Fire Safety Study

842 Mulgoa Road, Mulgoa

Penrith Waste Services Pty Ltd
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Penrith Waste Services Pty Ltd

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Rev	Date	Remarks	Prepared By	Reviewed By
A	16 June 2020	Draft issue for comment	Jason Costa	Renton Parker
0	29 June 2020	Issued Final		

Executive Summary

Background

Penrith Waste Services Pty Ltd (PWS) has proposed to develop a new biogas system to capture methane from decomposition of waste within the landfill and burn the off-gas to reduce the environmental impact from the methane off-gas. As part of the system, it will be necessary to have a flare to burn gas in a depressurisation system. The Council has requested that the installation of the biogas and flare system is to be subject to a Fire Safety Study (FSS) per the requirements of the Hazardous Industry Planning Advisory Paper (HIPAP) No. 2 (Ref. [1]).

PWS has commissioned Riskcon Engineering Pty Ltd (Riskcon) to prepare an FSS for the facility. This document represents the FSS study for the site located at 842 Mulgoa Road, Mulgoa.

Conclusions

A Fire Safety Study per the HIPAP No. 2 guidelines was prepared for the PWS site as required by Conditions of Consent for construction of the flare and the associated potential for fire scenarios at the site.

The analysis performed in the FSS was based on the credible fire scenarios to assess whether the protection measures at the site were adequate to combat the hazards associated with the quantities and types of commodities being stored. Based on the assessment, it was concluded that the designs and existing fire protection adequately managed the risks.

Recommendations

Based on the analysis, the following recommendations have been made:

- The biogas system shall be subject to a hazardous area classification per AS/NZS 60079.10.1:2009 to identify the potential for hazardous areas to exist around the system.
- Where electrical equipment is required to be installed within a hazardous area it shall comply with AS/NZS 60079.14:2017.
- All site personnel are to be trained in specific site procedures, emergency and first aid procedures.
- A site Emergency Response Plan per the requirements of HIPAP No. 1 shall be prepared and shall include measures to advise neighbouring premises in the event of an emergency with potential offsite impacts.

Implementation Commitment

An implementation commitment has been provided in **Appendix C**.

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Abbreviations

Abbreviation	Description
ADG	Australian Dangerous Goods Code
AS	Australian Standard
CBD	Central Business District
DA	Development Application
DGs	Dangerous Goods
DGS	Dangerous Goods Store
DPE	Department of Planning and Environment
FRNSW	Fire and Rescue New South Wales
HIPAP	Hazardous Industry Planning Advisory Paper
SEP	Surface Emissive Power
SEPP	State Environmental Planning Policy
SSC	Spread Sheet Calculator
VF	View Factor

1.0 Introduction

1.1 Background

Penrith Waste Services Pty Ltd (PWS) has proposed to develop a new biogas system to capture methane from decomposition of waste within the landfill and burn the off-gas to reduce the environmental impact from the methane off-gas. As part of the system, it will be necessary to have a flare to burn gas in a depressurisation system. The Council has requested that the installation of the biogas and flare system is to be subject to a Fire Safety Study (FSS) per the requirements of the Hazardous Industry Planning Advisory Paper (HIPAP) No. 2 (Ref. [1]).

PWS has commissioned Riskcon Engineering Pty Ltd (Riskcon) to prepare an FSS for the facility. This document represents the FSS study for the site located at 842 Mulgoa Road, Mulgoa.

1.2 Objectives

The objectives of the FSS are to:

- Review the site operations and storages for the potential to initiate or become involved in a fire including flammables gases which may be present at the site.
- Identify heat radiation impacts from potential fire sources at the site and determine the potential impacts on the surrounding areas and fire protection system, and
- Review the proposed fire safety features and determine the adequacy of the fire safety systems based on the postulated fires.

1.3 Scope of Services

The scope of work is for the preparation of an FSS for the PWS facility to assess the potential hazards at the site to ensure the fire protection systems are commensurate with the identified hazards. This document follows the methodology recommended in HIPAP No.2 (Ref. [1]).

The FSS focuses on the storage of commodities associated with the new development at the site in addition to the existing operations at the site as required by HIPAP No. 2. A review of the following components of the FSS are within the scope of work:

- Determination of risk and consequences from fire or explosion scenarios throughout the facility.
- The preparation of a report on fire prevention, fire detection, fire alarm and fire suppression systems for the site.
- Firewater storage capacity for compliance with Australian Standards and Regulations and relevant NFPA standards.
- Hydrant hydraulic design screening calculations for the fire water system including the fire main sizing.
- External fire hydrant configuration and locations.
- Recommendations based upon the study for implementation in the final design.

2.0 Methodology

2.1 Fire Safety Study Approach

The following methodology was used in the preparation of the FSS for the facility. The methodology is to follow items required by HIPAP No. 2 (Ref. [1]).

- The fire hazards associated with the facility were identified to determine whether there were any fire or explosion hazards that may impact offsite or result in a potential to escalate. Where fire hazards with the potential to impact offsite or escalate were identified, these were carried forward for consequence assessment.
- The heat radiation impacts or overpressure impacts (consequences) from each of the postulated incidents from the proposed equipment were then estimated and potential impacts on surrounding areas assessed.
- Impacts of the fires from the proposed equipment were plotted on a layout plan of the proposed facility, to determine whether heat radiation impacts any critical areas (i.e. adjacent storage areas, fire services, safety systems, etc.) and whether such impact affected the ability of fire fighters to respond to the postulated fire. The heat radiation impact from incidents at adjacent sites on the buildings and structures at the facility were then assessed against the maximum permissible levels in HIPAP No. 4 (Ref. [2]).
- The firefighting strategies were then assessed to determine whether these strategies require update in light of the location of the proposed equipment and storage areas.
- The response times for FRNSW in the immediate vicinity were assessed. In addition, further out lying FRNSW stations were included to provide a 'back-up plan' in the event that the closest fire brigades were unable to attend.
- A report was then developed for submission to the client and the regulatory authority.

2.2 Limitations and Assumptions

In this instance, the FSS is developed based on applicable limitations and assumptions for the development which are listed as follows:

- The report is specifically limited to the project described in **Section 2.1**.
- The report is based on the information provided.
- The report does not provide guidance in respect of incidents that relate to sabotage or vandalism of fire safety systems.
- The assessment is limited to the objectives of the FSS as provided in the guidelines issued as HIPAP No. 2 (Ref. [1]) and does not consider property damage such as building and contents damage caused by fire, potential increased insurance liability and loss of business continuity.
- Malicious acts or arson with respect to fire ignition and safety systems are limited in nature and are outside the scope of this report. Such acts can potentially overwhelm fire safety systems and therefore further strategies such as security, housekeeping and management procedures may better mitigate such risks.

- This report is prepared in good faith and with due care for information purposes only and should not be relied upon as providing any warranty or guarantee that ignition or a fire will not occur.

3.0 Site Description

3.1 Site Location

The site is located at 842 Mulgoa Road, Mulgoa which is approximately 76 km west of the Sydney Central Business District (CBD). **Figure 3-1** shows the regional location of the site in relation to the Sydney CBD. Provided in **Figure 3-3** is the layout of the site in Mulgoa.

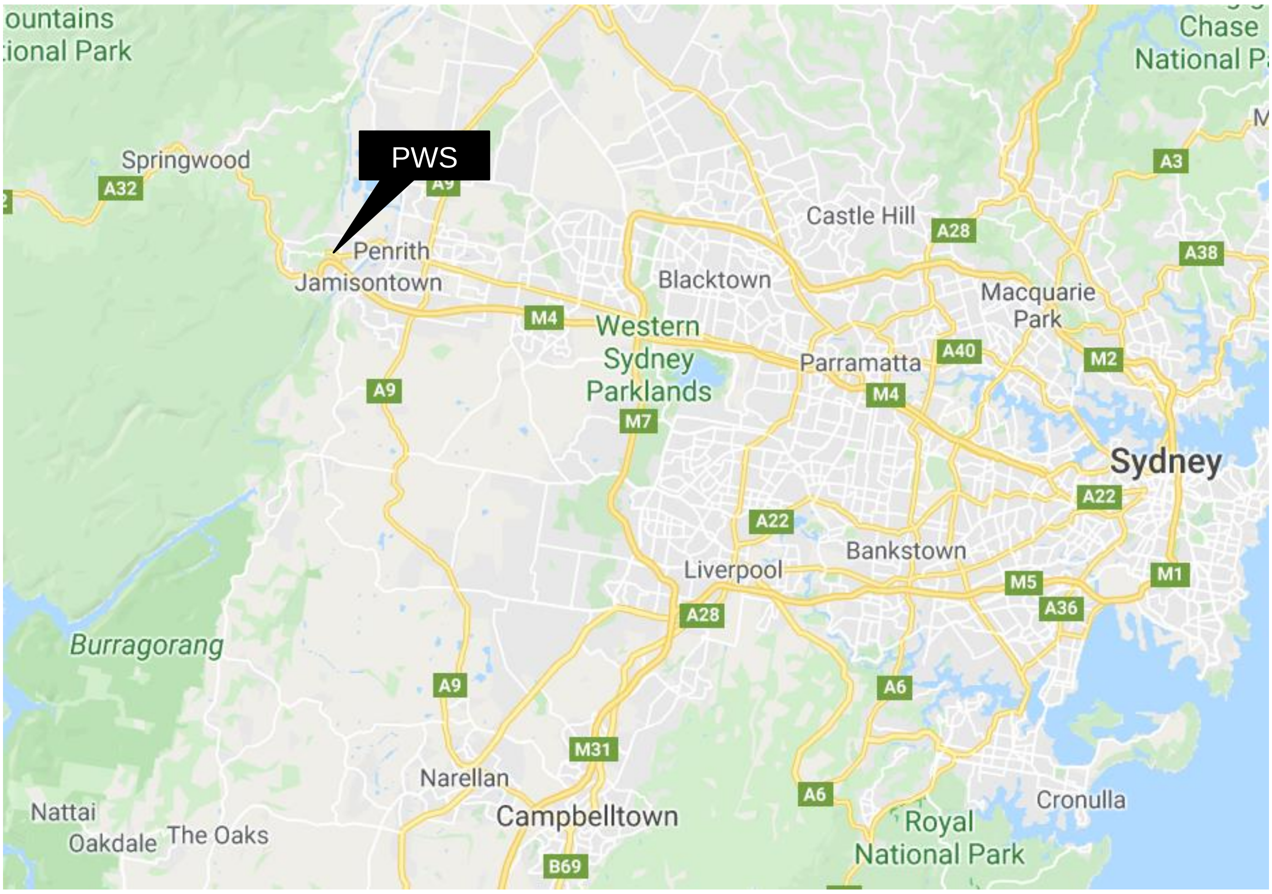

Figure 3-1: PWS Site Location (Source Google Maps)

3.2 Adjacent Land Uses

The land is located in an industrial area surrounded by the following land uses, which are adjacent to the site:

- North – Rural farmland
- South – Rural farmland
- East – Rural farmland
- West – Rural farmland

3.3 General Description

The site is currently a functioning landfill which will be modified to capture methane produced during the decomposition of the capped waste. The methane is produced via decomposition which then rises within the landfill and is captured before being funnelled to the flare where the gas will be combusted at a rate of approximately 500 m^3/hr. The purpose of the system is to prevent the release of methane into the atmosphere for odour and environmental reasons. The methane is converted into odourless and less globally warming carbon dioxide.

The system is composed of two primary collection cells which capture the methane which is then piped toward the southern end of the site where it will be combusted in a flare.

The flare will consist of a high temperature ceramic lined flare constructed of galvanized steel which will be designed to comply with Type B appliances per AS 3814-2015 (Ref. [3]) which requires the appliance to fulfil certain regulatory approvals and compliance with the standard to ensure the safe operation of the appliance. Specifically, the systems are prescriptively designed to prevent uncontrolled release of gas without ignition (i.e. if flameout of the pilot light occurs) such that a large volume of gas is unable to accumulate and ignite resulting in an explosion.

The height of the flare will be 6 m above ground to ensure sufficient dispersion of combusted bi-products to minimise the ground level impact. The flare design is shown in **Figure 3-2**.

3.4 Site Operations

The site operates during the following periods:

- Monday – Friday: 0700 to 1500
- Saturday: 0700 to 1530

The site is staffed by three personnel during operating hours which includes an attendant at the weight bridge, a site operator and a site supervisor. The site may be visited by 40-45 members of the general public each day delivery waste.

While the site will only operate for the previously defined hours, the flare itself will operate 24/7 as methane will be continuously produced within the landfill.

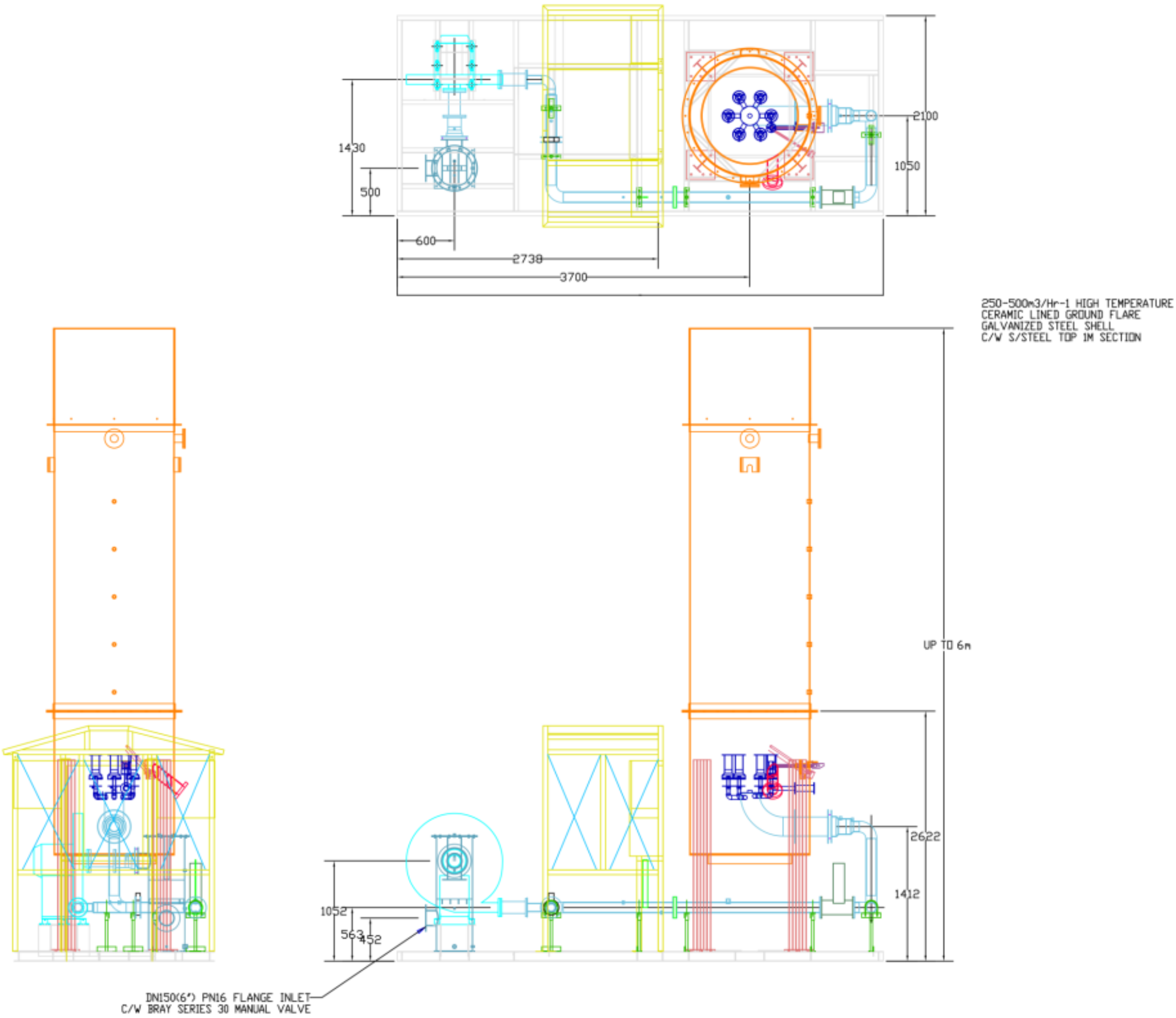

Figure 3-2: Flare Design

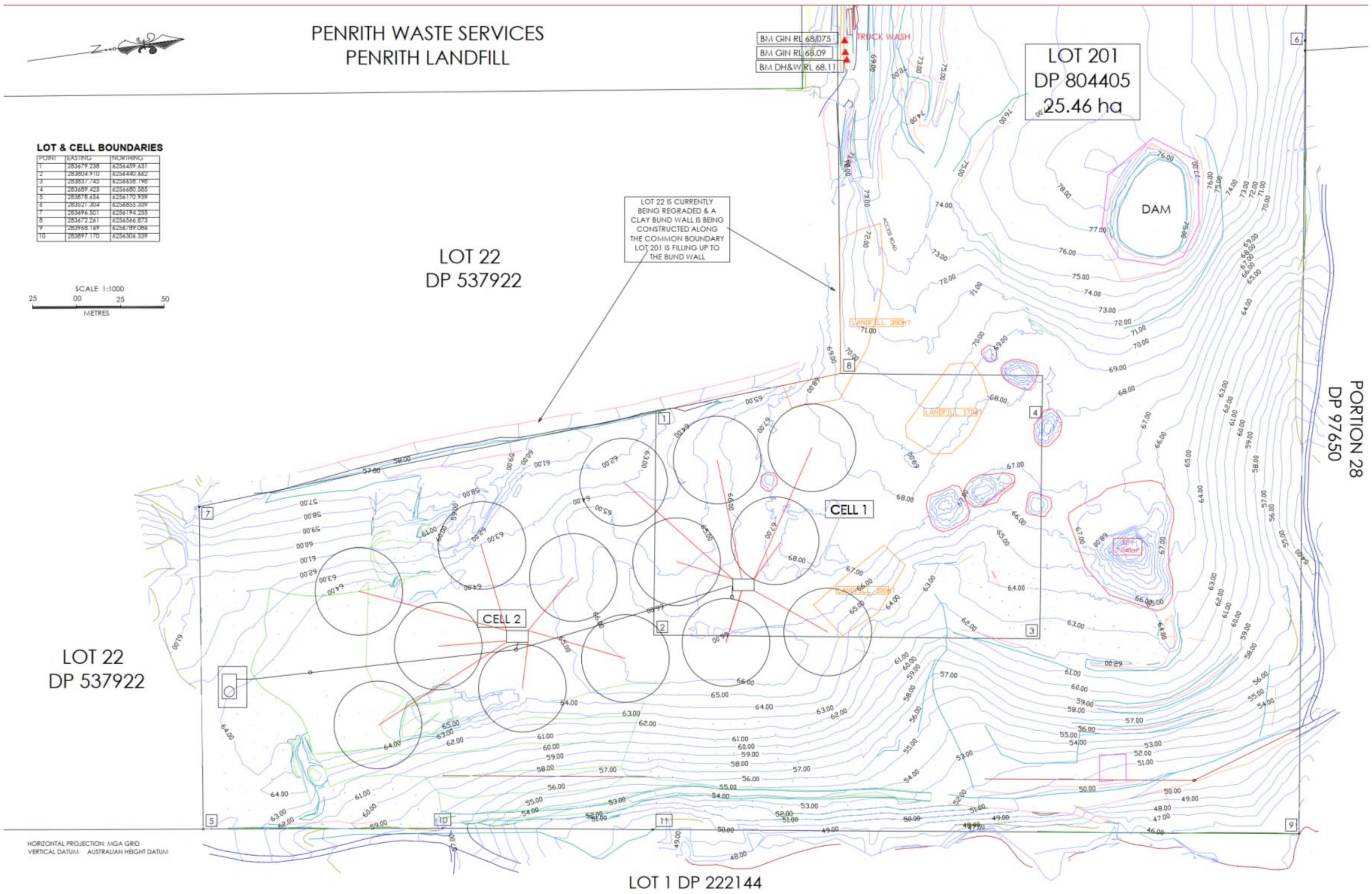

Figure 3-3: Site Layout

4.0 Hazard Identification

4.1 Introduction

A hazard identification table has been developed and is presented at **Appendix A**. Those hazards identified to have a potential fire or explosion impact are assessed in the following sections of this document.

4.2 Properties of Dangerous Goods

The type of DGs and quantities stored and used at the site has been described in **Section 3**. **Table 4-1** provides a description of the DGs stored and handled at the site, including the Class and the hazardous material properties of the DG Class.

Table 4-1: Properties* of the Dangerous Goods and Materials Stored at the Site

Class	Hazardous Properties
2.1 – Flammable Gas	Class 2.1 includes flammable gases which are ignitable when in a mixture of 13 per cent or less by volume with air or have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit. Ignited gas may result in explosion or flash fire. Where gas released under pressure from a hole in a pressurised component is ignited, a jet fire may occur.

* The Australian Code for the Transport of Dangerous Goods by Road and Rail (Ref. [4])

4.3 Hazard Identification

Based on the hazard identification table presented in **Appendix A**, the following hazardous scenarios have been developed:

- Ignition of flare gases, radiant heat and impact.
- Rupture of pipework, ignition and jet fire.
- Rupture of pipework, delayed ignition, and flash fire or explosion.
- Bushfire impact upon adjacent land uses.

Each identified scenario is discussed in further detail in the following sections.

4.4 Ignition of Flare Gases, Radiant Heat and Impact

The flare is designed to combust methane collected from the landfill at the top of the flare. The flare has been designed per AS 3814-2015 (Ref. [3]) which provides a high level of safety with respect to the ability of the flare to maintain combustion. However, as there is an intentional ignition of flammable gas which will result in radiant heat, it is necessary to review the impact of this radiant heat upon the surrounding area and to determine whether it is acceptable. Therefore, this incident has been carried forward for further analysis.

4.5 Rupture of Pipework, Ignition and Jet Fire

There is the potential that pipework leading to the flare may rupture (i.e. damaged by equipment, leaks, rusting or deterioration of pipework, etc.) which could result in a gas release. If the released gas were ignited immediately, it would result in a jet fire which may result in a far reaching jet flame and resultant radiant heat. The impact of the jet fire may have far reaching effects which could result in incident propagation.

It is noted that the release from the pipework is not considered a likely scenario as the pipework is fully welded (i.e. minimal points of failure) and is constructed of appropriate corrosion resistant materials. Therefore, the only likely scenario for rupture to occur would be a external damage (i.e. vehicular impact). The vehicles won't travel near the pipework and are speed limited which would minimise the potential for damage.

Furthermore, the potential for immediate ignition to occur is considered low as there are minimal sources of ignition at the site which could act as an ignition to the gas within the vicinity of the failure. Nonetheless, despite the low potential for pipework rupture and ignition, this scenario has been carried forward for further analysis.

4.6 Rupture of Pipework, Delayed Ignition, And Flash Fire or Explosion

Similar to the scenario discussed in **Section 4.6**, if immediate ignition didn't occur, there is the potential for the gas to accumulate resulting in a vapour cloud which if ignited may result in a flash fire or explosion.

Methane is a buoyant gas which will mix vertically with the air which will minimise the potential for accumulation to occur. In addition, the area is unconfined and naturally ventilated so the methane will disperse laterally as it mixes vertically further reducing the potential for ignition. The gas flow rate from the flare is 500 m^3/h or 0.13 m^3/s which is a relatively low flow rate which would likely be adequately dispersed by the air movement.

Assuming the gas is able to accumulate to a point where it exceeds the Lower Explosive Limit (LEL), the area is unconfined which would prevent the requisite pressure rise within the vapour cloud following ignition to result in an explosion. Therefore, an explosion would not be considered a credible scenario.

Where an explosion doesn't occur, the flame front will burn through the flammable mass to the point of ignition resulting in a jet fire as discussed in **Section 4.6**. A flash fire has a relatively short impact and does not result in far reaching radiant heat. Furthermore, a flash fire incident would likely occur prior to arrival of Fire & Rescue NSW (FRNSW) or the Rural Fire Services (RFS); hence, the direct impact of the flash fire would not affect the FRNSW / RFS personnel.

As an explosion would not occur, and a flash fire would not directly impact services / attending personnel this incident has not been carried forward. However, the escalated impact (i.e. jet fire) has been carried forward for further analysis.

4.7 Bushfire Impact Upon Adjacent Land Uses

The site is an existing operation and has been subject to a bush fire assessment and currently operates bush fire management procedures such as trimming and grazing of site grasses / shrubs to minimise combustible load. A bush fire assessment was conducted to determine the potential impact on the site from bush fire or for bush fire at the site to impact the residential areas. The assessment found that the separation distances provided sufficient distance to attenuate radiant heat below the assessment thresholds.

As the site is already operating and has been subject to bush fire assessments and currently operates bush fire mitigation procedures, the threat of bushfire is not considered to have been increased above the existing operations. Therefore, this incident has not been carried forward for further analysis.

5.0 Consequence Analysis

The following incidents were identified to have potential to impact off site:

5.1 Incidents Carried Forward for Consequence Analysis

The following incidents were identified to have potential to impact off site:

- Ignition of Flare Gases, Radiant Heat and Impact
- Rupture of Pipework, Ignition and Jet Fire

Each incident has been assessed in the following sections.

5.2 Ignition of Flare Gases, Radiant Heat and Impact

The flare will operate to combust the methane gas at a height of 6 m. A detailed analysis of the flare has been conducted in **Appendix B**. The results of the analysis are presented in **Table 5-1**.

Table 5-1: Radiant Heat Impacts from a Flare

Heat Radiation (kW/m^2)	Distance (m)
35	Not observed
23	Not observed
12.6	Not observed
4.7	Not observed
3.0	Not observed

A review of the results indicate that no radiant heat would be observed at ground level. This is due to the substantial attenuation distance from the flare flame surface to a sensitive receptor at ground level. As there is no observable increase in radiation at sensitive levels, there would be no potential for propagation or escalation of events from the flare operating in normal conditions.

In addition, due to the high level of protection afforded to Burner Management Systems (BMS) abnormal operation would be unlikely to result in any serious events. The BMS is designed to prevent accumulation of gas in a situation where flame out occurs. As there are no potential impacts from the flare, this incident has not been assessed further.

5.3 Rupture of Pipework, Ignition and Jet Fire

In the unlikely event that the pipework was to rupture and release gas which ignited, a jet fire may occur. A detailed analysis of the flare has been conducted in **Appendix B**. The results of the analysis are presented in **Table 5-2**.

Table 5-2: Radiant Heat Impacts from a Jet Fire

Heat Radiation (kW/m^2)	Distance (m)
35	1.0
23	1.4
12.6	2.1
4.7	3.7

Heat Radiation (kW/m^2)	Distance (m)
3.0	4.7

A review of the radiant heat impacts indicates there may be sufficient levels for incident propagation; however, the impact distances are small. It is noted the radiant heat impacts displayed in **Table 5-2** are for impacts perpendicular to the direction of the jet fire. The actual impact of the jet fire itself is 2.73 m. Nonetheless, the impact distance is not substantial; hence, it would be unlikely for critical infrastructure to be impacted or for propagation to occur.

The only potential for escalation would be ignition of combustible material around the site; however, this is managed under the bushfire management procedures via grazing and slashing of grasses to prevent accumulation. Therefore, it is considered the risk for spread is adequately managed via the current procedures.

Furthermore, if a jet fire did occur the upstream pipework may be isolated which would starve the jet fire of fuel allowing for the fire to be extinguished. Subsequently, it is considered the risks associated with the jet fire are adequately managed noting that the fully welded pipework would be unlikely to result in a release from which this scenario has been modelled.

6.0 Details of Prevention, Detection, Protection and Mitigation Measures

The fire safety systems at the site can be split into four main categories:

- **Fire Prevention** – systems, installed to prevent the conditions that may result in initiating fire.
- **Fire Detection** – systems installed to detect fire and raise alarm so that emergency response can be affected (both evacuation and firefighting)
- **Fire Protection** – systems installed to protect against the impacts of fire or explosion (e.g. fire walls)
- **Fire Mitigation** – systems installed to minimise the impacts of fire and to reduce the potential damage (e.g. fire water application)

Each category has been reviewed in the following sections, with respect to the existing systems incorporated into the design and those to be provided as part of the recommendations herein.

6.1 Fire Prevention

This section describes the fire prevention strategies and measures that will be undertaken at the site.

6.1.1 Control of Ignition Sources

The control of ignition sources reduces the likelihood of igniting a release of material. The site has a number of controls for ignition sources. These include controls for fixed potential ignition sources and controls for introduced ignition sources.

- A permit to work or clearance system will be used - hot work will be controlled as part of the permit to work system.
- Hazardous area classification for areas containing flammable liquids per the requirements of AS/NZS 60079.10.1:2009 (Ref. [5]).
- Electrical equipment selected for the classified hazardous area. Equipment is installed per the requirements of AS/NZS 60079.14:2017 (Ref. [6]).
- Designated smoking areas within the site (i.e. external from warehouse areas).

Table 6-1 presents the potential ignition sources and incidents for the facility which may lead to ignition and fire. The table also summarises the controls that will be used to reduce the likelihood of these potential sources of ignition and incidents resulting in a fire.

Table 6-1: Summary of Control of Ignition Sources

Ignition Source	Control
Smoking	No smoking policy for the site (i.e. within the warehouse) including processing and storage areas. Note: A designated smoking area is provided.
Housekeeping	The site will operate a housekeeping procedure to ensure accumulation of combustible material (i.e. grasses) is managed. The housekeeping is based upon grazing and slashing to control the accumulation of combustible vegetation.

Ignition Source	Control
Electrical	Fixed electrical equipment to be designed and installed to AS/NZS 3000:2007 (Ref. [7]). Equipment in hazardous areas installed per AS/NZS 60079.14:2017 (Ref. [6]). It is noted that there is minimal electrical equipment at the site.
Arson	The site will have a security fence and will be staffed during business hours.
Hot Work	A permit to work system and risk assessment prior to starting work will be provided for each job involving the introduction of ignition sources.

6.1.2 Housekeeping

The risk of fire spreading from the site is controlled via the management of combustible vegetation as previously noted. This occurs via grazing and slashing of vegetation to prevent accumulation.

6.1.3 Work Practices

The following work practices will be undertaken to reduce the likelihood of an incident. They include;

- DG identification
- Placarding & signage within the site
- Availability of Safety Data Sheets
- HAZCHEM code adherence
- Safe work practices adhered to
- Personal Protective Equipment
- Emergency response plan and procedures
- First aid fire equipment
- Personal hygiene requirements
- Security
- Training of personnel
- Hazardous area dossier (detailing zones, equipment, protection types and certification, etc.)

6.1.4 Emergency Plan

An emergency plan, prepared in accordance with HIPAP No. 1 – Industry Emergency Planning Guidelines (Ref. [8]), will be developed for the site as required by the Work Health and Safety Regulations 2017 (Ref. [9]). The emergency plan will clearly identify potential hazardous fire or explosion incidents and develop procedures fire response. The plan will also include evacuation procedures and emergency contact numbers as well as an onsite emergency response structure with allocated duties to various personnel on site. This will provide readiness response in the unlikely event of an incident at the site.

6.1.5 Site Security

Maintaining a secure site reduces the likelihood either of a fire being started maliciously by intruders or by accident. Access to the site will be restricted at all times and only authorised personnel will be permitted within the site.

6.2 Detection Procedures and Measures

It is not expected for leaks to occur in the pipework supplying the flare as it is fully welded which provides a high level of reliability and containment. The flare operates via controlled loss of containment and ignition. In the event ignition does not occur, this situation would be considered as a loss of containment scenario.

AS 3814-2015 (Ref. [3]) is the standard which covers industrial burner systems which provides a high reliability of the systems. In essence, it is designed to prevent gas release during flame out scenarios. This subsequently prevents the accumulation of a flammable vapours which if ignited could explode. The standard is prescriptive and inspected by the regulator prior to operation which ensure such systems are highly reliable.

6.3 Fire Protection

Fire protection at the site is limited based upon the location and the operations occurring at the site. The site is not fitted with a reticulated hydrant system; however, it is considered that the fire protection is commensurate with the fire risks at the site. Based upon the BMS within the flare and upstream system, it is not considered that the fire risks at the site and increased substantially. In addition, any fire scenarios arising from the gas systems may be contained via upstream isolation of gas flow.

6.4 Fire Mitigation

As noted, fires are mitigated via isolation upstream of any gas release / ignition. It is considered that this is an effective fire management system considering fire impacts would not impact structures and would be unlikely to propagate. Furthermore, application of fire water would note extinguish the fires which may arise from this system.

7.0 Local Brigade Access and Egress

7.1 Overview

In order to assess the likely fire brigade response times an indicative assessment of fire brigade intervention has been undertaken based on the methods defined in the Fire Brigade Intervention Model (FBIM, Ref. [10]).

The site is located within the Fire and Rescue New South Wales (FRNSW) jurisdictional turnout area. The two closest stations to the site are described in **Table 7-1** and the expected route from the closest station to the project site is illustrated in **Figure 7-1**.

Table 7-1: Station Locations

Station Name	Station Address	Distance (km)
Regentville Fire Station	2-6 Jeanette St, Regentville, 2745	5.4
Penrith Fire Station	290-294 High St, Penrith NSW 2750	9.7

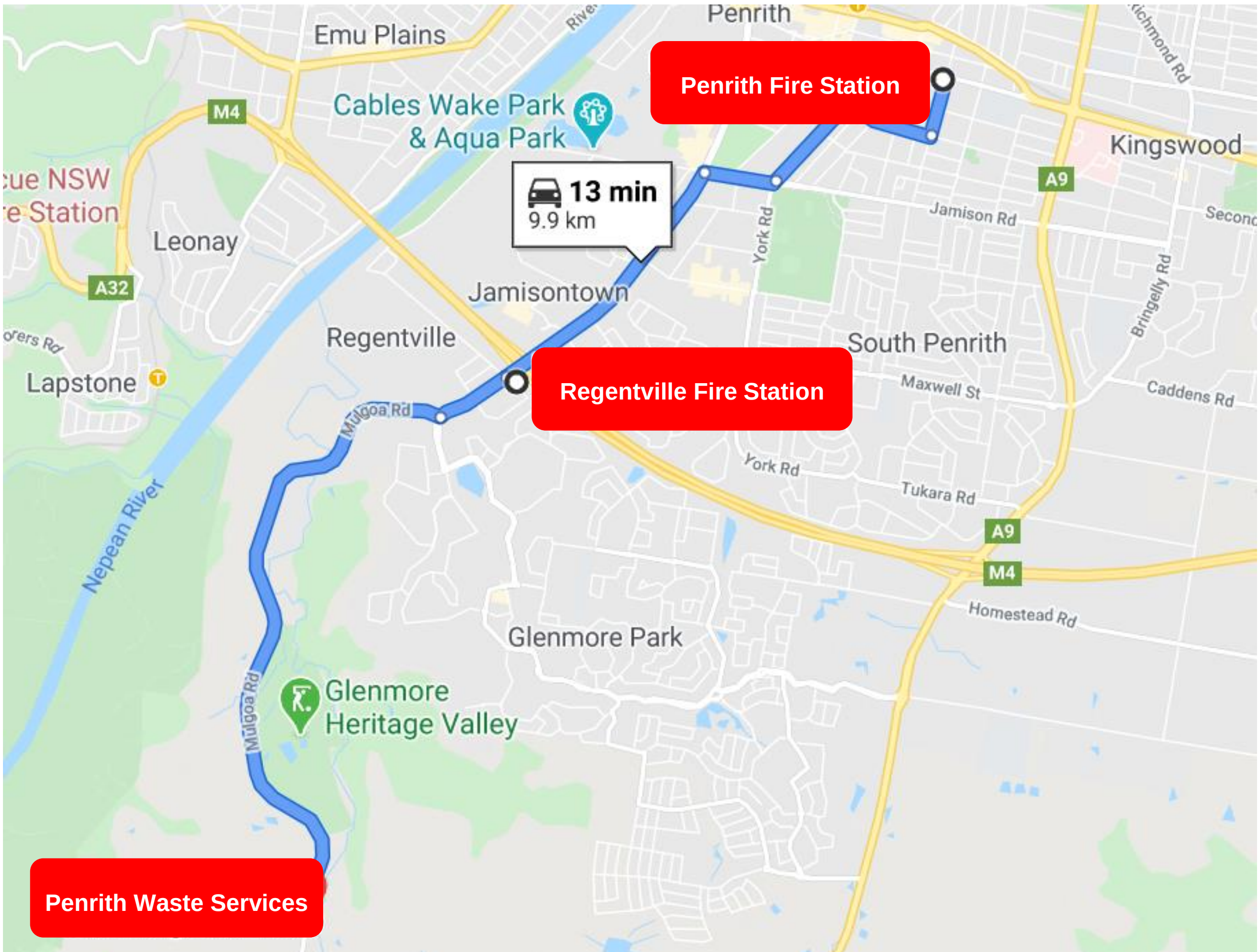

Figure 7-1: Location of Site with Respect to Closest Fire Brigade Stations (Source Google Maps)

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Due to the nature of the Fire Brigade Intervention Model (FBIM, Ref. [10]), it is necessary to justify the results through the inclusion of assumptions. The accuracy of results weighs heavily upon the measure of which assumptions are made and the sources from which they are derived. The model produced details the time it will take for brigade personnel within the aforementioned location to receive notification of a fire, time to respond and dispatch resources, time for resources to reach the fire scene, time for the initial determination of the fire location, time to assess the fire, time for fire fighter travel to location of fire, and time for water setup such that suppression of the fire can commence. The following are details of the assumptions utilised in this FBIM:

7.1.1 Location of Fire

This FBIM will only be an indicative model of one fire scenario within the facility. For conservative purposes, the FBIM will consider a fire in the furthest incident from the point of entry.

7.1.2 Time between Ignition and Detection

It is assumed that the initial brigade notification is via notification from a site operator. A fire scenario arising from the biogas system would be unlikely to be readily identifiable as the flare operates to burn and a jet fire provides a clean burning flame. Therefore, it would be necessary for the fire to propagate such that smoke is developed. Therefore, it has been assumed it’d take half an hour for notification to occur, or 1,800 s.

7.1.3 Time for Initial Brigade Notification

- Following identification by an operator, FRNSW will be notified.
- Time for fire verification and any notification delays is 20 seconds based on Table B of the Fire Brigade Intervention Model (Ref. [10]).
- Therefore, the time from ignition at which the fire brigade will be notified is (1800+20) = seconds after flaming combustion has commenced.

7.1.4 Time to Dispatch Resources

- The fire station is assumed to be manned at the time of the fire.
- Based on FRNSW statistics of response times from the 2018/2019 annual report (Ref. [11]), the average time for the fire brigade to respond to an emergency call (including call processing, turnout time and travel time) is less than 8 minutes. Further, the 90th percentile is less than 12 minutes which is **Figure 7-2** and as the site is within the FRNSW jurisdictional turnout area, a time of 12 minutes (720 seconds) has been conservatively assumed to represent the time required to react to a fire signal and reach the site.

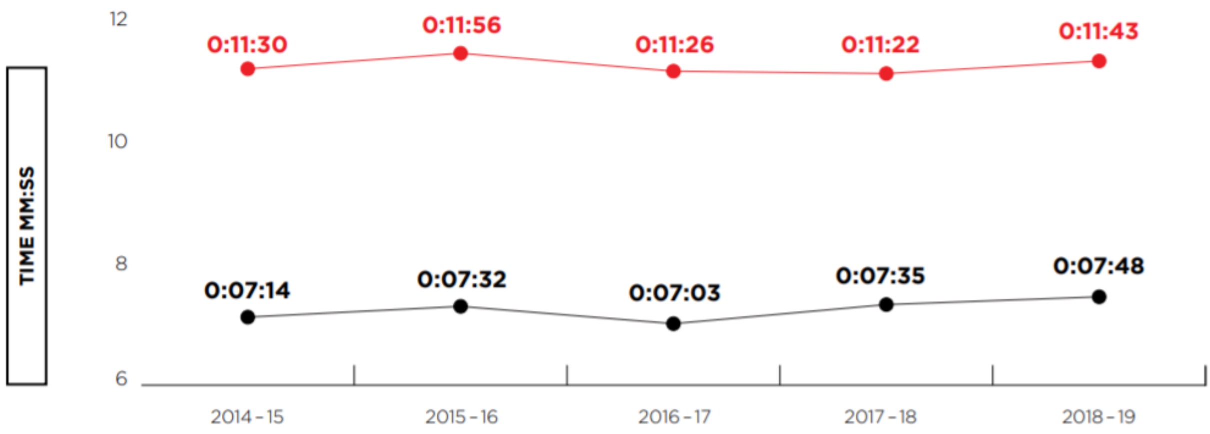

Figure 7-2: FRNSW Response Time from 2018/2019 Annual Report

- Therefore, with a brigade call out time of 1820 seconds fire brigade can be expected to arrive on site 2540 seconds after fire ignition.

7.1.5 Time for Initial Determination of Fire Location

- Based upon the scenario, the fire is likely smoking providing a visible signal as to where the fire is within the site which FRNSW may then approach.

7.1.6 Time to Assess the Fire

- The fire would require minimal assessment when compared to a building fire as the fire may be approached from an upwind position. The site is open and so FRNSW can approach effectively as required. It is not expected initial approach would occur on foot; hence, horizontal foot speed has not been assessed.

7.1.7 Time for Water Setup

- The first appliance would be expected to commence the initial attack on the fire.
- Time taken to connect and charge hoses from the appliance (as the site doesn't have a reticulated hydrant system) is based on V3 Table V of the Fire Brigade Intervention Model Guidelines, which indicates an average time of 45.3 seconds, and a standard deviation of 17.1 seconds. Using a 90th percentile approach as documented in the FBIM (Ref. [10]), the standard deviation is multiplied by a constant *k*, in this case being equal to 1.28. Therefore, the time utilised in this FBIM is 45.3 + (1.28 x 17.1) = 68 seconds.

7.1.8 Search and Rescue

The site is only staffed by 3 people and the general public are not permitted into areas where the gas system may initiate a fire; hence, it is not expected that search and rescue would be required as part of intervention activities and has therefore not been assessed.

Table 7-2: Summary of the Fire Brigade Intervention Model (FBIM)

Fire Station	Alarm Time	Travel Time	Set-up Time	Time of Attack	Time for Search & Rescue
Regentville & Penrith Fire station	1820 s	720 s	68 s	2608 s (43.5 Minutes)	n/a

As summarised in

Table 7-2, the FBIM (Ref. [10]) indicates that the arrival times of the brigade from the nearest fire stations is approximately 43.5 minutes after fire ignition including assessment and setup.

8.0 Fire Water Supply & Contaminated Fire Water Retention

8.1 Detailed Fire Water System Assessment

The site does not have a reticulated hydrant system installed at the site; hence, a hydraulic analysis of the most disadvantaged hydrant may not be performed. Containment of a fire scenario will be entirely based upon isolation of gas supply and extinguishment of any isolated grass fires by FRNSW appliance.

8.2 Contaminated Water/Fire Water Retention

The fire hazards at the site involve methane gas which is a naturally forming gas present in the atmosphere. In a fire scenario, it is expected the majority of the gas would be combusted into naturally present carbon dioxide or alternatively it would remain as methane. As both carbon monoxide and methane are naturally forming gases the contamination from such sources would be expected to be minimal.

Furthermore, any gas entrained within the applied water would evaporate from the liquid back into the atmosphere. Therefore, water contamination into the soil via these gases would not occur. As noted, these gases are present in the normal environment; hence, leaching into the soil would not be considered contamination.

The site does not have provisions for containment of potentially contaminated fire water; however, based upon the low potential for contamination it is not considered a requirement.

9.0 Conclusion and Recommendations

9.1 Conclusions

A Fire Safety Study per the HIPAP No. 2 guidelines was prepared for the PWS site as required by Conditions of Consent for construction of the flare and the associated potential for fire scenarios at the site.

The analysis performed in the FSS was based on the credible fire scenarios to assess whether the protection measures at the site were adequate to combat the hazards associated with the quantities and types of commodities being stored. Based on the assessment, it was concluded that the designs and existing fire protection adequately managed the risks.

9.2 Recommendations

Based on the analysis, the following recommendations have been made:

- The biogas system shall be subject to a hazardous area classification per AS/NZS 60079.10.1:2009 to identify the potential for hazardous areas to exist around the system.
- Where electrical equipment is required to be installed within a hazardous area it shall comply with AS/NZS 60079.14:2017.
- All site personnel are to be trained in specific site procedures, emergency and first aid procedures.
- A site Emergency Response Plan per the requirements of HIPAP No. 1 shall be prepared and shall include measures to advise neighbouring premises in the event of an emergency with potential offsite impacts.

10.0 References

[1] Department of Planning, "Hazardous Industry Planning Advisory Paper No. 2 - Fire Safety Study Guidelines," Department of Planning, Sydney, 2011.

[2] Department of Planning, "Hazardous Industry Planning Advisory Paper No. 4 - Risk Criteria for Land Use Safety Planning," Department of Planning, Sydney, 2011.

[3] Standards Australia, "AS 3814-2015 - Industrial and Commercial Gas Fired Appliances," Standards Australia, Sydney, 2015.

[4] National Transport Commission (NTC), "Australian Code for the Transport of Dangerous Goods by Road & Rail, 7th Edition," 2011.

[5] Standards Australia, AS/NZS 60079.10.1:2009 - Explosive Atmospheres Part 10.1: Classification of Areas, Explosive Gas Atmospheres, Sydney: Standards Association of Australia, 2009.

[6] Standards Australia, AS/NZS 60079.14:2017 - Explosive Atmospheres Part 14: Electrical Installations, Design, Selection and Erection, Sydney: Standards Australia, 2017.

[7] Standards Australia, "AS/NZS 3000:2007 - Wiring Rules," Standards Australia, Sydney, 2007.

[8] Department of Planning, "Hazardous Industry Planning Advisory Paper No. 1 - Industry Emergency Planning," Department of Planning, Sydney, 2011.

[9] SafeWork NSW, "Work Health and Safety Regulation," SafeWork NSW, Lisarow, 2017.

[10] Australasian Fire Authorities Council, "Fire Brigade Intervention Model V2.2," Australasian Fire Authorities Council, 2004.

[11] Fire & Rescue NSW, "Annual Report 2017/18," Fire & Rescue NSW, Sydney, 2018.

[12] I. Cameron and R. Raman, Process Systems Risk Management, San Diego: Elsevier, 2005.

[13] F. P. Lees, Loss Prevention in the Process Industries, London: Butterworth-Heinemann, 2005.

Appendix A

Hazard Identification Table

A1. Hazard Identification Table

Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
Flare	• Gas release from flare	• Fire and radiant heat • Delayed ignition, flash fire or explosion	• Flare designed per AS 3418-2015 (Ref. [3]) prevents flame out situations and delayed ignition situations (i.e. eliminates flash fire or explosion potential) • Methane is a buoyant gas dispersed at 6 m height which prevents accumulation of gas • Flare designed for combustion of gas products and associated radiant heat
Pipework	• Rupture of gas pipework and ignition	• Flash fire or explosion • Jet fire	• Pipework is fully welded minimising potential for rupture • Minimal ignition sources within the landfill (i.e. no fixed electrical installations) • Naturally ventilated location prevents accumulation of gas • Methane is a buoyant gas and will not accumulate at low levels
Bushland	• Ignition of combustible materials around flare / pipework	• Escalation to bushfire	• Existing bushfire management policies • Bushfire assessment

Appendix B

Consequence Analysis

B1. Incidents Assessed in Detailed Consequence Analysis

The following incidents are assessed for consequence impacts.

- Ignition of Flare Gases, Radiant Heat and Impact
- Rupture of Pipework, Ignition and Jet Fire

Each incident has been assessed in the sections below.

B2. Spreadsheet Calculator (SSC)

The SSC is designed on the basis of finite elements. The liquid flame area is calculated as if it is a circle to find the radius for input into the SSC model.

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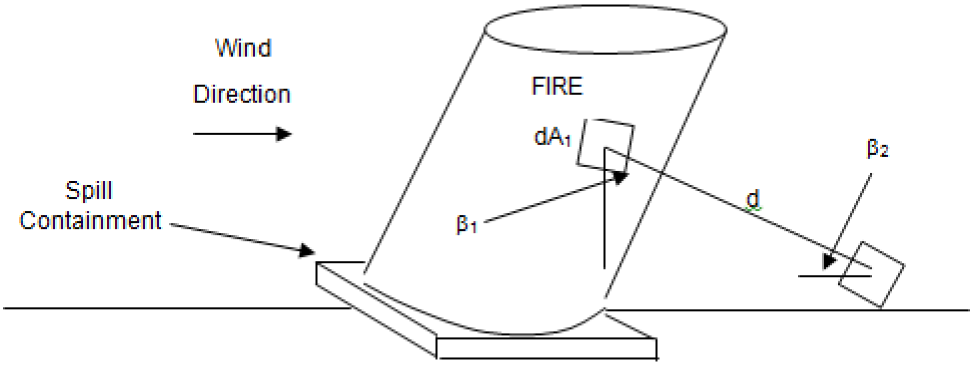

Appendix Figure B-1: Heat Radiation on a Target from a Cylindrical Flame

A fire in a bund or at a tank roof will act as a cylinder with the heat from the cylindrical flame radiating to the surrounding area. A number of mathematical models may be used for estimating the heat radiation impacts at various distances from the fire. The point source method is adequate for assessing impacts in the far field; however, a more effective approach is the view factor method, which uses the flame shape to determine the fraction of heat radiated from the flame to a target. The radiated heat is also reduced by the presence of water vapour and the amount of carbon dioxide in air. The formula for estimating the heat radiation impact at a set distance is shown in **Equation B-1** (Ref. [12]).

$$Q = EF\tau \qquad \textbf{Equation B-1}$$

Where:

- Q = incident heat flux at the receiver (kW/m^2)
- E = surface emissive power of the flame (kW/m^2)
- F = view factor between the flame and the receiver
- τ = atmospheric transmissivity

The calculation of the view factor (F) in **Equation B-1** depends upon the shape of the flame and the location of the flame to the receiver. F is calculated using an integral over the surface of the flame, S (Ref. [12]). The formula can be shown as:

$$F = \int \int s \frac{\cos \beta_1 \cos \beta_2}{\pi d^2}$$ **Equation B-2**

Equation B-2 may be solved using the double integral **or** using a numerical integration method in spread sheet form. This is explained below.

For the assessment of pool fires, a Spread Sheet Calculator (SSC) has been developed, which is designed on the basis of finite elements. The liquid flame area is calculated as if the fire is a vertical cylinder, for which the flame diameter is estimated based on the fire characteristics (e.g. contained within a bund). Once the flame cylindrical diameter is estimated, it is input into the SSC model. The model then estimates the flame height, based on diameter, and develops a flame geometric shape (cylinder) on which is performed the finite element analysis to estimate the view factor of the flame. **Appendix Figure B-1** shows a typical pool fire, indicating the target and fire impact details.

The SSC integrates the element dA_1 by varying the angle theta θ (the angle from the centre of the circle to the element) from zero to 90^o in intervals of 2.5 degrees. Zero degrees represents the straight line joining the centre of the cylinder to the target (x0, x1, x2) while 90^o is the point at the extreme left-hand side of the fire base. In this way the fire surface is divided up into elements of the same angular displacement. Note the tangent to the circle in plan. This tangent lies at an angle, gamma, with the line joining the target to where the tangent touches the circle (x4). This angle varies from 90^o at the closest distance between the liquid flame (circle) and the target (x0) and gets progressively smaller as θ increases. As θ increases, the line x4 subtends an angle phi Φ with x0. By similar triangles we see that the angle gamma γ is equal to 90- θ - Φ . This angle is important because the sine of the angle give us the proportion of the projected area of the plane. When γ is 90^o, sin(γ) is 1.0, meaning that the projected area is 100% of the actual area.

Before the value of θ reaches 90^o the line x4 becomes tangential to the circle. The fire cannot be seen from the rear and negative values appear in the view factors to reflect this. The SSC filters out all negative contributions.

For the simple case, where the fire is of unit height, the view factor of an element is simply given by the expression in **Equation B-3** (Derived from **Equation B-2**):

$$VF = \Delta A \frac{\sin \gamma}{\pi \times X4 \times X4}$$ **Equation B-3**

Where ΔA is the area of an individual element at ground level.

Note: the denominator (π. x4. x4) is a term that describes the inverse square law for radiation assumed to be distributed evenly over the surface of a sphere.

Applying the above approach, we see the value of x4 increase as θ increases, and the value of sin(γ) decreases as θ increases. This means that the contribution of the radiation from the edge of the circular fire drops off quite suddenly compared to a view normal to the fire. Note that the SSC adds up the separate contributions of **Equation B-3** for values of θ between zero until x4 makes a tangent to the circle.

It is now necessary to do two things: (i) to regard the actual fire as occurring on top of a fire wall (store) and (ii) to calculate and sum all of the view factors over the surface of the fire from its base to its top. The overall height of the flame is divided into 10 equal segments. The same geometric technique is used. The value of x4 is used as the base of the triangle and the height of the flame, as the height. The hypotenuse is the distance from target to the face of the flame (called X4'). The angle of elevation to the element of the fire (alpha α) is the arctangent of the height over the ground distance. From the cos(α) we get the projected area for radiation. Thus there is a new combined distance and an overall equation becomes in **Equation B-4 ((**Derived from **Equation B-3**):

$$VF = \Delta A \frac{\sin\gamma \times \cos\alpha}{\pi \times X4 \times X4} \qquad \textbf{Equation B-4}$$

The SSC now turns three dimensional. The vertical axis represents the variation in θ from 0 to 90º representing half a projected circle. The horizontal axis represents increasing values of flame height in increments of 10%. The average of the extremes is used (e.g. if the fire were 10 m high then the first point would be the average of 0 and 1 i.e. 0.5 m), the next point would be 1.5 m and so on).

Thus, the surface of the flame is divided into 360 equal area increments per half cylinder making 720 increments for the whole cylinder. Some of these go negative as described above and are not counted because they are not visible. Negative values are removed automatically.

The sum is taken of the View Factors in **Equation B-3**. Actually, the sum is taken without the ∆A term. This sum is then multiplied by ∆A which is constant. The value is then multiplied by 2 to give both sides of the cylinder. This is now the integral of the incremental view factors. It is dimensionless so when we multiply by the emissivity at the “face” of the flame (or surface emissive power, SEP), which occurs at the same diameter as the fire base (pool), we get the radiation flux at the target.

The SEP is calculated using the work by Mudan & Croche (Ref. [13] & Ref. [12]) which uses a weighted value based on the luminous and non-luminous parts of the flame. The weighting is based on the diameter and uses the flame optical thickness ratio where the flame has a propensity to extinguish the radiation within the flame itself. The formula is shown in **Equation B-5**.

$$SEP = E_{max}e^{-sD} + E_s(1 - e^{-sD}) \qquad \textbf{Equation B-5}$$

Where;

E_{max} = 140

S = 0.12

E_s = 20

D = pool diameter

The only input that is required is the diameter of the pool fire and then estimation for the SEP is produced for input into the SSC.

The flame height is estimated using the Thomas Correlation (Ref. [12]) which is shown in **Equation B-6**.

$$H = 42d_p\left[\frac{\dot{m}}{\rho_a\sqrt{gd_p}}\right]^{0.61} \qquad \textbf{Equation B-6}$$

Where;

d_p = pool diameter (m)

ρ_a = density of air (1.2 kg/m^3 at 20^{o}C)

$\dot{m}$ = burning rate (kg/m^2.s)

g = 9.81 m/s^2

The transmissivity is estimated using **Equation B-7** (Ref. [12]).

$$\tau = 1.006 - 0.01171(\log_{10} X(H_2O) - 0.02368(\log_{10} X(H_2O))^2 - 0.03188(\log_{10} X(CO_2) + 0.001164(\log_{10} X(CO_2))^2$$

Equation B-7

Where:

- τ = Transmissivity (%)
- X(H$_2$O) = $\frac{R_H \times L \times S_{mm} \times 2.88651 \times 10^2}{T}$
- X(CO$_2$) = $\frac{L \times 273}{T}$

and

- R_H = Relative humidity (% expressed as a decimal)
- L = Distance to target (m)
- S_{mm} = saturated water vapour pressure in mm of mercury at temperature (at 25^{o}C S_{mm} = 23.756)
- T = Atmospheric temperature (K)

B3. Jet Fire Modelling

The flow rate of a liquid from a hole may be calculated from **Equation B-8** (Ref. [12]).

$$m = C_d A (2\rho \Delta P)^{0.5}$$

Equation B-8

Where:

- m = Mass flow rate (kg/s)
- C_d = Discharge coefficient (0.6 for irregular holes)
- A = area of the orifice (m^2)
- ρ = Density of the material (kg/m^3)
- ΔP = Pressure difference across the orifice (Pa).

The flame length and width, as a result of a release, can be estimated from the empirical formula published by Lees (Ref. [13]). The equations for the length and width are shown in **Equation B-9** and **Equation B-10**.

$$L = 9.1 {G_L}^{0.5}$$

Equation B-9

Where:

- L = Length (m)
- G_L = Mass flow rate (kg/s)

$$W = 0.25L$$

Equation B-10

Where:

- W = Width (m)
- L = Length (m)

B4. Radiant Heat Impacts

Appendix Table B-1 provides noteworthy heat radiation values and the corresponding physical effects of an observer exposed to these values (Ref. [2]).

Appendix Table B-1: Heat Radiation and Associated Physical Impacts

Heat Radiation (kW/m^2)	Impact
35	• Cellulosic material will pilot ignite within one minute's exposure • Significant chance of a fatality for people exposed instantaneously
23	• Likely fatality for extended exposure and chance of a fatality for instantaneous exposure • Spontaneous ignition of wood after long exposure • Unprotected steel will reach thermal stress temperatures which can cause failure • Pressure vessel needs to be relieved or failure would occur
12.6	• Significant chance of a fatality for extended exposure. High chance of injury • Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure • Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
4.7	• Will cause pain in 15-20 seconds and injury after 30 seconds exposure (at least second-degree burns will occur)
3.0	• FRNSW exposure threshold
2.1	• Minimum to cause pain after 1 minute

B5. Ignition of Flare Gases, Radiant Heat and Impact

The flare has a flow rate of 500 m^3/h or 0.139 m^3/s. The volume of gas may be converted into mass flow by using the following equation:

$$pv = nRT$$

Where,

- P = pressure (Pa)
- V = volume (m^3)
- N = moles
- R = 8.314 Pa.m^3 / mol.K
- T = temperature (K)

The following data was input into the equation based upon an expanded gas at release:

- Pressure = 101325 Pa
- V = 0.139 m3

- T = 298

Substituting the values into the equation results in a molar flow rate of 5.7 mol/s. The molecular mass of methane is 0.016 kg/mol which results in a mass flow rate of 0.091 kg/s. Substituting the mass flow into **Equation B-9** results in a jet flame length of 2.73 m.

$$L = 9.1 \times (0.091)^{0.5} = 2.73\ m$$

$$L = 9.1{G_L}^{0.5}$$ **Equation B-11**

Where:

- L = Length (m)
- G_L = Mass flow rate (kg/s)

The height of the flame is then input into SSC at the height of the flare of 6 m to calculate the radiant heat impacts at various distances as shown in **Appendix Table B-2**. It is noted that the width of the flame is taken as the width of the flare which is considered conservative. The surface emissive power (SEP) of the flame was taken to be 140 kW/m^2 which is appropriate based upon empirical analysis conducted by Less (Ref. [13]).

Appendix Table B-2: Heat Radiation Impacts from a Flare

Heat Radiation (kW/m^2)	Distance (m)
35	Not observed
23	Not observed
12.6	Not observed
4.7	Not observed
3.0	Not observed

B6. Rupture of Pipework, Ignition and Jet fire

A rupture at ground level from the pipework would result in a worst case scenario of the equivalent of what occurs in the flare. However, the impact from a pipework jet fire is taken at ground level as opposed to 6 m in the air for the flare scenario.

The width of the jet fire is calculated using **Equation B-10** which is 0.25 x L or 0.25 x 2.73 = 0.68 m.

The results of the analysis are presented in **Appendix Table B-3**.

Appendix Table B-3: Heat Radiation Impacts from a Jet Fire

Heat Radiation (kW/m^2)	Distance (m)
35	1.0
23	1.4
12.6	2.1
4.7	3.7
3.0	4.7

Appendix C

Implementation Commitment

C1. Implementation Commitment

Penrith Waste Services Pty. Ltd.

A.C.N. 003 960 745

29th of June, 2020

Renton Parker
Director
Riskcon Engineering Pty Ltd
19 / 5 Pyrmont Bridge Road
Camperdown NSW 2050

RE: Penrith Waste Services Fire Safety Study

Penrith Waste Services Pty Ltd acknowledges receipt of the Fire Safety Study for the landfill located at 842 Mulgoa Road, Mulgoa, NSW.

We feel comfortable with the recommendations made and the business intention is to ensure the Customer implements the recommendations as outlined in the study. In addition, we commit to comply with the Prevention, Detection, Protection and Mitigation measures as detailed throughout the Fire Safety Study; specifically, the ongoing commitment to the findings and recommendations of the Fire Safety Study.

Yours Sincerely,

Bryan Singh
Director

842 Mulgoa Road, Mulgoa NSW 2745. Tel: (02) 4773 8778 Fax: (02) 4773 8761