Caulmert Limited

Engineering, Environmental & Planning
Consultancy Services

Bryn Posteg Landfill Site

Sundorne Products (Llanidloes) Ltd

Landfill Gas Management Plan

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APPROVAL RECORD

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DISCLAIMER

Bryn Posteg Landfill Site – Landfill Gas Management Plan

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1.0 INTRODUCTION

1.1 Report Context

1.1.1 Bryn Posteg Landfill Site in Llanidloes, Powys is operated by Sundorne Products (Llanidloes) Ltd Trading as Potters Waste Management (Potters) under Environmental Permit EPR/BU7766IC. Caulmert Ltd was appointed by Potters to update the current landfill gas management plan to incorporate changes to gas management on site.

1.1.2 The landfill gas at Bryn Posteg is collected by a gas extraction system for utilisation at two 1 MWe gas engines. The engines are operated under a separate Environmental Permit, TP3736SQ, held by Sundorne Products (Llanidloes) Ltd.

1.1.3 The gas management plan covers the landfill gas management for Bryn Posteg landfill in its entirety, and encompasses the requirements set out in both permits.

1.1.4 This management plan (LFGMP) accords with the guidelines set out in the Environment Agency's technical document LFTGN 03 'Guidance on the management of landfill gas' and the relevant conditions of the latest Environmental Permit (EPR/BU7766IC). The Plan describes Potters' implemented and proposed controls, plant and management measures to effectively manage and monitor the generated landfill gas at Bryn Posteg Landfill Site. This update of the LFGMP includes updates relating to the revised Landfill Gas Risk Assessment (LFGRA) for the site, completed in February 2018, and includes updated controls, monitoring and management measures in line with this revised LFGRA and specific conditions onsite that differ from those considered in previous versions of this document.

1.1.5 This landfill gas management plan includes:

- a summary of the key findings of the LFGRA;
- specification of the control measures employed onsite;
- definition of the operational procedures;
- a monitoring plan which allows the performance of the gas management system to be assessed against the conceptual model and set trigger levels. This is linked to the requirements of the Permit for the site. (The LFGRA update completed in February 2018, which considers the total waste accepted at the site, including overtip identified in 2017, did not identify any additional risks or requirements for additional monitoring over those identified in the site Permit.)
- the methodology for monitoring and balancing of the gas field (included as an Appendix).
- an Action Plan which sets out the actions that the operator must take during any failure scenarios

1.2 Site Location and Surrounding Land Use

1.2.1 Bryn Posteg Landfill Site is situated approximately 2.8km south-east of Llanidloes, Powys and is centered at National Grid Reference SN 971 822.

1.2.2 The site has been developed in the surface void associated with an old lead mine. Approximately 19 hectares of the site have been subject to controlled landfill since 1982. The site was operated by Montgomery County Council, later Powys County Council, from 1982 until April 1997, when it was taken over by Evans Logistics, now Potters Waste Management.

1.2.3 The site previously operated under a Waste Management Licence and was issued with a PPC permit in 2004 (now transferred to Environmental Permit). It is currently operating under Environmental Permit EPR/BU7766IC.

1.2.4 The site accepts municipal waste which consists of 60-70% household waste and 30-40% commercial trade waste. The waste accepted at the site is processed in a Materials Recycling Facility (MRF). The outputs from the process are; metals which are screened out and recycled, oversized fraction (>80 mm) which is landfilled, and fines (<80 mm) which are composted for two weeks and subsequently landfilled.

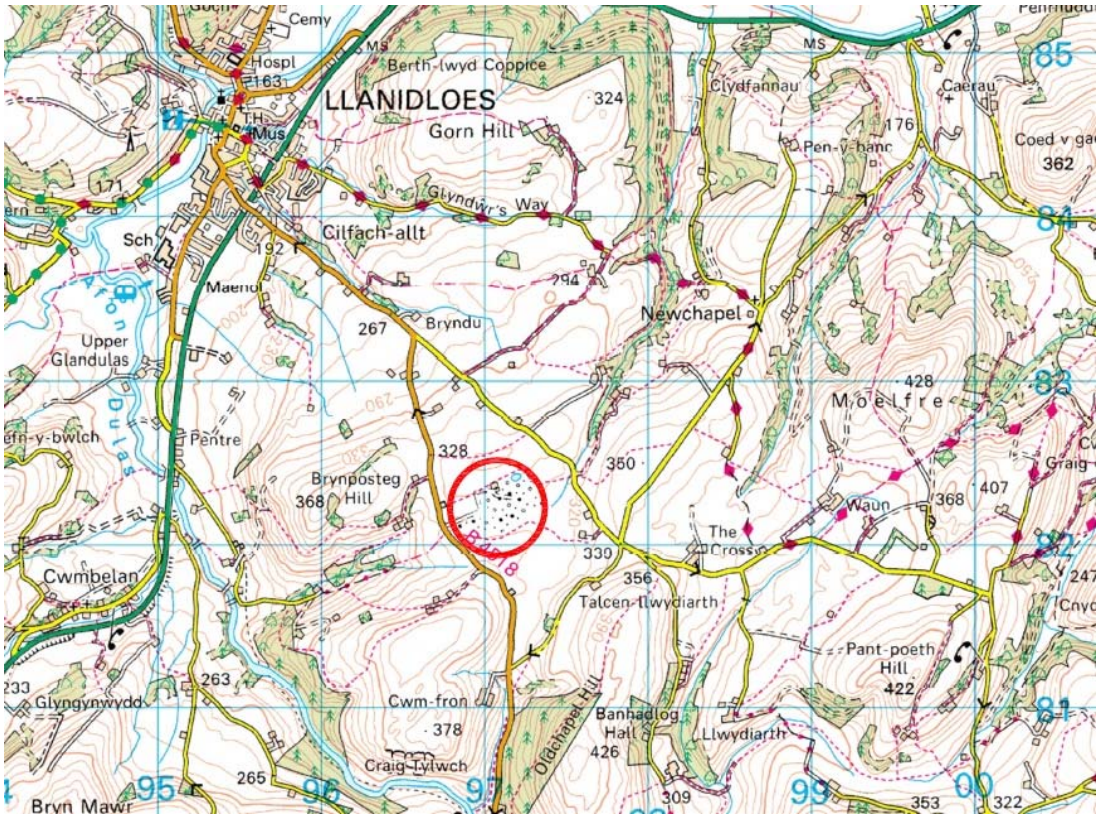


Figure 1: Site Location Plan

1.3 Geology

1.3.1 According to previous ground investigations[1], the site is underlain by clay. The clay is predominantly grey, with various quantities of sand and mudstone gravel. This gravel is interpreted as being the weathering product of the underlying mudstone bedrock.

[1] CL Associates, December 1998

1.3.2 Geological maps indicated that the region is underlain by strata of the Upper Llandovery Groups of Silurain age. These strata comprise mudstone, slates and sandstones. There are a number of faults through the region, two of which underlie the site. One fault is oriented east-west across the north of the site and the other is oriented south-west to north-east, approximately along the stream on the south side of the site.

1.4 Hydrology

1.4.1 The site is within the catchment area of the River Severn. The Afon Dulas runs 3km north-west of the site. Prior to development of this site the area was partly occupied by marshlands.

1.4.2 Due to the mining activities and later the landfilling activities at the site, the surface water regime around the site has been altered. Surface waters are discharged into the Nant-y-Bradnant to the east of the site and into the unnamed tributary of the Dulas on the western perimeter of the site.

1.5 Hydrogeology

1.5.1 The EA Groundwater Vulnerability Sheet No.20 indicates that the strata at the site are classified as a non-aquifer with negligible permeability. During the site investigation undertaken by CL Associates in 1998, in-situ testing in boreholes indicated permeabilities in the range of $1.28x10^{-4}$ m/s and $1.4x10^{-6}$ m/s in the underlying geological strata.

2.0 RISK ASSESSMENT

2.1.1 Bryn Posteg is an operational landfill which accepts biodegradable wastes. Anaerobic degradation of biodegradable waste results in the generation of landfill gas which is a potential risk to human health and to the environment and therefore needs to be monitored and managed.

2.1.2 Landfill gas has as its main component methane and carbon dioxide. The actual quantity and rate of landfill gas generation in the fill are dependent on a number of factors, including the carbon content of the waste and the nature of the carbon (types of waste), taking into consideration the gradual reduction of the biodegradable waste deposited in landfills in response to the European Legislation obligations. Consequently, onset and production rates vary, not only between different landfill sites, but also within the same site.

2.1.3 The composition of landfill gas will vary over time, but will typically consist of 50-60% methane (CH_4), 40-50% carbon dioxide (CO_2) as well as numerous trace compounds. Landfill gas is a potential hazard due to its explosive and asphyxiating properties. This is of particular concern if landfill gas is found to be migrating off-site and towards any close-by buildings or structures. Methane and carbon dioxide are potent greenhouse gases and their emissions should be minimised. In addition to this, landfill gas can also cause problems of odour and 'dieback' of vegetation.

2.1.4 The predicted gas generation curve for Bryn Posteg Landfill site, as generated in the GasSim model and justified, discussed and validated in the LFGRA for the site, document number 3428-CAU-XX-XX-RP-V-0302, is included below. The model contains a number of assumptions about future waste inputs etc. and is taken from the most recent GasSim 2 model for the site[2].

2.1.5 The average gas generation rate for the year 2018 was conservatively predicted to be ~1387 m^3/h. Waste generation rates are predicted to decrease sharply after final capping of the site.

2.1.6 The potential impacts of the landfill gas, generated at the site have been discussed in detail in the revised landfill gas risk assessment for the site3. 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 potential of the landfill.

2.1.7 In accordance with 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 incorporated into the Has Management Plan accordingly.

2.1.8 The LFGRA highlighted that further wells into the currently-active phase are required to allow extraction of gas generated there. They will be installed as parts of the phase are complete. It

[2] Caulmert Ltd, report number 3428-CAU-XX-XX-RP-V-0302. Bryn Posteg – Landfill Gas Risk Assessment, February 2018.

is noted that capping of the waste, once the phase is complete will likely increase extraction efficiency.

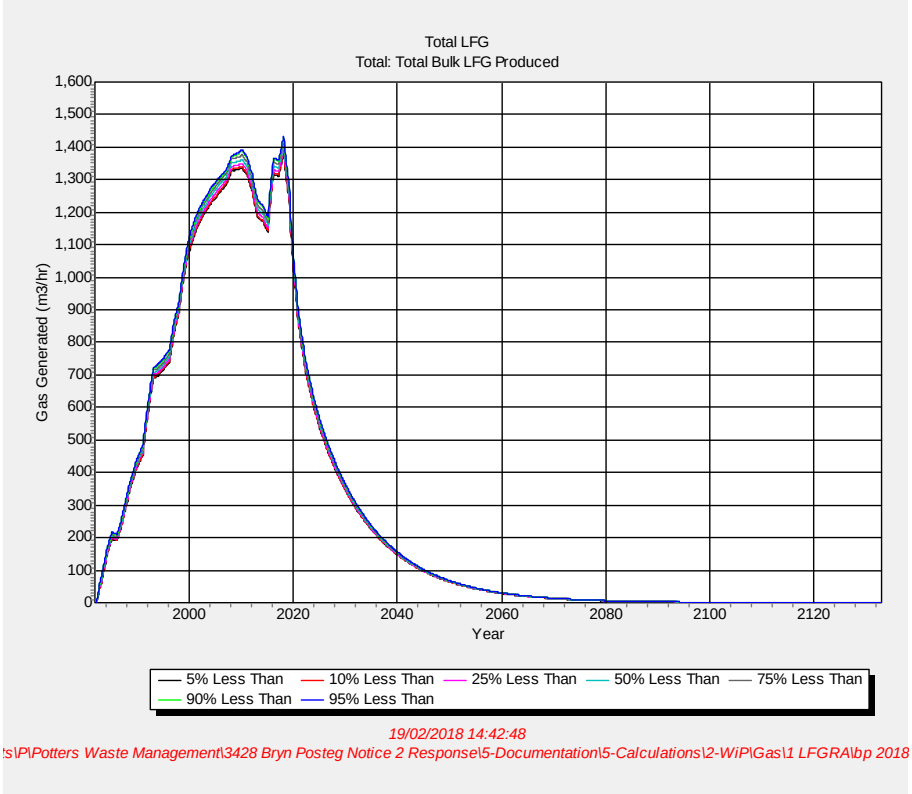


Figure 2: Theoretical Gas Yield for Bryn Posteg Landfill Site

2.1.9 The risk assessment indicated, that while the gas engines onsite have sufficient capacity to utilise the gas generated at the site now and into the future, the flare at the site is over-sized, and has surplus capacity. This has implications for the gas management of the site as the site enters the post-closure period, when gas generation rates are likely to decrease rapidly. The results suggest that the lower capacity of the current flare will be higher than the amount of gas that can be extracted from the site within 5-10 years after site closure.

3.0 LANDFILL GAS CONTROL MEASURES

3.1 General Principles of Landfill Gas Extraction

3.1.1 Landfill gas within the waste moves from areas of high pressure to areas of low pressure. The movement allows the capture and recovery of gas generated within the site. Vertical gas wells create 'artificial' regions of low pressure. The low pressure is applied to the waste via a network of pipes that are connected to the wells.

3.1.2 Gas flow through the waste is not easy to predict and is often affected by the boundary layer. Vertical gas flow can be prevented by soils and perched leachate while lateral gas flow can be blocked by soils and engineering structures. The result can be a localised pressure build-up.

3.1.3 The position of the wells within the site is influenced by the waste type, depth, moisture content and density. Well location on the site is critical to gas flow and recovery.

3.1.4 As landfill gas enters the pipe network it expands under the pressure reduction. As the gas expands, it cools down forming a condensate. The condensate must be collected, controlled and removed to prevent blockages and corrosion. An effective system must be incorporated for the disposal of condensate.

3.1.5 At Bryn Posteg landfill, a landfill gas management system has been installed in a phased manner following the infilling of waste and progressive capping of each phase. Control measures are in place to provide containment, collection and treatment of landfill gas when required and/or when the generation of sufficient quantities of methane warrants it. Currently, gas is controlled through active extraction, utilisation in two engines and flaring off the excess. As the source term declines through biodegradation and active extraction becomes less viable, alternative methods of control may need to be considered.

3.1.6 To minimise the lateral migration of landfill gas away from the landfill, specific engineering containment measures have been implemented. They are based on widely accepted waste management practices, and include the following:

- The landfill has been constructed on the principle of containment, using an engineered, low permeability perimeter and basal lining system;
- Installation of an active landfill gas extraction and flaring/engine system; and
- The operation of an active monitoring regime of in-waste gas and at the site's perimeter.

3.2 Containment system

3.2.1 The site is constructed in a series of phases: 1, 2, 3A, 3B, 3C, 4A, 4B, 5, 6, 7, 8, 9A, 9B, 9C, 9D. Waste is currently accepted in Cell 9D, all other cells are complete. Cells 1 to 9B are all capped. The lining and capping details are summarised in Table 1 below. The site is scheduled to be completed to the currently-agreed restoration contours in 2018.

Table 1. Engineering containment summary

Phase	Liner	Cap
1	1 m clay	1 m boulder clay 1 m cover soils
2		
3A		Geomembrane cap and cover soils
3B		
3C		
4A		
4B		
5		
6	GCL and HDPE	1 m mineral clay
7		
8		
9A	0.5 m min liner, GCL and Geomembrane	
9B		
9C		
9D		

3.3 Gas Field (Extraction Wells and Pipework)

3.3.1 An active gas control system has been installed at the site. This comprises gas extraction wells drilled after the completion of waste infilling and connected, via transmission pipe-work, to a gas plant (landfill gas engine and a flare, see 3.5).

3.3.2 The gas extraction wells currently cover cells 1 – 8, 9A, 9B, 9C and 9D. There are currently approximately 84 wells in the gas field, installed to an average of 30-35 m centres.

3.3.3 In recent years, several upgrades of the gas field have been undertaken. In 2009, 13 news gas wells were installed (referred to as Phase 1). In spring 2011, Phase 2 was undertaken [3], the main element of which were the installation of active gas extraction in Cells 9a and 9b. The wells were connected to two new manifolds and connected to the gas plant via a new section of ring main. Remediation and upgrading work was also undertaken in the north western part of the site, to include the installation of a ring main along the northern and western boundary and associated condensate management facilities, and the replacement of an old manifold with a new one. In September 2011, an additional 9 wells were installed and two old non-functional wells were re-drilled[4]. All new wells were connected to the gas main directly or via manifolds. Remediation work to some wells was also incorporated as part of the works. Most recently, 12 wells were installed in Cell 9D (in 2014). Drawing, ref no 3428-CAU-XX-XX-DR-V-1807 showing the complete gas field is appended.

[3] Extension of Landfill Gas Extraction System Phase 2 Construction Quality Assurance Validation Report 1220.1.POT.JDM.ILO.A0, June 2011, Caulmert Ltd

[4] Extension of Landfill Gas Extraction System Phase 2A Construction Quality Assurance Validation Report 1220.3.POT.KEB.ÅKS.A1, October 2011, Caulmert Ltd

3.3.4 Further extraction wells will be installed as capping and restoration progresses and as the onset of sufficient methane generation warrants their installation. A detailed CQA plan with full design justifications will be compiled and submitted to NRW prior to installation of each phase.

3.3.5 Typically, vertical wells are drilled into the waste and lined with butt-welded sections of PE with either 90 or 160 mm diameter as standard. Historically,

3.3.6 The wells are connected by transmission pipe-work, to a specification which has been agreed with NRW. The transmission pipe-work varies in diameter and has been designed to be adequate for the calculated maximum gas flow velocities and to minimise the potential for its blockage by the accumulation of condensate. This risk has also been minimised by ensuring that pipe-work is laid to suitable falls. There is a condensate trap prior to the gas entering the gas plant, and in addition condensate traps are installed at selected locations within the pipe-work to facilitate the removal of any condensate which may accumulate.

3.3.7 Each gas well is being inspected during each gas field balancing exercise. If any defects are noted, these are logged in the field log. Repairs are being undertaken immediately if possible, otherwise arranged as soon as possible. All defects and repairs are subsequently logged in the In-Waste Detail log sheet (Appendix 1). Well checks, monitoring and maintenance are discussed further in Sections 4 and 5 of this report.

3.4 Condensate Management

3.4.1 The gas field at Bryn Posteg has been designed so that condensate removal facilities (knock-out pots) are placed in low spots in the system. The knock-out pots are pumped, and condensate is discharged into the leachate collection system.

3.4.2 In addition, there is provision to insert pumps into the gas wells. Each gas well is pumped as required on a regular basis, to keep the liquid levels low within the gas well. This enhances gas generation and aids in gas collection, as perched leachate can inhibit gas flow and limit the zone of influence of the gas extraction wells.

3.4.3 The pumps are removed and serviced on a regular basis. The gas field at Bryn Posteg has been divided into 5 zones (see Drawing 1239.GEX.03). The pumps in one of the zones are removed and serviced each month, on a rotational basis. A leachate pump schedule (Appendix 1) is used to track the pump rota. Every time a pump is removed from a gas well, the gas well should be dipped.

3.4.4 The pump servicing, leachate dips and all other relevant data is recorded on the leachate pump schedule (Appendix 1). The schedule, in the format of an Excel workbook, is updated and kept on the computer on the weighbridge.

3.5 Gas Plant

Landfill Gas Engines

3.5.1 The landfill gas engines at the Site is operated under a separate PPC Permit, TP3736SQ, held by Sundorne Products (Llanidloes) Ltd, trading as Potters Waste Management. The company Gwynt Cymru Ltd is financially responsible for the Engines.

3.5.2 Currently, there are two 1 MW engines onsite: CAT 3516TA unit, installed at the beginning of 2003, and a second CAT 3516 A+ unit installed in 2013. Each is rated to utilise between 300 m^3/h and 600 m^3/h landfill gas at a methane concentration of 50%.

3.5.3 Gwynt Cymru is responsible for the upkeep and monitoring of the gas engines. Gwynt use both Potters and Finning to ensure that this is delivered. The gas engines are managed under a maintenance contract with Finnings UK, and are maintained and serviced as per Finnings standard protocols. The original engine had a major refit last year, as is standard after 40,000 hours of operation.

Landfill Gas Flare

3.5.4 Currently a high temperature GTS (Greenfield Technical Services) flare with a maximum capacity of 2000m^3/h and turn down ratio of 5:1 is installed in the gas compound to the north of the site. It is designed for positive collection and flaring of landfill gas arising from the site. The unit has an automatic flame temperature control in order to dispose of landfill gas in a controlled manner.

3.5.5 The GTS flare at the site has sufficient maximum capacity to act as back-up should both engines be out of operation concurrently[2]. The suitability of the flare at the site will be reviewed regularly (e.g. annually), using extraction and production monitoring records, so that the correct-sized unit can be sourced before gas generation has decreased to below the lower operational limit of the unit (~400 m^3/h at 50% CH_4).

3.5.6 The flare is operated and maintained in accordance with the requirements of the flare manufacturer and standard industry practice. The manufacturer is responsible for servicing the flare, they attend site quarterly and are available to assist in fault location at any time.

4.0 OPERATIONAL PROCEDURES

4.1 Routine operation and monitoring

4.1.1 Optimising gas extraction from the site is a function of a number of factors including:

- Leachate management (gas generation and migration is inhibited in saturated waste. This is addressed in the Leachate Management Plan for the site[5]);
- Site phasing (minimising uncapped areas of the site will enhance gas recovery from those areas as more efficient extraction can be achieved from permanently capped areas);
- Gas management (including infrastructure, operation and monitoring, discussed in this document).

4.1.2 Monitoring and balancing of the gas extraction field is undertaken twice weekly by trained, experienced technicians (Detailed in Table 2, section 4.2).

4.1.3 To ensure that landfill gas extraction is optimised, extraction rates will be reviewed and adjusted at a minimum frequency of quarterly.

4.2 Gas Management Responsibilities

4.2.1 The management responsibilities for landfill gas management of the personnel are outlined below:

4.2.2 **Site Manager** – Tony Webber: Holds the records and ensures that they are complete and, where possible, compliant with permit requirements.

4.2.3 **Technical Manager** – David Williams: Ensures that sufficient resources are made available to safely complete monitoring tasks; reviews monitoring data to ensure that results and trends are compliant with permit requirements. Ensures that monitoring and maintenance is completed in a safe and timely manner. Is responsible for review of the system efficiency and organisation of upgrade/repairs/remediation as and when required.

4.2.4 **Flare Manager**: Service contract currently undertaken by GTS. Quarterly service visits undertaken, and as required in response to alarm (24/7 call-out contract).

4.2.5 **Engine Manager** - Service engineers from Finning UK: Ensure that the engine is maintained and serviced in accordance with contract.

4.2.6 **Technician (In-Waste Gas)** – John Baker/ Paul Lloyd: responsible for sampling and analysis of gas fields and systems in accordance with the requirements of the permit and as per the Landfill Gas Monitoring Methodology (Appendix 1). They undertake basic and routine system maintenance (of gas well headworks, locks, signs/identification labels and dedicated sampling

[5] Leachate Management Plan, Bryn Posteg Landfill Site. 3033-CAU-XX-XX-RP-V-0300-A0-C2

installations) and balancing/adjustment in accordance with the Gas Field Balancing Protocol (Appendix 1).

4.2.7 **Technician (Perimeter Monitoring)** – Brian Davies: Responsible for sampling and analysis of perimeter gas boreholes in accordance with the requirements of the permit and as per the Landfill Gas Monitoring Methodology (Appendix 1), shall undertake basic repairs to boreholes (of headworks, locks, signs/identification labels and dedicated sampling installations).

4.2.8 Gwynt Cymru is responsible for the landfill gas engine and electricity generation. Potters take responsibility for all operational aspects of the landfill gas management. A table has been compiled to clarify the various responsibilities:

Table 2. Checks and maintenance/repair responsibilities

What	Who	When
NORMAL OPERATING CONDITIONS		
Gas collection	Sundorne	Continuous
Gas extraction	Sundorne	Continuous
Gas utilisation (energy production)	Gwynt Cymru	Continuous
Gas flaring	Sundorne	When collected gas cannot be used
Gas system inspection	Sundorne (Paul Lloyd/ John Baker)	Weekly recorded inspections
Gas field balancing	Sundorne (Paul Lloyd)	Twice weekly
Ensuring PPC permit & Variation Notice compliance	Sundorne & Gwynt Cymru (David Williams)	Continual
Gas quality monitoring	Potters (Paul Lloyd)	Continual
Preparation & submission of monitoring reports to NRW	Sundorne & Gwynt Cymru (David Williams)	As per Schedule in PPC permit
Perimeter borehole monitoring	Sundorne (Brian Davies)	Weekly/Monthly
Perimeter borehole maintenance	Sundorne (Brian Davies)	When required
Engine Emission Testing	Gwynt Cymru (organised by DW, subcontracted)	Annual using MCERT contractors, quarterly using in house monitoring equipment
Flare Emission Testing	Sundorne (organised by DW, subcontracted)	Annual if run >10% of the year
Trace Gas Testing	Sundorne (organised by DW, subcontracted)	Annually
ABNORMAL OPERATING CONDITIONS		
Gas system design	Gwynt Cymru (Appointed designer)	As required
Gas system installation/alteration	Gwynt Cymru (Appointed contractor)	As required

What	Who	When
CQA inspection & validation	Gwynt Cymru (Appointed competent person)	As required during gas system installation/alteration
Gas system commissioning	Gwynt Cymru (Appointed contractor)	As required
Gas pipework connection/disconnection	Potters/Gwynt Cymru (Sometimes appointed contractor)	As required
In-waste gas monitoring	Potters/Gwynt Cymru (Paul Lloyd)	Twice-weekly
Perimeter gas monitoring	Potters (Brian Davies)	Weekly
Gas system maintenance	Potters/Gwynt Cymru (Paul Lloyd/ John Baker)	When identified during inspection
Condensate removal from gas system	Potters/Gwynt Cymru (Paul Lloyd/ John Baker)	As required
EMERGENCY OPERATING CONDITIONS		
Resolving gas system failures/problems	Sundorne/Gwynt Cymru (David Williams)	Resolve as soon as possible. Isolate if required.
Resolving gas engine failures	Sundorne /Gwynt Cymru (David Williams)	Flare on automatic start. Finnings notified via telemetry and provides immediate response. Gwynt verify that Finnings is resolving engine failure.
Resolving gas flare failures	Sundorne /Gwynt Cymru (David Williams)	See section A in action plan.
Resolving gas well failures	Sundorne /Gwynt Cymru (Paul Lloyd/ John Baker)	Isolate immediately, resolve problem. Organise and appoint contractor if required.
Dealing with in-waste fires/explosions	Sundorne (David Williams/ Tony Webber)	Immediately
Responding to odour complaints	Sundorne (David Williams)	Immediately upon receipt of complaint
Investigating odour complaints	Sundorne (David Williams / Tony Webber)	Upon receipt of complaint
Notification of permit condition breaches to NRW	Potters (David Williams)	Immediately upon become aware of breach

4.3 Inspection and Maintenance

4.3.1 Routine inspections of the full gas extraction system are carried out weekly. The findings are recorded and kept on file. Maintenance is undertaken to repair any identified problems.

4.3.2 In addition, landfill gas extraction wells, manifolds and condensate wells are inspected during routine monitoring, gas field audits and condition surveys.

4.3.3 The blower, engines and flare are inspected daily, and gas flow, quality, and operational hours of the blower recorded, to verify ongoing operation of the system.

4.3.4 When the engines onsite undergo maintenance, the flare is used to manage the extracted gas. All gas plant is operated and maintained according to the manufacturer's specifications.

4.4 Competence and Training

4.4.1 All personnel involved in the gas management shall have been trained to be able to fulfil their responsibilities. This training may be suitable CIWM courses, by monitoring equipment providers, as well as on-the job training and mentoring by an experienced person.

4.4.2 Training Records (Appendix 1) shall be kept in a site file and be available for inspection at any time.

4.4.3 NRW shall be notified within 7 days of any changes in technically competent management and the name of any incoming person together with evidence that such person has the required technical competence[6].

[6] 4.3.6 in the permit

5.0 LANDFILL GAS MONITORING PLAN

5.1 General

5.1.1 The purpose of this Monitoring Plan is to outline the monitoring parameters, methodologies, reporting procedures and action plans with regards to landfill gas at Bryn Posteg Landfill Site.

5.1.2 Landfill gas is a composition of bulk gases methane (CH_4) and carbon dioxide (CO_2) and a wide range of trace gases such as hydrogen sulphide (H_2S), Volatile Organic Compounds (VOCs) and semi-VOCs, and residual metal compounds.

5.1.3 The presence of these gases in landfill gas mixture gives it a number of toxic, phytotoxic and hazardous properties, and result in odour impact and green-house climate effects. The presence of methane in landfill gas could result in in-waste fires, flash fires or explosion if accumulated in confined spaces. Carbon dioxide is one of the principal greenhouse gases (along with methane) and an asphyxiating gas. Trace gases such as hydrogen sulphide, organosulphurous compounds, carboxylic acids, aldehydes, carbon disulphide are odorous in negligible concentrations. A number of trace VOCs are toxic to human health due to their carcinogenic properties.

5.1.4 Landfill gas utilisation units produce emissions to air which are predominantly combustion gases NO_x, SO_2 and CO, which are nationally regulated air pollutants. Residual hydrocarbons are also present in stack gas emissions in various concentrations depending on the technical performance of the combustion system.

5.1.5 It is the intention of Potters to control and minimise lateral migration of landfill gas and surface emissions in the following ways, both during landfilling operations and once the landfill has been completed and capped :-

- Gas extraction and controlled destruction (in an engine or flare) is implemented and will be maintained until it is either not sustainable or the rate of gas production indicates that environmental risk is insignificant;
- At weekly intervals, any established sub-surface monitoring points will be monitored for concentrations (by volume) of methane, carbon dioxide and oxygen. The results will establish the effectiveness of any gas control system.
- The results obtained will be compared to specific trigger concentration as indicated in Section 5.3 and Table 5 of this document.

5.1.6 This Monitoring Plan is designed to meet the requirements of the Environmental Permits EPR/BU7766IC and TP3736SQ (for the landfill gas engines) and covers the following regulated in Schedule 3 emissions of landfill gas at the site:

- Point source emissions to air – landfill gas flare/engine (Permit table S3.2);
- Perimeter monitoring: monitoring of lateral migration in external monitoring boreholes (Permit table S3.6);
- Surface emission monitoring – permanently and temporarily capped areas (Permit table S4.8);

- Trace gas monitoring (Permit table S4.8);
- Gas collection system monitoring and balancing – active gas extraction wells. (Permit table S4.8).

5.1.7 This Monitoring Plan will be subject to review if significant changes are made to the landfill gas extraction system, and no changes to the approved Monitoring Plan will be made without prior consultation and agreement with NRW.

5.2 Point Source Emission Monitoring

5.2.1 Monitoring of the landfill gas flare and landfill gas engine emissions to air at Bryn Posteg will be carried out as per the Environmental Permit requirements and as per the relevant Environment Agency guidance documents.

5.2.2 Details of the monitoring schedule for the flare are as per EPR/BU7766IC Table S3.2 and are given in Table 3 below. Table 3 also includes the monitoring requirements for the engines at the site, as detailed in Table S3.1 of permit EPR/RP3338TA:

Table 3: Point Source Emission Monitoring Regime (Flare)

Test type and monitoring points	Parameter	Reference Period	Unit	Frequency
Landfill Gas Flare	Oxides of Nitrogen CO Total VOCs Operational Temperature	Hourly mean	mg/m^3 mg/m^3 mg/m^3 ˚C	Annually*
Biomass Boiler	Particulate matter SO_2	Hourly mean	mg/m^3	Annually*
Landfill Gas Engines	Oxides of Nitrogen CO Total VOCs	Hourly mean	mg/m^3 mg/m^3 mg/m^3	Annually

* Annual monitoring is only required when flares operate in excess of 10% of the time, taken on as annual assessment period.

Methodologies and Equipment

5.2.3 Point source emission monitoring for the flare will be carried out in accordance with the Environment Agency's technical document LFTGN 05[7]. Individual regulated pollutants will be sampled in accordance with the monitoring methods stated in Table S3.2 of the Permit and where not specified, in accordance with the standard reference monitoring method, as shown in Table 4 below.

5.2.4 Point source emission monitoring for the engine will be carried out in accordance with the Environment Agency's technical document LFTGN 08[8]. Individual regulated pollutants will be sampled in accordance with the monitoring methods stated in Table S2.3.2 of the Permit and where not specified, with the standard reference monitoring method, as shown in Table 4.

[7] Environment Agency (March 2011) – Guidance for monitoring enclosed landfill gas flares LFTGN 05 v2 2010
[8] Environment Agency (March 2011) – Guidance for monitoring landfill gas engine emissions LFTGN 08 v2 2010

Table 4: Flare and Engine Emissions Monitoring Methods and Limits

Parameter		Flare	Engine installed prior to 2005	Engine installed since 2005
Oxides of Nitrogen	Limit (mg/m^3)	150	650	500
	Method	ISO 10849:1996	Extractive Sampling and Chemiluminescence	
CO	Limit (mg/m^3)	50	1500	1400
	Method	ISO 10849:1996	Extractive Sampling and Non-dispersive infrared analysis	
Total VOCs	Limit (mg/m^3)	10	1750	1000
	Method	BS EN12619:1999	Extractive sampling and FID analysis	
Operational Temperature	Limit (°C)	>1000		
	Method	None Specified		

5.2.5 A designated sampling port on the gas flare will be used for stack gas monitoring and gas sampling. A temporary platform will be erected to allow access to the sampling port. Sampling will be carried out when the flare is operating normally. Duplicate samples will be collected and analysed along the field blank to provide the required Quality Assurance.

5.2.6 Sampling will be carried out by a specialist company which is endorsed by the Source Testing Association (STA) and have UKAS accreditation coveting on-site testing. All analysis will be undertaken by a UKAS accredited environmental laboratory.

5.2.7 A two man sampling team will carry out monitoring works to comply with Health and Safety requirements for working at height and hot surfaces.

5.3 Landfill Gas in External Monitoring Boreholes

5.3.1 Landfill gas concentrations are monitored at all external monitoring boreholes. Monitoring borehole locations are shown on drawing 3428-CAU-XX-XX-DR-V-1807.

5.3.2 Monitoring is undertaken as per the requirements of Table S3.6 in the Environmental Permit, reproduced in Table 5 below:

Table 5: Point Source Emission Monitoring Regime (Flare)

Test type and monitoring points	Parameter	Limits (including units)*	Frequency
All perimeter landfill gas monitoring boreholes	Methane Carbon dioxide Oxygen	1 % v/v 1.5 % v/v No Limit	Monthly Monthly Monthly
On-site weather station	Atmospheric pressure		Continuous

Methodologies and Equipment

5.3.3 Field monitoring of landfill gas will be carried out using an instrument capable of measuring concentrations and recording results for methane, carbon dioxide and oxygen (GEM2000 or similar).

5.3.4 The monitoring equipment will be maintained in good working condition and serviced according to manufacturer's recommendations. The calibration certificate and a log of any maintenance will be retained on site. Instrument service and calibration dates will be provided should NRW so request.

5.3.5 The landfill gas monitoring protocol to be used at Bryn Posteg is included in Appendix 1. The protocol has been created following the recommendations within the Environment Agency document Guidance on the Management of Landfill Gas[2] and been adapted to site specific conditions.

5.3.6 Meteorological conditions will be recorded at the time of the gas monitoring and include the general weather conditions and atmospheric pressure prior to and following field work.

Borehole Maintenance

5.3.7 Maintenance of borehole headworks, locks, signs/identification labels and dedicated sampling installations will be the responsibility of the monitoring technician.

5.3.8 Any lost or damaged sampling equipment will be repaired or replaced promptly following detection of the faults. Details of faults should be noted during the routine gas monitoring by the monitoring personnel. Sufficient spares should be carried to allow maintenance to be undertaken during routine monitoring visits. Details of all maintenance shall form part of the information recorded.

5.3.9 At all times installations shall be clearly visible and clearly identified on the ground. Vegetation should be cut as necessary from around both flush and raised headworks.

5.3.10 An identified need for maintenance of a particular installation should not reasonably prevent routine sampling and monitoring data being obtained.

5.4 Landfill Gas from Capped Surfaces

5.4.1 In order to assess the adequacy of the capping in terms of gas permeability, surface emission monitoring will be undertaken using Flame Ionisation Detector walk-over surveys and flux box monitoring.

5.4.2 Monitoring is undertaken as per the requirements of Table S3.7 in Environmental Permit EPR/BU7766IC, reproduced in Table 6 below:

Table 6: Landfill gas from capped surfaces

Monitoring area description	Parameter	Monitoring frequency*	Other specifications	Monitoring standard or method
Permanently capped zone	Average methane flux and total methane emissions	Annually	Average zone emission rate of 0.001 mg/m^2/second	Flame ionisation detector walkover, flux box or as otherwise agreed in writing with NRW Alternatively, as per LFTGN 07 Version 2, March 2011
Temporarily capped zone	Average methane flux and total methane emissions	Annually	Average zone emission rate of 0.1 mg/m^2/second is	

* If a cap has previously been shown compliant and there have been no significant physical changes in the gas management during the year, a detailed walkover survey with an FID can be used to demonstrate that the surface emissions are under control. If this survey shows no change in the pattern of methane emission, it may be used as the annual survey. The values for flux and total methane emissions measured in the previous year may be reported and a fresh flux box survey is not necessary. If the zone remains stable, the results of a full walkover survey may be accepted as the site report for a period of four years before a further quantitative flux box survey is required.

Methodologies and Equipment

5.4.3 The monitoring will be carried out in accordance with Environment Agency Technical Guidance Document LFTGN07[9], Guidance on the monitoring of landfill gas surface emissions.

5.4.4 A Flame Ionising Detector (FID) will be used during both the walk-over survey and the flux box monitoring. FIDs measure concentration of flammable gases, such as volatile hydrocarbons, inorganics etc. Within the context of landfill monitoring, FIDs are calibrated to methane (CH_4) and have a detection limit of 1 ppm CH_4.

5.4.5 An FID aided walk-over survey will be carried out as part of the emissions monitoring and will comprise of systematically traversing the area of interest in order identify any areas, zones or

[9] Environment Agency (March 2011) – Guidance on monitoring landfill gas surface emissions LFTGN 07, LFTGN07

features of the cap which have visually poor cap integrity or show signs of vegetation stress. During the survey methane concentrations will be continuously monitored close to the surface of the cap. In addition any landfill gas and leachate management installations which are present within the assessment area will be individually assessed. The results of the walk-over survey will be used to set up representative monitoring locations for the surface emissions monitoring of methane, if required.

5.4.6 Fugitive emissions of methane through the landfill cap will be assessed using a standard flux box and a portable FID. A "closed design" flux box will be used in the proposed monitoring study. This type of the device is based on measuring an increase in concentration of landfill gas (as CH_4) within a known enclosed space above the ground. The box will be placed on the surface of the cap and connected to a FID, which measures any increase in concentration of CH_4 within it over a period of time.

5.4.7 The monitoring data from the flux box locations will be used to calculate methane emissions from the assessed areas, zones and features and will be expressed in mg/m^2/second to make them comparable with the emission limits specified in Table S3.7. The methodology for calculating rates of surface emissions provided in LFTGN07 will be utilised.

5.4.8 The monitoring regime will incorporate the recommendation within the footnote of Table S3.7, replicated as a clarification of Table 6, regarding the frequency of full flux box surveys in relation to site operations and FID walkover survey results.

5.5 Gas Collection System Monitoring and Balancing

5.5.1 The gas collection system will be monitored regularly in order to provide information about the gas field and to assist the balancing of the gas extraction system. All in-waste gas wells and manifolds will be monitored. Details of the monitoring schedule are as per EPR/BU7766IC Table S3.8 and are given in Table 7 below:

Table 7: Landfill Gas Sampling Regime – Gas Collection System

Emission Point Reference	Parameter	Frequency	Monitoring Standard	Other Specifications
Gas Collection System	Methane	Monthly	LFTGN 03	Where the Oxygen level exceeds 5% or the % balance gas is greater than 20% an assessment of air ingress into the system shall be undertaken. Additionally where the concentration of carbon monoxide exceeds 100 ppm then further investigation shall be undertaken or where the addition of the Carbon Dioxide and Methane percentages is less than 80% an assessment of air ingress into the system shall be undertaken.
	Carbon Dioxide			
	Oxygen			
	Carbon monoxide			
	hydrogen sulphide			
	atmospheric pressure			
	differential pressure			
	meteorological data			
First EMS unit	Methane	Continuous when operational	LFTGN 03	
	Carbon Dioxide			
	Oxygen			
	gas flow or suction			
Input to LFG Utilization Compound	Trace Gas	Annually	LFTGN 04 (version 3.0 2010)	The concentration of trace gas components shall be assessed against the assumptions made in the Landfill gas risk assessment and dispersion modelling.
Input to LFG Utilization Compound	Methane	Weekly	LFTGN 04 (version 3.0 2010)	Where the oxygen concentration exceeds 5% or the % balance gas is greater than 20% an assessment of air ingress into the system shall be undertaken.
	Carbon Dioxide			
	Oxygen			
	gas flow rate			
	% balance gas			
	(Calculated as the difference between the sum of measured gases and 100 %)			

Methodologies and Equipment – in-waste gas monitoring and balancing

5.5.2 As before, a real-time landfill gas analyser GA2000 (or similar) will be used in monitoring of landfill gas concentrations in gas wells and manifolds. All used equipment (in-house or third party) should be serviced and calibrated in-line with the manufacturer's recommendations. All instrument service and calibration certificates will be kept in the site file and will be provided should NRW so request. It is recognised that the instrument can provide inconsistent data for carbon monoxide (CO) in the presence of hydrogen sulphide (H_2S). Therefore an H_2S filter shall be fitted and used during routine sampling.

5.5.3 All sampling procedures will be in line with the recommendations of the EA Guidance on the Management of Landfill Gas[3].

5.5.4 The gas field will be balanced as per the Gas Field Balancing Protocol and the Gas Monitoring Methodology in Appendix 1.

Trace Gas Monitoring

5.5.5 Table S3.8 in Environmental Permit EPR/BU7766IC requires that trace gas analysis is undertaken annually at the 'First EMS Unit'. The 'First EMS Unit' is not suitable for trace gas monitoring (due to too high suction pressure). Monitoring will be undertaken at a sample port on the gas main near the gas plant inlet.

5.5.6 Monitoring will be carried out in accordance with Environment Agency Technical Guidance Document LFTGN 04[10], Guidance for Monitoring Trace Components in Landfill Gas.

5.5.7 Trace gas samples will be analysed for the Environment Agency's (EA) Priority Trace Components suite which includes a range of volatile organic compounds (VOCs), aldehydes and arsenic.

5.5.8 Samples for each class of compound will be collected by using two sorbent tubes set in parallel, denoted left and right. A low-flow air pump will be used to draw the samples through the sorbent tubes, regulated by in-line flow rate calibrators.

5.5.9 Sampling volumes and flow rates will be set in accordance with LFTGN 04. All samples will be analysed by an UKAS accredited environmental laboratory. An infra-red gas analyser GA2000 (or similar) will be used to monitor the presence and concentrations bulk gases CH_4 and CO_2 as well as trace gases H_2S and CO at the sampling point.

5.6 Data Storage and Reporting

5.6.1 All monitoring data relating to routine and periodic landfill gas monitoring will be entered directly onto an electronic database system and hard copies of monitoring datasheets will be kept in files for reference. The Field log will also be kept in the site file.

5.6.2 The electronic database system will be used to collate, manage and report environmental data at the site. The system will hold details of all routine site landfill gas monitoring results, pressure measurements, and details of the monitoring points (coordinates, depth, etc.) In addition the system will hold all up to date monitoring requirements and trigger levels which if exceeded are highlighted on the system.

5.6.3 Routine landfill data will be downloaded onto the system directly from the site Gas Analyser.

5.6.4 Following a monitoring visit, the data will be assessed and a review of the monitoring results for the perimeter boreholes in relation to the gas field performance will be undertaken by the

[10] Environment Agency (March 2011) – Guidance for Monitoring Trace Components in Landfill Gas LFTGN 04 v3.0 2010

monitoring technicians. Any breaches of trigger levels (refer to Table 5.1) will be reported to NRW.

5.6.5 Reporting of landfill gas monitoring data to NRW will be in accordance with requirements of Schedule 4 of the PPC Permit as shown in Table 8 below:

Table 8: Reporting of Monitoring Data

Monitoring area description	Parameter	Monitoring frequency*	Other specifications
Permanently capped zone	Average methane flux and total methane emissions	Annually	Average zone emission rate of 0.001 mg/m^2/second
Temporarily capped zone	Average methane flux and total methane emissions	Annually	Average zone emission rate of 0.1 mg/m^2/second is

5.6.6 Point source emissions monitoring results will be reported annually as part of the annual monitoring review. All results will be provided in a detailed report, containing information on the sampling and analytical methodologies used operational details and the results reported at appropriate standard reference conditions and in comparison with the EP emission trigger levels. All monitoring data will be expressed in mg/m^3. Copies of all sampling worksheets, analytical certificates will be included in the report.

5.6.7 The perimeter landfill gas monitoring data will be reported quarterly (*quarterly review*) as factual reports containing summary of the collated data in tabulated form.

5.6.8 The results of landfill gas monitoring will be collated into annual monitoring report *(annual review*) detailing the following:

- The monitoring work undertaken during the reference period;
- Monitoring results (summarised as minimum, maximum and average);
- Plots of the data;
- Comparison of monitoring results to compliance limits
- Interpretation of the collated data and assessment of any trends;
- Details of any remedial actions carried out in the event of any breaches of compliance limits;
- Recommendations for any additional monitoring locations or changes to the monitoring frequency or analytical suites and amending the monitoring plan as appropriate.

5.6.9 Surface emission monitoring results will be reported annually as a monitoring report following the monitoring exercise. The reported results will include both factual tabulated data and the summarised calculated surface fluxes in every monitoring location. The report will provide interpretation of the collated data and assessment of the emissions against their PPC compliance limits. A site location plan showing the locations of flux box monitoring points will be provided with the report, and the completed Site Characterisation Summary as listed in LFTGN 07 will be used to summarise findings of the FID walk-over survey. A summary will be included in the Annual Review.

6.0 GAS ACTION PLAN

6.1 Introduction

6.1.1 This action plan establishes the steps required to be taken in the event of two key events relating to the control and monitoring of landfill gas at Bryn Posteg Landfill Site. These are:

a) Failure in any part of the gas control system; and
b) The breach of a trigger level or compliance limit for methane or carbon dioxide in any of the landfill gas monitoring points at the site.

6.2 Failure of Gas Extraction System

6.2.1 Landfill gas is currently managed by placing suction to the completed landfill and burning in a flare and in an engine. Gas extracted has condensate removed by a series of condensate traps and the resultant liquor is pumped to the leachate treatment plant or to soakaways within the existing landfill.

6.2.2 All extraction systems rely on mains electricity supply to provide power. Lack of mains electricity supply will result in an automatic failure of the gas extraction system.

6.2.3 Malfunction of the blower will stop collection of landfill gas and constitute a failure of the extraction system. Malfunction of the engines and/or the flare could mean that landfill gas can still be collected, but cannot be utilised and/or managed by flaring.

6.2.4 In addition, potential issues with the gas extraction system can inhibit extraction or active management and may lead to extraction system failure. Condensate accumulation within pipework can create localised 'blockages' to the flow of gas, particularly in areas where the extraction pipework may be undulating (e.g. due to differential settlement of the underlying waste). Air ingress due to breach of the integrity of the extraction system including well-heads, manifolds, valves, condensate management infrastructure and pipework could lead to high levels of oxygen entering the extraction system causing failure of the extraction system.

6.2.5 The gas extraction system will be inspected daily as part of the routine monitoring and management of the site (checks and recording of operational information at the blower), and during each monitoring visit to ensure the on-going operation of various components. Potters operate a system of undertaking regular checks of the gas collection system for any of the following:

- Cracks in any over-ground pipework
- Leaks at flange connection points on the gas infrastructure;
- Liquid build up in the over-ground pipework.

6.2.6 The results of each inspection will be recorded in the site records (field log), and any identified minor faults will be repaired immediately.

6.2.7 A failure of the extraction system to exert suction to the field will trigger the implementation of **section A of this Action Plan.**

6.3 Trigger Level Breach (lateral gas migration)

6.3.1 Landfill gas will be monitored at all boreholes located around the perimeter of the site, as required. The current trigger levels for the site are outlined in Table 9 below and are used as means of identifying possible lateral migration of LFG offsite. The trigger level represents the concentrations above background levels, at which the specified actions will be instigated, and is a lower concentration than the Permit Compliance Limit.

Table 9: Landfill Gas Control Levels

Trigger Level Action Plan			
Gas	**Monitoring point**	**Action level**	**Action**
CH_4	All perimeter boreholes	**0.8 %v/v (Control level)**	Inform site manager/supervisor. Measure differential pressure.
		1.0 % v/v (Permit Compliance Limit)	Inform NRW, and perform repeat monitoring for 3 consecutive days
		> 1.0 % v/v for 3 consecutive days or above 5.0% v/v on any visit	Follow steps outlined in this **Action Plan, Section B.**
CO_2	All perimeter boreholes	**1.3 % v/v (Control level)**	Inform site manager/supervisor. Measure differential pressure.
		1.5 % v/v (Permit Compliance Limit)	Inform NRW and perform repeat monitoring for 3 consecutive days.
		> 1.5 % v/v for 3 consecutive days	Follow steps outlined in this **Action Plan in Section B.**

6.3.2 Where there is evidence of background methane or carbon dioxide concentrations being above 0 %V/v due to the presence of off-site sources (such as peat), an investigation of the likely background concentrations will be carried out. This will include statistical analysis of the results and removal of any data likely to be affected by migration events from the site. These levels will be provided to NRW for review, and included in the site permit via a Permit Variation as appropriate.

6.4 Subsurface Landfill Fire

6.4.1 The site is routinely checked for the presence of possible landfill fires through visible inspection of the site and interpretation of monitoring results.

6.4.2 Fires in capped and uncapped areas are generally caused by the ingress of oxygen into the waste mass. The waste degradation process turns from anaerobic to aerobic generating more heat, which can result in spontaneous combustion. Fires can occur close to the surface or be deep seated

- Generally, a surface fire is the result of air ingress from atmosphere on an uncapped flank or infrastructure leak (e.g. well seal failure). They are relatively straightforward to deal with and affect a small area.
- Deep seated fires can be the result of long term air ingress into the waste or compressed air leaks. Because they are more difficult to access they have longer term effects and require a larger area of the gas extraction system to be isolated in order to manage the return to normal conditions.

6.4.3 A number of the following observations could indicate the presence of a sub-surface fire:

- Visual/olfactory signs:
  - Substantial settlement over a short period of time in a part of the site;
  - Smoke or smoulder emanating from the gas extraction system or landfill;
  - Combustion residue in extraction wells or headers;
  - Smell of damp bonfires
- Monitoring indicators:
  - Free (residual) nitrogen concentrations are often and significantly in excess of 20% (a sign of air ingress into the system and consumption of O_2);
  - Methane to carbon dioxide ratio is less than 1:1 (indication of aerobic conditions developing);
  - Elevated concentrations of oxygen, greatly exceeding 5% (high oxygen precedes a fire; once the fire is established, high CO_2 levels can be expected with low levels of methane and oxygen);
  - Increase in gas temperatures in the extraction system and excessive temperatures at the wells.
  - Elevated concentrations of CO (exceeding 100 ppm, trend of increase);

Carbon Monoxide

6.4.4 Carbon monoxide is created by incomplete combustion e.g. due to limited O_2 availability, and as such is a key indicator of the potential development of sub-surface fire.

6.4.5 Routine monitoring of carbon monoxide concentrations takes place using a Geotechnical Instruments portable gas analyser (GA2000). The typical accuracy of the GA2000 instrument CO reading is stated as +/- 10%. It is assumed that this is without any cross gas effect (interference with H_2S or H_2 gas). Table 10 below shows the approximate levels of CO concentration and the conditions of which they can be considered indicative:

Table 10: CO concentrations and likely conditions

Carbon Monoxide Concentration ppm	Likely conditions
1 ppm to 100 ppm	No underground combustion taking place
100 ppm to 500 ppm	Further investigation required (could indicate potential smouldering in the area)
500 ppm to 1000 ppm	Fire likely, further investigation required
>1000 ppm	Active sub-surface fire

Temperature monitoring

6.4.6 Carbon monoxide is created by incomplete combustion e.g. due to limited O_2 availability, and as such is a key indicator of the potential development of sub-surface fire.

6.4.7 During the initial aerobic degradation phase temperatures within waste may be as high as 80 to 90°C. Once methanogenesis is established temperature within the waste range from 30 to 50° and in the case of deep sites temperatures may reach 60°C. The likely conditions that can be inferred from temperatures in waste which is in established methanogenesis are included in Table 11 below.

Table 11: Temperatures and likely conditions

Temperature °C	Likely conditions
30°C to 50°C	Normal background temperatures during methanogenesis.
50°C to 100°C	Above typical background, area may be aerobic. Further investigation required.
Greater than 100°C	Unusually hot, subsurface fire likely. Further investigation required.

6.4.8 If it is suspected that a fire is present, then follow **Action Plan Section C**. Briefly, this entails:

- Creating conditions for the waste mass around the fire to become anaerobic – this will be achieved through turning off main isolation valves, closing all surrounding valves and wells, or completely turning off gas extraction depending on the size of the affected area;
- Sealing of pathways of air ingress – this involves locating all possible points of air (oxygen) ingress and sealing using engineered clay, hydrated bentonite or membrane.
- Cooling the affected area if required – this will be achieved through injection of water or leachate into the waste through existing wells, or if necessary, new wells;

A FAILURE OF GAS EXTRACTION SYSTEM

A.1 Identify cause of failure. Inform NRW immediately of the failure. Use the emergency number outside working hours.

A.2 If electric supply has failed, contact emergency electrician or if mains electricity supply has failed contact Manweb. If electricity cannot be restored for a period exceeding 4 hours, an alternative means of power generation will be pursued (e.g. using a diesel generator to power the blower/GEX).

A.3 If one or both gas engine unit has broken down, contact Finnings UK. The engine telemetry function notifies Finnings immediately of a failure, and they instigate an immediate response. Until the engine(s) are repaired, use the flare to control gas at the site, maintaining extraction. The flare has sufficient capacity to act as a back-up for both engines on site, either during routine maintenance or in the case of an emergency.

A4. If flare unit has broken down, contact GTS in the first instance. If it is deemed likely that the system will not be operational within 48 hours then make arrangements for alternative hire/replacement equipment to be provided. The sourcing of a back-up flare should start within 12 hours. This may be organising re-connecting of the old flare or provision of a rental flare. Contact details for flare providers are provided in the table below.

A.5 If the condensate pumping system has failed, contact Gwynt Cymru.

A.6 If elevated concentrations of methane are identified in the perimeter boreholes, the section B of this action plan should be instigated.

Table A: Emergency flare providers

Monitoring frequency*	**Other specifications**
Greenfield Technical Services (current Flare provider) Unit 5, The Old Factory Buildings, Battenhurst Road, Stonegate East Sussex TN5 7DU	Telephone +44 (0) 01580 201066 Mobile +44 (0) 7710 345917 or +44 (0) 7860 837857 – Email: info@greenfieldtechnical.com
SGG Environmental Services Ltd Units 2 & 3, 300 Cleveland Street, Birkenhead CH41 4JN	Telephone: +44 (0)1516471440 Email: info@sggesl.co.uk

B TRIGGER LEVEL BREACH IN PERIMETER MONITORING BOREHOLES

B.1 If a perimeter gas trigger limit is breached, the site manager/supervisor will be informed immediately and relative gas pressure will be monitored in the affected borehole.

B.2 If the concentration of methane or carbon dioxide in a perimeter monitoring point is detected above the Compliance Limit, NRW will be informed with the submission of a Schedule 5 Notification of the breach, once verified, as required by the Permit. The location of the breach will be sampled daily for 3 consecutive days to verify the obtained result and identify any trends.

B.3 If no decreasing trend can be identified after the 3 day repeat monitoring, or methane concentrations above 5% are identified on any of the repeat monitoring visits, immediately start investigating the reason and nature of the breach. This may include, but not be limited to:

- Review of gas control system in discussion with gas field manager, including if it is operating normally, its integrity, particularly in the area near the breach, and any recent changes to the extraction system or gas plant. This review shall include:
  - Visual inspection of the integrity of the gas extraction system, including condensate systems, pipework, and all associated headworks and valves for signs of physical failure and possible vandalism;
  - Checking 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.

  Instigate immediate measures to remediate any problems identified. If gas control system has failed instigate section **A** of Action Plan.
- An assessment of weather conditions at the times of monitoring, including evaluation of atmospheric pressure, frost or freezing ground conditions, heavy rainfall, etc.
- Possible fluctuations of leachate and groundwater in the vicinity of the site.

B.4 Whilst investigation is underway, the following measures will be implemented to aid the decrease of the methane and carbon dioxide to below the trigger levels.

- The borehole(s) shall be monitored weekly, until the gas is below the agreed trigger level. All results will be forwarded to NRW.
- In-waste wells in the closest part of the landfill will be monitored for gas quality and where possible, increased suction will be applied to wells in the vicinity of the affected boreholes

B.5 If after 14 days of non-compliance, methane levels are not reducing (or 4 weeks in the case of carbon dioxide), and a reason for gas migration is not evident, inform NRW immediately. Take gas samples as soon as practicable for confirmatory landfill gas chromatography analysis for methane, or trace analysis for carbon dioxide. A review of off-site monitoring measures and landfill gas extraction procedures should also be undertaken. This may include an options

appraisal for infrastructure improvements, including additional in waste landfill gas extraction wells, scavenger pin wells, or adding extraction head works to perimeter wells if very high concentrations of methane (over 40 %) are present.

B.6 Additional measures for controlling gas may need to be considered and implemented on a risk-benefit basis, including, but not limited to:

- connecting perimeter wells to the gas extraction system (and installation of further perimeter wells outside of the line of the connected wells to confirm efficiency of this measure in controlling lateral migration);
- Installation of gas cut-off trenches or walls, that would prevent migration towards sensitive receptors;

C SUB-SURFACE LANDFILL FIRE

Steps to investigate possible onset of subsurface fire

C.1 If the first indication of the development of a hotspot is high CO reading (above 100 ppm), with a hand-held analyser, a second reading should be taken within 24 hours with a H_2S filter fitted, to ensure that the presence of H_2S did not influence the CO reading. If the level is still above 100 ppm, a bag sample will be taken for laboratory analysis.

C.2 If CO levels in excess of 100 ppm are confirmed by the gas bag sample analysis, the well and surrounding area will be checked for other evidence of sub-surface fire. The temperature inside the well will be measured.

C.3 If CO concentrations are <500ppm and the temperature is >50°C, but below 100°C, repeat CO measurement daily in the affected borehole and all surrounding boreholes and monitor trend. Conduct an audit of the gas extraction infrastructure, looking for possible points of air ingress (e.g. FID survey). Decrease high suction in affected area to alleviate any air ingress.

C.4 If CO concentration is above 500 ppm, temperature is above 100°C after 5 days of daily monitoring, and/or trend of CO concentrations shows increase, Instigate emergency procedure actions (below).

Emergency procedures

C.5 If after the actions detailed above, CO concentrations, temperature and observations indicate that a subsurface fire is likely, or a sub-surface fire is evident from other visual and monitoring observations, instigate these emergency procedures.

C.6 The person discovering the suspected fire should notify immediately the Site Operations Manager or in his absence the Site Supervisor, and the Environmental Manager. NRW will be informed as soon as practical and be advised of actions to be taken.

C.8 Where a fire is suspected, the gas wells in the affected area should be turned off to minimise the ingress of oxygen. This should result in the oxygen being depleted and smothering the fire.

C.9 If the fire is in a vent or a leachate chamber in an area where no extraction is taking place, then the vent or chamber should be capped with clay-like material.

C.10 Any point sources of oxygen ingress shall be sealed. This may be by a fabricated seal or using clay-like material depending on the point requiring sealing.

C.11 Gas wells will not be turned back on in the affected area until CO concentrations and temperatures have returned to normal (see Table 10 and 11). This should be by agreement of the Site Manager, Technical Manager and NRW.

C.12 A monitoring and fire remediation strategy will be developed in consultation with the landfill operator NRW based on:

- The particular fire characteristics – location, depth, size, etc;
- The site location and site/cell design;
- Limitations – migration issues, leachate levels.

C.13 The monitoring strategy will include, but not be limited to, regular monitoring of the surrounding wells for temperature, nitrogen, carbon monoxide and hydrogen, in addition to bulk landfill gas parameters.

C.14 The information gained from this monitoring will be used to identify trends so that the development and remediation of the fire can be assessed. The first dataset should be obtained prior to making changes to the gas extraction system. The frequency, and duration of monitoring will depend on the type, location, and the speed of development of the sub-surface fire.

Long term management

C.15 Sub-surface fires may take some time to be brought under control. Following the initial action of cutting off the oxygen supply the following may be considered in consultation with NRW:

- Dig out waste away from the seat of the fire and infill with clay-like material to prevent fire from spreading to other areas
- Let leachate level in affected area to rise to douse fire;
- Introduce leachate to the affected area to douse fire;
- Where fires are shallows then infra-red may be used to monitor the fire.

Re-instating of extraction

C.16 When CO concentrations have remained below 100 ppm for at least six consecutive weeks, the 'no extraction' zone will be reviewed and gradually reduced. The length of time can vary depending on the size and location of the fire (surface or deep), and will be balanced against the risk assessment in terms of odour and gas migration that may be occurring while the system is switched off.

C.17 Providing no further evidence of the subsurface fire occurs, extraction will be resumed to balance levels (0 mbar) until remediation of infrastructure has been completed.

C.18 When infrastructure remediation is complete, extraction will be slowly (increased by 5% of previous levels on a weekly basis) returned to optimal levels.

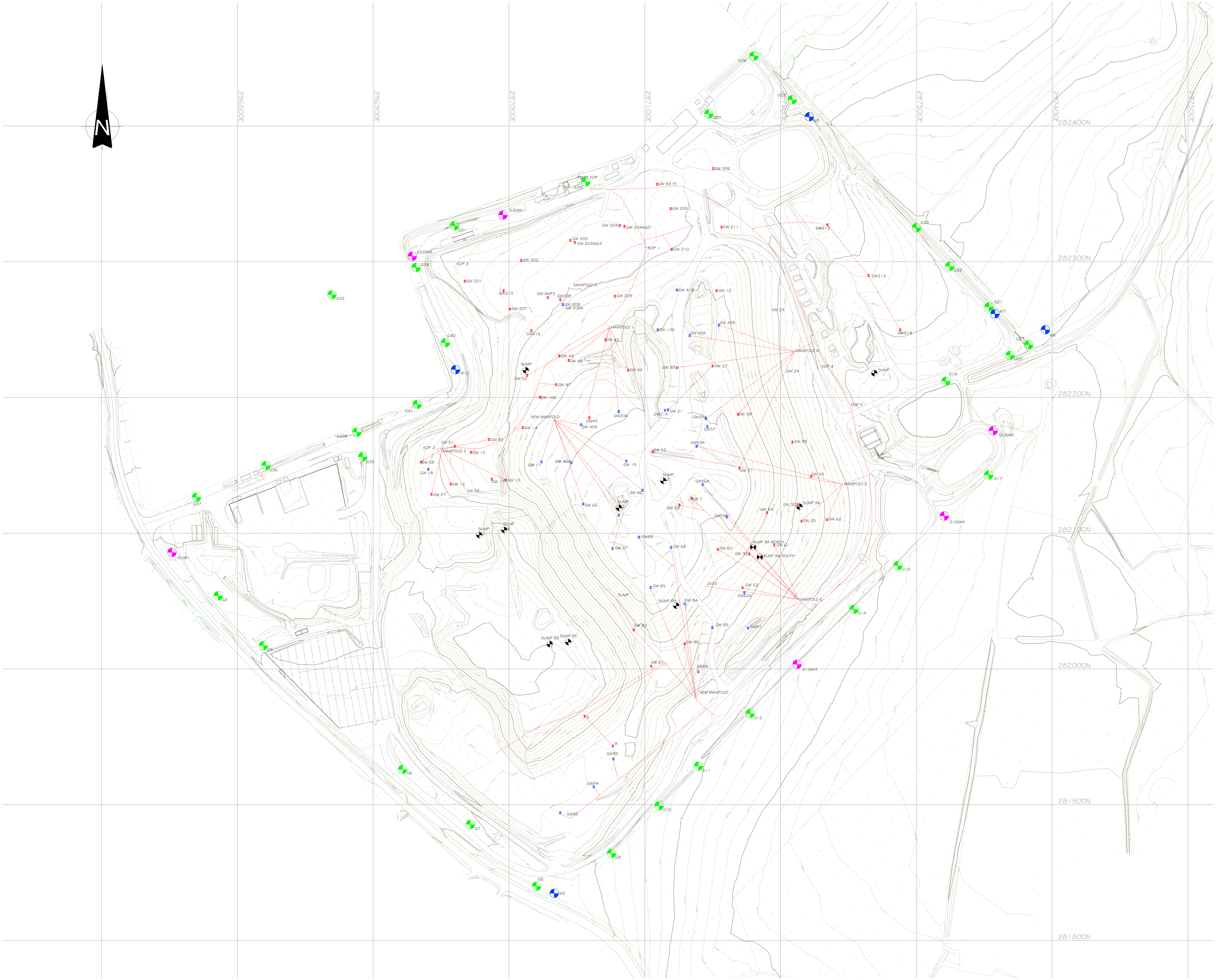
C.19 Intensive monitoring should continue during the period up to and after the vacuum has been reinstated to normal, based on site risk assessment and trends in the data.

7.0 AFTERCARE

7.1.1 The aspects of site aftercare, relating to the management of landfill gas after the closure of Bryn Posteg Landfill site, will be detailed in the Closure Plan for the site.

DRAWINGS

3428-CAU-XX-XX-DR-V-1807 Site monitoring and extraction infrastructure.



REV	MODIFICATIONS	BY	RE	AP	DATE
P2	RE-SCALED TO 1:1250	EJD	DB	DB	07.03.18
P1	ISSUED FOR COMMENT	EJD	DB	DB	20.02.18

POTTERS WASTE MANAGEMENT

PROJECT:

BRYN POSTEG LANDFILL SITE

TITLE:

GAS EXTRACTION AND MONITORING INFRASTRUCTURE PLAN

DRAWN BY: EJD	DATE: 20.02.2018
REVIEWED BY: DB	SCALE @ A1: 1:1250 — JOB REF: 3428
AUTHORISED BY: DB	ISSUE: S1 — REVISION: P2

DRAWING NUMBER: 3428-CAU-XX-XX-DR-S-1807

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APPENDIX 1

a) Landfill gas monitoring methodology
b) Monitoring field log
c) Landfill gas field balancing protocol
d) In-Waste gas well record
e) Condensate pump schedule
f) Employee training record

Landfill Gas Monitoring Methodology

Equipment and Maintenance

Gas monitoring will be carried out using an approved portable gas analyser, capable of reading methane, carbon dioxide, oxygen and atmospheric pressure.

The instruments will be serviced in accordance with the manufacturers' recommendations.

A log of maintenance and calibration is to be kept by the contractor and be available for inspection on demand.

Landfill Gas Protocol

Before leaving the office:

i. Check in-line hydrophobic filters and replace if necessary. Check the battery life is sufficient for the monitoring visit, and

ii. Check the analyser is within its calibration date.

On site:

i. Record the date, atmospheric pressure, pressure trend, instrument type and serial number, name of technician and on-site weather.

ii. During the course of the monitoring visit a visual inspection of the site and its surroundings should be carried out making a note in the Field Log of any vegetation die-back, leachate outbreaks, odour and similar.

At the borehole:

i. Record any damage to headworks, tap or cap in the Field Log;

ii. (Refer to Gas Analyser Manual): Attach sample tube to the sample tap, open tap, record atmospheric pressure then switch on analyser pump;

iii. Once constant readings are obtained, record readings;

iv. Close gas tap, remove tube, allow pump to run to flush out any residual gas before taking the next sample;

v. If water level data is required remove borehole cap and measure relative to cover level (or otherwise agreed borehole datum); and

vi. Reseal borehole.

Reporting Result:

i. Inform the Technical Manager of any results in excess of the control levels or any problems recorded as part of visual inspection.

ii. If required, instigate Section B of the Gas Action Plan; and

iii. After the visit, the data should be transferred to the Company's database. Any repair or remediation work should be organised if required. A Field Log for the visit should be created manually for the visit. A report should be printed and distributed and a copy kept on the site file in the weighbridge office.

PottersWasteManagement

Bryn Posteg Landfill Site - Environmental Monitoring Field Log	
Date:	
Personnel:	
Weather Conditions:	
Equipment Utilised:	

Comments and observations (ex broken equipment, odours, leachate outbreaks, vegetation dieback, gas wells/boreholes dipped, liquid levels, condensate management):

Actions on Site

Gas Well	Description	Action taken	Action Required	Date Repaired Inspected

Faults / Recommendation

Gas Well	Description	Action taken	Action Required	Date Repaired Inspected

Gas Analyser Data Downloaded?	
Required Remediation Actioned?	
Signature:	

Landfill Gas In-Waste Monitoring and Balancing Protocol

A typical landfill gas monitoring methodology that will be adopted by Potters is provided in the following table. The details given are for monitoring of the gas extraction system within the waste mass.

Monitoring Schedule – Gas Extraction Within the Waste Mass

When	Action
After Commissioning	• Connect wells to active extraction system having followed CQA plan for construction. • Walk system and set all new valves to just open. Visually inspect all mechanical connections, and look for signs of disturbance. • Commence extraction and monitor extraction pressure (p), methane (CH_4), carbon dioxide (CO_2), carbon monoxide (CO), oxygen (O_2) and balance gas at the extraction plant. • Allow to stabilise for @ 1 hour. Check each point of connection into the system (either individual wells or groups) for pressure, methane, carbon dioxide, carbon monoxide and oxygen. • Adjust valves to initially balance out pressure across the system (with appropriate regard for quality, if O_2> 5%, then close valve and investigate) • Upon completion record final settings and results – monitor boreholes to obtain revised baseline condition. • If gas quality of the extracted gas is inappropriate to the carrier system or means of disposal, isolate the system and undertake a design review.
After first 24 hours	• Undertake complete monitoring exercise prior to any adjustment of wells measuring p, CH_4, CO_2, CO, O_2 and balance gas at each well, and these parameters plus flow at the point of connection to the extraction system. • Record results. Provided CO and O_2 have not risen, or methane significantly declined, continue to operate at existing set points. If CO or O_2 have risen or methane reduced locate contributing well or wells and isolate or reduce outflow.
After 72 hours	• Undertake complete monitoring exercise prior to any adjustment of wells measuring p, CH_4, CO_2, CO, O_2 and balance gas at each well, and these parameters plus flow at the point of connection to the extraction system. • Record results. Review relationship between vacuum and flow across the system. • Adjust wells to account gas quality experienced – reduce flow or isolate if O_2 > 5% or CO > 100 ppmV or if CH_4 has declined by more than 2% since previous result, or is less than 35%.
Weekly thereafter	• Undertake complete monitoring exercise prior to any adjustment of wells measuring p, CH_4, CO_2, CO, O_2 and balance gas at each well, and these parameters plus flow at the point of connection to the

When	Action
	extraction system. • Record results. Review relationship between vacuum and flow across the system. • Adjust wells to account gas quality experienced – reduce flow or isolate if individual well O_2 > 5% or CO > 100 ppmV or if CH_4 has declined by more than 2% since previous result, or is less than 35%. • If steady state conditions are established, and migration to atmosphere is being contained by the control system, the frequency of system monitoring and balancing may be reduced to monthly, but using the weekly monitoring regime.
Monthly thereafter in addition to the weekly sequence.	• Undertake data review and assessment of operating conditions, well yields and impact on monitoring system. Compare actual result to original design and projection – if conditions have varied significantly complete design review and consider system augmentation.

Equipment and Maintenance

Gas monitoring will be carried out using an approved portable gas analyser, capable of analysing and recording methane, carbon dioxide, oxygen and atmospheric pressure.

The instruments will be serviced in accordance with the manufacturers' recommendations.

A log of maintenance is to be kept by the contractor for inspection on demand.

Landfill Gas Protocol

Before leaving the office:

i. Check in-line hydrophobic filters and replace if necessary. Check the battery life is sufficient for the monitoring visit, and
ii. Check the analyser is within its calibration date.

On site:

i. Record the date, atmospheric pressure, pressure trend, instrument type and serial number, name of technician and on-site weather.
ii. During the course of the monitoring visit a visual inspection of the site and its surroundings should be carried out making a note in the Field Log of any vegetation die-back, leachate outbreaks, odour and similar.

At the borehole:

i. Record any damage to headworks, tap or other infrastructure in the Field Log;
ii. (Refer to Gas Analyser Manual): Attach sample tube to the sample tap, open tap, record atmospheric pressure then switch on analyser pump;
iii. Once constant readings are obtained record readings;
iv. Close gas tap, remove tube, allow pump to run to flush out any residual gas before taking the next sample;
v. Adjust valves if required (see table above).
vi. If water level data is required remove borehole cap and measure relative to cover level (or otherwise agreed borehole datum); and
vii. Reseal borehole.

Reporting Result:

i. Inform the Technical Manager of any anomalies or any problems recorded as part of visual inspection.
ii. Inform NRW by fax or email of any breaches in trigger levels and the proposed actions, within 24 hours of the monitoring visit;
iii. After the visit, the data should be transferred to the Company's database. Repair/remediation work should be organised if required. A Field Log for the visit should be created manually for the visit. A report should be printed and distributed and a copy kept on the site file in the weighbridge office.

LS33

Description		Throttle Valve	
Well Depth		Monitoring Point	
Well Dia		Pump Type	
Well Head		Pump Depth	
Manifold	6	Pump Counter	
Gas Pipe Dia		Air	

Date Reported	Date Fixed	Fault / Description	Action Taken	Supplier	Price

LS33

Description — **Throttle Valve**
Well Depth — **Monitoring Point**
Well Dia — **Pump Type**
Well Head — **Pump Depth**
Manifold — **Pump Counter**
Gas Pipe Dia — **Air**

Date	Well Depth	Pump Depth	Dip 1 after taken pump out	Time Taken Out	Dip 2 before pump back in	Time Put In	Pump Depth	Pump Type, Top / bottom loader	Pump Serial Number	Fitter /Repairer

PottersWasteManagement

TRAINING RECORD

Name:	Position:	Sheet Number: 1
Date:	**Training Details (description, course title etc.):**	**Conducted / issued by:**

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