

Llanddulas Landfill Site

Annual Monitoring Review

February 2017 to January 2018 inclusive



Prepared by P. Birchall
25th April 2018

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1.0 INTRODUCTION

1.1 Background

FCC Environment has, in accordance with Permit condition 4.2.1a, undertaken an annual review of site monitoring data for Llanddulas Landfill collected between the period 1st February 2017 and 31st January 2018. The site is managed under a PPC Permit Ref. BU0800 and Permit Variations CP3332LG and BG3734XX.

Monitoring data has been submitted previously to the Environment Agency, and data represented within the Tables and Appendices of this report focuses on any issues or exceedances highlighted throughout the review, as required, to illustrate trends and support discussion. This report concentrates on those aspects of the monitoring that have been given trigger limits / emission limits by Natural Resources Wales (NRW) and / or other indicators of landfill impact. It does not attempt to present all data collected throughout the review period, but instead assesses whether or not the landfill is having an environmental impact and whether monitoring results are as expected.

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 (Drawing No. 1).

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 site's 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').

In terms of surrounding land use, agricultural grassland and open pasture lie 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 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.

Indicative maps, presented on the Environment Agency’s website, suggest that the floodplain associated with the Afon Dulas is extremely limited. Llanddulas landfill does not lie in any indicative flood plain.

2.0 LANDFILL GAS REVIEW

Routine monitoring for off-site landfill gas was undertaken on a fortnightly basis within 33 perimeter monitoring boreholes and monthly in a further 42 in accordance with the requirements of Table S4.5 of the Site Permit issued in June 2016. Following the new Permit issue, monitoring of perimeter boreholes was reduced in the most recent variation to fortnightly for the boreholes in the higher risk (of migration) area of site on the Eastern boundary and monthly for all perimeter boreholes.

Following on from discussions with NRW in March 2018, a proposal with justifications and risk analysis will be forwarded for consideration on frequency amendments to several boreholes in lower risk areas of site.

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. 2.

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 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. The Landfill Gas Management plan will be reviewed in 2018 in consultation with NRW.

2.1 Landfill Gas Data Summary

There were no breaches of the current methane trigger limit of 1.0% (v/v) throughout the reporting period. The highest methane concentration recorded was 0.2% (v/v) in borehole BH18, which is most likely a result of Gas Analyser drift, which has a CH₄ uncertainty of +/- 0.5% in the lowest gas volume range.

The borehole which, as reported in previous years, had recorded the most breaches was borehole BH40. However, as during 2016, in 2017 there were again no breaches of the trigger level for methane. Should any methane be detected above the limit then gas wells opposite BH40 would be rebalanced to re-establish gas control.

Borehole BH40 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 a previous Improvement Condition, IC13, 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% as detailed in Table S4.5 of the Site Permit, variation V011.

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.

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

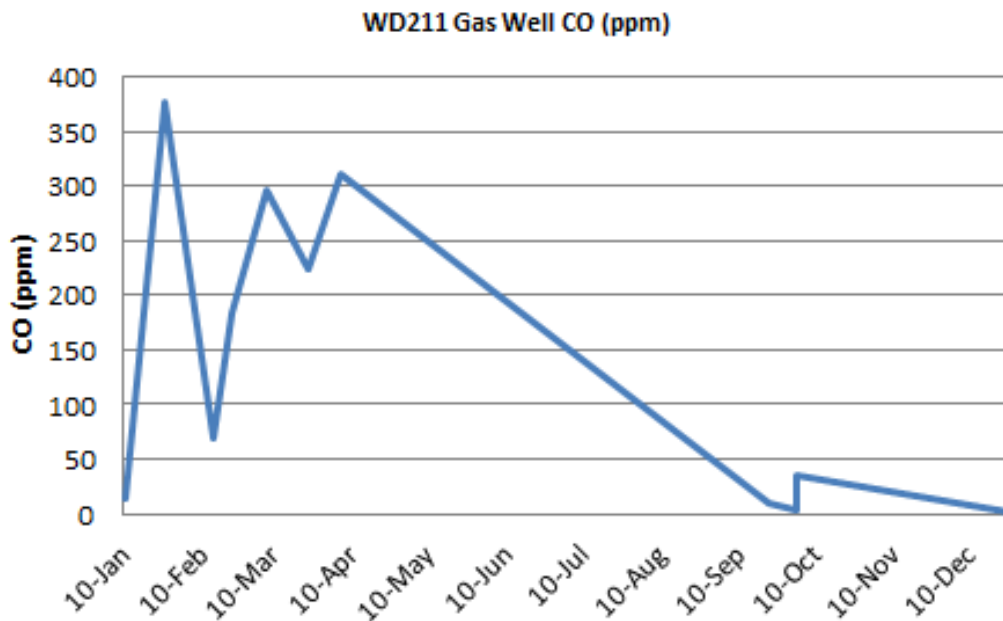
Landfill gas control currently consists of 3 X Jenbacher engines located in the LFG utilisation plant, comprising of 2 x 1000kW engines and 1 x 1065kW engine. In addition there is 1 X 2000m³ high temperature flare and 1 X 1000m³ high temperature flare which can provide sufficient gas control should the engines suffer any downtime.

Landfill gas is currently extracted and utilised at the site from Phases 1, 2, 3 and 3A.

The landfill gas control system was monitored in accordance with Tables S4.1, S4.2 and S4.7 of the site Permit, with a total of 2,907 readings taken throughout the review period. The annual trace gas analysis and engine emissions data are appended to the end of this report. After a review of the data, the following observations can be made.

- The emissions from the combined stack met the standard for NO_x, CO and TVOC as per Table S4.2 of the site permit on Engine 2 and Engine 3. Engine 1 recorded an average measured concentration of 668mg/Nm³ against a permit standard of 650mg/Nm³ but was within the permit limits with the parameters of uncertainty applied. This engine will be monitored closely.
- Compared with the results from last year, some components of trace gas have increased, others have decreased. 1 Pentane, 1,2 Dichloroethane, 1,4 Epoxy 1,3, Butadiene, Benzene, Ethyl butyrate, Toluene, Trichloroethylene, Vinyl chloride monomer and Formaldehyde have all increased during this review period compared with the previous review period.
- 1,2-Dichloroethylene, Carbon disulphide, Dichloromethane, Dimethyl disulphide, Dimethyl sulphide and Acetaldehyde have all decreased during this review period compared with the previous review period.
- Concentrations of Arsenic and Hydrogen Sulphide, reported as 537ug/m³ and 227070ug/m³ respectively during the previous review period, have decreased significantly to 59ug/m³ and 131057ug/m³ during this review period.
- The flares ran significantly less than 10% of the time during the review period, and therefore emissions' testing was not required.
- Average methane concentrations for the gas extraction wells during the review period were 38.66% (v/v), and average carbon dioxide concentrations were 28.41% (v/v). At the gas plant inlet, methane concentrations averaged 43.86% (v/v) and carbon dioxide averaged 32.27% (v/v).
- Carbon monoxide concentrations averaged 4.85ppm for the duration of the review period at the gas extraction wells, and 4.53ppm at the gas plant inlet.
- Oxygen readings at the gas extraction wells averaged 2.71% (v/v) throughout the review period, and recorded an average of 1.50% (v/v) at the gas plant inlet.
- Suctions within the field averaged -27.88mbar for the duration of the review period, and at the gas utilisation plant averaged -71.49mbar.

- The average flow recorded at the gas utilisation plant during 2017 was 939m³/hr and produced an average of approximately 1587kW of exportable energy per month.
- Gas extraction well WD211 exceeded the carbon monoxide assessment of 100ppm on 5 occasions throughout 2017, represented graphically below. As a result, this well was bag sampled by Infinis and laboratory result confirmed at 24ppm. This well continues to be monitored closely and any further approaches to assessment limit will result in repeat bag samples being taken and further investigation.



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.

There were a total of 2,907 readings obtained during the review period and of these, there were 1625 results which showed a total percentage of Carbon Dioxide and Methane of less than 80% (v/v) which was 55.9% of the readings.

A total of 468 results showed O₂ in excess of 5% which was 16.1% of the total readings for 2017. 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.

To summarise, the current landfill gas infrastructure is deemed to be adequate for the control of emissions on site, although with decreasing waste inputs with reducing biodegradable content gas volumes are seen to be declining over previous review periods.

GROUNDWATER REVIEW

3.1 Groundwater Levels

Table S4.10 of the site permit, requires that groundwater levels are recorded on a quarterly basis within the up, down and cross gradient groundwater monitoring points.

Summaries of the available groundwater level data are presented below.

Borehole	No. of recordings	Minimum	Maximum	Average	Range
GWBH01	4	46.22	53.65	49.46	7.43
GWBH02	4	46.45	48.31	47.66	1.86
GWBH04	4	38.76	45.72	41.49	6.96
GWBH06R	4	30.02	30.83	30.26	0.81
GWBH07	4	33.31	35.15	34.29	1.84
GWBH22	4	25.88	31.37	27.58	5.49
GWBH23	4	40.02	40.05	40.04	0.03
GWBH24	4	11.94	12.62	12.22	0.68
GWBH25	4	35.50	39.71	37.05	4.21
GWBH26B	4	31.38	31.55	31.46	0.17
GWBH27B	4	15.53	16.36	15.86	0.83
GWBH28	4	30.52	31.17	30.78	0.65
GWBH32	4	36.21	40.84	38.14	4.63
GWBH33	4	45.66	51.88	48.77	6.22
GWBH34	4	46.52	47.13	46.86	0.61
GWBH35	4	46.24	48.39	47.59	2.15
GWBH36	4	37.56	65.52	50.31	27.96

The groundwater level beneath the site varied between 11.94mAOD in borehole GWBH24 (downstream of groundwater flow across site) located in Llanddulas village to the North-East of site and 65.52mAOD in GWBH36 on the Eastern boundary. The boreholes displaying the minimum and maximum AOD levels are the same as in previous years with a minimum value close to previous years, yet the maximum value in GWBH36 nearly 15m below that of the previous year.

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 AOD groundwater levels within the individual boreholes varied from just 0.03m in GWBH23 to a maximum of 27.96m 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.

3.2 Groundwater Quality

Groundwater samples are scheduled to be taken in accordance with the requirements of Table S4.4 and S4.10 of the Site Permit.

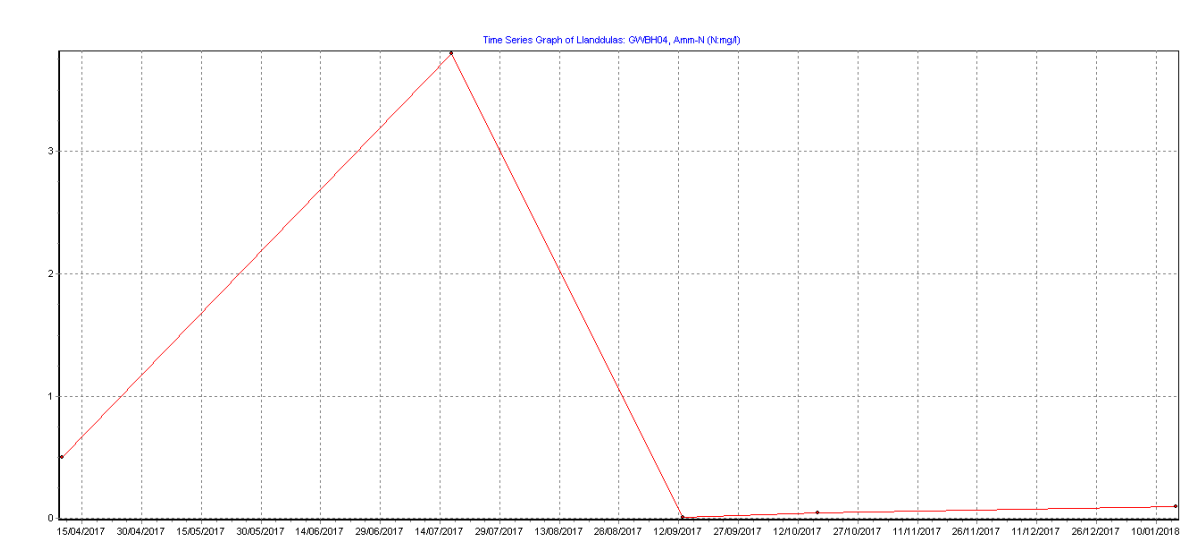
Table S4.4 of the site permit variation contains borehole specific trigger levels for groundwater quality which are detailed below.

Trigger levels for emissions into groundwater			
Boreholes GWBH4, GWBH7, GWBH23, GWBH25, GWBH34, GWBH35 & GWBH36			
Parameter	Limit	Parameter	Limit
Ammoniacal-N	1mg/l	Potassium	12mg/l
Chloride	250mg/l	Phenols	0.5ug/l
Mercury	0.01ug/l	Tributyl Tin	0.001ug/l
Mecoprop	0.04ug/l	Trifuralin	0.01ug/l

The following observations can be made in relation to groundwater quality:

There were no breaches of the site permit specific trigger limit for Chloride, Mercury, Mecoprop or Trifuralin throughout the review period. Chloride concentrations ranged from 12mg/l in borehole GWBH02 to 119mg/l in borehole GWBH24, recording an average across all boreholes of 43.37mg/l.

Ammoniacal Nitrogen concentrations were all within limits barring a result of 3.8mg/l in GWBH04 during July 2017 monitoring. There were no further breaches in this monitoring location throughout the remainder of the review period, illustrated graphically below;

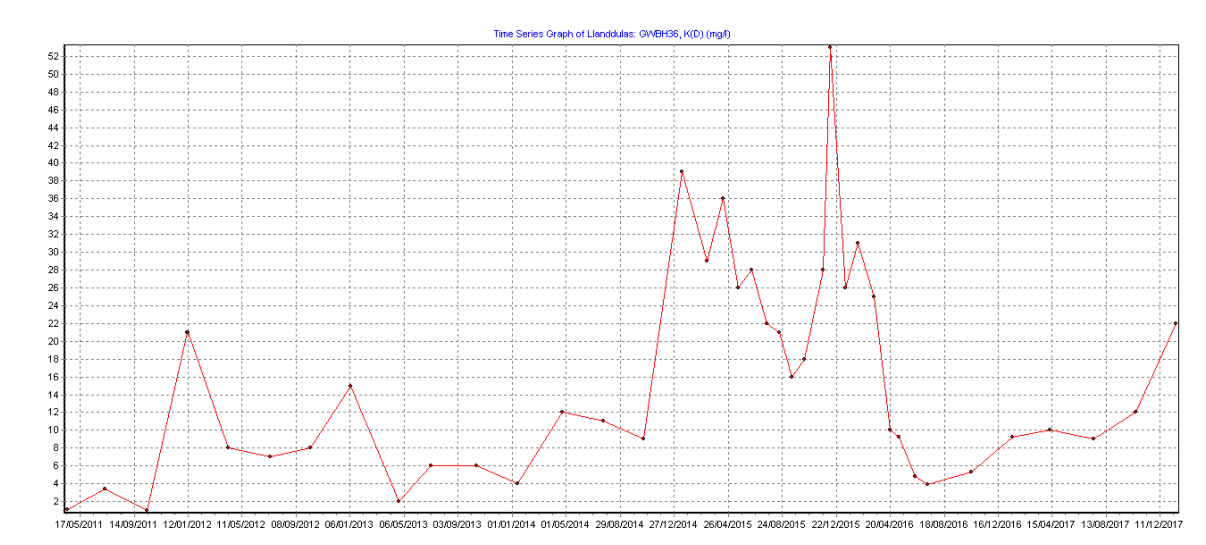


A single Mercury exceedance was recorded during the review period in borehole GWBH34 during October monitoring recording a result of 0.02ug/l against a trigger limit of 0.01ug/l. All remaining results were reported below the limit of detection of <0.01ug/l.

There have been historic breaches of the potassium limit in borehole GWBH36, and during the review period a concentration of 12mg/l was observed in October, the same value as the compliance limit and in the following quarter a concentration of 22mg/l was recorded. All other determinands and key pollutant indicators have not shown elevated levels or upward trends. The average ammoniacal nitrogen concentration during the review period was recorded as 0.06mg/l with a

maximum concentration of 0.17mg/l recorded. Chloride averaged 60.75mg/l with a maximum concentration of 65mg/l observed. This borehole is located upstream of the Dulas Valley Spring which has shown no deterioration in water quality during the last 24 months.

A review of the previous 10 years results would indicate historical elevated spikes during the winter months



During the review period, there were a total of 3 phenol exceedances recorded in boreholes GWBH07, GWBH33 & GWBH34. GWBH07 and GWBH34 recorded concentrations of 0.7ug/l and 0.6ug/l respectively in April 2017, and GWBH33 recorded a concentration of 1ug/l in July 2017. All results obtained in the boreholes after the months in which they breached were recorded as below the limit of detection. The highest concentrations recorded in GWBH33 & GWBH34 are both to the South and upstream of the engineered landfill cells which may indicate an offsite influence.

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 elevated results observed 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 monthly basis in accordance with Table S4.1 of the most recent Site Permit Variation (June 2016). Leachate samples are collected on a quarterly basis as agreed in writing (April 2013) with Natural Resources Wales.

Locations of the monitoring points can be found on Drawing 2, attached with this report.

The leachate samples are analysed for a range of determinands as specified in Table S4.8 of the Site Permit.

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. During the review period, all chambers recorded levels below the 2m trigger limit attaining a 100% compliance result. Each leachate chamber is checked weekly by site staff to ensure correct pumping operation and all leachate generated was treated via the on-site LTP.

4.2 Leachate Quality

The leachate quality was scheduled to be monitored in 7 Leachate Collection Points (across phases 1, 2, 3 and 3A) and compared to assessment limits set in the HRA (summarised below).

Parameter	Limit
Ammoniacal-N	3500mg/l
Chloride	3900mg/l
Lead	120mg/l

It should be noted that leachate composition will vary with the age and moisture content of the waste.

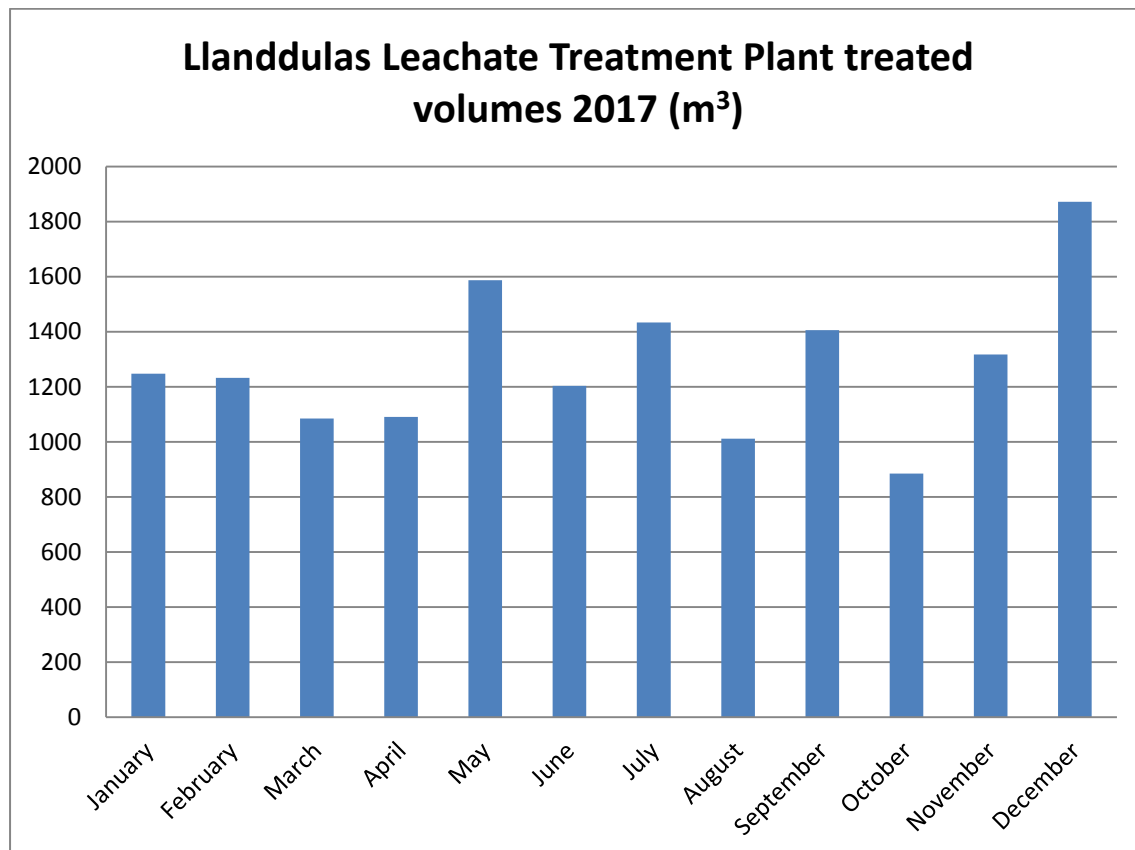
After a review of the leachate quality data, the following comments can be made:

- Ammoniacal-N concentrations were recorded below assessment level for the duration of the review period, with the highest concentration of 2067.5mg/l detected in LCP3A, the newest chamber on site. A minimum concentration of 350mg/l recorded in chamber LCP1AR represents the oldest chamber on site. An average concentration of 1405mg/l was recorded throughout the review period.
- Chloride concentrations were consistently below the assessment level throughout the monitoring period, with a maximum concentration of 2990mg/l recorded in chamber LCP2Br2, a minimum concentration of 646.67mg/l in chamber LCP1AR, and an average concentration of 2185mg/l recorded throughout the review period.
- Lead was only recorded once throughout the review period as 0.036mg/l in chamber LCP3A, with all other results being below the limit of detection.
- The leachate quality remains as modelled and appears to be typical of a landfill site that received a variety of waste types.

4.3 Leachate Management

A total of 39,725m³ of leachate was treated at the on-site treatment plant during 2017, approximately 2,500m³ less than in 2016. 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 treatment 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 during 2017.



5.0 SURFACE WATER REVIEW

Surface water is scheduled to be sampled in accordance with Table S4.3 and S4.9 of the Site Permit.

There were no emissions through the consented discharge point W1 for the duration of the review period, although this location was sampled on a monthly basis.

Concentrations of ammoniacal nitrogen in the Dulas River and Dulas Valley Spring sampling locations ranged from <0.01mg/l to 0.03mg/l.

Chloride concentrations averaged 29.79mg/l in all sampling locations, with a maximum concentration of 40.13 recorded from the Dulas Spring. These concentrations are lower than the previous review period and significantly below the UK DWS limit of 250mg/l.

Results of Mercury were reported at the limit of detection in the Dulas Spring of 0.000008mg/l, and lead was not reported above the limit of detection throughout the review period.

Mecoprop concentrations averaged 0.0125ug/l for the 3 surface water sampling locations, with a maximum concentration of 0.03ug/l recorded in the Dulas Valley Spring, well below the UKDWS of 0.1ug/l.

To summarise, there have been no emissions of site derived surface water run off through the W1 discharge point during the review period. All other sampling locations have shown no evidence to suggest any kind of environmental impact on the localised water courses that could be attributed to landfilling activities at Llanddulas. After discussions with NRW, a proposal to amend the frequency of sampling at Llanddulas Valley Spring will shortly be sent for consideration.

6.0 EMISSIONS TO AIR

6.1 Flux Box/FID Surveys

The Site Permit states that the Operator shall ensure that all appropriate measures are taken to prevent or where that is not practicable to reduce fugitive emissions to air from:

- open surfaces, unfilled, operational and filled landfill surfaces;
- storage areas
- buildings
- pipes, valves and other transfer systems.

Emissions to air are monitored in accordance with the requirements of Tables S4.6 & S4.11 of the Site Permit. A monthly walkover survey of the landfill and all infrastructure is carried out on a monthly basis using a TDL-500 Gazomat Inspectra Laser methane leak detector machine. Details of any exceedances found are reported to NRW on a now monthly basis and included in the quarterly reports using the TDL breach tracker. Any exceedances of 1000ppm at any point of infrastructure are remediated the same month via co-ordination between FCC and Infinis, with action plans developed and closed out accordingly.

A monthly perimeter survey of the site is also completed using an FID machine, of which no breaches of assessment limits have been seen throughout the review period.

Monthly Jerome surveys, concentrating specifically on detection of hydrogen sulphide, were conducted on a monthly basis throughout the review period, again recording no concentrations approaching any assessment limit. Recent discussions with NRW have seen this requirement moved to a quarterly frequency on a trial basis.

A full site flux box survey will be carried out during 2018 and will be included in the relevant quarterly / annual reporting to NRW.

APPENDIX 1

INFINIS ENERGY SERVICES LIMITED

Periodic monitoring of raw landfill gas

Llanddulas Landfill Site

Report LN013941-TG

Date 19 December 2017

Issue 1



PERIODIC MONITORING OF RAW LANDFILL GAS

LLANDDULAS LANDFILL SITE

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Issue history

Issue	Date	Approved
LN013941-TG, 1	19 December 2017	N Ford
First issue		N Ford

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Whilst every effort has been made to ensure the accuracy of the data supplied and any analysis interpretation derived from it, the possibility exists of variations in the ground and groundwater conditions around and between the exploratory positions. No liability can be accepted for any such variations in these conditions. Furthermore, any recommendations are specific to the development as detailed in this Report and no liability will be accepted should they be used for the design of alternative schemes without prior consultant with SOCOTEC UK Limited

1 Introduction

Infinis Energy Services Limited (Infinis) contracted SOCOTEC UK Limited (SOCOTEC) 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 (LFGTGN04, Table 1.1) specified in Environment Agency guidance (Guidance for monitoring trace components in landfill gas – LFGTGN04 v3.0, 2010). The test methodology should be in accordance with that specified within LFGTGN04.

Based on LFGTGN04 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

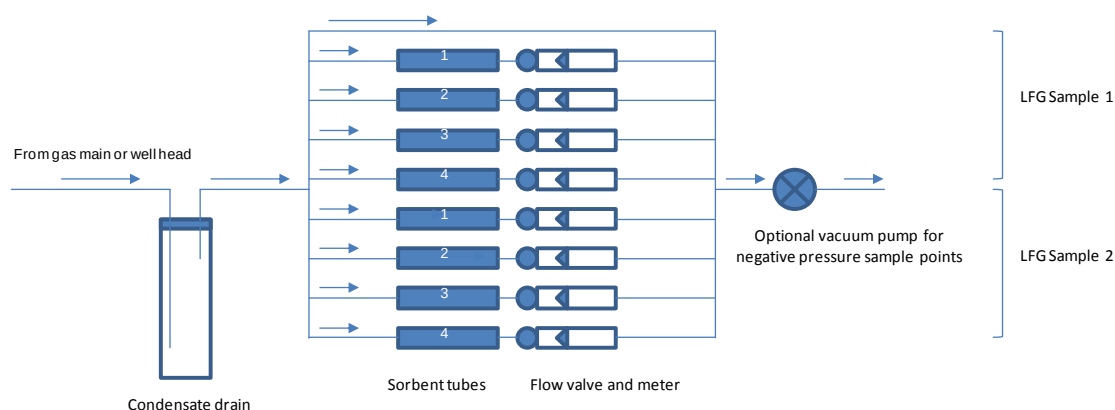
ICP-MS – inductively couple plasma/mass spectrometry

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 LFGTGN04 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	5 December 2017	Site	Llanddulas landfill site
Ambient temperature	12 °C	Atmospheric pressure	103.2 kPa
Monitoring organisation	SOCOTEC UKAS 1015	Analytical laboratory	SOCOTEC UKAS 1015
Location of sampling point	Gas main to compound After blower	Area of influence of collection system sampled	All
Type of sample point	¼" Tefen	Temperature of gas	14°C
Pressure at sample point	306 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 %	46.2
Carbon dioxide %	32.5
Oxygen %	1.3
Nitrogen (by difference) %	20
Hydrogen sulphide ppmv	200
Carbon monoxide ppmv	10

*carbon monoxide is measured with a hydrogen sulphide filter in the sampling line.

Preliminary bulk gas measurements were undertaken using a GFM 436 electrochemical cell analyser (no 12704. 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 ($\mu\text{g}/\text{m}^3$,STP)
1 Pentene		512
1,1-Dichloroethane		<31
1,1-Dichloroethylene		<46
1,2-Dichloroethane		307
1,2-Dichloroethylene		666
1,3-Butadiene		<36
1,4 epoxy 1,3 butadiene		1331
1-Propanethiol		<102
2-butoxyethanol		<102
Benzene		4915
Butyric acid		<205
Carbon disulphide		2611
Carbon tetrachloride		<51
Chloroethane		<51
Dichloromethane		461
Dimethyl disulphide		102
Dimethyl sulphide		1024
Ethyl butyrate		205
Ethyl mercaptan		<154
Methyl mercaptan		<512
N-Butyl mercaptan		<154
Styrene		<51
Toluene		12799
Trichloroethylene		102
Vinyl chloride monomer		512
Arsenic		59
Hydrogen sulphide		131057
Acetaldehyde	*	102
Formaldehyde	*	205

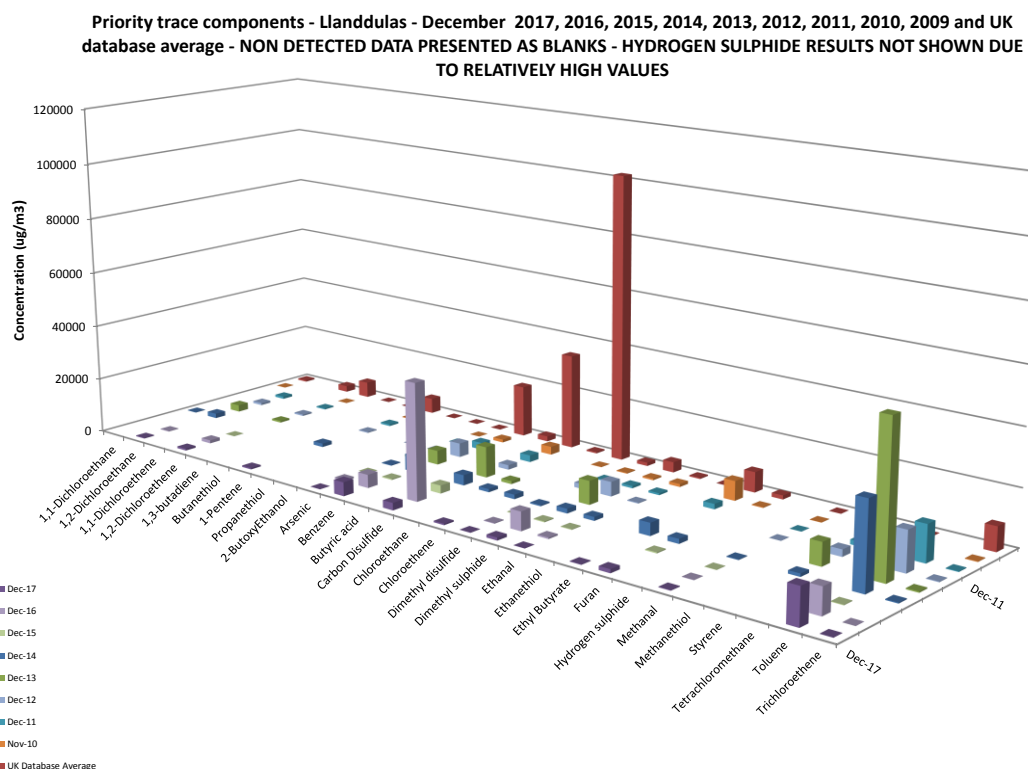
* indicates result is UKAS accredited

< 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 Socotec procedure GAS15 and is UKAS accredited under certificate 1015.

Analysis of collected samples was undertaken by SOCOTEC's Bretby laboratory. The analytical results which fall within SOCOTEC'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:

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Site: Llanddulas

Permit: BP 3734 XX

Reporting period: 6th February 2017 - 6th February 2018

Test date: 05-Dec-17

Engine Emission Data

Engine 1 (A2)	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)
	NOx	Chemiluminescence	BS EN 14792	3.5	668	30	868	468	650
	CO	IR	BS EN 15058	3.0	1,261	20	1513	1009	1,500
	TVOC	FID	BS EN 12619	3.0	1,234	40	1728	740	1,750

Engine 2 (A3)	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)
	NOx	Chemiluminescence	BS EN 14792	4.2	529	30	688	370	650
	CO	IR	BS EN 15058	3.3	1,112	20	1334	890	1,500
	TVOC	FID	BS EN 12619	3.0	1,428	40	1999	857	1,750

Engine 3 (A4)	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)
	NOx	Chemiluminescence	BS EN 14792	na	see note 4	30	na	na	650
	CO	IR	BS EN 15058	na	see note 4	20	na	na	1,500
	TVOC	FID	BS EN 12619	na	see note 4	40	na	na	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.

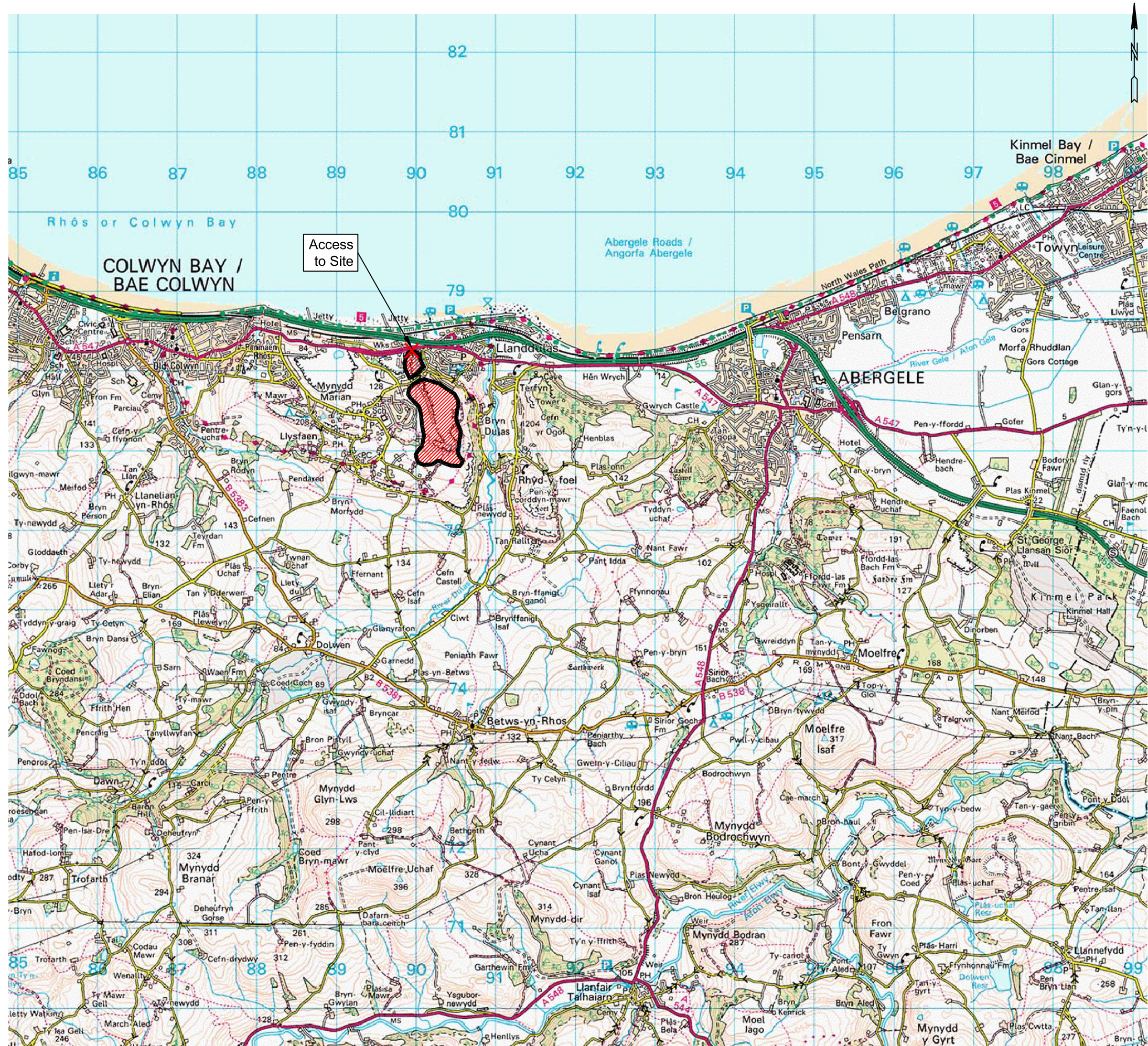
Note 3 Measurement uncertainty is shown. Overall site uncertainty could not be deduced from available data - maximum uncertainty values set out in LFTGN08 have therefore been applied.

Note 4 Engine 3 (A4) was removed from site in January 2016. Available landfill gas is normally controlled by the two remaining engines.

Note 5 Measured parameters on both engines met permit requirements with the exception of nitrogen oxides on Engine 1. The average measured concentration fell within the permitted range once measurement uncertainty was taken into account.

Note 6 Neither flare has run for more than 10% of the time over the previous 12 months, therefore testing was not required (standby flares).

DRAWING 1



Llanddulas Landfill Site
Abergele
Clwyd
LL22 8PH
Tel: 01492 518248

5km east of Colwyn Bay, North Wales
Site centred N.G.R. SH903776

REVISIONS				
No	Description	By	Chk'd	Date
A	Titlebox updated.	CMD	CJM	07.07.04

Project: **LLANDDULAS LANDFILL SITE**

Title: **Site Location Plan**

Drawn By	JRP	Date	21.06.01
Chk'd By	CJM	Date	21.06.01
Scale 1:	50,000	Sheet Size	A3

Waste Recycling Group
3 Sidings Court
White Rose Way
Doncaster
DN4 5NU



Drawing No
122T020A

DRAWING 2

