Wagga Wagga Lithium-Ion Battery Recycling Facility

Hazard and Risk Assessment

Calibre Metals Pty Ltd

November 2024

<table>
<tr><th colspan="2">Project name</th><td colspan="6">Wagga LIB Recycling Plant</td></tr>
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<tr><th colspan="2">Project number</th><td colspan="6">12622054</td></tr>
<tr><th colspan="2">File name</th><td colspan="6">12622054-Rev0_Hazard and Risk_Calibre Metals_LIB recycling facility.docx</td></tr>
<tr><th rowspan="2">Status Code</th><th rowspan="2">Revision</th><th rowspan="2">Author</th><th colspan="2">Reviewer</th><th colspan="3">Approved for issue</th></tr>
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Executive summary

Calibre Metals Pty Ltd (Calibre Metals) has identified that there is a need and demand for recycling facilities for Lithium-Ion Batteries (LIB) in Australia, with just one LIB recycling facility currently operational in Australia, in Melbourne Victoria. Currently less than ten percent of used LIB are being recycled in Australia and the remaining used LIB in Australia are being sent to landfill.

Calibre Metals proposes to establish a LIB recycling facility in Wagga Wagga, NSW (the project) using automated battery recycling equipment within a recently constructed industrial building. No additional buildings would be required, and no earthworks are needed as part of the proposed development.

Calibre Metals is seeking consent for use of the existing industrial building as a LIB recycling facility. The project will have capacity to process more than 1000 tonnes of LIB per year and is declared a State Significant Development (SSD).

Calibre Metals has engaged GHD Pty Ltd (GHD) to undertake a hazard and risk assessment through a preliminary risk screening and, if required, the corresponding Preliminary Hazard Analysis (PHA) as dictated by the *State Environmental Planning Policy (Resilience and Hazards) 2021* (*SEPP (Resilience and Hazards)*), to determine if the proposed LIB recycling facility is ‘potentially hazardous or offensive’.

The results of the preliminary risk screening indicate that the screening thresholds for dangerous goods storage and transport movements were not exceeded by any of the dangerous goods proposed to be stored. As a result, the project is not deemed a ‘potentially hazardous industry’.

Over the lifecycle of the project, and with safeguards, the project is not expected to release a significant quantity of pollutant emissions and is not considered to be an ‘offensive industry’.

Based on the hazard identification process, one hazard scenario (a release of LPG) was determined to have potential for off-site impacts and a PHA was completed. The outcome of the PHA determined that the risk arising from the Liquid Petroleum Gas (LPG) storage area does not exceed the fatality or injury risk criteria specified in Hazardous Industry Planning Advisory Paper four (HIPAP 4).

The PHA demonstrates that the project could be designed, constructed and operated in a manner that will meet relevant regulations, standards and policies.

The recommended safeguards already included in the design include:

– Prepare a traffic management plan, including designated pedestrian areas for construction and operation
– Prepare an emergency management plan
– Prepare a construction management plan
– Implement appropriate maintenance and inspection strategies
– Prepare standard operating procedures
– Provide spill kits and appropriate PPE
– Design buildings and equipment to appropriate standards/codes
– Install a fire protection system as outline in section 9.2
– Define housekeeping standards to minimise the build-up of combustible materials on-site
– Separate the LIB storage slab from combustible vegetation by a three-metre buffer
– Install appropriate ventilation in the processing building
– Provide process gas extraction to the scrubber tower
– Include baghouses to remove dust/particulates
– Erect barriers around LPG vessel and piping in key trafficable areas
– Provide a purpose designed waste LIB storage slab, including a bund.

Additionally, it is recommended that the following safeguard be implemented to prevent the identified risk scenarios occurring:

– Install hydrogen detection at roof level in the processing building.

It is important to note that any new equipment items should have procedures developed for their safe operation. This is particularly important for the operation of any new fixed or mobile machinery to prevent injury to people.

Any changes to the assumption used in this report should result in a review of the PHA and update as required.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.2 and the assumptions and qualifications contained throughout the Report.

Glossary

Abbreviation	Description
1.5/F	Weather conditions, refer to section 8.3.1
5/D	
ADG Code	Australian Dangerous Goods Code (National Transport Commission, 2024)
AGTs	Above ground tank
AS	Australian Standard
°C	Degrees Celsius
DG	Dangerous Goods
DoP	(NSW) Department of Planning
DPHI	(NSW) Department of Planning, Housing and Infrastructure
EIS	Environmental Impact Statement
EP&A Act 1979	Environmental Planning and Assessment Act 1979
g	Gram
GHD	GHD Pty Ltd
HAZID	Hazard Identification
HIPAP	Hazardous Industry Planning Advisory Paper
ISO	International Organisation for Standardisation
kg	Kilogram
kL	Kilolitre
km	Kilo metre
kWh	Kilowatt hour
kW/m^2	Kilowatt per square meter
L	Litre
L/min	Litres per minute
LIB	Lithium-Ion Battery
LPG	Liquefied petroleum gas
m	Meter
m^3	Cubic meter
NSW	New South Wales
PG	Packing Group
PHA	Preliminary Hazard Analysis
PHAST	Process Hazard Analysis Software Tool
PPE	Personal Protective Equipment
SEARs	Secretary’s Environmental Assessment Requirements
SDS	Safety Data Sheets
SSD	State significant development
SEPP	State Environment Planning Policy
UN	United Nations

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1. Introduction

Calibre Metals Pty Ltd (Calibre Metals) has identified that there is a need and demand for recycling facilities for Lithium-Ion Batteries (LIB) in Australia, with just one LIB recycling facility currently operational in Australia, in Melbourne Victoria. Currently less than ten percent of used LIB currently being recycled in Australia, and the remaining used LIB in Australia are currently being sent to landfill.

Calibre Metals proposes to establish an LIB recycling facility in Wagga Wagga, NSW (the project) using automated battery recycling equipment within a recently constructed industrial building. No additional buildings would be required, and no earthworks are needed as part of the proposed development.

Calibre Metals is seeking consent for the fit-out and use of the existing industrial building as an LIB recycling facility. The project will have capacity to process 3,000 tonnes of LIB per year and is declared a State Significant Development (SSD) pursuant to Schedule 1 of the State Environmental Planning Policy (Planning Systems) 2021 (Planning Systems SEPP).

1.1 Purpose of this report

Calibre Metals has engaged GHD Pty Ltd (GHD) to undertake a hazard and risk assessment through a preliminary risk screening and, if required, the corresponding Preliminary Hazard Analysis (PHA) as dictated by the *State Environmental Planning Policy (Resilience and Hazards)* (*SEPP (Resilience and Hazards)*)[1], to determine if the proposed LIB recycling facility is 'potentially hazardous or offensive'.

This report is for inclusion in the Environmental Impact Statement (EIS) to support the application for project approval under the Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (*EP&A Act*)[2]. It should be read in conjunction with the EIS, which contains further information on the project and site. It will provide sufficient information and assessment of risks to show that the project satisfies the risk management requirements of the NSW Department of Planning, Housing and Infrastructure (DPHI) to prevent or mitigate any identified impacts, including human health, the environment and property. By demonstrating that the residual risk levels are acceptable in relation to the surrounding land use, and that risk will be appropriately managed, the requirements under *SEPP (Resilience and Hazards)* and the planning development will be met.

1.2 Scope and limitations

This report focuses on the impact of potential hazards associated with the use of dangerous goods and hazardous substances that may arise during the construction and operation of the project, including hazardous interactions with neighbouring industry and infrastructure. Specifically, this report:

- Describes the existing environment with respect to the project
- Screens the quantities of dangerous goods expected to be used during construction and operation of the project
- Assesses the impacts of construction and operation of the project specific to dangerous goods and other hazardous substances and/or scenarios
- Recommends measures to mitigate the impacts identified.

Excluded from this report is assessment of general occupational health and safety hazards, such as confined space and working from height, as compliance to the NSW Work Health and Safety legislation will manage these on-site hazards appropriately through the site Safety Management System.

[1] Parliament of NSW, 2021
[2] Parliament of NSW, 1979

This report: has been prepared by GHD for Calibre Metals Pty Ltd and may only be used and relied on by Calibre Metals Pty Ltd for the purpose agreed between GHD and Calibre Metals Pty Ltd as set out in section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Calibre Metals Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.3 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Calibre Metals Pty Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

1.3 Assumptions

The following assumptions have been made in the preparation of this report:

- Dangerous good quantities provided are true and correct at the time of the screening.
- The chemical data (UN number, dangerous goods classification) was based on available Safety Data Sheets (SDS).
- All plant and equipment items are installed and operated in accordance with appropriate Australian Standards, codes, and guidelines.
- Dangerous goods are stored in accordance with the *Australian Code for the Transport of Dangerous Goods by Road & Rail* (*ADG Code*)[3], relevant standards and guidelines, even if not a licensable quantity.
- All equipment and systems are designed to be inherently safe.
- All equipment is maintained and operated as designed.

Any changes to the assumptions used in this report should result in a review of the screening process and update as required.

[3] National Transport Committee, 2024

2. Legislative and policy context

2.1 Secretary's Environmental Assessment Requirements

The project is an SSD and requires the preparation of an EIS in accordance with the Secretary's Environmental Assessment Requirements (SEARs), issued for the project. The assessment is currently in the scoping phase, however the likely assessment requirements relevant to hazards and risk based upon other similar industrial projects, together with a reference to where they are addressed in this report, are outlined in Table 2.1. Further detail regarding key documents is provided in the following subsections.

Table 2.1 Hazard and risk SEARs

SEARs for SSD-67983064	Reference
Fire and Incident Management	
Identification of the aggregate quantities of combustible waste products to be stockpiled at any one time.	Section 6.1.2
Technical information on the environmental protection equipment to be installed on the premises such as air, water and noise controls, spill clean-up equipment and fire management and containment measures (including location of fire hydrants and water flow rates at the hydrant).	Section 9.2 (spill and fire) EIS, Appendix G (Air Quality Impact Assessment) EIS, section 6.8 (Water) EIS, Appendix G (Noise and Vibration Impact Assessment)
Details regarding the fire hydrant system and its minimum water supply capabilities appropriate to the site's largest stockpile fire load.	Section 9.2
Details of size and volume of stockpiles and their management and separation to minimise fire spread and facilitate emergency vehicle access.	Section 9.2
Consideration of consistency with the *Fire safety guideline: Fire safety in waste facilities* (Fire and Rescue NSW, 2020).	Section 9.2
Detailed information relating to the proposed structures addressing relevant levels of compliance with Volume One of the *National Construction Code* (NCC)[4].	Section 9.2
Hazards and risks	
A preliminary risk screening completed in accordance with Chapter 3 of *SEPP (Resilience and Hazards)* and *Applying SEPP 33: Hazardous and Offensive Development Application Guidelines* (*Applying SEPP 33*)[5].	Section 6
A clear indication of class, storage and handling quantities and location of all dangerous goods and hazardous materials associated with the development.	Section 6.1
A hazard identification for the proposed process including but not limited to the hazards that may lead to generation of flammable or toxic materials during discharge of Li-ion batteries, batteries that are insufficiently discharged and require subsequent procedures, and incorrect concentration of saline solution.	Section 7 and section 9.1
Demonstration that adequate controls are available to safeguard consequences from the identified hazards.	Section 7 and section 9
Demonstration that the development would comply with the risk criteria as set out in *Hazardous Industry Advisory Paper No 4 – Risk Criteria for Land Use Safety Planning* (*HIPAP No 4*)[6].	Section 8.6

[4] Australian Building Codes Board, 2022
[5] DoP, 2011a
[6] DoP, 2011b

2.2 State Environmental Planning Policy (Resilience and Hazard) 2021

The *SEPP (Resilience and Hazards)* aims to manage risks and build resilience related to hazards. Development controls related to hazardous development and offensive industry, remediation of land and the approach to planning within coastal management areas are included. Chapter 3 outlines the development assessment process in relation to hazardous and offensive industries.

Applying SEPP 33 continues to provide the process for assessing if developments are potentially hazardous or offensive under the *SEPP (Resilience and Hazards)*, including threshold levels that trigger the potentially hazardous or offensive status. *Applying SEPP 33* is the main guidance document that has been followed for this PHA.

2.3 Hazardous Industry Planning Advisory Paper No 4 – Risk Criteria for Land Use Safety Planning

HIPAP No 4 sets out risk criteria for industries that are considered hazardous. This document is only used if *Applying SEPP 33* indicates a development is potentially hazardous and an assessment of risk within the PHA is required.

2.4 Hazardous Industry Planning Advisory Paper No 6 – Guidelines for Hazard Analysis

Hazardous Industry Planning Advisory Paper No 6 – Guidelines for Hazard Analysis (*HIPAP No 6*)[7] lists the process required for PHA. This document is only used if *Applying SEPP 33* indicates a development is potentially hazardous.

2.5 Multi-Level Risk Assessment

The *Multi-level Risk Assessment Guideline*[8] lists the process required for completing a risk assessment at a qualitative, semi-quantitative or fully quantitative level of detail. This document is only used if *Applying SEPP 33* indicates a development is potentially hazardous and a PHA is required.

[7] NSW Department of Planning, 2011c
[8] NSW Department of Planning, 2011d

3. Methodology

This section describes the methodology used to undertake the hazard and risk assessment.

3.1 Approach to assessment

3.1.1 Resilience and Hazard SEPP screening

SEPP (Resilience and Hazards) applies to any project which falls under the policy's definition of 'potentially hazardous industry' or 'potentially offensive industry'. If not controlled appropriately, some activities within these industries may create an offsite risk or offence to people, property or the environment thereby making them potentially hazardous or potentially offensive. The purpose of this report is to determine if the project is potentially hazardous using the *SEPP (Resilience and Hazards)* risk screening process or potentially offensive considering expected discharge requirements. If the screening indicates that the project is potentially hazardous, then a preliminary hazard analysis (PHA) is required. The overall risk screening process, as outlined in *Applying SEPP 33* is summarised in Figure 3.1. If the project is potentially offensive, after considering the quantity and nature of any discharges and the significance of the offence likely to be caused, having regard to surrounding land use and the proposed controls, then additional controls are required.

The risk screening process typically concentrates on the storage of specific dangerous good classes that have the potential for significant offsite effects. Specifically, the assessment involves the identification of classes and quantities of all dangerous goods to be used, stored or produced on site with an indication of storage locations. The quantities of dangerous goods are then assessed against the *Applying SEPP 33* threshold quantities. If any of the *Applying SEPP 33* threshold quantities are exceeded, then a PHA is required.

3.1.2 Hazard identification

Following screening and during the final assessment of the project, a determination of whether the project poses significant risk or offence is required. Hazard identification highlights any risks associated with the interaction of the project (as a whole) with the surrounding environment. This is a systematic process to identify any potential offsite impacts. The aim of the hazard identification process is to show the project does not pose any significant risk or offence.

The hazard identification is a desktop qualitative assessment and involves documenting possible events that could lead to a possible off-site incident. The assessment then lists potential causes of the incident, as well as identification of operational and organisational safeguards to prevent the incidents from occurring or to mitigate their impact. The hazard identification is conducted for both construction and operation of the project.

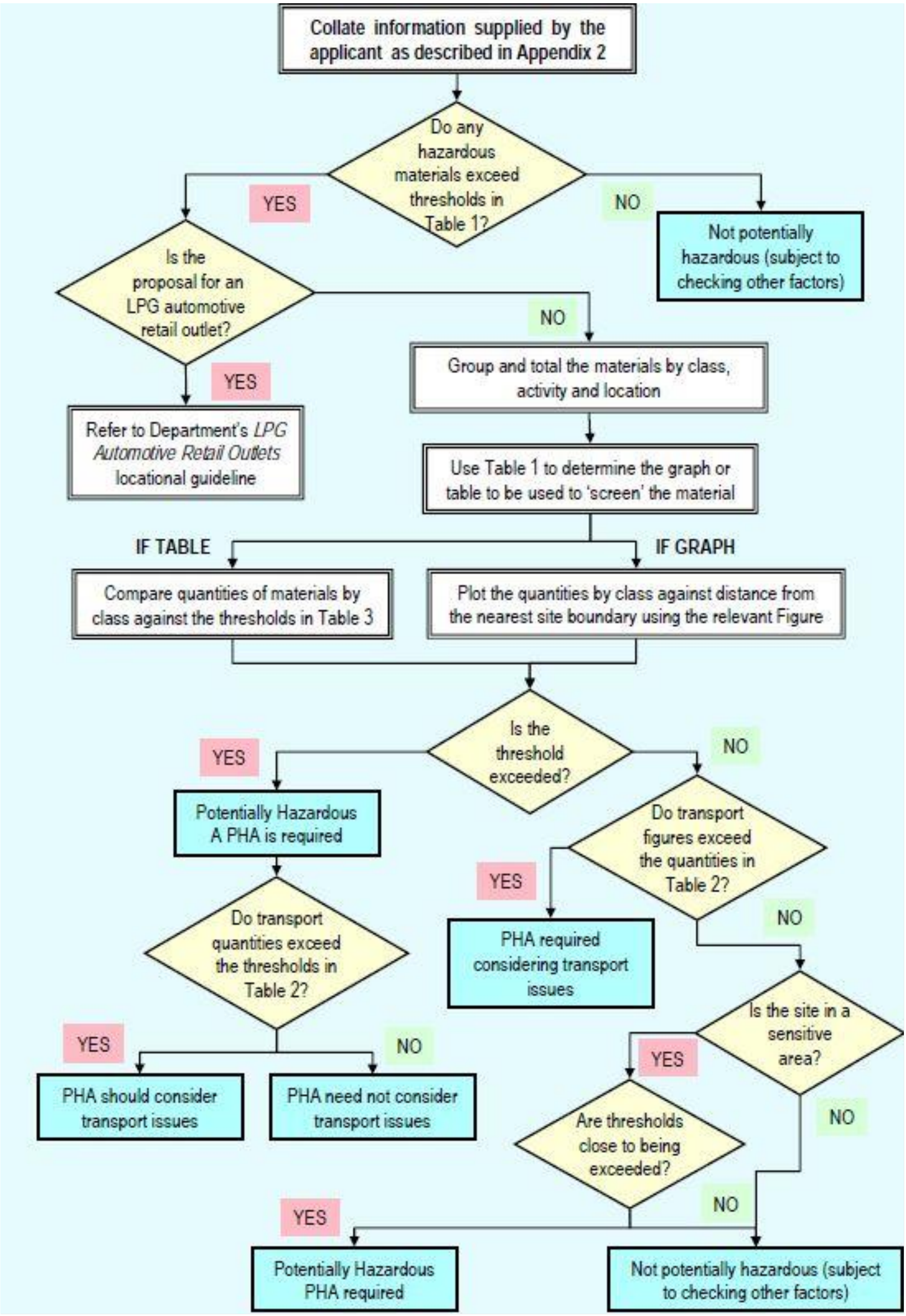


Figure 3.1 SEPP screening process

3.1.3 Preliminary Hazard Analysis

For development projects classified as ‘potentially hazardous industry’, a PHA is completed to determine the risk to people, property and the environment at the proposed location and in the presence of controls. Criteria of acceptability are used to determine if the development project is classified as a ‘hazardous industry’. If this is the case, the development project may not be permissible within most industrial zonings in NSW.

The PHA will identify potential hazards, analyse these hazards in terms of their impact to people and the environment and their likelihood of occurrence, quantify the resultant risk to surrounding land uses and assess the risk to demonstrate that the project will not impose an unacceptable level of risk.

Applying SEPP 33 identifies three levels of PHA. If a PHA is required, a judgement of the level of risk associated with the project is determined using the results of the screening and hazard identification stages. The three levels of PHA are:

– Level 1 – if significant but not serious potential for harm is identified, a qualitative PHA is completed.
– Level 2 – if medium potential for harm is identified, a semi-quantitative PHA is completed.
– Level 3 – if high potential for harm is identified, a quantitative PHA is completed.

All PHA levels use an approach based on comprehensive hazard identification to demonstrate that the activity does not pose a significant risk. The PHA process complies with Australian Standard AS 31000:2018 risk management – principles and guidance, and follows the following steps:

– System definition
– Hazard identification
– Likelihood analysis
– Consequence analysis
– Risk calculations/analysis
– Risk evaluation (compare against criteria and consider risk mitigation and management options).

4. Existing environment

The site is located within an existing industrial area of approximately 1.5 hectares, accessible via Edison Road, East Wagga Wagga, in the Wagga Wagga City Local Government Area (LGA). The project site is situated on pre-disturbed land that is currently undergoing construction of seven new industrial buildings, internal roads and carparking, approved by Wagga Wagga City Council (Council). All necessary services, including water, sewer, electricity and telecommunications, have been made available to the industrial estate.

The site was previously vacant and owned by the Council; the land was used for stockpiling of materials and leased for grazing of livestock. The project site is bounded to the east by an existing industrial development, further east, about 600 metres, is the Governors Hill large lot residential development. Land to the north west is currently vacant, undeveloped land that is zoned for industrial development. To the southwest the land is used for broad acre agriculture. To the north of the site existing facilities include a go-kart facility and the Australian Clay Target shooting range.

5. Project area

The site is sparsely vegetated having been used for historic stockpiling and grazing purposes. The topography of the project site is relatively flat with no watercourse or drainage lines traversing the site. Marshall’s creek is located approximately 590 metres north of the project site.

The following sensitive receivers have been identified in proximity to the project site:

– Wagga and District Kart racing club immediately north of the site
– Commercial and industrial services immediately east of the site
– Residences located less than one kilometre east and southwest of the site, noting the closest dwelling to the project is located about 800 metres east on Matilda Crescent.

6. Risk screening and emissions

A dangerous good is a substance or article that poses a risk to people, property, or the environment. Each class represents a different type of dangerous good. Some classes are divided into packing groups (PG), where PG I substances present a high level of danger, PG II substances present a medium level of danger, and PG III substances present a low level of danger. A summary of the different dangerous goods classes, as defined by the *Australian Dangerous Good (ADG) Code* is shown in Table 6.1.

Table 6.1 Dangerous good classes as per ADG Code

DG Class	Packing Group	Description
1.1	N/A	Substances and articles which have a mass explosion hazard
1.2	N/A	Substances and articles which have a projection hazard but not a mass explosion hazard
1.3	N/A	Substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both but not a mass explosion hazard
1.4	N/A	Substances and articles which present no significant hazard
1.5	N/A	Very insensitive substances which have a mass explosion hazard
1.6	N/A	Extremely insensitive articles which do not have a mass explosion hazard
2.1	N/A	Flammable gases
2.2	N/A	Non-flammable, non-toxic gases
2.3	N/A	Toxic gases
3	I, II, or III	Flammable liquids
4.1	I, II, or III	Flammable solids, self-reactive substances and solid desensitised explosives
4.2	I, II, or III	Substances liable to spontaneous combustion
4.3	I, II, or III	Substances which in contact with water emit flammable gases
5.1	I, II, or III	Oxidising substances
5.2	I, II, or III	Organic peroxides
6.1	I, II, or III	Toxic substances
6.2	I, II, or III	Infectious substances
7	N/A	Radioactive material
8	I, II, or III	Corrosive substances
9	I, II, or III	Miscellaneous dangerous goods and articles

6.1 Dangerous goods storage

6.1.1 Construction

A summary of the chemicals used and/or stored on-site during construction of the project is shown in Table 6.2. The maximum expected quantity and dangerous goods classification are provided in Table 6.2. The summary of the construction threshold compliance is provided in Table 6.3. During construction it is assumed that minimal storage of chemicals will occur, and no stockpiling will occur (use-on-demand regime). As such, the *Applying SEPP 33* storage thresholds for construction of the project are not exceeded for any chemical.

Table 6.2 Construction chemicals

Chemical / product	UN #	DG class	Packing group	Indicative storage quantity	Indicative quantity (tonne)
LPG	1075	2.1	N/A	2 cylinders stored on site	0.09
Spray paint	multiple	2.1 - pressurised	N/A	Minimal amount stored on site	0.02
Acetylene (welding)	1001	2.1 - pressurised	N/A	1 ten m^3 cylinder stored on site	0.01
Oxygen (welding)	1072	5.1	N/A	1 cylinder stored on site	0.05
Paint (oil based considered worst case)	1263	3	II	Minimal amount stored on site	0.1
Solvents	multiple	3	II	Minimal amount stored on site	0.1
Epoxy resins	multiple	3	III	Minimal amount stored on site	0.1
Cleaning products	multiple	8	II	Minimal amount stored on site	0.005
Diesel (C1)	3082	9	III	Minimal amount stored on site	0.03
General oils and lubricants (C2)	1791	9	III	Minimal amount stored on site	0.5
Detergent	N/A	Not classified as DG		Minimal amount stored on site	0.005

Table 6.3 Construction threshold summary

DG class	Combined storage threshold (tonnes)	Combined quantity (tonne)	Exceedance of SEPP 33 threshold
2.1 - pressurised (excluding LPG)	0.1	0.03	Pass (does not exceed)
2.1 (LPG only)	10	0.09	Pass (does not exceed)
3-II	5	0.20	Pass (does not exceed)
3-III	5	0.10	Pass (does not exceed)
5.1	5	0.05	Pass (does not exceed)
8 - II	25	0.005	Pass (does not exceed)
9 - III	None	0.53	Pass (excluded in accordance with *Applying SEPP 33*)

6.1.2 Operation

A summary of the chemicals used and/or stored on-site during operation of the project is shown in Table 6.4. A summary of the thresholds during operation are provided in Table 6.5. Based on the DG class, the *Applying SEPP 33* storage thresholds for operation of the project are not exceeded for any chemical.

Table 6.4 Operational chemicals

Chemical / product	UN #	DG class	Packing group	Maximum storage quantity	Quantity (tonne unless stated)
LPG	1075	2.1	N/A	2 x 7.5 kL tank	15 m^3
Nitrogen	1066	2.2	N/A	1 x pressure swing adsorption (PSA) generator	200 Nm^3/hr
LIB	3480	9	II	Receival pad	52.8
Lime, hydrated	N/A	Not classified as DG		Bulk bags	2
Lime, slurry	N/A	Not classified as DG		2 x 100 kg tanks	0.2
Salt	N/A	Not classified as DG		Bulk bags	2
Brine	N/A	Not classified as DG		24 x 500 L tanks	12
Fluorspar	N/A	Not classified as DG		Bagged powder	2.5
Black mass	N/A	Not classified as DG		Bagged powder	48
Copper metal	N/A	Not classified as DG		Granules	24
Aluminium metal	N/A	Not classified as DG		Granules	24
Stainless steel	N/A	Not classified as DG		Granules	12

Table 6.5 Operational threshold summary

DG class	Combined storage threshold	Combined quantity	Exceedance of SEPP 33 threshold
2.1 (LPG only)	16 m^3	15 m^3	Pass (does not exceed)
2.2	None	200 Nm^3/hr	Pass (excluded in accordance with *Applying SEPP 33*)
9 - II	None	53 tonnes	Pass (excluded in accordance with *Applying SEPP 33*)

6.2 Transport movements

6.2.1 Construction of the project

It is assumed that, during construction of the project, there would be low volumes of dangerous goods stored on site, with a use-on-demand regime. Therefore, the transportation volumes of chemicals during construction (as listed in Table 6.6) have been conservatively estimated and are considered minimal. Based on this, the SEPP transport movement thresholds for construction of the project are not exceeded, as shown in Table 6.7.

Table 6.6 Construction transport movements

Chemical / product	UN #	DG class	Packing group	Tank size	Number of units	Indicative monthly delivery	Indicative annual tank deliveries
LPG	1075	2.1	N/A	2 cylinders stored on site	2 cylinders	1	12
Spray paint	multiple	2.1 - pressurised	N/A	Minimal amount stored on site	1 box	1	12
Acetylene (welding)	1001	2.1 - pressurised	N/A	1 ten m^3 cylinder stored on site	1 cylinder	1	12
Oxygen (welding)	1072	5.1	N/A	1 cylinder stored on site	1 cylinder	1	12
Paint (oil based considered worst case)	1263	3	II	Minimal amount stored on site	5 tins	1	12
Solvents	multiple	3	II	Minimal amount stored on site	1 pallet	1	12
Epoxy resins	multiple	3	III	Minimal amount stored on site	1 box	1	12
Cleaning products	multiple	8	II	Minimal amount stored on site	1 pallet	1	12
Diesel (C1)	3082	9	III	Minimal amount stored on site	2 pails (20 litre)	13	156
General oils and lubricants (C2)	1791	9	III	Minimal amount stored on site	1 pallet	1	12
Detergent	N/A	Not classified as DG		Minimal amount stored on site	1 box	1	12

Table 6.7 Construction transport movement threshold summary

DG class	Transport movements threshold (annual)	Combined transport movements (annual)	Exceedance of SEPP 33 threshold
2.1	> 500	36	Pass (does not exceed)
5.1	> 500	12	Pass (does not exceed)
3 - II	> 750	24	Pass (does not exceed)
3 - III	> 1000	12	Pass (does not exceed)
8 - II	> 500	12	Pass (does not exceed)
9 - III	> 1000	168	Pass (does not exceed)

6.2.2 Operation of the project

Transport of dangerous goods during operation of the project will mainly be associated with movements of used LIB. A summary of the expected transport movements is provided in Table 6.8 and Table 6.9.

Table 6.8 Operational transport movements

Chemical / product	UN #	DG class	Packing group	Tank size	Number of units	Indicative monthly delivery	Indicative annual deliveries
LPG	1075	2.1	N/A	2 x 7.5 kL tank	2 AGTs	1	12
Nitrogen	1066	2.2	N/A	PSA generator	1	0	0
LIB	3480	9	II	Receival pad	Multiple	60	720
Lime, hydrated	N/A	Not classified as DG		Bulk bags	1	1	12
Lime, slurry	N/A	Not classified as DG		2 x 100 kg tanks	1	0	0
Salt	N/A	Not classified as DG		Bulk bags	1	1	12
Brine	N/A	Not classified as DG		24 x 500 L tank	24	0	0
Fluorspar	N/A	Not classified as DG		Drums	1	1	12
Black mass	N/A	Not classified as DG		Bulk bags	1	4	48
Copper metal	N/A	Not classified as DG		Bulk bags	1	4	48
Aluminium metal	N/A	Not classified as DG		Bulk bags	1	4	48
Stainless steel	N/A	Not classified as DG		Bulk bags	1	4	48

Table 6.9 Operational transport movement threshold summary

DG class	Transport movements threshold (annual)	Combined transport movements (annual)	Exceedance of SEPP 33 threshold
2.1	> 500	12	Pass (does not exceed)
9 - II	> 1000	720	Pass (does not exceed)

6.3 Emissions summary

Assessments of the air quality, and noise and vibration impact of the project have been completed as part of the EIS, as the development is ‘potentially offensive’.

Air quality emissions can be managed through appropriate selection of equipment, compliance monitoring in accordance with the site Environmental Protection Licence and community engagement. The results of the air quality assessment are detailed in Appendix G of the EIS.

For construction and operations, the predicted noise levels at residences against project noise trigger levels indicate compliance with the requirements after the incorporation of mitigation measures to reduce noise levels at the source. The results of the noise and vibration impact assessment are detailed in Appendix G of the EIS.

6.4 Screening summary

The results of the dangerous goods and transport screening indicate that the project does not exceed any of the thresholds for construction or operation. The project is not considered ‘potentially hazardous’ and a PHA does not need to be prepared.

The results from the air quality, and noise and vibration assessments indicate that if appropriate control measures are in place during construction and operation, the project will minimise the impact of the relevant amenity criteria. Over the lifecycle of the project, and with safeguards, the project is not expected to release a significant quantity of pollutant emissions and is not considered to be an ‘offensive industry’.

7. Hazard identification

The results of the hazard identification are provided in Table 7.1. The hazard identification was conducted as a desktop study and focussed specifically on both the construction and operation activities of the project. Safeguards are also outlined in Table 7.1 and are required to ensure the risk scenarios that were identified are contained or at least controlled to an acceptable level.

Table 7.1 Hazard identification list

Hazard Scenario	Causes	Consequence	Identified / Recommended Safeguards	Further assessment to assess potential off-site impacts
Vehicle interactions within the project area	– Vehicle movements in vicinity of personnel	– Personal injury	– Prepare traffic management plan including standard traffic rules and signage – Implement site speed limits. – Provide designated pedestrian areas for construction and operation – Driver competency	No
Natural hazards	– Flooding, earthquake, lightning, bushfire	– Personal injury – Asset Damage	– Prepare emergency management plan	No
External fire (adjacent to site)	– Fire or explosion from adjacent land users – Embers from offsite fire	– Asset damage – Plant shut down – Personal injury	– Site fuel management – Buildings designed to appropriate codes – Fire protection systems – Housekeeping standards	No
Internal site fire	– Electrical building fire, e.g. phone charger – Hot works	– Asset damage. – Plant shut down. – Personal injury	– Prepare emergency management procedure – Construction Management Plan – Hot work permit – Fire protection systems – Buffer zones	No
Ignition of organic electrolyte	– Insufficient LIB energy discharging – LIB shredding	– Personal injury – Asset Damage	– Use of brine during discharge – Use of nitrogen during shredding	No
Ignition of flammable gas	– LIB discharge process generates hydrogen gas	– Personal injury – Asset Damage	– Ventilation. – Hydrogen detection at roof level	No
Exposure to toxic gas	– Evaporated organic electrolyte during heating	– Health impacts	– Maintenance and inspection strategies – Gas extraction to scrubber tower	No

Hazard Scenario	Causes	Consequence	Identified / Recommended Safeguards	Further assessment to assess potential off-site impacts
Exposure to dust	– LIB recycle process	– Health impacts – Third party complaints	– Baghouses – Maintenance and inspection strategies	No
Exposure to noise	– General construction activities – LIB recycle process	– Health impacts – Third party complaints	– Maintenance and inspection strategies	No
Flammable gas leak and ignition	– Fire or explosion following an LPG leak due – Failure/ damage of pipework – Failure/ damage of cylinders – Impact damage – Corrosion	– Asset damage – Personal injury	– Barriers erected around gas pipe in key areas – Pressure piping and pressure vessel design – Compliance to *AS 1940 - The storage and handling of flammable and combustible liquids* – Standard operating procedures – Maintenance and inspection strategies	Yes
Loss of containment of chemicals, including dangerous goods	– Damage to storage vessels, e.g. due to external impact – Corrosion – Wear & tear	– Environmental damage. – Personal injury	– Purpose designed storage slab, including bund – Inspection and maintenance strategies – Handling procedures – Standard operating procedures – Spill kits	No
Contact with chemicals, including dangerous goods	– Transfer and handling	– Personal injury	– Transfer and handling procedures – Standard operating procedures – PPE	No

Due to the potential for off-site impacts occurring as a result of an ignition of an LPG release, a PHA has been completed.

8. Preliminary hazard analysis

It is considered that there is potential for moderately serious harm, and a Level 2 PHA is appropriate. A Level 2 PHA uses a semi-quantitative approach based on comprehensive hazard identification to demonstrate that the activity does not pose a significant risk. The PHA follows the process shown in Figure 8.1, which complies with the *Multi-level Risk Assessment Guideline*.

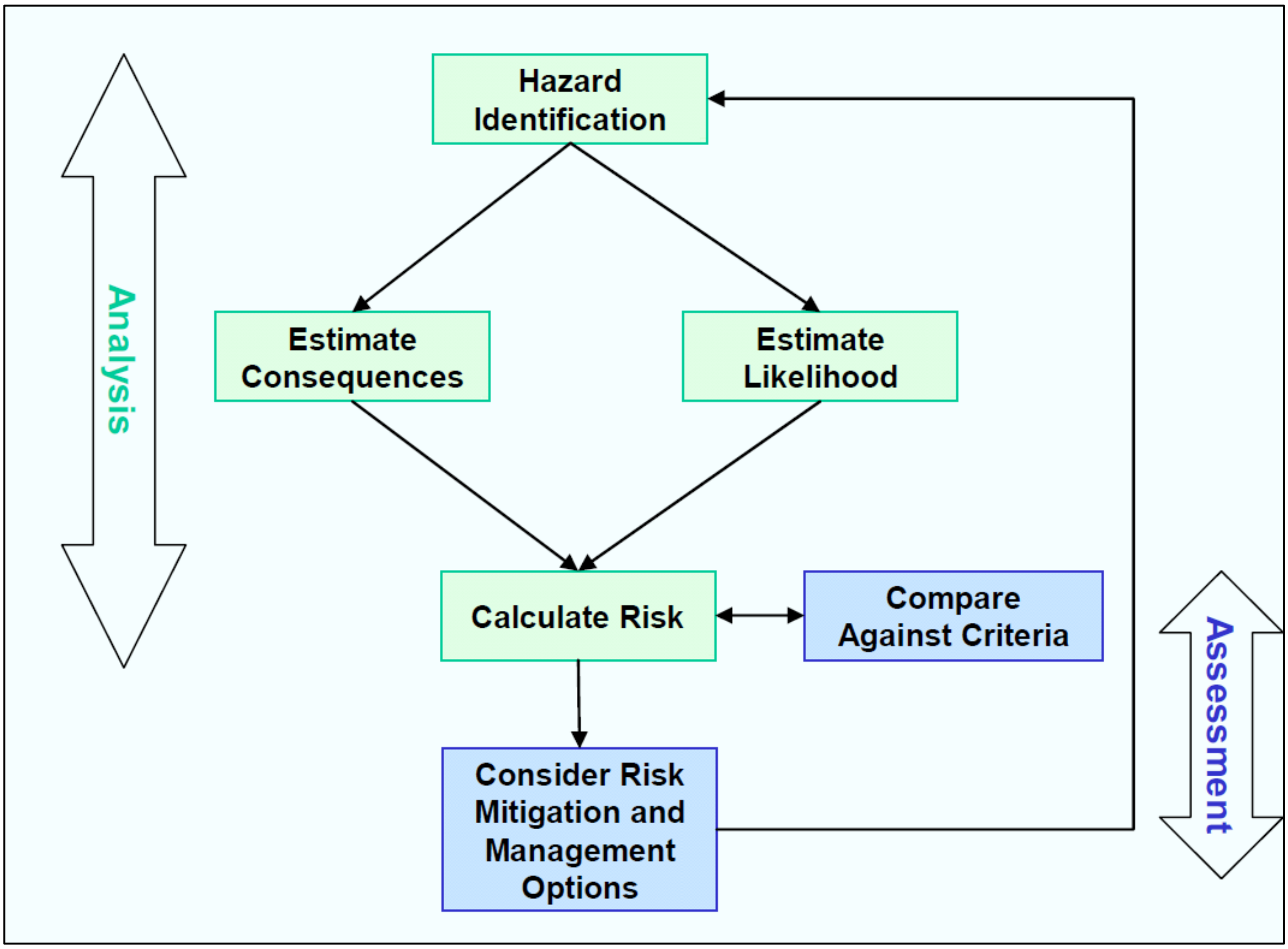


Figure 8.1 PHA process

8.1 Hazardous materials

8.1.1 LPG

LPG can be a mixture of butane and propane. In Australia, LPG is predominately propane. It is a colourless and odourless gas supplied in compressed liquid form. An additive (mercaptan) which has a strong odour is often used. LPG will vaporise rapidly when released into the atmosphere and is highly flammable. The density of LPG vapour is heavier than air and the vapours will settle in calm, low lying areas. The butane component of LPG has a time weighted average exposure of approximately 800 ppm.

The worst-case scenario considered is that of an ignited LPG release occurring at the bulk storage. Likely leak sources include piping connections and flanges.

8.2 Hazard scenarios

The following scenarios were identified as being worthy of further analysis:

– Catastrophic failure of the bulk LPG storage
– Connection leak (25 mm) at the bulk LPG storage.

Smaller leaks from the LPG storage and piping are also possible but will have consequences less than the hazard scenarios analysed. As such they have not been considered in this assessment.

8.3 Consequence determination

The release, dispersion and flammable effect for LPG are performed using PHAST (Process Hazard Analysis Software Tool) 8.9, a commercial software package. A description of the PHAST 8.9 package consequence models employed is provided in Appendix A. The package is widely used in Australia and is designed to perform consequence modelling for the range of scenarios relating to flammable gas releases.

It should be noted that consequence modelling is not the same as risk modelling. Consequence modelling only represents the impact zone that would be affected if a release should occur. It does not consider the following important risk considerations:

– Likelihood of a release, i.e. the leak frequency
– Probability of a wind direction towards a particular location.

8.3.1 Assumptions

The following conditions were used in the consequence determination.

Table 8.1 Consequence modelling inputs

Parameter	LPG (propane)
Temperature	25 °C
Storage Pressure	8.5 bar gauge
Quantity	7.5 m^3
Surface roughness	25 cm (scattered large objects)
Weather conditions	1.5/F (stable night conditions with light wind and moderate clouds) 5/D (stable night and day conditions with high wind and overcast)

8.4 Results

A summary of the determined consequences is provided in Table 8.2 and Table 8.3. The consequence contours are shown in Figure 8.2 and Figure 8.3. The consequences are worst case as they assume no intervention to limit the release. For the leak scenario, some level of intervention would be expected. As such, the contours can be considered conservatively worst case.

Table 8.2 Fire consequence summary

Release Scenario	Weather category	Maximum Distance Downwind of Release to Heat Radiation (m)		
		4.7 kW/m^2 (injury)	12.6 kW/m^2 (fatality)	23 kW/m^2 (property damage)
LPG bulk storage – connection leak with jet fire	1.5/F (night with low wind)	18	15	14
	5/D (day with high wind)	18	16	15
LPG bulk storage – catastrophic failure with fireball	1.5/F (night with low wind)	88	54	40
	5/D (day with high wind)	88	54	40

Table 8.3 Explosion consequence summary

Release Scenario	Weather category	Maximum Distance Downwind of Release to Overpressure (m)		
		0.07 bar (injury)	0.14 bar (property damage)	0.21 bar (fatality)
LPG bulk storage – connection leak with delayed explosion	1.5/F (night with low wind)	18	14	13
	5/D (day with high wind)	17	14	13
LPG bulk storage – catastrophic failure with delayed explosion	1.5/F (night with low wind)	72	46	37
	5/D (day with high wind)	76	48	38

The catastrophic failure of the LPG bulk storage has the potential for offsite impact. Both scenarios have potential to affect the on-site worker population.

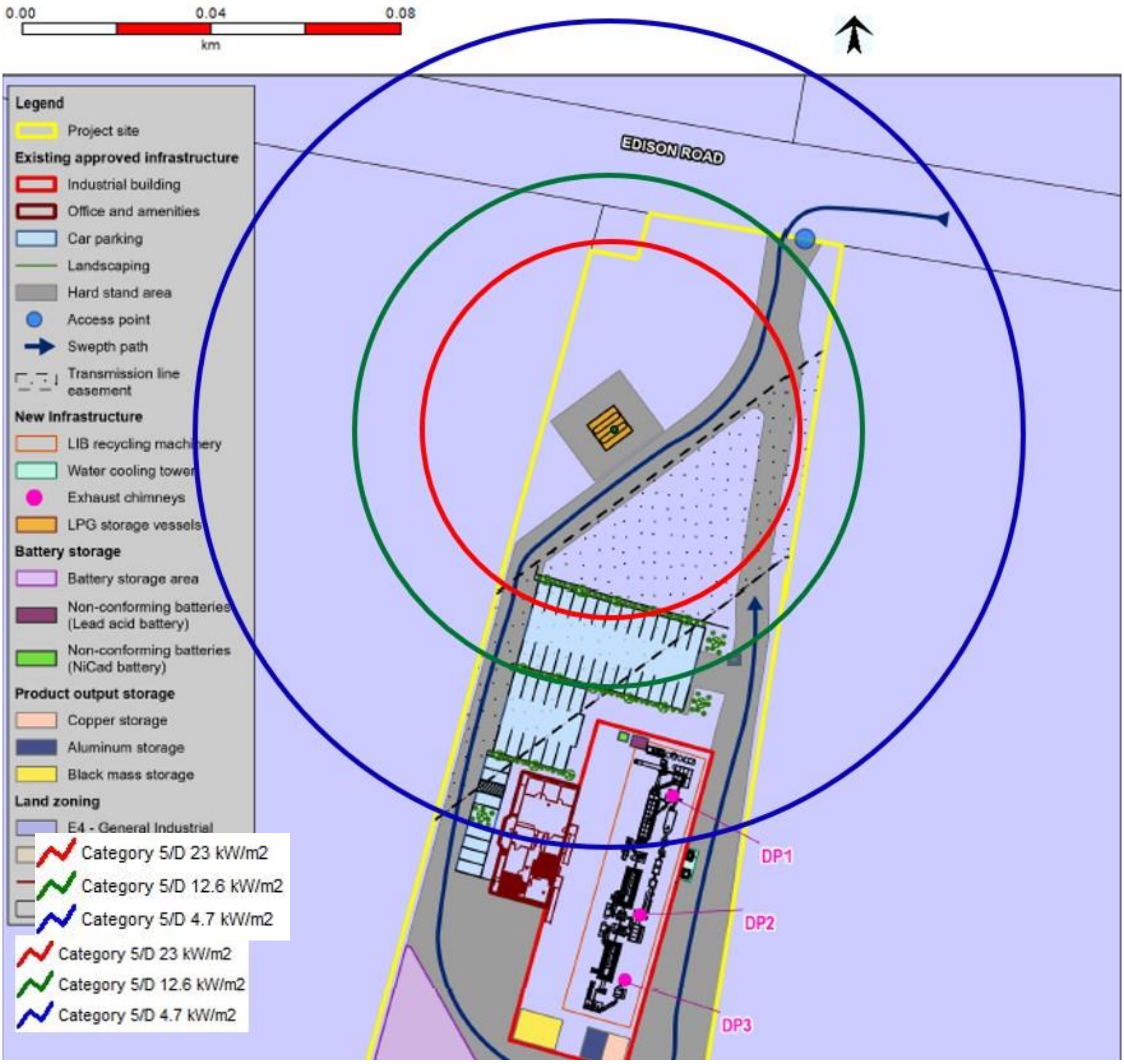


Figure 8.2 Catastrophic rupture fireball contours for 5/D weather

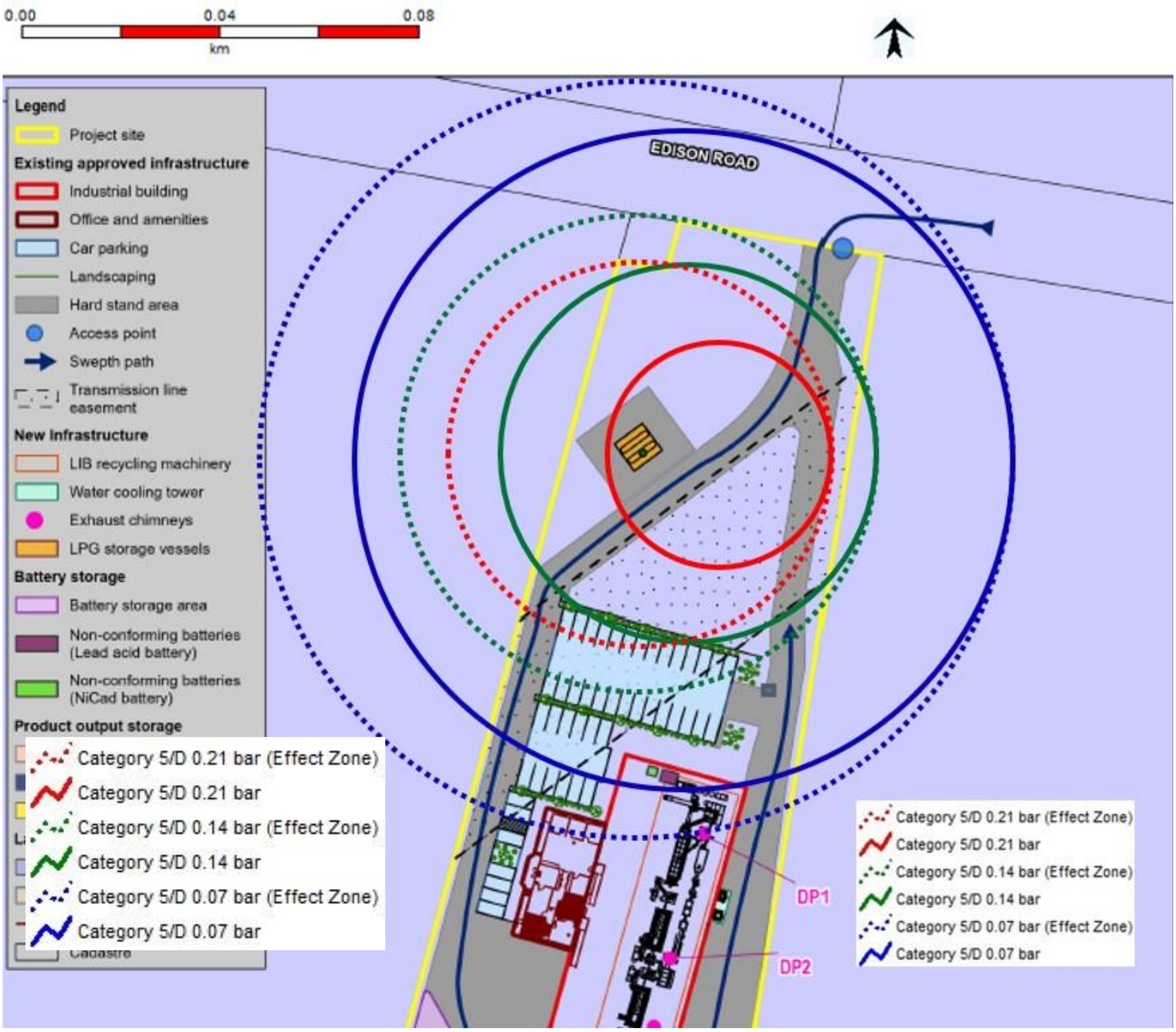


Figure 8.3 Catastrophic rupture explosion contours for 5/D weather

8.5 Likelihood estimation

The likelihood of the worst case scenarios resulting in a fatality or injury was calculated using an event tree, Table 8.4. The assignment of the frequency and probability values has been made based on industry failure frequencies, specialist risk management judgement and the quantified consequences, as shown in Table 8.5 and Table 8.6. It is important to note that the determination of 'absolute values' for assigned probabilities is less important than consistently using 'comparative' or 'relative' values. The overall aim is to provide a ranking to compare with risk criteria.

Once a gas leak has occurred, for a jet fire or a delayed explosion to eventuate, the escaping gas must be ignited by an ignition source. Ignition probability is dependent on the extent of the gas leak as well as the position of the ignition source in the surrounding area. Instantaneous releases from a vessel rupture are deemed to ignite immediately.

Table 8.4 Event tree inputs

Parameter	Value	Source
LPG pressure vessel rupture frequency (per vessel per year)	2.00×10^{-06}	Failure rate and event data for use within risk assessments (UK HSE, 2017), page 25
Connection failure frequency – 25 mm (per connection per year)	5.00×10^{-06}	Failure rate and event data for use within risk assessments (UK HSE, 2017), page 45
Ignition probability for a gas release within a small plant at 0.5 kg/s	0.0019	Risk assessment data directory - Ignition probabilities (OGP, 2010)

Table 8.5 Off-site event tree for scenarios

	LPG bulk storage – connection leak with jet fire	LPG bulk storage – catastrophic failure with fireball	LPG bulk storage – connection leak with explosion	LPG bulk storage – catastrophic failure with explosion
Frequency of gas release (per annum)	5.00×10^{-06}	2.00×10^{-06}	5.00×10^{-06}	2.00×10^{-06}
Probability of ignition	0.0019	1	1	1
Frequency of fire event (per annum)	9.50×10^{-09}	2.00×10^{-06}	5.00×10^{-06}	2.00×10^{-06}
Probability of person impacted (based on consequence and on access road to rail reserve - someone on road for two hours every day)	0.083	0.083	0.083	0.083
Probability impact results in fatality (conservative assumption based on consequence)	0	1	0	1
Probability impact results in injury (conservative assumption based on consequence)	1	1	1	1
Probability impact results in property damage (conservative assumption based on consequence)	1	1	0	1
Frequency of fatality (per annum)	0.00	1.67×10^{-07}	0.00	1.67×10^{-07}
Frequency of injury (per annum)	7.92×10^{-10}	1.67×10^{-07}	4.17×10^{-07}	1.67×10^{-07}
Frequency of property damage (per annum)	7.92×10^{-10}	1.67×10^{-07}	0.00	1.67×10^{-07}

Table 8.6 On-site event tree for scenarios

	LPG bulk storage – connection leak with jet fire	LPG bulk storage – catastrophic failure with fireball	LPG bulk storage – connection leak with explosion	LPG bulk storage – catastrophic failure with explosion
Frequency of gas release (per annum)	5.00×10^{-06}	2.00×10^{-06}	5.00×10^{-06}	2.00×10^{-06}
Probability of ignition	0.0019	1	1	1
Frequency of fire/explosion event (per annum)	9.50×10^{-09}	2.00×10^{-06}	5.00×10^{-06}	2.00×10^{-06}
Probability of person impacted (based on consequence for leak - someone in LPG area four hours a day, for rupture - someone always present in building area for a 12-hour period)	0.17	0.5	0.17	0.5
Probability impact results in fatality (conservative assumption based on consequence)	1	1	1	1
Frequency of fatality (per annum)	1.58×10^{-09}	1.00×10^{-06}	8.33×10^{-07}	1.00×10^{-06}

8.6 Risk assessment

A summary of the compliance to the relevant risk criteria from *HIPAP 4* for the cumulative risk is provided in Table 8.7. This assessment shows that the project will comply with the risk criteria.

Table 8.7 HIPAP 4 risk criteria compliance

Event	Cumulative Risk	One Injury / Fatality every X Years	HIPAP Risk Criteria	Compliance
Fire and explosion scenarios with fatality of off-site people	3.33×10^{-07}	3,000,000	5.00×10^{-05}	Complies
Fire and explosion scenarios with serious injury to off-site people	7.51×10^{-07}	1,332,000	5.00×10^{-05}	Complies
Fire and explosion scenarios with property damage off-site	3.34×10^{-07}	2,993,000	1.00×10^{-06}	Complies
Fire and explosion scenarios with fatality of on-site personnel	2.83×10^{-06}	352,700	5.00×10^{-05}	Complies

9. Hazard mitigation

9.1 Waste management

Due to the nature of recycling LIBs, the combustible waste products stockpiled on site are limited to waste LIB units. There will be no storage of paper, cardboard, wood, rubber, etc. The waste LIB units will be stored on a dedicated outdoor concrete pad within their transport containers, prior to the discharge process. This dedicated storage area will be separated from combustible vegetation by a three-metre buffer. A separate storage area for non-confirming batteries is in the sorting area, next to the discharge process. These non-conforming batteries will be transported away to other recycling facilities. Other general waste will be handled as necessary, and the collection location is outside next to the administration building, as shown in Figure 9.1.

The discharge process will utilise a brine solution that will be re-circulated and the brine concentration topped up as required. The primary discharge rate is based on the brine conductivity (Shaw-Stewart et. al., 2019). The higher the concentration, the faster the discharge rate will be at the start of the process; however, this is offset by increased corrosion and casing damage of the LIB which reduces conductivity (Torabian et. al., 2022). Therefore, there is a balance between concentration/conductivity and brine exposure time can provide a comparable discharge rate regardless of salt concentration.

Generation of hydrogen can occur during the discharge process. Management of this flammable gas requires appropriate ventilation to ensure extraction and dispersion, so the concentration of hydrogen does not reach the lower flammable level. Given hydrogen is lighter than air, hydrogen detectors at roof level (a similar process to managing hydrogen build-up at lead acid battery formation sites) is required.

Following discharge, the waste batteries will be shredded under a nitrogen blanket, significantly minimising the risk of short-circuiting due to insufficient discharge. The concentration of the solution is not critical in the discharge process given the discharge process is not time limited.

9.2 Fire management

The LIB recycling facility has a site-wide fire management system that includes fire hydrants, fire hose reels and spill management kits, as shown in Figure 9.1. These details and the relevant training requirements will be included in the chemical spill response procedure and the fire response procedure within overarching Emergency Response Plan for site. Emergency vehicle entry is via Edison Road, with suitable road access possible to all locations on site via the internal ring road. Smoke detectors will be used to detect a fire, with multi-zone activation. Six detectors will be in the processing building and three in the office building.

The details of the fire hydrant system, are:

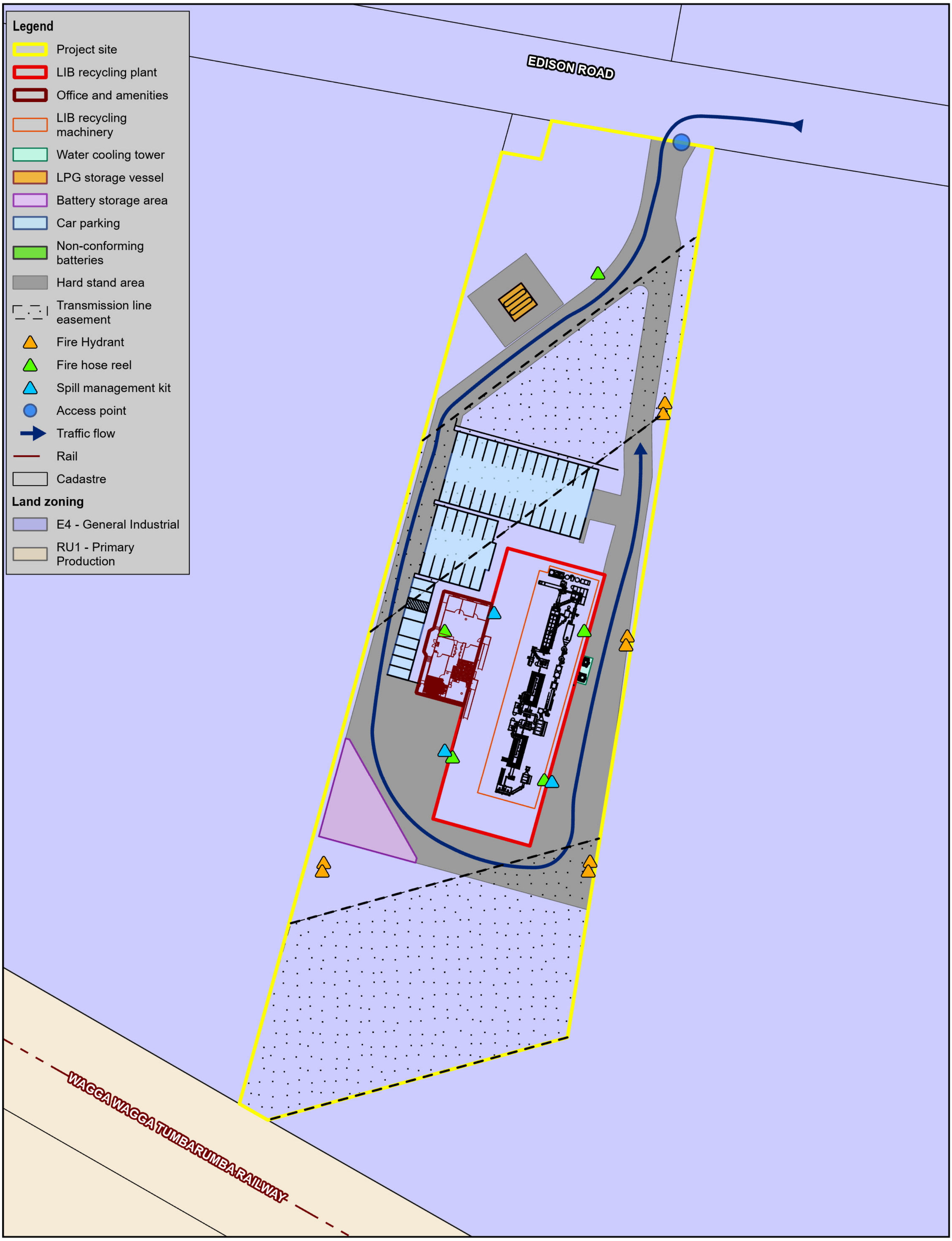
– Full hose coverage of the entire property, including the outdoor waste LIB storage area
– A connection to town mains with backflow prevention
– A dual port fire brigade booster
– Hydrant standpipes protected by bollards where subject to mechanical damage
– External hydrant standpipes located not less than 10 metres from buildings, electrical hazards or stored combustible gas
– A flow rate of 1201 L/min at 463 kPa.

The system complies with:

– AS 2419.1:2021 Fire hydrant installations, Part 1: System design, installation and commissioning
– AS 2441:2005 Installation of fire hose reels
– the *National Construction Code* and is consistent with
– *Fire safety guideline: Fire safety in waste.*

In addition to the fire hydrant system, the facility also includes portable fire extinguishers in the following locations:

– The processing building (seven 9 kg F-500, lithium battery specific extinguisher)
– The kitchen area of the office building (two 4.5 kg ABE)
– The exits of the office building (two 4.5 kg ABE)
– The electrical board (one 5 kg CO_2).



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Calibre Metals
Wagga Wagga Lithium Ion Battery Recycling Facility
Faculty PHA

Project No. 12622054
Revision No. 0
Date 14/03/2025

Emergency Equipment

FIGURE 9-1

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10. Conclusions

This report involved a preliminary risk screening of the project in accordance with the requirements of *SEPP (Resilience and Hazards)*. The results indicate that the screening thresholds for dangerous goods storage and transport movements were not exceeded by any of the dangerous goods proposed to be stored. As a result, the project is not deemed a ‘potentially hazardous industry’.

Over the lifecycle of the project, and with safeguards, the project is not expected to release a significant quantity of pollutant emissions and is not considered to be an ‘offensive industry’.

Based on the hazard identification process, one hazard scenario (a release of LPG) was determined to have potential for off-site impacts and a PHA was completed. The outcome of the PHA determined that the risk arising from the LPG storage area does not exceed the fatality or injury risk criteria specified in HIPAP 4.

The PHA demonstrates that the project could be designed, constructed and operated in a manner that will meet relevant regulations, standards and policies.

10.1 Recommendations

The recommended safeguards already included in the design include:

- Prepare a traffic management plan, including designated pedestrian areas for construction and operation
- Prepare an emergency management plan
- Prepare a construction management plan
- Implement appropriate maintenance and inspection strategies
- Prepare standard operating procedures
- Provide spill kits and appropriate PPE
- Design buildings and equipment to appropriate standards/codes
- Install a fire protection system as outline in section 9.2
- Define housekeeping standards to minimise the build-up of combustible materials on-site
- Separate the LIB storage slab from combustible vegetation by a three-metre buffer
- Install appropriate ventilation in the processing building
- Provide process gas extraction to the scrubber tower
- Include baghouses to remove dust/particulates
- Erect barriers around LPG vessel and piping in key trafficable areas
- Provide a purpose designed waste LIB storage slab, including a bund.

Additionally, it is recommended that the following safeguard be implemented to prevent the identified risk scenarios occurring:

- Install hydrogen detection at roof level in the processing building.

It is important to note that any new equipment items should have procedures developed for their safe operation. This is particularly important for the operation of any new fixed or mobile machinery to prevent injury to people.

Any changes to the assumption used in this report should result in a review of the PHA and update as required.

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Appendix A

PHAST Consequence Modelling Summary

Discharge Modelling

If there is a hole in a pipeline, vessel, flange or other piece of process equipment, the fluid inside will be released through the opening, provided the process pressure or static head is higher than ambient pressure. The properties of the fluid upon exiting the hole play a large role in determining consequences, e.g., vapour or liquid, velocity of release etc. Figure A1 illustrates an example scenario.

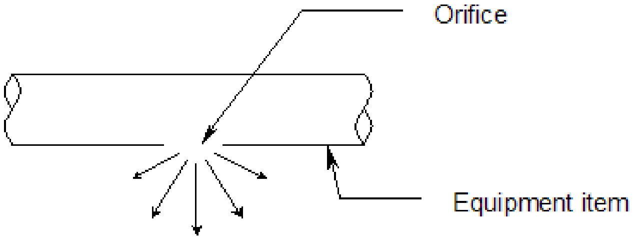

Figure A1 Typical Discharge

The discharge can be considered to have two stages; the first is expansion from initial storage conditions to orifice conditions, the second from orifice conditions to ambient conditions.

The conditions at the orifice are calculated by assuming isentropic expansion, i.e., entropy before release = entropy at orifice. This allows enthalpy and specific volume at the orifice to be calculated.

The equations for mass flow rate ($\dot{m}$) and discharge velocity (u_0) are then given by:

$$\dot{m} = C_d A_0 \rho_0 \sqrt{-2(H_0 - H_i)}$$

$$u_0 = C_d \sqrt{(-2(H_0 - H_i)}$$

Where:

C_d	=	Discharge Coefficients
A_0	=	Area of the Orifice
ρ_0	=	Density of the Material in the Orifice
H_0	=	Enthalpy at the Orifice
H_i	=	Enthalpy at Initial Storage Conditions

The discharge parameters passed forward to the dispersion model are as follows:

– Release height (m) and orientation
– Thermodynamic data: release temperature (single phase) (°C) or liquid mass fraction (two-phase), initial drop size (m)
– Other data:
  - For instantaneous release: mass of released material (kg), expansion energy (J)
  - For continuous release: release angle (degrees), rate of release (kg/s), release velocity (m/s), release duration (s)

Dispersion

When a vapour leak occurs, some material will be released into the atmosphere. Upon being released it will start to disperse and dilute into the surrounding atmosphere. The limiting (lowest) concentration of interest is related to flammable and toxic limits for flammable and toxic substances respectively. The model used to determine extent of release is described below, along with some of the key input parameters.

The consequence modelling package SAFETI utilises the Unified Dispersion Model. This models the dispersion following a ground level or elevated two-phase unpressurised or pressurised release. It allows for continuous, instantaneous, constant finite duration and general time varying releases. It includes a unified model for jet, heavy and passive two-phase dispersion including possible droplet rain out, pool spreading and re-evaporation.

Jet Dispersion

For a continuous, pressurised release, a vapour is released as a jet, i.e., high momentum release. The jet eventually loses momentum and disperses as a passive cloud. Figure A2 below shows a typical release and the various phases involved.

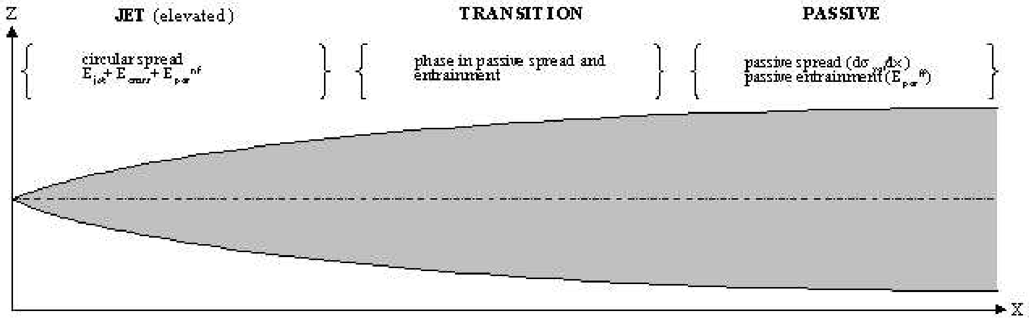

Figure A2 ***Jet Dispersion***

The cloud is diluted by air entrainment until it eventually reaches the lower limit of concern. During the jet phase, the mixing is turbulent, and much air is entrained. In the passive phase, less air is potentially entrained, and it occurs via a different mechanism to the turbulent jet phase. The calculation of the plume therefore depends on many factors, the key parameters being:

– Vapour released, specifically molecular weight.
– Discharge conditions including phase(s) of release, velocity etc.
– Atmospheric conditions (a cloud will generally travel further in more stable conditions with lower wind speeds).

Dispersion from Pool Evaporation

If a rupture occurs from a drum or vessel containing a liquefied gas, the liquefied gas pools on the ground whilst rapid vaporisation occurs forming a vapour cloud, which ultimately disperses, as a low momentum cloud. Due to the low momentum, the cloud is not turbulent, which is a significant factor in air entrainment and dilution of the cloud. Figure A3 below shows a typical release and some of the inputs into the calculation.

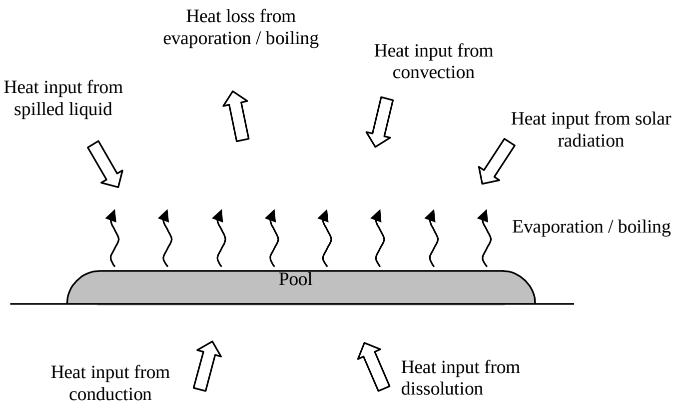

Figure A3 ***Pool Evaporation Heat Balance***

The rate of the evaporation depends on numerous factors, the most important ones being:

– Surface it is released onto (e.g. its thermal properties and temperature)
– Atmospheric conditions (a cloud will generally travel further in more stable conditions with lower wind speeds)
– Boiling point of the liquid
– Pool size.

The concentration of interest is normally related to the toxic limits or specified Emergency Response Planning Guideline (ERPG) limits set for the contained hazardous material.

Toxic Load and Probability of Death

The toxic load L_{toxic}, for a given component i, is calculated from the concentration of the material at a given position. In the case of a continuous cloud, the concentration does not vary with time and the toxic load is given by:

$$L_{Toxic}(i) = t_{exp} \times (f_i C)^{T_N(i)}$$

The probability of death P_{death}, for a given component i, at a given position is calculated from a "probit number", P_i, which is calculated from the "toxic load" and calculated given by the following equations:

$$P(i) = T_A(i) + T_B(i) \ln L_{Toxic}(i)$$

$$P_{Death}(i) = \frac{1}{2}\left\{1 + erf\left[\frac{P(i)-5}{\sqrt{2}}\right]\right\}$$

Where:

t_{exp}	=	Exposure Time
f_i	=	Fraction of the Toxic Component in the Cloud
C	=	Concentration of the Component at a Given Position
$T_{N(i)}$	=	Probit Number N of the Component i
$T_{A(i)}$	=	Probit Number N of the Component i
$T_{B(i)}$	=	Probit Number N of the Component i

Flammable Effects

If the release is of a flammable material, it is possible for the release to be ignited. The resulting type of fire (e.g. jet, pool, explosion etc.) depends on the physical properties of the release and whether the ignition is immediate or delayed.

Jet Fire

Jet fires are a result of high momentum releases. If a flammable release is ignited instantaneously, a jet fire will result. The flame will have a degree of 'lift off' as the flammable mixture must dilute to be within the flammable limits. This section briefly discusses the model used for jet fires as well as key parameters in the calculation.

The jet fire calculation utilises the Chamberlain model. In this model, jet fires are modelled as a conical flame, with the ignited portion lift off, inclination and shape being determined by the material being released, the pressure at which it is being released and the hole size that it is being released through. These release parameters are the main inputs to the jet fire radiation calculations. Figure A4 below shows a graphical representation of the jet fire model.

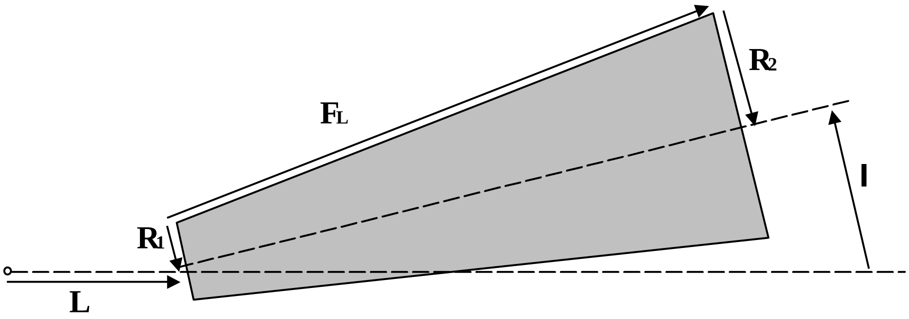

Figure A4 Truncated Cone Jet Fire Model

Where:

L = Lift off

I = Flame Inclination

R_1 = Flame Base Radius

R_2 = Flame End Radius

F_L = Flame Length

The jet fire calculations model radiation from the entire surface of the ignited portion of the jet. This includes radiation from the cone forming the body of the flame, as well as from the ends of the cone. The amount of radiation that a nearby receiver is exposed to is determined by its distance from the flame surface, as well as by the orientation of the flame relative to the receiver. The key parameters in the calculation of the radiation exposure of a receiver are therefore the flame lift off, the flame inclination, and the dimensions of the ignited portion of the jet (i.e. flame length and end radii).

Fireball Model

Fireballs are short-lived flames which generally result from the ignition and combustion of turbulent vapour/two phase (i.e. aerosol) fuels in air. Releases that fuel fireballs are usually near instantaneous and commonly involve the catastrophic failure of pressured vessels/pipelines. Fireballs can dissipate large amounts of thermal radiation which away from their visible boundaries may transmit heat energy that could be hazardous to life and property.

SAFETI uses static models to evaluate fireballs. Static models assume the fireball exist at its maximum size over its lifespan and ignore transient flame characteristics. It provides a conservative flame shape and incident radiation estimates.

The fireball model (Figure A5) determines the flammable mass, fireball duration, radius and lift-off height (height from the centre of the fireball to the ground under the fireball) as well as the surface emissive power to generate the heat radiation effect.

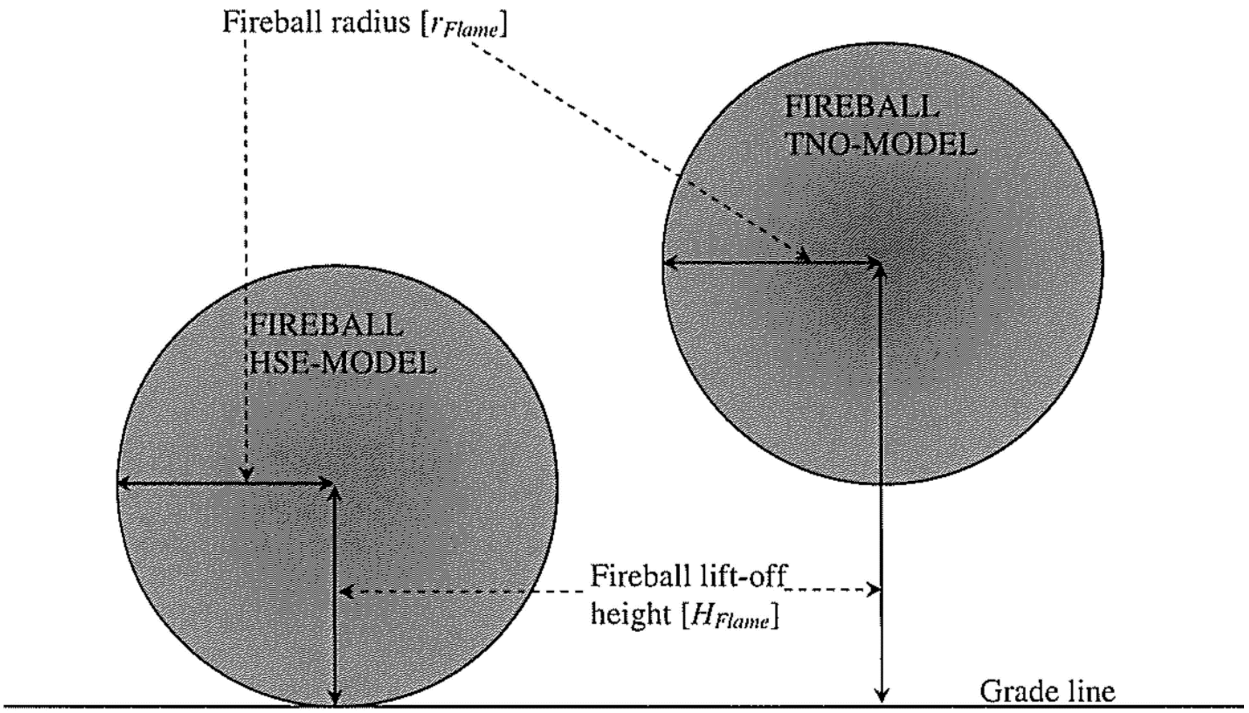

Figure A5 *Fireball Model*

Multi Energy Explosion Model

The Multi Energy Model gives overpressure of an explosion as a function of distance from the explosion. The explosion is modelled as a sphere and overpressure is calculated based on scaled distance from the centre. This section explains the key parameters involved in the multi energy model.

The energy released by the explosion, E, is calculated as the product of the mass of fuel in the cloud and the heat of combustion. This assumes a stoichiometric mixture of fuel and air.

The distance scaling factor, S, is related to the energy released by the explosion and the atmospheric pressure by

$$S = \left[\frac{E}{P_a}\right]^{1/3}$$

The scaled distance r is then given by

$$r = \frac{d}{S}$$

where d is the actual distance of the receiver from the cloud centre.

To calculate overpressure a set of 10 curves is used. The actual curve used depends on the degree of confinement, with a confinement of 1 being least confined and 10 most confined. Process plants generally have a confinement factor of 7, though it needs to be assessed for each individual process. The graph showing the 10 curves is included in Figure A6.

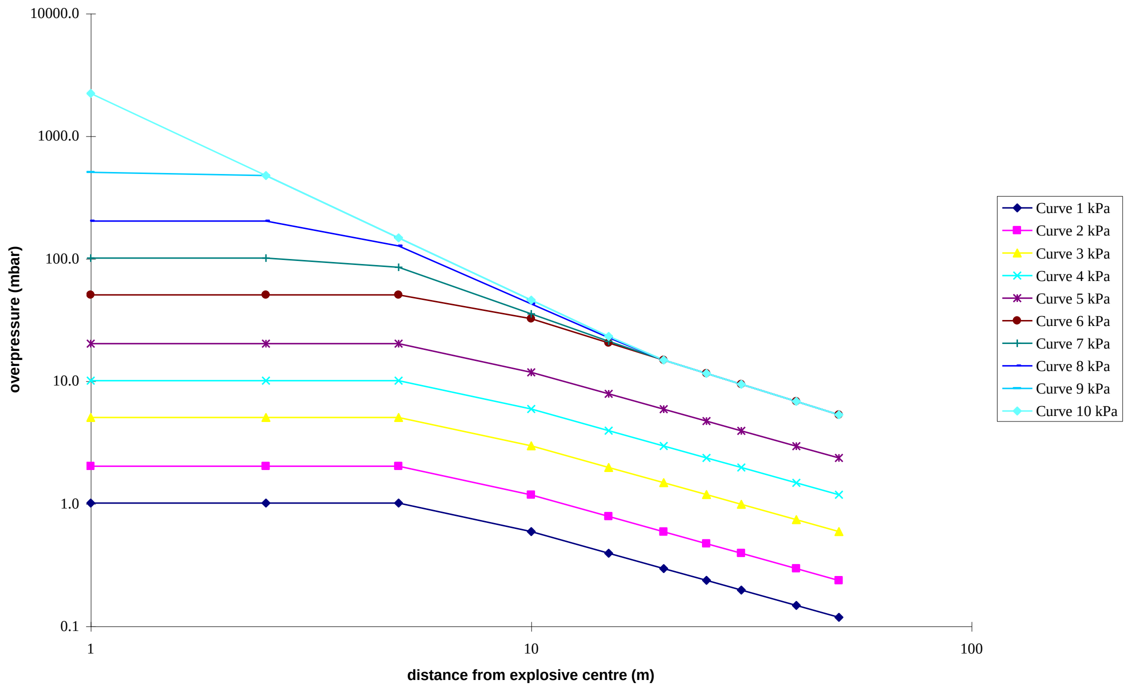

Figure A6 Multi Energy Curves

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