Landfill Gas Management Plan

Dardanup Landfill

Crooked Brook, WA 6236

License Number: L8904/2015/1

Version 003

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Contents

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1 Introduction

1.1 Purpose

This Landfill Gas Management Plan (LGMP) - Version 003 has been prepared by Cleanaway Solid Waste Pty Ltd (Cleanaway) for the Dardanup Landfill (the Site). The Site is a Class III putrescible landfill and liquid waste facility that is located in Crooked Brook, Western Australia. This LGMP has been prepared to satisfy regulatory requirements and for submission as part of the Cell 9 works approval.

1.2 Approach

Cleanaway owns and is responsible for operation and management of landfills across five States of Australia. Although the requirements for management of landfill gas vary from State-to-State, Cleanaway has adopted a standardised approach where the LGMP's that have been prepared for each landfill site follow the same general overall format. This provides a consistent approach across the company for management of landfill gas with respect to system design as well as procedures for operations, monitoring and reporting.

LGMP documentation associated with management of landfill gas at the site includes three parts, as follows:

- Part 1 - Landfill Gas Management Plan (this document).
- Part 2 - Site-specific monitoring reports.
- Part 3 – Reference Information, including regulatory guidelines and industry information.

The LGMP for the site is intended to be a living set of these three documents. The LGMP will be reviewed approximately once every two years and the LGMP may be updated as additional information and monitoring results become available.

1.3 Regulatory Framework

Landfills are recognised as being an important part of the waste management infrastructure in Western Australia and they are regulated by the Department of Water and Environment Regulation (DWER). In addition, the site must comply with relevant statutory instruments including but not limited to:

- Environmental Protection (Unauthorised Discharges) Regulations 2004, which pertain to management of stormwater.
- Environmental Protection (Controlled Waste) Regulations 2004, which pertain to management of controlled waste.
- Bush Fires Act 1954 (WA) provides for prevention control and extinguishment of bush fires and diminishing bush fire danger for the public.

DWER has issued a license for the site (License Number: L8904/2015/1, dated 12 May 2020) that allows for disposal of 350,000 tonnes per year of Class II or Class III putrescible waste and 353,000 tonnes of liquid waste. The expiry date of the license is 2 August 2035. The site also has land use approval from the Dardanup Shire Council.

1.4 Risk Assessment

Landfills produce landfill gas as organic materials decompose under anaerobic conditions. Anaerobic conditions occur when oxygen present in the voids of waste placed at a landfill is consumed by aerobes (micro-organisms which consume air to respire), leaving an environment that is free of oxygen.

The landfill gas generation rate is affected by many factors including refuse composition, the waste age and quantity, condition of the waste mass, moisture content, pH, temperature and maintenance of an anaerobic environment. Landfills can continue to generate landfill gas for many years following the closure of a landfill. An overview of landfill gas is provided in Appendix A.

The emission and migration of landfill gas can potentially cause adverse effects on the environment and these conditions were subject to a formal Risk Assessment in accordance with Cleanaway's HSE Management System. This manual provides a guide for the establishment and implementation of the risk management process involving the identification, assessment, evaluation, treatment and ongoing monitoring of risk. The risk assessment undertaken identified the following potential hazards associated with landfill gas at the site:

- Direct atmospheric emissions of landfill gas impacting both environmental receptors and human health.
- Exposure of on-site workers to landfill gas impacting human health, amenity and risk of fire or explosion.
- Subsurface migration of landfill gas impacting human health, groundwater contamination and fire and explosion risk.
- Fire or explosion on site due to landfill gas or accelerated by landfill gas, including fire coming from off site.
- Non-conformance with regulatory requirements and community expectation leading to exposure to enforcement action or reputational damage to Cleanaway.

By the implementation of risk mitigation strategies, the level of risk from landfill gas can be controlled. The risk mitigation strategies implemented at the site include engineering controls, administrative controls and use of personal protective equipment. Following implementation of these controls a number of risks remain rated as a medium risk or higher. The risks identified as having a medium or higher residual risk are:

- On-site worker exposure to LFG in excavation impacting odour and amenity. (Medium)
- On-site worker exposure to LFG in excavations impacting human health including the risk of asphyxiation. (High)
- On-site worker exposure to LFG within LFG infrastructure works impacting human health including the risk of asphyxiation. (High)
- Risk of fire or explosion within or close to LFG infrastructure impacting human health. (Medium)
- Risk of fire or explosion on site due to LFG, through accumulation or methane accelerant impacting environment including through liner damage. (Medium)
- Non conformance with regulatory requirements leading to Cleanaway exposure to regulator enforcement action. (Medium)
- Non conformance with community expectation leading to Cleanaway reputational damage. (Medium).

The controls identified within the risk assessment are discussed in the following sections of this LGMP. The primary control is the installation, operation, maintenance and monitoring of an active landfill gas recovery system at the site. The OH&S controls identified as a part of the risk assessment are contained within Cleanaway's OH&S system and are not addressed in this document. The risk assessment for the site is provided in Appendix B.

2 Site Information

2.1 Location

The site is located at Banksia Road, Crooked Brook, Western Australia, 6236, (Lot 2 Plan 65861) which is approximately 170 kilometres southwest of the Perth Central Business District. The site is located within a rural area that is predominately surrounded by State Forest and farmland. The site is bounded by the following land uses:

- North - Dardanup Shire former landfill
- East - Dardanup Conservation Park (State Forest)
- South – Dardanup Conservation Park (State Forest) Approx. 1.5 km to nearest residence
- West – Sand mining, Banksia Road, broad-scale agriculture. Closest resident approximately 0.54 km south-west.

The closest dwelling is located approximately 1.8 km northwest of the site. A site location and vicinity map is provided in ***Figure 2-1***.

2.2 Site Description

The site occupies 122 hectares and was originally developed by Kingscape Holdings Pty Ltd (J&P Metals). A licence was issued for the site to operate as a Class II landfill in June 2000. In May 2005, the license was reissued and upgraded to Class III Landfill. In October 2006, the license was transferred to Cleanaway. The site license currently allows for disposal of 350,000 tonnes per year of Category 64 Class II or Class III putrescible (solid) waste and 353,000 tonnes of Category 61 (liquid) waste. The site includes a solid waste disposal area, liquid waste area, ancillary facilities and buffer areas.

The landfill disposal area is an engineered structure that is being developed and filled in a progressive manner. New cells are constructed as previous cells are nearing completion and then filled with waste before being capped. Upon completion, the site will be capped and rehabilitated to provide a stable landform which prevents escape of harmful contaminants into the environment. The final contours of the site will be consistent with the surrounding landform and the rehabilitated landfill footprint is currently proposed to be suitable for open space land uses.

2.3 Site Layout

The landfilling activities and ancillary support facilities are located within the boundaries of the site. The historic filling areas are designated as follows:

- Cells 1 and 2 are located near the centre of the site.
- Cells 3 and 4 are located immediately adjacent and to the north of Cells 1 and 2.
- Cell 4B is located immediately adjacent and to the west of Cell 4.
- Cell 5 is located immediately adjacent and to the east of Cell 4.
- Cell 6 is located immediately to the east of Cell 5.
- Cell 7 is located immediately to the east of Cell 6.
- Cell 8 is located immediately to the east of Cell 7.
- Cell 12 is located immediately to the north of Cell 4B.
- Tronox Cells 1 & 2/2a are located to the south of Cells 1 and 2.

In addition to the landfill cells, there are separate processing areas for recovery of metals and construction and demolition wastes.

2.4 Utility Services

Utility services do not enter the site. All electrical power generation is supplied by multiple diesel generators. A landfill gas generator is installed at the site but is not currently in service. Potable water is delivered to the site in bottle dispensers for drinking requirements. Stormwater is collected for on-site for use and all taps and facilities are identified with signage indicating that the water is non-potable.

Wastewater is managed through on-site septic treatment systems, with pump-out to approved disposal facilities when required. Communications are via line of sight internet tower, mobile phones and a two-way radio system.

2.5 Geology and Hydrogeology

The site is located on the western edge of the Whicher Scarp with superficial deposits consisting of mainly sandy clays and clayey sands overlain by sandy topsoil and laterite. These deposits are underlain by variably laterised sandy clay or clayey sand over highly plastic sandy or silty clays of the Leederville Formation in the eastern portion of the site, and by the variably iron cemented clayey sands of the Yoganup Formation in the western portion of the site. The site is underlain by a shallow aquifer which is confined and is not connected to the deeper aquifer present in the Leederville formation or to any similar aquifers nearby.

2.6 Local Meteorology

Dardanup experiences a temperate climate with distinctly dry and hot summers (BOM, 2005); this climate is often referred to as Mediterranean. The closest Bureau of Meteorology weather stations are at Dardanup (rainfall only), Marriwood (5 km south, rainfall only) and Boyanup (9 km south, rainfall only). Weather stations at Bunbury (11 km west) and Donnybrook (20 km south) record rainfall, temperature, relative humidity, and wind speed and direction. Wokalup is the closest station recording evaporation and is 32 km north.

Mean annual rainfall is 718.4 and has varied from 484.4 mm in 2010 to 995.6 mm in 1999. On a monthly basis, mean rainfall is < 20 mm/month from December to March, increasing to over 115 mm/month in winter. Pan evaporation is 1825 mm/yr and is also markedly seasonal. Evaporation exceeds rainfall from October to April, is approximately equivalent in May and September and less than rainfall from June to August. Mean daily temperatures range from approximately 15-30 °C in summer and from 8-18 °C in winter. Wind roses for Perth show that afternoon spring and summer winds are predominantly from the south west at 20-30 km/hr whereas as autumn/winter winds are less frequent but mainly from the west to south-west and more likely to be 10-20 km/hr.

3 Landfill Gas Generation and Recovery Estimate

3.1 Methodology

Landfill gas generation rates for the site were modelled in 2015 using the Tier 2 First Order Decay model provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories - using site-specific input values that were selected based on site information and experience. This approach has been used extensively to model landfill gas generation rate curves for individual landfills. It can also be used to model gas generation for a set of landfills to develop country baseline emissions estimates or can be applied in a more general way to entire regions. The equation is as follows:

$$\mathbf{Q = L_o\, R\, (e^{-kc} - e^{-kt})}$$

Where:

Q	=	Methane generated in current year (m^3/yr)
L_o	=	Methane generation potential (m^3/Mg of refuse)
R	=	Average annual waste acceptance rate (Mg/yr)
k	=	Methane generation rate constant (1/yr)
c	=	Time since/to landfill closure (yr)
t	=	Time since landfill opened (yr)

To allow for variances in annual acceptance rates, a derivative of the above equation with respect to t can be used to estimate methane generation from waste landfilled in a single year (R_x). In this equation, the variable t is replaced with T-x, which represents the number of years the waste has been in the landfill. The resulting equation thus becomes:

$$\mathbf{Q_{T,x} = k\ R_x\ L_o\ e^{-k(T-x)}}$$

Where:

$Q_{T,x}$	=	The amount of methane generated in current year (T) by the waste R_x in (m^3/yr)
L_o	=	Methane generation potential (m^3/Mg of refuse)
R_x	=	The amount of waste disposed in the year (x) (Mg)
k	=	Methane generation rate constant (1/yr)
x	=	The year of waste input
T	=	Current year

In order to estimate the current emissions from waste placed in all years, the above equation can be solved for R_x and the results summed as shown below:

$$\mathbf{Q_T = Sum\ Q_{T,x}}$$

One model was developed for the site to provide an initial estimate of the landfill methane generation rate at the site. Input data for the model was developed from a review of available information for the site. The projected landfill gas generation rate for the site was calculated by multiplying the methane generation result by two, which is based on landfill gas comprising 50 percent methane and 50 percent carbon dioxide.
The area of coverage of the landfill gas system and the efficiency of this system was then used to estimate

the quantity of landfill gas that could potentially be recovered from the site. A brief discussion of the key input information, assumptions, and model output are provided below. In the future, the model will be “calibrated” against actual recovery results.

It should also be noted that the methodology that is provided under the National Greenhouse and Energy Reporting System (NGERS) was not used for estimating emissions to be managed in this LGMP. The rationale for this decision is that the NGERS is used for emissions reporting and due to uncertainties associated with the methodology it is not considered appropriate for design and management of landfill gas systems.

3.2 Inputs and Assumptions

Tonnages of Solid Waste

The annual quantities of solid waste received at the site were obtained from weighbridge records for the period from 2010 to 2014. Projections were also made for the expected waste disposal rate from 2015 until the site closes in 2050.

Methane Generation Potential (Lo)

The methane generation potential (L_o) depends upon the composition of refuse present in a landfill. The USEPA reports that the values for (L_o) can range from 6.2 to 270 m^3/tonne. In addition, the USEPA has established the following default parameters for L_o for municipal solid waste landfills in the United States:

- Clean Air Act (CAA) default value of 170 m^3/tonne
- AP-42 “old” default value of 125 m^3/tonne
- AP-42 default value of 100 m^3/tonne
- NGERS site-specific calculated value of 81.87

The AP-42 default value of 100 m^3/tonne was selected as being appropriate for the initial modelling and estimating landfill gas emissions from the site.

Methane Generation Rate Constant (k)

The methane generation rate constant (k) determines the rate of generation of methane for waste in a landfill. The value of k is a function of refuse moisture content, availability of nutrients for methanogens, pH, and temperature.

The USEPA reports that the values of k can range from 0.003 per year to 0.21 per year. The USEPA has also established the following default parameters for k in the United States:

- Clean Air Act (CAA) default value of 0.05/yr
- AP-42 default value of 0.04/yr for moderate climates and 0.02/yr for dry climates
- NGERS climatic zone value of 0.026/yr

Based on a review of the available information, the NGERS climatic zone value for k of 0.026/yr was selected as being appropriate for the site.

Landfill Gas System Coverage

It is estimated that the initial landfill gas recovery system will have coverage of approximately 45 percent of the waste in place and will have a collection efficiency of 65 percent. The system will be expanded over the remaining life of the site and the recovery rate will increase as final capping is placed over the completed disposal areas.

Landfill Gas System Monitoring

Monitoring results from the initial landfill gas recovery system that has been installed at the site, as described in Section 4.0, indicated that approximately 260 m^3/hour of landfill gas at 51.4 percent methane was being recovered from the site in November 2015. This information was used to “calibrate” the landfill gas generation and recovery model.

3.3 Results

Based on the information above, one model run was performed to estimate the total landfill gas generation and recovery rate at the site. Based on these assumptions, it is estimated that the initial recovery rate will be approximately 300 m^3/hour of landfill gas at 50 percent methane. Under the model projection, the total quantity of landfill gas that is generated at the site will increase to a peak following closure of the site in 2045. Landfill gas quantities will decrease after that time.

The landfill gas recovery system will be expanded as the site develops. It is estimated that the system will ultimately recover approximately 50 percent of the landfill gas that is generated. In addition, it is estimated that 10 percent of the remaining gas will be oxidised in the landfill cap – thereby reducing the potential for fugitive emissions and subsurface migration.

3.4 Uncertainty

There is uncertainty in the estimation of landfill gas emissions from solid waste disposal in landfills which is consistent with industry experience. The areas of uncertainty include:

- Uncertainty attributable to the method;
- Data uncertainty; and
- Uncertainty associated with the performance of the landfill gas recovery system.

The IPCC first order decay model has been used to estimate the landfill gas generation rate. Best estimates of site specific Lo and k values have been made based on the composition of the waste received, the historical rainfall values and site conditions. With regard to the uncertainties relating to the performance of the landfill gas recovery system, a modern well engineered system will be installed at the site.

Based on the considerations outlined above, the accuracy of the methane generation model is estimated to be in the range of ±25 percent for the current year, with potentially greater variances over the long-term. However, once the landfill gas recovery system has been installed at the site, the operational data and annual reporting results will be used to “calibrate” and update the model to reflect the site conditions.

4 Landfill Gas Recovery System

4.1 Overview

The principal function of the landfill gas system is to recover gas from the disposal cells. This will reduce the potential for discharges to atmosphere and reduce the potential for subsurface migration. An active landfill gas recovery system has been installed at the site. The initial landfill gas recovery system includes the following major components:

- Permanent vertical extraction wells
- Permanent horizontal extraction wells
- Laterals and headers
- Condensate system
- Blower flare station.

The layout and details regarding the design of the landfill gas recovery system is provided in Appendix D.

The landfill gas recovery system will be expanded in the future to recover gas from other disposal areas as the site is developed. In the future, options for beneficial use of the recovered landfill gas, such as for direct use of electricity generation, will be evaluated. The landfill gas system will be operated and maintained throughout the operational life of the landfill as well as the designated aftercare period.

4.2 Basis of Design

It is recognised that landfill gas recovery rates at modern landfills can be in the range from 60 to 75 percent. The initial landfill gas recovery system at the site was designed with the objective to recover approximately 30 percent of the landfill gas that is generated at the site. This system has been progressively expanded since the initial installation to increase the amount of landfill gas recovered. A proposal for further expansion of the recovery system has been submitted to DWER for approval. In addition, it is estimated that some of the remaining gas will be oxidised in the landfill cap, thereby further reducing the potential for direct release of emissions to atmosphere and reducing the potential for subsurface migration.

4.3 Quality Assurance

The active landfill gas recovery system at the site has been designed and installed by an experienced specialist contractor – Run Energy (www.runenergy.com). The blower/flare station was supplied by Australian Burner Manufacturers (ABM) (www.abmcombustion.com), an experienced equipment supplier. Run Energy is retained to conduct regular monitoring, maintenance and balancing of the landfill gas recovery system.

The landfill gas recovery system has been designed by Run Energy in general accordance with international practice and local standards for management of landfill gas. The design has been reviewed internally as part of Run Energy's quality assurance procedures. All expansions to the system will be subject to these design requirements, with the construction and commissioning overseen by qualified persons.

4.4 Gas Extraction Wells

Vertical Extraction Wells

Vertical extraction wells are installed on top of the landfill surface once the landfill cell has reached maximum height and is being prepared for progressive closure. The vertical wells are drilled into the waste mass at grid spacings of approximately 40 m apart. The gas wells are drilled and are typically between 10 m to 30 m deep. These gas extraction wells are then connected to the gas flare via a network of lateral pipes and manifolds, where the gas is ultimately combusted. Some vertical wells are installed in the waste mass and extended as the waste height increases.

Horizontal Extraction Wells

Horizontal wells have been installed in Cells 6 and 7, horizontal wells will be progressively installed as filling progresses. The horizontal wells are typically 100 m long perforated HDPE pipes buried in an aggregate-filled trench. The perforated pipes are then connected to the landfill gas extraction system, which transfers the collected landfill gas to the gas flare. The wells are typically installed at 5m vertical intervals and 30 m to 50 m horizontal intervals. The result is a network of horizontal pipes within the waste mass that collects landfill gas as the waste height progressively increases. This optimises landfill gas collection during the operational phase of each landfill cell and substantially reduces fugitive landfill gas emissions.

4.5 Laterals and Headers

The landfill gas extraction wells in each portion of the site are connected by lateral flow lines to manifolds. The manifolds include control valves (for controlling the extraction rate) and monitoring ports (for measuring gas quality and flow) for each extraction well. A header system, which is also constructed from HDPE, is used to convey the recovered gas to a central point, and a blower draws the gas out of the landfill under vacuum. The header system will be installed in a progressive manner around the site as waste placement takes place in the future. The laterals and header system are constructed below ground.

4.6 Condensate System

Condensate develops as a result of cooling of the gas in the landfill gas recovery system, and this liquid is removed from the collection piping system for disposal. In order to collect condensate, devices known as condensate traps, sumps, and knockouts are employed. The condensate is managed by returning it to the landfill cells or the leachate system. Landfill gas condensate will not be used for dust suppression purposes or be released on rehabilitated areas or areas being rehabilitated.

4.7 Blower/Flare Station

The purpose of the blower/flare station is to safely and efficiently combust the landfill gas that is recovered from the waste mass. The blower/flare station has been installed on a reinforced concrete slab and is contained in a secure chain link-fenced compound. The electricity for the blower is supplied by an on-site diesel generator. In the future, the possibility of using a portion of the recovered landfill gas for electricity generation will be explored.

The equipment consists of an extraction blower, flame arrestor, one vertical enclosed flare, one condensate knock out pot, one thermal dispersion flow meter, various monitoring devices, control valves, piping, control panels and an alarm system. The capacity of the flare is 2,000 m^3/hr, with turn down ratio of 10:1. It includes a centrifugal blower and compressor that complies with the requirements for emission of noise at the site. Details regarding the flare are provided in Appendix E.

5 Operation and Maintenance

5.1 Introduction

Operation and maintenance of the landfill gas recovery system will be performed by experienced contractors and/or trained personnel. The purpose of this chapter is to present information regarding operating criteria, operating considerations, operating procedures, and maintenance procedures that will be followed for the landfill gas recovery system. General procedures are provided below for each operational activity at the site. These activities will be performed throughout the operating life of the landfill, as well as the designated aftercare period, after the site closes.

5.2 Operating Criteria

Overview

The operational criteria for the landfill gas recovery system have been established based on engineering judgment, operational experience, and industry practice for a recovery system that incorporates flare to burn the collected landfill gas. The primary operating criteria include maintaining landfill gas quality and flow rate above target levels, while minimising air intrusion into the landfill.

Landfill Gas Properties

The landfill gas quality should be suitable for combustion at the blower/flare station, as follows:

- Methane: > 30 percent by volume
- Carbon Dioxide > 25 percent by volume
- Oxygen: < 2 percent by volume
- Nitrogen: < 25 percent by volume
- Carbon monoxide: < 25 ppm
- Gas temperature: < 55°C
- Pressure: < 0.0 mbar (all gas wells to be under a vacuum).

Ideally, the landfill gas parameters at each of the individual extraction wells should also meet these criteria. If the landfill gas parameters are found to be outside these target levels and the gas quality is low, the landfill gas recovery system should be adjusted. If the gas quality is high, the landfill gas recovery system may also be adjusted. These procedures are described in Section 5.4.

Landfill Gas Flow Rate

The landfill gas flow rate at the blower/flare station should be suitable for the designed flare. The capacity of the flare is 2,000 m^3/hr, with turn down ratio of 10:1. Hence the minimum flow rate required for the flare running is approximately 200 m^3/hr. Settings for the landfill gas recovery system have been established based on the projected flow rates from the landfill gas modelling for the site. These include setting the blower extraction rate initially to approximately 300 m^3/hr at the time of system start-up.

5.3 Operating Considerations

Overview

The landfill gas recovery system should be adjusted to obtain optimum gas quality and flows while preventing air intrusion into the landfill (overdrawing). Landfill gas quality can be controlled by adjusting the vacuum at each vertical extraction well and a control valve and sampling ports are provided on the manifolds to make this adjustment. Adjusting any individual vertical extraction well may also affect the surrounding wells. Adjusting flows at the blower/flare station will affect the entire landfill gas recovery system.

Air Intrusion

If the landfill gas extraction rate is set too high, the rate of withdrawal will exceed the rate of production. This situation will be evident by monitoring results that indicate methane quality below the target level and oxygen and nitrogen levels above the target levels.

NOTE: Continuous overdrawing on an extraction well or wells must be avoided as this condition will pull air into the landfill that is known as air intrusion. This condition can cause poor gas quality i.e. less methane. In addition, the heat produced by decomposition combined with oxygen (present through over drawing) can create suitable conditions for underground fires within the landfill.

Air intrusion can be diagnosed by monitoring landfill gas composition and vacuum at each extraction well. After initial system start-up, balancing, and resource verification the weekly monitoring results should remain fairly constant. Falling methane, rising oxygen, rising flow rates, rising carbon monoxide, rising nitrogen and falling well vacuums while header vacuums remain constant, may indicate air intrusion. If extreme conditions of air intrusion are suspected, temperatures at the extraction wells, and the blower/flare station should be checked. In addition, carbon monoxide samples should be checked for evidence of subsurface combustion. Increases in temperature and carbon monoxide can indicate the presence of a landfill fire.

System Integrity

An integral part of maintaining the performance of the landfill gas recovery system is to ensure that the landfill cover system and landfill gas recovery system components are in good condition. Lack of cover material or cracks in the landfill cover system can provide a pathway for air intrusion. In addition, breaks in piping can produce readings similar to those caused by over drawing. The solutions to these problems differ significantly, and system operators can diagnose the problem by reviewing differences in gas ratios, visual inspection of the landfill surface conditions, and trends in monitoring readings.

5.4 Operating Procedures

System Adjustment – Low Quality Gas

The landfill gas recovery system should be adjusted whenever an extraction well exhibits low quality landfill gas (below the target operating criteria) or low vacuums. Basic system adjustment steps are outlined below:

- Landfill gas concentrations, vacuums, flows, and temperatures should be monitored at each extraction well, and at the blower/flare station on a monthly basis.
- For wells exhibiting evidence of low quality landfill gas, the monitoring data should be checked for evidence of pipe breaks and a visual inspection should be performed of the landfill surface for cracks and settlement. Repairs should be made to the landfill surface or piping and the gas

composition and well vacuum should be rechecked.
- For wells that are overdrawing, the landfill gas flow rate should be reduced by approximately 20 percent by closing the control valve at the wellhead. Adjacent wells should also be checked for overdrawing and for background information.
- The well(s) should be retested in one week (or sooner if an anomalous situation, such as very high oxygen and nitrogen readings exists). If overdrawing still occurs, the landfill gas flow rate should be reduced again and the adjacent wells should also be tested.
- Testing and reducing vacuum should be performed until there is no longer evidence of overdrawing. If overdrawing persists, adjustments may be made to adjacent wells and a check should be made for other possible causes.
- Leachate levels within the well could also be checked, as elevated leachate levels within the landfill will flood the slotted portion of an extraction well and cause over drawing.

System Adjustment – High Quality Gas

The landfill gas system may also be adjusted to increase the landfill gas recovery rate if an extraction well exhibits high quality landfill gas (i.e. significantly above the target operating criteria such as > 60 % methane). Basic system adjustment steps are outlined below:

- Landfill gas concentrations, vacuums, flows, and temperatures should be monitored at each extraction well, and at the blower/flare station on a weekly basis.
- For wells exhibiting evidence of high quality landfill gas, the flow rate may be increased by approximately 20 percent by opening the control valve at the wellhead. Adjacent wells should also be checked for recovery rates and for background information.
- The well should be retested in one week. If landfill gas quality remains high, the flow rate may be increased again and the adjacent wells should also be tested.
- Testing and increasing vacuum may be performed until gas quality stabilises in the target range.

Factors Effecting System Adjustment

Climatological factors may cause changes in methane readings. In addition, mechanical factors may limit available vacuum and cause landfill fires. Climatological effects will be detected during monitoring and mechanical factors will influence system operation, as outlined below.

Hot dry weather conditions over an extended period of time can cause the landfill cover system to lose moisture and crack. This condition provides additional pathways for venting landfill gas and it can also provide a more efficient pathway for the landfill gas recovery system to draw air into the landfill. Excess air intrusion is manifested by a reduction in methane content and increases in oxygen and nitrogen. During extended periods of hot dry weather the overall rate of gas extraction may have to be reduced and this can be accomplished by reducing the extraction rate at the blower/flare station.

Wet weather conditions can create a more effective landfill cap and promotes landfill gas production. Under such conditions, less surface venting can occur and may create high pressures in the landfill. The combination of a good surface cap and high landfill gas pressures tend to increase gas quality and flow rates. During extended periods of wet weather the overall rate of gas extraction may be increased and this can be accomplished by increasing the extraction rate at the blower/flare station.

5.5 Routine Maintenance

Overview

The purpose of the routine maintenance program is to ensure the safe and efficient operation of the landfill gas recovery system and to prevent equipment breakdowns and unscheduled maintenance. The routine maintenance program consists of observing and servicing of the system's mechanical equipment and other components. In addition, the routine maintenance program involves inspecting and maintaining the landfill surface.

The landfill gas recovery system should be maintained weekly, unless manufacturer's specifications indicate otherwise. These maintenance frequencies will be the minimum recommended, and more frequent maintenance should be implemented if required to maintain the system. All maintenance shall be undertaken by the expert contractor in accordance with their OH&S management system and Cleanaway OH&S practices.

A summary of key operational activities for the landfill gas recovery system is provided below. Actions should be taken to determine and correct the cause of any shut down and to coordinate these activities with the operator of the landfill.

Extraction Wells

Routine maintenance tasks associated with operation of the vertical and horizontal extraction wells should include:

- Adjusting the landfill gas extraction rate at each individual well based on a review of monitoring data.
- Inspecting the physical condition of the well field components and performing maintenance and repairs if required.
- Inspecting the landfill surface for cracks, settlement, stressed vegetation, odour, or other signs where gas venting or air intrusion may be occurring. The landfill surface can generally be repaired by placing additional soil over the areas of concern.

Laterals and Headers

The laterals and headers have been constructed at grades that allow condensate to drain back into the extraction wells or condensate traps. Routine maintenance tasks associated with operation of the laterals and headers include:

- Inspecting the landfill surface for along the route where the laterals and headers are installed for signs of settlement or damage to the landfill surface by vehicles.
- Coordinating with the landfill owner/operator to ensure that stockpiles of soil or other materials are not placed on top of areas where the laterals and headers have been constructed. Placement of heavy loads on top of the landfill will "surcharge" the waste mass and increase settlement. Localised settlement may cause flooding of the laterals and headers.

Condensate System

The condensate system supports the operation of the landfill gas recovery system by removing liquid that condenses when landfill gas is extracted from the landfill. Routine maintenance tasks associated with operating the condensate system include:

- Verifying the proper operation of the condensate traps and sumps/pumps.
- Identifying restrictions caused by condensate build-up.

Landfill gas condensate must not be used for dust suppression purposes or be released on rehabilitated areas or areas being rehabilitated.

Blower/Flare Station

The blower draws landfill gas from the landfill and the recovered gas should be conveyed to the blower/flare station. Shutdowns can occur due to regularly scheduled maintenance or failures in the blower or flare.

The system will have a programmable logic controller to record some system performance data and includes automated monitoring that alerts maintenance personnel remotely in the event of the failure. Actions should be taken to determine and correct the cause of any shut down.

5.6 Troubleshooting

The landfill gas recovery system may not perform as designed due to wear, changed conditions, equipment failure, or other reasons. When this occurs, a process of deductive reasoning known as troubleshooting will be used. Troubleshooting will involve a systematic process of elimination of possible causes to establish the cause of a physical problem.

System monitoring and maintenance records should be used to recognise the development of conditions requiring corrective actions. Historic monitoring data should be checked to indicate when variations occurred. Items requiring frequent maintenance may indicate more serious difficulties, requiring significant action, such as replacement of specific components. Troubleshooting Procedures for diagnosis and correction of common operational problems are provided in Appendix F.

5.7 Record Keeping

All operations and maintenance work should be recorded promptly and neatly. This information should also be retained as a permanent record to indicate long-term changes or trends. It can also be used for planning preventative maintenance or in diagnosing equipment failure. The operating record should include:

- Design Plans – Showing the layout and design details for the landfill gas recovery system. The design plans should be updated to show any modifications to the “as-built” status of the system.
- Checklists – Written checklists should be used for documenting routine operation and maintenance tasks.
- Operating Log – An operating log should be kept to record other operational activities. The operating log should include photographs of major operation and maintenance activities.

5.8 Notification of Expansion

Cleanaway are required to notify DWER of any expansion to the landfill gas management system. According to Table 3.5.1 of the Licence, the Licensee (Cleanaway) is required to notify DWER of the scope and timeframes of any proposed expansion of the landfill gas collection and management system at least 6 months prior to any expansion occurring.

6 Monitoring Program

6.1 Introduction

The landfill gas recovery system and associated monitoring locations will be routinely monitored by experienced contractors and/or trained personnel to assure that the system is working effectively. If the system is not functioning effectively, corrective actions that may include flow rate adjustments to particular wells, header or blower equipment repair should be taken immediately. Other periodic monitoring required includes walk-over surveys, surface emissions monitoring and monitoring within structures and services.

General procedures for each monitoring activity at the site are discussed below. A summary of the landfill gas monitoring program is provided in Table 6-1 and a summary of landfill gas compliance conditions is provided in Table 6-2.

6.2 Monitoring Parameters

Methane

Measurement of methane will indicate the gas quality and heat content levels or indicate possible landfill gas overdrawing if low methane readings at the well occur. However, measurement of methane along may not necessarily identify current or future gas quality. As a result, measurement of all gas composition parameters will also be performed as this provides a check on the validity of all data.

Carbon Dioxide

It is usually necessary to measure carbon dioxide (the other primary component of landfill gas) in order to determine nitrogen (balance gas).

Oxygen

Oxygen is another key parameter and will also be measured during the sampling to identify whether air intrusion occurs. In properly operated landfill gas recovery system, the oxygen should be about one-fourth of nitrogen.

Residual Nitrogen

Residual nitrogen is a measure of aerobic decomposition in the landfill and will be measured to provide an indicator of air filtration. As air is drawn into the landfill, oxygen is consumed along with methane by aerobic bacteria to form water and carbon dioxide. The nitrogen portion of air (about 80%) that remains following removal of the oxygen by bacteria is called residual nitrogen. Residual nitrogen will be estimated by assuming that the residual nitrogen is the balancing of gas remaining after subtracting the concentrations of oxygen, methane and carbon dioxide.

Temperature

Temperature is an indicator of the state of anaerobic conditions at the well. Temperatures of landfill gas at the wellhead typically range from 16 to just above 50°C. When the landfill gas temperature is elevated above 50°C, it could be an indication that aerobic conditions may be present and that the landfill gas flow (the rate of extraction) should be reduced.

Carbon Monoxide

Carbon monoxide shall also be monitored. In conjunction with wellhead temperature, carbon monoxide can be used as an indicator of the possible presence of subsurface landfill fire.

Pressure

The pressure measurements of landfill gas are also important, as they may be indicative of a deficient landfill gas extraction rate. In general, the presence of higher pressure (on the order of approximately 2.5 cm of water column or more) will serve as an indicator to increase the rate of landfill gas extraction.

Barometric Pressure

The barometric pressure trend (prior to landfill gas monitoring) should be noted. This information will be obtained from portable monitoring instruments or a nearby weather station.

Landfill Gas Flow Rate

The landfill gas flow rate is considered a key parameter for well adjustment. Wells will be adjusted to a target flow determined empirically. The target flow rate will be validated when all other key parameters are within appropriate guide ranges. The well-field will be adjusted until the amount of methane or heat energy recovered is optimized for the long term to achieve smooth, steady state operation.

Leachate levels

Leachate levels at vertical wells will be measured and recorded. Measurements may be taken with a simple weighted line or electrical sounding meter. A high leachate level will severely limit the ability of the system to extract landfill gas from the well.

6.3 Monitoring Instruments

Portable instruments will be used for landfill gas monitoring at the site because of the remote locations and frequency of monitoring. The Landtec GEM 2000 or similar instruments will be utilised for monitoring landfill gas composition and pressure while a flow meter will be utilised for monitoring landfill gas flow and temperature at each extraction well.

Permanent monitoring instruments are installed at the inlet to the blower/flare station. All monitoring instruments, both portable and permanent, will be calibrated, operated and maintained in accordance with the manufacturer’s requirements. A record will be maintained of calibration and maintenance of the instruments.

6.4 Monitoring Procedures

Extraction Wells

Monitoring at individual wells will be on a regular basis at the manifolds to verify the quantity and quality of the gas that is recovered from the site. Monitoring data will be recorded directly to the portable monitoring instruments and subsequently downloaded into a database. All extraction wells shall be inspected for:

- Approximate valve setting in percentage
- Methane and oxygen concentrations at the monitoring point
- Pressure at the monitoring point
- Landfill gas flow rate and temperature at the monitoring point

If significant changes in gas temperature, i.e., in excess of 10°C have occurred at the blower/flare station, the gas temperature at each well will be checked.

Headers

Headers will be monitored for methane, oxygen and carbon dioxide concentrations and well field vacuum. Data gathered at the headers often serve as an indicator for the corresponding well field status.

Condensate Traps

Condensate traps will be checked for high fluid levels and for correct operation. High fluid levels would indicate a malfunctioning pumping system that could lead to a header blockage.

Blower/Flare Station

Blower/Flare Station inlet monitoring must be performed for methane, oxygen and carbon dioxide concentrations, well field vacuum and flow rate. Data gathered at the Blower/Flare inlet serves as an indicator for the overall well field status. Also at the Blower/Flare station the following items will be checked:

- Butterfly valve position
- Blower in operation and reading of blower frequency controller
- Flare in operation
- Landfill gas condensate tank level

Walk-Over Survey

A walkover survey for the site will be performed on a monthly basis to observe the condition of the landfill surface, vegetation and the landfill gas recovery system. It will involve physically walking across and around the landfill surface and identifying problems on a site base map. The site surface should be checked and recorded for the following:

- Settlement or depressions in the surface
- Surface cracks
- Unpleasant odours
- Vegetation dieback
- Changes/unusual surface conditions

Acceptance criteria are detailed in Table 6-2.

Surface Emissions Monitoring

Monitoring of surface emissions may be performed on a periodic basis using a Laser Spectrometer or Flame Ionisation Detector (FID) or similar instrument. The monitoring will be performed in accordance with the Victorian EPA *Landfill gas fugitive emissions guideline* (EPA Victoria, 2018).

Structures and Services

Monitoring of structures and services at the site will be performed on a periodic basis using a Laser Spectrometer or FID. The monitoring will be performed in accordance with the procedures outlined in the Victorian EPA *Landfill gas fugitive emissions guideline* (EPA Victoria, 2018).

6.5 Odour Monitoring

The site operations supervisor will conduct daily checks on the site. This includes driving around the site and making observation on the day to day operations. Should odours be detected, the source of the odour will be investigated immediately.

The site Operations Manager will also conduct weekly inspections of the site, reporting any odours beyond the boundary. Wind direction and site operations will be considered at the time of reporting.

6.6 Data Analysis and Initial Response

The data that are collected during site monitoring will be evaluated by a combination of techniques including analytical and mathematical analysis, inductive and deductive logic and subjective judgment. Monitoring data will be analysed for long-term trends (i.e., pressure drops indicating possible condensate blockage, decreased flow rates indicating possible integrity problems, decreased flow rates indicating possible decreased landfill gas generation, etc.). A landfill gas remedial action plan is provided in Table 6-2.

6.7 Record Keeping

All monitoring results should be recorded promptly and neatly. This information should also be retained as a permanent record to indicate long-term changes or trends. It can also be used for planning preventative maintenance or in diagnosing equipment failure. The monitoring record should include:

- A summary of monitoring activities performed at the site
- Average volume of landfill gas extracted in m^3/hr (when data is available)
- A comparison of the actual landfill gas production data with that predicted by modelling, including revised predictions if warranted
- Leachate levels within the landfill
- Equipment calibration and maintenance records

6.8 Complaints Register

Cleanaway maintains a complaints register to log any complaints that are made either directly or passed on from DWER. The objective of the Complaints Register is to maintain a record of complaints that may be received regarding the operation of the site. The Complaints Register will include categories for stormwater and erosion, leachate and groundwater protection, landfill gas, traffic, odour, dust, litter, birds, noise, visual impact, fire risk and community information.

The register records information on when the complaint was made, who made the compliant, the address, and description of the odour. Where complaints are made directly to Cleanaway or passed on from the DWER in a timely manner, the complaint will be investigated immediately. If it is deemed that the odour breach can be associated with activities on the site, corrective actions will be taken.

6.9 Annual Reporting

The objective of the Annual Environmental Reporting to compile information regarding the environmental monitoring program as required by DWER to satisfy the site license conditions. All site personnel will be made aware of the annual reporting program and key personnel will be trained in preparation of the report.

6.10 Notification

The objective of the notification program is to report to DWER any failure or malfunction of any pollution control equipment or any incident, which has caused, is causing or may cause pollution. All site personnel will be made aware of the notification program and the Regional Manager and Operations Manager will be responsible submitting any notifications to DWER.

7 Emergency Response Information

7.1 Overview

The following procedures will be used by on-site personnel in case of an emergency. The Operations Manager will be notified if any on-site emergencies occur and be responsible for ensuring that the appropriate actions are taken and procedures are followed.

7.2 Emergency Contact List

Emergency contact numbers are as follows:

Fire, Ambulance and Police	**000**
Bunbury Regional Hospital	**08 9722 1000**
John Mulholland, Operations Manager	**0466 391 105**

7.3 Fire

Upon notification of a fire or explosion on site, all site personnel will assemble at a safe location. Fire fighting procedures are detailed in the Fire Control Procedure which includes the following:

- Fire and hotspot response procedures
- Hot load response protocol
- Direction for fire services should they need to attend the site.

In the event of a fire the fire service will be alerted. If considered safe to do so, the nature of the fire could be assessed and controlled with Cleanaway resources.

7.4 Safety Equipment Failure

If any site worker experiences a failure, or alteration of safety equipment that affects the protection factor, that person should immediately leave the work area. Re-entry will not be permitted until the equipment has been repaired or replaced.

If any other equipment on site fails to operate properly, the Operations Manager will be notified and then determine the effect of this failure on continuing operations on site. If the failure affects the safety of personnel or prevents completion of work activities, all personnel will leave the site until the situation is evaluated and appropriate actions taken.

7.5 Record Keeping

A record will be maintained to document the emergencies and incidents that occur at the site. This operating record will include:

- Completed emergency response reporting forms.
- Photographic records of any incidents.
- Reports provided by third-parties, such as emergency response agencies.

8 References

Environmental Protection Regulations 1987, Cleanaway Solid Waste Pty Ltd, Licence L8904/2015/1, Department of Water and Environmental Regulation, 12 May 2020.

Landfill gas fugitive emissions guideline, Environment Protection Authority Victoria, Publication 1684, February 2018.

www.willyweather.com.au conditions and forecast for Postal Code 6236 (Dardanup).

9 Tables

Table 6-1 Summary of Landfill Gas Monitoring Program

	Location	Parameters Measured	Instrument / Method	Frequency	Responsibility
1	Site and perimeter	Odour	Olfactory	Daily	Site personnel
2	Gas Extraction Bores and associated equipment	CH4, CO_2, O_2, Balance Gas (% v/v) Pressures, flow	GEM2000	Daily during start-up period; Weekly for 1 month for initial base data; then Monthly	Contractor
3	Walkover Survey	Landfill surface condition, vegetation condition, and landfill gas recovery system integrity	Visual inspection	Monthly	Site personnel/ Contractor
4	Surface Emissions Monitoring	CH_4 (ppm)	Laser Spectrometer or FID	Periodically, as required	Contractor
5	Structures and Services Monitoring	CH_4 (ppm)	Laser Spectrometer or FID	Periodically, as required	Contractor

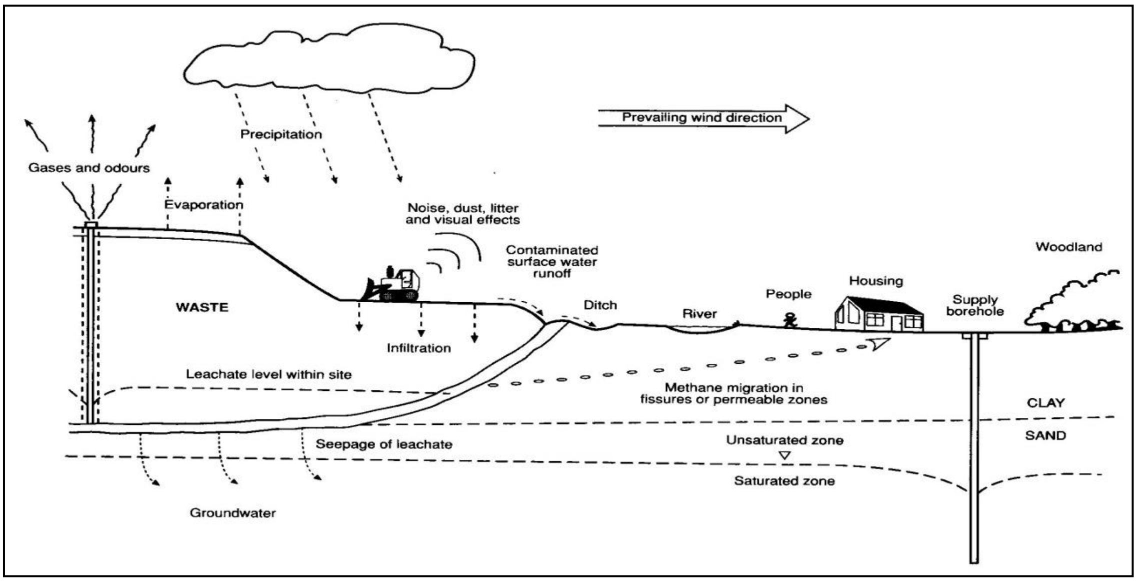
Table 6-2 Landfill Gas Remedial Action Plan

Location	Trigger Level	Remediation Action
Off-site odours	Detectable odours off-site. Complaints received.	1. Investigate source/s of odours and confirm odours are from the site. 2. Develop remediation action plan based on findings of the investigation.
Surface Walkover	Visual survey Observations of vegetation dieback Observations	1. Repair or replacement of cover material 2. Investigate if gas extraction can be improved. 3. Replacement of any impacted vegetation and appropriate cap remediation where required
Flare	Flame out Failure	1. Bypass and redirect gas 2. Shut off
Surface Emissions	500 ppm CH_4	1. Repair or replacement of cover material 2. Investigate if gas extraction can be improved
Facility structures	1.0% CH_4 1.5% CO_2	3. Repeat monitoring to confirm exceedance 4. Ventilate where possible. 5. Eliminate ignition sources. 6. Investigate source of migration and develop remediation action based on findings.
Underground Service Pits	1.0% CH_4 1.5% CO_2	1. Do not enter the pit. 2. Eliminate ignition sources. 3. Inform stakeholders. 4. Improve on-site control of landfill gas.

10 Figures

2-1 Site Location Map

Appendix A – Landfill Gas Overview



B.1 Generation

Landfills produce landfill gas as organic materials decompose under anaerobic conditions. Anaerobic conditions occur when oxygen present in the voids of waste placed at a landfill is consumed by aerobes (micro-organisms which consume air to grow), leaving an environment that is free of oxygen.

The landfill gas generation rate is affected by many factors including refuse composition, the waste age and quantity, condition of the waste mass, moisture content, pH, temperature, and maintenance of an anaerobic environment. Municipal solid waste landfills are capable of generating LFG for many years, with sources such as the United States Environmental Protection Agency (USEPA) citing a 20 to 30 year or longer life for generation of landfill gas.

B.2 Composition

Landfill gas contains approximately equal parts of methane and carbon dioxide by volume. Other gases such as volatile organic compounds (VOC's) and hydrogen sulphide may also be present in landfill gas in trace concentrations.

Methane is a colourless, odourless gas that is explosive in concentrations ranging from 5 percent (the lower explosive limit, LEL) to 15 percent (the upper explosive limit, (UEL) in air. At concentrations above 15 percent methane is flammable. Methane is a potent greenhouse gas, and has a Global Warming Potential (GWP) of 21, and is recognised as being a contributor to global warming.

Carbon dioxide is a colourless, odourless, and non-combustible gas. Carbon dioxide is also a greenhouse gas, which has a GWP of 1. However, carbon dioxide emissions from wastes that are disposed at the site, and other landfills, do not contribute to global warming as they are considered to be "biogenic" in nature (i.e. will occur naturally or by whatever waste management method that is used).

Landfill gas has its own characteristic odour due to the presence of trace compounds in the gas. Some of the more significant odour causing classes of trace constituents include esters, phenols, organic acids, solvents, and sulphur compounds.

B.3 Movement

Once generated, landfill gas will move through refuse and soil in a landfill disposal area site by both convection and diffusion. Convection is the movement of gas from an area of higher pressure to an area of lower pressure. Diffusion is the movement of gas from an area of higher concentration to an area of lower concentration.

Landfill gas may not be completely contained within the landfill disposal area and the landfill gas may be discharged through the landfill surface or could potentially migrate through subsurface soils outside the landfill disposal area. The rate of discharge to air is dependent on the nature of the landfill cover system and whether the landfill includes a landfill gas control system.

The distance which landfill gas can migrate is highly dependent on a number of factors including the quantity of refuse in the landfill, the configuration of the landfill, the geology of the surrounding strata, the presence of man-made pathways, the presence of physical barriers, and the type of cover system on the landfill. In addition, meteorological conditions can impact the rate of landfill gas emission and migration. These conditions include barometric pressure changes, precipitation, and other parameters (for example, ice and snow).

Landfill gas components can also be adsorbed onto soil particles, transferred to water or oxidised by methane consuming (methanotropic) bacteria. These phenomena may reduce emissions and migration of landfill gas from the site. A diagram showing the pathways that landfill gas can move from a landfill is provided in Exhibit A-1.

B.4 Issues

Overview

The emission and migration of landfill gas can potentially cause adverse effects on the environment including fire and explosion, health risk, odour nuisance, vegetative distress, and groundwater contamination. As previously indicated, the methane component of landfill gas is a potent greenhouse gas, which has been linked to global warming and climate change.

Fire and Explosion

The main potential environmental effect associated with landfill gas is the possibility of a fire and explosion hazard caused by the gas entering structures or confined spaces through cracks in foundations or utility services. After mixing of the gas with air in a confined space, an ignition source can cause an explosion.

Health Effects

Both of landfill gas's major components, methane and carbon dioxide, are asphyxiates. In closed structures or areas where landfill gas could potentially accumulate, landfill gas may present an asphyxiation hazard. In addition, landfill gas may contain trace amounts of toxic compounds. These do not generally pose a threat to human health or safety when confined to a landfill.

Odour

Odours associated with landfill gas are usually considered to be a secondary emission, but can cause annoyance in the area surrounding the landfill. The odours are due to many of the trace compounds commonly found in landfill gas, particularly the mercaptans, hydrogen sulphide and VOC's.

Vegetative Distress

Landfill gas can cause vegetative distress to plants on or in the vicinity of a landfill. The main reason for damage to vegetation from landfill gas is asphyxia by removal of oxygen in the root zone. High concentrations of carbon dioxide and the presence of some trace compounds are also toxic to plants.

Groundwater Contamination

LFG can contribute to groundwater contamination problems at landfill sites. These problems can occur when VOC's that are contained in the migrating gas come in contact with groundwater.

Global Warming

Methane that is produced by decomposition of organic waste in landfills is a significant contributor to global methane emissions. As methane is considered to be a potent greenhouse gas, control of methane emissions from large municipal solid waste landfills has been targeted internationally as part of greenhouse gas reduction programs.

B.5 Control

Overview

There are three types of systems that are used to control the discharge of landfill gas to the environment. These measures, which can be used either individually or in combination, include passive and active landfill gas systems and physical barriers.

Passive Systems

Passive landfill gas systems are the simplest form of control system and they are typically used on smaller landfills and closed sites. They can also be used as an interim measure to manage landfill gas in localised areas at larger landfills.

Passive systems involve installation of wells and/or vents within the landfill or in adjacent soils to provide a preferential pathway for the landfill gas to discharge to atmosphere. On some (typically smaller landfills or closed sites) sites, the landfill gas may be discharged directly to atmosphere without treatment. However, flaring or utilisation of the gas is a preferred approach, as this controls odours and methane emissions.

Active Systems

Active landfill gas systems are typically used on medium-sized and larger regional landfills for recovery and/or utilisation of the landfill gas. Active landfill gas systems generally include the following major components:

- Extraction Wells
- Header System
- Condensate System
- Blower/Flare Station
- Utilisation Equipment (Optional – depending on gas quantity and energy markets)
- Perimeter Monitoring System (Optional - depending on site conditions)

There are a number of alternatives for constructing active landfill gas systems to suit conditions at a particular site. These alternatives include installation of additional vertical extraction wells, additional horizontal collectors, hybrid collection systems, or a combination of various types of collectors; installing headers above or below-grade; various condensate management options; use of open on enclosed-type flares; various utilisation options; various types of monitoring systems.

Physical Barriers

Physical barriers are employed to prevent subsurface migration of landfill gas. They can be incorporated into the design of new landfills, such as the site, as liner systems and natural features. They can also be retrofitted to existing landfills as slurry trenches, engineered fill, and geo-synthetics. Physical barriers may also incorporate passive vents or active extraction wells to provide further protection against landfill gas migration.

Preferred Type of Landfill Gas System

The objectives for installation of a landfill gas system at a landfill site may include reducing fugitive (greenhouse gas) emissions, controlling odour, controlling off-site migration, for utilisation of the recovered gas, or for a combination of one or more of these objectives. The performance of the landfill gas system will be complimented by the landfill liner, which will serve as a physical barrier to reduce the potential for subsurface migration of landfill gas.

B.6 Beneficial Use

Landfill gas can also be utilised to generate energy, thus transforming an environmental problem into a useful energy source. The extraction and utilisation of landfill gas will result in:

- Utilisation of a waste product to generate electricity,
- Reduced greenhouse gas emissions to the atmosphere,
- Reduced potential for fire and explosion due to uncontrolled methane migration,
- Reduced odour emissions from the landfill site, and
- Increased re-vegetation potential of the landfill site.

Landfill gas can be extracted from a landfill site, processed and supplied as fuel to internal combustion engine generator sets. Electricity produced will be exported to the distribution system, displacing electricity that would otherwise need to be supplied from fossil-fuelled electricity generating plants.

Appendix B – Risk Assessment

1. CONSEQUENCE / IMPACT CRITERIA	Consequence / Impact Ratings (Where an event has more than one 'Loss Type', choose the 'Consequence / Impact' with the highest rating. If 'Near Miss' select potential rating).				
Description	**Insignificant**	**Minor**	**Moderate**	**Major**	**Significant**
Health and Safety	No treatment required	First aid treatment required	Medical treatment required	Lost time injury to worker, injury to member of the public or permanent injury or disability (public or workers)	One or more fatalities (public or workers)
Environmental	Limited or no environmental damage with no intervention required	Limited or minor damage requiring assessment on need for intervention	Environmental impact requiring treatment inside or outside site	Serious environmental harm requiring restoration and/or remediation inside or outside of site with possible regulatory intervention	Permanent/material damage to environment requiring ongoing remediation and monitoring with regulatory involvement and possible further enforcement action
Business Interruption	A temporary delay in servicing a small number of customers	Delay affecting customers but no damage to relationships	Inconvenience to customers that cause some harm to relationships	Widespread damage to customer relationships (some permanent)	Irreversible damage to a large number of customers (impacts viability of the business)
Reputational	Slight impact- public awareness may exist but no public concern.	Limited impact- local public concern.	Considerable impact- regional public concern. Client unease.	National public concern. Leads to share price volatility. Loss of client.	International public attention. Direct impact on share price. Loss of core client.
Financial *(Set locally)*	AUD $0 to < AUD $ X K EBIT	> AUD $ X K to < AUD $ X M EBIT	> AUD $ XM to < AUD $ XM EBIT	> AUD $ XM to < AUD $ XM EBIT	> AUD $ X M EBIT

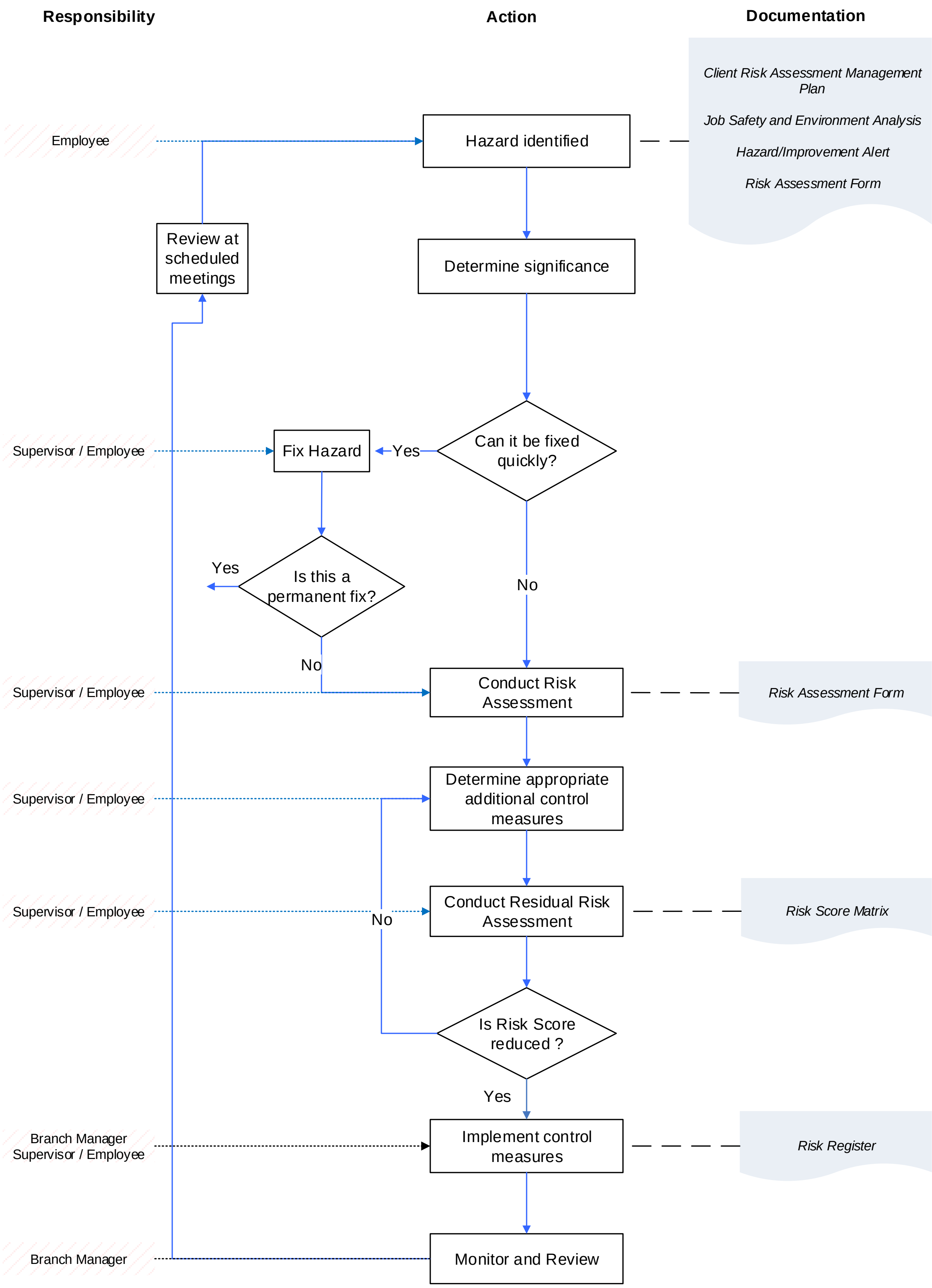
2. LIKELIHOOD / PROBABILITY & RISK RATING			Risk Rating				
Likelihood / Probability	**Examples** (Near-misses as well as actual events)	% chance of occurring					
Almost Certain	The unwanted event has occurred frequently; occurs in order of one or more times per year & is likely to reoccur within 1 year	>75% - 99%	5	10	15	21	25
Likely	The unwanted event has occurred infrequently; occurs in order of less than once per year & is likely to reoccur within 5 years	>50%-<74%	4	9	14	20	24
Possible	The unwanted event has happened in the business/industry at some time; or could happen within 10 years	>25%-<49%	3	8	13	18	23
Unlikely	The unwanted event has happened in the business/industry at some time; or could happen within 20 years	>11%-<24%	2	7	12	17	22
Rare	The unwanted event has never been known to occur in the business/industry; or it is highly unlikely that it will occur within 20 years	0- <10%	1	6	11	16	19

Risk Level: Extreme *NO WORK TO BE CONDUCTED* High *Requires Manager/Regional Manager Sign off* Medium *Requires Supervisor Sign off*
Low *Monitor*

RISK MANAGEMENT FLOWCHART

HSE MANAGEMENT SYSTEM

CLEANAWAY
Making a sustainable future possible



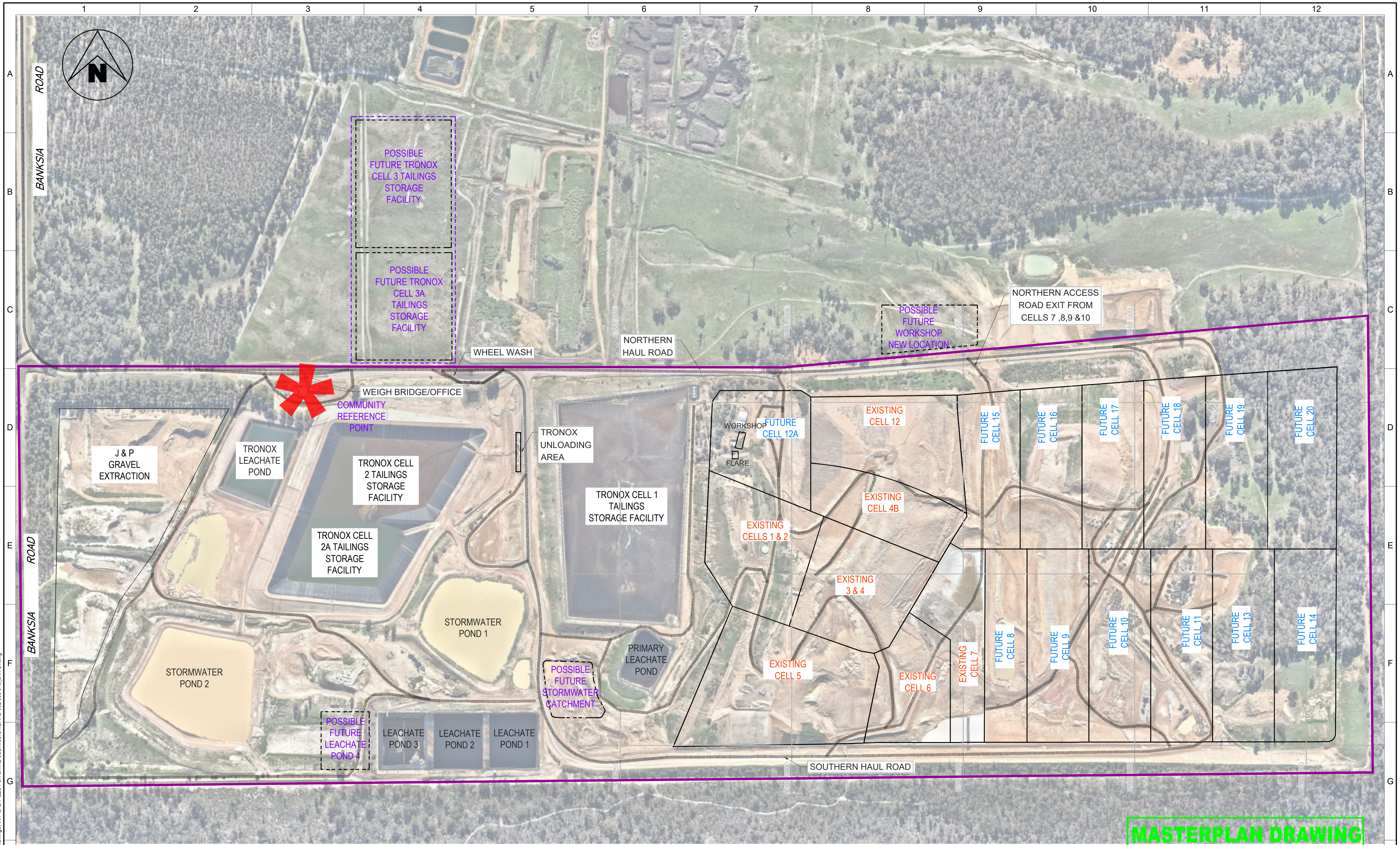
				Location Address:	Dardanup Landfill, WA					
PROJECT OR DESIGN ELEMENT:					Client				Project Number/Location Code:	
LFG Risk Assessment					Cleanaway				201515	

RISK ASSESSMENT

Activity or Task	Hazards or Impacts	Perceived Risk			Control Measures (Eliminate, Substitute, Isolate/Engineering Controls, Administrative Controls, PPE)	Residual Risk			Person responsible for Controls	Status
		Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating		
Atmospheric Emissions - Environmental Receptors	Environmental impacts of LFG Emissions Greenhouse Gas Impact Vegetation Dieback	3	5	15	Regular covering of waste with daily and interim cover Regular final capping campaigns as per masterplan Active tip face area minimised Active gas extraction system operational and expanded as required. Monthly monitoring and balancing of extraction system performance Continuous and remote monitoring of LFG system operational status Monitoring of vegetation health Replacement of impacted vegetation and cap remediation where required	2	2	7	Operator / LFG Contractor	
Atmospheric Emissions - Off-Site Human Receptors	Odour	3	4	14	Distance from closest human receptors to site boundary (0.45 km) Distance from closest human receptors from odour source (0.8 km) Regular covering of waste with daily and interim cover Regular final capping campaigns as per masterplan Active tip face area minimised Active gas extraction system operational and expanded as required. Continuous and remote monitoring of LFG system operational status Monthly monitoring and balancing of extraction system performance	1	2	2	Operator / LFG Contractor	
On-site worker exposure to LFG through tip face, interim cover or cap	Health impacts to workers from exposure to LFG including asphyxiation	4	3	18	Regular covering of waste with daily and interim cover Regular final capping campaigns as per masterplan Work undertaken in open environment Active tip face area minimised Active gas extraction system operational and expanded as required. Continuous and remote monitoring of LFG system operational status Monthly monitoring and balancing of extraction system performance Regular monitoring of condition of capped area Naturally odorous gas allowing for detection of LFG Site workers trained on LFG risks & recognition. Where LFG odours of concern noted contractors available to be called in to monitor.	2	2	7	Operator / LFG Contractor	
On-site worker exposure to LFG through interim cover or cap	Odour and Amenity	2	4	8	Work undertaken in open environment Active gas extraction system operational and expanded as required. Continuous and remote monitoring of LFG system operational status Monthly monitoring and balancing of extraction system performance Regular monitoring of condition of capped area Naturally odorous gas allowing for detection of LFG Site workers trained on LFG risks & recognition. Where LFG odours of concern noted contractors available to be called in to monitor.	2	2	7	Operator / LFG Contractor	
On-site worker exposure to LFG through tip face	Odour and Amenity	2	5	10	Regular covering of waste with daily and interim cover Regular final capping campaigns as per masterplan Work undertaken in open environment Active tip face area minimised Active gas extraction system operational and expanded as required. Continuous and remote monitoring of LFG system operational status Monthly monitoring and balancing of extraction system performance Regular monitoring of condition of capped area Naturally odorous gas allowing for detection of LFG Site workers trained on LFG risks & recognition. Where LFG odours of concern noted contractors available to be called in to monitor. Plant used at tip face fitted with air conditioning	2	4	9	Operator / LFG Contractor	
On-site maintenance worker exposure in excavations	Health impacts to workers from exposure to LFG including asphyxiation	5	4	24	Olfactory identification of LFG presence OHS Procedures kept on site and in online (MyOSH) system Avoid creation of confined spaces Confined Space procedures documented in Cleanaway OHS system mean no entry to excavations or confined spaces without appropriate controls eg gas monitoring and PPE.	4	2	17	Operator	
On-site maintenance worker exposure in excavations	Odour and Amenity	2	5	10	Olfactory identification of LFG presence OHS Procedures kept on site and in online (MyOSH) system Avoid creation of confined spaces Confined Space procedures that mean no entry to excavations or confined spaces without appropriate controls eg gas monitoring and PPE as required by CWY OHS procedures.	2	3	8	Operator	
On-site maintenance worker exposure in infrastructure works (headers , flares , generators)	Health impacts to workers from exposure to LFG including asphyxiation	5	4	24	Works on LFG extraction system generally undertaken by expert contractor Expert contractor undertakes work in accordance with their OHS management system for specific tasks related typically to gas management system & installation/construction CWY OHS Procedures kept on site and in online (MyOSH) system Gas management procedures - purging prior to maintenance & prior to restart. If a Confined Space entry required Confined space procedures so that mean no entry to confined spaces without appropriate the controls eg gas monitoring and PPE as required by CWY OHS procedures Monthly monitoring and balancing of extraction system performance	4	2	17	Operator/LFG Contractor	

				Location Address:	Dardanup Landfill, WA					
PROJECT OR DESIGN ELEMENT:					Client	Project Number/Location Code:				
LFG Risk Assessment					Cleanaway	201515				
On-site maintenance worker exposure in infrastructure works (headers , flares , generators)	Risk of fire or explosion close to or within LFG infrastructure (wells , flare , generator)	5	3	23	Works on LFG extraction system generally undertaken by expert contractor Expert contractor undertakes work in accordance with their OHS management system for specific tasks related typically to gas management system & installation/construction CWY OHS Procedures kept on site and in online (MyOSH) system Gas management procedures - purging prior to maintenance & prior to restart. If a Confined Space entry required Confined space procedures so that mean no entry to confined spaces without appropriate the controls eg gas monitoring and PPE as required by CWY OHS procedures Monthly monitoring and balancing of extraction system performance No smoking permitted on site Equipment used in potentially explosive atmospheres to be intrinsically safe No hot work permitted without appropriate controls as detailed in CWY OHS procedures	3	2	12	Operator/LFG Contractor	
Fire / Explosion on site	Methane explosion or fire due to LFG accumulation / emissions Methane accelerant or spreader of a landfill fire Liner damage from fire	4	3	18	Active tip face area minimised Regular covering of waste with daily and interim cover Regular final capping campaigns as per masterplan. Active gas extraction system operational and expanded as required. Continuous and remote monitoring of LFG system operational status Monthly monitoring and balancing of extraction system performance. Carbon monoxide concentrations monitored for signs of fire in the waste If fire occurs LFG system kept operational Landfill fire procedure documented (Water sources maintained on site, operators are trained, fire fighting processes documented) Minimisation of exposed liner area within operations Minimising litter accumulation against liner including litter fencing around tip face and active litter picking.	3	2	12	Operator / LFG Contractor	
Fire from off site	Bushfire / off site fire impacting on site Methane accelerant or spreader of off-site fire to on-site fire Liner damage from fire	3	3	13	Maintenance of buffer zone around property boundaries Setback of landfill cells from site boundary Active tip face area minimised Regular covering of waste with daily and interim cover Regular final capping campaigns as per masterplan. Active gas extraction system operational and expanded as required. Continuous and remote monitoring of LFG system operational status Monthly monitoring and balancing of extraction system performance If fire occurs LFG system kept operational Landfill fire procedure documented (Water sources maintained on site, workers are trained, fire fighting processes documented) and submitted to local fire agencies. Relationship maintained with local fire agencies and Shire rangers including site visits etc. Minimisation of exposed liner area within operations Minimising litter accumulation against liner including litter fencing around tip face and active litter picking.	2	2	7	Operator / LFG Contractor / Designer	
Impacts to on-site vegetation	Vegetation damage & dieback due to LFG. Possible impacts on cap performance due to vegetation impacts Visual Amenity impacts	3	4	14	Natural open areas minimise concentration in air Minimal sub-surface migration of LFG Regular final capping campaigns as per masterplan Regular monitoring of condition of capped area Active gas extraction system operational and expanded as required. Monthly monitoring and balancing of extraction system performance Continuous and remote monitoring of LFG system operational status	2	2	7	Operator / LFG Contractor	
Non-conformances with regulatory requirements	CWY exposure to regulator response (DWER licence)	4	5	21	Regular monitoring of flare emissions/LFG Management system and operation and comparison with regulatory requirements and active maintenance / balancing as required. Regular expansion of management system as required with notice to DWER. Controls as nominated within the LFG Management Plan	3	2	12	Operator	
Non-conformances with community expectation	CWY reputational damage	3	5	15	Dardanup landfill community reference group - meetings 2 monthly with community reference group is the mechanism to determine community expectations. Community complaints register maintained Regular monitoring of flare emissions/LFG Management system and operation and active maintenance / balancing as required. Regular expansion of management system as required with notice to DWER. Adequate fire management as per above	3	2	12	Operator	

Appendix C – Site Plan



SCALE 1:5,000
50 0 50 100 150 200 250
LENGTHS ARE IN METRES - PAPER SIZE A3

MASTERPLAN DRAWING JANUARY 2021

REV	DATE	DRAWN	REV'D	APP'D	REVISION
C6	08.01.21	F.A.	S.C.	B.G.	AMENDED PER SHIRE COMMENTS MADE 2-12-20
C5	06.11.20	F.A.	S.C.	B.G.	FONT CHANGE FUTURE AND EXISTING CELLS
C4	14.10.20	F.A.	S.C.	B.G.	POSSIBLE FUTURE TRONOX CELL 3 & WORKSHOP LOCATION
C3	15.09.20	F.A.	S.C.	B.G.	CELL 1 & 2 EXTERIOR BOUNDARY CORRECTED
C2	17.08.20	F.A.	S.C.	B.G.	APPROVED CONCEPT PLAN
C1	07.08.20	F.A	S.C.	B.G.	CONCEPT PLAN

DRAWING NUMBER	REFERENCE DRAWING TITLE

CLEANAWAY
Making a sustainable future possible

Banksia Road Landfill
Dardanup WA
Lot 2 Banksia Road,
Dardanup WA 6236
Australia

PROJECT BANKSIA ROAD LANDFILL MASTERPLAN

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
F.ABATE	SALLY CARLTON	S.CARLTON	B.GRIFFIN
DESIGNED F.ABATE	DESIGN REVIEW SALLY CARLTON	DATE 07.08.20	DATE 17.08.20

TITLE
SITE PLAN
OVERALL LAYOUT - CELL BOUNDARIES AND MAJOR INFRASTRUCTURE

SCALE	DRAWING No	REV
AS SHOWN	DARD-002	C6

A1

Appendix D – LFG System Plan

N

MAP GRID	MGA 50

FIELD SUMMARY

PIPE SIZE		LENGTH	ITEM	TOTAL
HORIZ WELL	63mm	0	⊗	0
	90mm	0	⊕	0
	110mm	0	■	0
	125mm	0	●	0
	160mm	0	★	0
	200mm	0	⋈	0
FLOW	63mm	0	✳	0
	90mm	0	◉	0
	110mm	0	⋈	0
	125mm	0	○ KOP	0
LATERAL	90mm	0	Ⓓ	0
	125mm	0	▭	0
	160mm	0		
	200mm	0		
AIR	32mm	0		
	63mm	0		
LEACHATE	63mm	0		
	90mm	0		
	125mm	0		
	160mm	0		
MAIN HEADER	90mm	0		
	110mm	0		
	125mm	0		
	160mm	0		
	200mm	0		
	225mm	0		
	250mm	0		
	280mm	0		
	315mm	0		
	355mm	0		
	400mm	0		
	450mm	0		
	500mm	0		

LEGEND

⊗	WELL
⊕	MONITORING BORE
⊗	MONITORING PROBE
■	WELLHEAD STATION – STANDARD
●	J TRAP
★	BAROMETRIC TRAP
⋈	ISOLATION VALVE
✳	PIT PUMPOUT
◉	LEACHATE SUMP / RISER PIPES
⋈	STANDALONE WELL
○ KOP	KNOCKOUT POT
Ⓓ	DUAL PURPOSE WELL
▭	FLARE/POWER STATION
A	WELLHEAD STATION NAME
A125	WELL NUMBER
MP1–1	MAIN GAS PIPE
— — —	FENCE LINE
——	CELL BOUNDARY
— — —	COMMUNICATION
——	POWER
——	63mm FLOW LINE
— AIR —	32mm AIR LINE
— AIR —	63mm AIR LINE
— LE —	63mm LEACHATE LINE
— LE —	90mm LEACHATE LINE
— LE —	125mm LEACHATE LINE
— LE —	160mm LEACHATE LINE
— HW —	90mm HORIZONTAL WELL
——	90mm MAIN LATERAL HEADER
——	125mm MAIN/LATERAL HEADER
——	160mm MAIN HEADER
——	200mm MAIN HEADER
——	225mm MAIN HEADER
——	250mm MAIN HEADER
——	280mm MAIN HEADER
——	315mm MAIN HEADER
——	355mm MAIN HEADER
——	400mm MAIN HEADER
——	450mm MAIN HEADER
——	500mm MAIN HEADER

Notes:

Aerial Photography from (Nearmap). Date: 13/05/2020

REV	DESCRIPTION	BY	CKD	APP	DATE
E	HORIZONTAL WELL INSTALLATION	ZB	RC	RC	27/10/2020
D	UPDATED NEARMAP OVERLAY	ZB	RB	RB	10/07/2020
C	ADDED MONITORING PROBES, INSTALLED 14/02/2020	ZB	AD	AD	14/02/2020
B	AS BUILT	ZB	AD	AD	27/03/2019
A	AS BUILT	BC	LH	LH	25/06/2017

REVISION HISTORY

run energy

199C OSBORNE AVE, CLAYTON STH, VIC 3169
PH: (03) 9538 6200
www.runenergy.com

PROJECT: BANKSIA ROAD LANDFILL

DRAWING TITLE: GAS COLLECTION SYSTEM SITE LAYOUT

DRAWING No: 070-AB-001			
DRAWING TYPE: ASBUILT			
DRAWN: ZB		CKD: AD	
DATE: 27/10/2020		APP: AD	
DESIGNED: AD		APP DATE: 27/10/2020	
SCALE: 1:1000	SHEET: 1 of 1	REV: E	SIZE: A1

Appendix E - Flare Information

Aust
2/2 Access Way
Carrum Downs, VIC, 3201
Telephone +613 9770 8545 Facsimile +613 9770 8546
Mobile 0407 887 864
Email info@australianburners.com
Website www.australianburners.com

ABM combustion for indus

Attention: Mr Russell Clarke

Run Energy Pty Ltd
Unit 8/20 Duerdin Street
Clayton, VIC
3168

28 February 2012

Our Ref: Q3598

Subject: **2,000m^3/h ENCLOSED FLARE: CROOKED BROOK, WA**

Dear Russell,

Many thanks for your new enquiry for ABM biogas flare equipment.

The equipment proposed has been selected after careful consideration of the technical data provided and our understanding of the existing and proposed operational requirements.

This flare has been designed with a high turndown capability, which will allow it to be simultaneously operated with a generator at a future date if required.

Please find following a technical description of the equipment, and our quotation for your consideration.

1. Features of the ABM Enclosed Flare System

- High turndown system with Bio Gas burner
- 1400 °C stacked on edge fibre lining eliminating of exposed anchors that fail with time and temperature
- 1000 °C chamber temperature & > 0.6 Seconds residence time
- Base section of flare is factory tested with gas train skid and controls
- Self check flame detection
- Stainless steel electrical control panel with weather shield
- Temperature control via separate quench air dampers
- Combustion air varied with bio gas flow allowing fast response from low fire
- Flat bottom Stainless Steel flame arrestor eliminates liquid collecting in the arrestor housing

Licensees for:

esa pyronics

pyronics inc.

2. Technical Description

The ABM flare is specifically designed to incinerate biogas between 400 and 2,000m^3/h.

Biogas enters via stainless steel knock-out pot and is drawn into the biogas fan.

The vertical flare three main components parts are the base and two insulated stainless steel chamber sections and a gas train skid.

Ignition & main flame is established using a Pyronics excess air burner with an interrupted natural gas pilot. The burner will run on bio gas at a fixed flow rate.

Natural draft air flow is controlled via two flow paths.

Combustion air is modulated by two diagonally apposed louvre dampers. As the biogas control valve is modulated a characterised link opens these dampers maintaining the air / biogas ratio within a stable range.

A second air flow path varies the quench air modulating a second pair diagonally apposed louvre dampers as part of the chamber temperature control loop. This avoids an over-temperature condition in the chamber whilst maintains the 1000^{o}C set point giving excellent destruction of the biogas.

The combination of the biogas burner and the air control scheme ensure a reliable, robust system that can accept rapid changes in throughput.

Both chamber sections are insulated with 1400^{o}C ceramic fibre 100mm stacked on edge. This method of construction eliminates any exposed anchors and is critical for durable high temperature service.

The hot dipped galvanised gas skid contains the following items;

Stainless steel control panel (remote option)
Double block SSOV
Flat bottom flame arrestor
Pressure transmitter
Biogas control valve
Natural gas Pilot train
Burner Air Fan (1.5kw)

The biogas pipe work is manufactured from 316L Sch10S stainless steel welded to AS4041.

TECHNICAL DETAILS

BIO GAS FLOW RATE		
MAX	2,000	m^3/h
MIN	400	m^3/h
TURNDOWN	5:1	
CHAMBER TEMPERATURE	1000	^oC
RESIDENCE TIME (MIN)	0.6	S
BURNER AIR FAN POWER	1.5	kW
BIOGAS FAN POWER	18.5	kW
INSULATION RATING	1400	^oC
INSULATION THICKNESS	100	mm
HEIGHT	9.1	m

ABM STANDARD EQUIPMENT	
PNEUMATIC SAFETY SHUT OFF VALVES	BURKET SOLENOID VALVES 240 VAC EL-OMATIC ACTUATORS TURNFLO BUTTERFLY VALVES
MANUAL BUTTERFLY VALVES	TURNFLO BUTTERFLY VALVES
FLAME ARRESTOR	PROTEGEO
PRESSURE TRANSMITTER	YOKOGAWA
BIOGAS FLOWMETER	FCI INSERTION TYPE MASS FLOW METER
BIOGAS FAN	AEROTECH Model No HP 371/70
VARIABLE SPEED DRIVE	DANFOSS VLT
OPERATOR CONTROL STATION	HORNER Model No XL6e OCS
IGNITION VALVES	LUCIFER 240VAC
MODULATION MOTOR	ABM SURELINK
AIR PRESSURE SWITCH	DUNGS / KROMSCHRODER
UV CELL & BURNER CONTROLLER	SIEMENS
METHANE ANALYSER	DRAEGER POLYTRON

Appendix F - Trouble Shooting Procedures

Example Troubleshooting Procedures
Landfill Gas Recovery Systems

Problem Area	Nature of Problem	Procedure
Flare	LFG Flare will not Maintain a Flame	1001
Blower	Blower Mechanical Failure Lack of Power to Blower Motor LFG Odour	2001 2002 2003
Vertical Extraction Wells	Low Vacuum High Vacuum Fluctuating Vacuum/Pressure Readings Low Methane/High Oxygen High Methane/Low Oxygen Leachate or Dirt in Extraction Well LFG Odour	3001 3002 3003 3004 3005 3006 3007
Condensate Traps	Significant Vacuum Drop across Condensate Trap Water Level Low	4001 4002
Condensate Sump	Water Level High	5001
Leachate Chamber	Air Intrusion into Leachate Chamber	6001
Laterals and Headers	Low Flow/High Vacuum High Flow/Low Vacuum Fluctuating Vacuum Readings Low Methane/High Oxygen Condensate/Dirt in Line	7001 7002 7003 7004 7005
Landfill Surface	Surface Cracks Depressions Ponding Distressed or Dying Vegetation	8001 8002 8003 8004
Landfill Fire	Subsurface Fire Elevated Temperature Carbon Monoxide Settlement	9001 9002 9003 9004

Troubleshooting Procedure WR – 1001

Location: Flare

Problem: LFG Flare will not maintain a Flame

Procedure:

When the flare will not maintain a flame, take the following troubleshooting steps:

1. Check the methane content of LFG at flare inlet. If insufficient methane is present, readjust control system operation. Reducing field vacuum will tend to increase methane content.

2. Check blower operation. Refer to “Blower Mechanical Failure” in this Manual.

3. Check pressure on the blower discharge line from blower to flare. If inadequate pressure is measured, check line for blockages and breaks.

4. Check the following and repair as needed:

   - UV scanner.
   - Operation of valves.
   - Thermocouple operation.
   - Flame arrestor.
   - Burner condition.

Troubleshooting Procedure WR – 2001

Location: Blower

Problem: Blower Mechanical Failure

Procedure:

If motor is operating, take the following troubleshooting actions:

1. Switch to standby blower. (If available)

2. Check motor blower coupling to assure proper connection and alignment.

3. Check inlet and outlet valves. Adjust as needed.

4. Check inlet piping for breakage. Repair as needed.

5. Check condition of blower impeller for excessive corrosion and abrasion by removing section of inlet or outlet piping.

6. Contact blower mechanic.

If motor is not operating, take the following troubleshooting actions:

1. Switch to standby blower. (If available)

2. Check fuses and circuit breakers.

3. Check for power outage at other on-site facilities (eg. the gatehouse).

4. Check for power outage with electrical supply company.

5. Check motor for obvious indications of malfunction (eg. electrical burns or odours).

6. Check movement of blower impeller by turning with hand. If impeller will not turn, check by removing section of inlet or outlet piping.

7. Contact blower mechanic.

Troubleshooting Procedure WR – 2002

Location: Blower

Problem: Lack of Power to Blower Motor

Procedure:

If a lack of electricity to the blower motor is apparent, take the following troubleshooting actions:

1. Check fuses and circuit breakers.

2. Check for power outage at other on-site facilities (eg. the gatehouse).

3. Contact local electrical supply company to determine if a power failure has occurred over a wider area.

4. Estimate probable power outage time based on discussions with local electrical supply company.

5. If power outage is estimated to be greater than 24 hours, arrange for alternative power source (e.g. electrical generator).

6. If power outage is estimated to be less than 24 hours, continue to monitor restoration of power with local electrical supply company.

Troubleshooting Procedure WR – 2003

Location: Blower

Problem: LFG Odour

Procedure:

The principal components of LFG are methane and carbon dioxide, both of which are odourless and colourless. Methane gas produced in landfills is typically associated with other gases produced by decomposition of the organic materials. Gases which may be found in lesser amounts are hydrogen sulfide (ie. Rotten egg smell), other acidic gases, organic vapours, nitrogen, and argon. As a result, LFG is comprised of both odourous and non-odourous components. If LFG odours are encountered, consideration of the following troubleshooting procedures is recommended.

1. The outlet piping for the blower should be examined for damage or incomplete connections (ie. Flanges).

2. Seals on the blowers and flex connectors should be examined for damage or wear.

Troubleshooting Procedure WR – 3001

Location: Vertical Extraction Wells

Problem: Low Vacuum

Procedure:

If the wellhead vacuum at any extraction well or other LFG collection point is less than that typically found, the zone of influence may have contracted, and the system may not adequately control off-site gas migration. Troubleshooting actions include:

1. Check the valve position at the wellhead. Has it been partially or completely closed? If so, adjust valve to predetermined setting.

2. Have there been breaks or blockages of the header pipe between this well and the blower/flare station? Check wellhead and header pipe vacuums from the subject well back to the blower, and observe variations from preset conditions. Check the integrity (ie. breakages, blockages, etc.) of the collection system piping.

3. Have other wells closer to the blower/flare station been opened more fully? This would diminish the vacuum delivered to the subject extraction well.

4. Have the valves at the blower been throttled back, thus reducing vacuum delivered to the overall system? If so, investigate as to the purpose of the change. The valve may need to be adjusted to its predetermined setting.

CAUTION: CHECK AIR QUALITY IN WELLHEAD VAULT BEFORE ENTRY TO VAULT.

Troubleshooting Procedure WR – 3002

Location: Vertical Extraction Wells

Problem: High Vacuum

Procedure:

Vacuum checks at any given extraction well or LFG collection point may reveal that it exceeds the typical operational range. Increased well vacuum may diminish the vacuum delivered to subsequent wells along the header pipe. In addition, overdrawing on a given well may allow excessive oxygen to enter the extracted gas. Another possibility consisted of subsurface flooding, resulting in plugging of the perforated section of the well casing, causing high vacuums and low flows. Troubleshooting actions include:

1. Check wellhead valve position. Has it been opened further? If so, adjust vacuum.

2. Check valves in blower/flare station. Has entire system been throttled? If so, investigate as to the reason for the change. If there is not a good reason, adjust to original settings.

3. Have other wells closer to the blower house been throttled back or closed? This would have the effect of delivering more vacuum to the subject well.

4. Check the integrity (ie. breakages, blockages, etc.) of the collection system piping.

CAUTION: CHECK AIR QUALITY IN WELLHEAD VAULT BEFORE ENTRY TO VAULT.

Troubleshooting Procedure WR – 3003

Location: Vertical Extraction Wells

Problem: Fluctuating Vacuum/Pressure Readings

Procedure:

Fluctuating readings indicate that water has clogged the extraction well. This condition can be caused by a rising leachate level, perched leachate zone, excessive condensate drainage down the well, or a low spot in the lateral header.

1. Check conditions down the well. Is leachate clogging the well? Well may temporarily have to be shut off to prevent surging at the blower.

2. Investigate lateral header for condensate collection at low spots. Look for surface settlement on lateral alignment. Otherwise use buried pipeline investigation techniques.

3. If low spots are identified, excavated and re-lay lateral header, ensuring minimum slope requirements are met.

CAUTION: CHECK AIR QUALITY IN WELLHEAD VAULT BEFORE ENTRY TO VAULT.

Troubleshooting Procedure WR – 3004

Location: Vertical Extraction Wells

Problem: Low Methane/High Oxygen

Procedure:

Methane contents lower than those found historically may be accompanied by higher oxygen concentrations. The zone of influence may have expanded unnecessarily at this well, or alternatively, a break may have occurred allowing air intrusion.

Troubleshooting actions include:

1. Check valve position. Has it been opened further? If so, adjust valve.

2. Check wellhead vacuum. Is the vacuum now higher than balanced conditions? If so, adjust valve.

3. Check conditions down the extraction well. Are breaks or blockages of the well apparent? If so, repair of the well is necessary.

CAUTION: CHECK AIR QUALITY IN WELLHEAD VAULT BEFORE ENTRY TO VAULT.

Troubleshooting Procedure WR – 3005

Location: Vertical Extraction Wells

Problem: High Methane/Low Oxygen

Procedure:

Methane contents higher than pre-set conditions may be accompanied by lower oxygen. This may be a sign of diminished radius of influence, thus reducing the effectiveness of the system to control off-site gas migration. Alternatively, blockages may have occurred in the well or accompanying header pipe, causing less vacuum to be delivered to the wellhead.

Troubleshooting actions include:

1. Check valve position. Has it been closed further?

2. Check wellhead vacuum. Is the wellhead vacuum now lower than pre-set conditions?

3. Check for breaks or blockages in the well, and nearby header and lateral lines.

CAUTION: CHECK AIR QUALITY IN WELLHEAD VAULT BEFORE ENTRY TO VAULT.

Troubleshooting Procedure WR – 3006

Location: Vertical Extraction Wells

Problem: Leachate or Dirt in Extraction Well

Procedure:

Checking of the down hole condition of the extraction well may reveal leachate or soil accumulations. This condition will adversely affect the performance of the well. Troubleshooting the source of this condition can be performed as follows:

1. Check for saturated conditions in nearby soil. If soil is badly saturated, the well may have flooded.

2. Check for surface intrusion of soil or silt. Has water or dirt flowed down the well from and opening at the surface?

3. Check condition of laterals and nearby headers. Have these flooded with condensate, leachate or soil?

4. Check condition of perforations below. Have perforations collapsed allowing silting in of the well casing.

5. Sound the depth of the extraction well or connecting piping has occurred.

6. Check to see if any damage to the extraction well or connecting piping has occurred.

7. Check records to see if any recent past damage could have allowed soil or silt to enter into the system.

If any of these scenarios have occurred, leachate levels should be reduced and/or repair or replacement of the well or lateral may be necessary.

CAUTION: CHECK AIR QUALITY IN WELLHEAD VAULT BEFORE ENTRY TO VAULT.

Troubleshooting Procedure WR – 3007

Location: Vertical Extraction Wells

Problem: LFG Odour

Procedure:

The well field area in the vicinity of the odour should be examined for surface cracks that may have developed due to hot or dry conditions, or landfill settlement. The LFG may be migrating through the crack to the surface. This could also indicate a non-functioning extraction well(s).

Extraction wells should be examined for damage and the pressure in the wells should be monitored. A damaged well head could indicate a vacuum leak that would allow the pressure within the well to become positive, and thus allow for the escape of LFG. A positive pressure at the well head could also indicate that the valve requires adjustment or that the adjacent lateral or header pipe has become obstructed.

CAUTION: CHECK AIR QUALITY IN WELLHEAD VAULT BEFORE ENTRY TO VAULT.

Troubleshooting Procedure WR – 4001

Location: Condensate Traps

Problem: Significant Vacuum Drop across Condensate Trap

Procedure:

The condensate traps perform an important function of draining condensate which drops out in the header pipe, while maintaining vacuum conditions in the header pipe. If a condensate trap is not functioning correctly, condensate entering the condensate trap may add to the fluid level and eventually block the header pipe. Alternatively, breakage of the trap or drain may lead to vacuum loss across the trap, with resulting loss of vacuum in the rest of the LFG extraction system. If a significant vacuum drop is observed across the condensate trap, perform the following troubleshooting actions:

1. Switch off blower at blower/flare station. Check condensate level in the condensate trap. At the traps on the primary LFG header pipeline, remove the steel lid that is secured and sealed by several bolts. Check the fluid level in the collection point.

CAUTION: LFG EMISSIONS WILL BE RELEASED WHEN THE LID OR FLANGE IS REMOVED

2. If that fluid level is high, cleaning or repair of the condensate trap is required. The condensate must be pumped or bailed out of the manhole riser.

3. If the fluid level within the HDPE pipe is low, or not visible, then the drain connection between the header and the trap is blocked or damaged.

4. Clean or repair the system as required

CAUTION: DO NOT ENTER THE SEALED CONDENSATE TRAPS UNLESS FULLY EQUIPPED AND STAFF SUPORT IS AVAILABLE FOR A CONFINED SPACE ENTRY

Troubleshooting Procedure WR – 4002

Location: Condensate Traps

Problem: Water Level Low

Procedure:

Water levels should be maintained at constant elevations in each condensate trap. If water levels are lower than preset conditions, perform the following troubleshooting actions:

1. Refill the condensate trap to the designated level with water. If water is retained to that level, all is well. If it drains quickly, further action is required.

2. Check for vacuum drop across trap. A severe loss of vacuum could indicate a plugged or broken trap.

Troubleshooting Procedure WR – 5001

Location: Condensate Sump

Problem: Water Level High

Procedure:

If the condensate pump is not functioning correctly, condensate entering the condensate sump may add to the fluid level and eventually block the header line. Troubleshooting includes:

1. Has the condensate sump become plugged with dirt or silt such that the pump will not function?

2. Does the pump control panel indicate that there is power?

3. Does the pump control panel display indicate a malfunction?

If any of these scenarios have occurred, repair or replacement of the pump may be necessary.

Troubleshooting Procedure WR – 6001

Location: Leachate Chamber

Problem: Air Intrusion into Leachate Chamber

Procedure:

A combination of low methane and high oxygen likely is a sign of air intrusion to the system. Troubleshooting actions include:

1. Check leachate chamber cover. Is it in right position? If not, put it in right position.

2. Check surface around leachate chamber. Are there surface cracks? If yes, cracks should be filled in and sealed with soil by the landfill operator.

Troubleshooting Procedure WR – 7001

Location: Laterals and Headers

Problem: Low Flow/High Vacuum

Procedure:

Low flow and/or extremely high vacuum at the inlet to the blower probably means that sufficiently sized zones of influence are not being established in the collection well field. Troubleshooting actions should include:

1. Check valves at the blower/flare station. Do they remain at previous settings?

2. Check valves at wellheads in the extraction field. Do they remain at previous settings?

3. Check for header pipe blockages. This could occur through header pipe collapse or sag, which might constrict flow. Repair of header pipe is necessary under these conditions.

4. Check for header pipe flooding. Check vacuum loss over the condensate trap.

5. Sound the extraction well for leachate level depth, or infiltration of soil or silt that indicates blockage of the well perforations.

Troubleshooting Procedure WR – 7002

Location: Laterals and Headers

Problem: High Flow/Low Vacuum

Procedure:

Combination of high flow and/or low vacuum likely means that gas is entering the extraction system more readily than normal. Under these circumstances, zones of influence in the collection well field have probably changed and control may not be provided. Troubleshooting actions would include:

1. Check methane and oxygen concentrations along the header. Are they consistent?

2. Check valve settings at the blower/flare station. Do they remain at prior settings?

3. Check valves at individual wellheads. Are they at prior settings?

4. Check header pipes, condensate trap, and extraction wells for openings or ruptures. Repair system as required.

Troubleshooting Procedure WR – 7003

Location: Laterals and Headers

Problem: Fluctuating Vacuum Readings

Procedure:

Fluctuating vacuum readings indicate that the LFG system is clogged or malfunctioning

1. Check condensate trap vacuum. Clear or repair trap or drain as necessary.

2. Check wellhead vacuums sequentially. Are particular wells surging due to clogging?

3. Check header pipe vacuums at wellheads starting with the last well. Is surging occurring in a specific header area? Header line may have settled, creating a low point allowing condensate to accumulate.

Troubleshooting Procedure WR – 7004

Location: Laterals and Headers

Problem: Low Methane/High Oxygen

Procedure:

A combination of low methane and high oxygen likely is a sign of air intrusion to the system. Troubleshooting actions include:

1. Check blower/flare station and wellhead valve settings. Do they remain at previous settings? If not, adjust valve(s) to predetermine settings.

2. Check for header pipe ruptures, or openings at condensate trap and wells.

Troubleshooting Procedure WR – 7005

Location: Laterals and Headers

Problem: Condensate/Dirt in Line

Procedure:

In some instances, condensate or dirt may appear at the inlet to the blower. Troubleshooting steps include:

1. Check condensate trap. Has it flooded, allowing condensate to enter the header pipe? Cleaning or repair of the trap drain is recommended.

2. Have there been any failures of the header pipe, condensate trap, or wells? Cave-ins may allow soil to be drawn toward the blower. Repair of damaged area is recommended.

3. Has there been saturation in and around wells. Heavy soil saturation may allow entry of water/leachate to the system.

Troubleshooting Procedure WR – 8001

Location: Landfill Surface

Problem: Surface Cracks

Procedure:

Surface cracks may develop due to hot or dry conditions, or landfill settlement. LFG may be migrating through the cracks to the surface, or air may be drawn into the landfill to the wells. Cracks should be filled in and sealed with soil by the landfill operator.

Troubleshooting Procedure WR – 8002

Location: Landfill Surface

Problem: Depressions

Procedure:

Depressions are evidence of landfill settlement. If occurring along a lateral header or by a well, piping should be checked for breakage. Depressions may lead to surface cracks and ponding. Depressions should be filled in with soil by the landfill operator.

Troubleshooting Procedure WR – 8003

Location: Landfill Surface

Problem: Ponding

Procedure:

Ponding can lead to higher moisture contents within a landfill. The landfill operator should fill in and level ponding areas with soil immediately.

Troubleshooting Procedure WR – 8004

Location: Landfill Surface

Problem: Distressed or Dying Vegetation

Procedure:

Vegetation may die in areas where LFG is migrating through the landfill cover. The cover should be checked for depth and cracking. The landfill operator should increase the depth, seal cracks, or take other actions to prevent gas migration.

Troubleshooting Procedure WR – 9001

Location: Landfill Fire

Problem: Subsurface Fire

Procedure:

In the case of a subsurface fire, smoke or odour may be detectable. Adjacent areas should be examined for settlement/depressions or surface cracks that would allow the smoke to escape to the surface.

Operation of the LFG extraction system with wells in the vicinity of a subsurface fire can result in drawing the residue of combustion processes through the extraction system. Visual evidence can be observed as a thick, black, tar-like coating in the well head, lateral, and header pipes. Residue may also coat valves and blower station components.

Troubleshooting Procedure WR – 9002

Location: Landfill Fire

Problem: Elevated Temperature

Procedure:

Elevated temperatures of LFG within the header pipe at the blower/flare station in the range of 60° C should be considered suspect.

Troubleshooting Procedure WR – 9003

Location: Landfill Fire

Problem: Carbon Monoxide

Procedure:

Analysis of venting and/or extracted gas for the presence of carbon monoxide (a product of incomplete combustion) can also identify the existence of subsurface fire. Gas analysis can be accomplished using portable equipment in the field, such as gas detector tubes, or via gas chromatography. Carbon monoxide concentrations exceeding a few parts per million in LFG should result in additional testing and observation fire.

Troubleshooting Procedure WR – 9004

Location: Landfill Fire

Problem: Settlement

Procedure:

Inspection of site surfaces for settlement resulting from subsurface void space can give an indication as to the location and extent of subsurface combustion. Distinguishing between settlements resulting from normal decomposition processes, as opposed to collapsing of upper refuse layers into void space created be subsurface combustion, may be difficult if the settlement is gradual. Surface settlement may provide no indication of subsurface fire if combustion is sufficiently deep within the landfill such that bridging supports upper refuse layers.