Environmental Monitoring Data Report

Llanddulas Landfill Site,

PPC PERMIT BU0800IZ

ANNUAL ENVIRONMENTAL MONITORING REPORT

1st February 2014 – 31st January 2015

FCC Environment,
Llanddulas Landfill Site,
Abergele Road,
Llanddulas
Conwy,
LL18 8HP

April 2015

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Background

FCC Environment (FCC) has undertaken a review of site monitoring data for Llanddulas Landfill site. The report has been compiled in order to comply with Condition 4.2.1a of the site's EP Permit BU0800 and Permit Variations CP3332LG and BG3734XX.

All monitoring data has been reported separately within quarterly data submissions, therefore only selected data is repeated here, as required to illustrate trends and support discussion. This report concentrates on those aspects of the monitoring that have been given trigger levels/emission limits by Natural Resources Wales (NRW) and/or are indicators of landfill impact. It does not attempt to present all data collected throughout the monitoring period but instead, it assesses whether or not the landfill is having an environmental impact and whether the monitoring results are as expected.

The data presented and reviewed within this report was collected over a one year period from 1st February 2014 to 31st January 2015.

1.2 Site Location and Surrounding Land-use

The Llanddulas Landfill (centred at National Grid Reference: SH 904 775) is located to the immediate south-west of Llanddulas village, approximately 5 km to the east of Colwyn Bay.

Llanddulas Landfill is located on an east/north-east sloping hillside with surface elevations falling from approximately 180mAOD, at the site's southern corner, to 120mAOD at the sites entrance tunnel beneath Pentregwyddel Road in the north. To the east of the quarry, the ground level falls steeply away to elevations of between 25 and 30mAOD, which are associated with the Afon Dulas Valley (sometimes referred to as the 'Dulas Gap').

The surrounding land use is agricultural grassland and open pasture which lies immediately adjacent to the site's western and southern boundaries, while development associated with Llanddulas village is present along the site's north-eastern boundary. Much of the eastern site boundary lies adjacent to limestone crags that form the upper slopes to the steep valley of the Afon Dulas. This area lies within the 'Llanddulas Limestone and Grwyth Castle Wood' Site of Special Scientific Interest (SSSI), which is of special interest for its limestone grassland, heath and woodland communities.

A worked-out quarry (the 'Lower Quarry') is located to the immediate north-west of the landfill site. This quarry is no longer operational and now holds a series of lagoons. Historically these lagoons were used to treat effluent generated by the on-site mineral processing plant. However, following the cessation of mineral extraction, their operational use has been limited to providing water for dust suppression activities.

1.3 Site History and Development

Quarry operations at Llanddulas have been on-going for over 100 years, with operations beginning within the Lower Quarry located to the immediate south of the old A55 Coast Road. Mineral extraction moved progressively southwards, with the area to the south of Pentregwyddel Road being developed subject to a number of planning approvals.

Phase 1 of the Llanddulas Landfill was developed by Colwyn Borough Council during 1985 and landfilling within Phase 1 was initially completed during 1994. However, further re-profiling occurred within Phase 1C during the latter part of 2001 in order to increase the height of the site and to correspond to the appropriate restoration contours. These operations allowed the capping and restoration of previously unrestored areas of this phase. During 2010, a total of 1000m2 of temporary capping was installed on the North flank of cell 3a and 6000m2 of permanent HDPE capping installed to Phase 3a southern flank plus 1m of restoration soils.

Historically Phase 2 operations began in 1994 while Phase 3 was developed during 2002. Phase 2 capping was completed in 2002. Phase 3 is also capped.
During the reporting period the Central area of Phase 3A was operational, the North Western, North Eastern area and the southern half are now all capped.

1.4 Geology

The superficial deposits present within the vicinity of the landfill are located to the east and north-east of the site and comprise Boulder Clay. These materials are present within the base of the Afon Dulas valley as well as the western and eastern valley sides. It is anticipated that the greatest depth of this material is located within the Afon Dulas valley, although there is no direct evidence to confirm this. In addition to the Boulder Clay, River Terrace Deposits and Alluvium are also associated with the water course.

The solid geology comprises limestones deposited within the Carboniferous Limestone Series. More specifically, the site is located in the Dyserth Limestone Group. Below the Dyserth Limestone Group and outcropping several hundred metres to the south of the site are the Carboniferous Limestone Basement Beds, which comprise a variable sequence of limestones, sandstones and conglomerates. The local dip of the limestone beds is approximately 15 degrees towards the north-north-east.

There are four main faults located within the vicinity of the site, the details of which are as follows; the Llysfaen and Plas Farm Faults are orientated approximately east to west and traverse the quarry. Both faults dip towards the south at approximately 45 degrees and have around 40m of displacement to the south.

The Llysfaen fault is located to the immediate south of Phases 1 and 3 and north of Phase 2. The Plas Farm Fault effectively defines the southern extent of the currently consented landfill area. The Dulas Gap Fault is orientated north to south and is near vertical with a downthrow of approximately 75m to the east.

The geological map information for the area suggests that this fault truncates the eastern ends of the Llysfaen and Plas Farm Faults. It is probable that the Llysfaen Fault is downthrown by the Dulas Gap Fault. If this is the case, then the surface manifestation of the truncated Llysfaen Fault could be in the location of the Dulas Spring, owing to the dip of the Llysfaen Fault to the south and the 75m downthrow to the east of the Dulas Gap Fault.

The Tyn-y-Caeau Fault located to the east of the Dulas Gap Fault, is near vertical and has a 120m throw to the west. It intersects the Dulas Gap Fault to the north of the quarry. In addition to the above, smaller unnamed faults are present to the south of Llanddulas Landfill within the southern end of the quarry. Two sets of vertical joints, parallel to the geological strike are also present.

1.5 Hydrogeology

The site is located within the Carboniferous Limestone Series, which is classified as a "principal aquifer" within the Groundwater protection policy, 2010, owing to the rock potentially possessing significant fracturing and extensive well-developed joint system and the potential for high bulk permeability. This classification is confirmed by the Groundwater Vulnerability Map1 for the area.

The Carboniferous Limestone aquifer is a hard rock where primary porosity is low (less than 1%) and flow through open cavities, such as fractures, fissures and joints, is dominant. The Carboniferous Limestone is mechanically strong, but can undergo solutional weathering (karstification) which, under some circumstances, can produce caves (conduits) through which groundwater can flow preferentially.

Even though preferential routes exist within the Carboniferous Limestone aquifer, an extremely large volume of aquifer will still consist of rock that possesses tight fractures where water flow is extremely slow (i.e. the diffuse zone). The diffuse zone of the Carboniferous Limestone aquifer is generally highly anisotropic, that is to say that hydraulic conductivities vary significantly with direction. Groundwater flow within a karstified Carboniferous Limestone aquifer usually occurs along bedding planes, which are laterally continuous within the rock.

1.6 Hydrology

The main watercourse within the vicinity of Llanddulas Landfill is the Afon Dulas, located approximately 200 to 400m to the east of the site. This watercourse flows in a northerly direction and discharges into the Irish Sea approximately 1.3km to the north-east of the site. The coastline lies approximately 600m and 300m to the north of Phase 1 and the Lower Quarry areas respectively. An unnamed tributary of the Afon Dulas, which flows in an easterly direction, is located over 1km to the south of the site.

Llanddulas Landfill does not lie within any indicative floodplain.

[1] Groundwater Vulnerability Map, Sheet No.15, North Wales Coast

2.0 LANDFILL GAS REVIEW

Routine monitoring for off-site landfill gas was undertaken on a weekly basis within 54 perimeter monitoring boreholes and monthly in a further 22 in accordance with the requirements of Table S4.5 of the site Permit. Methane, Carbon Dioxide, Oxygen, relative pressure and atmospheric pressure are all recorded.

The locations of monitoring points are shown on the site monitoring plan, Drawing No. 1.

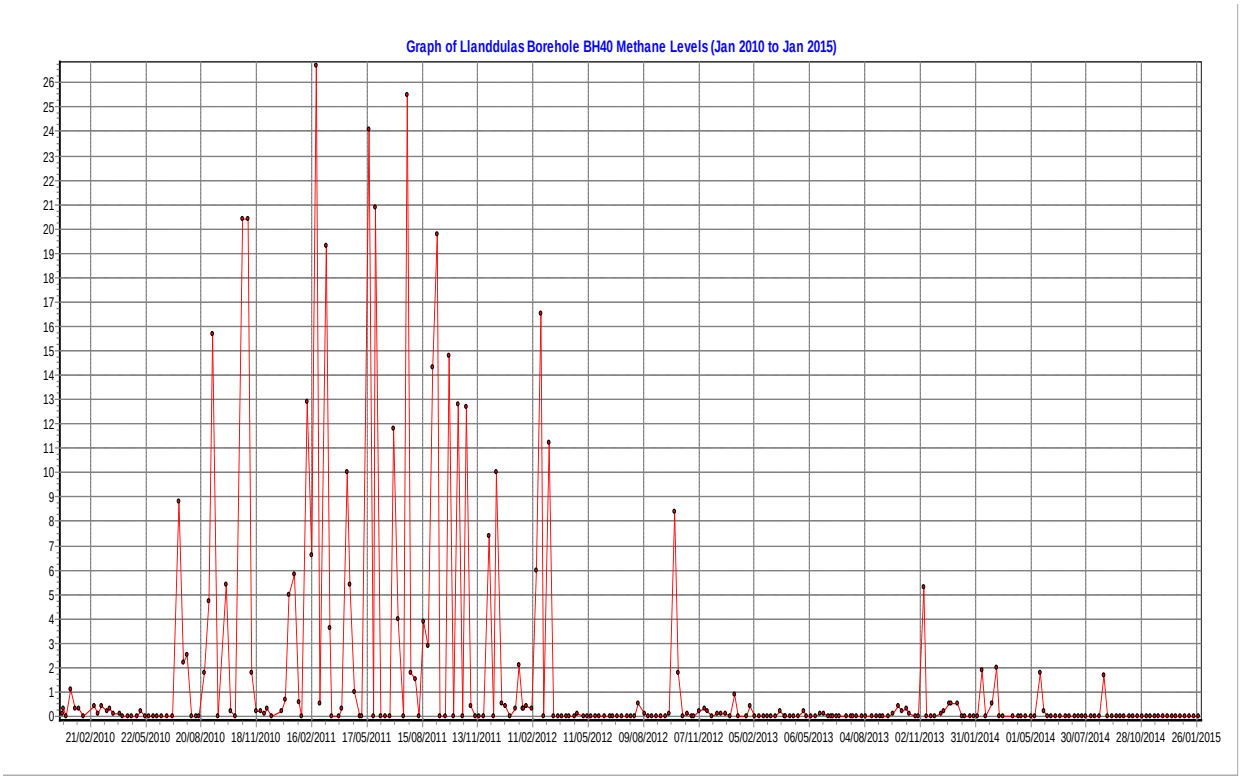
The trigger levels for landfill gas concentrations are those submitted and agreed with NRW in accordance with improvement condition S1.3.13, agreed with the then EA Wales in November 2012 (CAR form RDR/121105).
The new trigger limit for methane is 1% (action limit of 0.5%), with the exception being 2.5% in borehole Bh40 which has an action limit of 1.5%. Specific actions to be taken if the limits are breached are detailed in the latest version of the site Landfill Gas Management Plan. Borehole specific CO2 action limits were also agreed.

2.1 Landfill Gas Data Summary

A review of the gas quality data indicates the following;

There were no breaches of the current methane trigger limit of 1.0%(v/v) throughout the reporting period.
The borehole which, in previous years had recorded the most breaches was borehole BH40, however, there were 3 instances when the 'action limit' for methane was exceeded in the 12 month period with levels of between 1.7% and 1.9%v/v recorded.
On each occasion the gas wells opposite Bh40 were rebalanced to re-establish gas control.

Graph 1: Historical Methane Levels in borehole BH40 (Jan 2010 to Jan 2014)



This borehole is not situated on the site boundary and is not considered to reflect evidence of off-site gas migration but is used as a control measure and any breaches of the methane trigger level are reported accordingly. This borehole was included in Improvement Condition IC13 of the PPC permit and following the submission of the above IC borehole BH40 now has a methane trigger level of 2.5% and action level of 1.5%.

Active measures are in place to discourage gas migration towards borehole Bh40 from the adjacent Phase 1, whereby suction is being applied at a constant rate to the two nearest gas wells. It can be seen (in Graph 1 above) that the number of methane breaches and general background levels of gas in Bh40 have much reduced in the last few years.

Since November 2012 (following the agreement of CO2 Action Limits, as part of the IC13 submission), Carbon Dioxide has no longer been used as a landfill gas migration indicator in the absence of methane.

To summarise, there are no trends of elevated Methane within the perimeter boreholes that would indicate ongoing lateral migration of landfill gas beyond the site perimeter. Elevated readings of Carbon Dioxide are thought to be present because of the localised geology.

2.2 Landfill Gas Management

The landfill gas control system was monitored in accordance with Tables S4.7 of the site Permit. Capping of the North Eastern section of Phase 3A was completed during 2014 and this, along with the drilling of further gas wells and the proactive installation of pin wells in the North East corner of Phase 3A, has enhanced the gas capture at the site and assisted in the control of fugitive emissions.
Reports for trace gas analysis and engine emissions data are appended at the end of this report.
After a review of the gas well monitoring data, the following observations can be made.

- Average methane concentration for the gas extraction wells (from 5898 readings) during the 12 month period was 46.4%(v/v).

- Average carbon dioxide concentrations were observed to be 33.4%(v/v) within the gas wells for the duration of the review period.

- Oxygen readings averaged 2.2%(v/v).

- Suctions within the field averaged -29.6mbar for the duration of the review period.

Landfill gas is currently extracted and utilised at the site from Phases 1, 2, 3 and 3A.
The LFG utilisation plant, located on site, comprises of three Jenbacher engines capable of producing 2 x 1000kWs and 1x 1065kWs respectively.
The total flaring capacity on site consists of one 2000m3 high temperature flare and one 1000m3 high temperature flare commissioned in September 2008. These are capable of sufficient gas control in the event of the engines being unavailable.

Llanddulas produced an average of approximately 2500kW of exportable energy per month during 2014. The gas quality at the engine inlet averaged 44.1% methane,1.8% oxygen, -87.6mb differential pressure and an average flow of 1623m3/h.

Gas volumes predicted within the most recent Landfill Gas Risk Assessment (SLR Ref.404.0197.00529 August 2009) quote gas generation volumes in excess of 2000m3/hr, however, this was calculated based on waste inputs of 160,000t/yr, whereas during 2014,

waste inputs at Llanddulas totalled just over a third of the above projected figure at 58,175t, 25% of which would be classed as non-biodegradable.

Monitoring of the flare and gas engine emissions and trace gas analysis was undertaken during December 2014 in accordance with Table S4.2 of the site permit. The results are contained in Appendix 1 of this report.

Table 1: Engine and Flaring Capacity at Llanddulas Landfill Site 2014

Site	Flares			Engines			
	No.	Total Capacity (m3/hr)	Total Volume to Flare (Nm3)	No.	Total Capacity (MW)	Total Capacity (m3/hr)	Total Volume to Engines (Nm3)
Llanddulas	2	3000	901,000	3	3.07	1800	13,692,000

Emissions from engines 1 and 2 remained within the overall uncertainty limit for NOx and met the standard for CO and TVOCs. Engine 3 was compliant with the standard. – see notes 1 – 7 of the attached report (Appendix 1).
As the main flare ran for more than 10% of the time the flare emissions were also tested (see Appendix 1) and were compliant with the standard.

With regard to the inlet trace gas.

- Compared with the results from last year, some component concentrations have increased, others have decreased. 1,2 Dichloroethene was detected last year, but was not detected this year. 1,1, Dichloroethane; 1-Pentene; Chloroethene; Dimethyl disulphide; Ethanal; Ethyl butyrate; Furan and Methanal were not detected last year, but were detected this year.

- Arsenic; Chloroethane; Ethanal; Furan; Hydrogen Sulphide and Methanal were detected above the national UK database average (within an order of magnitude of the database average). All other detected components were below the database average.

- Hydrogen sulphide concentration has decreased to a level only a little higher than typical for all FCC sites

The effectiveness of the gas management system is tested by monitoring gas compositions at the gas collection and extraction wells. Monitoring of the gas extraction system is carried out in accordance with the requirements of Tables S4.2 and S4.7 of the site Permit.
Table S4.7 specifies that where oxygen levels exceed 5%(v/v), or where the addition of Carbon Dioxide and Methane percentages is less than 80%, an assessment of air ingress shall be undertaken. Also, where the concentration of Carbon Monoxide exceeds 100ppm, then further investigations shall be carried out. A review of the gas well data in relation to the above control limits would indicate the following.

There were a total of 5898 readings obtained during the review period and of these, there were 2174 results which showed a total percentage of Carbon Dioxide and Methane of less than 80%(v/v) which is almost 300 readings less than the total recorded in 2013. A total of 773 results showed O2 in excess of 5% which was 1.3% less than in 2013. Assessments of these wells showed that the majority of readings led to the valves at these points being closed or significantly reduced, to prevent any potential oxygen ingress, yet maintaining a degree of gas control.
Investigations are actioned when the control limits specified within Table S4.7 of the Site Permit are exceeded and corresponding remedial actions promptly instigated by our gas contractors.

There was five exceedence of the 100ppm control limit for Carbon Monoxide during the review period at gas well C146, D238 and D270 with the highest value in gas well C146 at 157ppm.

During the last few years there have been various reviews of the effectiveness of the gas extraction system, including NRW gas audits. Remedial works have taken place as a result including decommissioning of redundant gas wells and the installation of a significant number of new wells. Both permanent and temporary capping has also taken place and the removal of elevated liquid levels contained within some gas wells continues.

3.0 GROUNDWATER REVIEW

3.1 Groundwater Levels

Groundwater levels are recorded on a monthly basis within the sampling boreholes specified in Table S4.10 of the site Permit and locations are indicated on Drawing No.1.

Following a review of the data the following conclusions may be drawn:

The groundwater level beneath the site varied between 11.97mAOD in borehole GWBH24 (downstream of groundwater flow across the site) located in Llanddulas village to the north-east of the site and 71.10mAOD in GWBH36 (downstream) on the Eastern site boundary. The boreholes displaying the minimum and maximum AOD levels are the same as in 2012 and 2013 with values close to those recorded in previous years. The wide variation in groundwater levels is in part a function of the wide variation in topography across the site ranging between 180mAOD to the south and 30mAOD in the north. It is also possible that proximity to the sea could give rise to tidal fluctuations within the aquifer, especially in the more northerly boreholes. Wide groundwater fluctuations are typical of karstic aquifers and their response to recharge events.

The range in groundwater levels within individual boreholes varied from 1.11m in GWBH2 to maximum of 40.58m in GWBH36. It is common to observe a wide variation because the nature of recharge event response varies depending on the degree of fissuring or solution cavity exposed to the screened section of the monitoring well.

To summarise, groundwater levels observed within the perimeter monitoring boreholes are generally consistent with historic results.

3.2 Groundwater Quality

Groundwater samples are taken from the locations and at frequencies as specified in Tables S4.4 and S4.10 of the site Permit.
A review of the groundwater monitoring data for 2014, in relation to the compliance limits specified within the Site Permit and assessment criteria stated within the most recent approved HRA (SLR – Ref 404-0197-00529, December 2008) indicates the following;

Ammoniacal Nitrogen and Chloride concentrations remained below the trigger level throughout the review period in boreholes with trigger limits applied.
Elevated NH4N readings were recorded in borehole GWBH26b (which has no trigger limit) on a number of occasions, to a maximum of 40.3mg/l. During dry weather this borehole becomes almost dry with stagnant silty/sludgy deposits at the base which when sampled produces elevated Ammonium results at the laboratory. Technicians have found difficulty retrieving a sample from the borehole and often reported an 'oily' or 'fishy' smell when sampling. There have been no other elevated readings of any other substance analysed from these samples.
There was no breach of the 250mg/l trigger limit for Chloride during the review period. The highest value recorded was 183mg/l in borehole GWBH24.

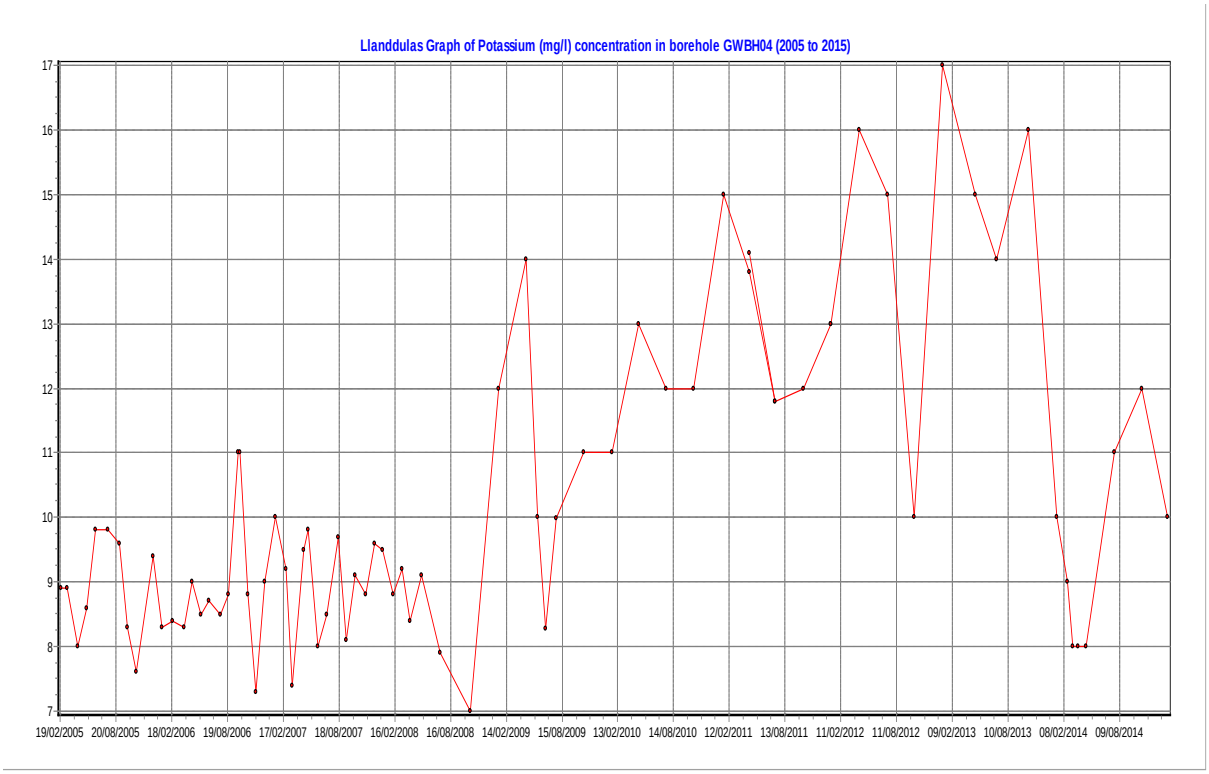
There were no breaches of **Potassium** in any of the groundwater boreholes with trigger limits for K, however there were a number of elevated levels in three other boreholes; GWBH06r, GWBH26b and GWBH36.
Three other boreholes (with no trigger limits) recorded levels of potassium above 12mg/l. These occurred in borehole downgradient **GWBH6r** with concentrations of 43 to 73mg/l recorded during the review period. Given the high levels of Potassium in this borehole, other determinands have been closely monitored. Chloride levels showed small fluctuations in concentration between 125 and 162mg/l but with no increasing trend and Ammoniacal Nitrogen levels showed no discernible trend with very low values recorded of <0.01 and 0.4mg/l
Borehole **GWBH26b** is situated physically below and downgradient of GWBH6r. Potassium levels above 12mg/l were recorded on two occasions at 16 and 20mg/l with elevated Ammoniacal Nitrogen levels in this borehole already discussed above. Chloride levels are relatively low and were steady throughout the review period between 58 and 70mg/l.

Borehole **GWBH36** can be described hydrogeologically as cross-gradient and recorded an elevated Potassium reading of 39mg/l in January 2015. The same set of analysis data showed Ammoniacal Nitrogen at 0.01mg/l but Chloride was elevated compared to previous months at 111mg/l. Looking back over the previous 5 years of data, Chloride has been above 100mg/l on several occasions.

The 3 boreholes discussed above are all upstream of the **Dulas Valley Spring** which has shown no deterioration in water quality during the last 12 months.

In previous years, potassium was recorded above the trigger limit of 12mg/l in water sampled from borehole **GWBH04.** Since the instigation of regular purging of the borehole prior to sampling the potassium levels have remained at or below the trigger limit.
Historically, GWBH04 has shown higher readings for Potassium than any of the other groundwater monitoring locations. In the absence of any obvious trends in other key indicators (that would show any potential failure in the containment system) this is deemed to be sourced from localised background conditions in the groundwater. Given that the increase in Potassium levels, seem to occur every April, there is a possibility, that with the borehole location being in the front quarry (a relatively short distance from the sea) that Spring tides may be flushing seawater into the area below ground.

Graph 2: Potassium concentrations in groundwater borehole GWBH04 (2005 to 2015)



There were no breaches of the **Mecoprop** trigger limit for the third year in a row which is an improvement on previous years when there were several breaches across a number of boreholes. There were 3 boreholes (without trigger limits) with elevated Mecoprop values above the EA guidance limit of 0.1ug/l, these were GWBH02 (0.24ug/l), GWBH27b (0.11ug/l) and GWBH28 (0.14ug/l) which all occurred in December 2014.

There were no breaches of the **Mercury** trigger limit, although there were two elevated levels of (0.39ug/l) recorded in borehole GWBH6r in August and (0.30ug/l) in GWBH27b in November. It should be noted that these slightly elevated levels are significantly below the EAL of 1.0ug/l specified in Table HRA6 of the most recently approved HRA.

Table 2: Maximum background concentrations of substances in groundwater boreholes (HRA, table 6, 2008) versus 2014 concentrations.

Determinand	Ammonium	Chloride	Lead	Mercury	Mecoprop	Cadmium
HRA 2008	0.84	62	0.013	0.001	0.14	0.0005
Maximum	40.3	183	0.03	0.00039	0.24	<0.0001
Minimum	0.01	12	0.01	0.0001	0.02	<0.0001
Average	0.72	57	0.01	<0.0001	0.02	<0.0001

The Annual screen for hazardous substances was completed in October 2014 and from 428 results returned, there were four positive detections.

The requirement for the purging of groundwater boreholes prior to sampling was reviewed by FCC and the findings submitted to Natural Resources Wales who agreed that purging of boreholes is not necessary.

To summarise, groundwater quality is generally considered to be consistent with historic review periods. There are no trends evident within the data sets that would indicate a potential failure in the site containment system. There were occasional, isolated, slightly, elevated results, but none that would indicate a potential risk to the surrounding environment. An assessment has also been made against the most recent HRA and background results tend to be consistent with the Environmental assessment limits.

4.0 LEACHATE REVIEW

Leachate levels are recorded on a weekly basis in accordance with Table S4.1 of the site Permit. Leachate samples are collected on a quarterly basis as agreed in writing (April 2013) with Natural Resources Wales.

4.1 Leachate Levels

Leachate monitoring within restored and active phases currently occurs at 7 leachate extraction and 7 leachate monitoring points in accordance with the requirements of Table S4.1 of the site Permit.

A review of the leachate level data indicates the following:

All leachate chambers monitored on site were consistently within the compliance limit of 2m specified within Table S4.1 of the Site Permit for the majority of the review period.

4.2 Leachate Quality

Leachate is sampled in the 7 leachate collection chambers (across Phases 1, 2, 3 and 3A) specified in Table S4.8 of the site Permit.

Following a review of the results compared to the source term data stated in Table HR4 of the Site HRA, the following comments can be made:

Ammoniacal Nitrogen concentrations ranged from a minimum of 169mg/l in LCP1AR (the oldest leachate well on site), to 3090mg/l in LCP3A with an overall average of 1,341mg/l (a slight decrease on 2013). The maximum value is within the range of the source term concentrations modelled in the HRA.

Concentrations of **Chloride** ranged from 484mg/l in LCP1Ar to 3650mg/l recorded in LCP2Cr, which is around 500mg/l higher than the maximum figure in 2013. The overall average of 2255mg/l is slightly down on the 2013 total and significantly lower than the maximum source term concentration of 3900mg/l.

Lead concentrations ranged from below detection limits in the majority of chambers, to a maximum of 0.03mg/l in both LCP2Cr and LCP3, which is significantly below the source term maximum of 120mg/l.

Table 3: Concentrations of major contaminants in leachate at Llanddulas (2014)

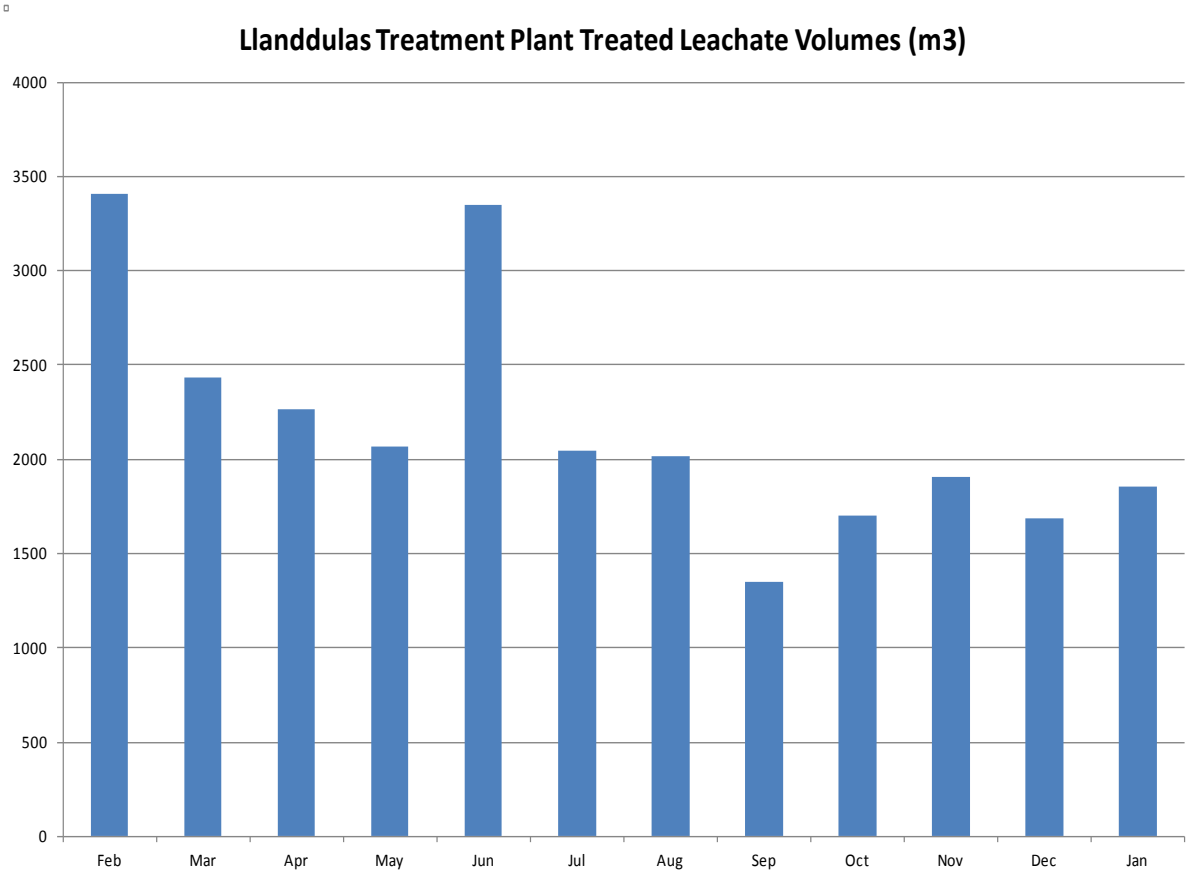
Determinand	Ammonium (mg/l)	Chloride (mg/l)	COD (mg/l)	BOD (mg/l)	Conductivity (us/cm)	Lead (mg/l)	Mecoprop (ug/l)
Max Value	3090	3650	11700	13800	36878	0.03	109
Min Value	169	484	250	10	4400	0.01	12.5
Average	1341	2255	4389	1284	17412	0.01	55

To summarise, leachate quality is similar in strength to historic reports and is of a typical composition for a non-hazardous landfill site receiving municipal solid waste. All results obtained were generally within the ranges of the Source Term Concentrations stated in Table HRA4 of the most recently approved HRA.

4.3 Leachate Disposal

A total of 40,366m3 of leachate was treated at the on-site treatment plant during 2014. This total includes imported leachate from either other FCC sites or from landfill sites on Anglesey. Leachate is pumped from 7 collection chambers, 6 monitoring points and in addition a series of pumped 'pots' which range in depth from 10m to 15m. Leachate is also pumped to the LTP from a number of gas wells. Priority is always given to the treatement of on-site leachate when the plant is at full capacity of 150m3/day.

See graph below of monthly leachate treated volumes excluding imported leachate.



5.0 SURFACE WATER REVIEW

Surface water is sampled in accordance with the requirements of Tables S4.3 and S4.9 of the site Permit.

After a review of the surface water quality, the following conclusions can be made;

There were no emissions through discharge point W1 for the duration of the review period, although the location was sampled throughout the period. Water quality analysis from this location is provided on a quarterly basis.

Concentrations of **Ammoniacal Nitrogen** in the Dulas Valley Spring and River Dulas sampling locations, ranged from 0.01mg/l to a maximum result of 1.00mg/l recorded from the River Dulas downstream sampling location. Average concentrations were calculated at 0.12mg/l across the period which is 0.03mg/l lower than the previous review period.

Chloride concentrations averaged 39mg/l in all sampling locations, with a maximum observed concentration of 62mg/l recorded at the Dulas Valley Spring. These concentrations are slightly higher than the previous review period but the results remained significantly beneath the UK DWS of 250mg/l.

Results for **Lead** and **Mercury** were all below detection limits for the duration of the review period.

Mecoprop concentrations averaged 0.04ug/l for the 3 surface water sampling locations, with a maximum observed concentration of 0.28ug/l recorded in the Dulas Valley spring. This concentration is slightly higher than in the previous review period with the average concentrations below the UK DWS of 0.1ug/l.

The Annual Hazardous Substance screen required by Table S4.9 was completed in October 2014 with no positive detections of two substances.

To summarise, there has been no emissions of site derived surface water run off through the discharge point W1 during the review period. All other sampling locations have been monitored in accordance with the site permit, and there is no evidence to suggest any kind of environmental impact on the localised water courses that could be attributed to landfilling activities at Llanddulas.

6.0 EMISSIONS TO AIR

Emissions to air are monitored in accordance with the requirements of Tables S4.6 and S4.11 of the site Permit.

6.1 FID Surveys

Walkover FID surveys, both across all phases of the site and at the perimeter are completed on a monthly basis in accordance with the requirements of Table S4.11 of the site Permit. Results generated by these surveys are reported on a quarterly basis to NRW.
In addition, there is an ongoing program of fortnightly FID surveys, to identify areas or point sources of fugitive emissions, followed by remedial works to resolve any issues identified.
A perimeter survey is also carried out monthly using a 'Jerome' unit which measures hydrogen sulphide in parts per billion.

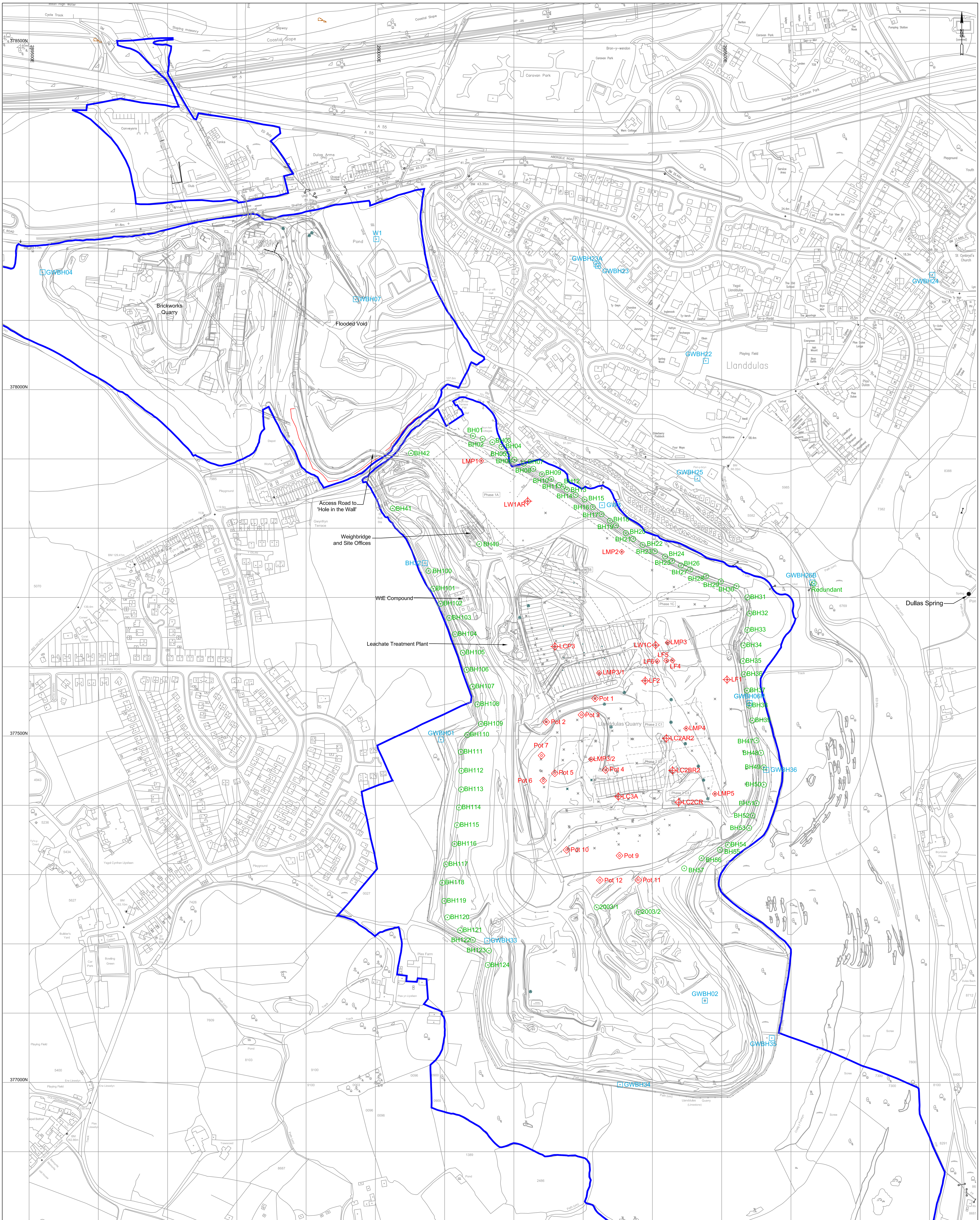
6.2 Flux Box Surveys

A full site flux box survey was carried out in September 2014 (in accordance with Table S4.6 of the site Permit) however there was an intermittent failure of the instrument used for the surface emissions testing. As a result of the instrument failure, although most results were below the guidance limit, many were deemed to be not representative or inconclusive. The consultants attempted to re-do the survey in October but met with poor weather conditions and so the whole survey will be carried out again in the summer of 2015.
New permanent capping took place in the North East corner of Phase 3A during 2014. In addition, FID surveys, with follow up sealing works have continued to be carried out across all areas of the site on a fortnightly basis.

7.0 Monitoring Amendments and Future Monitoring Requirement

- A full site flux box survey will take place during 2015.
- Proposals were submitted by FCC to Natural Resources Wales on 20th April 2015 for monitoring reductions in line with recommendations within Agency guidance.
- Proactive monitoring of emissions (FID surveys) are to continue on a fortnightly basis during 2015.

DRAWINGS



LEGEND

Symbol	Description
Ownership Boundary	Ownership Boundary
	Landfill Gas Monitoring Borehole
	Landfill Gas Surface Monitoring Point
	Combined Gas/ Groundwater Monitoring Point
	Gas Flare Stack
	Landfill Gas Extraction/ Leachate Monitoring Point
	Condensate Unit (Knock-out Pot)
	Gas Manifold
	Groundwater Monitoring Borehole
	Groundwater Pumping Point
	Surface Water Monitoring Point
	Leachate Collection Point
	Leachate Monitoring Point
	Leachate Recirculation Point
	Leachate Collection Sump
	Leachate Discharge Sampling Point
	Leachate Detection Point
	Underdrainage Monitoring Point
	Site Investigation Borehole
	Drain/ Dewatering Tank
	Valve
	As-built Cell Footprint

Files Used:
Site Survey: 122E1490
Monitoring Plan: 122M1126
Cell Footprints: 122B014

REVISIONS

No	Description	By	Chk'd	Date
A	New Ground Water Boreholes Added	LH	JP	22.02.13
B	New Leachate Re-drill added	LH	JP	08.03.13

Project:
LLANDDULAS
LANDFILL SITE

Title:
Environmental Monitoring Plan

Drawn By LH Date 09.01.13
Chk'd By GF Date 09.01.13
Scale 1: 2500 Sheet Size A1

FCC Environment (UK Limited)
3 Sidings Court
White Rose Way
Doncaster
DN4 5NU

FCC Environment
FCC Environment (UK Limited)
3 Sidings Court, White Rose Way, Doncaster. DN4 5NU

Drawing No
122M238A
Plan 4A

APPENDIX 1

Engine Emissions & Trace Gas Analysis

- Trace Gas Analysis
- Engine Emissions Data
- Flare Emissions Data

Infinis Energy Services Limited

Periodic monitoring of raw landfill gas

Llanddulas Landfill Site

Report	LNO12154-TG
Date	23 January 2015
Version	2

1015

PERIODIC MONITORING OF RAW LANDFILL GAS

LLANDDULAS LANDFILL SITE

Report prepared for

Infinis Energy Services Limited
500 Pavilion Drive
Northampton Business Park
Northamptonshire
NN4 7YJ

Report prepared by

ESG
Unit D
Bankside Business Park
2 Wilkinson Road
Cirencester
Gloucestershire
GL7 1YT

Approved **Dr N Ford**

N Ford

23 January 2015

Issue history

Version	Date	Approved	
LNO12154-TG, 1	19 January 2015	N Ford	N Ford
First issue			
LNO12154-TG, 1	19 January 2015	N Ford	N Ford
Clarification of hydrogen sulphide concentration in section 4.			

1 Introduction

Infinis Energy Services Limited (Infinis) contracted Environmental Scientifics Group (ESG) to undertake monitoring of the landfill gas supply to its combustion operations at the Llanddulas landfill site.

2 Test methodology

Infinis requested that duplicate samples of landfill gas be collected and analysed for the priority trace components (LFGTGN08, Table 1.1) specified in Environment Agency guidance (Guidance for monitoring trace components in landfill gas – LFGTGN08 v3.0, 2010). The test methodology should be in accordance with that specified within LFGTGN08.

Based on LFGTGN08 the priority trace gas components are sampled using a combination of four sampling media as shown in Table 1.

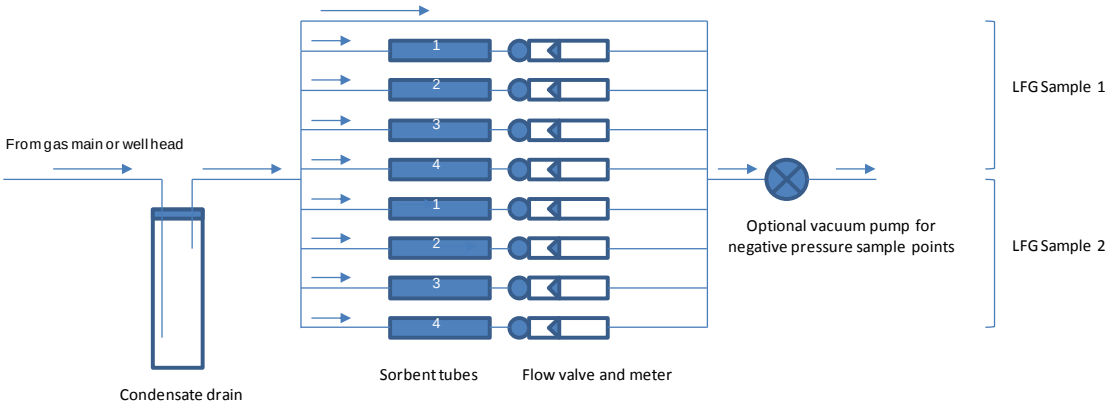
Table 1 Sampling media and analytical methods

Trace component	CAS number	Sampling method	Analytical method
1,1-dichloroethane	75-34-3	Dual solid sorbent	ATD-GC-MS
1,2-dichloroethane	107-06-2	Dual solid sorbent	ATD-GC-MS
1,1-dichloroethene	75-35-4	Dual solid sorbent	ATD-GC-MS
1,2-dichloroethene	540-59-0	Dual solid sorbent	ATD-GC-MS
1,3-butadiene	106-99-0	Dual solid sorbent	ATD-GC-MS
1-butanethiol	109-79-5	Dual solid sorbent	ATD-GC-MS
1-pentene	109-67-1	Dual solid sorbent	ATD-GC-MS
1-propanethiol	107-03-9	Dual solid sorbent	ATD-GC-MS
2-butoxyethanol	111-76-2	Dual solid sorbent	ATD-GC-MS
Arsenic (as As)	7440-38-2	Charcoal	ICP-MS
Benzene	71-43-2	Dual solid sorbent	ATD-GC-MS
Butyric acid	107-92-6	Dual solid sorbent	ATD-GC-MS
Carbon disulphide	75-15-0	Dual solid sorbent	ATD-GC-MS
Chloroethane	75-00-3	Dual solid sorbent	ATD-GC-MS
Chloroethene (vinyl chloride)	75-01-4	Dual solid sorbent	ATD-GC-MS
Dichloromethane	75-09-2	Dual solid sorbent	ATD-GC-MS
Dimethyl disulphide	624-92-0	Dual solid sorbent	ATD-GC-MS
Dimethyl sulphide	75-18-3	Dual solid sorbent	ATD-GC-MS
Ethanal (acetaldehyde)	75-07-0	Silica gel/2,4 DNPH	HPLC-DAD
Ethanethiol	75-08-1	Dual solid sorbent	ATD-GC-MS
Ethyl butyrate	105-54-4	Dual solid sorbent	ATD-GC-MS
Furan (1,4-epoxy-1,3-butadiene)	110-00-9	Dual solid sorbent	ATD-GC-MS
Hydrogen sulphide	7783-06-4	Charcoal	IC
Methanal (formaldehyde)	50-00-0	Silica gel/2,4 DNPH	HPLC-DAD
Methanethiol	74-93-1	Dual solid sorbent	ATD-GC-MS
Styrene	100-42-5	Dual solid sorbent	ATD-GC-MS
Tetrachloromethane	56-23-5	Dual solid sorbent	ATD-GC-MS
Toluene	108-88-3	Dual solid sorbent	ATD-GC-MS
Trichloroethene	79-01-6	Dual solid sorbent	ATD-GC-MS

ATD – automated thermal desorption
GC-MS – gas chromatography and mass spectrometry
ICP-MS – inductively couple plasma/mass spectrometry
HPLC-DAD – high performance liquid chromatography and diode array detection
IC – ion chromatography

Sampling for all components is undertaken simultaneously using a multiple stream sampler as shown in Figure 1.

Figure 1 Landfill gas sampling arrangement



A sample is taken from either the gas main or well head and passed through a condensate drain to remove excess moisture. The sample gas is then split to pass through a series of eight regulated rotameters arranged in two banks of four. There is also a bypass stream for excess sample. This allows the duplicate simultaneous sampling at regulated flow rates onto four sampling media. The flow rates and sampling duration are set in accordance with LFGTGN08 requirements as summarised in Table 2.

Table 2 Sampling media and analytical methods

Media	Target species	Sampling rate (ml/min)	Sampling duration (min)	Sample volume (l)
Dual solid sorbent (Tenax/Sulficarb)	VOCs	20	10	0.2
Silica gel and 2,4 DNPH (SKC 226-119)	Aldehydes	20	50	1.0
Activated carbon 1 (SKC 226-09)	Arsenic	100	50	5.0
Activated carbon 2 (SKC 226-09)	Hydrogen sulphide	100	50	5.0

In the case of negative pressure sources it is necessary to employ a vacuum pump at the sampler's common outlet. This is not normally required with positive pressure systems

This results in two duplicate samples of landfill gas with each sample comprising the four sub-samples above covering all of the priority trace components within Table 1.

The samples are subject to the analytical procedures described in Table 1 to provide a mass on the collected sample which can then be related to the volume of gas sampled to provide a component concentration in the sampled landfill gas.

The sampling followed internal procedure GAS15 and is accredited under test certificate 1015.

3 Site information

Sample point details			
Date	17 December 2014	Site	Llanddulas landfill site
Ambient temperature	13 ^{o}C	Atmospheric pressure	100.4 kPa
Monitoring organisation	ESG UKAS 1015	Analytical laboratory	ESG UKAS 1015
Location of sampling point	Gas main to compound	Area of influence of collection system sampled	All
Type of sample point	¼" Tefen	Temperature of gas	45^{o}C
Vacuum on sample point	213 mb	Type of waste	Not recorded
Status of gas system	Active	Age of waste	Not recorded

4 Preliminary checks and field measurements

Parameter		Concentration
Methane	%	41.3
Carbon dioxide	%	32.7
Oxygen	%	2.1
Nitrogen (by difference)	%	23.9
Hydrogen sulphide	ppmv	n.m.
Carbon monoxide	ppmv	8

n.m. no measurement was made on this occasion

Preliminary bulk gas measurements were undertaken using a Gasdata LMSxi electrochemical cell analyser (no 1227). Reported measurements are spot readings following gas sampling for a period of 5 minutes.

5 Results of landfill gas analysis

The results of the sampling and analysis are summarised in Table 3 below.

Table 3 Priority trace component measurement results

Parameter		**Concentration ($\mu g/m^3$,STP)**
1 Pentene		1269
1,1-Dichloroethane		159
1,1-Dichloroethylene		<48
1,2-Dichloroethane	*	1692
1,2-Dichloroethylene		<26
1,3-Butadiene		<37
1,4 epoxy 1,3 butadiene		1692
1-Propanethiol		<106
2-butoxyethanol		<106
Benzene	*	5818
Butyric acid		<212
Carbon disulphide		3649
Carbon tetrachloride	*	<53
Chloroethane		1111
Dichloromethane	*	3332
Dimethyl disulphide		423
Dimethyl sulphide		1640
Ethyl butyrate		4495
Ethyl mercaptan		<159
Methyl mercaptan		<529
N-Butyl mercaptan		<159
Styrene	*	1111
Toluene	*	30146
Trichloroethylene	*	317
Vinyl chloride monomer		1587
Arsenic	*	233
Hydrogen sulphide	*	465410
Acetaldehyde	*	1343
Formaldehyde	*	233

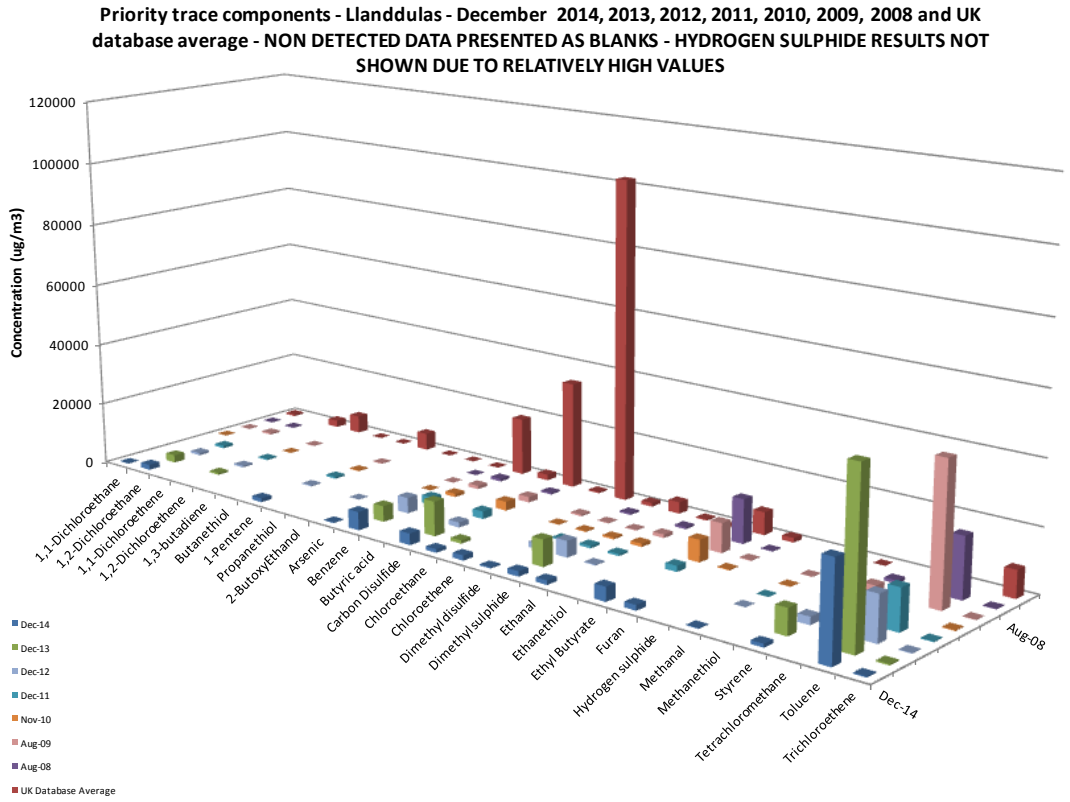
* indicates result is UKAS accredited

< indicates result is below the method limit of detection

The above reported results are the maximum concentrations measured for each parameter in two samples.

The maximum results of the current analyses are compared with historical data and the UK database average in Figure 2.

Figure 2 Historical priority trace component analysis results at Llanddulas



6 NOTES

Sampling of landfill gas was undertaken in accordance with ESG procedure GAS15 and is UKAS accredited under certificate 1015.

Analysis of collected samples was undertaken by ESG's Bretby laboratory. The analytical results which fall within ESG's scope of accreditation under certificate 1015 are identified in Table 3.

The priority component measurements which can be considered to be within the scope of UKAS accreditation are identified in Table 3.

Any interpretations and opinions expressed are outside of the scope of UKAS accreditation.

Contact:

Dr Nick Ford
ESG
Unit D
Bankside Business Park
2 Wilkinson Road
Cirencester
Gloucestershire
GL7 1YT

T: 07768 257628
E: nick.ford@esg.co.uk

LLANDDULAS LANDFILL GAS UTILISATION ENGINE EMISSIONS DATA

Site: **Llanddulas**

Permit: **BP 3734 XX**

Reporting period: **6th February 2014 - 6th February 2015**

Test date: **17th December 2014**

Engine Emission Data

	Species	Method description		Measurement uncertainty (+ or - %)	Average measured emission concentration (mg/Nm3)	LFTGN08 overall uncertainty (+ or - %)	Maximum emission including uncertainty (mg/Nm3)	Minimum emission including uncertainty (mg/Nm3)	Permit emission standard (mg/Nm3)
Engine 1 (A2)	NOx	Chemiluminescence	BS EN 14792	3.0	694	30	902	486	650
	CO	IR	BS EN 15058	3.0	1,217	20	1460	974	1,500
	TVOC	FID	BS EN 12619	4.3	557	40	780	334	1,750

	Species	Method description		Measurement uncertainty (+ or - %)	Average measured emission concentration (mg/Nm3)	LFTGN08 overall uncertainty (+ or - %)	Maximum emission including uncertainty (mg/Nm3)	Minimum emission including uncertainty (mg/Nm3)	Permit emission standard (mg/Nm3)
Engine 2 (A3)	NOx	Chemiluminescence	BS EN 14792	2.9	794	30	1032	556	650
	CO	IR	BS EN 15058	3.0	1,283	20	1540	1026	1,500
	TVOC	FID	BS EN 12619	4.2	624	40	874	374	1,750

	Species	Method description		Measurement uncertainty (+ or - %)	Average measured emission concentration (mg/Nm3)	LFTGN08 overall uncertainty (+ or - %)	Maximum emission including uncertainty (mg/Nm3)	Minimum emission including uncertainty (mg/Nm3)	Permit emission standard (mg/Nm3)
Engine 3 (A4)	NOx	Chemiluminescence	BS EN 14792	3.5	433	30	563	303	650
	CO	IR	BS EN 15058	3.3	1,162	20	1394	930	1,500
	TVOC	FID	BS EN 12619	4.9	389	40	545	233	1,750

Note 1 All data is expressed as mg/Nm3 at 273K, 101.3kPa, dry gas, corrected to an oxygen content of 5%. Average measured emissions concentration is calculated from data collected over a one hour period.

Note 2 The monitoring and reporting were carried out by ESG, an MCERTS accredited contractor. ESG staff attending: C Briggs Team Leader Level 2 with TE1, TE2, TE3 and TE4. M Derbyshire Technician Level 1.

Note 3 Measurement uncertainty is shown. Overall site uncertainty could not be deduced from available data - maximum uncertainty values set out in LFTGN08 have therefore been applied.

Note 4 Emissions from engines #1 and #2 remained within the overall uncertainty limit for NOx and met the standard for CO and TVOC. Emissions from engines #1 and #2 are therefore 'approach to the limit' and deemed compliant.

Note 5 Emissions from engine #3 are compliant with the standard.

Note 6 Flare #2 (lead flare) has run significantly so the emissions have been tested - see separate sheet.

LLANDDULAS FLARE EMISSIONS DATA

Site: **Llanddulas**

Permit: **BP 3734 XX**

6th February 2014 - 6th February 2015

Date: **16th December 2014**

Flare Emission Data

	Species	Method description		Measurement uncertainty (+ or - %)	Average measured emission concentration (mg/Nm3)	LFTGN05 overall uncertainty (+ or - %)	Maximum emission including uncertainty (mg/Nm3)	Minimum emission including uncertainty (mg/Nm3)	Permit emission standard (mg/Nm3)
Flare 2 (A7)	NOx	Chemiluminescence	BS EN 14792	12.7	30.0	30	39.0	21.0	150
	CO	IR	BS EN 15058	24.4	18.0	20	21.6	14.4	50
	TVOC	FID	BS EN 12619	26.6	6.4	40	9.0	3.8	10

Note 1 All data is expressed as mg/Nm3 at 273K, 101.3kPa, dry gas, corrected to an oxygen content of 3%. Average measured emissions concentration is calculated from data collected over a one hour period.

Note 2 The monitoring and reporting were carried out by ESG, an MCERTS accredited contractor. ESG staff attending: C Briggs Team Leader Level 2 with TE1, TE2, TE3 and TE4. M Derbyshire Technician Level 1.

Note 3 Measurement uncertainty is shown. Overall site uncertainty could not be deduced from available data - maximum uncertainty values set out in LFTGN05 have therefore been applied.

Note 4 The emissions have been monitored in line with the EA interim guidance. Emissions have been sampled from a single location via a port towards the top of the flare.

Note 5 Over the past 12 months, flare #2 (which is the lead flare) has run for more than 10% of the time - emissions testing was therefore required.

Note 6 Flare #2 emissions are compliant with the standard.