Silent Valley Waste Services Limited

Silent Valley Landfill

2018 First Quarterly Monitoring Report (January to March)

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1 Introduction

This 2018 First Quarter Monitoring Report presents the surface water, groundwater, landfill gas and leachate results for the monitoring undertaken in the period January to March 2018 in accordance with the Silent Valley Environmental Permit (Permit no. MP3835SV, Ref. [1]) and the Aftercare Phase Environmental and Infrastructure Monitoring Program (Ref. [4]).

A total of seven groundwater wells, twelve surface water locations, fifteen gas monitoring wells and nine leachate monitoring wells/drain outfalls have been monitored during this period. The assessment of the monitoring results against relevant screening criteria is also presented.

The data has been collected as referenced in Schedule 3 of the Consolidated Permit (Ref. [1]).

This report makes reference to the 2017 Annual Monitoring Report (Ref. [2]).

2 The Site

2.1 Site Location and Description

The site is currently occupied by Silent Valley Landfill and is located at National Grid Reference SO185 071, as shown on **Figure 1**.

The landfill area is bounded by steep valley sides to the west, north and east. The Cwm Merddog Nature Reserve, which is a designated SSSI site, is located to the south. The Nant Merddog stream runs down the valley and to the south of the site. Where the landfill is present, it has been diverted into a pipeline that passes to the east of the landfill.

Access to the landfill site is via a minor road which ascends the hillside from the village of Waun Lwyd, Cwm, Ebbw Vale.

The site lies in a partially infilled valley at a level of between 300m AOD and 420m AOD. The landfilled waste rises from the southern toe in a mound with an approximate maximum elevation of 405m AOD. The southern toe line of the landfill crosses the valley with levels ranging approximately from 310m AOD to 360m AOD and gradients of between 1 in 4 and 1 in 2.

No waste has been accepted at the landfill since August 2011.

The earthworks for the capping of the Phase 1 Landfill, that was found to not have a Landfill Directive compliant capping, was completed in September 2015. The capping will prevent infiltration into the Phase 1 landfill and consequently is expected to achieve a reduction in leachate production within the landfill (refer to **Appendix A**).

2.2 Summary of cut-off and Monitoring systems

As part of the engineered mitigation measures pursuant to conditions included in the Permit for the site (Ref.[1]), a groundwater cut-off has been implemented by installing a line of pumping wells at the southern toe of the landfill to prevent the migration of any leachate-impacted groundwater downstream of landfill.

Phase 1 of this scheme was carried out in 2005 with the installation of eleven trial pumping and two monitoring wells. Phase 2 works were carried out between November 2006 and February 2007 and the pumping system was installed and commissioned in October 2007.

The system has been maintained and improved since October 2007, with the installation of an automatic water level monitoring system in 2009 and the addition of a stand-by compressor in 2010. Replacement pumps and low-draw pumps were also installed in a number of wells in early 2009.

In November 2009, new leachate monitoring wells were installed following a series of pumping tests at three locations. Between June and July 2010, further works have been undertaken to install additional monitoring and pumping wells and to replace one monitoring well.

Details of these improvement works are provided in **Appendix A**.

On-going non-compliance with regards to the non-hazardous species of ammoniacal nitrogen and chloride at one of the compliance wells, GW9, has been identified, as discussed in previous monitoring reports. Investigation works have been undertaken to address this and are presented in the issued report (Ref. [3]) and summarised in **Appendix A**. These works included a walkover of the area downstream of the site within the SSSI, with the relevant permissions of the NRW, to investigate the presence and quality of potential groundwater breakouts and streams inputting to the Nant Merddog. The walkover identified two break-outs and a monitoring regime has since been implemented at sampling locations SW1 to SW10 (refer to Section 3.3.1) with the objective to sample and analyse these waters for the presence of landfill leachate species. A full year of monitoring has been completed in January 2015 and the findings of this monitoring are presented and discussed in an updated issue version of the GW9 report, originally submitted to NRW in September 2013 and issued in May 2015 (Ref. [3]). Monitoring of the outbreak locations has now been included within the permit requirements until further review.

3 Monitoring Regime

The monitoring regime is undertaken in accordance with the Aftercare Phase Environmental and Infrastructure Monitoring Program (Ref. [4]) which has been summarised within the following sections. Refer to Figure 2 for monitoring locations.

3.1 Rainfall

Rainfall is measured at intervals of 0.5hrs daily, and measurements are used in the assessment of leachate and groundwater monitoring results.

3.2 Leachate

Monitoring of leachate for both leachate quality and leachate levels (to confirm leachate heads) is undertaken in accordance with sections S3.1 and S3.7 of the Consolidated Permit (Ref. [1]).

3.2.1 Monitoring locations and frequency of monitoring

The following locations are monitored:

- Monitoring wells LC1A, LC2A, LC4A, LC5A, for leachate quality and leachate levels:
  - LC1A is located within Cell 1 of the landfill, on the eastern flank of the valley, in an area where the final level was completed by 1996;
  - LC2A is located in Cell 2, on the northern flank of the landfill. This well is near to the base of the old valley bottom. Leachate in this area may be slightly diluted by groundwater ingress but this is not considered as significant as that present at the landfill toe. The waste in this area was placed around the year 2000;
  - LC4A is located in Cell 4, on the north-western flank of the landfill, in refuse waste placed around 2002. Similarly to LC1A, this well is located away from the valley 'drain';
  - LC5A is located in Cell 5, on the western flank of the landfill. Waste in this area was last placed in August 2011;
- Monitoring wells L1A and L1B, for leachate quality and L1A, L1B and L1 for leachate levels (leachate levels from these wells are no longer considered in the assessment of leachate head – see Section 3.2.2 below);
- Leachate drain outfalls LP3A and LP4 feeding into a concrete holding leachate lagoon at the toe of the landfill, for leachate quality only. LP4 directly outfalls into the lagoon including the leachate pumped directly from Cell 5. LP3A monitors the combined leachate from several pipes/drains, which is collected in a sump and then pumped to the lagoon from where it is discharged to the foul sewer. The following flows are monitored from LP3A:
  - LP1: BSC outfall pipe at the toe of the landfill;

- LP2: Armco outfall pipe at the toe of the landfill;
- LP2A: combined outfall from LP2 and other groundwater (weep hole) inputs from LP3, LP5, LP6 and LP7.

LP1 and LP2A are also monitored individually in addition to the monitoring locations agreed in the Permit (Ref. [1]). The results from these are discussed as part of the results obtained from LP3A.

The locations of the monitoring wells and leachate lagoons are presented on **Figure 2**.

Monitoring for leachate quality is undertaken quarterly in LC1A, LC2A, LC4A, LC5A, L1A, L1B, LP3A and LP4 for the determinand suite included in Table 6 and Table 7 of the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [4]), as required by the Permit (Ref. [1]). A hazardous substance suite is to be carried out every four years in LC1A, LC2A, LC4A, LC5A, L1A, L1B, LP3A and LP4 if there is an increase in contamination, as per the Permit (Ref. [1]).

Monitoring for leachate levels at LC1A, LC2A, LC4A, LC5A, L1A, L1B and L1 are undertaken **quarterly** with levels from L1A, L1B and L1 not used in the leachate head assessment. L1 is consistently recorded dry.

3.2.2 Compliance criteria

Assessment limits have been set for leachate head and composition as agreed in the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [4]) and in the Hydrogeological Risk Assessment (Ref. [5]). These are summarised in Tables 3.1 and 3.2 below.

3.2.2.1 Leachate head

As noted in Table 3.1, it is required that the monthly average leachate head level above the base of the landfill in LC1A, LC2A, LC4A and LC5A is less than 3m. The average leachate head compliance value was derived from the Hydrogeological Risk Assessment (Ref. [5]) undertaken in 2004, when limited leachate monitoring results were available and it was necessary to assume a probability density function for modelling the leachate head. The 3m head is considered the maximum head at which the landfill would be acting as if a liner had been placed at the bottom of the landfill in the 1980s.

Table 3.1: Leachate Assessment Limits

Measurement	Assessment limit	Assessment Test
Leachate Head/Level	Maximum head assumed in risk assessment (3m)	Mean leachate head measured in wells as set out in the Permit, exceeds assessment limit on three consecutive surveys.
Leachate Composition	Maximum concentration assumed in risk assessment	Mean concentration from wells in waste mass exceeds assessment limit on three consecutive surveys.

3.2.2.2 Leachate quality

Assessment limits for the contaminants for leachate quality, listed in Table 3.2, have also been set out in the Hydrogeological Risk Assessment (Ref. [5]), based on data from leachate wells L1, L1A and L1B.

Leachate quality is assessed from leachate wells L1A, L1B, LC1A, LC2A, LC4A and LC5A. Assessment of leachate quality is also undertaken in LP3A and LP4 but the results are not included in the assessment. For monitoring leachate quality, a reduced suite of contaminants is tested for on a quarterly basis as per the permit [1]. The revised suite of contaminants tested are present below:

- Manganese (mg/l)
- Mercury (mg/l)
- Nickel (mg/l)
- Zinc (mg/l)
- pH (pH units)
- Conductivity (uS/cm)
- Alkalinity as $CaCO_3$ (mg/l)
- Ammoniacal Nitrogen (mg/l)
- Chloride (mg/l)
- Sulphate (mg/l)
- Redox Potential (mV)
- Total Organic Carbon (TOC) (mg/l)
- Dissolved Oxygen (DO) (mg/l)
- Suspended Solids (mg/l)
- Dissolved Solids (mg/l)

The assessment limits are compared with the calculated mean contaminant concentrations from the monitoring wells in waste the mass. If the mean concentrations from wells in the waste mass exceed the assessment levels on three consecutive surveys, contingency actions will be triggered, as described in the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [4]) and summarised in Table 3.3.

Table 3.2 Leachate Acceptable Maximum Concentrations AMCs (from Ref. [8])

Contaminant	Acceptable Maximum Concentration AMCs (mg/l)
NH_3	526
Chloride	1408
Sulphate	999
Nickel	0.0681
Zinc	1.38/
Mercury	0.56 µg/l

Table 3.3: Leachate Monitoring Contingency Actions (from Ref. [8])

Contingency Action	Response Time
Report to NRW including initial assessment of possible causes	1 month
Report to NRW on re-appraisal of risk to groundwater and surface water and options for corrective measures	3 months
If risks are acceptable revise assessment criteria as appropriate. Continue monitoring. If risks are not acceptable implement agreed corrective actions (i.e. increase monitoring and frequency as agreed with the NRW)	6 months

3.3 Surface Water

Surface water sampling of the Nant Merddog is undertaken in accordance with the sampling protocols defined in the Aftercare Phase Environmental and Infrastructure Monitoring Program Report (Ref. [4]).

3.3.1 Monitoring locations and frequency of monitoring

Monitoring of surface water quality is currently being undertaken at the locations listed in Table 3.4 in order to identify any adverse impact resulting from escape of leachate from the landfill, particularly in relation to the Nant Merddog.

Monitoring point locations are marked on **Figure 2** and **Figure 3**.

Table 3.4: Surface Water Monitoring Locations

Monitoring Point		Location
Upstream locations	SWU	On the Nant Merddog, north (upstream) of landfill
	SW2AI	On drainage ditch system on northern perimeter of landfill. The ditch intercepts surface water run-off from the area north of the landfill and discharges to the Nant Merddog
	SWW4	On drainage ditch system north of the landfill, at point where the northern perimeter ditch system joins the eastern perimeter ditch system
	SWW1	On ditch system north-west of the landfill
	SWW2	On ditch system north-west of the landfill
Downstream locations	SWD	On the Nant Merddog, approximately 70m downstream of the landfill (15m downstream of the point where the diverted stream joins its original course).
	SWD1	On the Nant Merddog, approximately 300m downstream of SWD
	SW1, SW2, SW3, SW9 and SW10	A stream, feeding into the Nant Merddog some 190m downstream of SWD issuing on the eastern slope of the valley
	SW4, SW5, SW6	A potential groundwater out-break, feeding into the Nant Merddog some 155m downstream of SWD issuing on the eastern slope of the valley
	SW7	Nant Merddog immediately downstream of the above confluence
	SW8	Nant Merddog immediately downstream of the above stream confluence

Surface water sampling locations SW1 to SW10 have been set up and monitored since December 2013 following the recommendations made in the Arup 2011 report on investigations into the western flank of the cut-off system (Ref. [6]) and a walkover through the SSSI south of the landfill in November 2013. The monitoring regime was implemented in order to confirm the presence of landfill leachate species in these groundwater breakouts and the impact to the Nant Merddog.

The regime for surface water monitoring is in accordance to the requirements of the Permit (Ref. [1]), as follows:

- **quarterly** monitoring for locations SWD and SWD1;
- **six-monthly** monitoring for locations SWU, SWW1, SWW2, SW2AI, SWW4;
- **monthly** monitoring of the surface water monitoring locations SW1 to SW10.

3.3.2 Compliance criteria

The compliance criteria for surface water quality are the Environmental Quality Standards (EQS) which are appropriate for the Nant Merddog for all contaminants for which these are available, as defined in Table 13 of the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [4]).

The following suite of contaminants are tested for on a monthly basis for SW1 to SW10, as per the permit [1].

- Ammoniacal Nitrogen (mg/l)
- Chloride (mg/l)
- Mercury (mg/l)

The following suite of contaminants are tested for on a quarterly basis for SWD and SWD1 and six-monthly basis for SWU, SWW1, SWW2, SW2AI and SWW4, as per the permit [1], with the addition of calcium which is required for determining the bioavailable metal concentration, as described below.

- Manganese (mg/l)
- Mercury (mg/l)
- Nickel (mg/l)
- Zinc (mg/l)
- pH (pH units)
- Conductivity (uS/cm)
- Alkalinity as $CaCO_3$ (mg/l)
- Calcium (mg/l)
- Ammoniacal Nitrogen (mg/l)
- Chloride (mg/l)
- Sulphate (mg/l)
- Redox Potential (mV)
- Total Organic Carbon, filtered (TOC) (mg/l)
- Dissolved Oxygen (DO) (mg/l)
- Suspended Solids (mg/l)

Previously, site specific EQS values for freshwater had been derived, for nickel, manganese and zinc, based on the annual average concentration of water hardness in the Nant Merddog, downstream of the landfill. The Water Framework Directive [Ref12] has subsequently been updated with a number of the EQS compliance criteria no longer relying on hardness values. Instead for a number of heavy metal species the EQSs are now based on the bioavailable concentrations which are derived from the recorded dissolved concentrations.

The bioavailability of a metal depends on a number of physico-chemical factors which govern both metal behaviour and the interactions of the toxic forms of the metals with a biological receptor. The Water Framework Directive – United Kingdom Technical Advisory Group (WFD-UKTAG) have developed a model known as the "Metal Bioavailability Assessment Tool (M-BAT) [Ref 13] which predicts the bioavailable concentration from dissolved concentrations.

To calculate the bioavailable concentration of the specific metals, calcium (Ca) and dissolved organic carbon (DOC) levels need to be obtained and input into the M-BAT tool along with pH and the recorded dissolved metal concentrations.

All compliance criteria values, including the updated heavy metals, are set out in **Table 3.5**.

Table 3.5: Compliance Criteria for the Nant Merddog

Contaminant	EQS (ug/l)	Updated EQS (µg/l)	Notes
Ammoniacal Nitrogen (unionised)	15	15	EQS
Sulphate	400 mg/l	400 mg/l	EQS
Chloride	250 mg/l	250 mg/l	EQS
Nickel (Dissolved)	100	4	EQS
Zinc (Total)	10	13.7*	EQS
Mercury (Total)	1	1	EQS
Manganese	30	123	EQS

Notes:

* This level is based on the standard EQS value 10.9ug/l plus the Ambient Background Concentration (AMC) of the River Taff of 2.8ug/l [Ref. (12)].

3.3.3 Contingency Actions

As discussed in the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [4]), background water quality monitoring upstream of the landfill indicates that concentrations of some determinands may exceed the compliance criteria in some cases. The assessment of breaches of compliance criteria therefore includes an assessment of background levels. Such breaches may be acceptable in cases where they result from background levels. No Assessment Levels are set, but assessment is made by monitoring the data for trends of increasing contaminant concentrations.

If a significant trend of increasing contaminant concentration is identified then the following contingency actions and timescales should be followed.

Table 3.6: Surface Water Monitoring Contingency Actions (from Ref. [8])

Contingency Action	Response Time
Advise NRW with initial assessment of possible causes e.g. unusual activities, leachate discharges etc.	1 month
Report to NRW on re-appraisal of risk to the Nant Merddog and report on monitoring since the increasing trend was identified.	3 months
If risks are acceptable continued monitoring and assessment will be undertaken with three monthly reporting and risk re-appraisal concerning the contaminants of concern until such time as no continued potentially unacceptable risk is considered to exist.	6 months
If risks are unacceptable agreed corrective measures will be implemented (i.e. increase monitoring location points and increase frequency as agreed with the NRW)	

If there is a particular incident that may result in surface water pollution additional monitoring will be agreed with the NRW.

3.4 Groundwater

Monitoring of groundwater is undertaken in accordance with Table S3.9 of the Permit (Ref. [1]), the Environment Agency guidance on groundwater monitoring (Ref. [7]) and in line with the monitoring schedule agreed with the NRW, as discussed in the 2010 Annual Monitoring Report (Ref. [8]).

3.4.1 Monitoring locations and frequency of monitoring

The following locations are currently monitored on a quarterly basis:

- Monitoring wells GW3A and GW4, located upstream of the landfill (referred to as 'upstream wells');
- Monitoring wells GW6, GW7, GW9, GW10, and GW12, located downstream of the landfill (referred to as 'downstream wells' or 'compliance wells');

GW11A can no longer be monitored as the location was covered during the construction of the Waste Transfer Station. It is proposed to replace this well in the near future. The locations of the monitoring wells are presented on Figure 2.

For details of previous monitoring undertaken at the site, refer to **Appendix B**.

3.4.2 Compliance criteria

Control and Trigger Levels have been developed for those contaminants addressed in the Hydrogeological Risk Assessment (Ref. [5]) as shown in **Table 3.6**. These contaminants cover a range of substances indicative of landfill leachate contamination which are potentially harmful to downstream groundwater and to the aquatic environment of the Nant Merddog.

The Control Levels allow the identification of any unexpected or adverse trends in the monitoring data and should be treated as an early warning system to enable investigative or corrective measures to be implemented, particularly where Trigger Levels might be breached.

Trigger Levels are specific compliance levels, or regulatory standards. They are defined as criteria at which significant adverse environmental effects and/or breaches of legislation have occurred. Such effects would be consistent with the groundwater having been polluted.

As discussed in the Hydrogeological Risk Assessment Supplementary Revision (Ref. [9]), during routine reviews of the groundwater monitoring results, it was noted that for certain contaminants (e.g. mercury, zinc and manganese), background concentrations measured upstream of the landfill in groundwater and surface water exceeded the applied Control and Trigger Levels (or in the case of manganese, the corresponding EQS), particularly following high rainfall events. As a result, a review of the background levels and their likely origin was undertaken and revised Control and Trigger Levels (or in the case of manganese,

assessment level) were proposed and agreed with the Environment Agency, as presented in Table 3.7.

Table 3.7: Groundwater Control and Trigger Levels (and Assessment Level for manganese)

Determinand	Control Levels (mg/l)		Trigger Level (mg/l)
	A	B	
Ammoniacal Nitrogen	0.8*	0.9*	1.0*
Chloride	210*	230*	250*
Mercury	0.0001**	0.00015**	0.0002**
Nickel	0.03*	0.04*	0.05*
Sulphate	300*	350*	400*
Zinc	0.02**	0.035**	0.05**
Manganese	-	-	1.0**

Notes:

* From Hydrogeological Risk Assessment (Ref. [8]).

** From Hydrogeological Risk Assessment Supplementary Revision (Ref. [9]) and Groundwater Monitoring: Trigger Levels report (Ref. [10]).

EQS values for freshwater are also included in the screening criteria for the majority of contaminants, specifically for manganese and unionised ammoniacal nitrogen, where Control and Trigger Levels do not exist. The EQS values for the certain metals, including manganese, are no longer based on the hardness values taken from the Nant Merddog and are now based on the bioavailable concentrations (refer to Section 3.3.2) and are used in the assessment.

3.4.3 Contingency Actions

If the Control or Trigger levels are exceeded on three consecutive monitoring rounds, contingency actions will be triggered, as described in the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [4]) and summarised in Table 3.8.

Table 3.8: Groundwater Monitoring Contingency Actions (from Ref. [8])

Contingency Action	Response Time
Advise NRW with initial assessment of possible causes e.g. unusual activities.	1 month
Report to NRW on re-appraisal of risks to the Nant Merddog based on risk assessment review and Nant Merddog monitoring and further groundwater monitoring subsequent to breach.	3 months
If risks are acceptable the assessment criteria may be re-evaluated. If monitoring shows concentrations to have fallen back to below the control/trigger levels no further action may be necessary.	6 months
If risks are unacceptable agreed corrective measures will be implemented. The corrective measures if required and appropriate may include additional monitoring (frequency and location).	

If there is a particular incident that may result in groundwater pollution additional monitoring will be agreed with the NRW.

3.5 Landfill Gas

Landfill gas monitoring is carried out in accordance with the requirements of the Permit (Ref. [1]).

3.5.1 Monitoring locations and frequency of monitoring

The following locations are monitored for landfill gas (methane and carbon dioxide):

- GWM1 to GMW10;
- GMW12 to GMW14;
- GMW17 and GMW18.

These wells are located around the site perimeter, as shown on **Figure 2**.

The original well GMW1 was damaged at some point in the past and was replaced with GAS01 in February 2007. For ease of reference, this well is now referred to as GMW1.

3.5.2 Compliance criteria

Control and Trigger Levels for landfill gas have been established by Golder Associates (Ref. [10]).

For each monitored well, up to three monitoring points (valves) have been installed at different depths. Trigger and Control Levels have therefore been set for each monitoring point, where appropriate.

Currently, no Control and Trigger Levels are set for GMW1, GMW8, GMW9, GMW10, GMW17 and GMW18. Boreholes GMW8, 9 and 10 are located within 20m of the waste mass, in conflict with the Environment Agency's guidance on landfill gas management (Ref. [11]), which recommends perimeter wells be

located at a distance greater than 20m from the boundary of the waste. To overcome this, additional wells (GWM12, 13, 14, 17 and 18) were installed at a greater distance from the landfill boundary, and Trigger Levels derived for GWM12, GWM13 and GMW14. Monitoring at GMW1, GMW17 and GMW18 is now required by the Permit (Ref. [1]), however there are still no Control and Trigger Levels for these locations.

As stated by Golder Associates (Ref. [10]), single exceedances need no immediate action. However, ongoing exceedances require informing the relevant people and organisation and appropriate measures of identification and solutions identified.

4 Monitoring Results

4.1 Rainfall

Measured rainfall data is illustrated in **Appendix C**, **Figures C1** to **C3**.

Figure C1 shows daily rainfall totals for the period January 2013 to March 2018 and highlights the dates when samples have been taken for analysis from the downstream compliance wells GW6, GW7, GW9, GW10, and GW12.

Figure C2 shows monthly rainfall totals for the same period in 2018, with monthly leachate head average data for 2016 and 2017 for comparison, as further discussed in Section 4.2.2.

Figure C3 shows monthly rainfall from July 2010 to March 2018.

March recorded the highest monthly rainfall of the quarter with 130.1mm and the highest daily rainfall total with 24.6mm. These values are typical for this time of year and similar rainfall was recorded in previous years (refer to previous monitoring reports).

4.2 Leachate

4.2.1 Leachate Quality Monitoring

Leachate quality monitoring results from within the waste body and from leachate standpipes are presented in **Appendix D**, **Table D1** and include contaminant concentration averages and Acceptable Maximum Concentrations (AMCs) for mercury, nickel, zinc, ammoniacal nitrogen, chloride and sulphate. For the respective AMCs refer to **Table 3.2**.

In accordance with the Permit requirements, the leachate quality monitoring has been undertaken quarterly since March 2015. Leachate well LC1A was not sampled due to there not being enough leachate to obtain a sample for testing. Samples were obtained from L1A, L1B, LC2A, LC4A and LC5A.

The average values for the majority of the monitored contaminants from the first quarter were all below the AMC values, with the exception of ammoniacal nitrogen. The highest recorded result was recorded in well LC5A with a value of 2100mg/l, slightly above last quarter's value of 2000mg/l. The average value of ammoniacal nitrogen was recorded as 619mg/l which is above the AMC of 526mg/l and an increase from last quarter's value of 593.36mg/l, which was the lowest recorded level since the well monitoring began.

Due to the continuing high levels of ammoniacal nitrogen over the past few years the contingency plan has been implemented and an investigation of the increasing ammoniacal nitrogen levels in leachate well LC5A is required. It is currently proposed to undertake well pump testing at this well with the possibility of replacing the well, however, the results should continue to be closely monitored in 2018.

For the respective AMCs refer to **Table 3.2**.

It should be noted that mercury has been consistently recorded below the laboratory analytical detection limit of 0.1µg/l in all the analysed samples and has been a continuing trend since 2013.

Consequently, the monitored concentrations of mercury have not only been below the Acceptable Maximum Concentration (refer to **Table 3.2**), but also below the Trigger Level set for the groundwater compliance wells (see **Table 3.6**).

4.2.2 Leachate Level Monitoring

Field monitoring readings report the depths to leachate from the top of each well casing. The leachate head for each well is calculated as follows:

> The leachate level (mAOD) is calculated by subtracting the depth to leachate (m) from the well head elevation (mAOD). The leachate level (mAOD) is then subtracted from the base of landfill level (mAOD).

The well height and ground level elevations were re-surveyed in 2015 in accordance with the requirements of the permit [Ref.1]. Leachate levels monitoring results are presented in **Appendix D**, **Table D2.**

The quarterly average leachate head was calculated for January with an average leachate head level of 2.35m recorded, within the 3m limit stipulated in the Permit (Ref. [1]).

The quarterly leachate head averages have been increasing since 2013 and even during dry periods the leachate head has continued to remain higher than pre-2013. Figure C2, Appendix C, shows the monthly rainfall plotted against the leachate head averages. Since the Cell 5 capping was completed in November 2011 and later the Phase 1- completed in September 2015, the leachate head levels within LC5A have not decreased as would have been expected but have actually increased, specifically since July 2016. However, this quarter's leachate head levels have recorded a decrease.

As discussed in the Annual Monitoring report for 2017 (Ref. [2]), the quarterly leachate head has showed a continuous rising trend since 2013. The average leachate head per year has been increasing since 2013, as detailed in Table 4.1 below.

Table 4.1: Annual Average Leachate Head

Year	Average Leachate Head	Maximum Leachate Head
2013	1.01m	2.45m
2014	1.14m	3.95m
2015	1.81m	4.96m
2016	2.54m	4.83m
2017	2.70m	5.09m

Within the first quarter of 2018 the maximum leachate head was recorded at 3.55m in LC5A, which is a 1.54m decrease from the previous quarter and the lowest recorded since November 2014. The average leachate head has been recorded as 2.35m which has fallen from last quarter which recorded 2.74m. All the average leachate head values recorded are still below the 3m limit as per the Permit (Ref[1]) and have been on a continuingly increasing trend until this quarter. The graph in Figure C2 shows the sudden increase of leachate head in January 2016. This is a result of applying the revised survey data (survey date from May 2015) in the calculations.

the maximum leachate levels have been recorded at LC5A which since 2013 has been showing a strong increasing trend. The leachate heads recorded in the remaining wells are stable with only well LC5A showing the biggest change. Wells located in the Phase 1 cell, specifically LC1A have recorded low levels of leachate with not enough to collect samples for testing. Samples were collected from L1A during this quarter.

Although the monthly average level for all the wells remains below the required 3.0m and the average level in well LC5A has decreased this quarter, it is still considered that there is a general increasing trend in the average leachate head, and therefore there is still the potential to reach the 3m limit in the future. Investigations are proposed to be undertaken into the possible causes of the leachate head increase, and subsequent decrease, these include well pump testing and the potential replacement of LC5A, however the decrease shown in this quarter should be closely monitored.

No significant variations of the leachate heads have been observed in the remaining leachate wells, with the monitored levels of L1, LC1A, LC2A and LC4A generally comparable to the 2017 levels.

4.3 Surface Water

4.3.1 Surface Water Quality Monitoring

The surface water quality monitoring results are presented in **Appendix D**, **Tables D3** and **D4**, and graphically in **Appendix C**, **Figure C4**.

Commentaries are provided for upstream and downstream monitoring points in the Nant Merddog, including locations SW1 to SW10 located downstream of the landfill, as discussed below.

4.3.1.1 SWU, SW2A1, SWW4, SWW1 and SWW2 (upstream of the landfill)

In accordance with the Permit requirements, these locations are now monitored on a six-monthly basis. Therefore, there are no results for this quarter.

4.3.1.2 SWD and SWD1 (downstream of the landfill)

A full suite of determinands is analysed on downstream samples SWD and SWD1 on a quarterly basis, as discussed in **Section 3.3.1**.

Ammoniacal nitrogen has remained below the measured level of detection of 0.41mg/l in both locations with the calculated concentration of unionised ammoniacal nitrogen recorded below the assessment level of 0.015mg/l in SWD1 but recorded slightly above the assessment level in SWD with a level of 0.021mg/l recorded. This was due to a slight increase in pH, which at a level of 8.6 is the highest recorded since July 2016.

Chloride and sulphate concentrations were reported below the applied EQS level of 250mg/l and 400mg/l respectively. The chloride concentration values were recorded as 8.8mg/l at SWD and 12.6mg/l at SWD1. Sulphate concentrations were also well below the EQS freshwater level with values of 54.4mg/l and 48.9mg/l at SWD and SWD1 respectively.

Zinc concentrations in the first quarter tested below the detection limit of <0.018mg/l in both SWD and SWD1 which continues the trend since January 2017. It should be noted that the EQS Freshwater level is lower than the recorded LOD, however this is due to a laboratory sample dilution issue. Elevated levels of zinc continue to be recorded within the majority of groundwater monitoring wells, but this is not being mirrored in the potential surface water receptor of the Nant Merddog, however the results should continue to be monitored closely in the surface waters.

Mercury, manganese and nickel were all detected at concentrations well below the applied EQS values at both SWD and SWD1.

4.3.1.3 SW1 to SW10 (downstream of the landfill)

Surface water sampling of the groundwater break outs at SW1 to SW10 has been carried out since December 2013 on a monthly basis, comprising rounds of sampling for testing of ammoniacal nitrogen, chloride and mercury. Samples were collected from the majority of locations from January to March 2018 with the exception of the following due to the location being recorded as frozen;

- SW9 in February. SW9 is located at the end of the southern groundwater breakout.

During the reporting period, ammoniacal nitrogen and mercury were measured below the laboratory detection limit of 0.41mg/l and 0.1mg/l respectively at all monitored locations.

Chloride was measured well below the EQS limit during the first quarter with levels fluctuating between the highest point of 60.8mg/l in SW4 in February and the lowest point of 8.5mg/l in SW8 in January. SW4 recorded the highest concentrations of chloride in January, February and March.

These break outs are from the same groundwater body as that monitored by GW9 and therefore it is considered that currently the non compliance at GW9 continues to not present discernible impact on the Nant Merddog.

4.4 Groundwater

4.4.1 Groundwater Quality Monitoring

Groundwater quality monitoring results are presented in graphical format in **Appendix C**, **Figures C6** and **C7** and in tabular format in **Appendix D**, **Table D5.** In the table, exceedances of the compliance criteria are highlighted using a colour-coded legend.

Chloride and ammoniacal nitrogen are the two main indicators of groundwater contamination by landfill leachate at the site. Chloride, in particular, is not attenuated in the groundwater by processes other than dilution, and would be expected to be present wherever leachate contamination occurs.

For nickel, manganese and zinc the updated EQS assessment criteria are for bioavailable metals present within the sample, and not the total dissolved concentration that has been determined in the laboratory. An assessment has been undertaken using the M-BAT tool [Ref (13)], (as described in section 3.2.2) to determine the bioavailable concentrations of these metals for screening against the EQS criteria. The assessment is included in Appendix E and the results detailed in the following sub-sections.

Commentaries are provided for both upstream and downstream compliance wells. As reported in previous monitoring reports, the results from the latter have been compiled in relation to the different sandstone strata in which they are installed, i.e. S1, S2 and S3.

The groundwater quality monitoring results for the first quarter 2018 are detailed in the following sub-sections.

4.4.1.1 Upstream Groundwater wells GW3A and GW4

GW3A and GW4 monitor the sandstone strata classified as S3-East, and GW11A has been installed in the sandstone strata classified as S2-West. Well GW11A is no longer sampled as the well was lost during the construction of the Waste Transfer Station. Options for the replacement of this are currently being reviewed.

Ammoniacal Nitrogen and Chloride

During the first quarter of 2018, ammoniacal nitrogen concentrations were measured below the laboratory limit of detection of 0.41mg/l in both upstream wells, GW3A and GW4.

Chloride has continued to be measured at below the Control and Trigger Levels at concentrations of 8.7mg/l for GW3A and 8.4mg/l for GW4. Well GW3A has continued to show a decreasing trend since January 2016, with the lowest level

recorded since monitoring began. Well GW4 is also showing a general decreasing trend with the lowest recorded level since October 2016.

Metals

Mercury concentrations were recorded below the laboratory limit of detection of 0.1µg/l in GW4 and GW3A.

Zinc has been recorded below level of detection, <0.018mg/l, in GW4, higher than the EQS freshwater level but the lowest recorded level since July 2010. The level recorded in GW3A was also below level of detection of <0.18mg/l, although this is higher than the set Trigger Level. Both samples recorded LOD's above the assessment criteria due to laboratory dilution issues.

Manganese concentrations continue to be elevated in GW4, recording a level of 1.29mg/l, above the set criteria for the landfill. However, this is the lowest recorded manganese concentration since September 2015. The bioavailable concentration of manganese is 0.265mg/l which is below the assessment level but still above the updated EQS Freshwater value of 0.0137mg/l.

In the upstream wells, sulphate concentrations were recorded at 64.4mg/l in GW4 and 117.0mg/l in GW3A. These values are well below any of the assessment criteria.

4.4.1.2 Downstream Groundwater well GW10

GW10 has been installed in the sandstone strata classified as S3-East.

Ammoniacal nitrogen was measured below the laboratory detection limit of 0.41mg/l, a continuing trend since February 2016. Unionised ammoniacal nitrogen was recorded below the EQS freshwater level of 0.015mg/l.

Zinc concentrations have continued to be measured above the compliance level, with a level of 0.0733mg/l being recorded. This level exceeds the 0.05mg/l trigger level, recording the highest level since July 2016 and shows a slight increase from the previous quarter. However, these levels are still much lower than those preceding 2016. The bioavailable concentration of zinc of 0.033mg/l is nearly half that of the dissolved concentration but still above the EQS value of 0.0137mg/l. The gradual increase should be monitored closely during 2018.

Mercury concentrations were measured below the level of detection of <0.1ug/l in January.

Manganese concentrations have been recorded above level of detection in January, with a level of 0.105mg/l. This is the highest recorded level since February 2016, however it is still below the assessment level of 1.0mg/l and also the updated EQS freshwater level of 0.123mg/l.

Chloride was measured at a low concentration of 15.3mg/l, a slight increase on last quarter's level of 12.8mg/l but still well below the assessment criteria.

4.4.1.3 Downstream Groundwater well GW9

GW9 has been installed in the sandstone strata classified as S2-East.

GW9 continues to be non-compliant for ammoniacal nitrogen in relation to the Trigger Level of 1mg/l (refer to previous monitoring reports, Reference [2]). Investigation works to address this have been undertaken in 2014 and are presented in a separate report (Reference [6]).

The ammoniacal nitrogen concentration was above the trigger level with a concentration of 5.25mg/l recorded in January, an increase from the previous quarter of 2.12mg/l in October but lower than the same quarter in 2017. The levels were showing a continued decreasing trend prior to January's results, with last October recording the lowest value since August 2011, which is considered likely due to completion of the capping to Phase 1. There have been occasional variations where infrequent single increases have occurred, which is possible for this quarter. Therefore, the concentrations of ammoniacal nitrogen should be closely monitored throughout 2018.

The calculated unionised ammoniacal nitrogen concentration has been recorded in January slightly above the EQS level at GW9, with a level of 0.0218mg/l. This is the first exceedance recorded since October 2016.

The mercury concentration was recorded below laboratory limit of detection of 0.1ug/l, which is the same as the previous quarter.

The zinc concentration recorded in January is above the Control Level A and EQS value but was below the trigger level of 0.05mg/l and the Control Level B value of 0.035mg/l, with a concentration of 0.0331mg/l recorded. This is a decrease on last quarter when a level of 0.0479mg/l was recorded and is the lowest recorded since October 2016. Currently the options for a new pumping well, to be installed within the vicinity of well GW9, are being reviewed however zinc concentrations should continue to be monitored closely following installation.

Manganese remains below the assessment level of 1.0mg/l with a level of 0.505mg/l recorded. This is an increase from the previous quarter, however, the bioavailable concentration of manganese was recorded as 0.127mg/l which is only slightly above the updated EQS value of 0.123mg/l.

The chloride concentration for January was 53.8mg/l, which is a slight increase from the level recorded in October but still well below the control and Trigger Levels.

4.4.1.4 Downstream Groundwater well GW12

GW12 has been installed in the sandstone strata classified as S2-West.

The concentration of ammoniacal nitrogen has continued to record below level of detection of <0.41mg/l in January and has done since July 2016.

Mercury was recorded below level of detection of <0.1ug/l, a continuation from last quarter and the lowest recorded since October 2016. Mercury concentrations

have fluctuated over the past year, therefore the low levels recorded over the past two quarters should be closely monitored during 2018.

Zinc has continued to be measured at concentrations above the EQS, Control and Trigger Levels. The level recorded for January was 0.331mg/l which is above the trigger level of 0.05mg/l, however a significant decrease from the previous quarter in which a level of 1.03mg/l was recorded. The level recorded this quarter is similar to those from the beginning of 2017 and indicates an increasing trend may not be occurring, as initially thought from the results of the last two quarters.

Sulphate levels have previously been recorded above the Trigger Level and in exceedance of the freshwater EQS level of 400mg/l with levels consistently being recorded above 300mg/l since 2013. The level recorded in January was 378mg/l, above the Control Level values and an increase from the previous quarter when a level of 346mg/l was recorded.

Manganese has been reported at a level of 0.0198mg/l, similar to those recorded in 2017 with the exception of October when a significant increase of 1.16mg/l was recorded. Due to the decrease in levels in both manganese and zinc, it is unlikely to be an increasing trend.

4.4.1.5 Downstream Groundwater wells GW6 and GW7

GW6 and GW7 have been installed in the centre of the valley in the sandstone strata classified as S1.

Ammoniacal nitrogen concentrations were recorded below the analytical detection limit in January, for both GW6 and GW7. The unionised ammoniacal nitrogen levels were recorded below the EQS freshwater level in both wells.

Sulphates were also measured within compliance levels in both wells, with 91.9mg/l recorded at GW6 and 76.7mg/l at GW7.

In January, both wells recorded mercury concentrations of <0.10mg/l, below the trigger, control and EQS levels. Mercury levels in GW6 have remained <0.10mg/l since January 2017, however they have been found to fluctuate in the past and should be closely monitored.

Manganese concentrations in GW6 were recorded below the assessment level of 1.0mg/l, however recorded above the previous EQS value of 0.03mg/l with a level of 0.339mg/l. This has increased from the previous quarter and is the highest recorded since September 2015. However, the bioavailable concentration of manganese was recorded as 0.0226mg/l which is below the updated EQS freshwater value of 0.123mg/l therefore manganese is not considered to be an issue. Manganese levels in GW7 have been recorded above the EQS and assessment level, with a concentration of 1.89mg/l recorded in January. This has decreased from the last quarter which had a concentration of 2.26mg/l. Historically manganese has fluctuated within this well, therefore the current decrease should be monitored closely.

In GW7 zinc was measured below level of detection, <0.018mg/l, which is above the 0.01mg/l EQS level. However, the bioavailable concentration of <0.0072 is

below the updated EQS level of 0.0137mg/l. Zinc was measured as 0.229mg/l in GW6, above the trigger level for the first time since October 2016 and above the upstream concentrations. Zinc levels have historically been recorded above the trigger level with levels decreasing during 2017. The increase in zinc should be reviewed during the next quarter to determine if there is an increasing trend.

4.4.2 Groundwater Levels Monitoring

Groundwater levels have been monitored in the compliance wells GW6, GW7, GW9, GW10 and GW12, as discussed in **Section 3.4**. The monitoring results are illustrated graphically in **Appendix C**, **Figure C8**. Prior to the second quarter in 2016, groundwater levels were monitored monthly. However, groundwater levels are now monitored quarterly in accordance with the permit.

Water levels continue to be monitored at similar levels within each well. The levels recorded in GW6, GW9 and GW12 recorded slight increases in January with the groundwater level rising by 0.28m in GW6, 0.24m in GW9 and 0.19m in GW12 compared to the levels recorded in October. The level in GW7 remained the same and the level in GW10 decreased by 0.02m. The general lack of variation is consistent with the locations of the compliance wells, i.e. some 30m downstream of the pumping cut-off system that is expected to exert a controlling influence on groundwater levels downstream of the landfill.

4.5 Landfill Gas

4.5.1 Landfill Gas Quality Monitoring

The landfill gas monitoring results are presented in **Appendix D**, **Table D6** for the period January to March 2018. The results are discussed in detail in the sub-sections below for both monitored gases (methane and carbon dioxide).

Monitoring could not be undertaken in GMW2, all valves and GMW7 in the white valve due to the wells being flooded.

Access to GMW14 is restricted due to its location being within a cattle quarantine paddock. Monitoring of this well has been limited since March 2014, with no readings undertaken this quarter.

The recommendation of repositioning GMW14 as discussed in previous monitoring reports remains valid due to access difficulties (Ref. [2]), and is currently being pursued. Considering the recorded concentrations to date, monitoring of landfill gas in GMW14 should be undertaken on a regular basis and contingency actions implemented, if necessary.

4.5.1.1 Methane

During the first quarter methane concentrations were recorded below the respective Control and Trigger Levels in all monitoring locations where assessment levels have been set, with levels recorded between 0% and 0.3%.

In GMW10 elevated levels of methane have continued to be recorded in the red valve ranging from 41.3% in February to 52% in January, and in the yellow valve ranging from 46.8% in February to 51.5% in January. Concentrations in the white valve varied from 26.2% in March, increasing to 41.7% in January. The first quarter levels were generally lower than the previous quarter.

Elevated levels of methane continue to be measured in monitoring wells GMW1, GMW8 and GMW9 (yellow valve), where the maximum recorded concentrations in this reporting period for GMW1 were 11.7%, 6.7% for GWM8 and 41.2% for GWM9, all recorded in January.

As discussed in **Section 3.5.1**, GMW8, 9 and 10 are located within 20m of the waste mass, where elevated methane concentrations are anticipated.

During the first quarter, no methane was detected in GMW17 and GMW18, where Control or Trigger Levels are not available.

4.5.1.2 Carbon Dioxide

Carbon dioxide concentrations were recorded below the respective Control and Trigger Levels, where available, in the majority of monitoring locations with the exception of GMW5, GMW6 and GMW13.

Exceedances were recorded in GMW5 in the white valve throughout the first quarter with the control and trigger levels exceeded in January with 5.8% and in February with 5.0%. The control level was exceeded in the yellow valve in March with 3.7% recorded, the first time an exceedance has been recorded in the yellow valve since February 2016.

GMW6 recorded a single elevated level of carbon dioxide in the red valve above the Control and Trigger Levels with a concentration of 4.8% recorded in February. Carbon dioxide levels have been recorded in the red valve above assessment levels since July 2017 with the exception of January recording 3.8% and March recording 2.4%.

GMW13 has recorded concentrations of carbon dioxide in the yellow valve above the control and trigger levels with a level of 6.6% recorded in February. January and March recorded below the trigger and control levels for the first time since June 2017. Although low levels of carbon dioxide have been recorded in January and March, exceedances continue to be recorded on a regular basis. Therefore, it is recommended the composition of the gas is investigated as it is also considered to be impacted by the presence of marshland and bedrock geology on which this is located.

Elevated levels of carbon dioxide also continue to be measured in GMW1, GMW8, GMW9, GMW10, GMW17 and GMW18. However, no Control/Trigger Levels have been derived for these locations which are in close proximity to the waste mass. Gas monitoring will continue in accordance with the agreed programme and the relevant Permit conditions.

Two additional gas pumping wells were drilled in the vicinity of GMW1 in February 2015 in the hope that it would reduce the levels of carbon dioxide.

However, the levels recorded during this quarter are similar to those recorded prior to the installation of the additional wells. The wells are still under extraction and are intermittently pumped.

5 Conclusions

The monitoring regime has been undertaken in accordance with the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [4]) with monitoring and testing done in accordance with the Permit (Ref. [1]). The following section concludes the assessments for leachate, surface water, groundwater and landfill gas.

5.1 Leachate

5.1.1 Leachate Quality

The majority of the determinands tested recorded average concentrations well below their respective AMC values except for ammoniacal nitrogen.

The average value of ammoniacal nitrogen was recorded above the AMC value of 526mg/l during the first quarter of 2018, with a level of 619mg/l, an increase from the previous quarter. Review of the previous year's readings indicates that exceedances were recorded throughout 2017, occurring due to LC5A continuing to record high results up to 3 times greater than the next highest reading. In accordance with the Aftercare Phase Environmental and Infrastructure Monitoring Program report (Ref. [4]) and summarised in Table 3.3., the contingency plan is to be implemented after three consecutive exceedances have been recorded. It is proposed to undertake pump tests of LC5A with the possibility of installing a new well within Cell 5. This will confirm if the elevated ammoniacal nitrogen levels are an issue across the whole of cell 5 or whether it is localised to LC5A.

5.1.2 Leachate Head Monitoring

An increasing trend in leachate head has been continually recorded in LC5A, with the leachate level steadily rising from 2013, however, the first quarter of 2018 has recorded a significant decrease in leachate head within LC5A. The leachate head recorded in the remaining wells has remained stable with all maximum leachate values recorded in LC5A.

The leachate level for LC5A in January 2018 has decreased from the previous quarter by 1.54m. The quarterly average level for all the wells remains within the 3m limit stipulated in the Permit (Ref. [1]) with a calculated level of 2.35m, compared to the average level of 2.74m recorded in the last quarter. However, there is still the potential for the average quarterly level to reach the 3m limit within the near future. It is therefore proposed to undertake pumping tests within well LC5A with the possibility of installing a second well within Cell 5 which will help to correlate the leachate head level across the cell. This should help determine whether well LC5A is performing efficiently or whether the leachate head levels are due to an issue within this well.

The wells located in the Phase 1 cell, specifically LC1A have recorded low levels of leachate with not enough to collect samples for testing and well L1 has consistently been recorded as dry.

5.2 Surface Water

The monitoring results for surface water generally indicate that the majority of the determinants are recorded at less than the detectable limit levels at both upstream and downstream monitoring locations, and the evidence indicates that there is currently no discernible impact on surface water receptors by the landfill.

5.2.1 SWU, SW2AI, SWW1, SWW2 and SWW4

These locations are monitored on a six-monthly basis, therefore they have not been monitored during this quarter.

5.2.2 SWD and SWD1

The surface water results for the monitoring points located downstream of the landfill indicate no environmental impact on this receptor. Ammoniacal nitrogen, mercury, zinc and manganese were recorded at less than detectable levels with chloride, sulphate and nickel all measured below their respective Freshwater EQS. The calculated concentrations of unionised ammoniacal nitrogen were recorded above the Freshwater EQS during the first quarter for SWD.

Concentrations of sulphate were showing a decreasing trend throughout 2017, however the levels recorded during the first quarter of 2018 have increased slightly with a highest value of 54.4mg/l being recorded in SWD. Low levels of sulphate have been detected in the groundwater upstream wells during the reporting period, therefore suggesting a source of sulphate other than the landfill.

5.2.3 SW1 – SW10

Monitoring of these downstream locations is still conducted monthly as of the amended permit [1]. Sampling could not be undertaken at SW9 during February due to the location being frozen.

Ammoniacal nitrogen and mercury were recorded below the limit of detection at all monitored locations during the first quarter. The higher ammoniacal nitrogen levels recorded in GW9 are showing no impact on the surface water. Mercury has not been recorded above the detection level at any monitoring location since May 2014.

Chloride levels remained well below the EQS freshwater concentration level of 250mg/l, with a maximum of 60.8mg/l recorded. This shows that the pumps are effective at stopping the leachate, which has high levels of chloride, from leaching into the Nant Merddog downstream of the landfill.

Surface water monitoring will continue in accordance with the agreed programme and the relevant Permit conditions.

5.3 Groundwater

The The background groundwater quality monitoring continues to record elevated levels of mercury, sulphates and manganese suggesting other sources than the landfill for these determinants.

5.3.1 Upstream Wells

The upstream wells GW3A and GW4 continue to show elevated levels of zinc. However, the levels recorded during this quarter were less than the level of detection, which is recorded higher than the assessment criteria. The high LOD level is because of laboratory dilution issues due to the integrity of the sample.

Manganese has continually been recorded above the assessment level in GW4, however the level has decreased in this quarter to the lowest recorded since September 2015.

The elevated concentrations upstream suggest there are sources other than the landfill for these determinands. This is likely to be from steel works waste deposited to the north of the landfill and old mine workings in the area which are likely to be the source of the elevated levels of zinc. Manganese is also a typical contaminant of mine drainage, which is considered to be impacting the groundwater in the locale of the landfill.

5.3.2 Downstream Wells / Compliance Wells

The results from the compliance wells indicate that generally the pumping system at the toe of the landfill is continuing to successfully control the potential egress of leachate from the landfill. No issues associated with pump failure within the cut-off system have been recorded during this quarter.

The elevated concentrations of manganese and zinc observed in the downstream wells are likely to reflect background concentrations. This is supported by the zinc and manganese concentrations being low in the leachate testing therefore indicating a different source from the landfill.

5.3.2.1 Compliance well GW9

GW9 is continuing to be non-compliant with ammoniacal nitrogen reported above the Trigger Level. Monitoring results have been showing a general decreasing trend since 2012, with the exception of limited occasions which are considered to be associated with seasonal variations and periods of persistent elevated rainfall. On completion of the Phase 1 capping in September 2015 the levels of ammoniacal nitrogen significantly decreased. There was a slight increase in January 2016, however the level of ammoniacal nitrogen has continued to decrease throughout 2016 and 2017, with the level recorded in the fourth quarter of 2017 being the lowest recorded level since August 2011. However, the first quarter of 2018 recorded an increased level of ammoniacal nitrogen and unionised ammoniacal nitrogen was recorded above the EQS freshwater value for the first time since October 2016. Therefore, concentrations of ammoniacal nitrogen

should be closely monitored throughout 2018 to determine if this is a seasonal variation and a continuing decreasing trend or if the levels are beginning to increase.

The monitoring of the downstream environmental impact of the non-compliance at GW9 (sampling and analysis of the Nant Merddog and identified stream and break outs in the SSSI) is currently on-going. The available monitoring results to date show that the concentrations of ammoniacal nitrogen and chloride are not detectable in these streams, and no impact on the Nant Merddog has been shown. As discussed in the updated GW9 report (Ref. [6]), it is considered that the on-going non-compliance at GW9 is due to the heavily fractured stratum in that locale that prevents the pumping system from intercepting all leachate-impacted groundwater, and that pumping from the locale of GW9 is currently being reviewed. These levels should be closely monitored in 2018 prior to further investigation being agreed.

Zinc was monitored in GW9 at concentrations above the Control Level in January, however this level was lower than the levels recorded during 2017, continuing to show a decreasing trend. The levels should be monitored closely in 2018 to confirm this trend is continuing. However, elevated concentrations of zinc were monitored in the upstream wells during the reporting period, hence suggesting the presence of a source of zinc external to the landfill as discussed above.

Manganese concentrations have increased from the last quarter, remaining above the freshwater EQS level of 0.03mg/l. However, the WFD have updated the EQS value to 0.123mg/l based on the bioavailable concentration of manganese, as discussed in Section 3.3.2. The recorded bioavailable concentration was only slightly above the updated EQS value with a level of 0.127mg/l recorded. Manganese concentrations should be closely monitored during 2018 to confirm if the levels are likely to continue to fall below the updated EQS value. Elevated background manganese concentrations have been observed in the upstream groundwater wells during the reporting period, suggesting a source of manganese other than the landfill.

Mercury, chloride and sulphate levels continue to record below the assessment criteria with mercury recorded below level of detection.

5.3.2.2 Compliance well GW10

In GW10, ammoniacal nitrogen and mercury were recorded below level of detection during the first quarter monitoring with chloride and sulphate recorded below all assessment criteria. Leachate analysis did not record mercury above the detection level at any of the wells so the landfill is not considered to be the source of mercury.

Zinc has remained above the trigger level during the first quarter and is continuing to steadily increase, as reported throughout 2017. Since elevated concentrations of zinc have been recorded in the upstream wells and no or low levels of leachate species have been detected in GW10, it is considered likely that a source of zinc, other than the landfill exists which impacts on the groundwater monitored by GW10.

Manganese has been recorded above the EQS value of 0.03mg/l, the first since February 2016. However, the bioavailable concentration of manganese has been recorded below the updated EQS value of 0.123mg/l and is therefore not considered an issue.

5.3.2.3 Compliance well GW12

Groundwater contained within the sandstone strata S2-west is monitored by GW12. The ammoniacal nitrogen concentrations have continued to record below level of detection in January. The last result recorded above level of detection was in April 2016 where the result was above the Control Level A value.
Mercury was recorded below level of detection in GW12, the same as the previous quarter's result, with the last trigger level exceedance recorded in January 2017. The levels of mercury have been shown to fluctuate over the past year, generally coinciding with the fluctuations recorded in GW6 even though this well has a response zone in a different stratum. The leachate quality testing did not detect elevated levels of mercury, therefore any elevated mercury in the groundwater in GW12 is not considered to originate from the landfill. However, levels of mercury should still be closely monitored during 2018.

Sulphate levels have historically been recorded as elevated since 2015, although have fluctuated above and below the assessment criteria throughout 2016 and 2017. Sulphate levels were recorded above the Control Level in January, an increased from last quarter. The elevated levels do not seem to have a direct correlation with elevated rainfall or increase in water level and elevated levels of sulphate are not recorded in any other monitoring well. There has been an increasing trend in the yearly average concentrations, however the 2017 yearly average had decreased compared to previous years. Although the sulphate results have shown an increase in January, they should be monitored closely during 2018 to assess whether the results continue to fluctuate and if the yearly average is declining.

Zinc has continued to exceed the assessment criteria during the first quarter of 2018 with a level of 0.331mg/l recorded. An increase in levels was noted in the latter part of 2017 following a decreasing trend recorded since July 2016. The level recorded in January has decreased significantly from the previous quarter, therefore zinc should be monitored closely in 2018 to determine if there is a decreasing trend. As previously mentioned, zinc is also found at elevated concentrations in the upstream wells, indicating the presence of a source of zinc other than the landfill.

Manganese was recorded below the assessment criteria in January, compared to the previous quarter when the highest level since March 2009 was recorded. As with zinc, manganese concentrations coincide with elevated background concentrations, suggesting a contamination source other than the landfill.

5.3.2.4 Wells GW6 and GW7

Elevated levels of zinc continue to be recorded within sandstone strata S1, monitored by GW6 and GW7. In GW6, zinc has been recorded above the Trigger Level for the first time since October 2016. This may be a localised event and

should be closely monitored during the next quarter. In GW7 zinc was measured below level of detection which, due to dilution issues in the laboratory, is above the original EQS value. However, the bioavailable concentration of zinc is below the updated EQS level. Zinc levels coincide with elevated background concentrations, suggesting a contamination source other than the landfill. The bioavailable concentration of manganese in GW6 was recorded below the updated EQS freshwater value. In GW7, manganese levels have been recorded above the EQS and assessment level in January, but has decreased from the previous quarter. Historically manganese has fluctuated within this well, therefore the current decrease should be monitored closely.

No concentrations of mercury, nickel, ammoniacal nitrogen, chloride or sulphate have been recorded in either well above the assessment criteria.

5.4 Landfill Gas

The gas monitoring results showed compliance with the set Control and Trigger Levels in the majority of gas monitoring locations.

5.4.1 Methane

Methane concentrations continue to be recorded below the respective Control and Trigger Levels (where available) in all monitoring locations.

Elevated levels of methane continue to be measured in monitoring wells GMW1 (yellow and white valve), GMW8 (yellow valve), GMW9 (yellow valve) and GMW10 (all three valves). However, no Control/Trigger Levels are available for these locations. No methane was detected in GMW17 or GMW18, where Control or Trigger Levels are also not available.

5.4.2 Carbon dioxide

Carbon dioxide continues to be recorded above the Control and/or Trigger Levels in the yellow valve of GMW13, however only in February in the first quarter. This well is considered to be impacted by the presence of marshland and bedrock geology on which this is located. The levels should be closely monitored to see if they continue to exceed the assessment levels and it is recommended that gas analysis is carried out at this location and the Control/Trigger Levels reassessed as necessary.

Concentrations of carbon dioxide in the white valve of GMW5 were recorded above the Trigger and Control levels in January and February and above the Control Level in the yellow valve in March, first since February 2016.

GMW6 recorded elevated levels of carbon dioxide in February, in exceedance of Control and Trigger Levels in the red valve. This exceedance was recorded in the same month as the ones in GMW5 and GMW13.

Monitoring in GMW14 continues to have accessibility issues due to its location within a cattle quarantine paddock. The required monitoring frequency cannot currently be sustained due to its current location. It is currently proposed to install

a new monitoring well in close proximity to the current location, within the Permit requirements.

Elevated levels of carbon dioxide continue to be measured in GMW1, GMW8, GMW9, GMW10, GMW17 and GMW18. However, no Control/Trigger Levels have been derived for these locations as they are in close proximity to the waste mass. Gas monitoring will continue in accordance with the agreed programme and the relevant Permit conditions.

In order to mitigate the elevated levels of carbon dioxide previously recorded in GMW1, two additional gas pumping wells were drilled in its vicinity in February 2015. However, the elevated levels recorded during this quarter are similar to those recorded prior to the installation of the additional pumping wells. This suggests the additional pumping is not reducing the carbon dioxide in GMW1. This will require to be investigated further.

Gas monitoring will continue in accordance with the agreed programme and the relevant Permit conditions.

5.5 Summary

The monitoring data and interpretation produced in this report indicates that the landfill continues to generally comply with the requirements of the permit and shows no evidence of an adverse environmental impact.

References

[1] Environment Agency, Silent Valley Landfill Site, Pollution Prevention and Control (England and Wales) Regulations 2000, Landfill (England and Wales) Regulations 2002, Permit number MP3835SV, November 2005, Permit amended as of 04/03/16.

[2] Arup, Silent Valley Landfill, 2016 Annual Monitoring Report, 31st January 2017.

[3] Arup, Silent Valley Landfill, Interim GW9 and Nant Merddog W, Issue May 2015.

[4] Arup, Silent Valley Landfill, Aftercare Phase Environmental and Infrastructure Monitoring Program, Issue June 2013.

[5] Arup, Silent Valley Landfill, Hydrogeological Risk Assessment, document reference 04/6363, November 2004.

[6] Arup, Silent Valley Landfill, Investigation in to the Western Flank of the Cut-off System. Compliance Well GW9 and GW10, document reference 115825, August 2011.

[7] Environment Agency, Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water, report reference LFTGN02, June 2014.

[8] Arup, Silent Valley Landfill, 2010 Annual Monitoring Report, document reference 11/7956, February 2011.

[9] Arup, Silent Valley Landfill, Hydrogeological Risk Assessment (Supplementary Revision May 2009), document reference 09/7543, June 2009.

[10] Golder Associates, Establishment of Trigger Levels at Silent Valley landfill site, letter report dated 21 December 2006.

[11] Environment Agency, Guidance on the management of landfill gas, document reference LFTGN03, June 2014.

[12] The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

[13] Water Framework Directive - United Kingdom Technical Advisory Group (WFD-UKTAG), “Metal Bioavailability Assessment Tool (M-BAT),” 2014.

Figures

Figure 1 Site Location Plan

Figure 2 Layout of Monitoring System

Figure 3 Location of Additional Surface Water Monitoring Locations

A4

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Job Title
Silent Valley Landfill

Drawing Title
Site Location

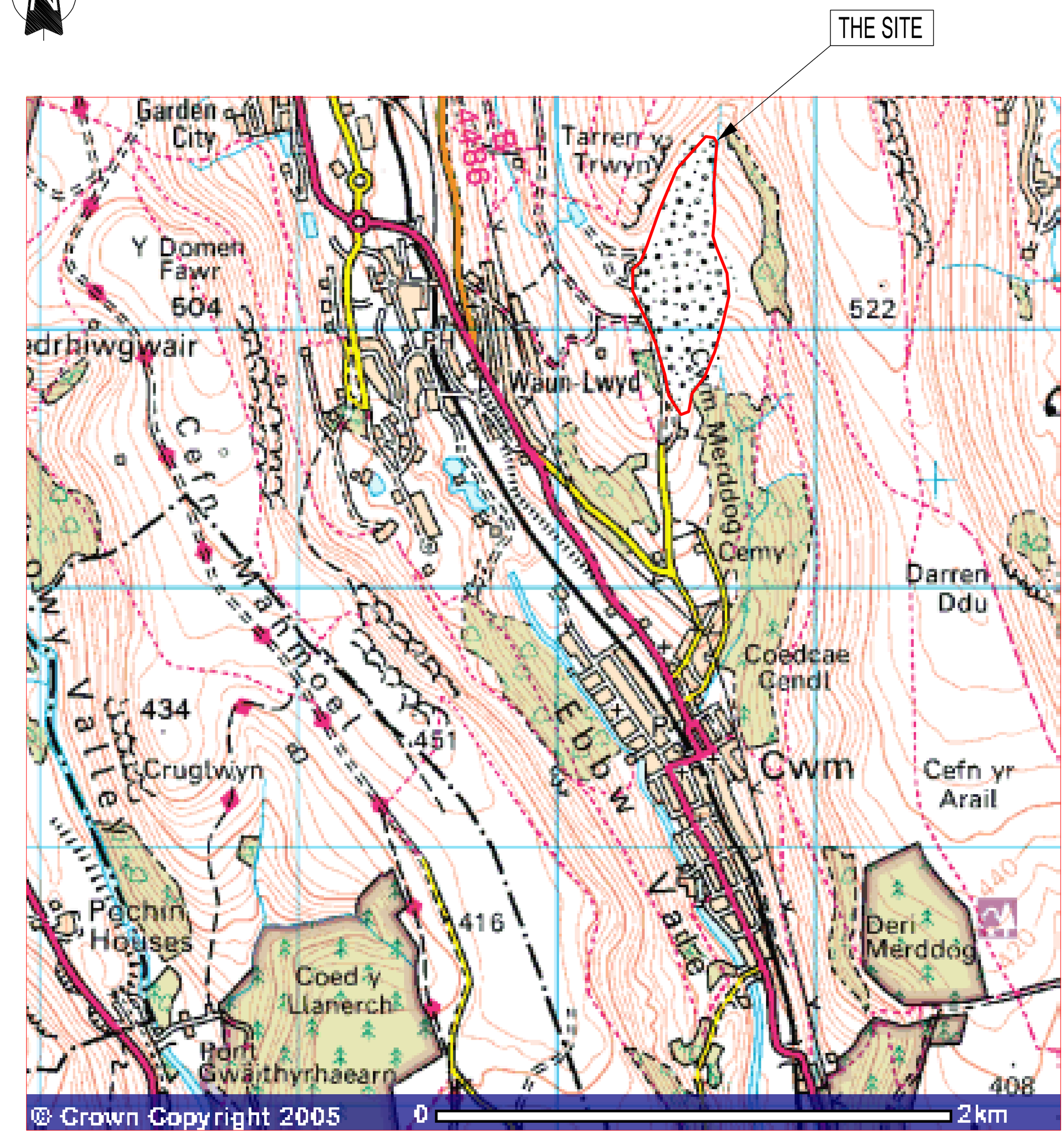
Scale at A4 N.T.S

Plot ID zfigure1.dgn

Drawing Status
Information

Job No	Drawing No	Issue
115825	**Figure 1**	**I0**

I0	02/05/07	RP		
Issued For Information				



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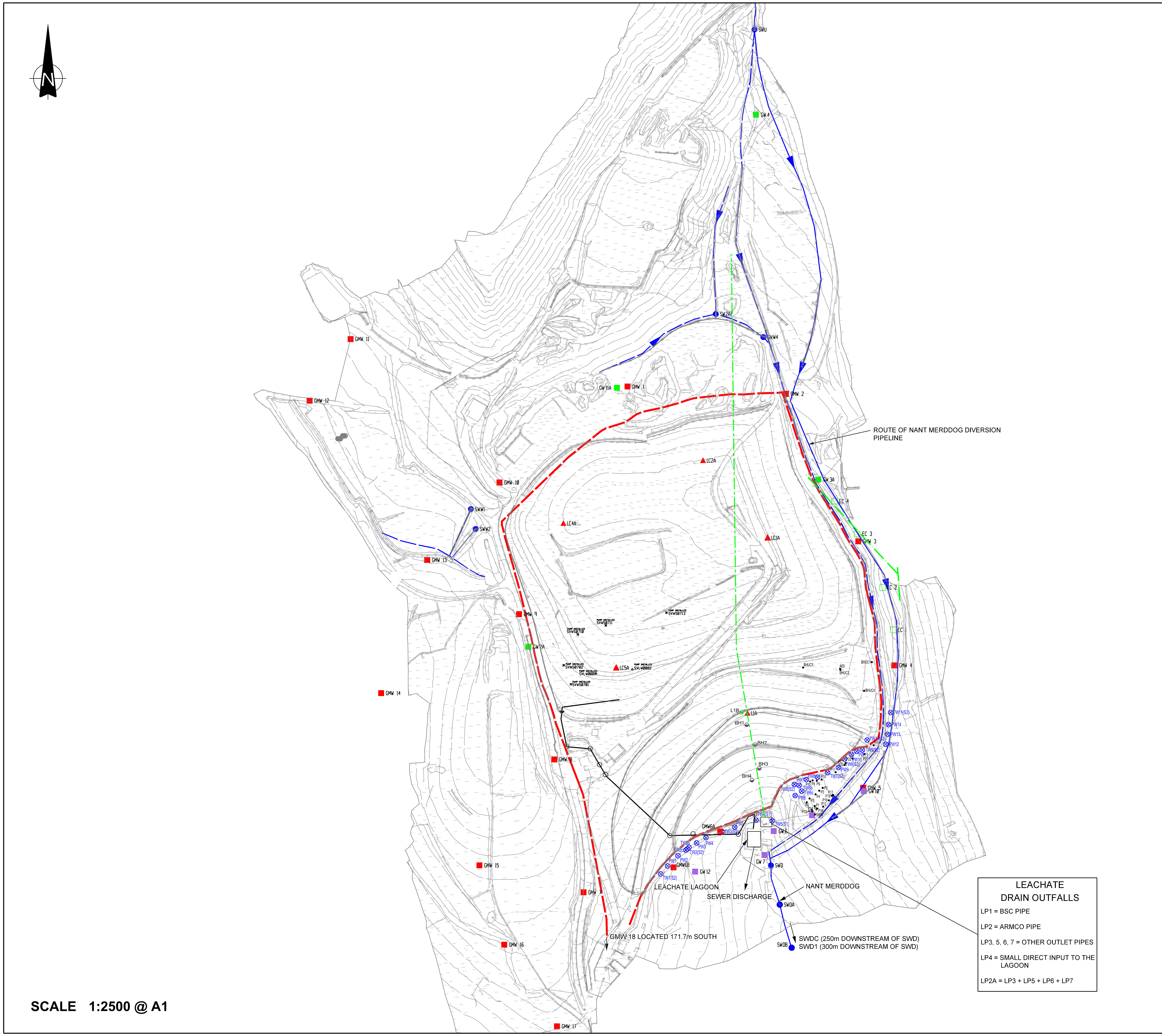


LEGEND

- EC 1 — EASTERN CUT-OFF MONITORING WELLS
- GMW5 — GAS MONITORING POINTS
- GW10 — COMPLAINCE POINT GROUND WATER WELLS
- GW4 — GROUND WATER MONITORING WELLS
- SW1 — SURFACE WATER SAMPLING POINTS
- LC1 — LEACHATE MONITORING WELLS
- SURFACE WATER DITCHES
- EXTENT OF LANDFILLED WASTE
- TWs & PWs — PUMPING WELL CUT OFF SYSTEM

LEACHATE DRAIN OUTFALLS

LP1 = BSC PIPE

LP2 = ARMCO PIPE

LP3, 5, 6, 7 = OTHER OUTLET PIPES

LP4 = SMALL DIRECT INPUT TO THE LAGOON

LP2A = LP3 + LP5 + LP6 + LP7

SCALE 1:2500 @ A1

SILENT VALLEY LANDFILL
SITE PLAN
ENVIRONMENTAL MONITORING

115825-00 FIGURE 2

J:\115000\115825-00\4 Internal Project Data\4-30 Drawings\4-33 Civil\Figure 2 Site_Plan_Env_Monitor_Prog.dgn

CCTV SURVEY
IN MAY 1996
SHOWED 750 dia
PIPE ENDS HERE

800mm dia ARMCO HELCOR
PIPELINE (ALIGNMENT APPROX.
AS SHOWN ON 1983 AERIAL
PHOTOGRAPH) (DESIGN INVERT
LEVELS SHOWN)

CH 0

CL 365.38
IL 363.17

L1B

750mm DIA
BSC PIPELINE

650mm dia
CONCRETE
PIPELINE

PE ENTRIES FROM
UBBLE DRAINS
STABLISHED BY
CTV SURVEY IN
AY 1996

CONCRETE CHAMBER (NOW BURIED
BUT SEEN IN CCTV SURVEY AND
VISIBLE ON 1983 AERIAL PHOTOGRAPH)

CL 354.37
IL 353.10

FRENCH DRAIN

CL 350.75

GW 10

CL 346.77

COR

900 dia CONCRETE
PIPELINE

GW 9

FRENCH DRAIN

CONCRETE CHANNEL
AND CASCADE

GW 6

LAGOON

OUTLET
TO STREAM

300mm dia CONCRETE PIPELINE
(pre 1982) (BGBC Dwg No RDE 61
SHOWS THIS PIPELINE PASSING
BENEATH THE LAGOON AND
DISCHARGING INTO NANT MERDDOG
20m DOWNSTREAM OF THE 900dia
PIPELINE OUTFALL, WITH IL 94.57)

GW 7

SWD

NANT MERDDOG

GW 8

SWDA

SWDB

SW4

SW5

SW6

SW7

SW1

SW2

SW3

SW8

REVISED STREAM LOCATIONS

Appendix A

Details of cut-off and monitoring systems

A1 Pumping cut-off system and monitoring

The following is a summary of the activities that have taken place at the site in relation to the pumping and monitoring system since its installation in 2007.

2007 **October:** The pumping system became operational.

2008 **November/December:** A programme of inspection and maintenance was undertaken to check the level and performance of each well and pump following the findings of the January to September 2008 interim report, which indicated that the cut-off system operated less efficiently post high rainfall events, with concentrations within the compliance wells temporarily increasing. A number of wells were found to be silting up and required cleaning. Details are presented in the Annual Monitoring Report 2008.

2009 **January:** The majority of wells were successfully cleaned. The base of wells TW2, TW7, PW4 and PW10 were found to be above the depth shown on the logs. Deeper replacement wells were installed at TW2, TW6 and TW7, (called TW2A, TW6A and TW7A), construction details as shown in the sketch at the end of this Appendix;

February: Low-draw pumps were installed to improve the situation at PW4, PW7, PW10 and PW14;

March: Existing pumps were replaced with more robust pumps, to cope with silting and iron hydroxide deposition;

April: Pumping from these replacement wells commenced;

November/December: The pumps in wells TW2A and TW6A were overwhelmed during periods of very heavy rainfall, producing impacts in the compliance wells downstream, at GW9 and GW12 and monthly average leachate heads often in excess of permitted values. There was concern that the monitored heads may have been influenced by perched leachate bodies, the monitoring wells having been constructed with slag gravel response zones extending through the body of the landfill. As a result, two more pumping wells were installed alongside each of wells TW2A and TW6A, with the aim that these wells would provide support to the existing wells and prevent further migration of leachate. Pumping tests and the installation of new leachate monitoring wells at the locations of LC1, LC2 and LC4 (LC1A, LC2A and LC4A) were undertaken to obtain additional information on the leachate heads. The new wells were installed with 3m long response zones in contact with the base of the landfill and isolated from potential perched leachate bodies higher up within the landfill mass. As such, they are representative for measuring the hydrostatic head of leachate that acts on the base of the landfill and potentially drives leakage. The wells have consistently indicated leachate heads that are much lower than those measured previously in the corresponding former monitoring wells LC1, LC2 and LC4. This is

corresponding former monitoring wells LC1, LC2 and LC4. This is considered strong evidence that the average leachate heads derived previously were influenced by perched leachate bodies.

2010 **February:** Wells TW2B, TW2C, TW6B and TW6C were installed alongside wells TW2A and TW6A. The monitoring results indicate there has been an improvement of water quality in GW12 in relation to ammoniacal nitrogen and chloride (i.e. in TW2A, only one exceedance of the compliance limit for ammoniacal nitrogen and no exceedances for chloride were recorded since the installation of the new pumps). However, this improvement was not replicated at GW9 downstream of TW6A, B and C. Extensive investigations including sampling and laboratory analyses have been undertaken to confirm the source of the leachate species encountered in GW9 and measures to address this issue have been undertaken (see Reference [8]). The investigations identified an uncapped plateau area on the eastern flank of the landfill and concluded that one of the sources of the leachate monitored in GW9 may be groundwater infiltrating into the waste body from this uncapped area and flowing towards GW9 within fractured mudstone and sandstone layers, in line with the geological and hydrogeological model also presented in the report. Part of the leachate body in the uncapped waste was also considered to be flowing towards a gabion mattress-lined ditch located on the eastern flank of the landfill. This leachate was found to be diluted by the surface waters flowing in the ditch and potentially by groundwater from the valley sides, and was also considered likely to be impacting GW9. The capping of the eastern plateau was completed in August 2011 (see below).

June/July: A replacement monitoring well LC5A was drilled adjacent to LC5. A back-up compressor has been installed to provide support to the compressor currently in use at Silent Valley.

August: The new leachate well, LC5A, was commissioned and subsequently monitored in accordance with the quarterly monitoring regime.

2011 Leachate pumping was temporarily ceased due to bio-fouling of the pumps and wells. The pumping was shortly after reinstated using gas extraction wells and the pumping continues to date.

August: The capping of the eastern plateau was completed. Since its installation, the levels of ammoniacal nitrogen and chloride in GW10 were observed to have significantly reduced towards the end of 2011; however, these continued to be above the compliance level in GW9 and further sampling was recommended to monitor the trend.

2012: No specific maintenance or upgrades on the monitoring infrastructure were required or undertaken in 2012.

2013 **March to July:** The pump in PW12, which pumps from sandstone strata S3, was found to be not working. Following a number of maintenance works, the pump was still found to be failing. On reinstatement of the

electronic groundwater monitoring system in July (see further details below), it was evident that the pump in this location was continuing to have issues. The pump was consequently changed in August and the groundwater levels within the well have since returned to the required level. Maintenance issues were also recorded in the eastern section of the cut-off system, wells between April and September 2013 in TW10.

December: Although there is no current evidence to suggest issues with the efficacy of the BSC pipe located in the southern flank of Phase 1 landfill, SVWS commissioned the installation of four additional leachate monitoring wells (BH1 to BH4) along the alignment of the BSC pipe in December. The objective is for these boreholes to be monitored to confirm both the nature and level of leachate within the Phase 1 area and any long-term trends in leachate level (note that monitoring has temporarily ceased due to the works undertaken for the capping of Phase 1 landfill – see following sentence). During the installation of these wells, observations indicated that the capping of Phase 1 landfill was not typical of a low permeability capping system and further investigations, including the excavation of 19no shallow trial pits, confirmed that the existing capping was likely to not be preventing infiltration of rainwater. SVWS are currently undertaking works to improve the capping of the Phase 1 area in order to achieve a reduction in the leachate production and achieve regulatory compliance (see below).

2014 **July:** Earthworks for the installation of the capping system in Phase 1 landfill commenced. A combination of cut and fill is used to slacken the existing landfill slope angles to a maximum gradient of 1V:2.5H to achieve a stable angle for the capping system.

July to September: Further issues were identified within the eastern section of the cut-off system, particularly in TW11, and also in TW10 and PW14, all installed within the Sandstone S3 stratum. Pump failure was recorded in TW11 from July the 7th till September the 4th. After a number of attempts, the pump was finally retrieved and further delay in a pump reinstatement was caused by the delivery of required replacement parts. In addition, pumps installed in TW10 and PW14 repeatedly failed after service, however are now fully operational.

2015 **January:** capping of Phase 1 landfill is ongoing, with the earthworks largely complete. In addition to the new capping, improvements are also being made to both the surface water drainage and the leachate drain at the toe of the landfill. A new access track has also been constructed across the landfill to provide access for construction and future maintenance.

A1.1 Electronic Monitoring System

Since April/May 2009, the water levels within the pumping wells have been continuously monitored using electronic devices installed within the wells, so-called 'divers'. These send water level data at a specified frequency directly to an office-based computer, allowing continuous remote monitoring of the efficiency of the cut-off system. This has enabled immediate investigation and remedial actions to be taken when the water level within any well has risen unacceptably or abnormally.

In March 2013, however, problems have occurred with some of the modems, devices collecting data and sending this information to the office-based computer. During the repair period, the efficiency of parts of the pumping system was monitored manually. The modems have been successfully reinstalled in July 2013 and no further issues have been recorded since then.

A1.2 Future maintenance and reinforcement

The pumping well cut-off system is considered to be both robust and flexible. There is considerable redundancy in its design, both in terms of the spacing of the wells and the capacity of the pumps. The system can be easily modified or augmented by the addition of new wells as necessary (as has already taken place in 2008, 2009 and early 2010). In addition to this, the electronic monitoring system, together with routine on-going maintenance of the wells and pumps and provision of replacement pumps, enables corrective actions to be taken in advance of any acute problem that could have an adverse impact on the local groundwater environment. It is clear that for the significant majority of the site, the pumping system is preventing the impact of leachate species from within the body of the waste (or discharge zone as per the Groundwater Regulations 2009 incorporated into EPN2012) on the groundwater. Where there is the one non-compliance, GW9, Silent Valley has undertaken extensive investigations and works (References [7] and [8]).

Appendix B

Previous Site Monitoring

B1 Groundwater Monitoring

There are eight monitoring wells located upstream of the landfill site, where background groundwater quality monitoring has been carried out. These are GW2A, GW3A, GW4, GW11A and EC1 to EC4. Of these, GW2A, EC3 and EC4 were frequently dry and therefore a sample could not always be collected. The EC wells were installed in April 2008 as part of the initial feasibility study into an eastern pumping cut-off system and were included into routine monitoring in October 2008 until June 2010.

B2 Surface Water Monitoring

Locations S1 to S6 and SW2AO (see table below) were monitored from October 2008 to April 2010 to check the background quality of groundwater emerging from the eastern hillside, to supplement existing information and particularly identify any trends associated with the passage of water through abandoned mine workings and associated mudstone/seat- earth strata. Each of the monitoring locations comprised a perennial stream originating from groundwater issues.

Table B1: Former surface water monitoring locations

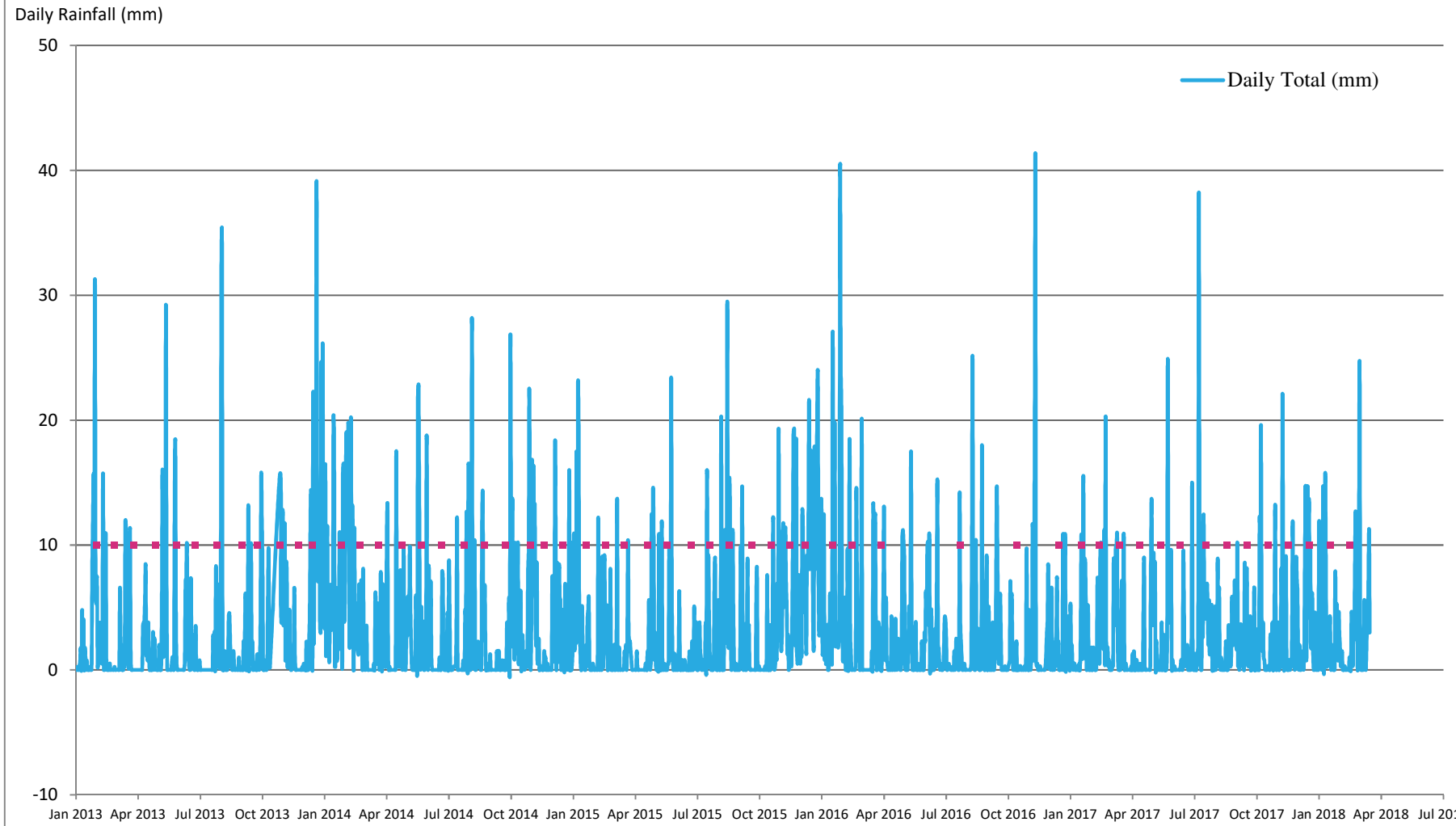
Monitoring Point	Location
S1	A stream, located 20m east of the landfill; approximately 100m north of the recorded landslide; emerging from the backfill of a former opencast site.
S2	A stream, located 20m east of the landfill; 100m south of S1, emerging from within the recorded landslide.
S3	A stream, located 350m downstream of the point where the diverted Nant Merddog joins its original course; the sampling point S3 is located approximately 150m upstream of the confluence with the Nant Merddog; the stream originates from issues downhill of the Old Tramway Path.
S4	A stream, located 650m south-east of the landfill, issuing from the foot of a cliff above the Old Tramway Path; the sampling point S4 is located approximately 10-20m above the path.
S5	A stream, located 70m south of S4; the stream crosses the pathway; the sampling point is located directly downstream of the path.
S6	A stream, located just outside the fence perimeter, the sampling point is located some 20m south of compliance well GW10.
SW2AO	Aqua-pipe outfall discharging to Nant Merddog (pipe buried beneath landfill in north-south direction) – sampling point abandoned, pipe is collapsed and collecting leachate from landfill, and was subsequently diverted into the leachate lagoon sump.

Between February and April 2010, water hardness in the Nant Merddog was undertaken in monthly rounds in order to select appropriate hardness dependant EQS levels. Previously, hardness data used was for the River Ebbw Fawr at the confluence of the Nant Big and the Nant Merddog.

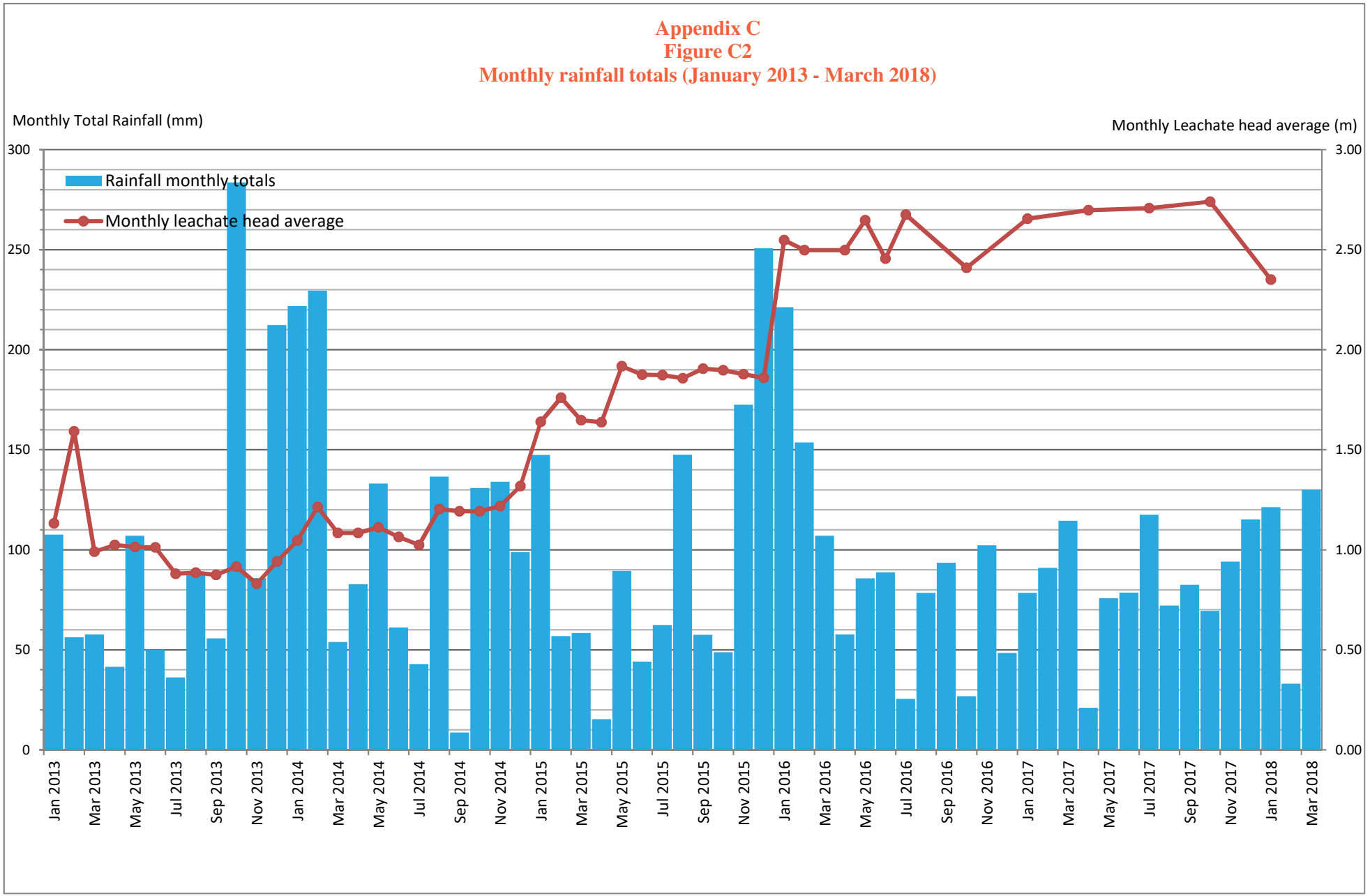
Appendix C

Monitoring Results - Graphs

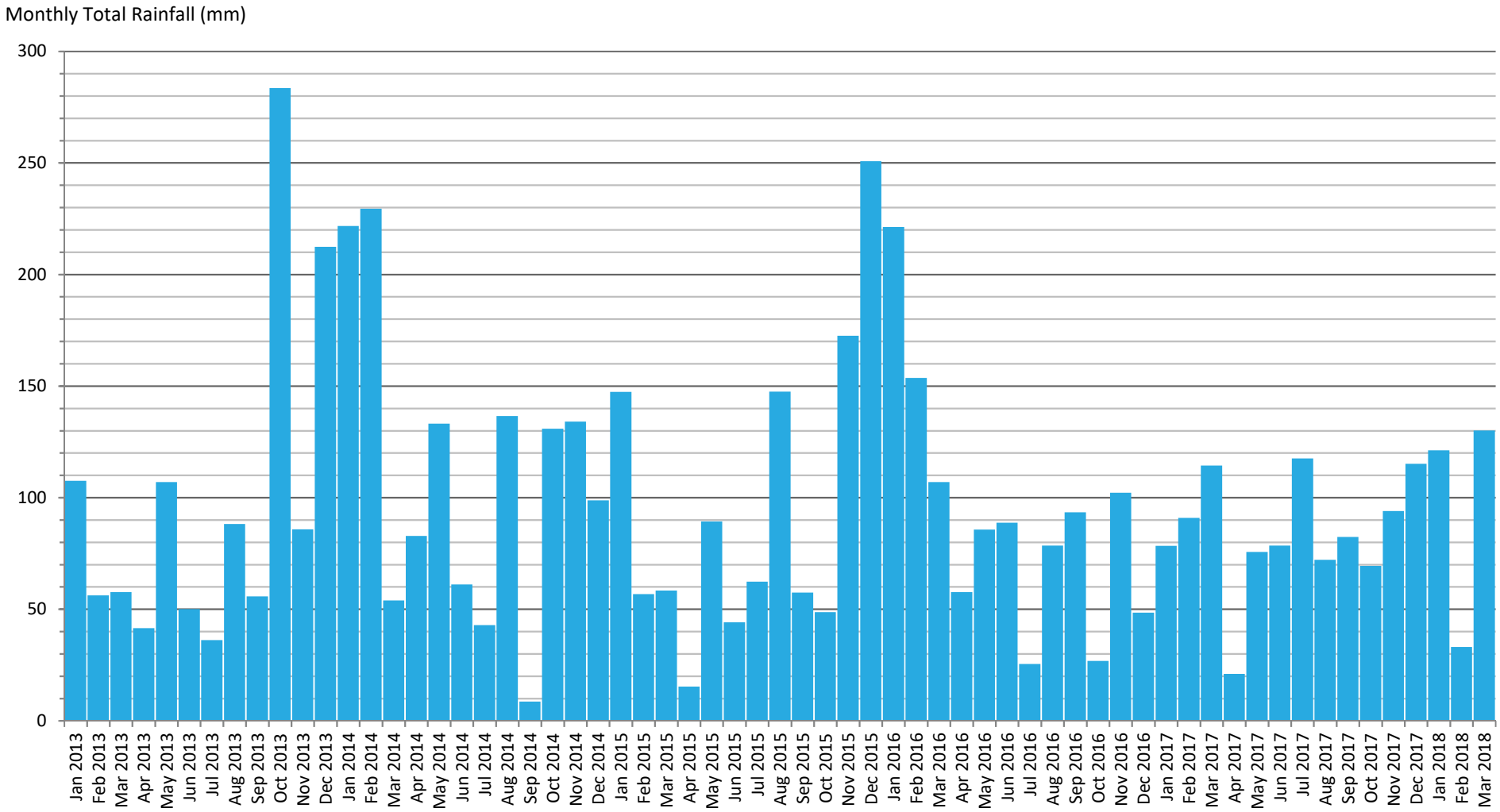
Appendix C
Figure C1
Daily rainfall totals and sampling events (January 2013 - March 2018)

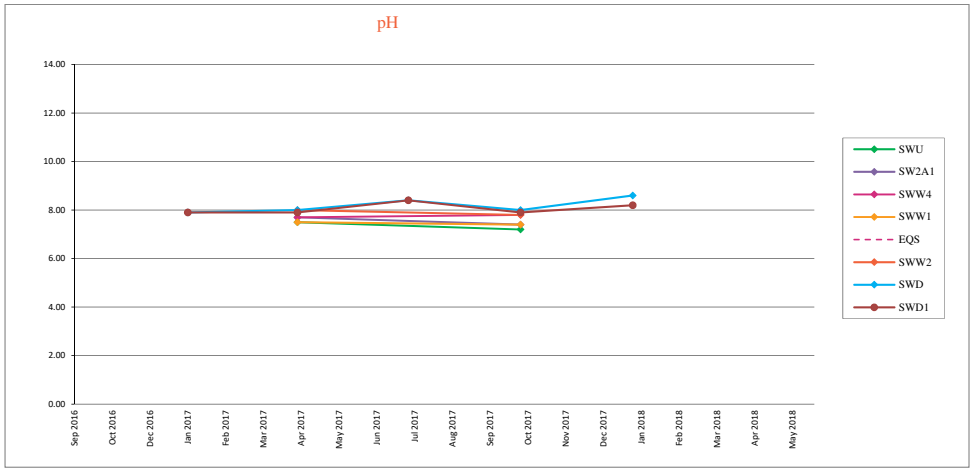


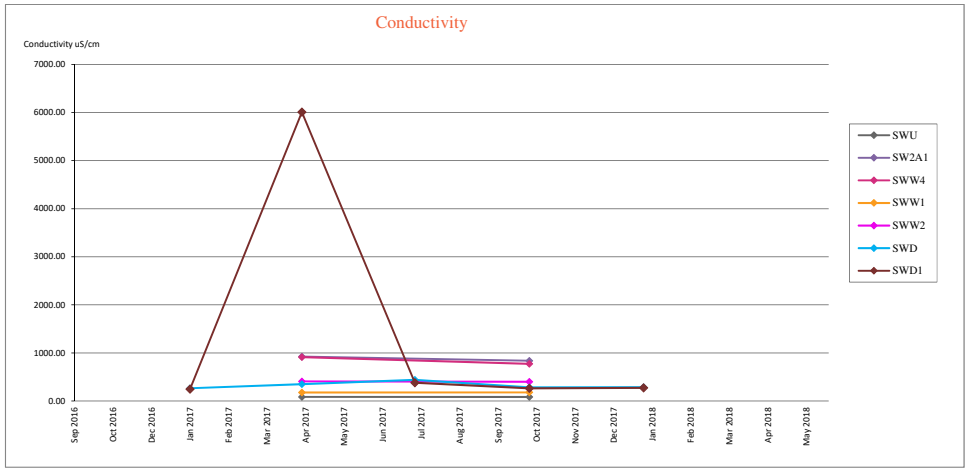
Appendix C
Figure C2
Monthly rainfall totals (January 2013 - March 2018)



Appendix C
Figure C3
Monthly total rainfall (January 2013 - March 2018)




pH
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Sep 2016
Oct 2016
Dec 2016
Jan 2017
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017
Oct 2017
Nov 2017
Dec 2017
Jan 2018
Feb 2018
Mar 2018
Apr 2018
May 2018
SWU
SW2A1
SWW4
SWW1
EQS
SWW2
SWD
SWD1


Conductivity
Conductivity uS/cm
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
Sep 2016
Oct 2016
Dec 2016
Jan 2017
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017
Oct 2017
Nov 2017
Dec 2017
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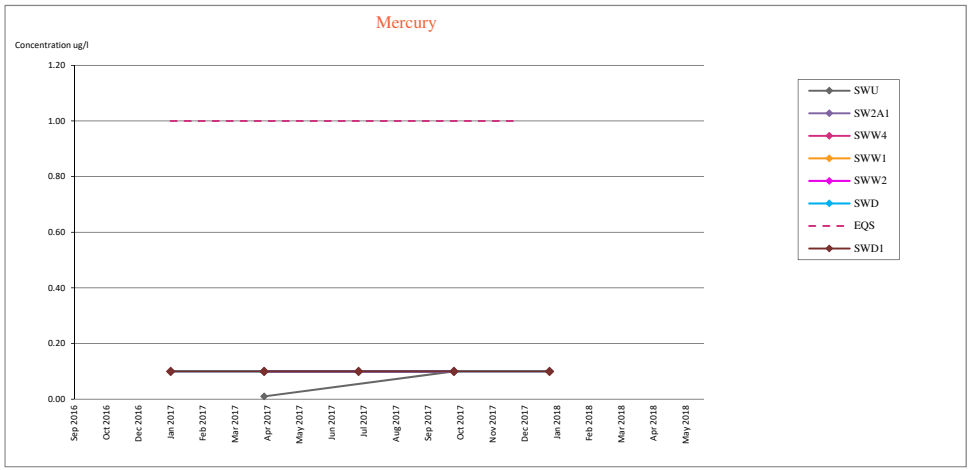
SWU
SW2A1
SWW4
SWW1
SWW2
SWD
SWD1


Mercury
Concentration ug/l
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Sep 2016
Oct 2016
Dec 2016
Jan 2017
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017
Oct 2017
Nov 2017
Dec 2017
Jan 2018
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Mar 2018
Apr 2018
May 2018
SWU
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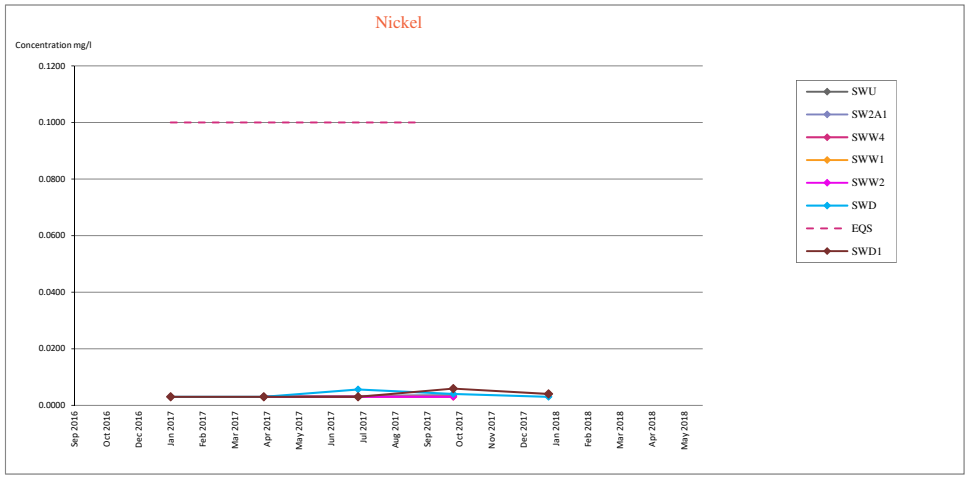
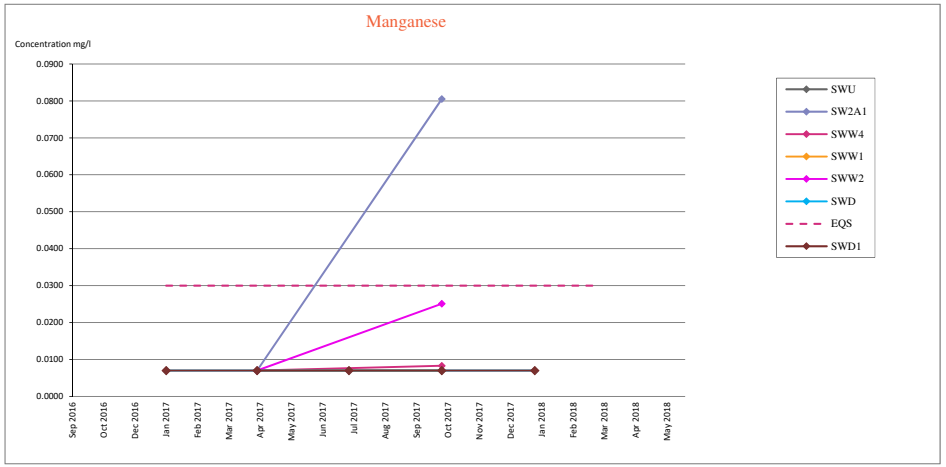
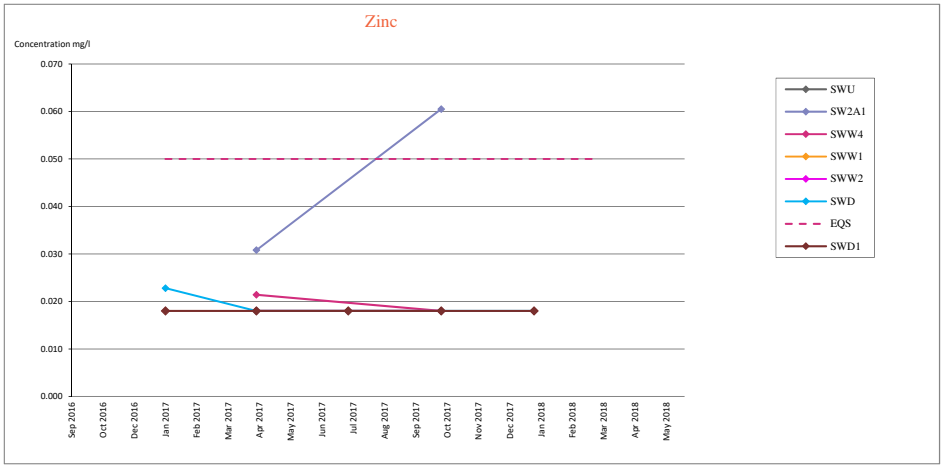
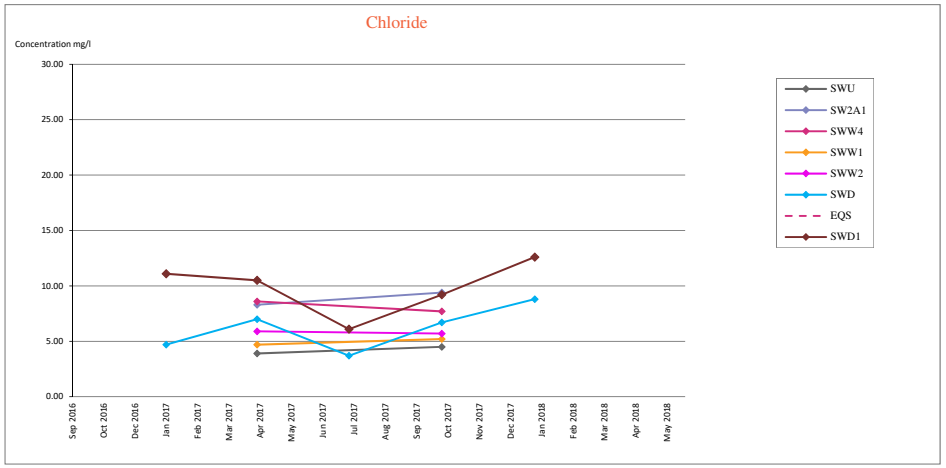
SWW4
SWW1
SWW2
SWD
EQS
SWD1

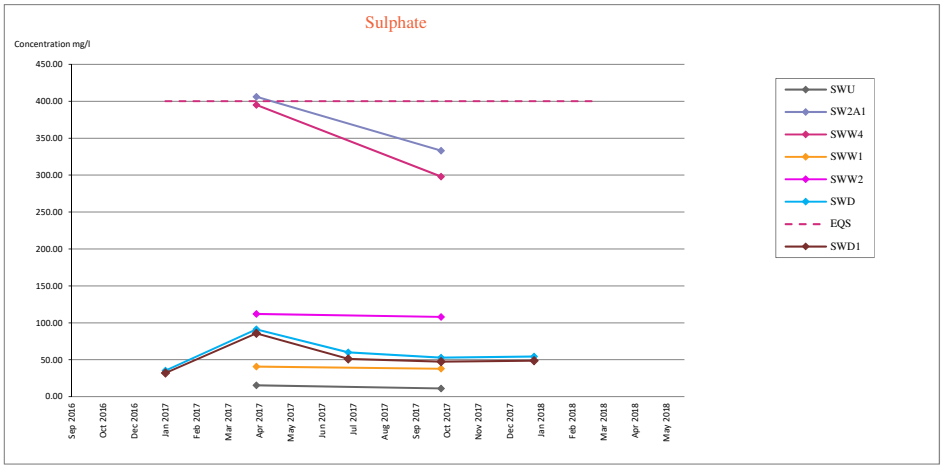

Nickel
Concentration mg/l
0.1200
0.1000
0.0800
0.0600
0.0400
0.0200
0.0000
Sep 2016
Oct 2016
Dec 2016
Jan 2017
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 2017
Jul 2017
Aug 2017
Sep 2017
Oct 2017
Nov 2017
Dec 2017
Jan 2018
Feb 2018
Mar 2018
Apr 2018
May 2018
SWU
SW2A1
SWW4
SWW1
SWW2
SWD
EQS
SWD1

APPENDIX C
Figure C4
Surface water monitoring graphs

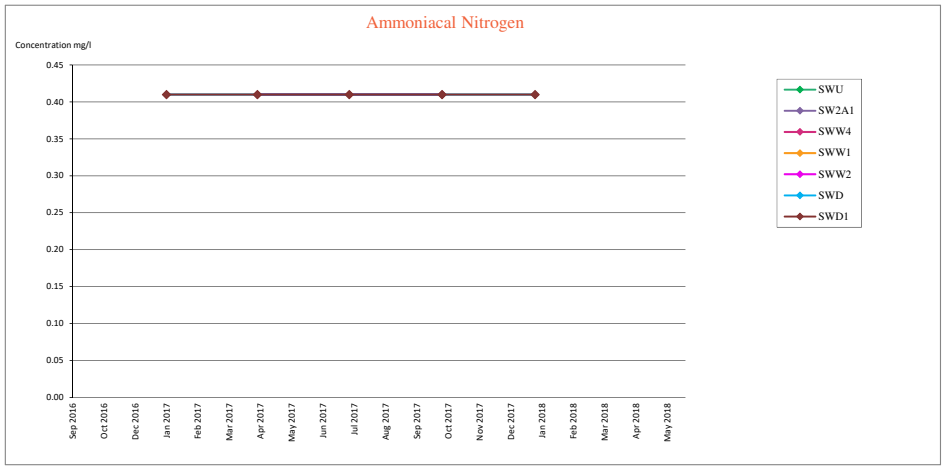


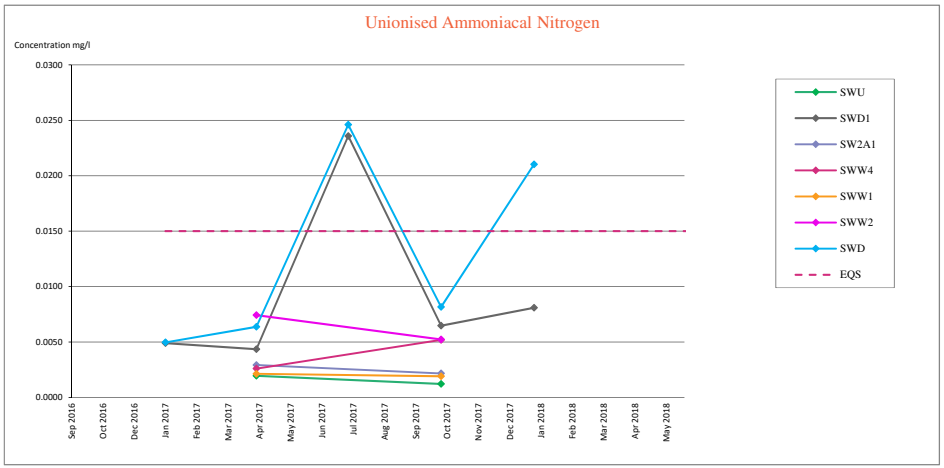




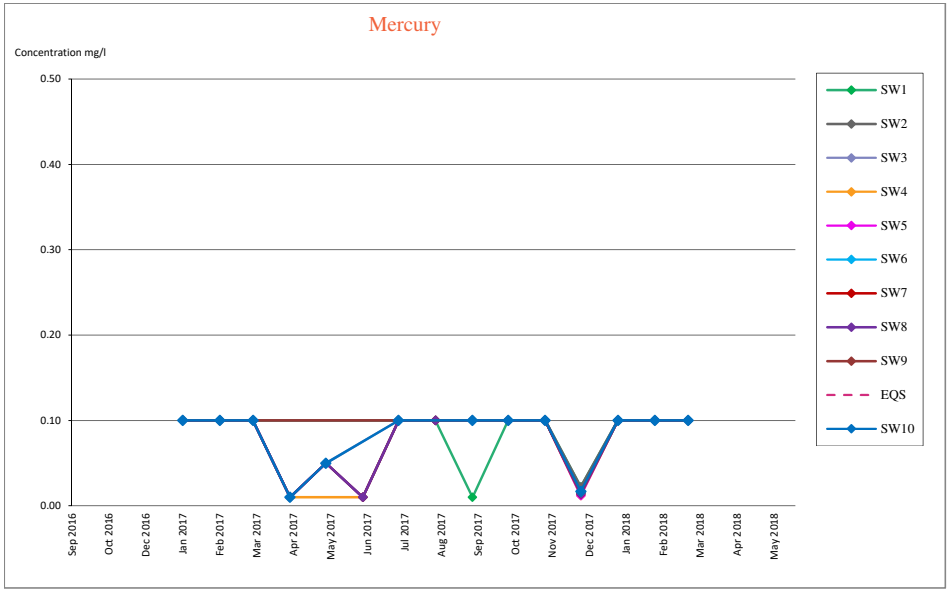


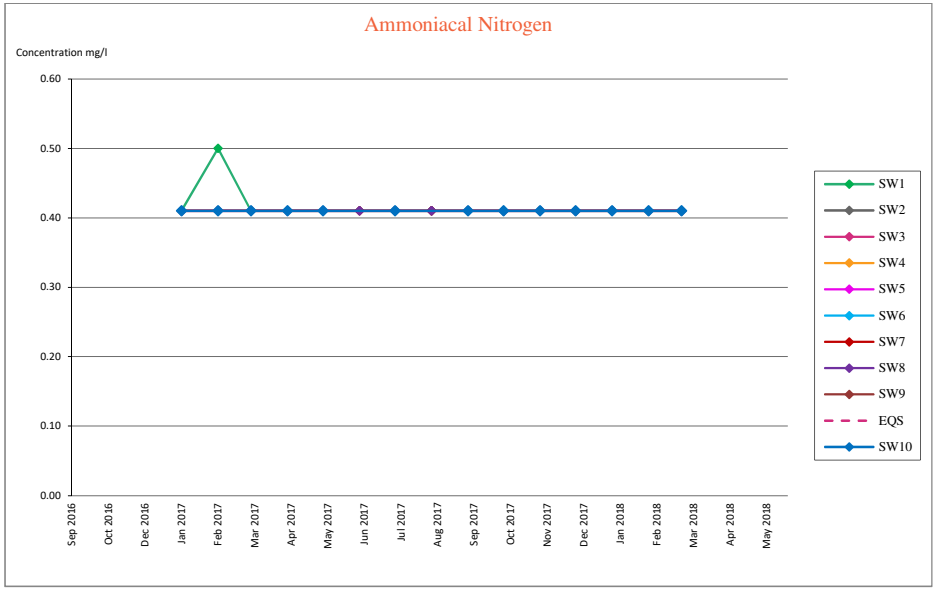
APPENDIX C
Figure C4
Surface water monitoring graphs

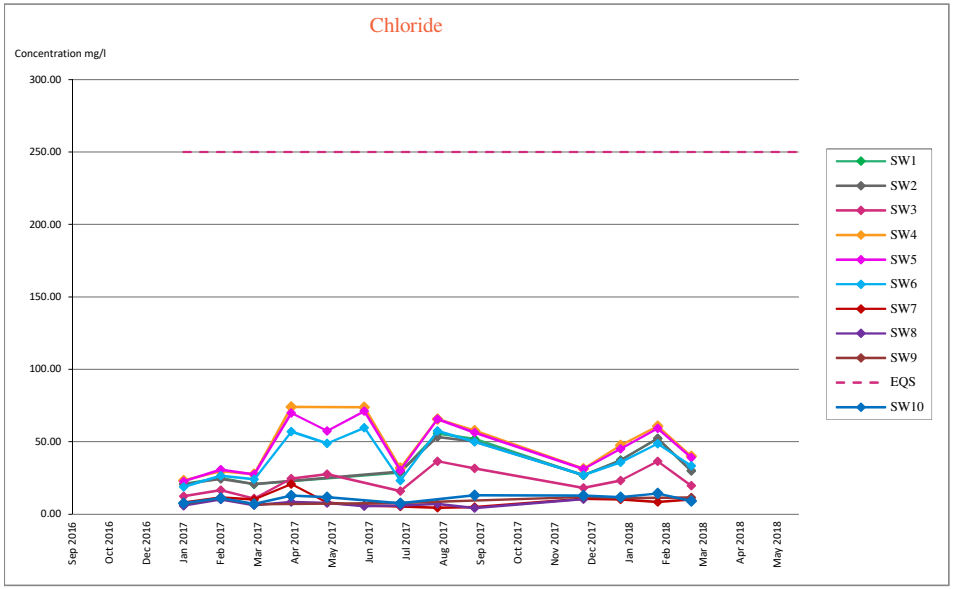




APPENDIX C
Figure C5
Surface water monitoring graphs (SW1 to SW10)

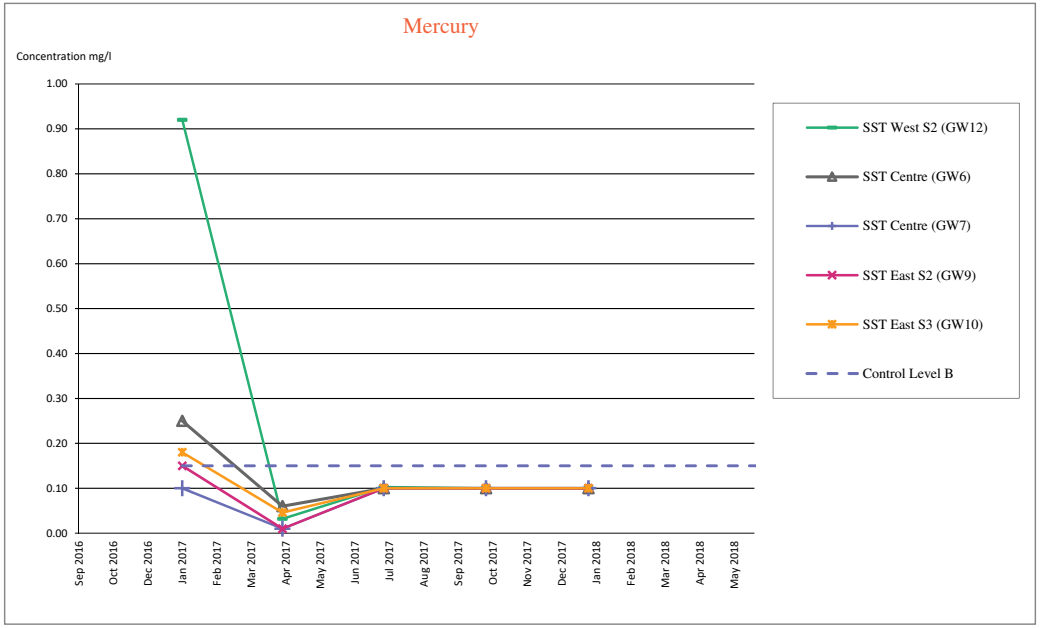


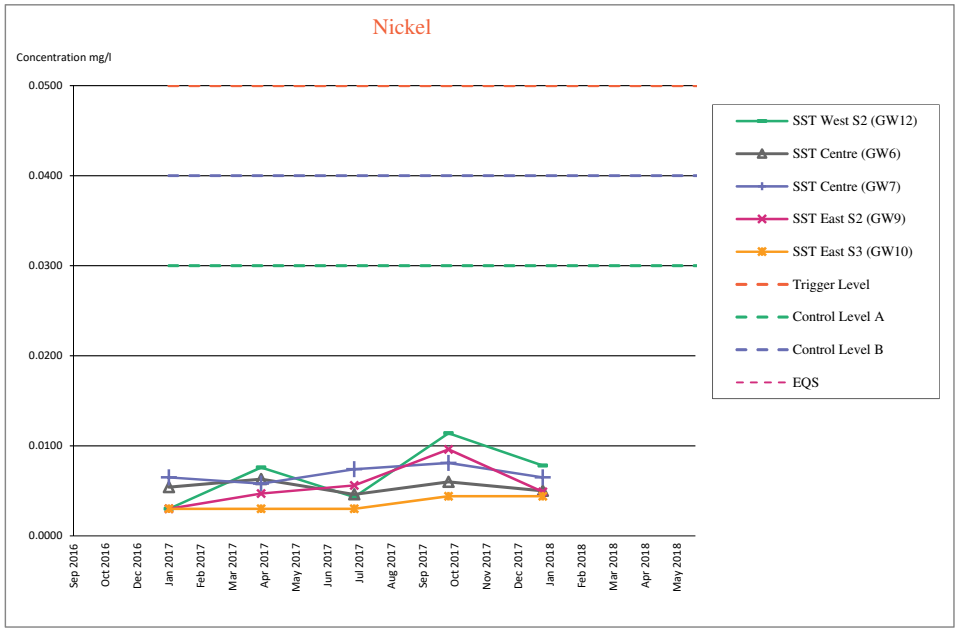


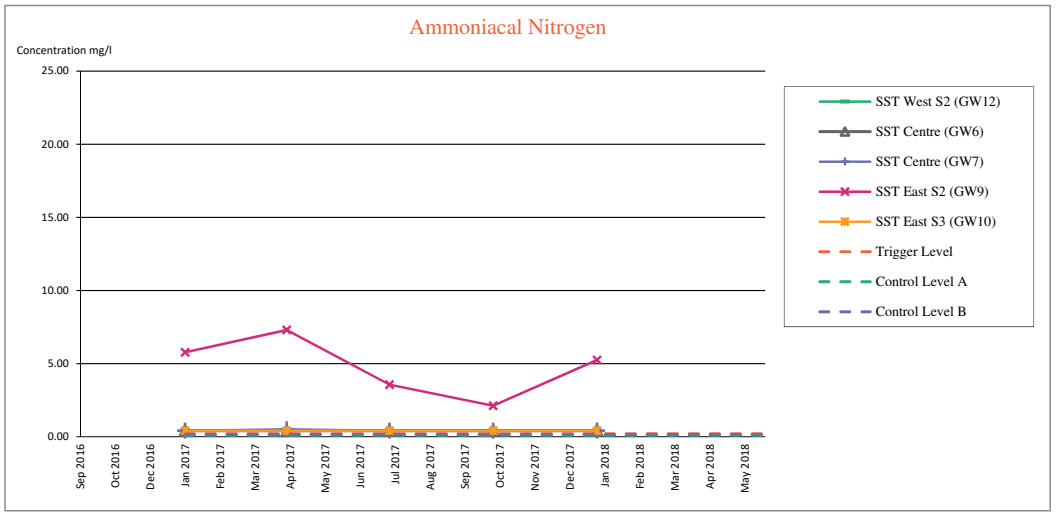


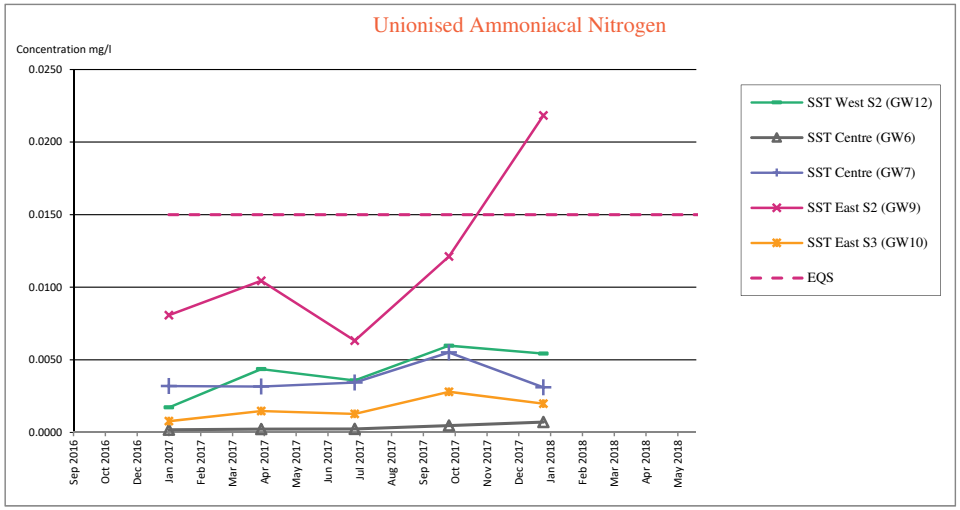
APPENDIX C
Figure C6
Groundwater quality monitoring results - Compliance wells graphs

Compliance wells graphs



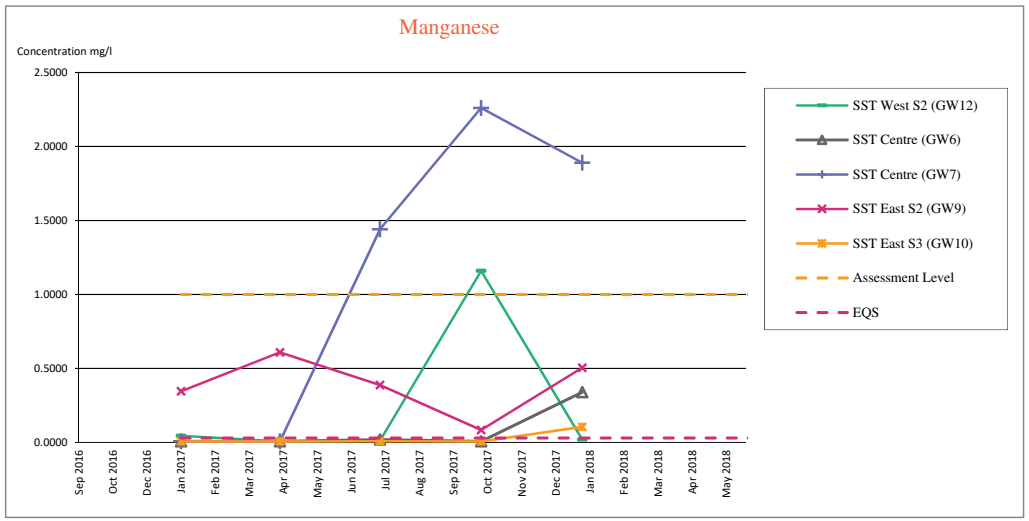


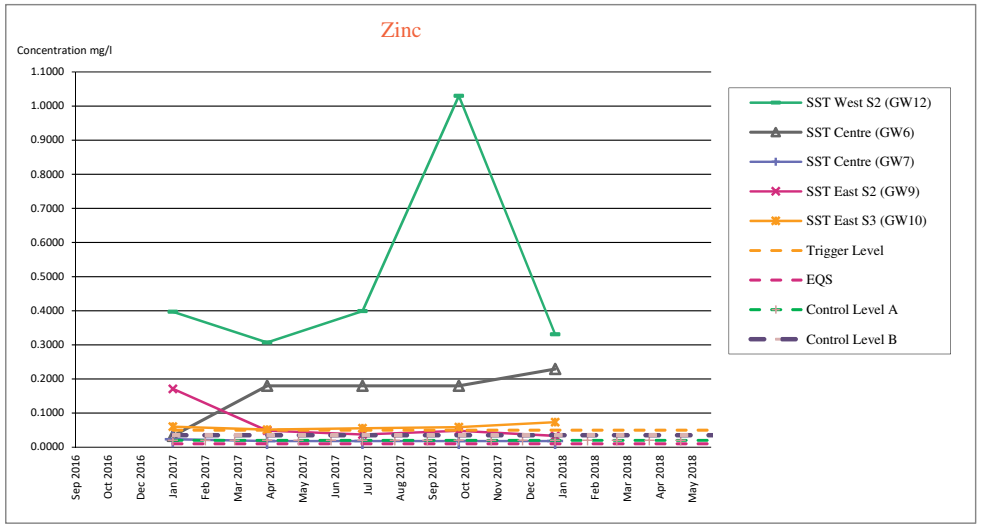


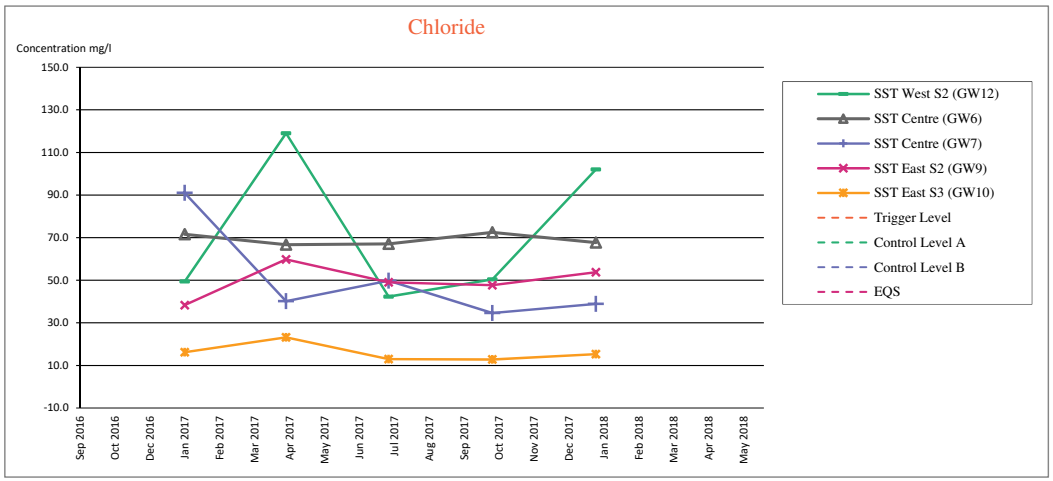


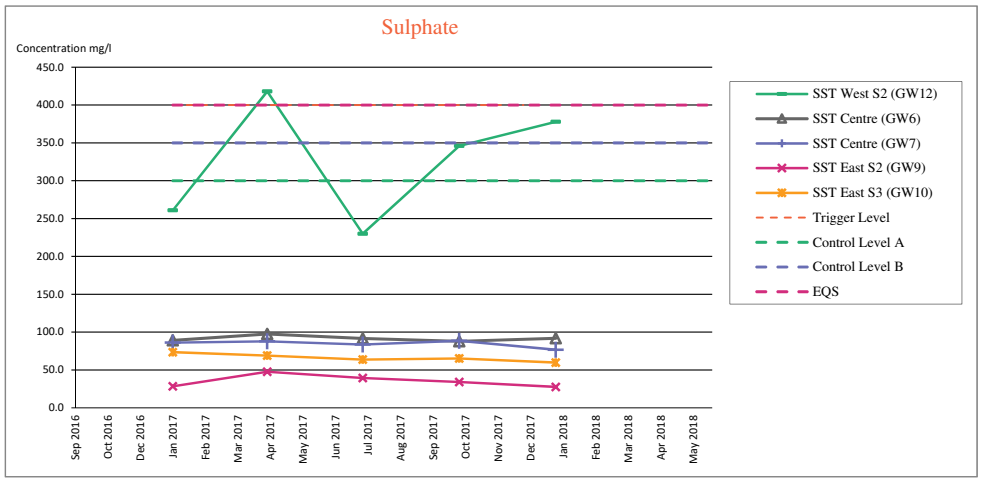
APPENDIX C
Figure C6
Groundwater quality monitoring results - Compliance wells graphs

Compliance wells graphs



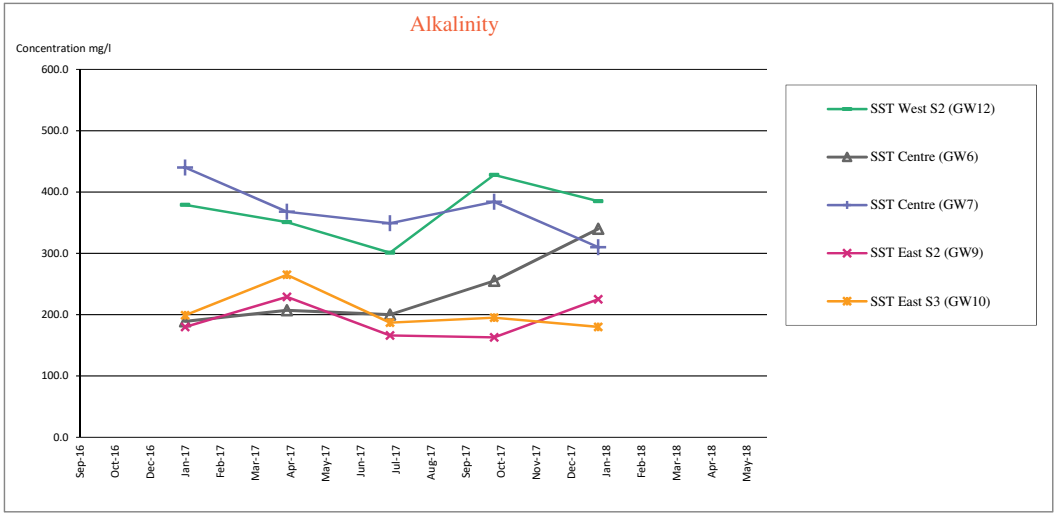


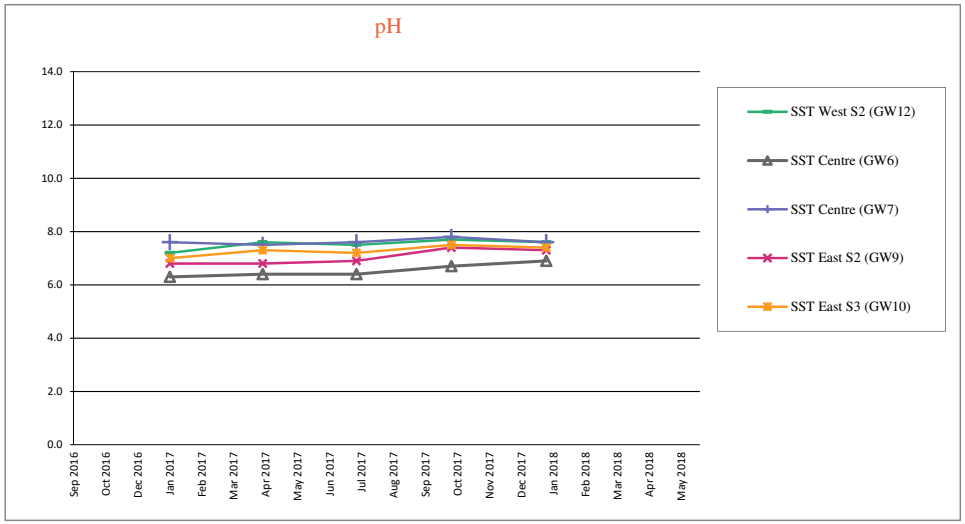




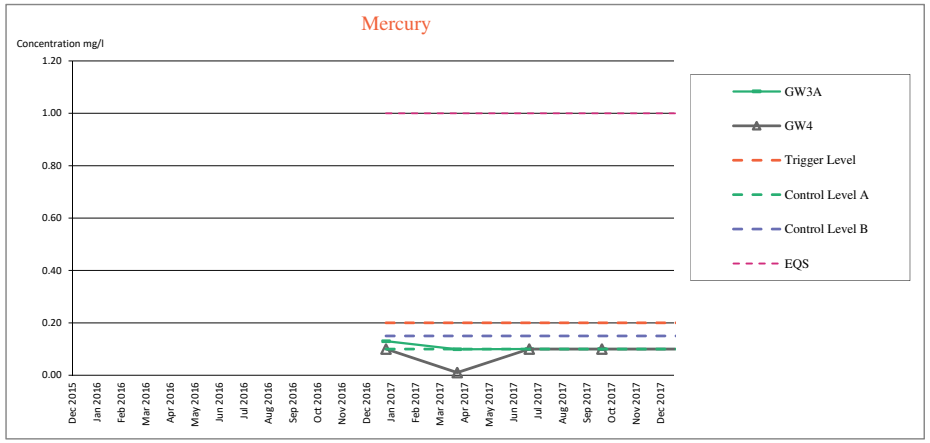
APPENDIX C
Figure C6
Groundwater quality monitoring results - Compliance wells graphs

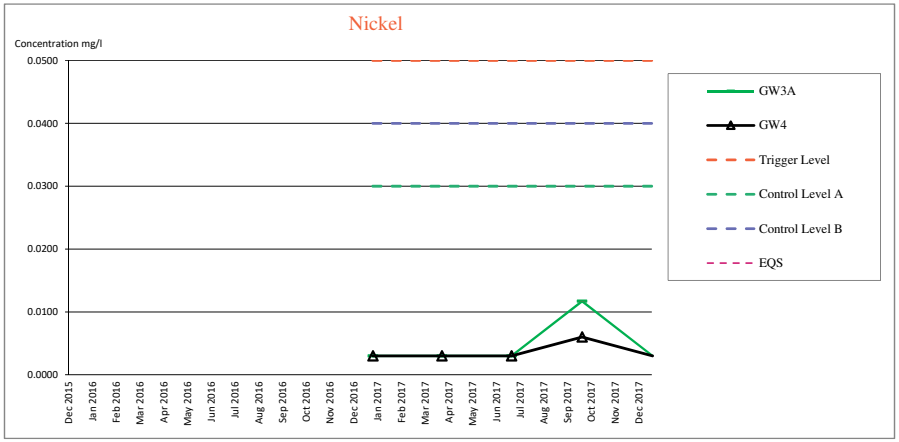
Compliance wells graphs

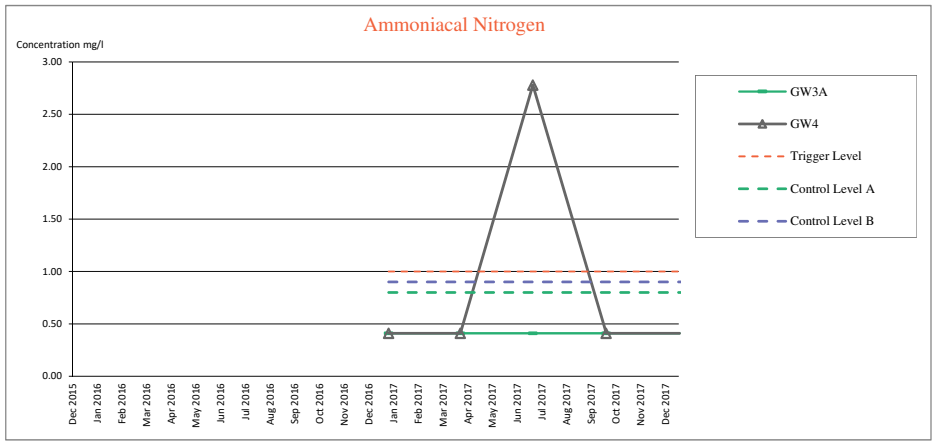


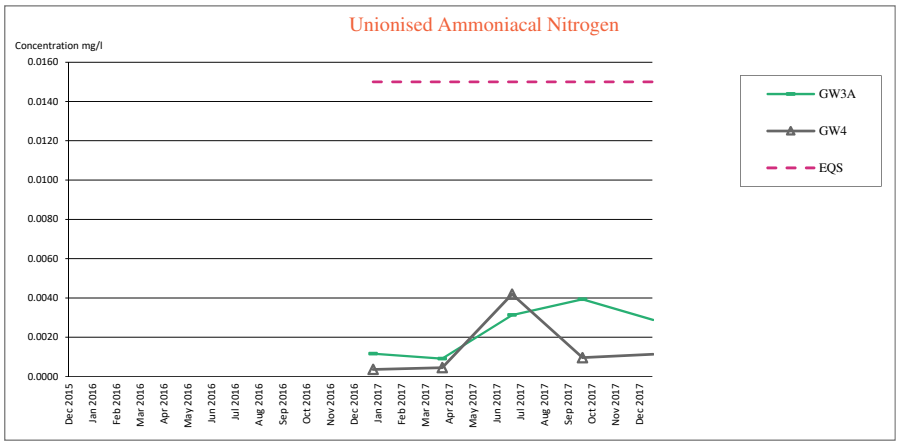


APPENDIX C
Figure C7
Groundwater quality monitoring results - Upstream wells graphs

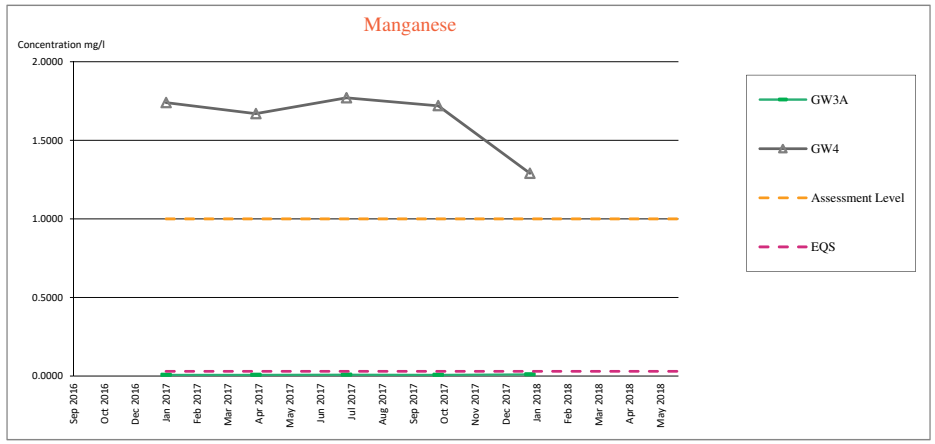


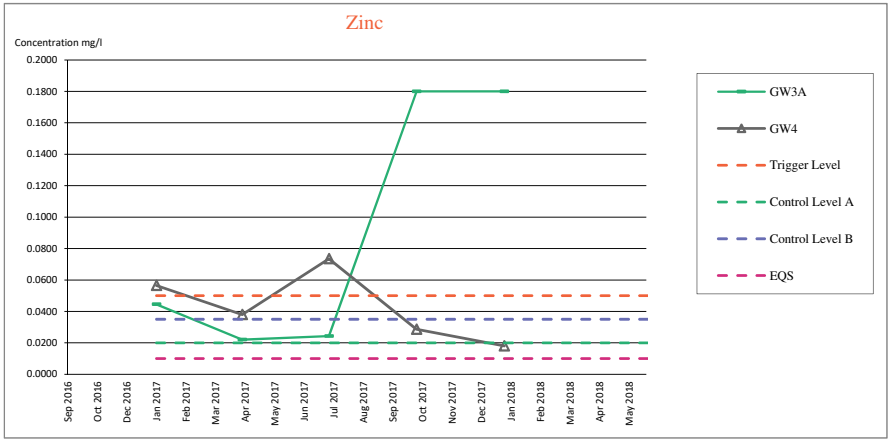


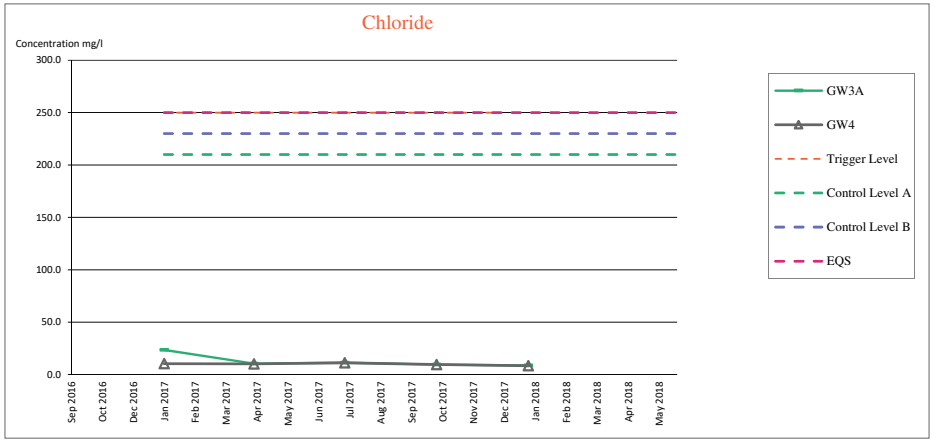


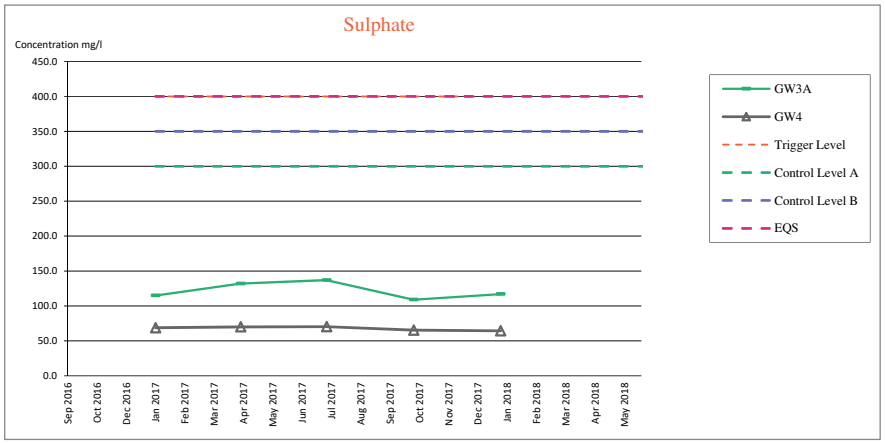


APPENDIX C
Figure C7
Groundwater quality monitoring results - Upstream wells graphs

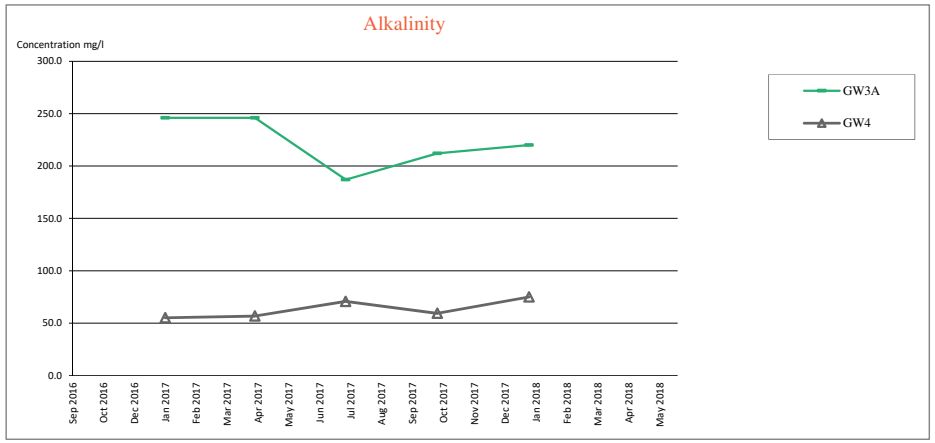


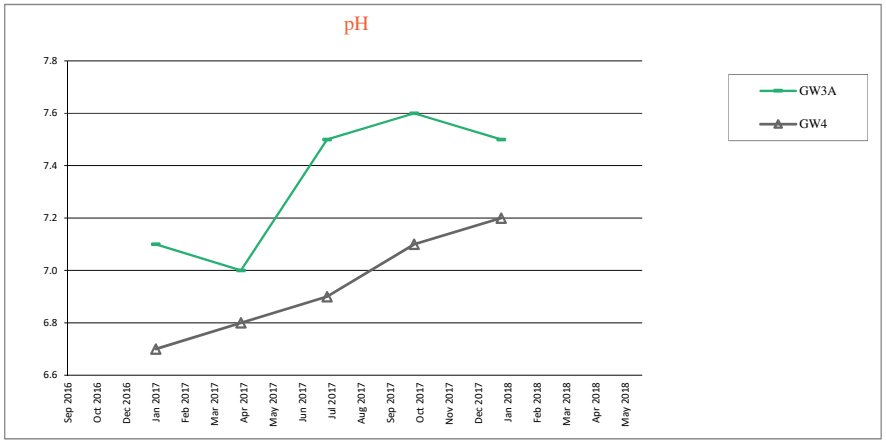




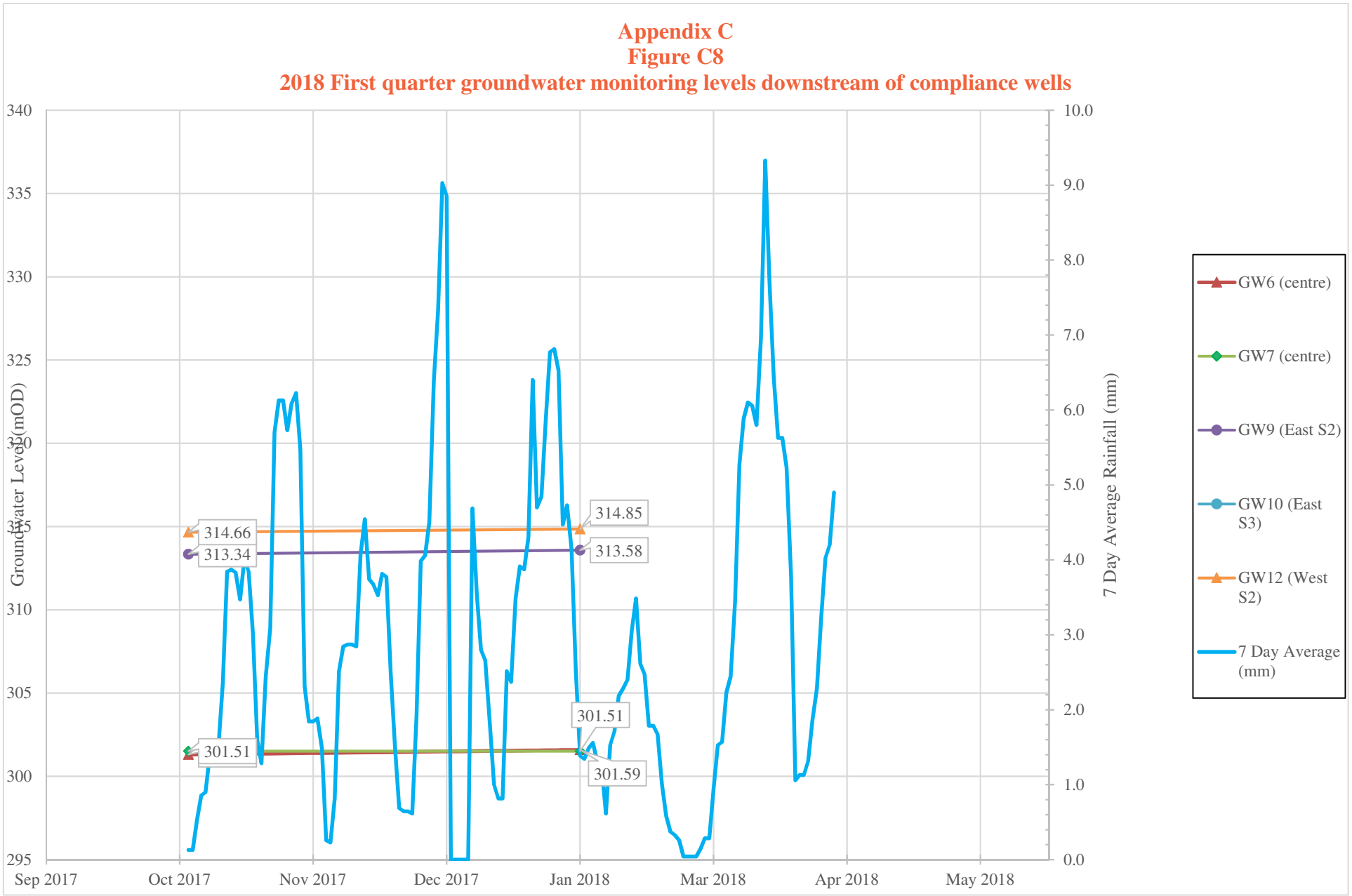


APPENDIX C
Figure C7
Groundwater quality monitoring results - Upstream wells graphs





Appendix C
Figure C8
2018 First quarter groundwater monitoring levels downstream of compliance wells



Appendix D

Monitoring Results - Tables

Appendix D
Table D1
Leachate Monitoring Results

January 2018

LOCATION	Units	L1A	L1B	LC1A	LC2A	LC4A	LC5A	Maximum concentration (mg/l)	Monthly Average (mg/l)	Acceptable Maximum Concentration (AMC) (mg/l)	LP3A	LP4
Date Sampled	-							-	-	-		
Manganese in filtrate as Mn	mg/l	0.36	0.146	N/S	0.111	0.693	0.0948	**0.693**	**0.281**	--	0.104	0.279
Mercury, filt trace as Hg	mg/l	< 0.0001	< 0.0001	N/S	N/T*	N/T*	N/T*	< **0.00010**	< **0.00010**	**0.00056**	< 0.0001	< 0.0001
Nickel in filtrate as Ni	mg/l	0.0294	0.0235	N/S	0.0721	0.0082	0.165	**0.165**	**0.0596**	**0.0681**	0.0074	0.0086
Zinc, ultra-low filtered as Zn	mg/l	0.0204	0.022	N/S	2.02	1.54	0.165	**2.02**	**0.753**	**1.380**	0.0208	0.033
pH	pH Units	8	7.7	N/S	8.4	7.8	8.3	**8.40**	**8.040**	--	8	7.9
Conductivity- Electrical 20C	uS/cm	2150	2460	N/S	9400	4370	24000	**24000.0**	**8476.0**	--	1630	2080
Alkalinity as CaCO3	mg/l	1090	440	N/S	5380	2490	12800	**12800.0**	**4440.0**	--	360	550
Ammoniacal Nitrogen as N	mg/l	< 0.41	29	N/S	674	293	2100	**2100.0**	**619**	**526**	4.9	28.4
Chloride as Cl	mg/l	182	206	N/S	788	219	1900	**1900.0**	**659**	**1408**	138	153
Sulphate as SO4	mg/l	86.3	441	N/S	7.01	< 4.4	35.14	**441.0**	**115**	**999**	256	294
Redox Potential (see note 4)	mV	67	88	N/S	110	93	104	**110.0**	**92.4**	--	84	93
Total Suspended Solids	mg/l	1230	18	N/S	2990	2120	304	**2990.0**	**1332.4**		6	10
Solids, Total Dissolved 180 deg C	mg/l	1470	1650	N/S	4460	1900	10100	**10100.0**	**3916.0**		1100	1280
Dissolved Oxygen, Fixed	mg/l	< 0.5	2.3	N/S	< 0.5	< 0.5	< 0.5	**2.30**	**0.9**		6.1	4.4
TOC (filtered)	mg/l	16.1	27.8	N/S	272	60	1060	**1060.0**	**287.2**		15.7	17

Notes

1. < denotes 'less than'.
2. L1A,L1B, LC1A, LC2A,LC4A, LC5A: Wells in Waste.
3. -- denotes 'no acceptable maximum concentration available'.
4. The redox potential was not measured on site and there is a possibility that it has changed between sampling and analysis
5. LC5A is a replacement for LC5 well.
6. NS denotes 'not sampled.

Appendix D
Table D2
Leachate Head Levels

		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
	Elevation of base of landfill mAOD	357.62	N/S	N/S	357.62	N/S	N/S	357.62	N/S	N/S	357.62	N/S	N/S
	Elevation at top of casing mAOD	398.88	N/S	N/S	398.88	N/S	N/S	398.88	N/S	N/S	398.88	N/S	N/S
	Depth to leachate from top of casing (m)	40.40											
LC1A	Leachate elevation (mAOD)	358.48	N/S	N/S	398.88	N/S	N/S	398.88	N/S	N/S	398.88	N/S	N/S
	Calculated leachate head (m)	0.86	N/S	N/S		N/S	N/S		N/S	N/S		N/S	N/S
	Elevation of base of landfill mAOD	362.49	N/S	N/S	362.49	N/S	N/S	362.49	N/S	N/S	362.49	N/S	N/S
	Elevation at top of casing mAOD	401.26	N/S	N/S	401.26	N/S	N/S	401.26	N/S	N/S	401.26	N/S	N/S
LC2A	Depth to leachate from top of casing (m)	35.83											
	Leachate elevation (mAOD)	365.43	N/S	N/S	401.26	N/S	N/S	401.26	N/S	N/S	401.26	N/S	N/S
	Calculated leachate head (m)	2.94	N/S	N/S		N/S	N/S		N/S	N/S		N/S	N/S
	Elevation of base of landfill mAOD	372.27	N/S	N/S	372.27	N/S	N/S	372.27	N/S	N/S	372.27	N/S	N/S
	Elevation at top of casing mAOD	401.24	N/S	N/S	401.24	N/S	N/S	401.24	N/S	N/S	401.24	N/S	N/S
LC4A	Depth to leachate from top of casing (m)	26.92											
	Leachate elevation (mAOD)	374.32	N/S	N/S	401.24	N/S	N/S	401.24	N/S	N/S	401.24	N/S	N/S
	Calculated leachate head (m)	2.05	N/S	N/S		N/S	N/S		N/S	N/S		N/S	N/S
	Elevation of base of landfill mAOD	350.14	N/S	N/S	350.14	N/S	N/S	350.14	N/S	N/S	350.14	N/S	N/S
	Elevation at top of casing mAOD	380.98	N/S	N/S	380.98	N/S	N/S	380.98	N/S	N/S	380.98	N/S	N/S
	Depth to leachate from top of casing (m)	27.29											
LC5A	Leachate elevation (mAOD)	353.69	N/S	N/S	380.98	N/S	N/S	380.98	N/S	N/S	380.98	N/S	N/S
	Calculated leachate head (m)	3.55	N/S	N/S		N/S	N/S		N/S	N/S		N/S	N/S
	Casing height (mAOD)	356.80	N/S	N/S	356.80	N/S	N/S	356.80	N/S	N/S	356.80	N/S	N/S
	Leachate (mbgl)	-			-								
	Leachate (m AOD)	-	N/S	N/S	-	N/S	N/S	-	N/S	N/S	-	N/S	N/S
L1	Base of landfill (m AOD)	336.80	N/S	N/S	336.80	N/S	N/S	336.80	N/S	N/S	336.80	N/S	N/S
	Depth of well from top of casing (m)	21.03	N/S	N/S	21.03	N/S	N/S	21.01	N/S	N/S	21.01	N/S	N/S
	Base of well (m AOD)	336.80	N/S	N/S	336.80	N/S	N/S	335.79	N/S	N/S	335.79	N/S	N/S
	Calculated leachate head (m)	-	N/S	N/S	-	N/S	N/S	-	N/S	N/S	-	N/S	N/S
	Casing height (mAOD)	354.84	N/S	N/S	354.84	N/S	N/S	354.84	N/S	N/S	354.84	N/S	N/S
	Leachate (mbgl)	19.31											
	Leachate (m AOD)	335.53	N/S	N/S	354.84	N/S	N/S	354.84	N/S	N/S	354.84	N/S	N/S
L1A*	Base of landfill (m AOD)	316.64	N/S	N/S	316.64	N/S	N/S	316.64	N/S	N/S	316.64	N/S	N/S
	Depth of well from top of casing (m)	21.12	N/S	N/S	21.03	N/S	N/S	20.93	N/S	N/S	20.95	N/S	N/S
	Base of well (m AOD)	334.84	N/S	N/S	334.84	N/S	N/S	334.84	N/S	N/S	334.84	N/S	N/S
	Calculated leachate head (m)	18.89	N/S	N/S		N/S	N/S		N/S	N/S		N/S	N/S
	Casing height (mAOD)	354.34	N/S	N/S	354.34	N/S	N/S	354.34	N/S	N/S	354.34	N/S	N/S
	Leachate (mbgl)	24.60											
	Leachate (m AOD)	329.74	N/S	N/S	354.34	N/S	N/S	354.34	N/S	N/S	354.34	N/S	N/S
L1B*	Base of landfill (m AOD)	319.60	N/S	N/S	319.60	N/S	N/S	319.60	N/S	N/S	319.60	N/S	N/S
	Depth of well from top of casing (m)	35.50	N/S	N/S	35.50	N/S	N/S	35.50	N/S	N/S	34.86	N/S	N/S
	Base of well (m AOD)	319.34	N/S	N/S	319.34	N/S	N/S	319.34	N/S	N/S	319.34	N/S	N/S
	Calculated leachate head (m)	10.14	N/S	N/S		N/S	N/S		N/S	N/S		N/S	N/S

2018	Quarterly Leachate Head Averages (m)
January	2.35
February	N/S
March	N/S
April	#DIV/0!
May	N/S
June	N/S
July	#DIV/0!
August	N/S
September	N/S
October	#DIV/0!
November	N/S
December	N/S

Minimum monthly leachate head average
Maximum monthly leachate head average

Notes:
Top of casings were re-surveyed in 2015

1. LC1A top of casing is 1580mm above ground level.

2. LC2A top of casing is 846mm above GL.

3. LC4A top of casing is 1109mm above GL.

4. LC2A and LC4A reduced (protruding pipe length cut) on 23 Feb 10.

5. Levels in L1 were not measured due to well being dry.

* Well not included in monthly average.

** Cover level re-surveyed in September 2009.

Note: L1 is generally dry or with very little water in it.

Appendix D
Table D3
Surface Water Monitoring Results

Month	Location		Date	Mercury, ultra-low total as Hg	Redox Potential	Manganese in filtrate as Mn	Nickel in filtrate as Ni	Zinc, ultra-low total as Zn	pH	Conductivity-Electrical 20C	Alkalinity as CaCO3	Ammoniacal Nitrogen as N	Unionised Ammoniacal Nitrogen **	Measured surface water temperature	Chloride as Cl	Sulphate as SO4	Solids, Suspended	Dissolved oxygen	TOC (Filtered)
				ug/l	mV	mg/l	mg/l	mg/l		uS/cm	mg/l	mg/l	mg/l	°C	mg/l	mg/l	mg/l	mg/l	mg/l
	Freshwater EQS**			1	-	0.03	0.1*	0.05*	-	-	-	-	0.015**	-	250	400	-	-	-
January	Upstream of Landfill	SWU	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SW2AI		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW4		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	NW Ditch System	SWW1	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW2		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	Downstream of Landfill	SWD	01/02/2017	< 0.10	47.00	< 0.0070	< 0.0030	< 0.0180	8.60	288.00	85.00	< 0.41	0.0210	5.8	8.80	54.40	4.00	11.10	1.00
		SWD1		< 0.10	54.00	< 0.0070	0.0040	< 0.018	8.20	273.00	70.00	< 0.41	0.0081	4.9	12.60	48.90	3.00	11.10	1.20
February	Upstream of Landfill	SWU	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SW2AI		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW4		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	NW Ditch System	SWW1	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW2		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	Downstream of Landfill	SWD	Quarterly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWD1		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
March	Upstream of Landfill	SWU	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SW2AI		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW4		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	NW Ditch System	SWW1	Six-monthly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWW2		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	Downstream of Landfill	SWD	Quarterly	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
		SWD1		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	Minimum			< 0.1000	47.0	< 0.007	< 0.003	< 0.0180	8.2	273.0	70.00	< 0.41	0.0081	4.90	8.80	48.90	3.00	< 11.10	< 1.00
	Maximum			< 0.1000	54.0	0.007	0.004	0.0180	8.6	288.0	85.00	< 0.41	0.02	5.80	12.60	54.40	4.00	11.10	1.20
	Count			2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

Exceedance of EQS
Upstream of Nant Merddog
Downstream of Nant Merddog

Notes
The redox potential was not measured on site and there is a possibility that it has changed between sampling and analysis
Not analysed
Water hardness data obtained from SWU, SWD and SWD1 is between 50 and 100mg/l.
Unionised ammoniacal nitrogen based on measured
Reporting limits raised for
Environmental Quality Standard EQS 1 for freshwater is derived to protect the most sensitive aquatic life.
North Western (ditch system)

Appendix D
Table D4
Surface water monitoring SW1 to SW10

MONTH	LOCATION	DATE		Mercury, ultra-low total as Hg		Ammoniacal Nitrogen as N	Chloride as Cl
				ug/l		mg/l	mg/l
	Freshwater EQS			**1**		**n/a**	**250**
January	**SW1**	01/02/2018	<	0.10	<	0.41	37.4
	SW2	01/02/2018	<	0.10	<	0.41	37.2
	SW3	01/02/2018	<	0.10	<	0.41	23.4
	SW4	01/02/2018	<	0.10	<	0.41	47.6
	SW5	01/02/2018	<	0.10	<	0.41	45.3
	SW6	01/02/2018	<	0.10	<	0.41	36
	SW7	01/02/2018	<	0.10	<	0.41	10.4
	SW8	01/02/2018	<	0.10	<	0.41	8.5
	SW9	01/02/2018	<	0.10	<	0.41	11.1
	SW10	01/02/2018	<	0.10	<	0.41	11.8
February	**SW1**	27/02/2018	<	0.10	<	0.41	52.3
	SW2	27/02/2018	<	0.10	<	0.41	52.4
	SW3	27/02/2018	<	0.10	<	0.41	36.6
	SW4	27/02/2018	<	0.10	<	0.41	60.8
	SW5	27/02/2018	<	0.10	<	0.41	59.3
	SW6	27/02/2018	<	0.10	<	0.41	48.8
	SW7	27/02/2018	<	0.10	<	0.41	8.6
	SW8	27/02/2018	<	0.10	<	0.41	10.4
	SW9	27/02/2018		N/S		N/S	N/S
	SW10	27/02/2018	<	0.10	<	0.41	14.4
March	**SW1**	05/04/2018	<	0.10	<	0.41	30.20
	SW2	05/04/2018	<	0.10	<	0.41	29.90
	SW3	05/04/2018	<	0.10	<	0.41	19.70
	SW4	05/04/2018	<	0.10	<	0.41	40.10
	SW5	05/04/2018	<	0.10	<	0.41	39.30
	SW6	05/04/2018	<	0.10	<	0.41	33.60
	SW7	05/04/2018	<	0.10	<	0.41	10.20
	SW8	05/04/2018	<	0.10	<	0.41	11.20
	SW9	05/04/2018	<	0.10	<	0.41	11.70
	SW10	05/04/2018	<	0.10	<	0.41	9.10
Minimum			<	0.1000	<	0.4100	8.5
Maximum			<	0.1000	<	0.4100	60.8
Count				29.00		29.00	29.00

Notes:
pH values based on measured pH at SWD and SWD1.

Appendix D
Table D5
Groundwater monitoring results

Location	Month	Date	Test reference number	Redox Potential	Mercury, filtrate as Hg	Manganese in filtrate as Mn	Bioavailable Manganese	Nickel in filtrate as Ni	Bioavailable Nickel	Zinc, ultra-low filtered as Zn	Bioavailable Zinc	pH	Electrical Conductivity 20C	Alkalinity as CaCO3	Ammoniacal Nitrogen as N	Unionised Ammoniacal Nitrogen ***	Measure water temperature	Chloride as Cl	Sulphate as SO4	Calcium	D.O. concentration	TOC (Filtered)
				mV	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	pH units	uS/cm	mg/l	mg/l	mg/l	°C	mg/l	mg/l	mg/l	mg/l	mg/l
Trigger Level					**(0.2[a])**			**0.05**		**(0.05[a])**		**--**	**--**	**--**	**1**	**--**	**--**	**250**	**400**	**--**	**--**	**--**
Control Level A					**(0.1[aa])**	**--**		**0.03**		**(0.02[aa])**		**--**	**--**	**--**	**0.8**	**--**	**--**	**210**	**300**	**--**	**--**	**--**
Control Level B					**(0.15[aa])**	**--**		**0.04**		**(0.035[aa])**		**--**	**--**	**--**	**0.9**	**--**	**--**	**230**	**350**	**--**	**--**	**--**
EQS Freshwater					**1**	**0.03**		**0.1^**		**0.01^**		**--**	**--**	**--**	**--**	**0.015**	**--**	**250**	**400**	**--**	**--**	**--**
Updated EQS Freshwater					**1**		**0.123**		**0.004**		**0.0137**					**0.015**		**250**	**400**			
Assessment Level					**--**	**(1.0[a])**		**--**		**--**		**--**	**--**			**--**	**--**	**--**	**--**	**--**	**--**	**--**
UPSTREAM WELLS																						
SST East S3																						
GW3A	Jan-17	30/01/17	15849039	-63	0.13	< 0.0070		< 0.0030		0.0445		7.1	682.0	246.0	< 0.41	0.0012	12.6	23.5	115.0		6.7	2.8
	Feb-17		Quarterly																			
	Mar-17																					
	Apr-17	24/04/17	16040348	97	0.099	< 0.0070		< 0.0030		0.0220		7.0	694.0	246.0	< 0.41	0.0009	12.4	10.4	132.0		5.2	2.0
	May-17		Quarterly																			
	Jun-17																					
	Jul-17	01/08/17	16290503	-19	< 0.10	0.0084		< 0.0030		0.0243		7.5	573.0	187.0	< 0.41	0.0031	13.6	11.3	137.0		8.2	2.5
	Aug-17		Quarterly																			
	Sep-17																					
	Oct-17	24/10/17	16530927	59	< 0.10	< 0.0070		0.0117		< 0.1800		7.6	602.0	212	< 0.41	0.0039	13.6	9.5	109		7	2.2
	Nov-17		Quarterly																			
	Dec-17																					
	Jan-18	30/01/18	16812270	156	< 0.10	0.0101	0.00215	< 0.0030	< 0.00112	< 0.1800	< 0.1060	7.5	605.0	220.0	< 0.41	0.0029	12.5	8.7	117.0	110.0	9.9	1.5
	Feb-18		Quarterly																			
	Mar-18																					
	Apr-18																					
	May-18		Quarterly																			
	Jun-18																					
	Jul-18																					
	Aug-18		Quarterly																			
	Sep-18																					
	Oct-18																					
	Nov-18		Quarterly																			
	Dec-18																					
GW4	Jan-17	30/01/17	15849040	-61	< 0.10	1.7400		< 0.0030		0.0565		6.7	256.0	55.2	< 0.41	0.0004	9.1	10.3	68.8		4.1	< 0.7
	Feb-17		Quarterly																			
	Mar-17																					
	Apr-17	24/04/17	16040349	91	< 0.01	1.6700		< 0.0030		0.0380		6.8	280.0	56.8	< 0.41	0.0004	9.1	10.1	70.0		4.1	< 0.7
	May-17		Quarterly																			
	Jun-17																					
	Jul-17	01/08/17	16290504	-19	< 0.10	1.7700		< 0.0030		0.0735		6.9	291.0	70.8	2.78	0.0042	10.3	11.2	70.3		< 0.5	3.4
	Aug-17		Quarterly																			
	Sep-17																					
	Oct-17	24/10/17	16530928	45	< 0.10	1.7200		0.0060		0.0286		7.1	267.0	59.4	< 0.41	0.0010	10.0	9.5	65.4		1.9	< 0.7
	Nov-17		Quarterly																			
	Dec-17																					
	Jan-18	30/01/18	16812271	147	< 0.10	1.2900	0.26473	< 0.0030	< 0.00208	< 0.0180	< 0.0180	7.2	289.0	75.0	< 0.41	0.0011	9.2	8.4	64.4	13.0	4.3	< 0.7
	Feb-18		Quarterly																			
	Mar-18																					
	Apr-18																					
	May-18		Quarterly																			
	Jun-18																					
	Jul-18																					
	Aug-18		Quarterly																			
	Sep-18																					
	Oct-18																					
	Nov-18		Quarterly																			
	Dec-18																					
DOWNSTREAM WELLS / COMPLIANCE WELLS																						
SST West S2																						
GW12	Jan-17	30/01/17	15849046	-8	0.92	0.0448		< 0.0030		0.3970		7.2	1120.0	379.0	< 0.41	0.0017	14.8	49.4	261.0		11.1	4.8
	Feb-17		Quarterly																			
	Mar-17																					
	Apr-17	24/04/17	16040355	164	0.032	< 0.0070		0.0076		0.3070		7.6	1790.0	351.0	< 0.41	0.0044	15.0	119.0	418.0		9.5	9.7
	May-17		Quarterly																			
	Jun-17																					
	Jul-17	01/08/17	16290510	229	0.10	0.0113		0.0043		0.3990		7.5	1110.0	301.0	< 0.41	0.0036	15.4	42.3	230.0		10.0	4.3
	Aug-17		Quarterly																			
	Sep-17																					
	Oct-17	24/10/17	16530934	91	< 0.10	1.1600		0.0114		1.0300		7.7	1340	428	< 0.41	0.0060	16.2	50.4	346		9.2	4.7
	Nov-17		Quarterly																			
	Dec-17																					
	Jan-18	30/01/18	16812277	185	< 0.10	0.0198	0.00511	0.0078	0.00135	0.3310	0.0835	7.6	1760.0	385.0	< 0.41	0.0054	18.0	102.0	378.0	209.0	5.7	10.7
	Feb-18		Quarterly																			
	Mar-18																					
	Apr-18																					
	May-18		Quarterly																			
	Jun-18																					
	Jul-18																					
	Aug-18		Quarterly																			
	Sep-18																					
	Oct-18																					
	Nov-18		Quarterly																			
	Dec-18																					

Appendix D
Table D5
Groundwater monitoring results

Location	Month	Date	Test reference number	Redox Potential	Mercury, filtrate as Hg	Manganese in filtrate as Mn	Bioavailable Manganese	Nickel in filtrate as Ni	Bioavailable Nickel	Zinc, ultra-low filtered as Zn	Bioavailable Zinc	pH	Electrical Conductivity 20C	Alkalinity as CaCO3	Ammoniacal Nitrogen as N	Unionised Ammoniacal Nitrogen ***	Measure water temperature	Chloride as Cl	Sulphate as SO4	Calcium	D.O. concentration	TOC (Filtered)
				mV	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	pH units	uS/cm	mg/l	mg/l	mg/l	°C	mg/l	mg/l	mg/l	mg/l	mg/l
	Trigger Level				**(0.2[a])**			**0.05**		**(0.05[a])**		**--**	**--**	**--**	**1**	**--**	**--**	**250**	**400**	**--**	**--**	**--**
	Control Level A				**(0.1[aa])**	**--**		**0.03**		**(0.02[aa])**		**--**	**--**	**--**	**0.8**	**--**	**--**	**210**	**300**	**--**	**--**	**--**
	Control Level B				**(0.15[aa])**	**--**		**0.04**		**(0.035[aa])**		**--**	**--**	**--**	**0.9**	**--**	**--**	**230**	**350**	**--**	**--**	**--**
	EQS Freshwater				**1**	**0.03**		**0.1^**		**0.01^**		**--**	**--**	**--**	**--**	**0.015**	**--**	**250**	**400**	**--**	**--**	**--**
	Updated EQS Freshwater				**1**		**0.123**		**0.004**		**0.0137**					**0.015**		**250**	**400**			
	Assessment Level				**--**	**(1.0[a])**		**--**		**--**		**--**	**--**			**--**	**--**	**--**	**--**	**--**	**--**	**--**
SST Centre																						
GW6	Jan-17	30/01/17	15849041	-30	0.25	< 0.0070		0.0054		0.0330		6.3	731.0	189.0	< 0.41	0.0002	12.2	71.6	89.1		4.4	3.9
	Feb-17		Quarterly																			
	Mar-17																					
	Apr-17	24/04/17	16040350	102	0.06	< 0.0070		0.0063		< 0.1800		6.4	764.0	207.0	< 0.41	0.0002	12.0	66.7	97.5		4.4	3.7
	May-17		Quarterly																			
	Jun-17																					
	Jul-17	01/08/17	16290505	25	< 0.10	0.0188		0.0046		< 0.1800		6.4	744.0	200.0	< 0.41	0.0002	12.7	67.1	91.7		5.4	3.6
	Aug-17		Quarterly																			
	Sep-17																					
	Oct-17	24/10/17	16530929	69	< 0.10	< 0.0070		0.0060		< 0.1800		6.7	823	255	< 0.41	0.0005	12.7	72.5	87.9		3.4	3.3
	Nov-17		Quarterly																			
	Dec-17																					
	Jan-18	30/01/18	16812272	166	< 0.10	0.3390	0.02258	0.0050	0.00109	0.2290	0.11295	6.9	930.0	340.0	< 0.41	0.0007	12.1	67.7	91.9	90.4	3.2	3.6
	Feb-18		Quarterly																			
	Mar-18																					
	Apr-18																					
	May-18		Quarterly																			
	Jun-18																					
	Jul-18																					
	Aug-18		Quarterly																			
	Sep-18																					
	Oct-18																					
	Nov-18		Quarterly																			
	Dec-18																					
GW7	Jan-17	30/01/17	15849042	-23	< 0.10	< 0.0070		0.0065		0.0233		7.6	1250.0	440.0	< 0.41	0.0032	10.8	91.0	86.1		3.2	13.0
	Feb-17		Quarterly																			
	Mar-17																					
	Apr-17	24/04/17	16040351	157	< 0.01	< 0.0070		0.0058		< 0.0180		7.5	950.0	368.0	0.51	0.0032	10.8	40.2	87.8		3.3	7.1
	May-17		Quarterly																			
	Jun-17																					
	Jul-17	01/08/17	16290506	38	< 0.10	1.4400		0.0074		< 0.0180		7.6	966.0	349.0	< 0.41	0.0034	11.8	49.8	83.5		3.4	7.4
	Aug-17		Quarterly																			
	Sep-17																					
	Oct-17	24/10/17	16530930	89	< 0.10	2.2600		0.0081		< 0.0180		7.8	957.0	384	< 0.41	0.0055	12.0	34.6	88.5		4.1	7.7
	Nov-17		Quarterly																			
	Dec-17																					
	Jan-18	30/01/18	16812273	173	< 0.10	1.8900	0.87429	0.0065	0.00169	< 0.0180	< 0.0072	7.6	870.0	310.0	< 0.41	0.0031	10.4	38.9	76.7	69.0	3.0	5.0
	Feb-18		Quarterly																			
	Mar-18																					
	Apr-18																					
	May-18		Quarterly																			
	Jun-18																					
	Jul-18																					
	Aug-18		Quarterly																			
	Sep-18																					
	Oct-18																					
	Nov-18		Quarterly																			
	Dec-18																					
GW14	Jan-18	N/S	N/S	N/S	N/S	N/S		N/S		N/S		N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	Feb-18		Quarterly																			
	Mar-18																					
	Apr-18																					
	May-18		Quarterly																			
	Jun-18																					
	Jul-18																					
	Aug-18		Quarterly																			
	Sep-18																					
	Oct-18																					
	Nov-18		Quarterly																			
	Dec-18																					
SST East S2																						
GW9	Jan-17	30/01/17	15849043	-24	0.15	0.3460		< 0.0030		0.1710		6.8	570.0	180.0	5.77	0.0081	12.4	38.3	28.4		3.3	4.9
	Feb-17		Quarterly																			
	Mar-17																					
	Apr-17	24/04/17	16040352	152	< 0.01	0.6090		0.0047		0.0485		6.8	710.0	229.0	7.30	0.0105	12.7	59.8	47.6		2.5	4.5
	May-17		Quarterly																			
	Jun-17																					
	Jul-17	01/08/17	16290507	28	< 0.10	0.3880		0.0056		0.0372		6.9	603.0	166.0	3.56	0.0063	12.5	49.0	39.3		4.2	3.9
	Aug-17		Quarterly																			
	Sep-17																					
	Oct-17	24/10/17	16530931	75	< 0.10	0.0841		0.0096		0.0479		7.4	599.0	163.0	2.12	0.0121	12.8	47.7	34.1		6.2	4.6
	Nov-17		Quarterly																			
	Dec-17																					
	Jan-18	30/01/18	16812274	166	< 0.10	0.5050	0.12698	0.0049	0.0014	0.0331	0.0139	7.3	691.0	225.0	5.25	0.0218	11.6	53.8	27.6	38.8	3.4	5.2
	Feb-18		Quarterly																			
	Mar-18																					
	Apr-18																					
	May-18		Quarterly																			
	Jun-18																					
	Jul-18																					
	Aug-18		Quarterly																			
	Sep-18																					
	Oct-18																					
	Nov-18		Quarterly																			
	Dec-18																					

Appendix D
Table D5
Groundwater monitoring results

Location	Month	Date	Test reference number	Redox Potential	Mercury, filtrate as Hg	Manganese in filtrate as Mn	Bioavailable Manganese	Nickel in filtrate as Ni	Bioavailable Nickel	Zinc, ultra-low filtered as Zn	Bioavailable Zinc	pH	Electrical Conductivity 20C	Alkalinity as CaCO3	Ammoniacal Nitrogen as N	Unionised Ammoniacal Nitrogen ***	Measure water temperature	Chloride as Cl	Sulphate as SO4	Calcium	D.O. concentration	TOC (Filtered)
				mV	ug/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	pH units	uS/cm	mg/l	mg/l	mg/l	°C	mg/l	mg/l	mg/l	mg/l	mg/l
	Trigger Level				**(0.2[a])**			**0.05**		**(0.05[a])**		**--**	**--**	**--**	**1**	**--**	**--**	**250**	**400**	**--**	**--**	**--**
	Control Level A				**(0.1[aa])**	**--**		**0.03**		**(0.02[aa])**		**--**	**--**	**--**	**0.8**	**--**	**--**	**210**	**300**	**--**	**--**	**--**
	Control Level B				**(0.15[aa])**	**--**		**0.04**		**(0.035[aa])**		**--**	**--**	**--**	**0.9**	**--**	**--**	**230**	**350**	**--**	**--**	**--**
	EQS Freshwater				**1**	**0.03**		**0.1^**		**0.01^**		**--**	**--**	**--**	**--**	**0.015**	**--**	**250**	**400**	**--**	**--**	**--**
	Updated EQS Freshwater				**1**		**0.123**		**0.004**		**0.0137**					**0.015**		**250**	**400**			
	Assessment Level				**--**	**(1.0[a])**		**--**		**--**		**--**	**--**			**--**	**--**	**--**	**--**	**--**	**--**	**--**
SST East S3																						
	Jan-17	30/01/17	15849044	-29	0.18	< 0.0070		< 0.0030		0.0601		7.0	535.0	199.0	< 0.41	0.0008	10.2	16.2	73.5		7.2	5.4
	Feb-17		Quarterly																			
	Mar-17																					
	Apr-17	24/04/17	16040353	156	0.046	< 0.0070		< 0.0030		0.0514		7.3	700.0	265.0	< 0.41	0.0015	9.6	23.2	69.0		7.4	6.5
	May-17		Quarterly																			
	Jun-17																					
	Jul-17	01/08/17	16290508	7	< 0.10	0.0080		< 0.0030		0.0553		7.2	498.0	187.0	< 0.41	0.0013	10.8	13.0	63.8		7.5	4.5
	Aug-17		Quarterly																			
	Sep-17																					
	Oct-17	24/10/17	16530932	61	< 0.10	< 0.0070		0.0044		0.0586		7.5	513.0	195.0	< 0.41	0.0028	12.1	12.8	65.2		7.3	4.2
	Nov-17		Quarterly																			
	Dec-17																					
GW10	Jan-18	30/01/18	16812275	158	< 0.10	0.1050	0.03235	0.00440	0.00117	0.0733	0.03333	7.4	500.0	180.0	< 0.41	0.0020	10.5	15.3	59.8	55.9	10.0	4.2
	Feb-18		Quarterly																			
	Mar-18																					
	Apr-18																					
	May-18		Quarterly																			
	Jun-18																					
	Jul-18																					
	Aug-18		Quarterly																			
	Sep-18																					
	Oct-18																					
	Nov-18		Quarterly																			
	Dec-18																					

Exceedance of Control Level
Exceedance of Trigger Level
Exceedance of freshwater EQS
Exceedance of Assessment Level

Notes
* The redox potential was not measured on site and there is a possibility that it has changed between sampling and analysis{*/}
** Unionised ammoniacal nitrogen based on measured Temperature and pH; unionised ammoniacal nitrogen = total ammonia/$(1+10^{(10.055-(0.0324*Tc)-pH)})$, where T°C is measured water temperature.
^ Ammonia result confirmed on duplicate analysis.
^^ Reporting limits raised for EH analysis due to sample matrix.
NM temperature not measured on site therefore 10°C is applied for the unionised ammoniacal nitrogen calculation

Empty' denotes not enough water in well for sample

Appendix D
Table D6
Landfill Gas Monitoring Results

METHANE (% by Volume)

Location	Valve	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
GMW2	Red Valve	0.1	0	water									
	Yellow Valve	0	0	water									
	White Valve	0	0	water									
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Trigger Level Red	-	-	-	-	-	-	-	-	-	-	-	-
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level Red	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-
GMW3	Red Valve	0	0	0									
	Yellow Valve	0	0	0.2									
	White Valve	0.3	0	0.3									
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Trigger Level Red	-	-	-	-	-	-	-	-	-	-	-	-
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level Red	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-
GMW4	Red Valve	0	0	0									
	Yellow Valve	0	0	0									
	White Valve	0	0	0									
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Trigger Level Red	-	-	-	-	-	-	-	-	-	-	-	-
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level Red	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-
GMW5	Red Valve	0	0	0									
	Yellow Valve	0	0	0									
	White Valve	0	0	0									
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Trigger Level Red	-	-	-	-	-	-	-	-	-	-	-	-
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level Red	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-
GMW6	Red Valve	0	0	0									
	Yellow Valve	0	0	0									
	White Valve	0	0	0									
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Trigger Level Red	-	-	-	-	-	-	-	-	-	-	-	-
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level Red	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-
GMW7	Yellow Valve	0	0	0									
	White Valve	0	0	flooded									
	Trigger Levels	1	1	1	1	1	1	1	1	1	1	1	1
	Control Levels	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Trigger Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Trigger Level White	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level Yellow	-	-	-	-	-	-	-	-	-	-	-	-
	Control Level White	-	-	-	-	-	-	-	-	-	-	-	-
GMW12	Red Valve	0	0	0									
	Yellow Valve	0	0	0									
	White Valve	0	0	0									
	Trigger Level Red	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89
	Trigger Level Yellow	1	1	1	1	1	1	1	1	1	1	1	1
	Trigger Level White	1	1	1	1	1	1	1	1	1	1	1	1
	Control Level Red	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39

CARBON DIOXIDE (% by Volume)

Location	Valve	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Comments
GMW2	Red Valve	0.1	0.8	water										Red Valve, 25.5m depth
	Yellow Valve	0	0.1	water										Yellow Valve,14m depth
	White Valve	2.6	0.8	water										White Valve, 4m depth
	Trigger Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Red	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
	Trigger Level Yellow	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	
	Trigger Level White	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	
	Control Level Red	1	1	1	1	1	1	1	1	1	1	1	1	
	Control Level Yellow	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	
	Control Level White	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	
GMW3	Red Valve	6.2	5.3	6.1										Red Valve, 19m depth
	Yellow Valve	0.1	0.0	0.3										Yellow Valve,9m depth
	White Valve	20.3	3.8	2.6										White Valve, 3.5m depth
	Trigger Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Red	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	
	Trigger Level Yellow	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	
	Trigger Level White	24.02	24.02	24.02	24.02	24.02	24.02	24.02	24.02	24.02	24.02	24.02	24.02	
	Control Level Red	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	
	Control Level Yellow	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	
	Control Level White	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	
GMW4	Red Valve	0	0	0										Red Valve, 30m depth
	Yellow Valve	0.2	0	0.1										Yellow Valve,20m depth
	White Valve	0.1	0	0										White Valve, 5m depth
	Trigger Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Red	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
	Trigger Level Yellow	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	
	Trigger Level White	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	
	Control Level Red	1	1	1	1	1	1	1	1	1	1	1	1	
	Control Level Yellow	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	
	Control Level White	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	
GMW5	Red Valve	6.1	5.9	5.9										Red Valve, 26.3m depth
	Yellow Valve	3.6	2.6	3.7										Yellow Valve,15m depth
	White Valve	5.8	5	3.2										White Valve, 5m depth
	Trigger Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Red	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	8.48	
	Trigger Level Yellow	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	
	Trigger Level White	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	
	Control Level Red	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	7.98	
	Control Level Yellow	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	
	Control Level White	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	
GMW6	Red Valve	3.8	4.8	2.4										Red Valve, 26.3m depth
	Yellow Valve	2.2	2.1	2.4										Yellow Valve,15m depth
	White Valve	1.9	1.6	0.9										White Valve, 5m depth
	Trigger Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Red	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	
	Trigger Level Yellow	5	5	5	5	5	5	5	5	5	5	5	5	
	Trigger Level White	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	
	Control Level Red	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	
	Control Level Yellow	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	
	Control Level White	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	
GMW7	Yellow Valve	0.7	0.5	0.2										Yellow Valve,12 depth
	White Valve	0.6	0.6	flooded										White Valve, 5m depth
	Trigger Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Control Levels	-	-	-	-	-	-	-	-	-	-	-	-	
	Trigger Level Yellow	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	
	Trigger Level White	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	
	Control Level Yellow	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	
	Control Level White	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	
GMW12	Red Valve	0.1	0.1	0.2										Red Valve, 26.3m depth
	Yellow Valve	0.1	0.2	0.2										Yellow Valve,15m depth
	White Valve	0.1	0.3	0.2										White Valve, 5m depth
	Trigger Level Red	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	
	Trigger Level Yellow	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	
	Trigger Level White	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	
	Control Level Red	4	4	4	4	4	4	4	4	4	4	4	4	

Appendix D
Table D6
Landfill Gas Monitoring Results

Location	Valve	METHANE (% by Volume)												CARBON DIOXIDE (% by Volume)											
		Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Comments
	Control Level Yellow	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	
	Control Level White	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5	5	5	5	5	5	5	5	5	5	5	5	
	Red Valve	0	0	0										1.2	1.5	1.2										Red Valve, 26.3m depth
	Yellow Valve	0	0.1	0										4.1	6.6	5.2										Yellow Valve,15m depth
	White Valve	0	0	0										3.7	3.3	2.7										White Valve, 5m depth
	Trigger Level Red	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	
GMW13	Trigger Level Yellow	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	6	6	6	6	6	6	6	6	6	6	6	6	
	Trigger Level White	1	1	1	1	1	1	1	1	1	1	1	1	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	
	Control Level Red	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	
	Control Level Yellow	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	
	Control Level White	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	5.32	
	Red Valve	nt	nt	nt										nt	nt	nt										Red Valve, 26.3m depth
	Yellow Valve	nt	nt	nt										nt	nt	nt										Yellow Valve,15m depth
	White Valve	nt	nt	nt										nt	nt	nt										White Valve, 5m depth
	Trigger Level Red	1	1	1	1	1	1	1	1	1	1	1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
GMW14	Trigger Level Yellow	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	
	Trigger Level White	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	
	Control Level Red	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	1	1	1	1	1	1	1	1	1	
	Control Level Yellow	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	
	Control Level White	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	
	Red Valve	0.5	0.5	0.5										1.3	1.5	1.3										Red Valve, 23.5m depth
GMW1**	Yellow Valve	11.7	10.8	11.3										4.1	6.2	4.2										Yellow Valve,14.7m depth
	White Valve	11.8	10.9	0.1										4.1	1	0										White Valve, 6.5m depth
GMW8*	Yellow Valve	6.7	4.3	3.4										13.4	14.2	10.6										Yellow Valve,17.5m depth
	White Valve	0	0	0										5.8	6.1	5.1										White Valve, 5.7m depth
	Red Valve	0	0	0										1.9	2.2	2.1										Red Valve, 27m depth
GMW9*	Yellow Valve	41.2	40.5	40.6										16.6	20.1	16.9										Yellow Valve,15m depth
	White Valve	0.1	0.1	0.1										0.1	0.3	0.2										White Valve, 8.5m depth
	Red Valve	52	41.3	49.3										10.3	13	9.6										Red Valve, 19.5m depth
GMW10*	Yellow Valve	51.5	46.8	48.2										10.4	13.7	9.3										Yellow Valve,15m depth
	White Valve	41.7	31.7	26.2										9.6	10.8	6.3										White Valve, 8m depth
	Red Valve	0	0	0										1.3	1.3	1.4										Red Valve, 26.3m depth
GMW17**	Yellow Valve	0	0	0										6	6.6	5.3										Yellow Valve,15m depth
	White Valve	0	0	0										5.1	4.6	4.3										White Valve, 5m depth
GMW18**	Yellow Valve	0	0	0										0.1	1.5	3.3										Yellow Valve,12 depth
	White Valve	0	0	0										7.1	6.9	9										White Valve, 5m depth

Notes:
1. Water denotes 'water in well - reading abandoned'.
2. NT denotes 'reading not taken'.
3. Readings were not taken in March due to unspecified reasons.
4. NT in GMW17 is due to cattle feeding area at location of the well.
5. NT in GMW14 is due to cattle quarantine paddock around well location.
6. NT in GMW7 due to capping contract soil stockpile machinery working above well location.
7. Where the asterisc (*) is present, no trigger levels have been set, as high levels of methane and carbon dioxide gas are recorded. This is likely to be associated with the presence of bog/marshland.
8. Where two asterisks (**) are present, no trigger levels have been set, as not require by the Permit (Reference [2]).

Exceedance of Trigger
Exceedance of Control

Appendix E

Bioavailable Metal Assessment

Silent Valley Bioavailability Assessment

The site specific data from this site was input into the model, and the predicted concentrations are reported in Tables 1 to 3 below, with exceedances highlighted:

Table 1 - Results of Metal Bioavailability Tool for Zinc

Sample	Dissolved Zinc Concentration (lab data) µg/l	Data Derived from M-BAT		Assessment criteria (EQS)
		Site specific PNEC dissolved Zinc	Bioavailable Zinc concentration µg/l	
GW3A	180	18.51	106.0	13.7
GW4	18	10.90	18.0	13.7
GW6	229	22.10	112.95	13.7
GW7	18	27.24	7.20	13.7
GW9	33.1	25.99	13.88	13.7
GW10	73.3	23.97	33.33	13.7
GW12	331	43.20	83.51	13.7

The tool has predicted that six of the seven samples of groundwater contain bioavailable zinc concentrations above the EQS freshwater value for zinc.

Table 2 - Results of Metal Bioavailability Tool for Manganese

Sample	Dissolved Manganese Concentration (lab data) µg/l	Data Derived from M-BAT		Assessment criteria (EQS)
		Site specific PNEC dissolved Manganese	Bioavailable Manganese concentration µg/l	
GW3A	10.1	577.98	2.15	123
GW4	1290	599.37	264.73	123
GW6	339	1846.56	22.58	123
GW7	1890	265.90	874.29	123
GW9	505	489.16	126.98	123
GW10	105	399.21	32.35	123
GW12	19.8	476.25	5.11	123

The tool has predicted that three out of seven samples of groundwater contain bioavailable manganese concentrations above the EQS freshwater value for manganese.

Table 3 - Results of Metal Bioavailability Tool for Nickel

Sample	Dissolved Nickel Concentration (lab data) µg/l	Data Derived from M-BAT		Assessment criteria (EQS)
		Site specific PNEC dissolved Nickel	Bioavailable Nickel concentration µg/l	
GW3A	3	10.74	1.12	4
GW4	3	5.76	2.08	4
GW6	5.5	20.13	1.09	4
GW7	6.5	15.39	1.69	4

Sample	Dissolved Nickel Concentration (lab data) µg/l	Data Derived from M-BAT		Assessment criteria (EQS)
		Site specific PNEC dissolved Nickel	Bioavailable Nickel concentration µg/l	
GW9	4.9	14.30	1.37	4
GW10	4.4	15.02	1.17	4
GW12	7.8	23.10	1.35	4

The tool has predicted that the bioavailable nickel concentrations are below the SEPA EQS for nickel.