Pen-Y-Bont Landfill Site

Gas Management Plan

Pen-Y-Bont Landfill Site
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Chirk
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Version 5: April 2016

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1.0 INTRODUCTION

1.1 Report Context

Pen-y-Bont landfill operates under a Landfill Gas Management Plan which formed part of the original landfill gas risk assessment (Encia Ref:WR4446/GRA), contained in the Pen-Y-Bont PPC Permit application documents, dated November 2004, and subsequent revisions contained in Improvement Condition 1.4.1.9 of the site Permit (Ref GP3830BG). This document comprises a review, update and re-template of the original Gas Management Plan.

1.2 Landfill Gas Management Plan

Defined within the Agency publication LFTGN 03, 'Guidance on the management of landfill gas', the Gas Management Plan:

'…provides a framework for the management of landfill gas based on the site characteristics and the nature and extent of the gas control system…'

Key elements of the Gas Management Plan include the landfill gas risk assessment, specification of control measures and definition of operational procedures, monitoring plan, action plan and a completion and aftercare plan. The following report details each of these elements as applied to Pen-y-Bont Landfill.

1.3 Quantities, Types of Waste, Rates and Methods of Filling

Waste inputs are declining year on year at Pen-Y-Bont with approximately 80,000 tonnes landfilled in 2013. This consisted of 25% construction/demolition waste, 11% from waste management or water treatment processes and 63% municipal waste. The balance was made up of wastes from human/animal health care & other sources.

The waste is placed in layers and compacted in a uniform manner so as to produce a working face not exceeding 2.0 metres in height. Any difficult or malodorous waste will be placed below the working face so that it can be progressively covered. Cover material (which consists of frag and inert material) will be placed at the end of each day to prevent escape of litter or odour and to prevent fly infestation or scavenging by birds or animals.

1.4 Estimated Quantity of Gas Extraction

The volume of landfill gas utilized by the engines and flare is continually monitored with the information available to Natural Resources Wales upon request.

2.0 LANDFILL GAS RISK ASSESSMENT

The range and quantities of wastes deposited at the site can be expected to generate landfill gas. The anaerobic degradation of biodegradable wastes results in the production of landfill gas; a mixture of methane and carbon dioxide in approximately 60:40 proportions with trace quantities of a number of organic gases.

A detailed assessment of the generation of landfill gas and associated risk assessment was completed as part of the PPC Permit application process (Volume 2 Section D) and is detailed within the following Report:

- Encia Consulting Ltd (Nov 2004); Landfill Gas Risk Assessment – Pen-Y-Bont Landfill Site. Report Ref :WR4446/GRA

The assessment considered the potential landfill gas generation over the lifetime of the site, potential fugitive emissions from the landfill surface and sides, potential combustion emissions from the engines and flare, vegetation stress and the global warming and ozone depletion potentials of the landfill.

In accordance with Agency guidance LFTGN 03, this risk assessment will be updated and reviewed on a regular basis. The risk assessment forms the basis upon which each aspect of the Gas Management Plan is defined, and as such changes to the risk assessment will be subsequently incorporated into the Gas Management Plan.

3.0 LANDFILL GAS CONTROL MEASURES

A scheme for the monitoring and control of landfill gas within the performance specifications detailed in LFTGN 03 is set out below. It is anticipated that within the period of operation of the site, changes in the understanding of the technology will occur, which will be reflected in amendments to the advice given to the industry or the regulations issued by Government. This statement will be periodically reviewed to reflect such changes.

Gas management and control will be achieved by:

- the operation of an internal gas monitoring system;
- the operation of an external gas monitoring system;
- a permanent active gas extraction system that has been installed across the site and currently includes one high temperature flare and 2 gas engines;
- the low permeability lining system installed across the base and the perimeter slopes of the Site.

The Landfill Gas Management at the site is undertaken by an outsourced gas operator; Infinis PLC. Infinis manage both the landfill gas collection infrastructure and the gas utilisation compound and operate through a Service Level Agreement which exists between FCC Environment and Infinis Limited and is dated July 16th, 2006. The gas utilisation plant is regulated by the landfill permit (Ref GP3830BG) as a listed activity for the gas engines and as a directly associated activity for the flaring of landfill gas as defined in table S4.2 of the permit variation (Ref PP3032LN). The gas utilisation plant is therefore regulated by the landfill permit.

An active gas control system is required for the Site due to the waste types and quantities that are deposited. The active landfill gas extraction system connects the gas extraction wells to the landfill gas management compound by the use of pipe work and manifolds. The layout of the current landfill gas collection system is shown on Drawing 1

3.1 Containment System

Details of the landfill containment system are presented within the following Report:

- Golder Associates (March 2009); Hydrogeological Risk Assessment – Pen-Y-Bont Landfill Site. Report Ref :08514290228.500

3.2 Collection System/Landfill Gas Extraction

Landfill gas (LFG) control is based on an active gas extraction system incorporating a Gas Utilisation Plant (GUP).
The gas collected is utilised within the GUP by 2 landfill gas engines. In the event of engine maintenance or shutdown, residual gas is flared.

Gas wells and extraction infrastructure are installed according to Construction Quality Assurance (CQA) principles and a CQA plan is followed for each phase of the management. Gas extraction wells installed across the site consist of a combination of horizontal, vertical built-up and drilled wells. All types of extraction well are connected to a gas extraction gas main.

Optimal well spacing has been defined through site-based knowledge and in line with original Environment Agency (EA) guidance, Industry Codes of Practice and operational experience. Gas extraction wells have been spaced with a radius of influence to ensure that the landfill gas is drawn back towards the centre of the site, to minimise the risk of oxygen being drawn into the system from outside the landfill. The landfill gas extraction wells are typically situated with a nominal spacing of approximately 30m and a maximum spacing of 40m. The lateral zone of influence and depth coverage of the wells is reviewed as part of the gas well condition survey carried out twice per year by the gas contractor and the results, along with recommendations for additional or enhanced infrastructure forwarded to FCC. Once received from the gas contractor, FCC will assess and approve any amendments to the gas system infrastructure that may be required to enhance gas collection.

Where open waste flanks are not sealed, shallow pin wells have been installed along flanks to control fugitive emissions. These can be operated at lower extraction rates to reduce emissions and reduce the possibility of oxygen ingress.

The current gas field infrastructure is shown on Drawing 1, attached with this management plan.
Vertical wells are drilled into the waste and lined with flush threaded or butt-fused sections of polyethylene (PE). The vertical wells are retro drilled into the waste to no more than 80% of the depth of the waste or a minimum of three metre stand-off from the base to ensure there is no interference with the basal lining system.

Gas extraction pipework consists of various sizes typically ranging from 63mm outside diameter to 355mm. The majority of well heads are located above ground and have their own valves. Where wells are buried, a valve is fitted above ground. The site ring main comprises 355mm diameter gas collection mains along the boundary of site connecting to the gas compound.
Where practicable pipework falls will adhere to the following;

1 in 100 – where the pipe is laid on stable ground and the fall and gas flow are in the same direction.
1 in 50 – where the pipe is laid on stable ground and the fall and gas flow are in opposite directions
1 in 50 – where the pipe is laid on landfilled waste and the fall and gas flow are in the same direction.
1 in 25 – where the pipe is laid on landfilled waste and the fall and gas flow are in opposite directions.

Allowances to the above may be required within the difficult and changing environment of the operational area.

3.2.1 Condensate Management

Condensate management within the gas system comprises of a series of 6 pumped knock-out pots. These are MDPE vessels installed at natural or engineered low points within the gas main for the collection of condensate. Pneumatic pumps are installed in each pot to allow the condensate to be pumped back into the landfill.
The efficiency of this system is checked monthly by the gas contractor, including assessments of pipe falls for any deficiencies that could lead to condensate traps, (reported to FCC) and any improvements carried out or faults rectified without delay.
The fall of pipes in the operational area is more thoroughly checked due to the irregular profile of the ground on which the pipe is laid.

3.2.2 Inspection, maintenance and servicing regime

Landfill gas extraction wells are inspected during each monitoring round as well as during a weekly visual inspection to ensure their integrity. Also, six monthly gas well condition surveys are undertaken with liquid levels within the wells measured using an electronic dip meter. Where the condition survey results suggest further investigation is necessary (e.g. blockage, uncertain results) then rodding of the well may be undertaken or CCTV can be utilised. Where accurate drill logs do not exist detailing the extent of perforated well casing then again, CCTV can be undertaken.
A combination of drill log information, up to date survey data and liquid levels can be used to ascertain the percentage of perforations available in the well. This, in combination with results of monthly fugitive emissions surveys can be used to determine if pumping of liquid from certain gas wells may be of benefit. Due to the environmental impact of unnecessarily removing, transporting and treating leachate, dewatering of gas wells will only be undertaken as a temporary measure to prevent or resolve a permit breach.

If during any of these surveys further remedial works are identified, which may include (but not be limited to) re-sealing wells, remediating damaged wells, decommissioning redundant wells, replacing wells, actions will be taken to progress these works as soon as is reasonably practicable.
If the works are extensive they shall be carried out in accordance with Agency guidance LFTGN 03, Construction Quality Assurance (CQA). Commissioning data for gas wells installed by Infinis is contained within Construction Quality Assurance reports.

3.2.3 Permanent gas extraction

See section 3.2.

3.2.4 Utilisation, flaring and treatment options

See section 4.1

4.0 OPERATIONAL PROCEDURES

4.1 Routine operation and monitoring

Landfill gas extraction wells (and strategic points as appropriate) will be monitored in accordance with Table 1 below and in line with the typical accuracy range of the gas analyser used on site.

Table 1: In-waste landfill gas monitoring frequencies

Determinand	Monitoring Frequency	Typical Accuracies
Methane (CH_4) (%)	monthly	%v/v ±3
Carbon Dioxide (CO_2) (%)	monthly	%v/v ±3
Oxygen (O_2) (%)	monthly	%v/v ±1
Atmospheric Pressure (mb)	monthly	±5mb

A dedicated hydrogen sulphide (H_2S) monitoring sweep is typically completed for all gas wells at a six monthly frequency.

Carbon Monoxide (CO) is recorded using the infra-red gas analyser; however, due to the potential for interference between substances gas bag samples will be taken for any internal gas wells which breach 100ppm CO (with an H2S filter in place) as indicated by the hand-held instrument.

Trends will be reviewed monthly against the Environmental Permit (EP) trigger levels and agreed Gas Operating Parameters (GOPs) for the site. Extraction rates will be reviewed and adjusted at a frequency of at least once per month or more frequently if required.

Field based investigations are instigated where observed values are outside of these parameters to assist with fault-finding. Monitoring will be completed at one or all of the strategic points located in key locations along the gas extraction main pipeline.

Landfill gas extraction wells are inspected during each monitoring round to ensure integrity. Any anomalies identified are reported to the appropriate site representative for rectification.

Long term trends of oxygen concentration, methane concentration, carbon dioxide concentration, power output and extraction vacuum are recorded in the engine management system. The regional gas engineer / technician will review these trends monthly against the following typical values;

- Oxygen (O2) 0.1 – 3 % v/v
- Methane (CH4) 32 - 45 % v/v
- Carbon dioxide (CO2) 35 – 40 % v/v
- Applied vacuum 75 - 100 mBar
- Electrical output 3.4MW

Field-based investigations are instigated where observed values are outside of these optimal ranges. Monitoring will be completed at one or all of the strategic monitoring

points located in key locations along the gas extraction main pipe line. Monitoring in this manner enables rapid identification and adjustment of any under-performing well(s) and/or pipes.

Data recorded at the gas well heads, is assessed against the gas quality criteria specified in Table S4.7 of the site Permit, and thorough assessments and investigations are completed. All remedial works are recorded and tracked on the Infinis Maximo system.

4.2 Extraction Rate Maximisation

Maximisation of gas extraction from the landfill is a key aspect of gas plant operations with environmental drivers ensuring optimisation of this task. These environmental drivers are primarily driven by parameters specified within the site permit and as agreed by the site manager and Infinis limited to maximise extraction rates whilst ensuring environmental control.

4.3 Limiting of Uncapped Areas

Throughout the operation of the Site, consideration will be given to the minimisation of uncapped areas as filling progresses. In addition, gas extraction infrastructure will be installed progressively within active areas of the Site prior to the capping of the area with the objective of maximising gas extraction and minimising surface emissions.

5.0 MONITORING PLAN

The following monitoring plan has been developed in accordance with NRW guidance (LFTGN03) and covers the following aspects of gas monitoring at the site as required by schedule 4 of the site permit variation:

- Annual surface emissions monitoring;
- Monthly internal waste monitoring;
- Annual trace gas component monitoring;
- Monthly perimeter borehole monitoring (subsurface emissions);
- Annual gas flare (If required) and engine emissions monitoring.

5.1 SURFACE EMISSIONS MONITORING

In accordance with LFTGN03 and LFTGN07 and Permit Table S4.6, a flux box monitoring survey to determine surface emissions through capped and temporarily capped areas will be undertaken on an annual basis using the approach described in Section 5.1.1. If the cap has previously been shown to be compliant, a detailed walkover survey will be acceptable for the annual review, in accordance with Table S4.6 of the permit variation. Walkover surveys will be completed, using the approach detailed in Section 5.1.2.

5.1.1 Site Walkover Survey

The site walkover survey is undertaken in accordance with the Landfill Monitoring Procedures provided in Appendix C but shall in general follow the methodology below:

1. Background data relating to the site shall be provided by FCC to the allocated contractor.
2. The sites major characteristics will be identified at the outset and the site divided into a number of zones dependant on cap properties.
3. Prior to the walkover survey any major faults in the gas management system will be identified and rectified to ensure that the survey is being undertaken under normal operating conditions.
4. The general weather conditions will be noted including barometric pressure, recent precipitation, wind speed and direction.
5. The walkover survey will be conducted with a Flame Ionisation Detector (FID) or similar. The sample probe will be held as close to the surface (<5cm) as possible. The air at head height will be periodically sampled to enable the distinction of surface emissions from the landfill from other potential upwind sources. The site will be traversed in a systematic manner, typically along regular lines approximately 50m apart. In practice since the survey will encompass all protrusions through the cap the path between these locations

will result in the majority of the cap being surveyed with only side flanks or areas where gas extraction wells are not located being subject to a systematic survey. Where high concentrations of methane are detected, the survey will deviate to locate the likely source of the emission. Care will be taken in the vicinity of heavy plant, as the un-burnt hydrocarbons in diesel exhausts will register on the FID and give potentially misleading results. LFTGN07 notes that the FID will respond to a number of hydrocarbon gases so the instrument will usually overestimate the methane concentration. However, in landfill gas the dominant hydrocarbon is methane, so the FID reading is regarded as an adequate measurement of methane concentration. The following control concentrations are used to ensure that the methane flux is likely to be well below the acceptable limit:

- Permanently capped zone = 10ppm
- Temporarily capped zone = 50ppm

6. In addition to the full cap survey it will also identify:
    - Surface cracking or fissures;
    - Stressed vegetation;
    - Interfaces between capped zones;
    - Landfill edges and side slopes;
    - Gas and Leachate Wells
7. Where the survey identifies cap locations with particularly high emissions the location will be recorded and described in relation to a fixed point on the cap together with the GPS reference to allow identification for subsequent remedial work. Discrete features such as gas or leachate wells emitting substantial amounts of gas will be recorded and reported.
8. The site survey and subsequent remedial action will continue until the concentration of methane in air is:
    - Less than 50 ppmv immediately above the surface of the cap.
    - Less than 1000 ppmv close to any discrete features.

5.1.2 Flux Box Survey

Following the initial site walkover phase, and if required by the criteria specified in Table S4.6 of the site permit, a flux box survey will be carried out, where necessary, according to the following methodology:

1. The site walkover results will be used to define those zones of the site that require a flux box survey;
2. An appropriate number of sample points and average spacing will be determined using the methodology outlined in Section 5.5 of LFTGN07;
3. The survey will be carried out when the emissions are representative of normal operation of the gas management system; and

4. The survey will be carried out under appropriate meteorological conditions as summarised below:
    - During periods of falling or low pressure;
    - Not during and following periods of heavy rain;
    - Not during periods of frost.

The flux box survey will be designed based on information gathered during walkover surveys already conducted. Surveys will be undertaken following methodology outlines in Chapter 6, *measuring emissions using a flux box'* contained within LFTGN07. Data will be processed and a mass emission rate for each zone calculated.

Emissions data will be assessed and the average flux of methane from the surface of the cap in each zone will be compared to the following emissions standards set by the Agency:

- Permanently capped zone: 0.001 mg CH_4/m^2/second; and
- Temporary capped zone: 0.1 mg CH_4/m^2/second.

5.1.3 Reporting of Results

The results of annual walkover surveys will be provided to the NRW in the format agreed with the Natural Resources Wales. The initial submission and a final report detailing the process, method and results will be issued to the NRW as an attachment to the annual monitoring review, including:

- Meteorological details during the survey
- Results of the structures survey, walkover survey and flux box.
- Remediative actions planned, undertaken and results of retested points.

5.1.4 Remediation

The areas identified by the walkover survey as being non-compliant will be remediated as soon as practicable and within timescales agreed with NRW. Remediation will be conducted by an approved contractor as directed by FCC. Remediation will be conducted until resample results indicate the breach-point is compliant.

5.1.5 Summary

Surface emission monitoring will incorporate:

- An initial site FID walkover survey to investigate cracks, fissures, dieback etc and all on-waste structures at the well base and well head will be conducted.
- A cycle of remediation and re-sampling until all points become compliant.
- A flux-box survey if required by the criteria specified in Table S4.6 of the site Permit.
- A final report to be issued to NRW to be contained within the annual monitoring review.

5.2 INTERNAL WASTE MONITORING

Landfill gas extraction wells will be used as monitoring points to determine gas concentrations within the waste mass. Monitoring is currently occurring across the site and will commence in new wells as soon as practicable following installation and commissioning of further landfill gas extraction wells – see section 4.3, routine operation and monitoring.

Carbon Monoxide is recorded using the GA2000 gas analyser, however this is known widely within the industry to provide inaccurate data. The procedure of sampling, using Tedlar bags at any internal gas wells which breach 75ppm has been adopted. Previously, these have returned the majority of results significantly less than 75ppm.

Where volume and quality of gas decreases with time after site closure and gas collection ceases, on-site landfill gas concentrations will be monitored in a limited number of wells.

5.2.1 Maintenance and Inspection

Landfill gas extraction wells are inspected during each monitoring round to ensure integrity. Any anomalies identified are reported to the appropriate site representative and rectified. Internal gas well condition surveys are completed on a six monthly basis.

5.2.2 Hot Spot Detection and Action Plan

The site is routinely checked for the presence of possible hot-spots through visual inspection of the site and interpretation of monitoring results.

Where monitoring results suggest excessive air ingress, further investigations will be conducted to determine CO, H_2 and temperature levels. This will be undertaken at the relevant wells (in addition to the parameters outlined in Table 1 above).

A hot-spot may be suspected if a number of the following are observed during site inspection and monitoring;

- Substantial settlement over a short period of time
- Smoke emanating from the gas extraction system or landfill
- Elevated levels of CO (exceeding 100ppm as indicated on hand-held IR instrument with the H_2S filter in place)
- Elevated levels of oxygen greatly exceeding 5%
- Combustion residue in extraction wells or headers or
- Increase in gas temperatures in the extraction system/excessive temperatures

If it is suspected that a hot-spot is present, Infinis will follow procedure reference CAS 35: Hotspot Management. Once a hotspot has been closed-out, procedure reference CAS 36: Returning Extraction After a Hotspot Event will be implemented.

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6.0 TRACE GAS MONITORING

Annual trace gas monitoring will be conducted in accordance with the requirements of the Environmental Permit and LFTGN04.

The laboratory undertaking the analysis will be suitably accredited in accordance with LFTGN04.

Samples will be taken from a representative location e.g. from the main gas line entering the gas utilisation compound or other location as required by the Permit.

Sampling will be conducted under representative conditions. Preliminary bulk gas analysis will be conducted to confirm that the composition is suitable for monitoring trace gases. See Table 2 below for preliminary parameters monitored:

Table 2: Trace gas monitoring - preliminary checks and field measurements

Parameter	Units
Methane	%
Carbon dioxide	%
Oxygen	%
Nitrogen	%
Hydrogen sulphide (field value)	ppmv*
Carbon monoxide (field value)	ppmv*

*parts per million by volume

Carbon monoxide levels greater than 25ppmv (as determined within the laboratory), may indicate a fire. Where levels above 100ppmv are found during the above preliminary checks, the monitoring organisation will notify Infinis without delay so appropriate action can be taken.

Trace gases which are to be monitored at the site include the standard priority components identified within LFTGN04. Duplicate samples will be taken for each substance requiring determination.

The results will be summarised in a way that allows meaningful interpretation. Data will be assessed for consistency with previously reported data (if available) any priority trace components that are not positively identified using the recommended methods will be reported as being below their respective detection limits. The report will be submitted to NRW by FCC.

6.1 PERIMETER MONITORING (Subsurface emissions)

6.1.1 General

Landfill gas control measures and management systems will be introduced as necessary, to ensure that landfill gas does not migrate unacceptable concentrations from the site. Gas management is actively undertaken at the site and in combination

with the lining and capping system, is designed to minimise gas migration from the site. Landfill gas monitoring is conducted in accordance with Table S4.5 of the site Permit. Perimeter gas monitoring boreholes are monitored on a monthly basis for CH4, CO2, O2, Atmospheric Pressure and Relative Pressure. Gas monitoring is undertaken either by a nominated technically competent contractor or the FCC Environment environmental monitoring team.

6.1.2 Monitoring of Boreholes

The site has a total of 29 perimeter gas monitoring boreholes at which gas composition is recorded on monthly basis in accordance with Table S4.5 of the permit variation. These are outlined in the monitoring schedule (Appendix A) and are shown on the site's environmental monitoring plan (Drawing 2).
The total number of boreholes monitored was 30 but borehole T11 is no longer monitored for landfill gas. This borehole consistently showed high levels of methane which were proved to have been present prior to tipping operations. In addition when the gas was sampled it showed a chemical signature pointing to a source that was something other than landfill in origin.

6.1.3 Trigger and Action Limits

Background (action) limits for Carbon Dioxide (using the Perimeter Soils Gas Emissions Criteria ICoP, January 2011) have been agreed with Natural Resources Wales. The methane and carbon dioxide action limits are as provided in Table S4.5 of the permit and summarised in Table 4 below:

Table 4: Borehole Specific Trigger Limits for CH_4 and Action Limits for CO2 (%v/v)

Borehole	CH4%(v/v) Trigger Limit	CO2%(v/v) Action Limit	Borehole	CH4%(v/v) Trigger Limit	CO2%(v/v) Action Limit	Borehole	CH4%(v/v) Trigger Limit	CO2%(v/v) Action Limit
G1	1.0	3.22	G11	1.0	2.72	T4	1.0	4.99
G2	1.0	3.21	G12	1.0	3.33	T5	1.0	3.85
G3	1.0	2.91	G13	1.0	2.28	T6	1.0	3.69
G4	1.0	2.57	G14	1.0	2.82	T7	1.0	2.91
G5	1.0	2.53	G15	1.0	2.27	T8	1.0	3.50
G6	1.0	2.77	G16	1.0	2.18	T9	1.0	3.90
G7	1.0	3.36	G17	1.0	3.19	T10	1.0	2.40
G8	1.0	3.62	T1	1.0	2.86	T11	1.0	2.27
G9	1.0	3.48	T2	1.0	2.90	T12	1.0	2.71
G10	1.0	2.76	T3	1.0	3.49	T13	1.0	2.96

6.1.4 Proposed Monitoring Boreholes

There are currently no scheduled installations of proposed, new perimeter gas monitoring boreholes at Pen-Y-Bont LFS.

6.1.5 Monitoring Borehole Design

Monitoring borehole designs are in accordance with the FCC Environment schematic 900D002A.

6.1.6 Maintenance of LFG Perimeter Monitoring Points

Landfill gas perimeter monitoring boreholes will be maintained in a condition that allows them to fulfil their required duty. Landfill gas monitoring boreholes will be inspected visually for damage each time that they are monitored or sampled. Any damage noted shall be repaired within the shortest practicable timeframe. Where a borehole is damaged such that it requires replacement, a replacement borehole will be drilled as soon as is practicably possible subject to availability of drilling contractor, weather conditions and access to the location.

Details of inspections of landfill gas perimeter monitoring boreholes will be recorded, remedial actions undertaken or replacement borehole will be recorded in the site installation log.

6.1.7 Routine LFG Monitoring

The site has a total of 30 boreholes at which gas composition is recorded at 29 of them on a monthly basis in accordance with Table S4.5 of the permit variation. These are outlined in the monitoring schedule and are depicted on the site's environmental monitoring plan.

6.1.8 Monitoring Personnel

Landfill gas monitoring of the boreholes will only be undertaken by suitably trained personnel. Such persons (or contractors) will be able to calibrate and correctly use gas analysers and interpret landfill monitoring data. Training Records and calibration certificates will be stored in the site filing system.

When required in accordance with the landfill gas action plan, samples may be taken for subsequent laboratory analysis using an appropriately approved technology and relevant sampling methodology (e.g. Tedlar gas bags).

6.1.9 Monitoring Equipment

Monitoring by portable instruments will be carried out for methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulphide.

The equipment used will be from the list below:

- Geotechnical Instruments GA2000, GA2000+ or similar ATEX approved gas analyser.

Calibration and servicing of the portable instruments will be carried out in accordance with the manufacturer's recommendations and records of calibration certificates will be provided upon request, as per externally verified QA procedures.

As part of calibration and servicing, the manufacturer will carry out a pre-calibration test against calibration gases to a known and traceable standard, to confirm the accuracy of the instrument pre-calibration.

Servicing is undertaken at six monthly intervals, and includes a pre-calibration check against gases of known standard, repairs and servicing, calibration and a post calibration check.

6.1.10 Monitoring Methodology

Perimeter borehole monitoring will be carried out in accordance the methodologies specified in the FCC Environment monitoring protocols document.

Before taking gas measurements, the gas monitoring instrument will be switched on and the methane and carbon dioxide readings allowed to zero whilst drawing clean air (away from any potential sources of venting landfill gas). This is known as purging.

All perimeter landfill gas monitoring boreholes will be monitored by connecting the probe from the gas measuring instrument directly to the sample tap/Tefen valve of the borehole to be monitored. Boreholes will not be monitored with the removable cap taken off as this would allow air dilution of the gases within the borehole being monitored.

Once connected to the borehole, gas will be drawn through the instrument and the readings monitored until stable readings are obtained. Once stable readings have been obtained, the values will be recorded. Where a Geotechnical Instruments analyser is being used, the results are logged electronically on the instrument for future reference and downloading. The instrument will be allowed to purge and Methane and Carbon Dioxide readings allowed to zero, before connecting to the next borehole to be monitored.

When required in accordance with the landfill gas action plan, samples may be taken for subsequent laboratory analysis using an appropriately approved technology and relevant sampling methodology (e.g. Tedlar gas bags).

6.1.11 Analytical Methodologies

The Geotechnical Instruments hand-held instruments have infra-red gas detection for methane and carbon dioxide, and electrochemical cells for other analytes. Where samples are sent for laboratory determination, gas chromatographic (GC) analytical techniques will be used to obtain the required analysis. External laboratories to be used for GC analysis will be accredited to NAMAS/UKAS or equivalent accreditation scheme.

6.1.12 QA Plan and QC Procedures

Validation of results will be undertaken by the trained monitoring personnel, and assessment against compliance limits specified in schedule 4 of the site permit.

To aid this process, a number of data filtering systems have been created within the FCC Environment monitoring database, MP5. When data is uploaded into this system, it is scanned against specified control and trigger limits contained within the site permit, and a report is automatically emailed to all relevant parties, notifying if any breaches of limits have occurred.

6.1.13 Methodology of Data Storage, Retrieval and Presentation

Data obtained from the gas analysers in the field is uploaded into the FCC Environment data management system, MP5, within 24hrs of each monitoring visit. Within this database, there are a variety of data interpretation, filtering and reporting tools that can be utilised.

6.1.14 Methodology for Data Interpretation

The FCC Environment monitoring database contains many interpretive tools that are available to users once trained, which enable trend analysis and adequate data reviews to be completed.

6.1.15 Means of Communicating Results to the Regulator

Results will be reported to NRW at the frequency specified in Schedule 5 of the permit or at other frequencies agreed in writing with NRW. Upon receipt of the data, results will be assessed against the compliance limits specified in schedule 4 of the site permit. Breaches will be notified to the NRW in accordance with the requirements of condition 4.3 of the site permit. If the trigger levels have been exceeded the action plan will be followed as detailed in Section 6.1 of this management plan.

6.2 PERIMETER AND RECEPTOR MONITORING (Aerial emissions)

6.2.1 Particulate Monitoring

Monitoring of particulates is not required by the current site Permit.

6.2.2 Odour Monitoring

Qualitative off site odour monitoring is undertaken as detailed in the site odour management plan. Any occurrence of malodour is noted in the site installation log, along with a record of remedial action undertaken. Additional monitoring will be undertaken as appropriate in the event of substantiated complaints from relevant receptors.

7.0 FLARE AND ENGINE EMISSION MONITORING

Monitoring of the emissions from the flare and engines will be conducted at frequencies specified within the Environmental Permit. Reference will also be made to Environment Agency Guidance LFTGN 05 (flares) and LFTGN 08 (engines).

Enclosed flares will be monitored (where this is a permit requirement) unless they have been operational for less than 10 per cent of the time (on an annual basis).

The parameters to be monitored and methodology will be determined by the guidance documents above and the Environmental Permit and will be outlined in a Site Specific Protocol (SSP). Results will be compared with relevant emission limit values dependent upon the commissioning date for the plant item as indicated in Table 3 below.

Table 3: Landfill gas flare and engine emission monitoring parameters

	Emission limit values (mg/m^3)*		
Parameter	**Flares**	**Engines first commissioned 2006 onwards**	**Engines first commissioned after 1 January 1998 and before 31 December 2005**
Nitrogen Oxides as (NOx)	150	500	650
Carbon monoxide (CO)	100 for flares first commissioned prior to 2004. 50 for flares first commissioned 2004 onwards	1400	1500
Total volatile organic compounds (VOC's)	10	1000	1750

*Engines which were commissioned prior to 1997 have site-specific emission limit values. See Environmental Permit for details.

Note: NMVOCs are no longer included in the annual monitoring as Environment Agency guidance specifies that no suitable method is available – see LFTGN08 for details.

Engine emissions samples will typically be taken from the sampling port situated immediately after the engine turbo. Flare emissions samples will be taken from an agreed single location close to the top of the flare.

To ensure the sample is representative, engines should be running under typical operational conditions.

The test will be reported in accordance with the Agency's LFTGN 05 and LFTGN 08 guidance and will include details of:

- The test methods
- Variations from standard methods
- A tabulated data summary
-

Any data which is determined to be approaching the limit (as defined in LFTGN 05/08) will be highlighted in the report.

Any data which is determined to be non-compliant, will be investigated and reported to the Permit Regulator (if applicable) by the Permit Operator.

Quarterly engine emission monitoring results will be used primarily to optimise engine operation. Whilst every effort will be made to ensure parameters remain in line with EP limit values, they will not be compared against said values from a Permit compliance perspective.

8.0 Landfill Gas Emergency Action plan

This section reviews various responses to differing scenarios that could result in the potential loss of environmental control on site, due to system failures, potential breaches of current trigger levels or possible sub surface fires.

8.1 Landfill Gas Emergency Procedures

Perimeter gas monitoring boreholes are monitored in accordance with Table S4.5 of the site Permit variation. Current control levels for methane and carbon dioxide are shown in Table 4, section 5.4.3 of this document.

The following action plan, shown in Table 6 below will be implemented where on-going trends of methane concentrations are in excess of appropriate control levels agreed with the Environment Agency. Single exceedence incidents will be notified to the Environment Agency in accordance with condition 4.3.1 of the site permit, and monitored to identify any trends with no immediate action taken.

Table 6: Landfill Gas Action Plan

Action Level	Immediate action by technician	Action by Environment Manager/Site Manager	Subsequent action
Control levels exceeded	Report Data to Environment Manager. Inform Site Manager. Review data for signs of increasing trends.	EM to report in quarterly review	None
Methane levels in any boreholes exceeding 1.0% (v/v) of the defined background concentration	Move to increased monitoring of the boreholes subject to exceedance. Inform Site Manager and Environment Manager.	Natural Resources Wales notified via Schedule 6 notification.	Further investigation and/or control measures as agreed with the Agency

The gas extraction system incorporates a telemetry system with 24 hour cover provided by the Infinis Logistics Centre. Actions to prevent non-compliance in the event of various scenarios are discussed below.

8.1.1 Failure Scenario 1; Loss of 1 Engine

The flare on site has sufficient capacity to combust landfill gas in the event of engine failures. Action will be taken to ensure plant becomes operational as soon as practicable.

8.1.2 Failure Scenario 2; Loss of Both Engines

In the event of a total engine failure, the on-site 2000m3 back up flare will automatically ignite to maintain environmental control on the gas field. This is programmed to start in the event of engine failure to resume normal operation of the gas plant and there is adequate capacity within the flare on site to maintain environmental control.

8.1.3 Failure Scenario 3; Flare Failure

In the event of the flare failing, arrangements will be made for the supply of a temporary flare/flares until the permanent flare is repaired.

6.1.4 Failure Scenario 4; Loss of Engines and Flare (total site shutdown)

In the event of a total power failure, a back up generator is held on standby within the region and can be fully installed within 12 hours of the system failure. A change over switch for the generator is available for immediate installation once the generator is on site. The main aim is to ensure that environmental control is maintained on the gas field in all potential eventualities.

8.1.5 Failure Scenario 5; Fracture of the Gas Collection Main

In the event that a fracture of the gas collection main has occurred, the relevant section of pipework will be isolated. Pipework will be repaired prior to resumption of extraction.

8.1.6 Gas Plant (blower) failure

The site operates on duty and standby blowers. In the event of a blower failure, the affected unit would be isolated and the standby blower would be operated until repairs can be made to the duty blower.

8.1.7 Inform all Relevant People

The Site Manager and the FCC Environment Manager will be informed of the borehole name/number and the limits which have been breached.

The Environment Agency will be informed via a schedule 6 notification as required by the permit.

8.1.8 Verify Consistency of Monitoring Results

If the breach is deemed to be due to landfill gas migration the gas extraction system will be adjusted where possible. Where appropriate the monitoring will be repeated following adjustment to the extraction system.

Historical and recent gas monitoring data will also be examined.

Boreholes that indicate a clear trend of exceedence will be re-monitored to verify the results. If verified, the monitoring frequency may be increased for the affected and adjacent boreholes where this is an appropriate response. Results of the additional monitoring will be forwarded to Natural Resources Wales and FCC ENVIRONMENT within the earliest practicable timeframe. Monitoring at the increased frequency will continue until the gas concentrations recorded are consistently below the current control level unless otherwise agreed by Natural Resources Wales..

8.1.9 Assessment of Nearby Properties

An assessment of whether any on-Site or off-Site buildings/properties are at immediate risk from the elevated gas concentrations will be undertaken. This will comprise an assessment of gas concentrations where trigger levels have been exceeded and consideration of the distances to any buildings within the vicinity of the exceedance.

If necessary based on an assessment of the risk associated with the potential gas migration, additional gas wells or gas boreholes will be installed to improve control of landfill gas. The remedial measures will be presented in a Landfill Gas Management Improvement Plan which will be submitted to and agreed by Natural Resources Wales.

8.1.10 Undertake a Review of Possible Causes

Investigation into possible causes of the gas migration will be undertaken, and will comprise identification of:

- whether the gas extraction system/gas plant are operating normally
- the integrity of the gas extraction system
- any recent changes to the gas extraction system/gas plant
- an assessment of weather conditions at the times of monitoring, including the evaluation of atmospheric pressure, frost or freezing conditions, heavy rainfall; and
- possible fluctuations of leachate and groundwater levels in the vicinity of the site.

In order to identify the possible cause of potential gas migration it may be necessary to evaluate:

- the integrity of the gas extraction system, including pipe work. All associated headworks and valves will be visually inspected for signs of physical failure and possible vandalism
- the gas extraction system will be checked for condensate blockages and well failures and
- the affected area of the site will be assessed for signs of gas leakage and vegetation dieback.

If the breaches in trigger levels are verified or the cause cannot be easily detected and rectified, Natural Resources Wales will be informed.

8.1.11 Persistent Gas Migration

Where migration is identified, investigation into possible causes of the gas migration will be undertaken between Infinis and FCC. This will comprise identification of:

- Whether the gas extraction system/gas plant are operating normally
- The integrity of the external perimeter and gas extraction system

- Any recent changes to the gas extraction system/gas plant
- An assessment of weather conditions at the times of monitoring
- Possible fluctuations of leachate and groundwater levels in the vicinity of the migration
- Any other abnormal site condition or operation

In order to identify the possible cause of gas migration it may be necessary to:

- Visually inspect the integrity of the gas extraction system, including pipework and all associated headworks and valves (for signs of physical failure and possible vandalism)
- Check the gas extraction system for condensate blockages and well failures
- Assess the affected area of the site for signs of gas leakage and vegetation dieback

If the breaches in trigger levels are verified or the cause cannot be easily detected and rectified, then NRW will be informed by FCC.

If no possible cause of gas migration is identified, and if, after an extended period of time gas levels show no sign of stabilising, the following measures will be considered by the landfill operator in consultation with Infinis and FCC:

- Further investigation (if possible) to determine the composition of gases and to identify the possible source of the gas
- Consideration of additional external boreholes further from the landfill to assess possible extent of gas migration
- Extension of the gas extraction system within affected areas and
- Revision of the landfill gas risk assessment (where relevant)

Following the evaluation of measures highlighted above, it may be necessary to agree to implement further measures.

If no possible cause of gas migration is identified, and after an extended period of time gas levels show no sign of stabilising, the following measures will be considered after discussions with NRW:

- laboratory sampling of gases and subsequent interpretation to identify the possible source of the gas
- increased number of boreholes to decrease borehole spacing within affected areas
- consideration of additional boreholes further from the landfill to assess possible extent of gas migration
- extension of the gas extraction system within affected areas
- revision of the landfill gas risk assessment

Following the evaluation of measures highlighted above, it may be necessary to implement further measures, in agreement with Natural Resources Wales, such as:

- installation of methane detectors within on and off-Site buildings which are deemed to be at risk from gas migration and
- installation of other remedial measures as appropriate.

8.2 Landfill Fire Action Plan

The site is routinely checked for the presence of possible landfill fires through visible inspection of site and interpretation of monitoring results. A hot-spot may be suspected if a number of the following are observed during site inspection and monitoring:

- substantial settlement over a short period of time
- smoke or smoulder emanating from the gas extraction system or landfill
- elevated levels of CO – exceeding 100 parts per million (ppm) indicated on hand held IR instrument
- combustion residue in extraction wells or headers
- Increase in gas temperatures in the extraction system and excessive temperatures

If it is suspected that a fire is present the following procedures will be followed:

1. The waste mass in and around the hot spot needs to become anaerobic – this will be achieved through turning off of main isolation valve on the affected wells, adjusting all surrounding valves and wells as appropriate to minimise suction from the area.

2. The waste mass in and around the hot spot may need to be cooled – this will be achieved through injection of water or leachate into the waste through existing wells, or if necessary new wells.

3. The point at which oxygen enters into the waste mass needs to be identified and sealed – this will be achieved through location of all possible points and sealing using engineered clay, hydrated bentonite or pre membrane.

This basic procedure will be followed for all suspected fires and adapted for each individual situation along with carbon monoxide analysis and temperature recording appropriate to each situation.

9.0 AFTERCARE

Prior to closure of the site a Closure Plan will be submitted and agreed with the Natural Resources Wales, in accordance with the relevant Environment Agency guidance at that time. The plan will set out the post closure management and aftercare of the site.

10.0 REFERENCES

Environment Agency, LFTGN 03, Guidance on the Management of Landfill Gas

Environment Agency, LFTGN 04, Guidance for Monitoring Trace Components in Landfill Gas

Environment Agency, LFTGN 05, Guidance for Monitoring Enclosed Landfill Gas Flares

Environment Agency, LFTGN 08, Guidance on Monitoring Landfill Gas Engine Emissions

Industry Code of Practice for the Management of Landfill Gas