules (hydrated)
Top of Seal (m bgl): GL
Base of Seal (m bgl): 0.6
Seal Length (m): 0.6

Headworks
Headworks Description: Cylindrical lockable steel 'top hat' cover
Top of Headworks above Ground Level (m agl): 0.43

Dedicated Monitoring Equipment
Description: To be confirmed

Access and Safety
Describe Special Requirements for Access or Safety Precautions: Borehole is adjacent to landfill working area with regular vehicular activity, site induction required plus hi-vis jacket, safety boots and hard hat.

Construction QC Checks			
	Name and Position of Competent Person	Date	Initials
Borehole Log (**no log due to drilling method**)	Simon Howard, Consultant	23/04/2012	SH
Lining Details (Y)	Simon Howard, Consultant	23/04/2012	SH
QC Check (Y)	Simon Howard, Consultant	23/04/2012	SH
EA Registered (Y/N)			
EA Approved (Y/N)			

Monitoring Well Construction Record	Monitoring Well Reference Number
Site Name: Ffridd Rasus Area 2 / Area 3 Landfill	**BH35**
WML Number: NOW-24-L / GP3330BY	
Site Operator: Gwynedd Council	Sheet 1 of 1
No. of Monitoring Points in Borehole: 1	
Area Reference: Area 2 / Area 3 boundary	

Monitoring Point Information
Monitoring Point Type: Single installation
Monitoring Point Use: Combined groundwater/gas monitoring
Strata: Unconsolidated sands over Gamlan Formation (siltstone/mudstone)
Response Zone: 0.7 m bgl - 8.7 m bgl

Construction Record
BH Ref: BH35
Hole Diameter (mm): 100
Hole Depth (m bgl): 8.7
Date Completed: 28/2/12
Contractor: Environmental Sampling Ltd
Supervisor: Simon Howard (AMEC) / Sue Francis (Gwynedd Council)
Construction Method: Sonic drilling with hollow rods and plastic lost head. Pipework then installed through hollow rods as they were withdrawn.

Ground Survey at Time of Construction
Surveyor: DMS (elevation) AMEC (XY estimates using available drawings)
Ground Elevation (m AOD): 6.55
Easting (m): 257732.41
Northing (m): 333854.24
Datum Point Description: Ordnance Datum
Height of Datum (m agl): 0.0
Datum Elevation (m AOD): 0.0

Lining Completion Record
Lining Material: HDPE
Lining Diameter (mm): 63 (external) 50 (internal)
Depth to Base of Lining (m bgl): 8.7
Top of Lining above Ground Level (m agl): 0.3
Screen Description and Size: 1mm slotted with 50 micron geosock
Top of Screen (m bgl): 0.7
Base of Screen (m bgl): 8.7
Screen Length (m): 8.0
Annular Filter Description and Size: planned to be 6mm washed gravel but was 'bridging' between drill pipe and HDPE pipework, so no gravel added - in-situ sand allowed to collapse back in up against the pipework, which was carefully fitted with a geosock
Top of Filter (m bgl): 0.6
Base of Filter (m bgl): 8.7
Filter Length (m): 8.1
Annular Seal Description: Bentonite granules (hydrated)
Top of Seal (m bgl): GL
Base of Seal (m bgl): 0.6
Seal Length (m): 0.6

Headworks
Headworks Description: Cylindrical lockable steel 'top hat' cover
Top of Headworks above Ground Level (m agl): 0.4

Dedicated Monitoring Equipment
Description: To be confirmed

Access and Safety
Describe Special Requirements for Access or Safety Precautions: Borehole is adjacent to landfill working area with regular vehicular activity, site induction required plus hi-vis jacket, safety boots and hard hat.

Construction QC Checks			
	Name and Position of Competent Person	Date	Initials
Borehole Log (**no log due to drilling method**)	Simon Howard, Consultant	23/04/2012	SH
Lining Details (Y)	Simon Howard, Consultant	23/04/2012	SH
QC Check (Y)	Simon Howard, Consultant	23/04/2012	SH
EA Registered (Y/N)			
EA Approved (Y/N)			

Monitoring Well Construction Record	Monitoring Well Reference Number
Site Name: Ffridd Rasus Area 2 / Area 3 Landfill	**BH36**
WML Number: NOW-24-L / GP3330BY	
Site Operator: Gwynedd Council	Sheet 1 of 1
No. of Monitoring Points in Borehole: 1	
Area Reference: Area 2 / Area 3 boundary	

Monitoring Point Information
Monitoring Point Type: Single installation
Monitoring Point Use: Combined groundwater/gas monitoring
Strata: Unconsolidated sands over Gamlan Formation (siltstone/mudstone)
Response Zone: 1.0 m bgl - 8.5 m bgl

Construction Record
BH Ref: BH36
Hole Diameter (mm): 100
Hole Depth (m bgl): 8.5
Date Completed: 28/2/12
Contractor: Environmental Sampling Ltd
Supervisor: Simon Howard (AMEC) / Sue Francis (Gwynedd Council)
Construction Method: Sonic drilling with hollow rods and plastic lost head. Pipework then installed through hollow rods as they were withdrawn.

Ground Survey at Time of Construction
Surveyor: DMS (elevation) AMEC (XY estimates using available drawings)
Ground Elevation (m AOD): 7.22
Easting (m): 257711.09
Northing (m): 333799.46
Datum Point Description: Ordnance Datum
Height of Datum (m agl): 0.0
Datum Elevation (m AOD): 0.0

Lining Completion Record
Lining Material: HDPE
Lining Diameter (mm): 63 (external) 50 (internal)
Depth to Base of Lining (m bgl): 8.5
Top of Lining above Ground Level (m agl): 0.3
Screen Description and Size: 1mm slotted with 50 micron geosock
Top of Screen (m bgl): 1.0
Base of Screen (m bgl): 8.5
Screen Length (m): 7.5
Annular Filter Description and Size: planned to be 6mm washed gravel but was 'bridging' between drill pipe and HDPE pipework, so no gravel added - in-situ sand allowed to collapse back in up against the pipework, which was carefully fitted with a geosock
Top of Filter (m bgl): 0.9
Base of Filter (m bgl): 8.5
Filter Length (m): 7.6
Annular Seal Description: Bentonite granules (hydrated)
Top of Seal (m bgl): GL
Base of Seal (m bgl): 0.9
Seal Length (m): 0.9

Headworks
Headworks Description: Cylindrical lockable steel 'top hat' cover
Top of Headworks above Ground Level (m agl): 0.38

Dedicated Monitoring Equipment
Description: To be confirmed

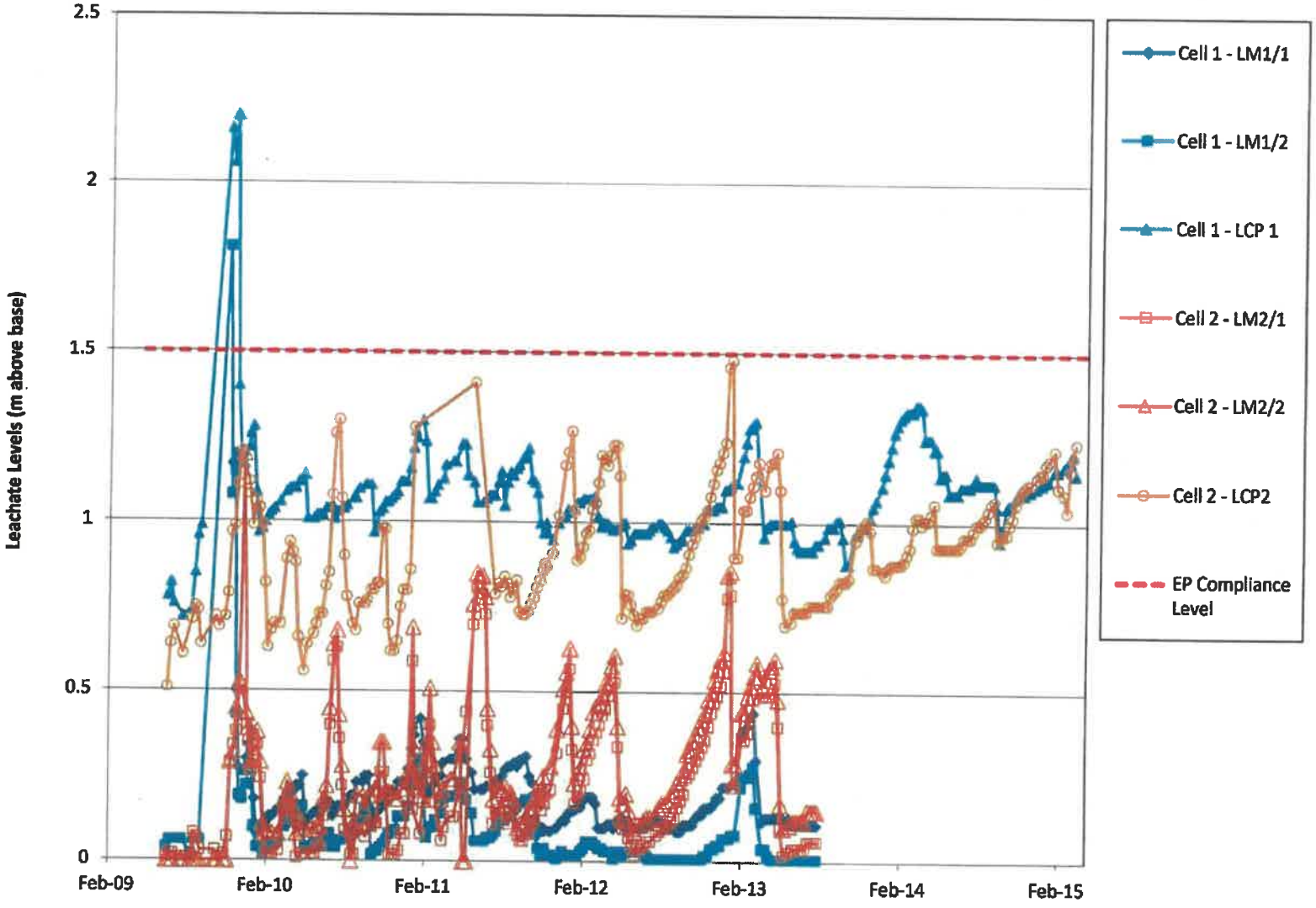
Access and Safety
Describe Special Requirements for Access or Safety Precautions: Borehole is adjacent to landfill working area with regular vehicular activity, site induction required plus hi-vis jacket, safety boots and hard hat.

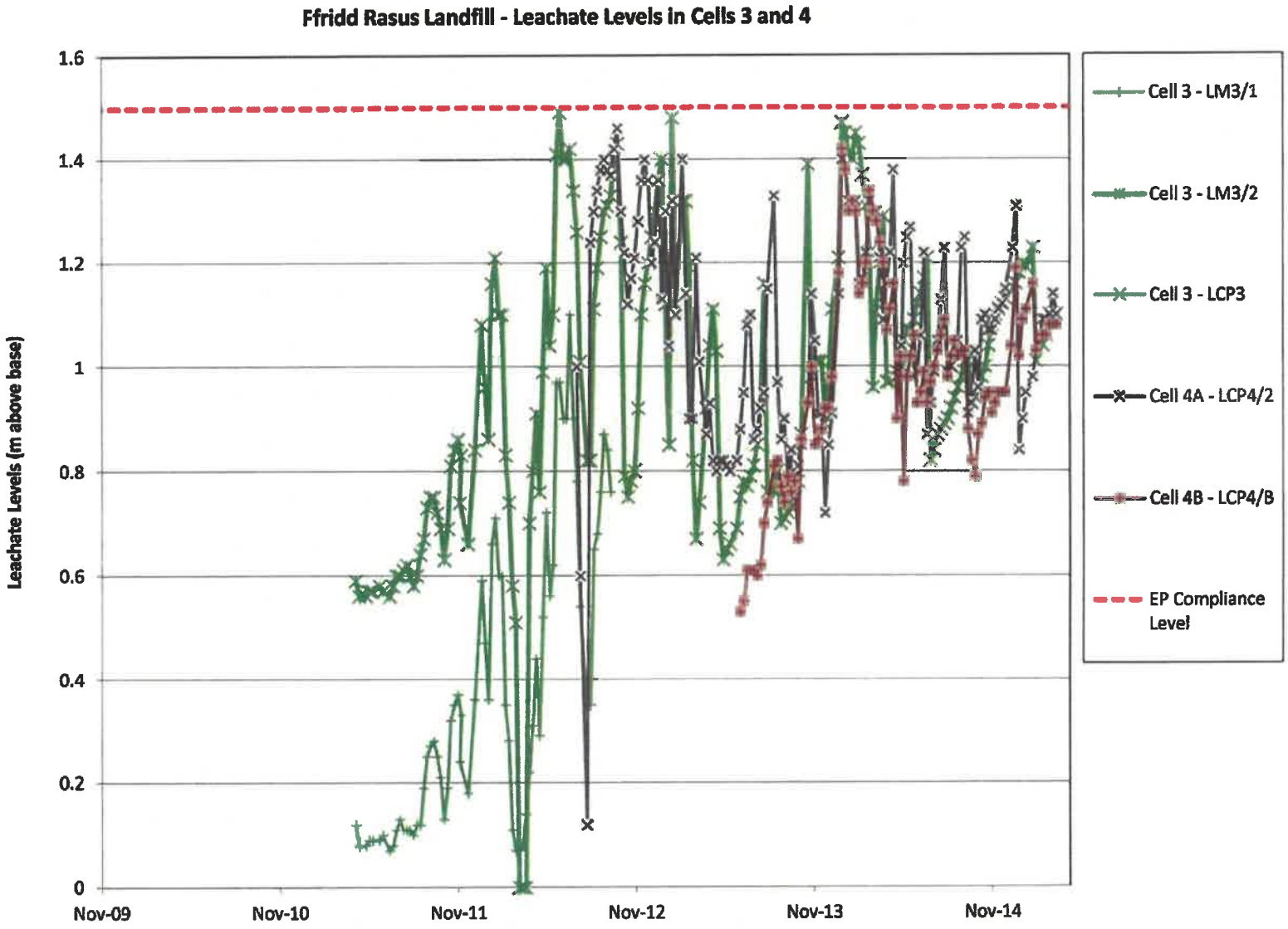
Construction QC Checks			
	Name and Position of Competent Person	Date	Initials
Borehole Log (**no log due to drilling method**)	Simon Howard, Consultant	23/04/2012	SH
Lining Details (Y)	Simon Howard, Consultant	23/04/2012	SH
QC Check (Y)	Simon Howard, Consultant	23/04/2012	SH
EA Registered (Y/N)			
EA Approved (Y/N)			

Appendix B
Leachate Level Charts

June 2015
Doc Ref. 28587rr954i2

Ffridd Rasus Landfill - Leachate Levels in Cells 1 and 2




Ffridd Rasus Landfill - Leachate Levels in Cells 3 and 4
Leachate Levels (m above base)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Nov-09
Nov-10
Nov-11
Nov-12
Nov-13
Nov-14
Cell 3 - LM3/1
Cell 3 - LM3/2
Cell 3 - LCP3
Cell 4A - LCP4/2
Cell 4B - LCP4/B
EP Compliance Level

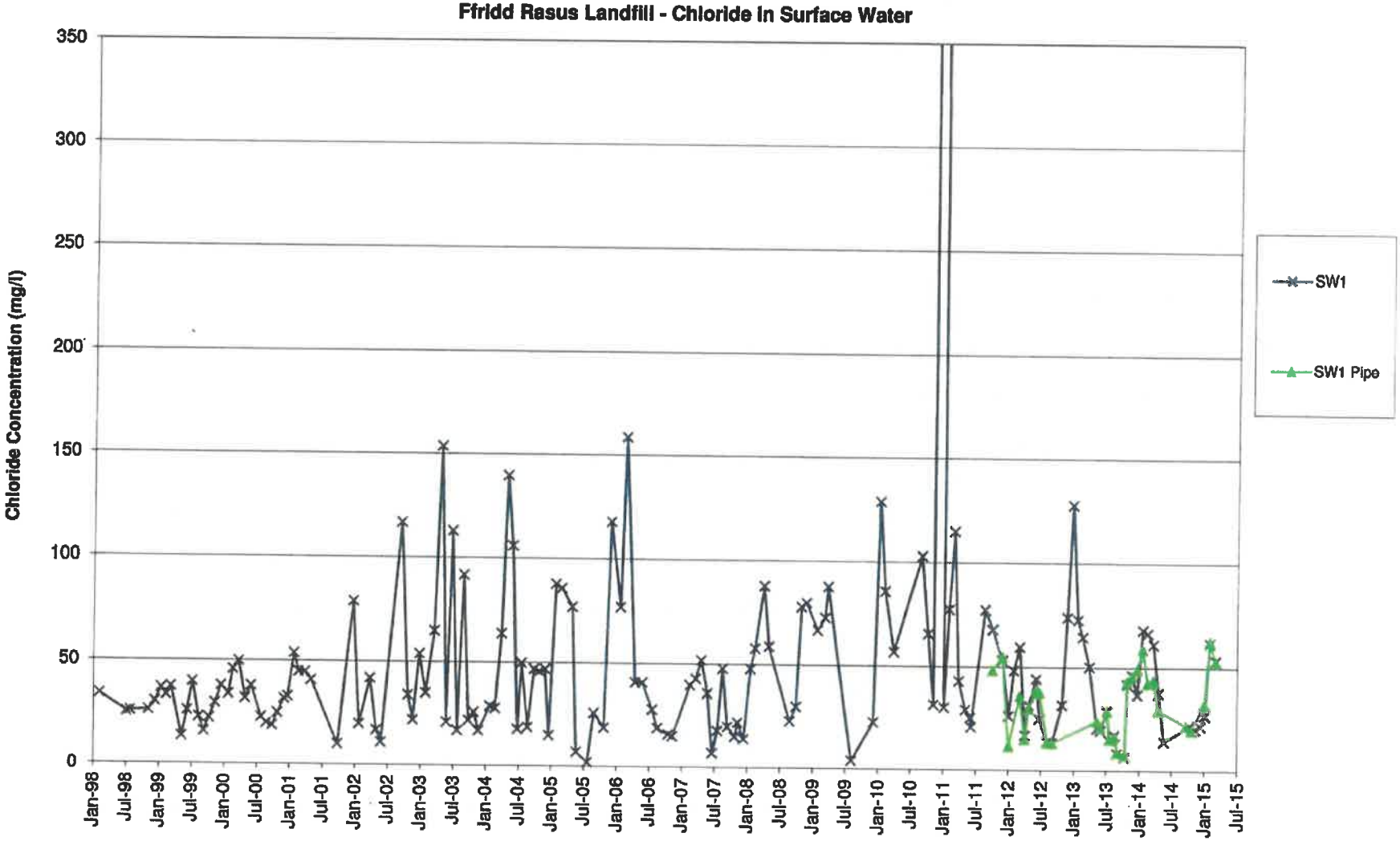
Appendix C
Leachate Quality Charts

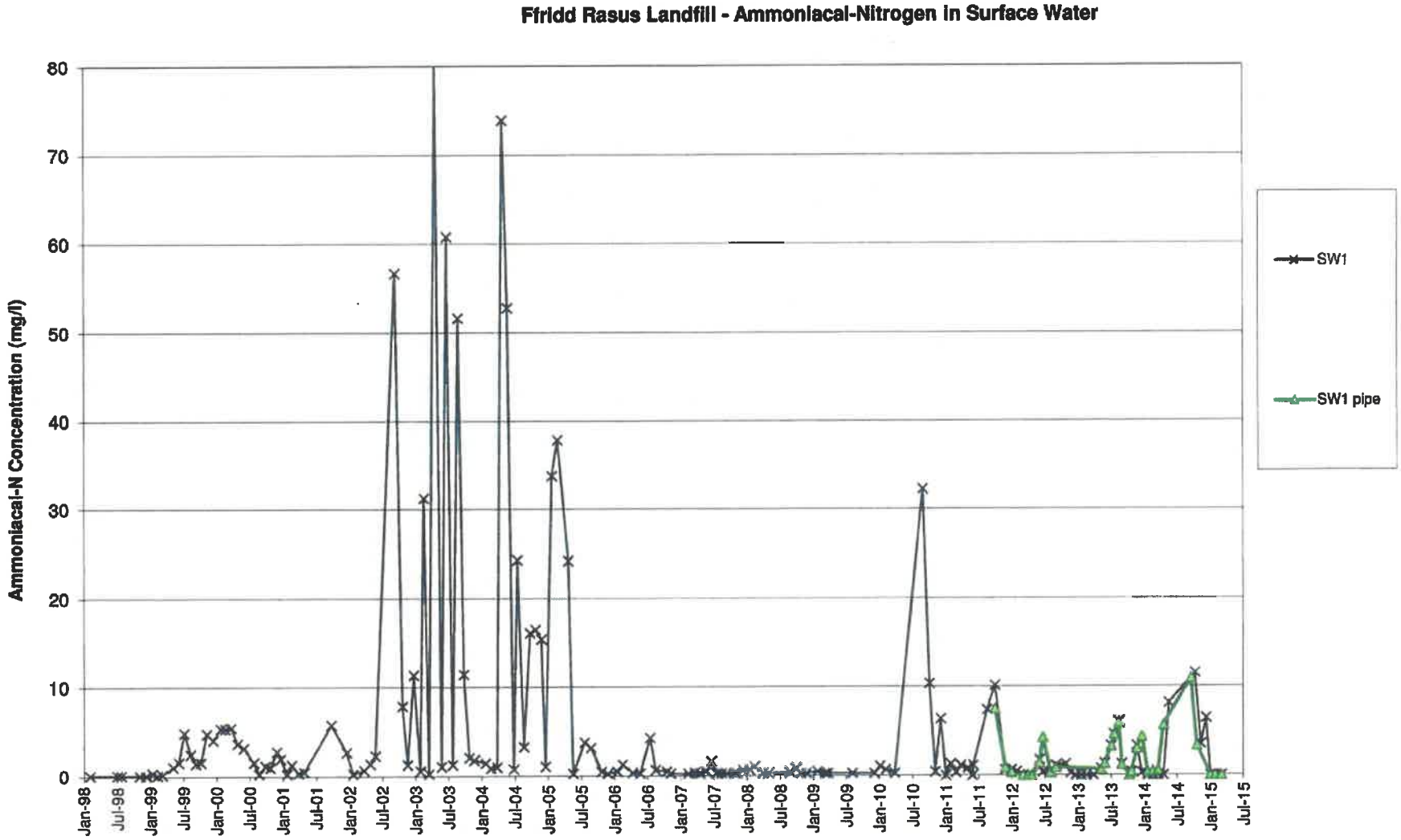
Hazardous organic substances above detection limit

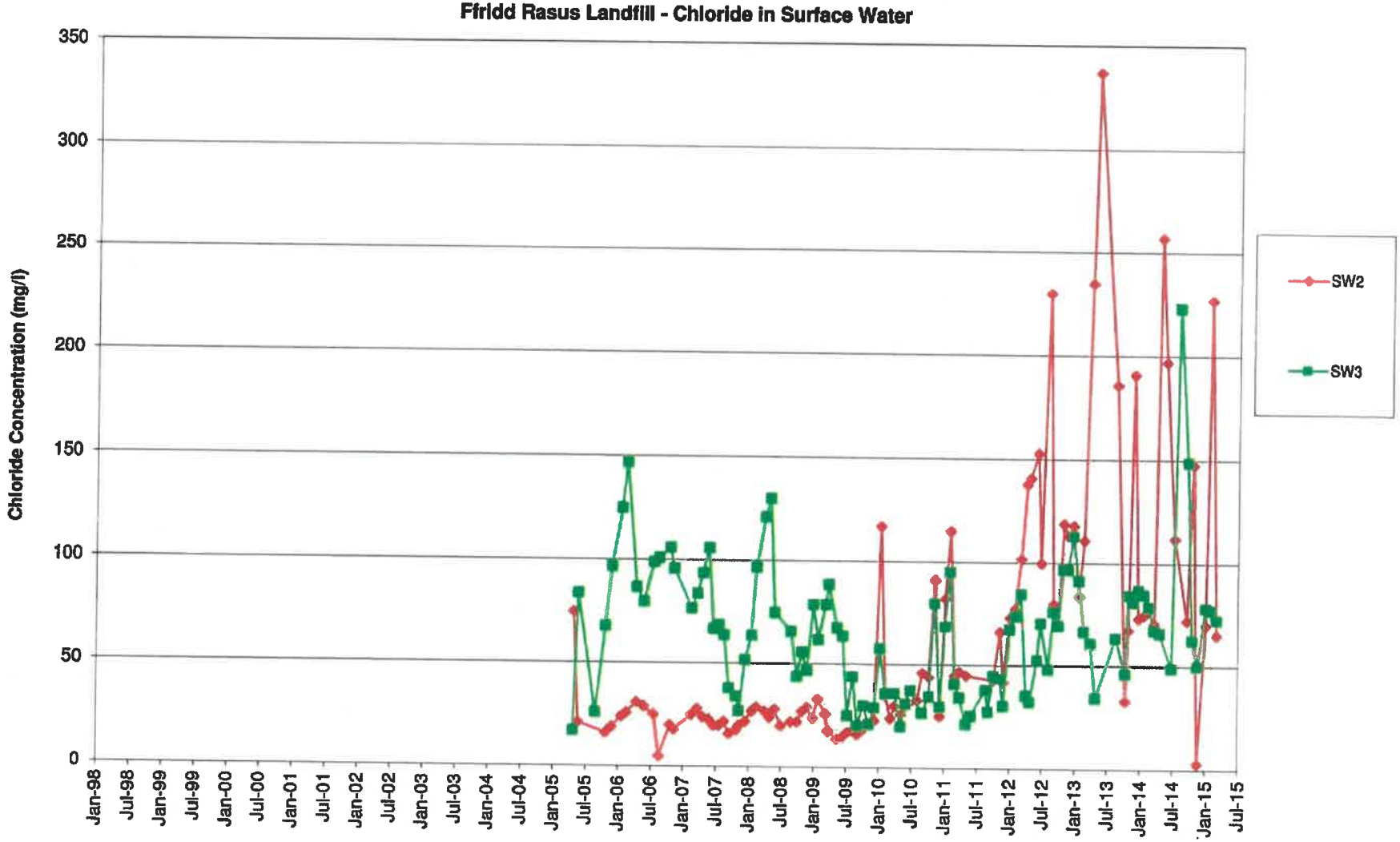
Substance	2009 to 2014 Data			
	No	No>dl	Min (µg/l)	Max (µg/l)
Pesticides				
Chlopyralid	6	6	2.63	10.4
Mecoprop	10	10	19.4	68.1
Chlorpyriphos	3	1	<0.014	0.016
MCPB	3	1	<0.50	8.21
Dichlorprop	8	8	0.67	12.6
Dicamba	3	3	2.03	4.5
BTEX				
Toluene	2	2	124	417
Hydrocarbon Bands				
EH >C6 - C8	2	2	137	294
EH >C8 - C10	2	1	<200	150
TPH >C10-C16	9	9	269	1550
TPH >C16-C24	4	4	226	1290
TPH >C24-C40	4	4	346	1560
TPH >C6-C40	5	5	334	3260
Phenols				
2-Methylphenol	1	1	61.6	61.6
3&4-Methylphenol	1	1	232	232
2,4,6-Trichlorophenol	3	1	<4.0	13
Other Aromatics				
Parathion-methyl	1	1	0.142	0.142
di-n-Butylphthalate	3	2	5.6	20.1

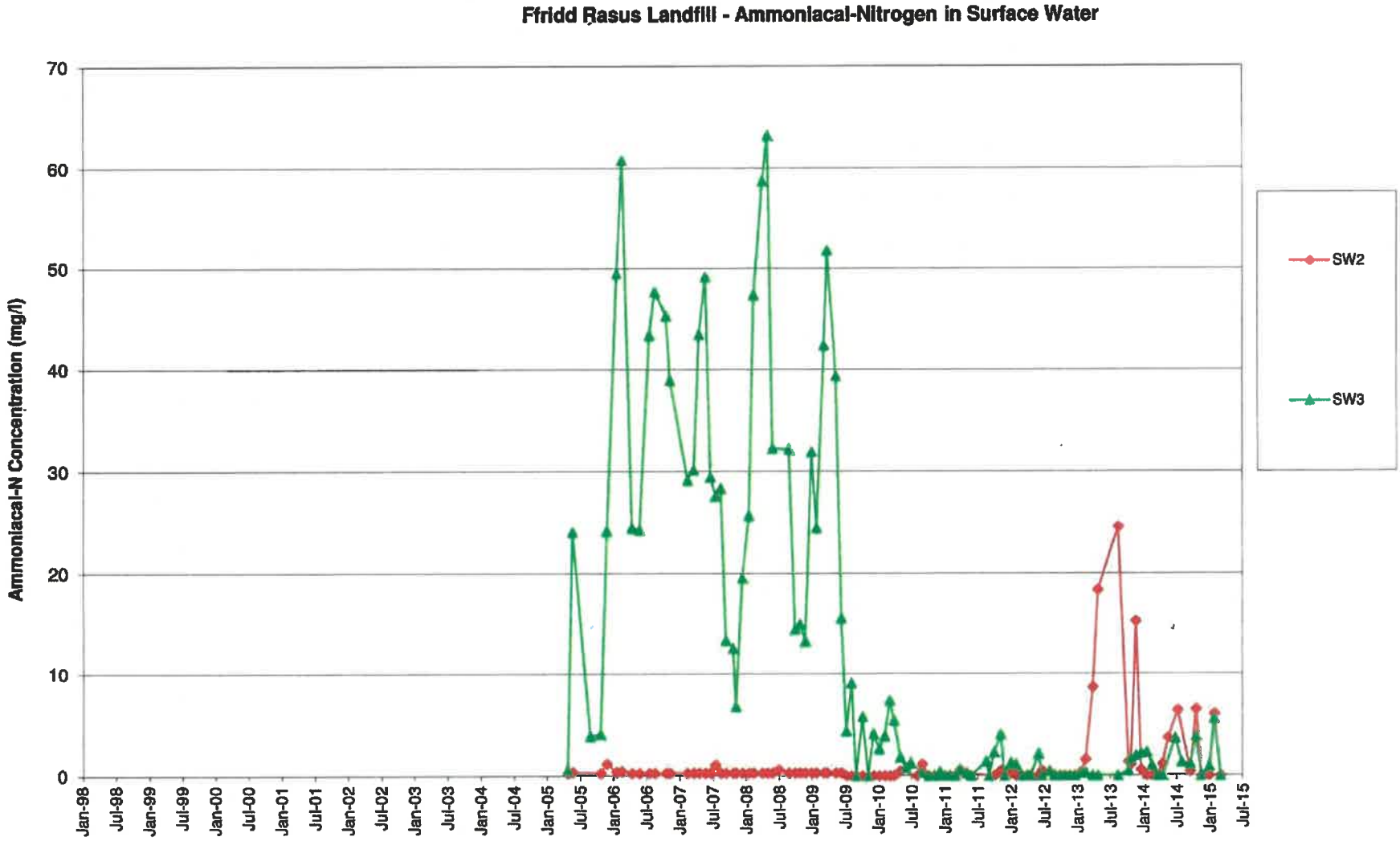
Appendix D
Surface Water Quality Charts

June 2015
Doc Ref. 28587m954i2


Ffridd Rasus Landfill - Chloride in Surface Water
Chloride Concentration (mg/l)
350
300
250
200
150
100
50
0
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
SW1
SW1 Pipe


Ffridd Rasus Landfill - Ammoniacal-Nitrogen in Surface Water
Ammoniacal-N Concentration (mg/l)
80
70
60
50
40
30
20
10
0
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
SW1
SW1 pipe

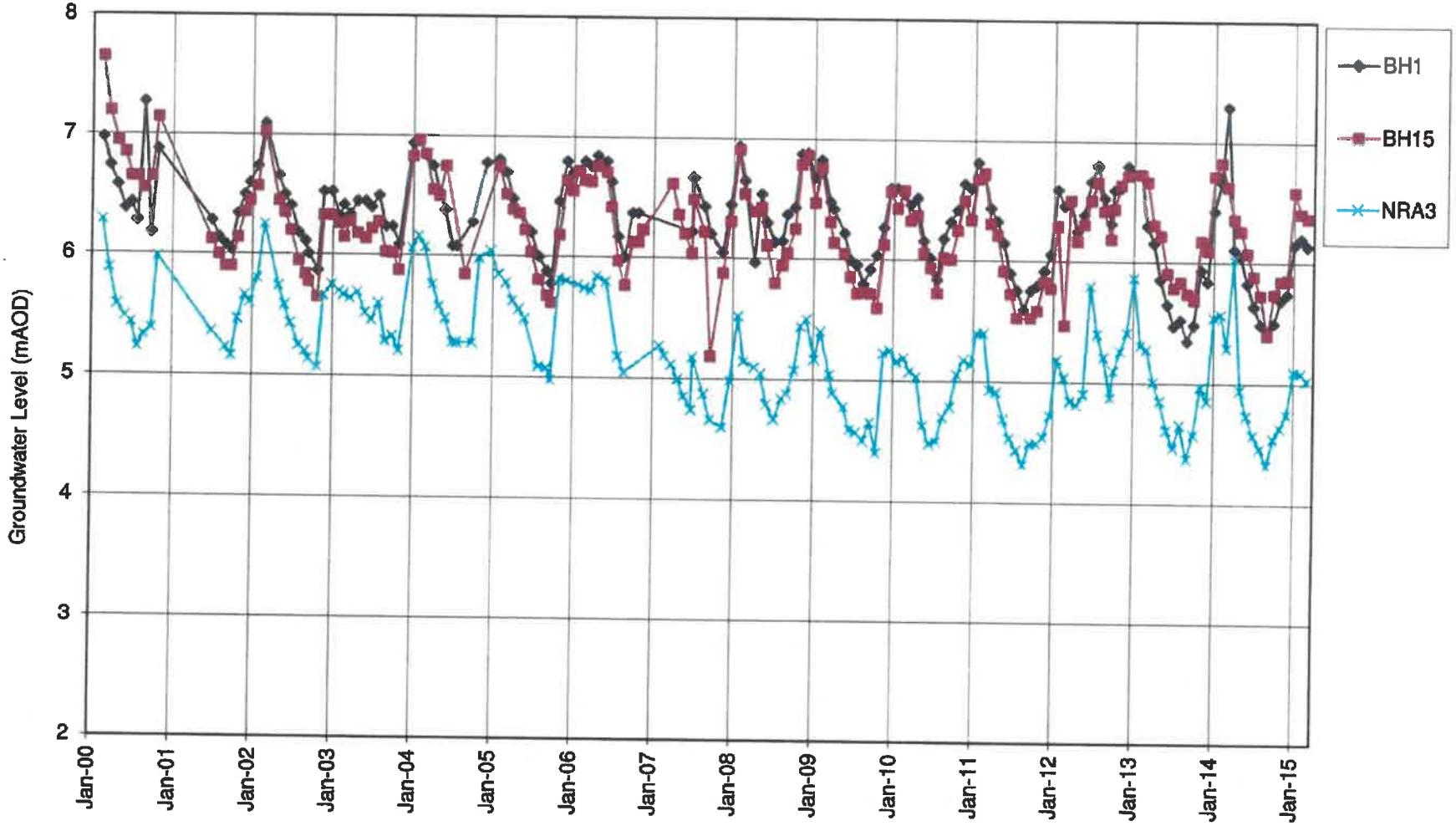

Ffridd Rasus Landfill - Chloride in Surface Water
Chloride Concentration (mg/l)
350
300
250
200
150
100
50
0
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
SW2
SW3


Ffridd Rasus Landfill - Ammoniacal-Nitrogen in Surface Water
Ammoniacal-N Concentration (mg/l)
70
60
50
40
30
20
10
0
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
SW2
SW3

Appendix E
Groundwater Hydrographs

June 2015
Doc Ref. 28587rr954i2

Ffridd Rasus Landfill - Groundwater Levels (Boreholes drilled pre-2004)



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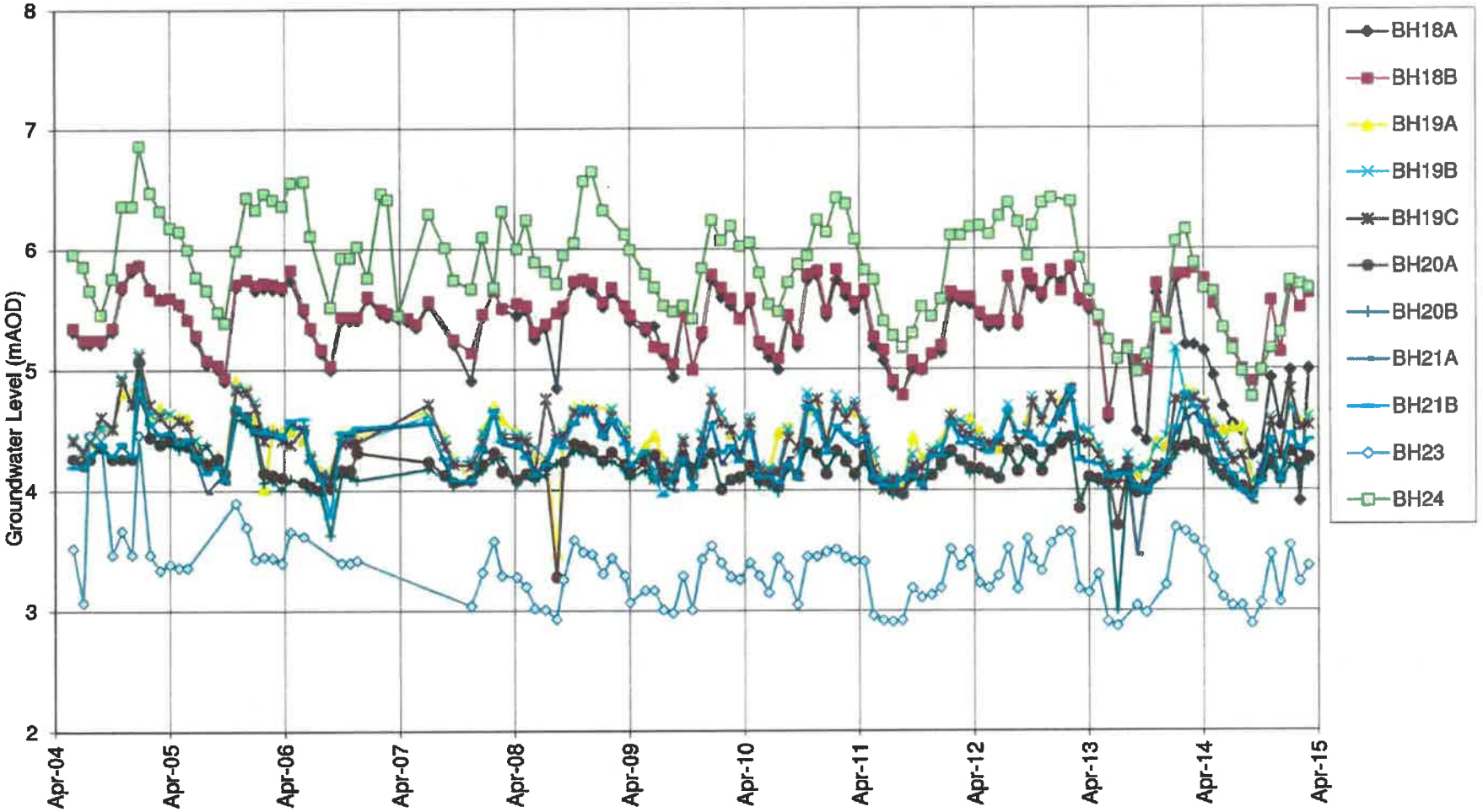
- water level old bhs

Ffridd Rasus Landfill - Groundwater Levels (Boreholes drilled in 2004)



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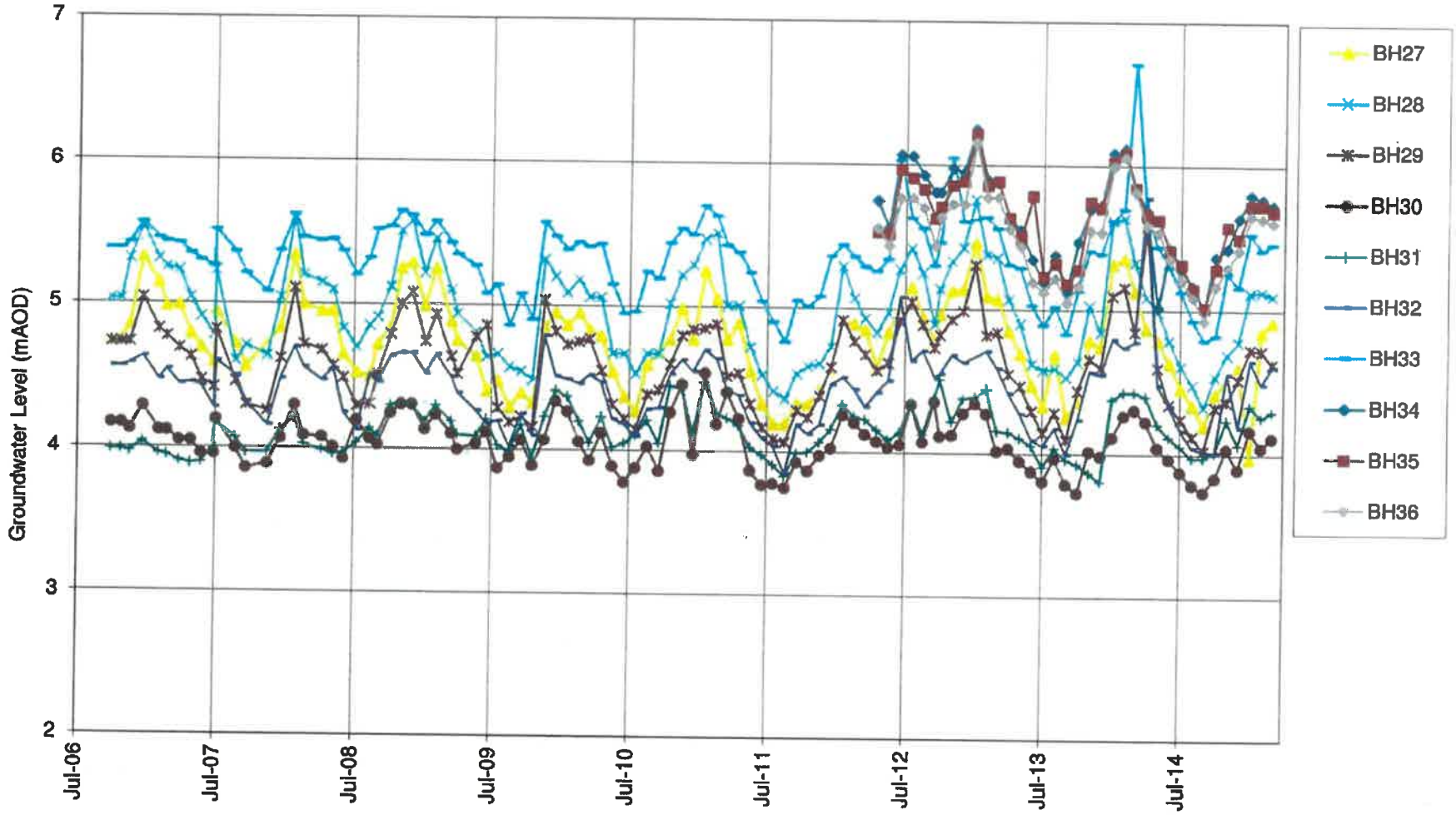
Ffridd Rasus Landfill - Groundwater Levels (Boreholes drilled in 2006 and 2012)



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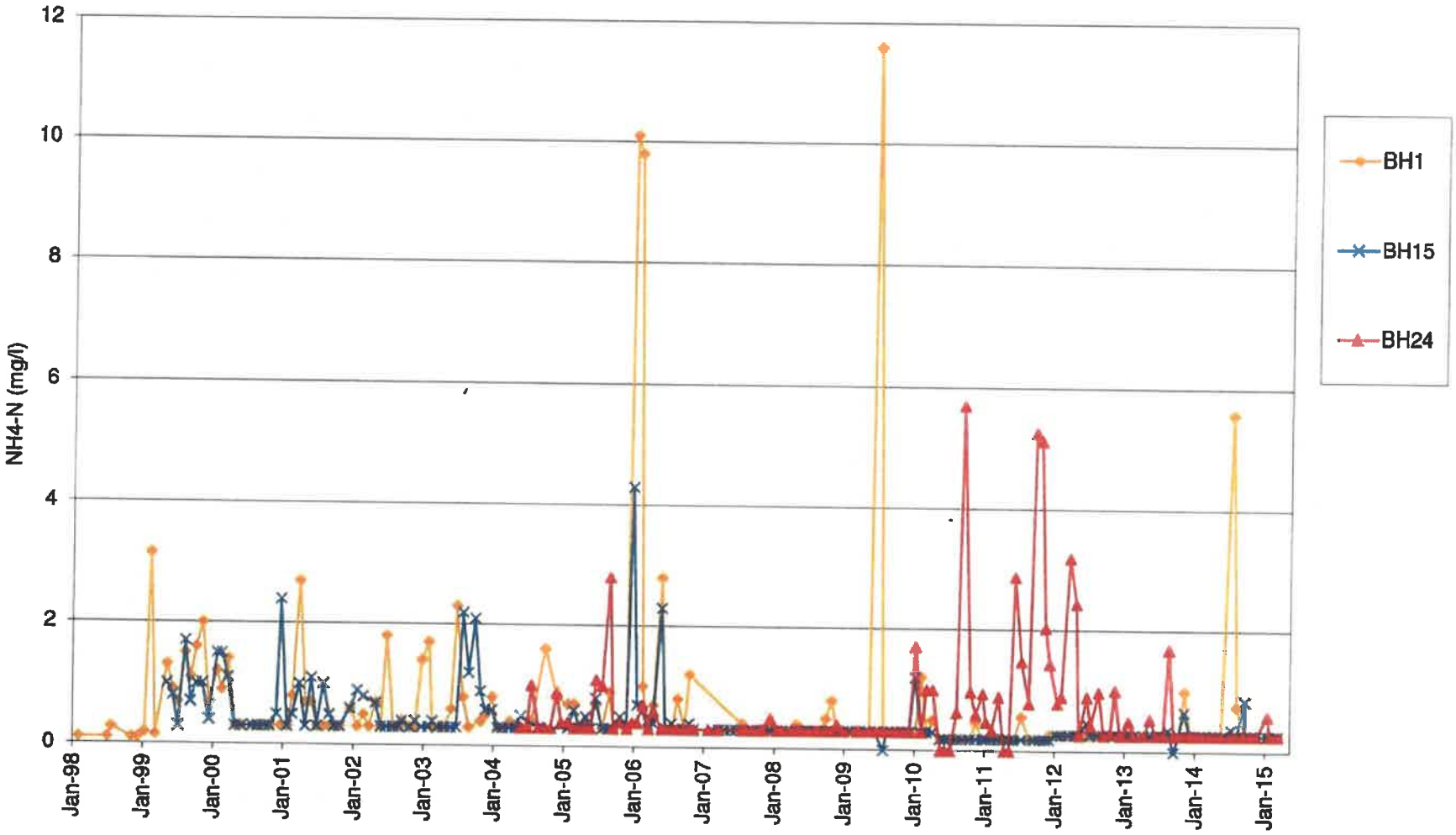
- Ffridd Rasus Groundwater.xls

Appendix F
Groundwater Quality Charts

June 2015
Doc Ref. 28587rr954i2

Ffridd Rasus Landfill - Ammoniacal Nitrogen in Boreholes Upgradient of Areas 2 and 3



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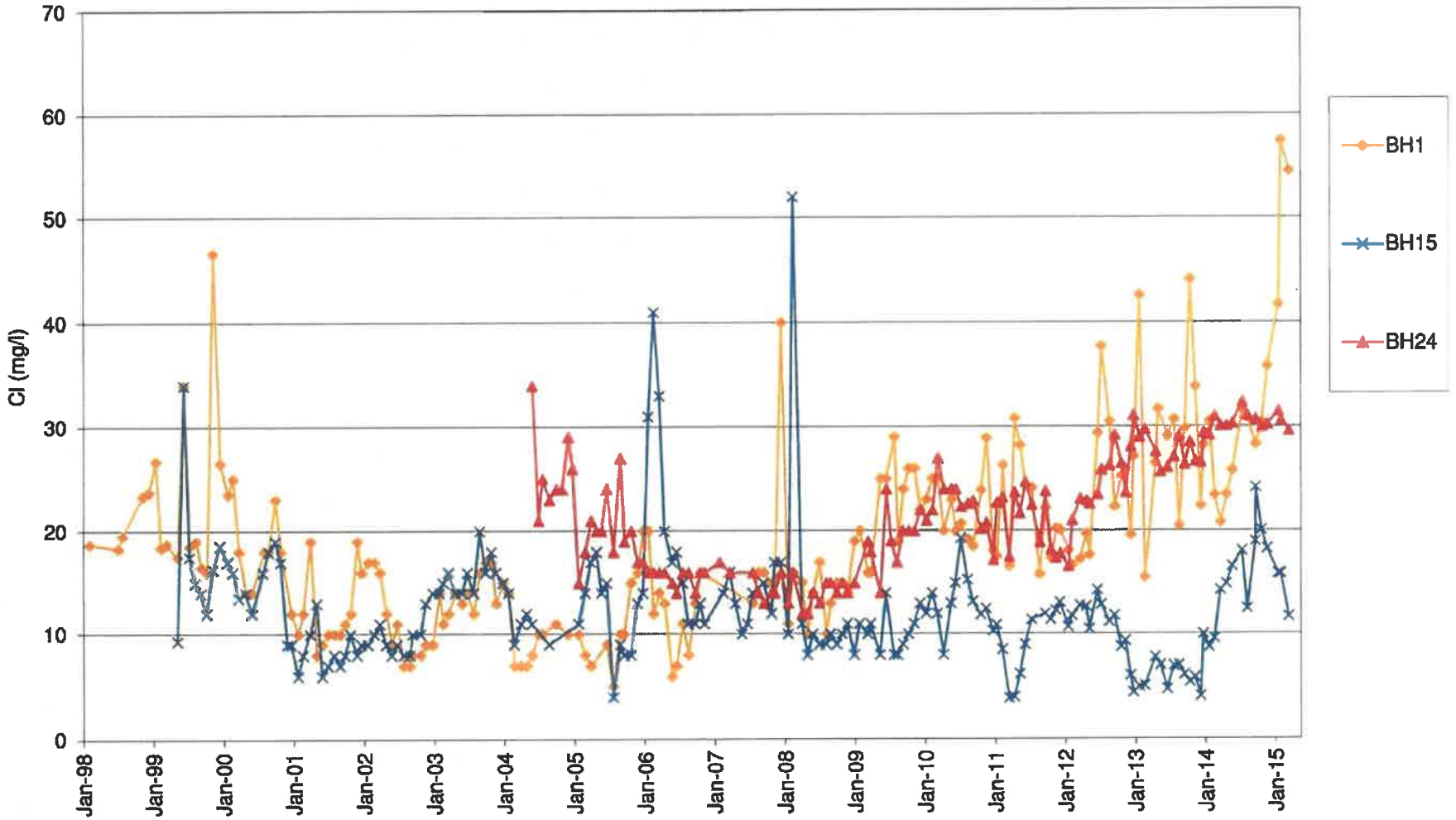
Ffridd Rasus Landfill - Chloride in Boreholes Upgradient of Areas 2 and 3



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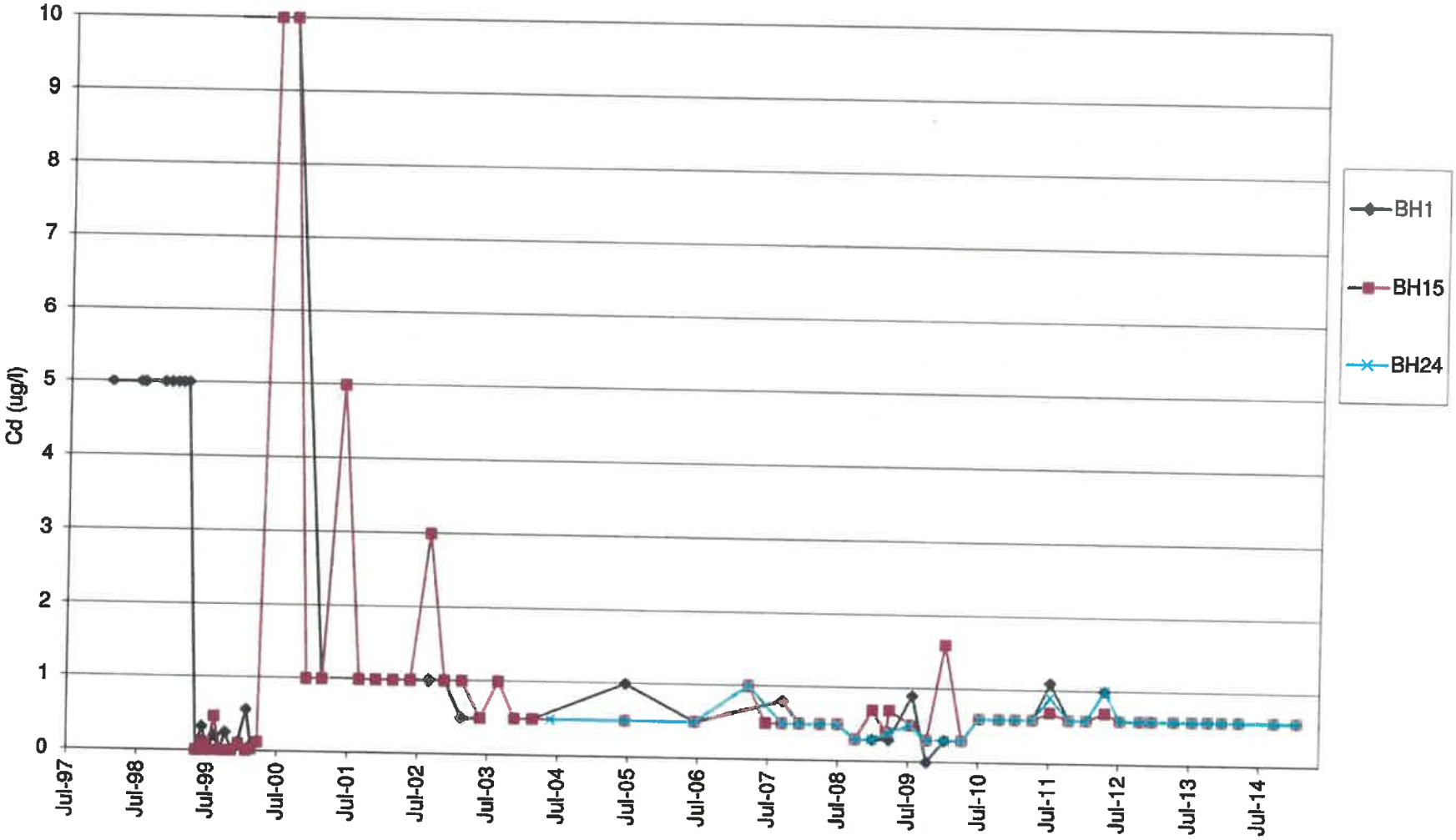
Ffridd Rasus Landfill - Cadmium in Boreholes Upgradient of Areas 2 and 3



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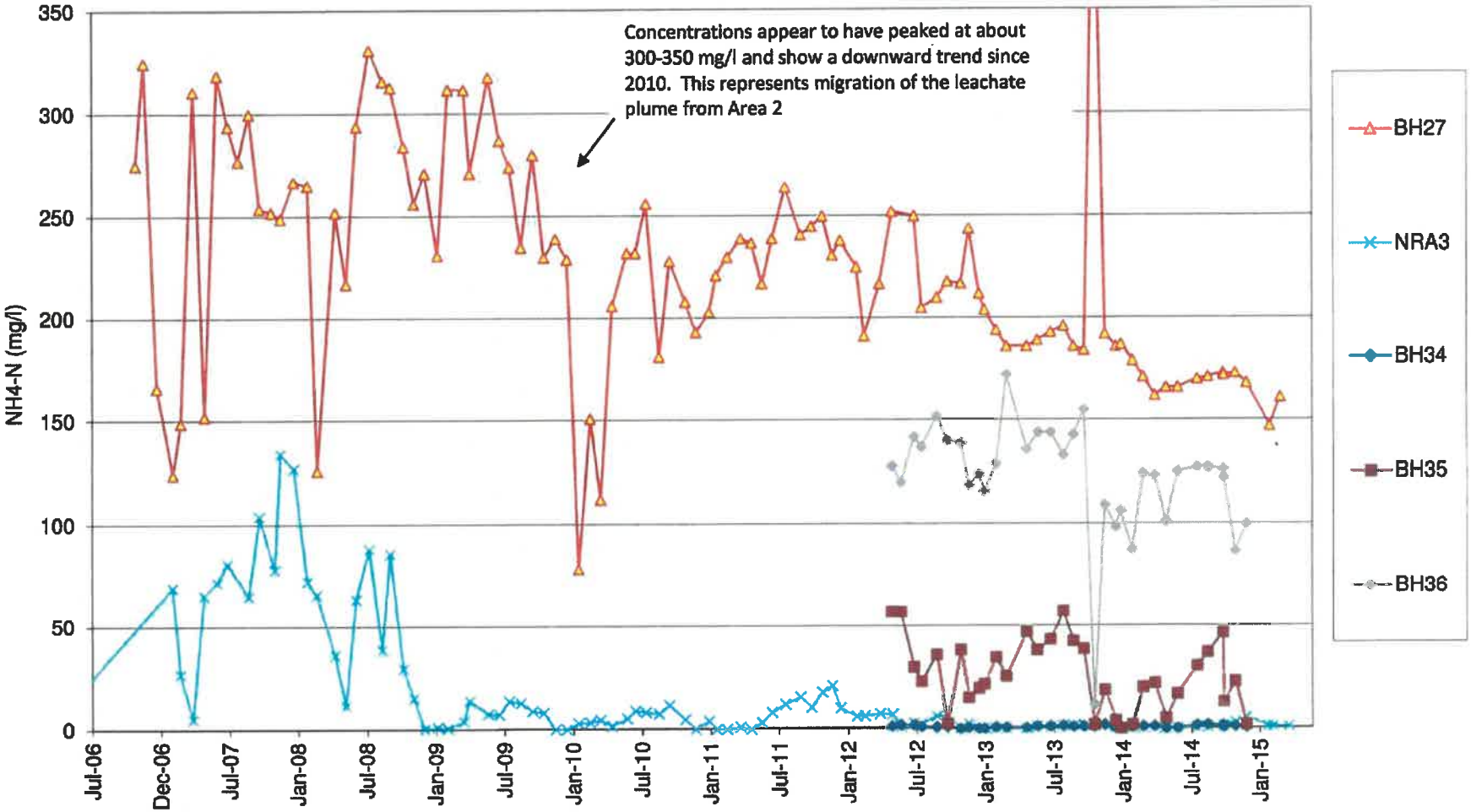
Ffridd Rasus Landfill - Ammoniacal Nitrogen in Boreholes Upgradient of Area 3 & Downgradient of Area 2



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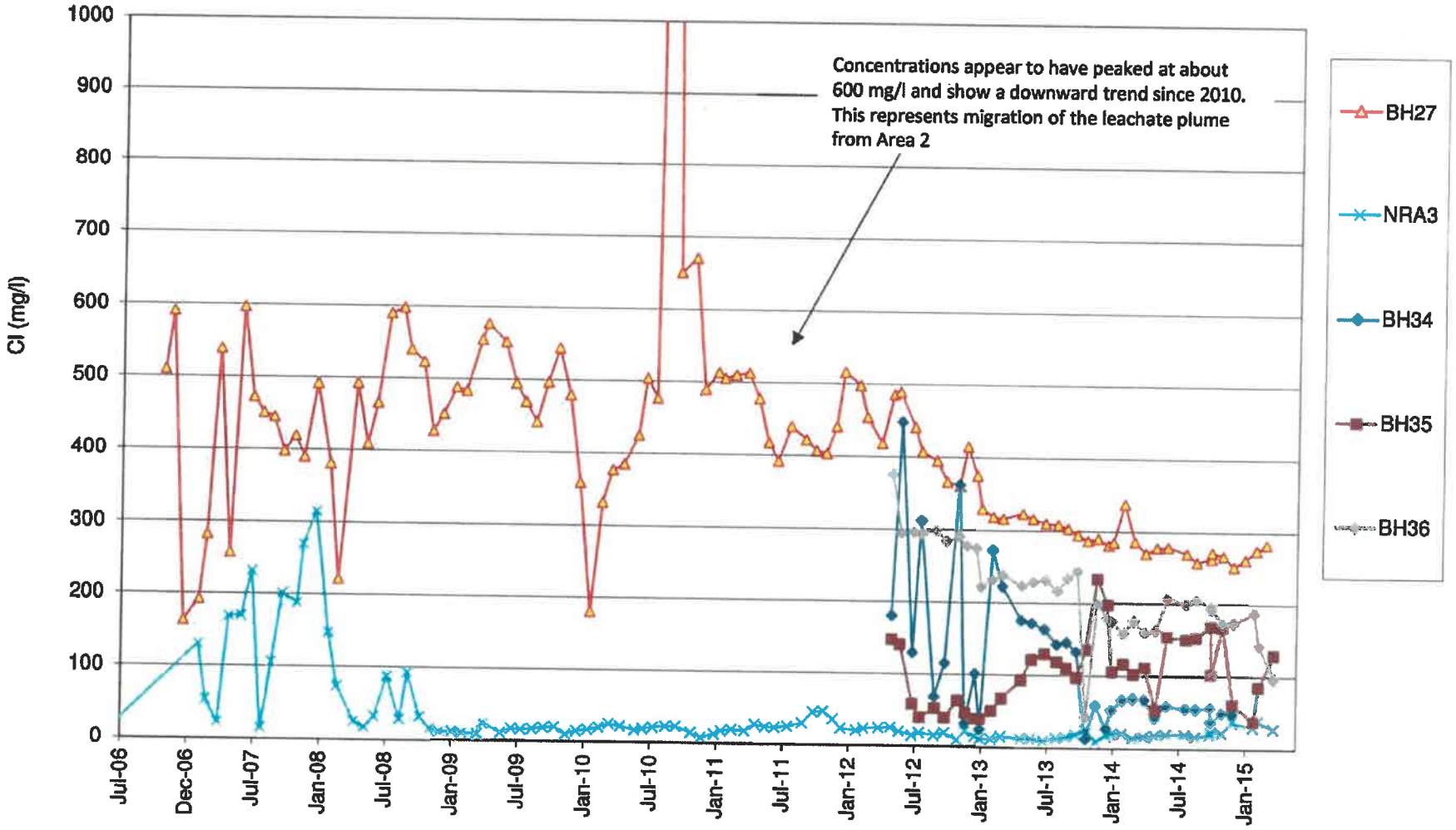
Ffridd Rasus Landfill - Chloride in Boreholes Upgradient of Area 3 & Downgradient of Area 2



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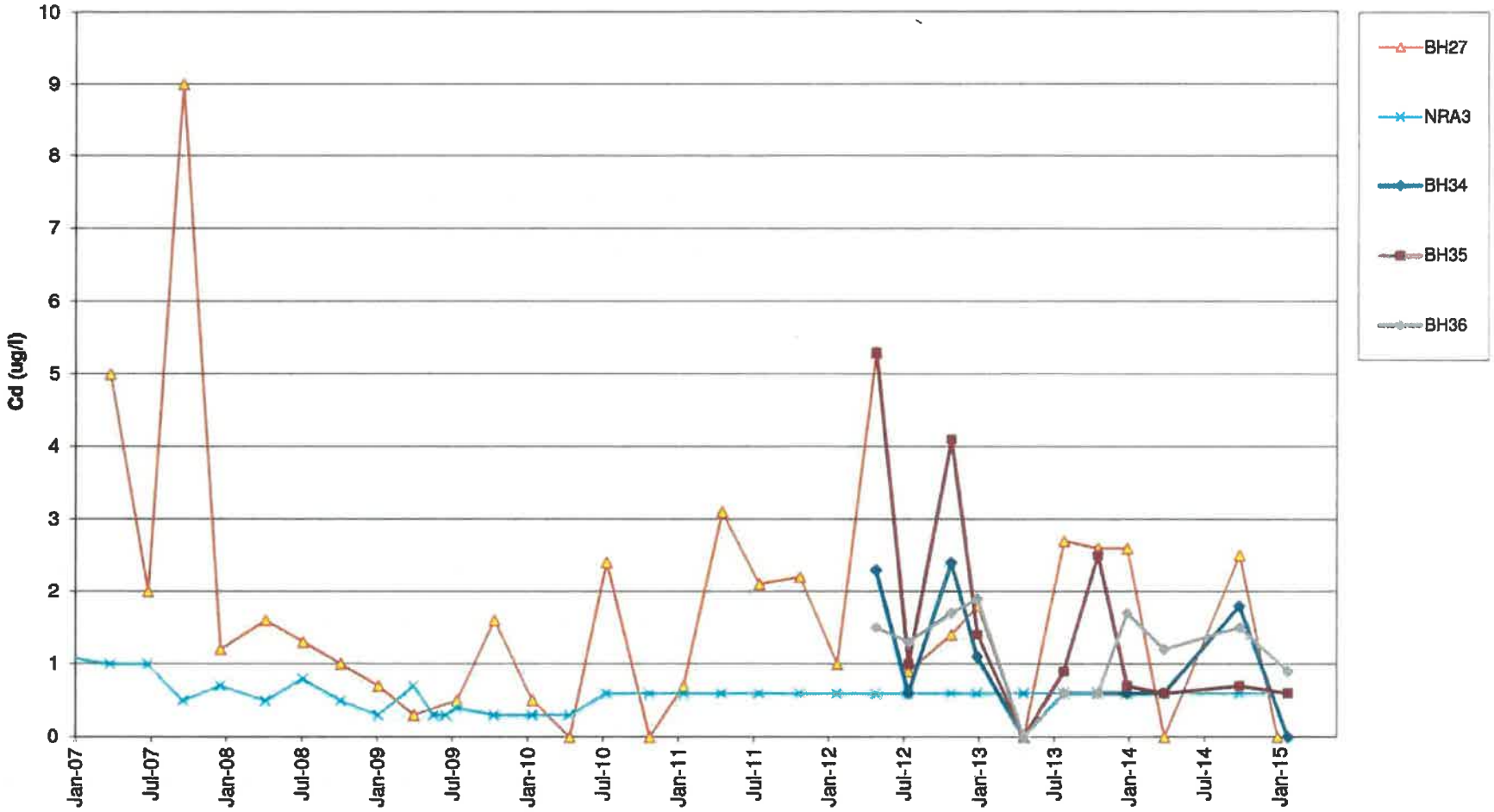
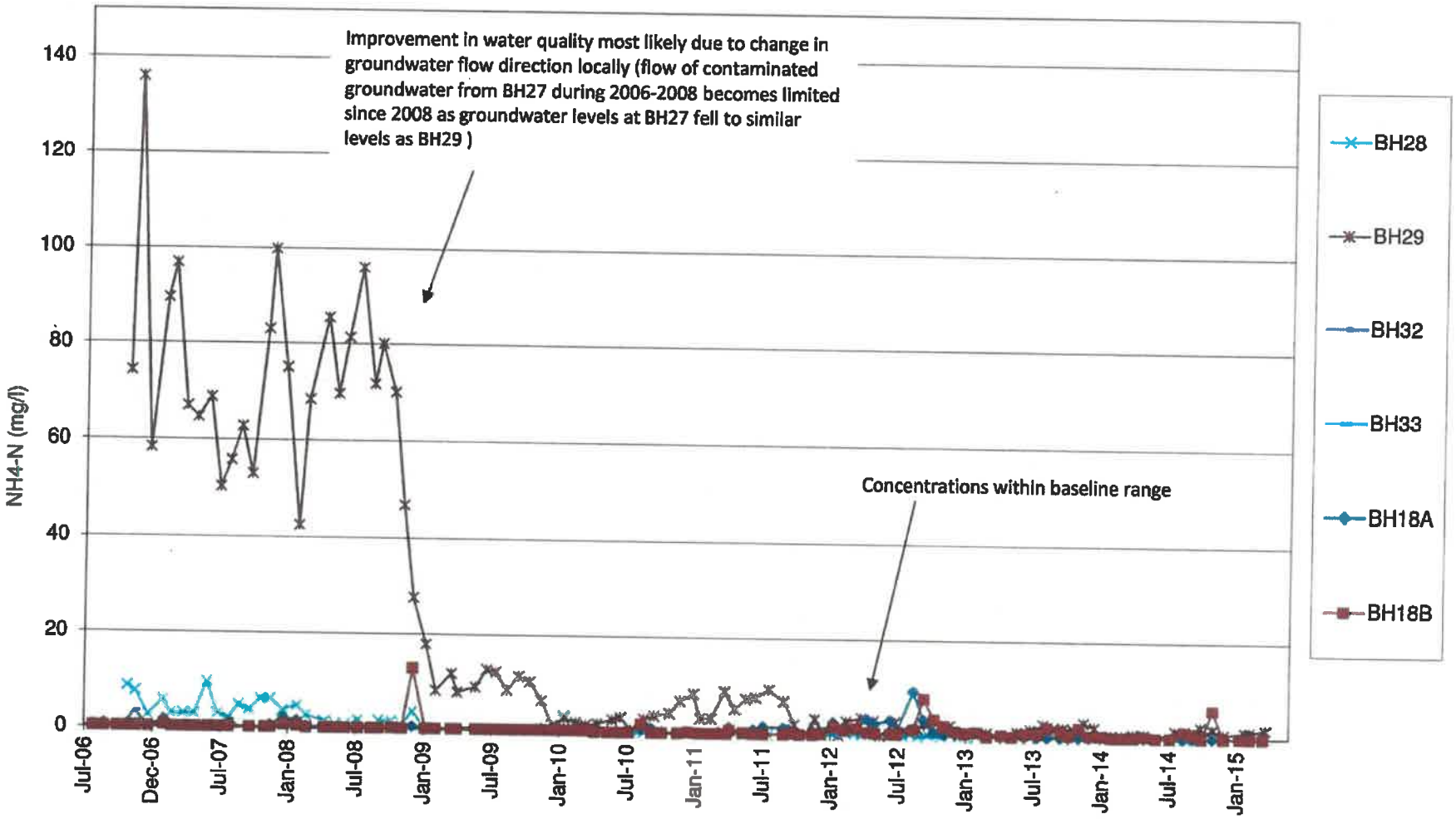
Ffridd Rasus Landfill - Cadmium in Boreholes Upgradient of Area 3 & Downgradient of Area 2



Ffridd Rasus Landfill - Ammoniacal Nitrogen in Boreholes Lateral to Groundwater Flow



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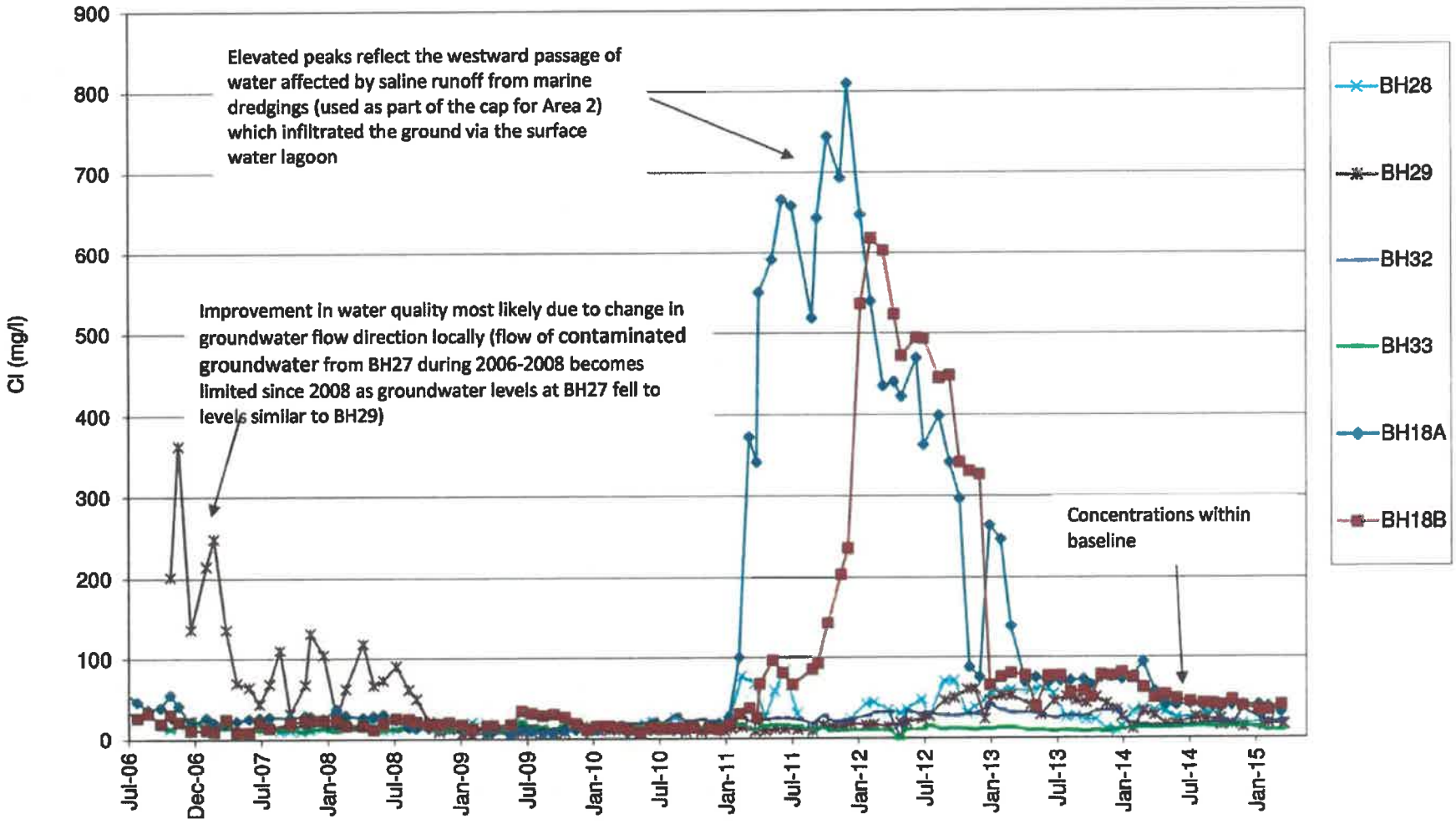
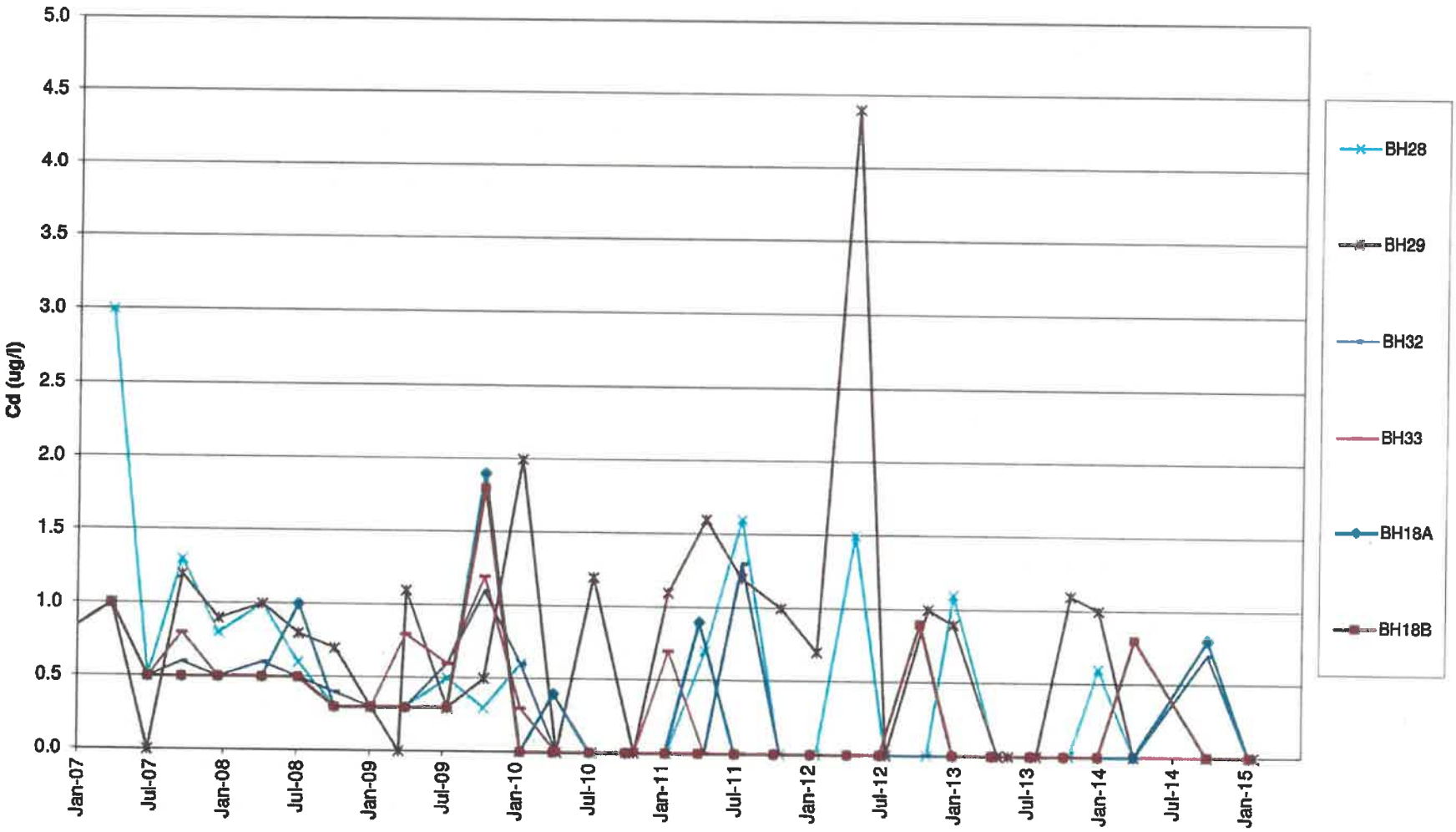
- Lat NH4

Ffridd Rasus Landfill - Chloride in Boreholes Lateral to Groundwater Flow



Ffridd Rasus Landfill - Cadmium in Boreholes Lateral to Groundwater Flow



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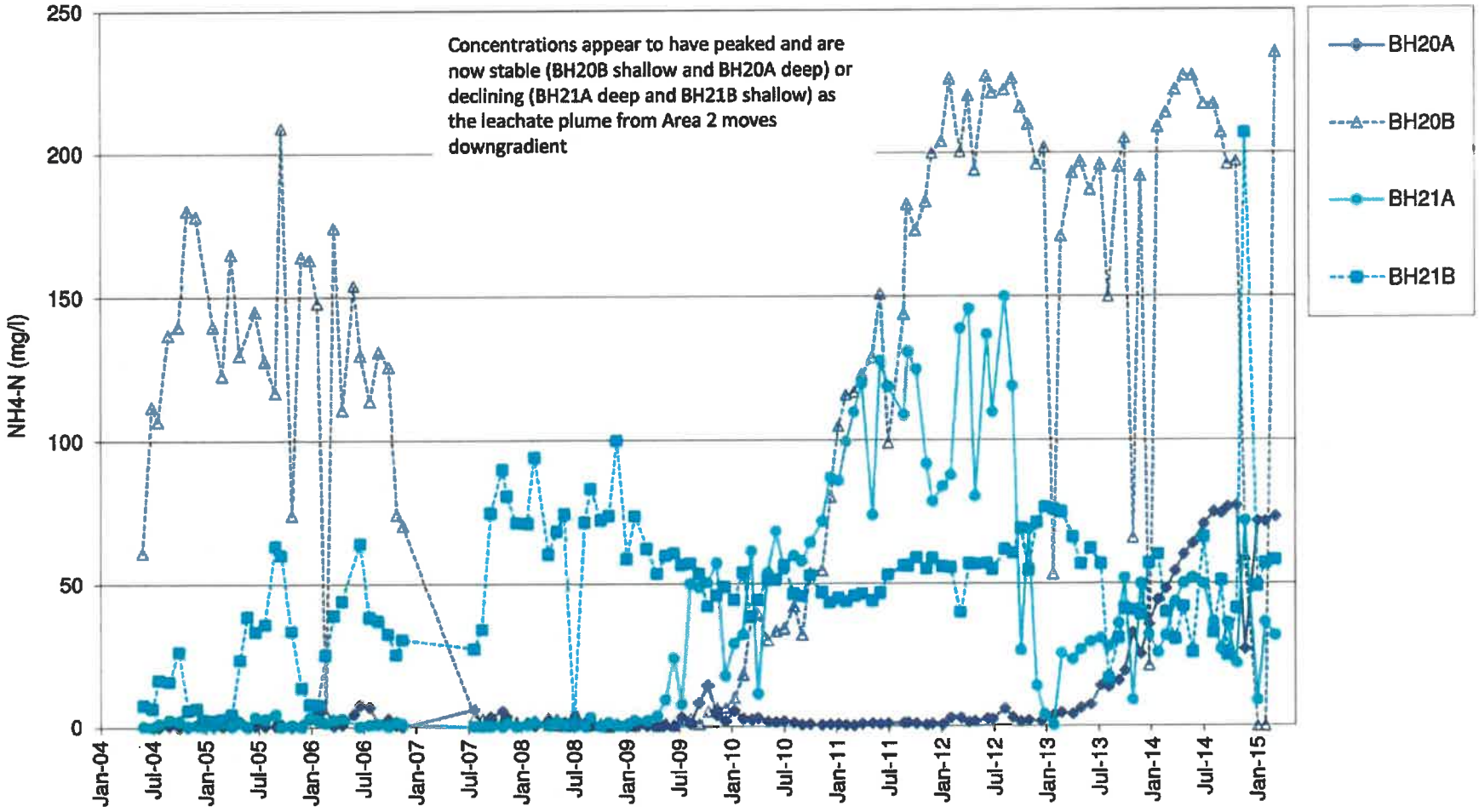
Ffridd Rasus Landfill - Ammoniacal Nitrogen in Boreholes Downgradient of Areas 2&3 (BH20A/B & BH21A/B)



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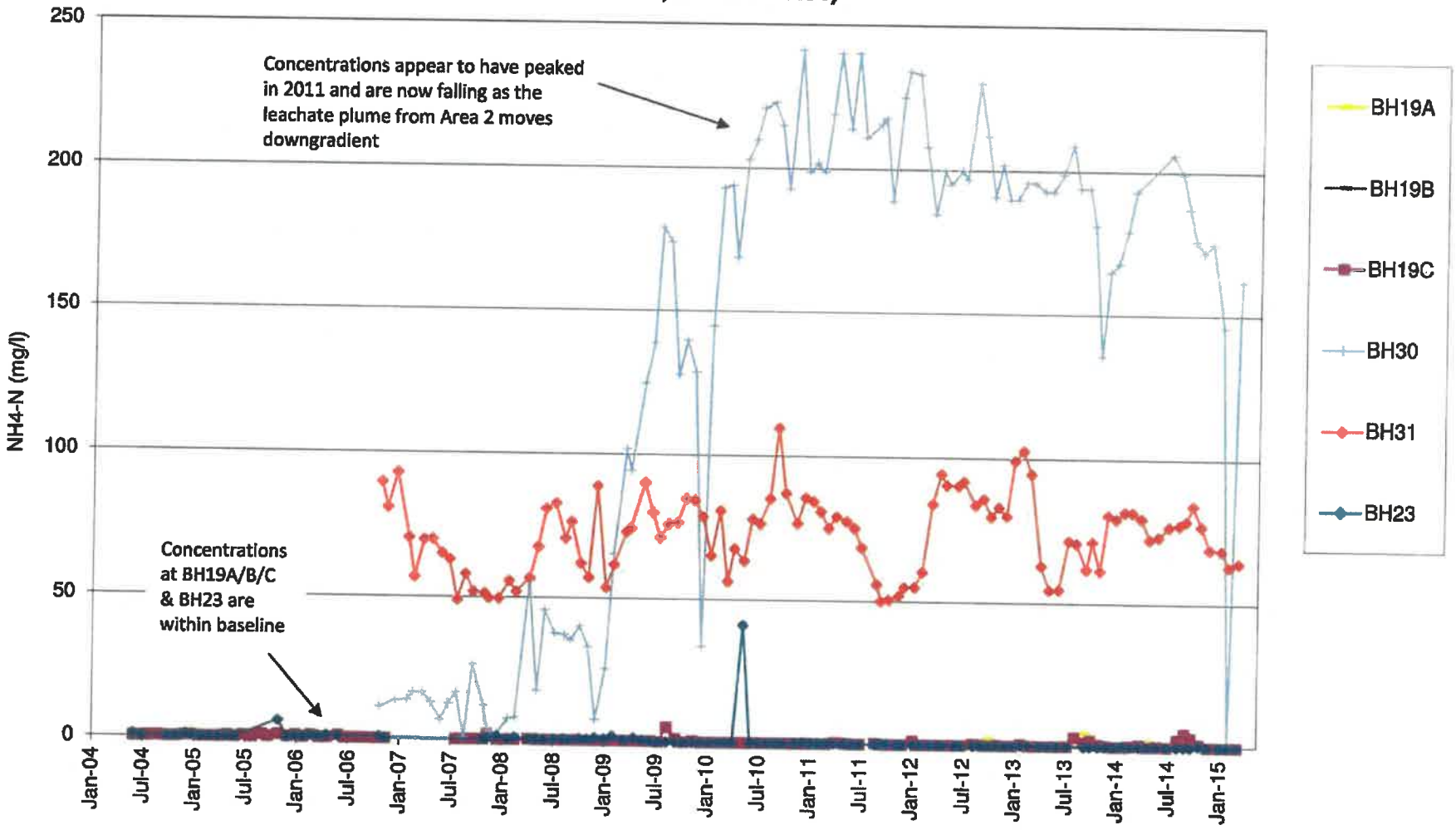

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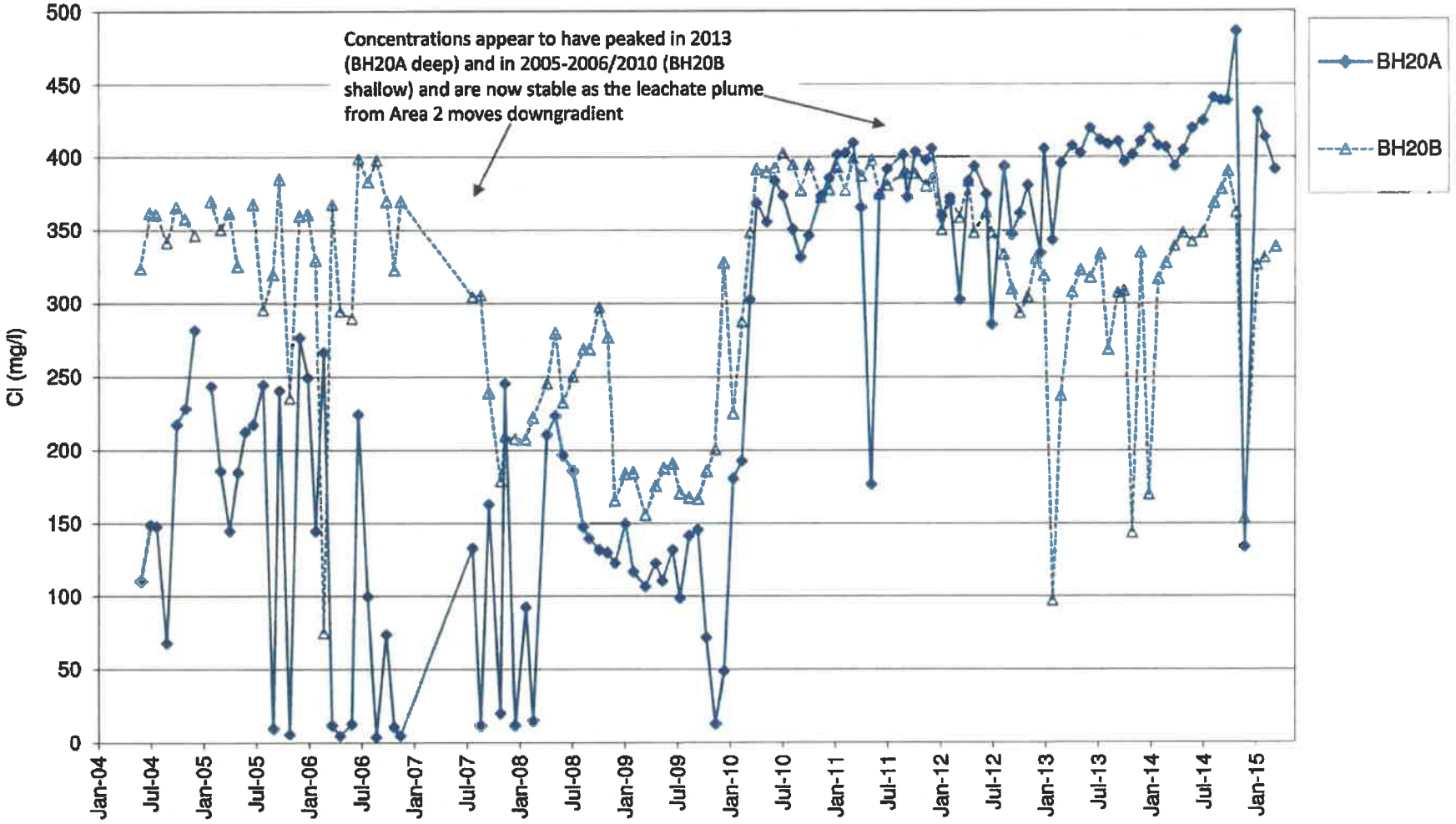
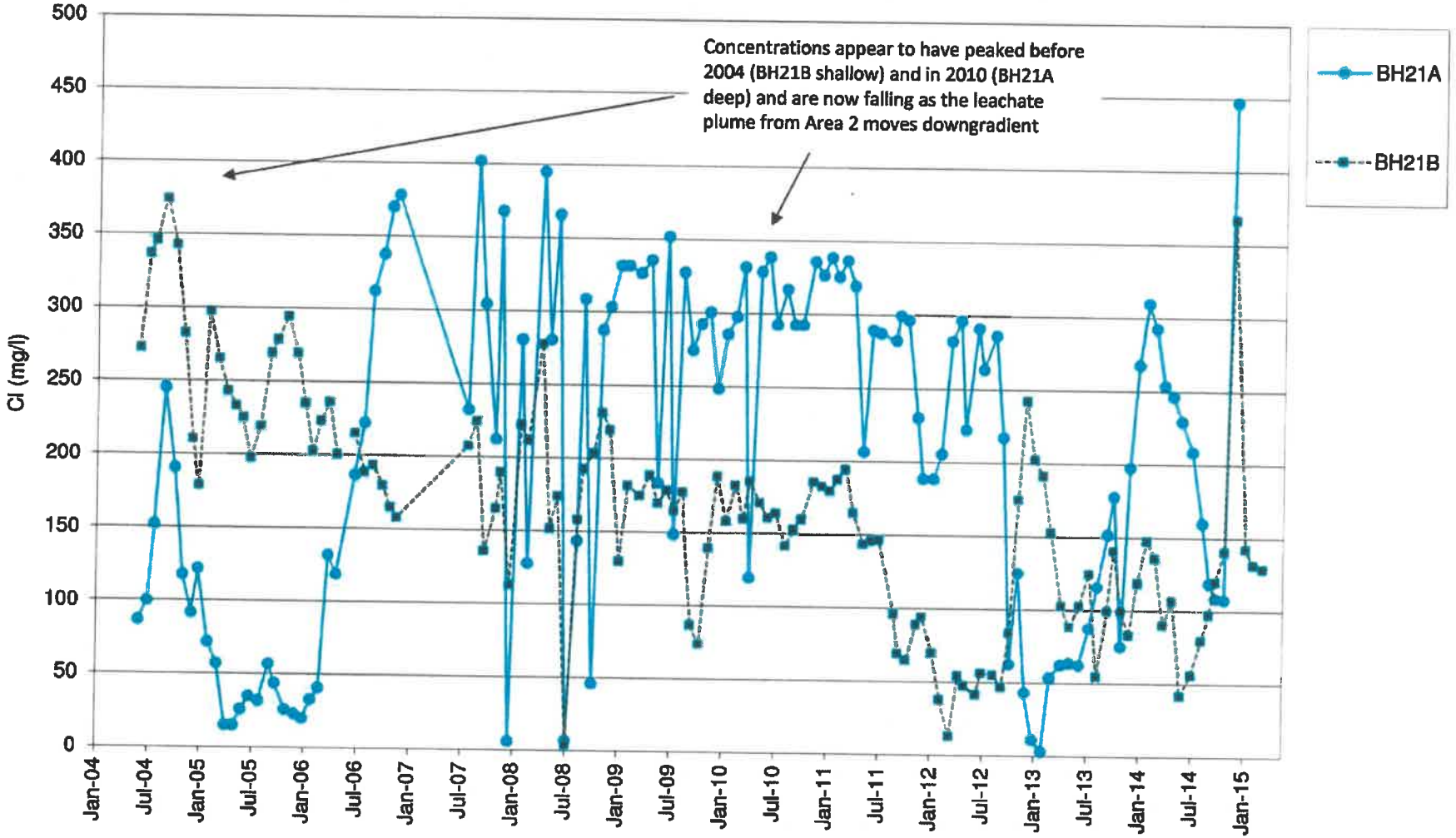


Ffridd Rasus Landfill - Chloride in Boreholes Downgradient of Areas 2&3 (BH21A/B)



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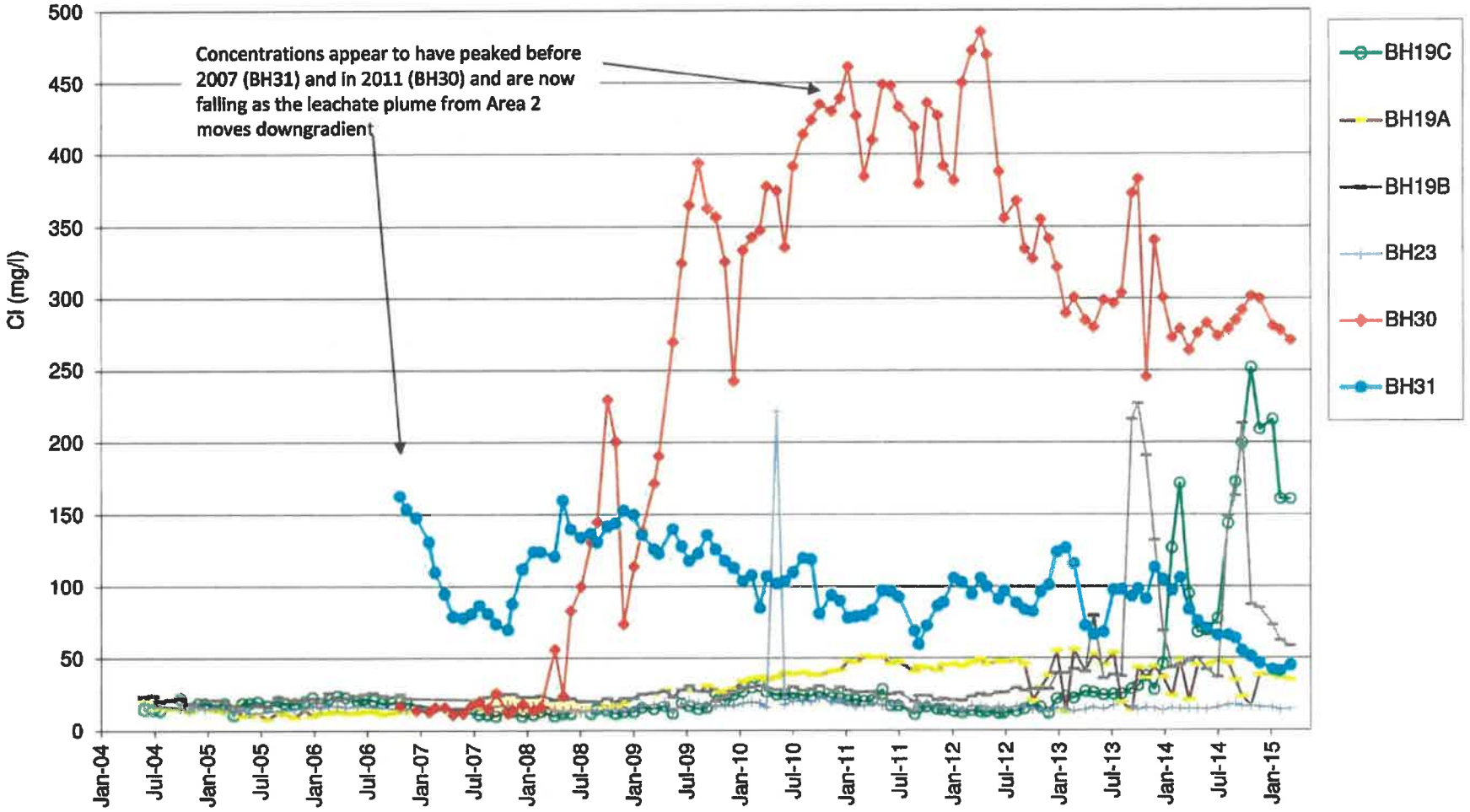
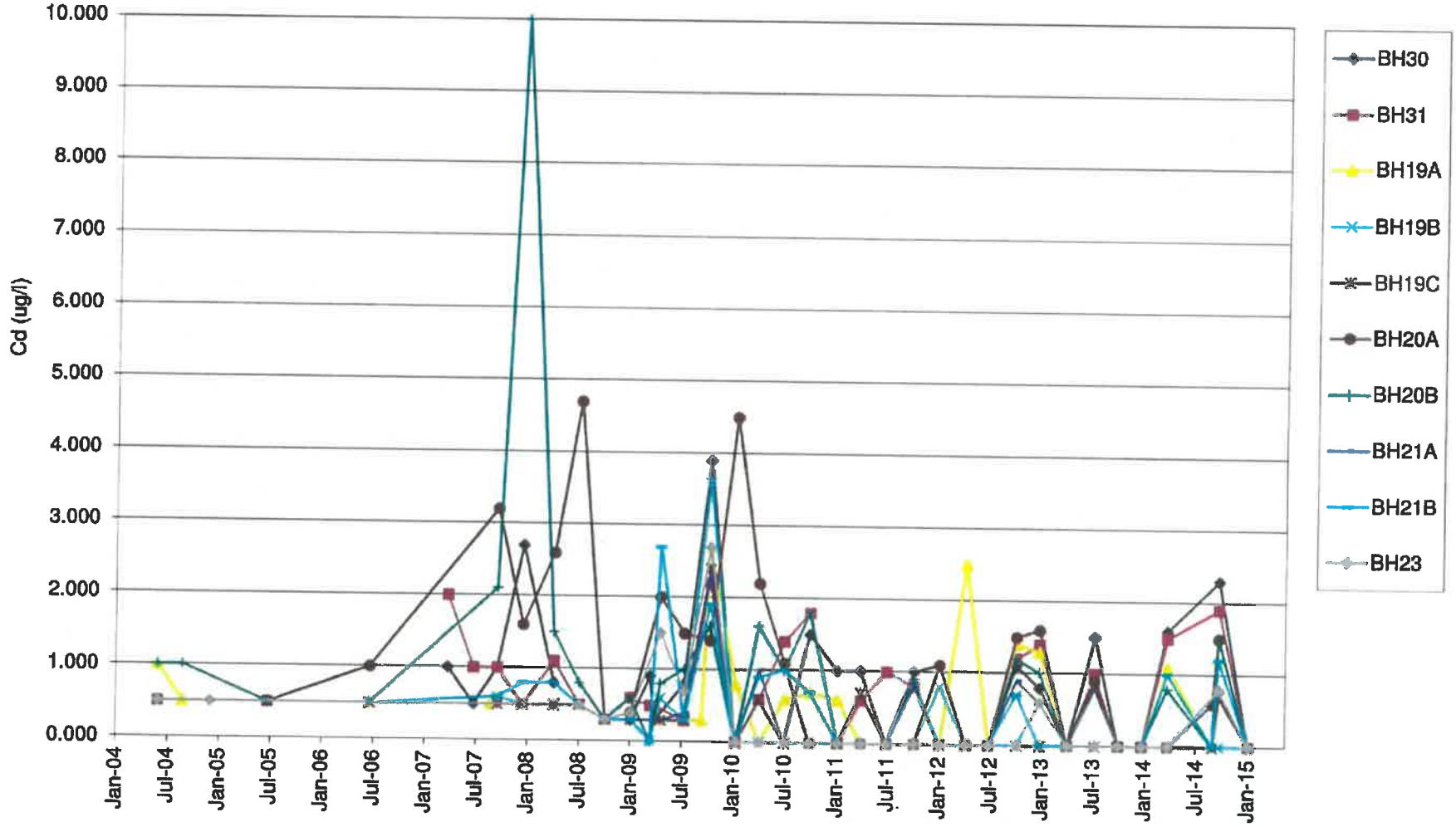
Ffridd Rasus Landfill - Chloride in Groundwater in Boreholes Downgradient of Areas 2&3 (BH19A/B/C, BH23, BH30 & BH31)



Ffridd Rasus Landfill - Cadmium in Boreholes Downgradient of Areas 2&3



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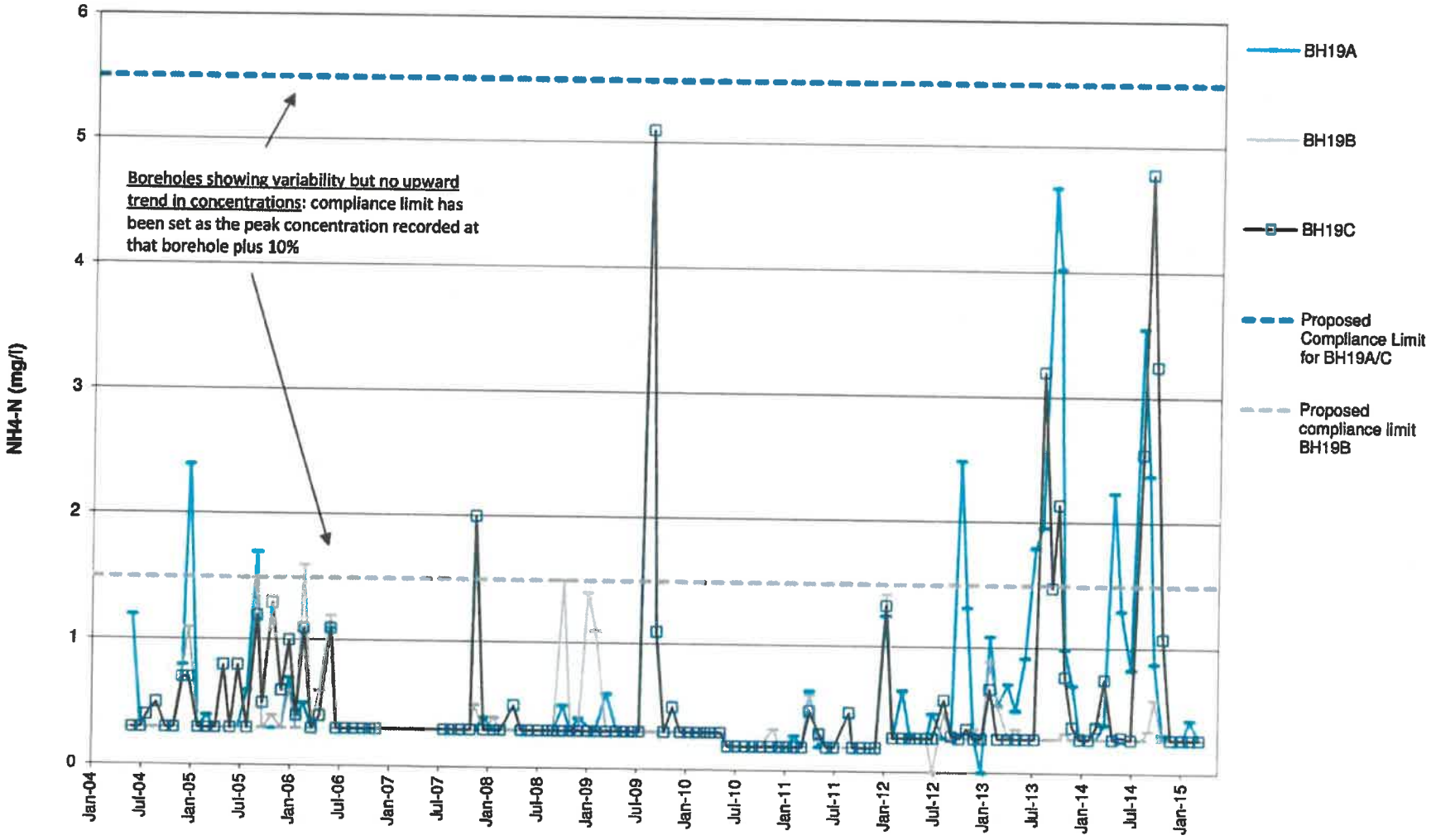
- DG Cd

Appendix G
Proposed Groundwater Compliance Limits

June 2015
Doc Ref. 28587rr954i2

Ffridd Rasus Landfill - Proposed Compliance Limits for Ammoniacal Nitrogen at Boreholes BH19A/B/C



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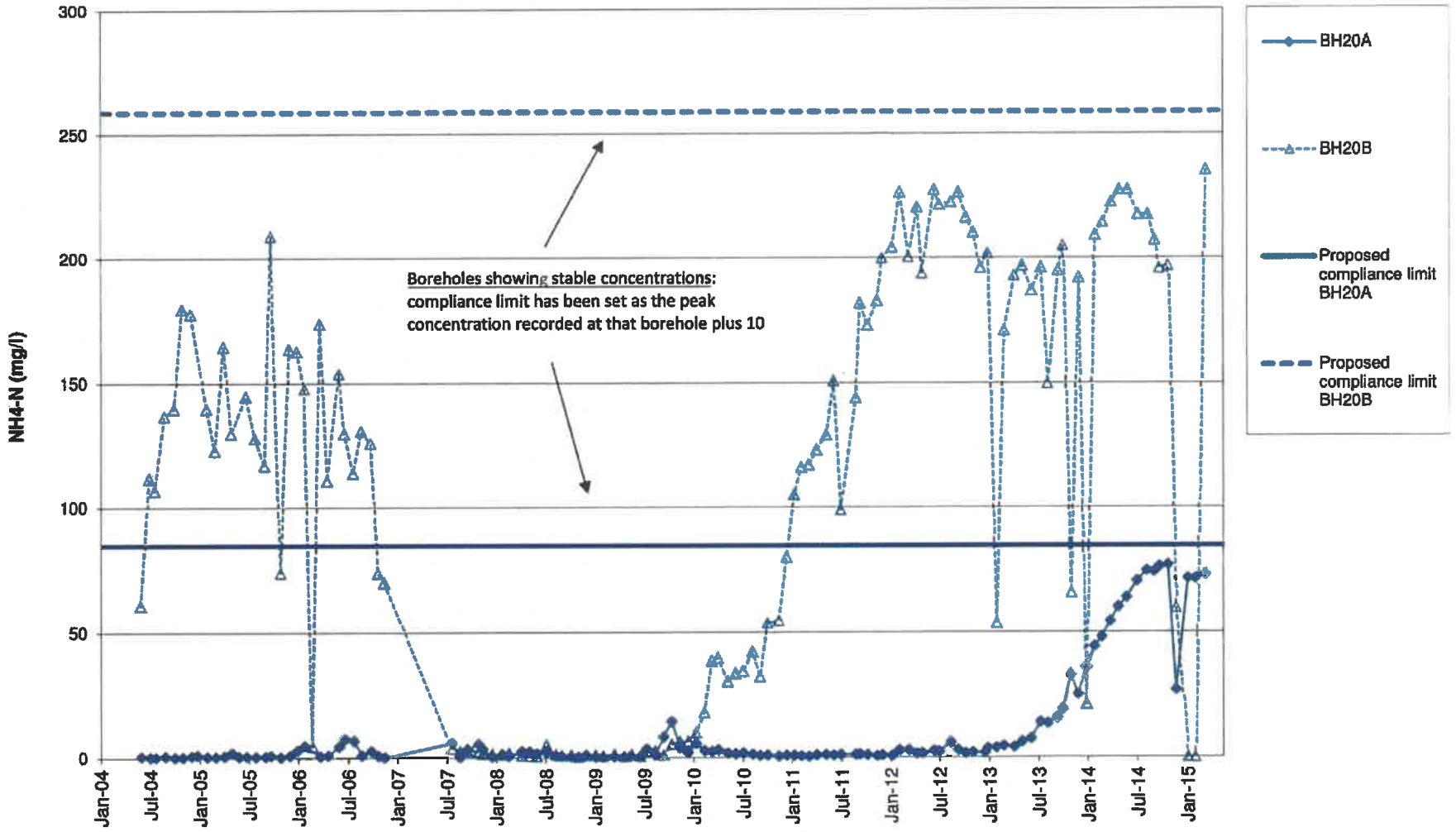
Ffridd Rasus Landfill - Proposed Compliance Limits for Ammoniacal Nitrogen at Boreholes BH20A/B



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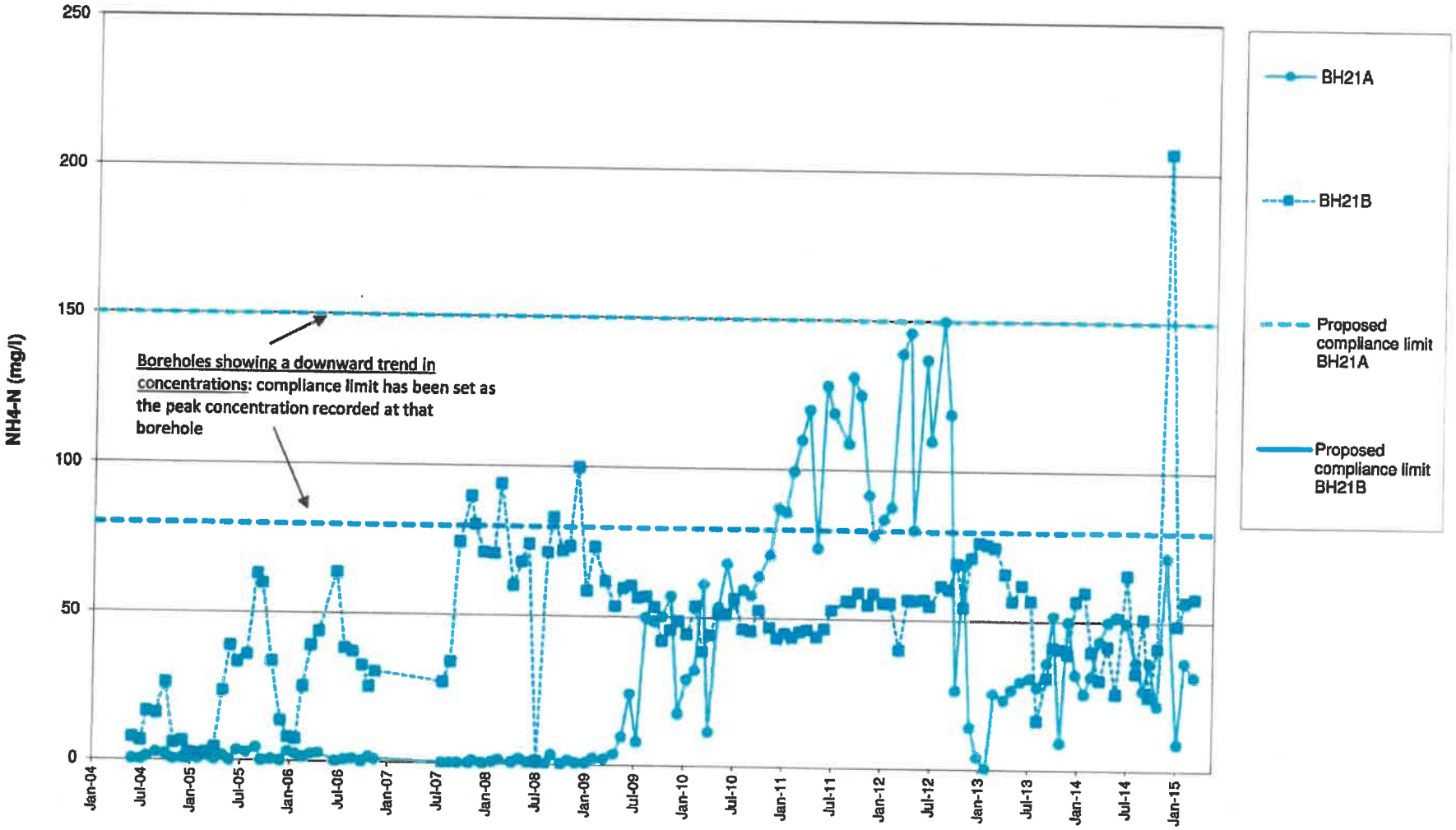
Ffridd Rasus Landfill - Proposed Compliance Limits for Ammoniacal Nitrogen at Boreholes BH21A/B



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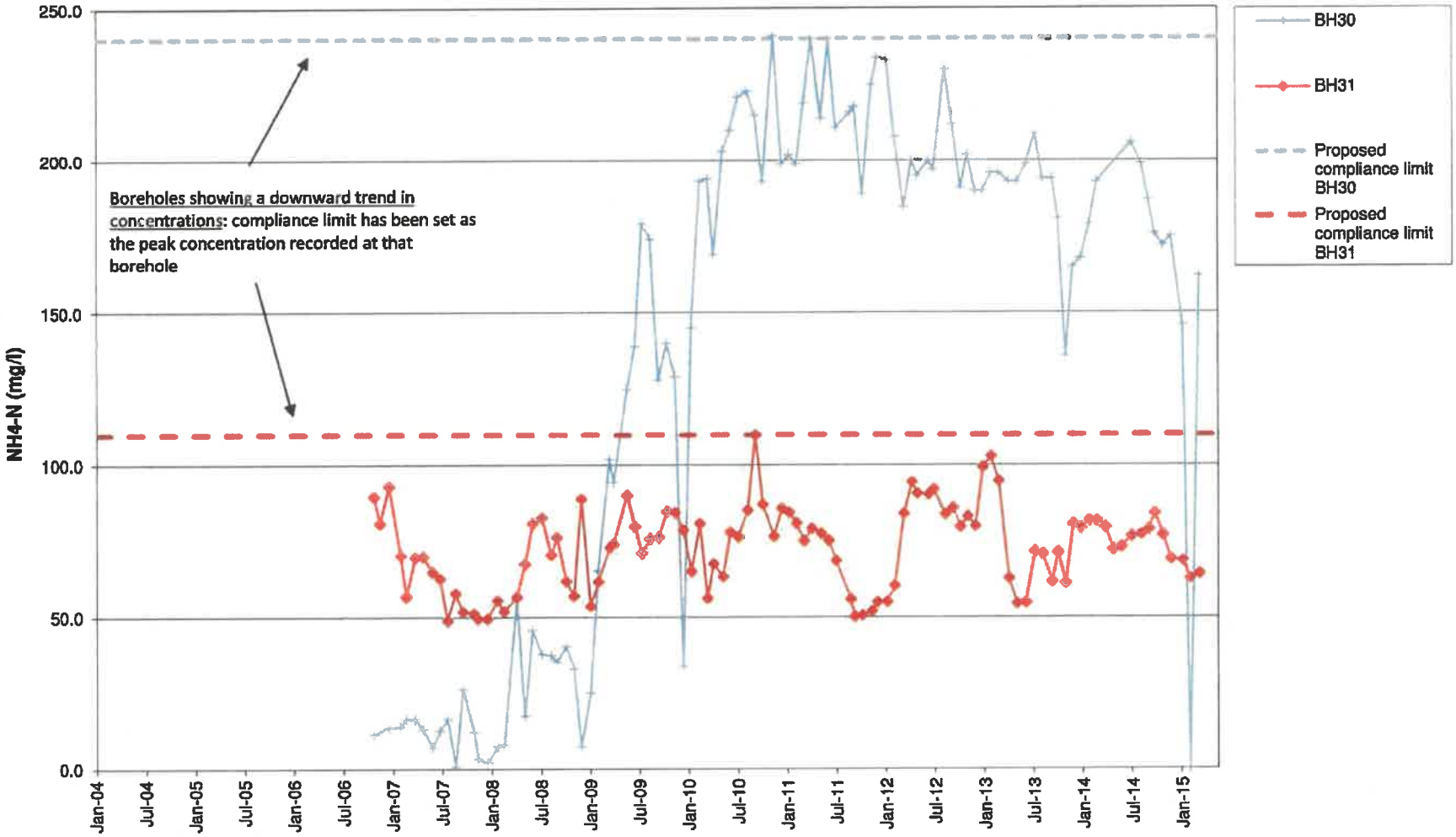
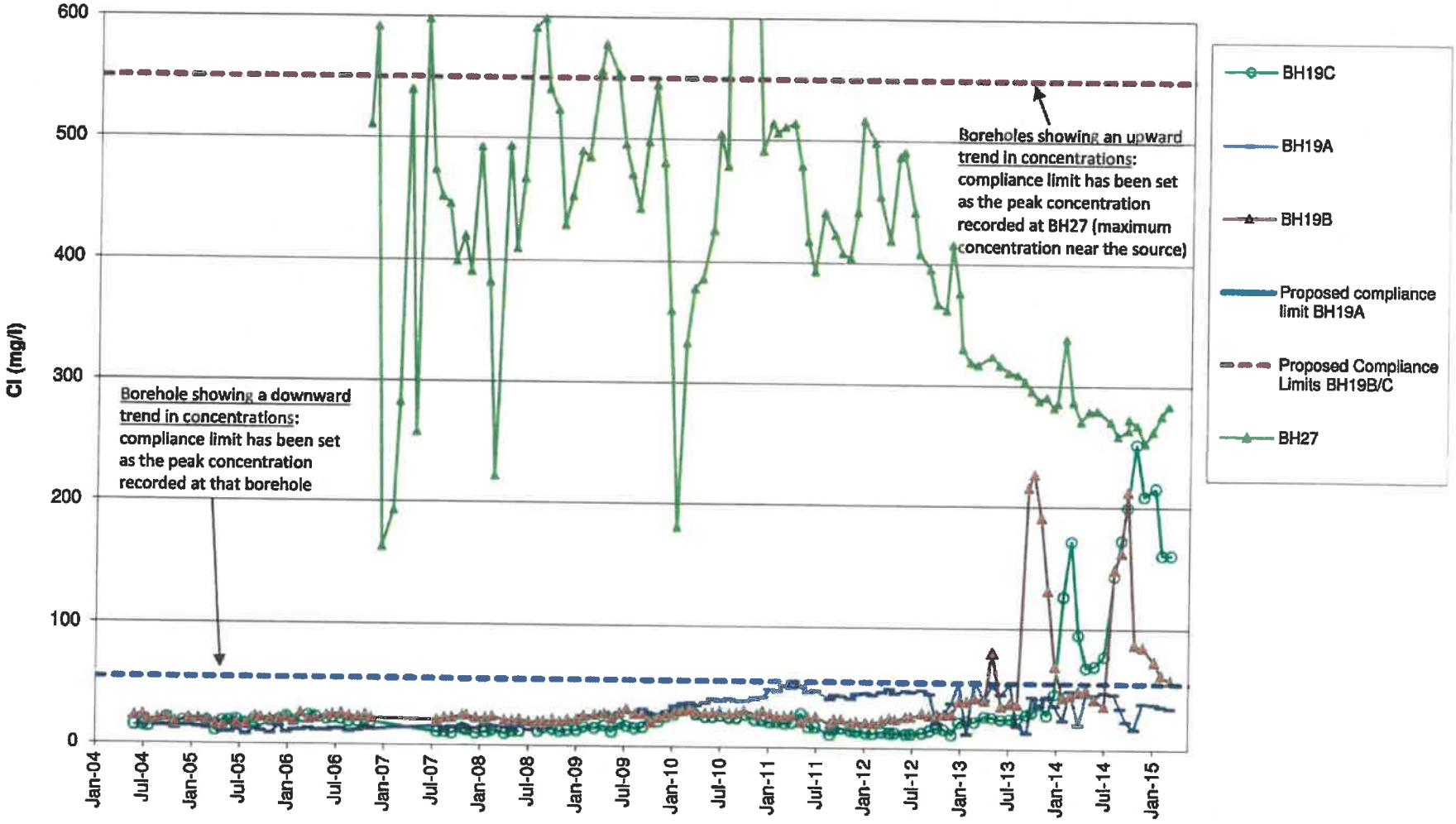
Ffridd Rasus Landfill - Proposed Compliance Limits for Ammoniacal Nitrogen at Boreholes BH30 & BH31



Ffridd Rasus Landfill - Proposed Compliance Limits for Chloride at Boreholes BH19A/B/C



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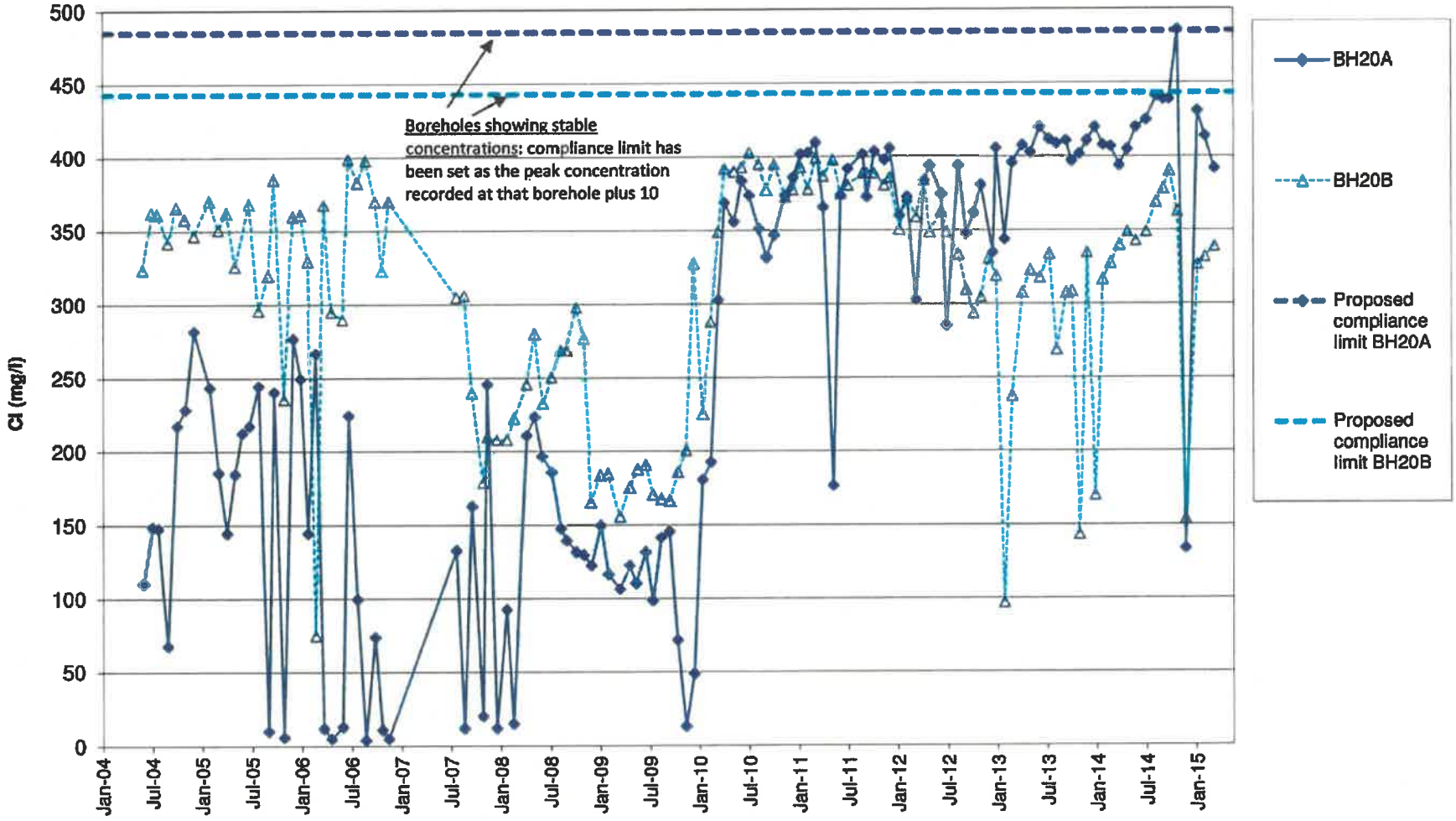

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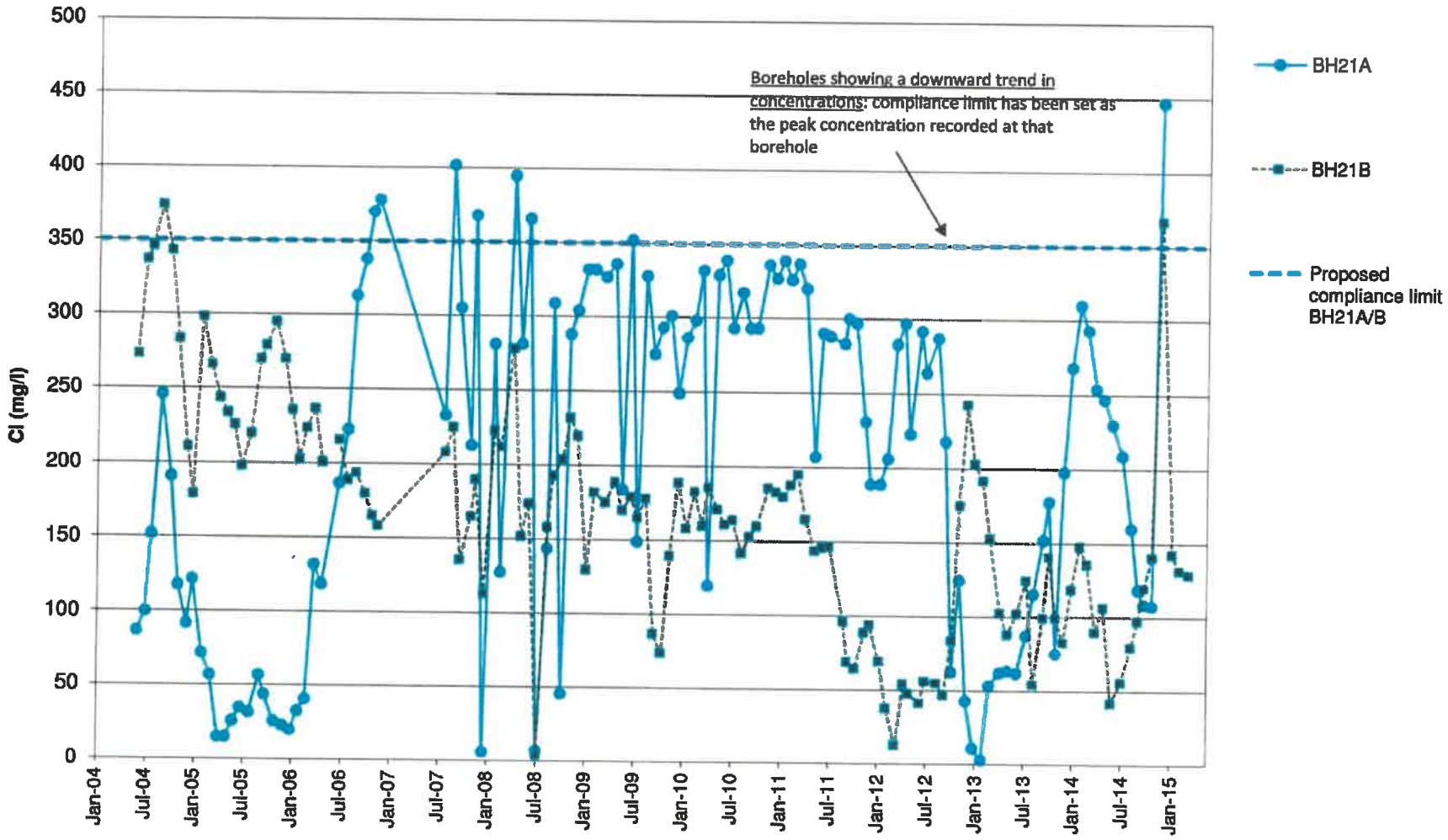

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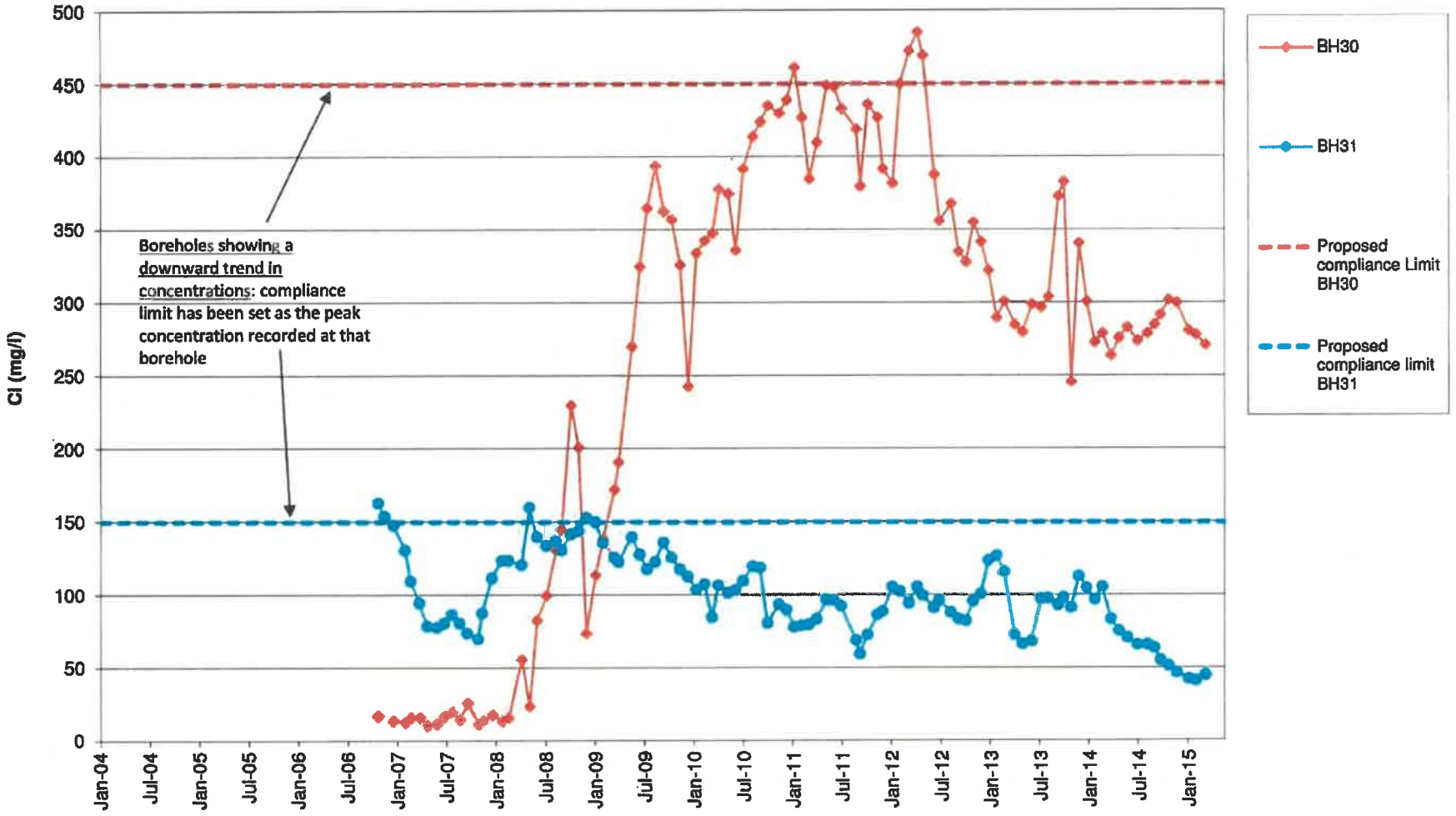
Ffridd Rasus Landfill - Proposed Compliance Limits for Chloride at Boreholes BH30 & BH31



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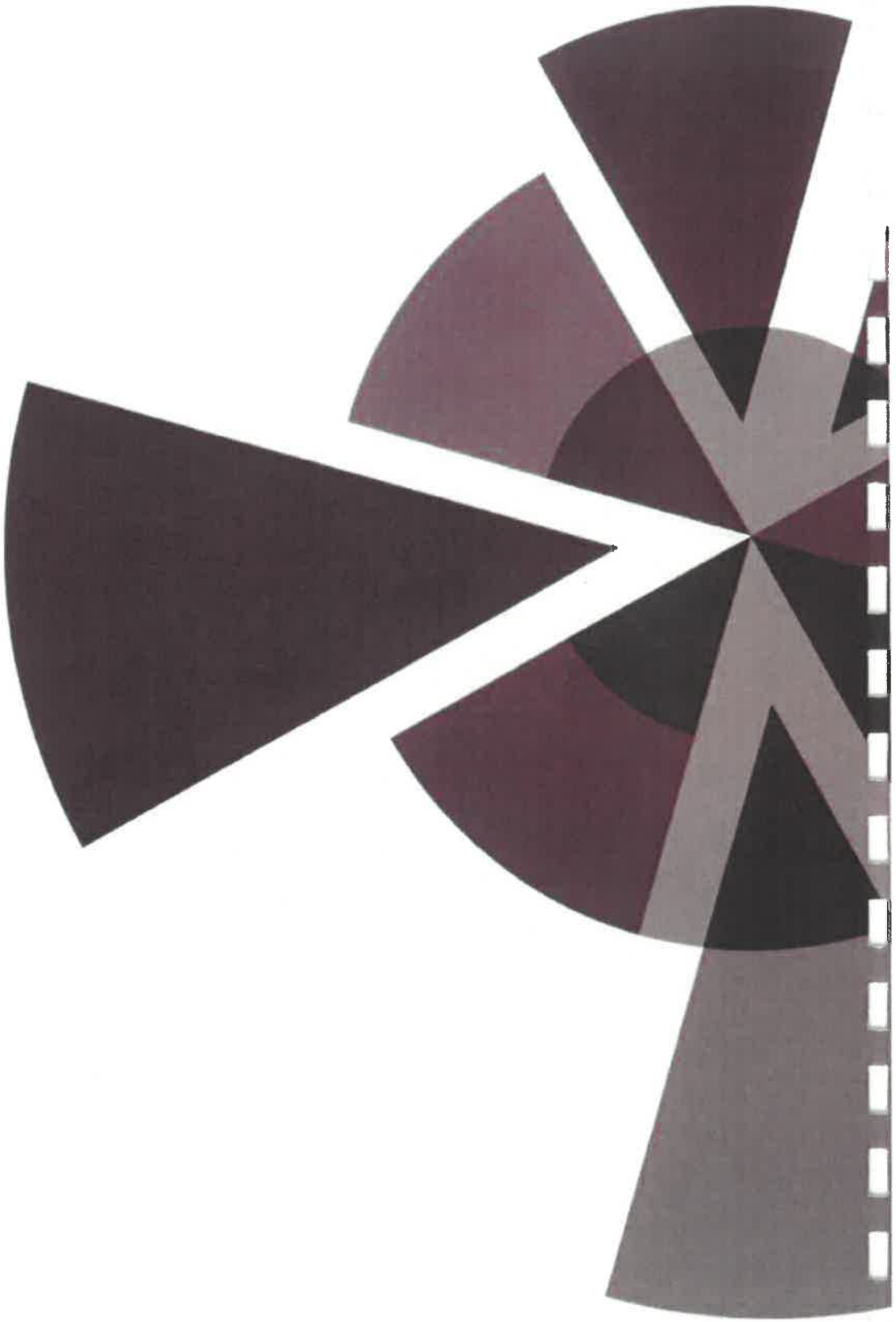

June 2015
Doc Ref. 28587rr954l2