Riskcon engineering

Preliminary Hazard Analysis

SSD - Nepean Hospital Derby Street, Kingswood

Nepean Hospital
Document No. RCE-21071_NH-SSD_PHA_Final_18Oct21_Rev(0)
Date 18/10/2021

Preliminary Hazard Analysis

SSD - Nepean Hospital Derby Street, Kingswood

Nepean Hospital

Prepared by

Riskcon Engineering Pty Ltd
Unit 618/159 Ross Street
Forest Lodge, NSW 2037
www.riskcon-eng.com
ABN 74 626 753 820

Quality Management

Rev	Date	Remarks	Prepared By	Reviewed By
A	16 September 2021	Draft issue for comment	Lucy Jimenez	Renton Parker
0	18 October 2021	Final Issued		

Executive Summary

Background

Nepean Hospital is being upgraded as part of a redevelopment proposal for the facility. The development is a State Significant Development (SSD); hence, the Secretary Environmental Assessment Requirements (SEARs) have been issued requiring the preparation of a State Environmental Planning Policy No. 33 (SEPP 33) assessment for the proposed expansion. This assessment determined that the SEPP 33 thresholds were exceed, and hence, a Preliminary Hazard Analysis (PHA) is required to demonstrate the risks are compliant with the land zoning.

CBRE Pty Limited (CBRE), on behalf of the Nepean Hospital, has requested Riskcon Engineering Pty Ltd (Riskcon) to prepare the PHA report for the proposed redevelopment of the Nepean Hospital facility.

Conclusions

A hazard identification table was developed for Nepean Hospital to identify potential hazards that may be present at the site as a result of the storage of materials. Based on the identified hazards, scenarios were postulated that may result in an incident with a potential for offsite impacts. Postulated scenarios were discussed qualitatively and any scenarios that would not impact offsite were eliminated from further assessment. It was determined that no scenarios would have offsite impacts, hence none were carried forward for consequence analysis.

Based on the analysis conducted, it was concluded that the risks at the site boundary are not considered to exceed the acceptable risk criteria; hence, the proposed redevelopment does not increase the risk profile of the overall site to an unacceptable level; hence, the proposed additions would be permitted within the current land zoning for the site.

Recommendations

Notwithstanding the conclusions following the analysis of the facility, the following recommendations have been made:

- Ensure all hazardous chemical storage facilities onsite comply with the relevant Australian Standards.
- Undertake a Hazardous Area Classification (HAC) for the hospital precinct where flammable gases (Class 2.1) or flammable liquids (Class 3) are stored.
- Prepare the documentation required for the hospital precinct per Part 7.1 of the Work Health and Safety Regulation 2017.

Table of Contents

Executive Summary i

1.0 Introduction 1

1.1 Background 1
1.2 Objectives 1
1.3 Limitations and Exclusions 1

2.0 Methodology 2

2.1 Multi-Level Risk Assessment 2
2.2 Risk Assessment Study Approach 3

3.0 Site Description 4

3.1 Site Location 4
3.2 Adjacent Land Uses 4
3.3 General Description and Layout 4
3.4 Quantities of Dangerous Goods Stored and Handled 6
3.5 Aggregate Quantity Ratio 6

4.0 Hazard Identification 8

4.1 Introduction 8
4.2 Properties of Dangerous Goods 8
4.3 Hazard Identification 9
4.4 Flammable Gas Release, Ignition and Flash Fire / Explosion 10
4.5 Non-Flammable, Non-Toxic Gas Cylinder Release, Potential Asphyxiant 11
4.6 Oxygen and Nitrous Oxide Cylinder Release, Oxygen Enriched Environment, Potential Exacerbation of Fire 11
4.7 Bulk Oxygen Tank Leak, Release of Cryogenic Gas Resulting in Injuries 12
4.8 Bulk Oxygen Tank Leak, Release in the Presence of Fire 12
4.9 Chlorine Gas Release and Toxic Dispersion 13
4.10 Flammable Liquid Release, Ignition, and Fire 13
4.11 Flammable Liquid Release, Delayed Ignition, and Flash Fire or Explosion 13
4.12 Flammable Solids Release, Ignition and Fire 14
4.13 Oxidising Substances Release and Environmental Incident 14
4.14 Oxidising Substance Release in the Presence of Fire 15
4.15 Organic Peroxide Release and Environmental Incident 15
4.16 Organic Peroxide Release, Ignition and Fire 15
4.17 Toxic Substances Release and Environmental Incident 16
4.18 Corrosive Substances Release and Environmental Incident 16
4.19 Miscellaneous Dangerous Goods Release and Environmental Incident 16
4.20 Diesel Tank Leak/Spill and Environmental Incident 17
4.21 Diesel Tank Leak/Spill, Ignition and Fire 17
4.22 Mixing of incompatible materials and exothermic reactions 17

5.0 Conclusion and Recommendations 19

5.1 Conclusions 19
5.2 Recommendations 19

6.0 References 20

A1. Dangerous Goods Quantities 23
B1. Hazard Identification Table 32

List of Figures

Figure 2-1: The Multi-Level Risk Assessment Approach 2

Figure 3-1: Site Location 4

Figure 3-2: Nepean Hospital Site Layout 5

List of Tables

Table 2-1: Level of Assessment PHA 2

Table 3-1: Classes and Quantities of Dangerous Goods Stored 6

Table 3-2: Major Hazard Facility Thresholds 7

Table 4-1: Properties* of the Dangerous Goods and Materials Stored at the Site 8

Abbreviations

Abbreviation	Description
AS	Australian Standard
CBD	Central Business District
DGs	Dangerous Goods
LPG	Liquefied Petroleum Gas
NZS	New Zealand Standard
PG	Packing Group
PHA	Preliminary Hazard Analysis
SEARs	Secretary Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SSD	State Significant Development

1.0 Introduction

1.1 Background

Nepean Hospital is being upgraded as part of a redevelopment proposal for the facility. The development is a State Significant Development (SSD); hence, the Secretary Environmental Assessment Requirements (SEARs) have been issued requiring the preparation of a State Environmental Planning Policy No. 33 (SEPP 33) assessment for the proposed expansion. This assessment determined that the SEPP 33 thresholds were exceed, and hence, a Preliminary Hazard Analysis (PHA) is required to demonstrate the risks are compliant with the land zoning.

CBRE Pty Limited (CBRE), on behalf of the Nepean Hospital, has requested Riskcon Engineering Pty Ltd (Riskcon) to prepare the PHA report for the proposed redevelopment of the Nepean Hospital facility.

1.2 Objectives

The objective of this study was to undertake a PHA of Nepean Hospital to evaluate offsite risk levels in the event of emergency or major failure scenario. The aim of the report is to:

- Provide a PHA assessment of the offsite hazards and risks associated with the facility in accordance with the Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 (Ref. [1]).
- Determine the risk levels for offsite impacts to community and environment associated with the proposed facility.
- Provide guidance and recommendations for mitigation of hazards.
- Demonstrating compliance with the accepted risk criteria for hazardous industry as outlined in HIPAP No. 4 (Ref. [2]).

The scope of the study includes an assessment of the Nepean Hospital including both the existing DG storages and operations and the new storages and operations as part of the redevelopment.

1.3 Limitations and Exclusions

The PHA does not cover:

- General operational impacts
- Vehicle movements within the site
- Transport of hazardous materials to and from site
- Onsite or employee risk or health or safety.

The PHA is based on proposed concept designs and inventories and is a conservative estimate of the hazardous risk.

2.0 Methodology

2.1 Multi-Level Risk Assessment

The Multi-Level Risk Assessment approach (Ref. [3]), published by the NSW Department of Planning and Environment, has been used as the basis for the study to determine the level of risk assessment required. The approach considered the development in context of its location, the quantity and type (i.e. hazardous nature) Dangerous Goods stored and used, and the facility's technical and safety management control. The Multi-Level Risk Assessment Guidelines are intended to assist industry, consultants and the consent authorities to carry out and evaluate risk assessments at an appropriate level for the facility being studied.

There are three levels of risk assessment set out in Multi-Level Risk Assessment which may be appropriate for a PHA, as detailed in **Table 2-1**.

Table 2-1: Level of Assessment PHA

Level	Type of Analysis	Appropriate If:
1	Qualitative	No major off-site consequences and societal risk is negligible
2	Partially Quantitative	Off-site consequences but with low frequency of occurrence
3	Quantitative	Where 1 and 2 are exceeded

The Multi-Level Risk Assessment approach is schematically presented in **Figure 2-1**.

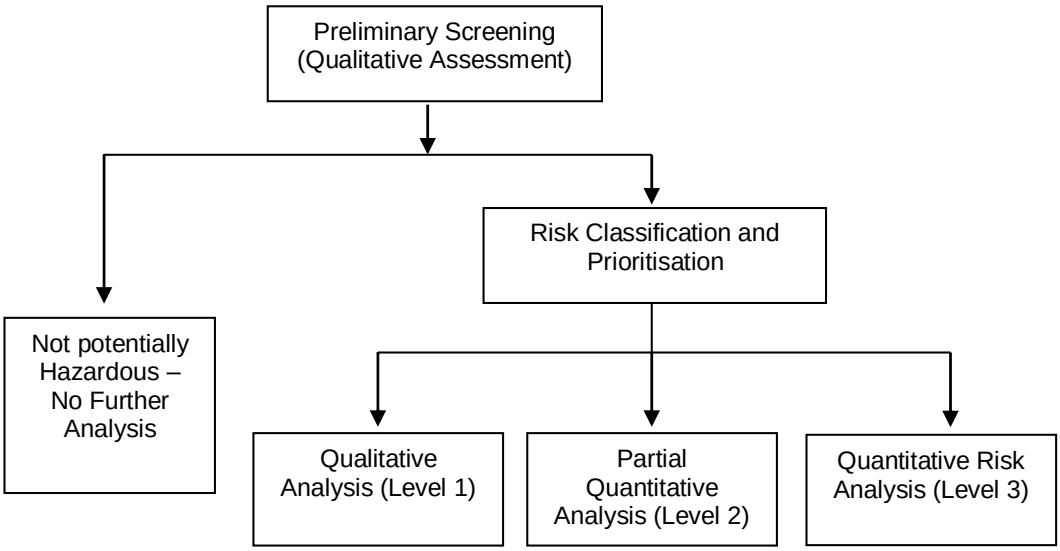

Figure 2-1: The Multi-Level Risk Assessment Approach

Based on the type of DGs to be used and handled at the proposed facility, a **Level 2 Assessment** was selected for the Site. This approach provides a qualitative assessment of those DGs of lesser quantities and hazard, and a quantitative approach for the more hazardous materials to be used on-site. This approach is commensurate with the methodologies recommended in "Applying SEPP 33's" Multi Level Risk Assessment approach (DPE, 2011).

2.2 Risk Assessment Study Approach

The methodology used for the PHA is as follows:

Hazard Analysis – A detailed hazard identification was conducted for the site facilities and operations. Where an incident was identified to have a potential off-site impact, it was included in the recorded hazard identification word diagram (**Appendix B**). The hazard identification word diagram lists incident type, causes, consequences and safeguards. This was performed using the word diagram format recommended in HIPAP No. 6 (Ref. [1]).

Each postulated hazardous incident was assessed qualitatively in light of proposed safeguards (technical and management controls). Where a potential offsite impact was identified, the incident was carried into the main report for further analysis. Where the qualitative review in the main report determined that the safeguards were adequate to control the hazard, or that the consequence would obviously have no offsite impact, no further analysis was performed.

Consequence Analysis – For those incidents qualitatively identified in the hazard analysis to have a potential offsite impact, a detailed consequence analysis was conducted. The analysis modelled the various postulated hazardous incidents and determined impact distances from the incident source. The results were compared to the consequence criteria listed in HIPAP No. 4 (Ref. [2]).

Where an incident was identified to result in an offsite impact, it was carried forward for frequency analysis. Where an incident was identified to not have an offsite impact, and a simple solution was evident (i.e. move the proposed equipment further away from the boundary), the solution was recommended, and no further analysis was performed.

Frequency Analysis – In the event a simple solution for managing consequence impacts was not evident, each incident identified to have potential offsite impact was subjected to a frequency analysis. The analysis considered the initiating event and probability of failure of the safeguards (both hardware and software). The results of the frequency analysis were then carried forward to the risk assessment and reduction stage for combination with the consequence analysis results.

Risk Assessment and Reduction – Where incidents were identified to impact offsite and where a consequence and frequency analysis was conducted, the consequence and frequency analysis for each incident were combined to determine the risk and then compared to the risk criteria published in HIPAP No. 4 (Ref. [2]). Where the criteria were exceeded, a review of the major risk contributors was performed, and the risks reassessed incorporating the recommended risk reduction measures. Recommendations were then made regarding risk reduction measures.

Reporting – on completion of the study, a draft report was developed for review and comment. A final report was then developed, incorporating the comments received, for submission to the regulatory authority.

3.0 Site Description

3.1 Site Location

The site is located on Derby Street, Kingswood NSW which is approximately 48 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.

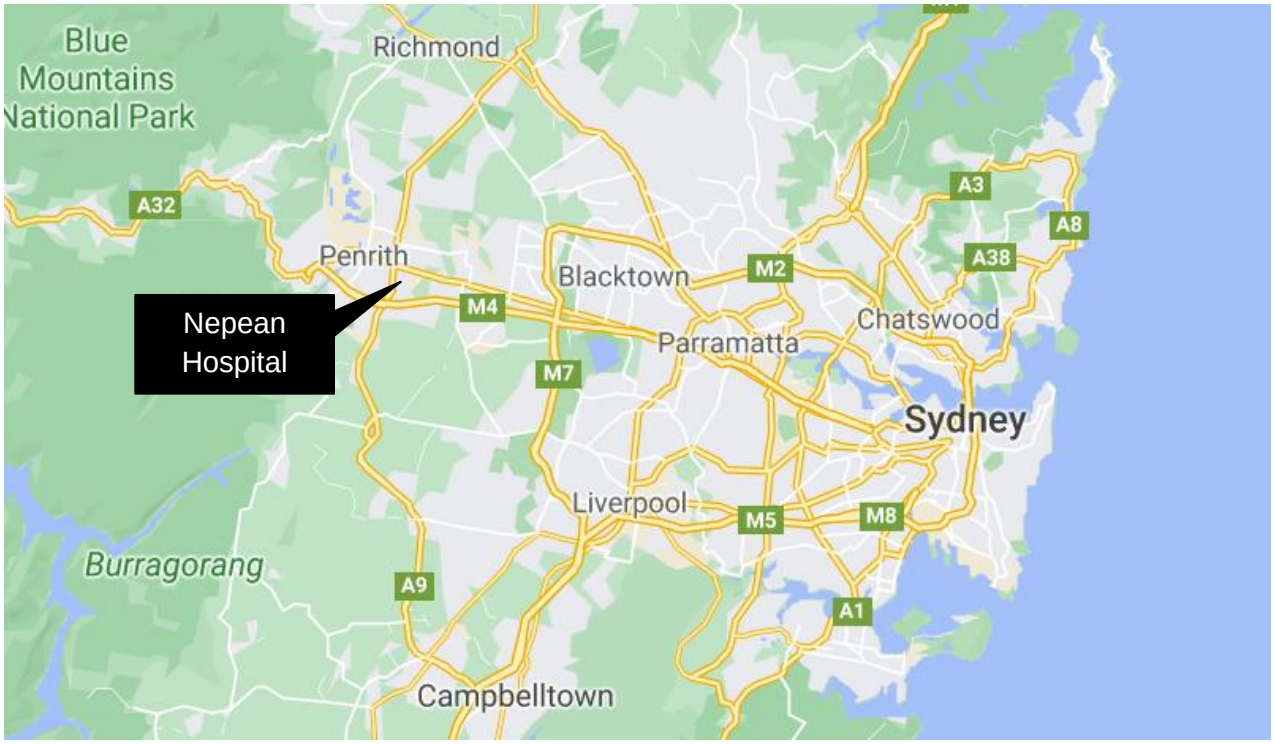

Figure 3-1: Site Location

3.2 Adjacent Land Uses

The Nepean Hospital is located in the Kingswood area and is surrounded by both residential and industrial land use. The following uses are directly adjacent to the site:

- North – Railway line and industrial area
- East – Residential housing
- South – Residential housing
- West – Residential housing

3.3 General Description and Layout

Nepean Hospital is a tertiary hospital, teaching hospital and regional trauma centre. The main areas of the hospital are:

- North Block – containing aged care, stroke care and rehabilitation
- South Block – containing maternity, gynaecology, neonatal intensive care, and paediatrics
- East Block – containing surgical suites, surgical outpatients, and physiotherapy

- West Block – containing diagnostics, coronary care, rehabilitation, and diabetes services
- Mental Health Centre
- Oral Health Centre
- Nepean Cancer Care Centre
- Tresillian Family Care Centre

The Dangerous Goods (DGs) stored on the site are primarily for medical application purposes. The vast majority of DGs are Cass 2.2 non-flammable non-toxic gases such as Oxygen and Carbon Dioxide for use within the hospital rooms and operating theatres. There are both bulk and minor stores of these gases on site, as per **Figure 3-2**. A number of medicines are also classified as DGs and are all stored in small packages for administering to patients (e.g. small vials / syringes); thus, the risk posed by these small quantities is significantly reduced compared to traditional stores of DGs. Several diesel generators are also located throughout the hospital for use as back-up power sources. Provided in **Figure 3-2** is the site layout for the Nepean Hospital, including the locations where Dangerous Goods (DGs) are stored.

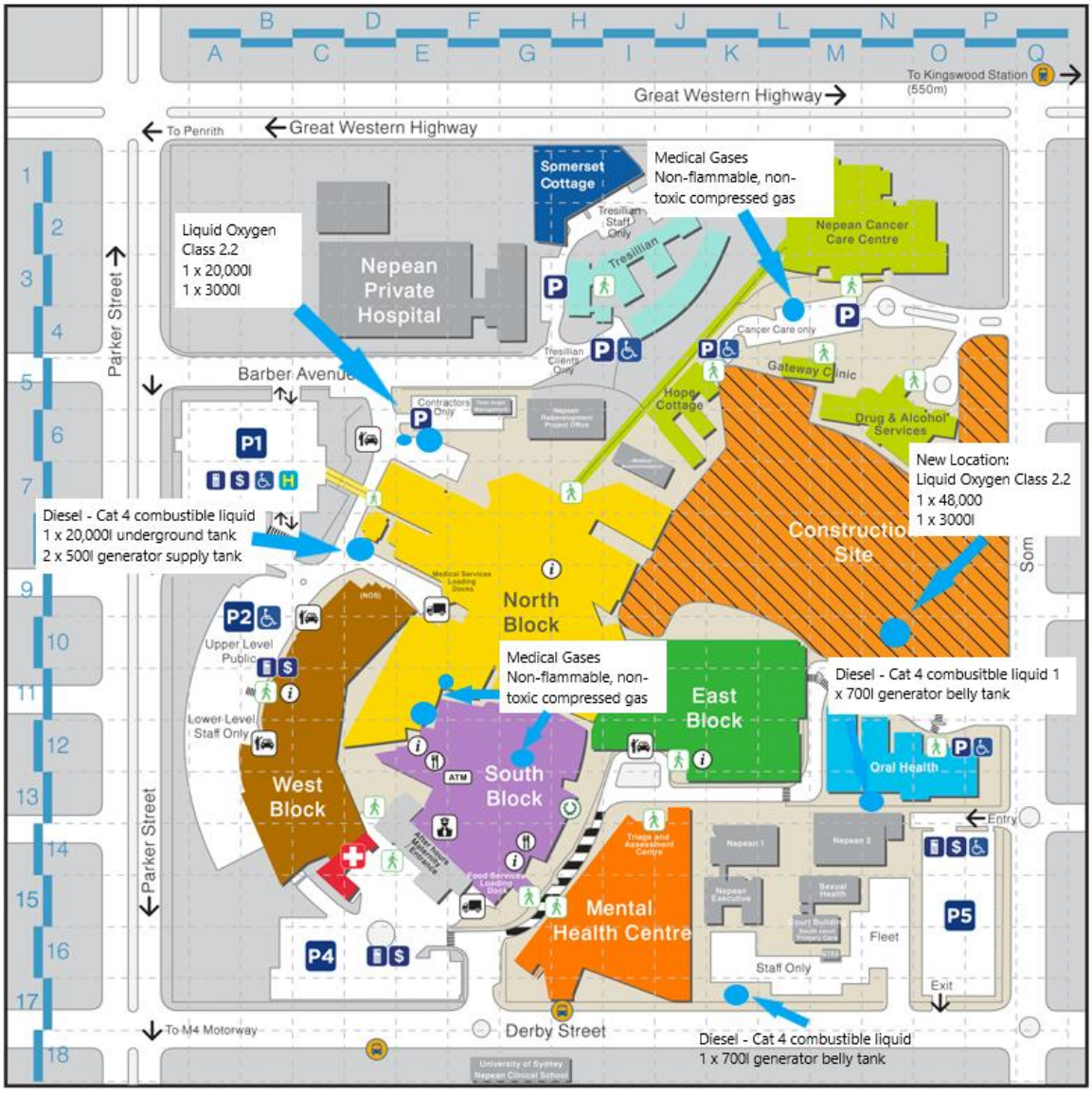

Figure 3-2: Nepean Hospital Site Layout

3.4 Quantities of Dangerous Goods Stored and Handled

The aggregate classes and quantities of DGs to be stored throughout the facility are summarised **Table 3-1**. A detailed description of all dangerous goods has been outlined in **Appendix A.**

Table 3-1: Classes and Quantities of Dangerous Goods Stored

Class	Description	PG	Quantity (kg)
2.1	Flammable Gases	n/a	146
2.2	Non-Flammable, Non-Toxic Gases	n/a	2,129
2.2 (5.1)	Non-Flammable, Non-Toxic Gas (subrisk Oxidising Substance) (Including Liquid O_2)	n/a	26,512
2.3 (5.1, 8)	Toxic Gas (subrisk Oxidising Substance and Corrosive Substance) (Chlorine Gas)	III	0.25
3	Flammable Liquids	I	0.03
		II	2,400
		III	1,866
4.1	Flammable Solids	I	0.04
		II	102
		III	3.6
4.2	Substances liable to spontaneous combustion	III	1.0
4.3	Substances that emit flammable gases on contact with water	II	0.5
5.1	Oxidising Substances	II	9.4
		III	1.2
5.2	Organic Peroxides	II	43
6.1	Toxic Substances	I	0.2
		II	262
		III	8.9
8	Corrosive Substances	II	520
		III	798
9	Miscellaneous DGs	III	236
C1	Combustible Liquid (Diesel)	n/a	26,200

3.5 Aggregate Quantity Ratio

Where more than one class of DGs are stored and handled at the site, and aggregate quantity ratio (AQR) exists. This ratio is calculated using **Equation 3-1**, from Schedule 15 of from the NSW Work Health and Safety Regulation (Ref. [4]).

$$AQR = \frac{q_x}{Q_x} + \frac{q_y}{Q_y} + [\ldots] + \frac{q_n}{Q_n}$$ **Equation 3-1**

Where:

x,y […] and n are the dangerous goods present

q_x, q_y, […] and q_n is the total quantity of dangerous goods x, y, […] and n present.

Q_x, Q_y, […] and Q_n is the individual threshold quantity for each dangerous good of x, y, […] and n

Where the ratio AQR exceeds a value of 1, the site would be considered a Major Hazard Facility (MHF). The threshold quantities for each class are taken from Schedule 15 of the NSW Work Health and Safety Regulation (Ref. [4]). These are summarised in **Table 3-2**, noting that Class 2.2, Class 4.1(II & III), Class 8, Class 9, and combustible liquids are not subject to MHF legislation.

Table 3-2: Major Hazard Facility Thresholds

Class	PG	Description	Threshold (tonnes)	Storage (tonnes)
2.1	n/a	Flammable Gases	200	0.146
2.2	n/a	Non-flammable, non-toxic gases	n/a	0.002
2.2 (5.1)	n/a	Non-Flammable, Non-Toxic Gases (Subrisk Oxidising Substance)	2,000	26.5
2.3 (5.1, 8)	III	Toxic Gas (Subrisk Oxidising and Corrosive Substance) (Chlorine)	25	0.00025
3	I	Flammable Liquids	200	0.00003
	II&III		50,000	4.27
4.1	I	Flammable Solids	200	0.00004
	II&III		n/a	4.266
4.2	III	Substances liable to spontaneous combustion	n/a	0.001
4.3	II	Substances that emit flammable gases on contact with water	n/a	0.0005
5.1	I&II	Oxidising Substances	200	0.009
	III		n/a	0.0012
5.2	II	Organic Peroxides	200	0.043
6.1	I, II & III	Toxic Substances	200	0.271
8	II&III	Corrosive Substances	n/a	1.31
9	III	Miscellaneous DGs	n/a	0.236
C1	n/a	Combustible Liquid (Diesel)	n/a	26.2

A review of the thresholds, commodities and packing groups listed in **Table 3-2** indicates that only Class 2.1, 2.2 (5.1), 2.3, 3, 4.1(I), 5.1(I & II) and 6.1 are assessable against the MHF thresholds. Therefore, substituting the storage masses into **Equation 3-1**, the AQR is calculated as follows:

$$AQR = \frac{0.146}{200} + \frac{26.5}{2000} + \frac{0.00025}{25} + \frac{0.00003}{200} + \frac{4.3}{50{,}000} + \frac{0.00004}{200} + \frac{0.009}{200} + \frac{0.04}{200} + \frac{0.27}{200} = 0.016$$

The AQR is less than 1; hence, the facility would not be classified as an MHF.

4.0 Hazard Identification

4.1 Introduction

A hazard identification table has been developed and is presented at **Appendix B**. This table has been developed following the recommended approach in Hazardous Industry Planning Advisory Paper No .6, Hazard Analysis Guidelines (Ref. [1]). The Hazard Identification Table provides a summary of the potential hazards, consequences, and safeguards at the site. The table has been used to identify the hazards for further assessment in this section of the study. Each hazard is identified in detail and no hazards have been eliminated from assessment by qualitative risk assessment prior to detailed hazard assessment in this section of the study.

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% or less by volume with air or have a flammable range with air of at least 12% 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.
2.2 – Non-Flammable, Non-Toxic Gas	Class 2.2 includes non-flammable and non-toxic gases which are asphyxiant (dilute or replace the oxygen normally in the atmosphere).
2.3 – Toxic Gas (Chlorine)	Class 2.3 are gases which are known to be so toxic or corrosive to humans as to pose a hazard to health; or are presumed to be toxic or corrosive to humans because they have an LC50 value equal to or less than 5,000 mL/m^3 (ppm). Note, the only toxic gas at the hospital is one cylinder of chlorine (0.25 kg).
3 – Flammable Liquids	Class 3 (flammable liquids) are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (for example, paints, varnishes, lacquers, etc.) which give off a flammable vapour at temperatures of not more than 60^{o}C closed-cup test or not more than 65.6^{o}C open-cup test. Vapours released may mix with air and if ignited, at the right, concentration will burn resulting in pool fires at the liquid surface.
4.1 – Flammable Solids	Class 4.1 DGs are solids which, under conditions encountered in transport, are readily combustible or may cause or contribute to fire through friction; self-reactive substances which are liable to undergo a strongly exothermic reaction; solid desensitised explosives which may explode if not diluted sufficiently.
4.2 – Substances liable to spontaneous combustion	Class 4.2 DGs are substances which are liable to spontaneous heating under normal conditions encountered in transport, or to heating up in contact with air, and being then liable to catch fire.

Class	Hazardous Properties
4.3 – Substances which in contact with water emit flammable gases	Class 4.3 DGs are substances which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.
5.1 – Oxidising Substances	Class 5.1 (oxidising substances) are substances which, while in themselves not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material. Such substances may be contained in an article.
5.2 – Organic Peroxides	Class 5.2 (organic peroxides) are substances which contain the bivalent -O-O- structure and may be considered derivatives of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals. Organic peroxides are thermally unstable substances, which may undergo exothermic self-accelerating decomposition.
6.1 – Toxic Substances	Class 6.1 Substances (toxic substances), are substances which are liable either to cause death or serious injury or to harm human health if swallowed or inhaled or by skin contact.
8 – Corrosive Substances	Class 8 substances (corrosive substances) are substances which, by chemical action, could cause damage when in contact with living tissue (i.e. necrosis), or, in case of leakage, may materially damage, or even destroy, other goods which come into contact with the leaked corrosive material. Releases to the environment may cause damage to sensitive receptors within the environment.
9 – Miscellaneous Dangerous Goods	Class 9 substances and articles (miscellaneous dangerous substances and articles) are substances and articles which, during transport present a danger not covered by other classes. Releases to the environment may cause damage to sensitive receptors within the environment. Note, the diesel used at the hospital is classified as Class 9.
C1 Combustible Liquids	Combustible liquids are typically long chain hydrocarbons with flash points exceeding 60.5^{o}C. Combustible liquids are difficult to ignite as the temperature of the liquid must be heated to above the flash point such that vapours are generated which can then ignite. This process requires either sustained heating or a high-energy ignition source.

* The Australian Code for the Transport of Dangerous Goods by Road and Rail (Ref. [5])

4.3 Hazard Identification

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

- Flammable gas release, ignition and flash fire or explosion
- Non-flammable, non-toxic gas cylinder release, resulting in asphyxiant environment
- Oxygen and nitrous oxide cylinder release in the presence of fire
- Bulk oxygen tank leak, release of cryogenic gas resulting in injuries
- Bulk oxygen tank leak, release in the presence of fire
- Chlorine gas release and toxic dispersion

- Flammable liquid release, immediate ignition, and fire
- Flammable liquid release, delayed ignition and flash fire or explosion
- Flammable solids release, ignition and fire
- Oxidising substances release and environmental incident
- Oxidising substances release in the presence of a fire
- Organic peroxide release and environmental incident
- Organic peroxide release, ignition, and fire
- Toxic substances release and environmental incident
- Corrosive substances release and environmental incident
- Miscellaneous dangerous goods release and environmental incident
- Diesel tank leak/spill and environmental incident
- Diesel tank leak/spill, ignition and pool fire
- Mixing of incompatible DGs and exothermic reactions

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

4.4 Flammable Gas Release, Ignition and Flash Fire / Explosion

Flammable gases are stored and used throughout the hospital. The majority of flammable gases are present as aerosol cleaning products, containing less than 1 kg of flammable gases, stored throughout the hospital for general use. There are also several cylinders of flammable gases including Liquefied Petroleum Gas (LPG) (7 cylinders, 1.25 L - 200 L), Methyl Acetylene (1x0.5 kg cylinder) and Acetylene (1x10 L cylinder). In the event a cylinder or aerosol container is dropped or damaged, there is potential for a release of flammable gas, formation of a flammable gas cloud and ignition resulting in a flash fire or explosion.

All class 2.1 cylinder and aerosol stores contain less than the 500 L minor store threshold outlined in AS 4332-2004 (Ref. [6]). The standard indicates that for minor stores, the quantities stored are so small that they add little to the building's fire load and therefore are unlikely to contribute to a fire resulting in off-site impacts.

Notwithstanding this, further precautions have also been taken to minimise the likelihood of a flash fire or explosion. In order for a gas cloud to explode it must be confined, it must accumulate within the explosive limits, and an ignition source must be present. The risk of explosion has been mitigated by ensuring all cylinder stores are adequately ventilated, thereby minimising the potential for the accumulation of gas above the lower explosive limits, and by eliminating ignition sources via compliance with AS/NZS 60079 series of standards. Stores containing flammable liquids shall be zoned as hazardous areas in accordance with AS/NSZ 60079.10.1:2009 (Ref. [7]), and all electrical equipment within the store shall be compliant with AS/NZS 600079.14:2017 (Ref. [8]). As vapour cloud will not be able to accumulate and ignition sources will be minimised, an explosion is unlikely to occur. The potential for a flash fire is similarly mitigated, by use of ventilation and eliminating ignition sources.

Therefore, it is considered that a release of flammable gas resulting in fire or explosion with offsite impact is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.5 Non-Flammable, Non-Toxic Gas Cylinder Release, Potential Asphyxiant

Non-flammable, non-toxic gases (Class 2.2) are stored throughout the hospital for use as medical gases (Compressed Air, CO_2, N_2, Helium and Argon), refrigerant gases (R134a, R22, R404A), and as general cleaning products (aerosols). In the event a cylinder or aerosol container is dropped or damaged, there is potential for release of a non-flammable, non-toxic gas. If released, these gases may accumulate resulting in an oxygen deprived environment, leading to asphyxiation and potential injuries or fatalities.

The majority of the Class 2.2 gases are medical grade gases, stored throughout the hospital in C to G size cylinders (2.9 L to 50 L capacity). Note, most of these cylinders contain compressed air, which does not pose an asphyxiation hazard. All class 2.2 cylinder stores (excluding compressed air stores) contain less than the 2,000 L minor store threshold outlined in AS 4332-2004 (Ref. [6]). The standard indicates that for minor stores, the quantities stored are so small that they present minimal risk to personnel. Therefore, these stores are unlikely to have offsite impacts.

Class 2.2 gases in aerosol containers are used as the propellant gas, and typically comprise 25% of the total volume of the container. This, in addition to the small size of the containers (0.5 kg), means that the release of class 2.2 gas is unlikely to result an oxygen deprived environment.

Therefore, it is considered that a release of class 2.2 gas resulting in an asphyxiation hazard with offsite impact is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.6 Oxygen and Nitrous Oxide Cylinder Release, Oxygen Enriched Environment, Potential Exacerbation of Fire

Compressed oxygen and nitrous oxide cylinders (Class 2.2 sub-risk 5.1) are stored throughout the hospital for use as medical gases. In addition to the risks outlined in **Section 4.5**, these gases are also oxidising substances. Oxidising substances may contribute to the combustion of other materials by providing sources of oxygen. Therefore, in the event a release occurs in conjunction with a fire, the gases may exacerbate the existing fire, leading to propagation in other areas, and potential injuries or fatalities.

The cylinder stores have been designed in accordance with AS 4332-2004 (Ref. [6]), including segregation from flammable materials, and minimum fire protection requirements. The majority of the class 2.2 (5.1) cylinder stores contain less than the 1,000 L minor store threshold outlined in AS 4332-2004 (Ref. [6]). The standard indicates that for minor stores, the quantities stored are so small that they are unlikely to play a significant part in the propagation of fire. Therefore, these stores are unlikely to have offsite impacts.

The largest store contains 2,800 C-size oxygen cylinders (233,333 L total), located in the West Block ‘Big Bathroom’. This is an indoor store, located more than 5 m from the site boundary, which the meets the minimum separation distance to protected places as per AS 4332-2004 (Ref. [6]). The standard has been developed with reference to the likely impact scenarios for gases in cylinders. Therefore, the required separation distances are indicative of the potential impact distances as considered by the standard. Hence, compliance with the separation distance requirement indicates that any release is unlikely to impact beyond the site boundary.

Therefore, it is considered that a release of class 2.2 (5.1) gas resulting in propagation of a fire with offsite impact is not a credible scenario. Hence, this incident has not been carried forward for further analysis.

4.7 Bulk Oxygen Tank Leak, Release of Cryogenic Gas Resulting in Injuries

The hospital has proposed to install a new 22,000 L liquid oxygen tank, for medical use throughout the hospital. Cryogenic oxygen may be released in the event that piping, valves or flanges are damaged, or in the event of vehicle collision. In the event of a release, there is a potential for the cryogenic gas to disperse beyond the site boundary, resulting in serious injuries or damage to nearby structures.

The tank has been designed by Air Liquide, a reputable supplier, in accordance with AS 1894-1997 (Ref. [9]). The tank has been located within a compound constructed of three walls with an FRL rating of 240/240/240, and louvred opening on the remaining side, minimising the potential spread of a release. As the tank is located within a compound, the potential for damage to the tank from a vehicle collision is very low.

In addition, the tank is located 13 m from the site boundary and other protected places, exceeding the minimum 2 m separation distance as required by the standard. The standard has been developed with reference to the likely impact scenarios for the tanks. Therefore, the required separation distances are indicative of the potential impact distances as considered by the standard. Hence, compliance with the separation distance requirement indicates that any release is unlikely to impact beyond the site boundary. Furthermore, any release will be dispersed by air movement further preventing the potential for a high concentration of oxygen to substantially impact over the site boundary.

Therefore, it is considered that a release of class 2.2 (5.1) gas resulting in propagation of a fire with offsite impact is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.8 Bulk Oxygen Tank Leak, Release in the Presence of Fire

As discussed in **Section 4.7**, there is potential for a release of oxygen from the proposed bulk oxygen tank. Oxygen is a class 2.2 (5.1) gas, hence if a release occurs adjacent flammable materials or to an existing fire, the oxygen may acceleration combustion, resulting in propagation of the fire to off-site locations.

In addition to the safeguards discussed in **Section 4.7,** the potential for fire in the bulk tank store has been minimised by segregation from flammable materials. The tank compound is constructed of walls with an FRL of 240/240/240, segregating the tank from the nearby diesel generator, and protecting the tank from any potential fire in adjacent locations. Note, the diesel generator is located underground, and the filling point for the tank is located 14 m away from the oxygen tank compound, further ensuring segregation of the two materials. In addition, the compound shall be protected by a fire hose reel or a dry powder type extinguisher, allowing trained staff to engage in first-attack firefighting techniques to control the spread of any fires by the store.

As the store has been adequately segregated from flammable materials and ignition sources, it is considered that a release of class 2.2 (5.1) gas resulting in propagation of a fire with offsite impact is not a credible scenario, hence, this incident has not been carried forward for further analysis.

4.9 Chlorine Gas Release and Toxic Dispersion

One cylinder of chlorine gas (0.25 kg) (Class 2.3) is to be stored in the maintenance gardeners shed. In the event that the cylinder is dropped, or the valve is damaged, there is potential for release and dispersion of toxic gas.

The minor store threshold for Class 2.3 gases is 50 L, as per AS 4332-2004 (Ref. [6]). This indicates that the quantity of chlorine gas stored is so small, that it presents minimal risk to personnel and is unlikely to contaminate the surrounding area with toxic gas. In addition, the location of the cylinder satisfies the minimum separation distance to protected places for cylinder stores (greater than minor store), as the gardener's shed is further than 15 m from the boundary. Compliance with this requirement ensures that any toxic dispersion is unlikely to reach beyond the site boundary.

Therefore, as the likelihood for offsite impact is very low, this incident has not been carried forward for further analysis.

4.10 Flammable Liquid Release, Ignition, and Fire

Several cleaning products, medicines, and laboratory materials used in the hospital are classified as flammable liquids (Class 3). These materials are stored for general use throughout the hospital, as well as in dedicated storage sheds, pharmacy areas, and research labs. In the event that flammable liquids packages are dropped or damaged, there is a potential for ignition of the flammable liquid pool, resulting in a fire.

Stores containing flammable liquids shall be design in accordance with AS 1940-2017 (Ref. [10]), including first-attack firefighting equipment. The majority of the packages contain 0.1 to 20 L of fluid, and typically are not comprised of 100% flammable liquid. Therefore, most spills would be small, and easily managed by trained staff using first-attack firefighting equipment.

The largest container is an Intermediate Bulk Container (IBC) of ethanol (1,000 L), located in the West Block flammable liquid store. The IBC shall be bunded to limit the potential spread of any spill, thereby limiting the potential size of a fire. As previously mentioned, flammable liquid stores will be equipped with fire protection equipment. The hospital is fitted with smoke detectors and sprinkler system, which shall be capable of controlling any fire, preventing propagation to other areas.

Furthermore, ignition sources in flammable liquid stores shall be controlled via compliance with AS/NZS 60079 series of standards. Stores containing flammable liquids shall be zoned as hazardous areas in accordance with AS/NSZ 60079.10.1:2009 (Ref. [7]), and all electrical equipment within the store shall be compliant with AS/NZS 600079.14:2017 (Ref. [8]). Therefore, as ignition sources shall be eliminated, a fire is very unlikely to occur.

Therefore, it is considered that a flammable liquids fire resulting in offsite impacts is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.11 Flammable Liquid Release, Delayed Ignition, and Flash Fire or Explosion

As discussed in **Section 4.10**, there is the potential for flammable liquids to be released if packages are dropped or damaged. The largest package stored is a 1000 L IBC of ethanol located in the West Block. In the event that a flammable liquid pool forms and it is not identified and cleaned quickly, there is a potential for a vapour cloud to accumulate in the store, which may ignite, resulting in a flash fire or explosion.

In order for a vapour cloud to explode it must be confined, it must accumulate within the explosive limits, and an ignition source must be present. The explosive limits of ethanol are 3.1%-19%, so it possible for a vapour cloud to accumulate within the explosive limits. The risk of explosion has been mitigated by ensuring that the store is adequately ventilated in accordance with AS 1940-2017 (Ref. [10]). Ventilation limits the potential for the accumulation of the vapour to occur by extracting vapours and discharging them externally to the store.

In the event that the ventilation system fails, and a vapour cloud accumulates above the lower explosive limit within the store, it will not be able to explode as ignition sources have been eliminated via compliance with AS/NZS 60079 series of standards as discussed in **Section 4.10**. Ignition sources shall also be controlled by placarding stores in accordance with AS 1940-2017 (Ref. [10]). As vapour cloud will not be able to accumulate and ignition sources will be minimised, an explosion is unlikely to occur. For the same reason, a flash fire is unlikely to occur.

Therefore, it is considered that a release of flammable liquids resulting in a flash fire or explosion is not a credible scenario. Hence, this incident has not been carried forward for further analysis.

4.12 Flammable Solids Release, Ignition and Fire

Flammable solids (Class 4.1, 4.2 and 4.3) will be stored throughout the hospital for use as cleaning products, medicines, and laboratory materials. These materials are stored in for general use throughout the hospital, as well as in dedicated storage rooms, pharmacy areas and research labs. In the event that a package is damaged, and an ignition source is present, there is a potential for ignition of the flammable solids resulting in a fire.

The size of the packages ranges from 0.01 kg to 0.5 kg. In the event of ignition, the fire would be very small, and therefore readily managed by trained staff with first attack firefighting equipment. The largest store of flammable materials is a 9 kg store of Class 4.1 substances, which is below the minor store threshold as per AS 5026-2012 (Ref. [11]). The standard indicates that any store containing less than the minor store threshold presents minimal increase to the fire load of the building. Therefore, a fire resulting from flammable solids is unlikely to propagate resulting in offsite impacts. Note, a large portion of the flammable solids stored are cleaning wipes, which do not ignite easily.

Therefore, it is considered that a flammable solids fire with offsite impact is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.13 Oxidising Substances Release and Environmental Incident

Oxidising substances (Class 5.1) will be stored throughout the hospital for use as cleaning products, medicines, and laboratory materials. These materials are stored in for general use throughout the hospital, as well as in dedicated storage rooms, pharmacy areas and research labs. In the event that packages are dropped or damaged, there is potential for release of oxidising substances into the hospital drainage system, resulting in an environmental incident. Contamination could result in serious damage to the local environment.

The total quantity of oxidising agents stored at the hospital is less than 15 kg, which is significantly less than the 250 kg minor store threshold for PG II toxic substances as per AS 4326-2008 (Ref. [12]). The standard indicates that any store containing less than the minor store threshold presents minimal risk of contaminating surrounding areas. In addition, the size of the packages ranges from 0.01 L to 2 L. Therefore, all spills would be very small and readily managed by trained staff. Spill

response kits are available for safe clean-up and disposal of minor spills. Therefore, a release of oxidising substances is not likely to result in in an environmental release.

It is considered that an offsite release is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.14 Oxidising Substance Release in the Presence of Fire

As discussed in **Section 4.13**, there is the potential for oxidising substances to be released if packages are dropped or damaged. As noted in **Section 4.6**, oxidising substances may contribute to the combustion of other materials by providing a source of oxygen. Therefore, in the event a release occurs in conjunction with a fire, the oxidising substances may exacerbate the existing fire, leading to propagation in other areas, and potential injuries or fatalities.

For this reason, oxidising substances are segregated from flammable materials (class 2.1, 3 & 4) throughout the hospital. Stores containing oxidising substances have been designed in accordance with AS 4326-2008 (Ref. [12]), including appropriate fire protection. In addition, the hospital is fitted with smoke detectors and sprinkler system. Moreover, minor quantities of oxidising substances (total 15 kg) are stored throughout the hospital, in small packages (0.01 L to 2 L). Hence, a release would not contribute enough oxygen to result in significant propagation of a fire. Therefore, a release of oxidising substances during a fire is not likely to result in offsite impacts.

It is considered that this is scenario does have credible offsite impacts and hence, this incident has not been carried forward for further analysis.

4.15 Organic Peroxide Release and Environmental Incident

Organic peroxides (Class 5.2) will be stored throughout the hospital for use as cleaning products, medicines, and laboratory materials. These materials are stored in for general use throughout the hospital, as well as in dedicated storage rooms, pharmacy areas and research labs. In the event that a package is dropped or damaged, there is potential for release of organic peroxides into the hospital drainage system, resulting in an environmental incident. Contamination could result in serious damage to the local environment.

The size of the organic peroxide packages ranges from 0.01 L to 5 L, and the total quantity of organic peroxides stored at the hospital is less than 50 L. Therefore, most spills would be small and readily managed by trained staff. Spill response kits are available for safe clean-up and disposal of minor spills.

Therefore, a release of organic peroxides is not likely to result in offsite impacts. It is considered that an offsite release is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.16 Organic Peroxide Release, Ignition and Fire

As discussed in **Section 4.13**, there is the potential for organic peroxides to be released if packages are dropped or damaged. Organic peroxides are thermally unstable substances, which may undergo self-accelerating decomposition, and can release flammable vapours. Therefore, in the event a release occurs in the presence of an ignition source, there is potential for a fire to occur, which may propagate to other areas and result in potential injuries or fatalities.

As previously mentioned, minor quantities of organic peroxides (50 L) are stored at the hospital, in small packages (0.01 – 5 L). Hence, an organic peroxides fire would be small, and readily managed

by trained staff with first attack firefighting equipment. Stores containing organic peroxides have been designed in accordance with AS 2714-2008 (Ref. [13]), including appropriate fire protection. In addition, the hospital is fitted with smoke detectors and sprinkler system. Therefore, a fire resulting from a release of organic peroxides is not likely to result in offsite impacts.

It is considered that this is scenario does have credible offsite impacts and hence, this incident has not been carried forward for further analysis.

4.17 Toxic Substances Release and Environmental Incident

Toxic substances (Class 6.1) will be stored throughout the hospital for use as medicines and laboratory materials. These materials are stored in dedicated storage rooms throughout the hospital, pharmacy areas, and research labs. In the event that a package is dropped or damaged, there is potential for release of toxic substances into the hospital drainage system, resulting in an environmental incident. Contamination could result in serious damage to the local environment.

The total quantity of toxic substances stored at the hospital is less than 20 kg, which is significantly less than the 100 kg minor store threshold for PG II toxic substances as per AS 4452–1997 (Ref. [14]). The standard indicates that any store containing less than the minor store threshold presents minimal risk of contaminating surrounding areas. In addition, the size of the packages ranges from 1 mL to 5 L. Therefore, the spills would be small and readily managed by trained staff. Spill response kits are available for safe clean-up and disposal of minor spills. Hence the likelihood of a spill resulting in an environmental release is very low.

Therefore, it is considered that an offsite release is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.18 Corrosive Substances Release and Environmental Incident

Corrosive substances (Class 8) will be stored throughout the hospital for use as cleaning products and laboratory materials. These materials are stored for general use throughout the hospital, as well as in dedicated storage rooms, pharmacy areas, and research labs. In the event that a package is dropped or damaged, there is potential for release of corrosive substances into the hospital drainage system, resulting in an environmental incident. Contamination could result in serious damage to the local environment.

The size of the corrosives packages ranges from 0.1 L to 20 L. Therefore, most spills would be small and readily managed by trained staff. Spill response kits are available for safe clean-up and disposal of minor spills. In addition, stores containing corrosive substances have been designed in accordance with AS 3780-2008 (Ref. [15]). The stores are designed to be resistant to corrosion, minimising the likelihood that packages would be dropped.

Therefore, it is considered that an offsite release is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.19 Miscellaneous Dangerous Goods Release and Environmental Incident

Miscellaneous DGs (Class 9) will be stored throughout the hospital for use as cleaning/ maintenance products, and laboratory materials. These materials are stored for general use throughout the hospital, as well as in dedicated storage rooms/sheds, pharmacy areas, and research labs. In the event that a package is dropped or damaged, there is potential for release of Class 9 substance into the hospital drainage system, resulting in an environmental incident. As

several Class 9 substances are classified as environmentally hazardous materials, contamination could result in serious damage to the local environment.

The total quantity of Class 9 DGs stored at the hospital is less than 235 kg, which is significantly less than the 1,000 kg minor store threshold for environmentally hazardous substances as per AS 4681-2000 (Ref. [16]). The standard indicates that any store containing less than the minor store threshold presents minimal risk of contaminating surrounding areas. In addition, the size of the Class 9 packages ranges from 0.01 to 2.5 kg. Therefore, most spills would be small and readily managed by trained staff. Spill response kits are available for safe clean-up and disposal of minor spills. Hence the likelihood of a spill resulting in an environmental release is very low.

Therefore, it is considered that an offsite release is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.20 Diesel Tank Leak/Spill and Environmental Incident

The hospital is equipped with several diesel generators. Diesel is stored in generator tanks (500 L to 2,000 L capacity) throughout the hospital, and in an underground storage tank (22,000 L) adjacent to the North Block. There is potential for loss of containment of diesel during fuel transfers (spills, overfilling etc.) or in the event of damage to the tank (vehicle collision, tank corrosion etc.), which could result in serious damage to the local environment.

The tanks are fitted with overfill sensors and protections. In the event these protections fail, trained delivery drivers will be present to respond to the spill, limiting the release to small volumes. Furthermore, the majority of the diesel tanks are small integrally bunded tanks, hence any minor overfill will be contained in the bund. In the event the internal tanks corrode and fail, the contents of the tank shall be fulling contained by the integral bund.

Several of the tanks are installed underground, therefore vehicle impact and damage to the tank is not possible. The tanks which are located above ground are protected by impact protection (i.e. bollards), preventing any wayward vehicles from contacting the tank; hence, significant damage to the tank is unlikely to occur.

Therefore, it is considered that a major release of diesel resulting in offsite environmental impact is not a credible scenario; hence, this incident has not been carried forward for further analysis.

4.21 Diesel Tank Leak/Spill, Ignition and Fire

As discussed in **Section 4.20**, there is potential for release of diesel from the generator and underground tanks. Diesel is classified as a combustible liquid (Class C1). Therefore, in the event of a spill, there is potential for ignition of the diesel, resulting in a pool fire. In addition to the safeguards discussed in **Section 4.20**, it is noted that diesel has a high flash point and so is unlikely to ignite. Therefore, a major release of diesel resulting in a fire is not a credible scenario. Hence, this incident has not been carried forward for further analysis.

4.22 Mixing of incompatible materials and exothermic reactions

Several classes of DGs (Class 3, 4, 5.1, 5.2, 6.1, 8 and 9) may be stored in mixed class stores throughout the hospital for general use, as cleaning products, medicines, and laboratory materials. In the event that several packages are dropped or damaged at the same time, there is potential for incompatible dangerous goods to mix, resulting is hazardous exothermic reactions. If substantial volumes of DGs of were to interact the reaction would be sustained and may result in sufficient

heat to ignite combustible material within the area (i.e. detritus, leaves, debris, etc.) which may result in a fire.

Any stores containing mixed classes of DGs have been designed in compliance with AS 3833-2007 (Ref. [17]), which requires that incompatible dangerous goods are adequately segregated. In addition, the majority of the dangerous goods stored at the hospital are contained in small packages, therefore any reactions would be minor, and could be readily cleaned by trained staff.

It is noted that for this scenario to occur, it requires the simultaneous release of incompatible DGs, which is an unlikely event. Therefore, it is considered that this scenario is not a credible and no offsite impact would occur. Hence, this scenario has not been carried forward for further analysis.

5.0 Conclusion and Recommendations

5.1 Conclusions

A hazard identification table was developed for Nepean Hospital to identify potential hazards that may be present at the site as a result of the storage of materials. Based on the identified hazards, scenarios were postulated that may result in an incident with a potential for offsite impacts. Postulated scenarios were discussed qualitatively and any scenarios that would not impact offsite were eliminated from further assessment. It was determined that no scenarios would have offsite impacts, hence none were carried forward for consequence analysis.

Based on the analysis conducted, it was concluded that the risks at the site boundary are not considered to exceed the acceptable risk criteria; hence, the proposed redevelopment does not increase the risk profile of the overall site to an unacceptable level; hence, the proposed additions would be permitted within the current land zoning for the site.

5.2 Recommendations

Notwithstanding the conclusions following the analysis of the facility, the following recommendations have been made:

- Ensure all hazardous chemical storage facilities onsite comply with the relevant Australian Standards.
- Undertake a Hazardous Area Classification (HAC) for the hospital precinct where flammable gases (Class 2.1) or flammable liquids (Class 3) are stored.
- Prepare the documentation required for the hospital precinct per Part 7.1 of the Work Health and Safety Regulation 2017.

6.0 References

[1] Department of Planning, “Hazardous Industry Planning Advisory Paper No. 6 - Guidelines for Hazard Analysis,” 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] Department of Planning, Multi-Level Risk Assessment, Sydney: Department of Planning, 2011.

[4] SafeWork NSW, “Work Health and Safety Regulation,” SafeWork NSW, Lisarow, 2017.

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

[6] Standards Australia, “AS 4332-2004 - Storage and Handling of Gases in Cylinders,” Standards Australia, Sydney, 2004.

[7] 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.

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

[9] Standards Australia, “AS 1894-1997 - Storage and Handling of Non-Flammable Cryogenic and Refrigerated Liquids,” Standards Australia, Sydney, 1997.

[10] Standards Australia, AS 1940-2017 - Storage and Handling of Flammable and Combustible Liquids, Sydney: Standards Australia, 2017.

[11] Standards Australia, “AS/NZS 5026:2012 - The storage and handling of Class 4 dangerous goods,” Standards Australia, Sydney, 2012.

[12] Standards Australia, “AS 4326-2008 - Storage and Handling of Oxidising Agents,” Standards Australia, Sydney, 2008.

[13] Standards Australia, “AS 2714-2008 - The storage and handling of organic peroxides,” Standards Australia, Sydney, 2008.

[14] Standards Australia, “AS 4452-1997 - Storage and Handling of Toxic Substances,” Standards Australia, Sydney, 1997.

[15] Standards Australia, “AS 3780-2008 - The storage and handling of corrosive substances,” Standards Australia, Sydney, 2008.

[16] S. Australia, AS/NZS 4681:2000 - The storage and handling of Class 9 (miscellaneous) dangerous goods and articles, 2000.

[17] Standards Australia, “AS/NZS 3833:2007 - Storage and Handling of Mixed Classes of Dangerous Goods, in Packages and Intermediate Bulk Containers,” Standards Australia, Sydney, 2007.

[18] Standards Australia, “AS 1692-2006 - Steel tanks for flammable and combustible liquids,” Standards Australia, Sydney, 2006.

Appendix A

Detailed Outline of DG Quantities

A1. Dangerous Goods Quantities

Class	Description	UN Number	Name	PG	Quantity	
					kg	L
DG 2.1	Flammable Gases	UN 1001	Acetylene	-		10
		UN 1060	Methyl Acetylene and propadiene mixtures, stabilised	-	0.5	
		UN 1075	Liquefied Petroleum Gas	-	33.05	203.3
		UN 1950	Aerosols, n.o.s	-	111.02	286.53
		UN 1954	Compressed gas, flammable, n.o.s.	-		3.78
		UN 1965	Hydrocarbon gas mixtures, liquefied, n.o.s.	-		50
DG 2.2	Non-flammable, Non-toxic Gases	UN 1002	Compressed Air	-		1,891.61
		UN 1006	Argon, compressed	-		413.03
		UN 1013	Carbon dioxide	-		235.01
		UN 1018	Chlorodifluoromethane (Refrigerant Gas R22)	-	10	
		UN 1046	Helium, compressed	-		199
		UN 1066	Nitrogen, compressed	-		86.51
		UN 1078	Refrigerant gases, n.o.s	-	10	
		UN 1080	Sulfer hexafluoride	-		10
		UN 1950	Aerosols, n.o.s	-	0.99	2
		UN 1956	Compressed gas, n.o.s.	-	1.06	172.3
		UN 1977	Nitrogen, refrigerated liquid cryogenic liquid	-		25
		UN 3159	1,1,1,2-Tetrafluoroethane or Refrigerant gas R 134a	-	10	1.2
		UN 3337	Refrigerant gas R404A	-	10	

Class	Description	UN Number	Name	PG	Quantity	
					kg	L
DG 2.2 / 5.1	Non-flammable, non toxic gases (subrisk oxidising substance)	UN 1070	Nitrous Oxide	-		1,119.3
		UN 1072	Oxygen, Compressed	-		242,416.46
		UN 1073	Oxygen, refrigerated liquid (cryogenic liquid)	-		22,000
		UN 1950	Aerosols, n.o.s	-	0.07	
		UN 3156	Compressed gas, oxidizing, n.o.s.	-		342.96
DG 2.3 /5.1/8	Toxic Gas (subrisk oxidising substance and corrosive substance)	UN 1017	Chlorine	-	0.25	
DG 3	Flammable Liquids	UN 1090	Acetone	PG II	0.08	29.7
		UN 1120	Butanols	PG III		3
		UN 1133	Adhesives, containing a flammable liquid	PG II	1.11	8.01
		UN 1170	Ethanol or Ethanol solution	PG II	12.04	1,882.42
				PG III		1,272.32
		UN 1173	Ethyl Acetate	PG II		1
		UN 1197	Extracts, flavouring, liquid	PG II		0.5
		UN 1203	Gasoline, or petrol, or motor spirit	PG II		40
		UN 1210	Printing ink flammable, or Printing ink related material (including ink thinning or reducing compound), flammable	PG III		0.04
		UN 1219	Isopropanol / Isopropyl alcohol	PG II	1.64	56.15
		UN 1247	Methyl methacrylate monomer, inhibited	PG II	0.3	6.35
		UN 1263	Paint-related materials including paint, lacquer, enamel, stain, shellac solutions, varnish, polish, liquid filler, lacquer base	PG II		17.94
				PG III	0.35	46.75

Class	Description	UN Number	Name	PG	Quantity	
					kg	L
DG 3	Flammable Liquids	UN 1268	Petroleum distillates, n.o.s. or petroleum products, n.o.s	PG II		0.5
		UN 1300	Turpentine substitute, or mineral turpentine	PG III		52.75
		UN 1307	Xylenes	PG III		102
		UN 1648	Acetonitrile	PG II		3.85
		UN 1866	Resin solution, flammable	PG II	1.37	
		UN 1987	Alcohols, (Ethanol), n.o.s.	PG II		36
				PG III		3.9
		UN 1993	Flammable liquids, n.o.s.	PG I		0.25
				PG II	1.2	31.68
				PG III		230.66
		UN 2052	Dipentene	PG III		115
		UN 2265	N,N-Dimethylformamide	PG III		0.5
		UN 2283	Isobutyl methacrylate, inhibited	PG III		0.13
		UN 2319	Terpene hydrocarbons, n.o.s.	PG III		15.2
		UN 2372	1,2-Di-(dimethylamino)ethane	PG II		0.06
		UN 3295	Hydrocarbons, liquid, n.o.s.	PG II		0.04
DG 3 / 6.1	Flammable Gases (Subrisk Toxic Substances)	UN 1230	Methanol	PG II		227.5
				PG III		0.02
		UN 1992	Flammable liquids, toxic, n.o.s.	PG II		27.6
				PG III		3.1

Class	Description	UN Number	Name	PG	Quantity	
					kg	L
DG 3 / 8	Flammable Gases (Subrisk Corrosive Substances)	UN 1198	Formaldehyde, solutions, flammable	PG III		20
		UN 2924	Flammable liquid, corrosive, n.o.s.	PG I		0.03
				PG III	0.38	
DG 4.1	Flammable Solids	UN 1325	Flammable solids, organic, n.o.s.	PG III	2.3	
		UN 1344	Trinitrophenol, wetted with not less than 30 percent water, by mass	PG I	0.01	
		UN 2213	Paraformaldehyde	PG III	0.75	
		UN 2717	Camphor, synthetic	PG III	0.5	
		UN 3175	Solids containing flammable liquid, n.o.s.	PG II	101.51	
DG 4.1 / 6.1	Flammable Solids (sub-risk Toxic Substances)	UN 1320	Dinitrophenol, wetted with not less than	PG I	0.03	
		UN 2926	Flammable solids, toxic, organic, n.o.s.	PG II	0.1	
DG 4.2	Substances liable to spontaneous combustion	UN 1362	Carbon, activated	PG III	1	
DG 4.3	Substances that emit flammable gases in contact with water	UN 3208	Metallic substance, water-reactive, n.o.s.	PG II	0.5	
DG 5.1	Oxidising Substances	UN 1444	Ammonium persulfate	PG III	0.14	
		UN 1479	Lead nitrate	PG III	0.5	
		UN 1493	Silver nitrate	PG II	0.06	2
		UN 1498	Sodium nitrate	PG III	0.5	
		UN 2465	Dichloroisocyanuric acid, dry or Dichloroisocyanuric acid salts	PG II	0.36	

Class	Description	UN Number	Name	PG	Quantity	
					kg	L
DG 5.1 / 6.1	Oxidising Substances (subrisk Toxic Substances)	UN 1500	Sodium Nitrite	PG III	0.01	
DG 5.1 / 8	Oxidising Substances (subrisk Corrosive Substances)	UN 2014	Hydrogen peroxide, aqueous solutions with more than 20 percent but not more than 60 percent hydrogen peroxide (stabilized as necessary)	PG II		6.89
DG 5.2	Organic Peroxides	UN 3108	Organic peroxide type E, solid	PG II	1.75	
DG 5.2 / 8	Organic Peroxides (subrisk Corrosive Substances)	UN 3109	Organic peroxide type F, liquid	-	34.77	6.9
DG 6.1	Toxic Substances	UN 1687	Sodium azide	PG II	0.06	0.5
		UN 1690	Sodium fluoride	PG III	0.1	
		UN 1851	Medicine, liquid, toxic, n.o.s.	PG III	0.02	
		UN 1888	Chloroform	PG III		2.9
		UN 2074	Acrylamide, Solid	PG III	0.1	
		UN 2587	Benzoquinone	PG II		11.34
		UN 2688	1-Chloro-3-bromopropane	PG III		0.2
		UN 2810	Toxic liquids, organic, n.o.s. or Toxic, liquids, organic, n.o.s. Inhalation Hazard, Packing Group I, Zone A or B	PG III		1
		UN 2811	Toxic solid, organic, n.o.s.	PG I	0.12	
				PG II	0.1	0.2
				PG III	0.17	0.2
		UN 2821	Phenol solutions	PG III		0.5
		UN 2966	Thioglycol	PG II		0.01

Class	Description	UN Number	Name	PG	Quantity	
					kg	L
		UN 3249	Medicine, solid, toxic, n.o.s.	PG II	0.01	
				PG III	0.01	
		UN 3288	Toxic solid, inorganic, n.o.s.	PG III	0.1	
		UN 3426	Acrylamide solution	PG III		0.5
DG 6.1 / 8	Toxic Substances (subrisk Corrosive Substances)	UN 2927	Toxic liquid, corrosive, organic, n.o.s. or Toxic liquid, corrosive, organic, n.o.s. Inhalation Hazard, PG I, Zone A or B	PG II		0.7
DG 8	Corrosive Substances	UN 1719	Caustic alkali liquid, n.o.s.	PG II		40
				PG III		46
		UN 1740	Hydrogen difluorides, n.o.s. solid	PG II	0.2	
		UN 1760	Corrosive liquids, n.o.s.	PG III	0.15	36.13
		UN 1773	Ferric chloride, anhydrous	PG III	0.5	
		UN 1789	Hydrochloric acid	PG II		235.62
				PG III		2.34
		UN 1791	Hypochlorite solutions	PG II		0.3
				PG III		425
		UN 1805	Phosphoric acid	PG III	0.2	52.34
		UN 1813	Potassium hydroxide, solid	PG II	0.75	
		UN 1814	Potassium hydroxide, solution	PG II		11.01
				PG III		1
		UN 1823	Sodium hydroxide, solid	PG II	4	20

Class	Description	UN Number	Name	PG	Quantity	
					kg	L
DG 8	Corrosive Substances	UN 1824	Sodium hydroxide, solution	PG II		140
		UN 1830	Sulfuric acid, more than 51% acid	PG II		6.5
		UN 2209	Formaldehyde, solutions, with not less than 25 percent formaldehyde	PG III		1
		UN 2491	Ethanolamine or Ethanolamine solutions	PG III		8
		UN 2735	Amines, liquid, corrosive, n.o.s. or Polyamines, liquid, corrosive, n.o.s.	PG III		0.1
		UN 2790	Acetic acid solution, not less than 50 percent but not more than 80 percent acid, by mass or Acetic acid solution, with more than 10 percent and less than 50 percent acid, by mass	PG III		0.12
		UN 2802	Copper chloride	PG III	0.05	
		UN 3253	Disodium trioxosilicate	PG III	33.5	4.5
		UN 3259	Amines, solid, corrosive, n.o.s. or Polyamines, solid, corrosive, n.o.s.	PG III		1
		UN 3260	Corrosive solid, acidic, inorganic, n.o.s.	PG III	0.25	
		UN 3263	Corrosive solid, basic, organic, n.o.s.	PG III	0.1	
		UN 3264	Corrosive liquid, acidic, inorganic, n.o.s.	PG II		0.04
				PG III		1.5
		UN 3265	Corrosive liquid, acidic, organic, n.o.s.	PG II		0.2
				PG III		110
		UN 3266	Corrosive liquid, basic, inorganic, n.o.s.	PG II		0.45
				PG III		69.25

Class	Description	UN Number	Name	PG	Quantity	
					kg	L
DG 8 / 3	Corrosive Substances (subrisk Flammable Liquids)	UN 1779	Formic acid	PG II		1.05
		UN 2789	Acetic acid, glacial or Acetic acid solution, with more than 80 percent acid, by mass	PG II		10.5
		UN 2920	Corrosive liquids, flammable, n.o.s.	PG II		0.02
DG 8 / 5.1	Corrosive Substances (subrisk Oxidising Substances)	UN 3084	Corrosive solid, oxidizing, n.o.s.	PG II	0.03	
DG 8 / 6.1	Corrosive Substances (subrisk Toxic Substances)	UN 2922	Corrosive liquids, toxic, n.o.s.	PG II		0.01
				PG III		5.13
		UN 3495	Iodine	PG III	0.1	
DG 9	Miscellaneous Dangerous Goods	UN 1845	Carbon dioxide, solid (Dry ice)	-	1.00	
		UN 3077	Environmentally hazardous substance, solid, n.o.s. (not including waste)	PG III	159	4.6
		UN 3082	Environmentally hazardous substance, liquid, n.o.s.	PG III	3.51	61.57
		UN 3316	Chemical kit or First Aid kit containing dangerous goods	PG II		0.25
		UN 3334	Aviation regulated liquid, n.o.s.	PG III		5.10
C1	Combustible Liquid	n/a	Diesel	n/a		26,200

Appendix B

Hazard Identification Table

B1. Hazard Identification Table

ID	Hazard	Hazard Cause	Hazard Consequence	Safeguards	Potential for offsite impacts?	Carried forward?
1	Flammable Gases in Cylinders (Class 2.1)	• Loss of containment of cylinder – formation of hazardous atmosphere • Ignition sources in hazardous area • Damage to cylinders, packages / aerosols	• Fire or explosion resulting in injuries or fatality • Spread of fire to adjacent areas – incident escalation.	• Storage area to comply with and AS 4332-2004 (Ref. [6]) • Fire protection shall be provided in accordance the standards • Separation distance in accordance with the standards • Hazardous Area Classification (HAC) in accordance with AS/NZS 60079.10.1:2009 (Ref. [7])	No. Compliant design is considered appropriate for containing potential impacts onsite	No
2	Non-flammable, Non-toxic Gases in Cylinders (Class 2.2)	• Loss of containment of non-flammable gas • Damage to cylinders (dropped cylinder, vehicle collision etc)	• Potential asphyxiation hazard	• Storage area to comply with AS 4332-2004 (Ref. [6], including impact protection. • Staff are trained in DG handling • Speed limits and signage at storage areas. • Small cylinder sizes (C-G size cylinders)	No. Compliant design is considered appropriate for containing potential impacts onsite	• No
3	Oxygen and Nitrox cylinders (Class 2.2 (5.1))	• Loss of containment of oxygen, resulting in hypoxic environment • Loss of containment of oxygen in the present of fire • Damage to cylinders (dropped cylinder, vehicle collision etc)	• Potential oxygen enriched environment • Exacerbation of fire and / or explosion incidents onsite • Potential for injuries and / or fatalities	• Storage area and vessels to comply with AS 1894-1997 (Ref. [9]), including impact protection • Separation distances in accordance with the standard. • Staff are trained in DG handling • Speed limits and signage • Minor stores.	No Compliant design is considered appropriate for containing potential impacts onsite	• No

ID	Hazard	Hazard Cause	Hazard Consequence	Safeguards	Potential for offsite impacts?	Carried forward?
4	Bulk Oxygen Tank (Class 2.2 (5.1))	• Failure of Vacuum Insulated Evaporation (VIE) storage vessel • Loss of containment associated with piping / valves / flanges / evaporators / etc. • Vehicular impact during deliveries	• Potential oxygen enriched environment • Exacerbation of fire and / or explosion incidents onsite • Potential for injuries and / or fatalities	• Storage area and vessels to comply with AS 1894-1997 (Ref. [9]), including impact protection • Separation distances in accordance with AS 1894-1997 • Fire protection equipment in accordance with AS 1894-1997 • Vessel is contained within a compound with FRL 240/240/240 • Spill containment around process equipment • Spill clean-up equipment • Plant inspections and preventative maintenance system • Staff are trained in DG handling • Speed limits and signage	No. Compliant design and controls, in addition to distance from the boundary are considered appropriate for containing potential impacts onsite	• No
5	Bulk Oxygen Tank (Class 2.2 (5.1))	• Failure of Vacuum Insulated Evaporation (VIE) storage vessel • Loss of containment associated with piping / valves / flanges / evaporators / etc. • Vehicular impact during deliveries •	• Release of cryogenic gas / liquid – risk of cryogenic burns • Oxygen enriched environment • Damage to nearby structures as a result of exposure to extremely low temperatures	• Storage area and vessels to comply with AS 1894-1997 (Ref. [9]), including impact protection • Separation distances in accordance with AS 1894-1997 • Vessel is contained within a compound with FRL 240/240/240 • Spill containment around process equipment • Spill clean-up equipment • Process equipment located above impervious concrete slab	No. Compliant design and controls, in addition to distance from the boundary are considered appropriate for containing potential impacts onsite	• No

ID	Hazard	Hazard Cause	Hazard Consequence	Safeguards	Potential for offsite impacts?	Carried forward?
				• Plant inspections and preventative maintenance system • Staff are trained in DG handling • Speed limits and signage		
6	Chlorine gas cylinder (Class 2.3)	• Loss of containment of chlorine gas cylinder • Damage to cylinders	• Dispersion of toxic gas • Potential for injuries and / or fatalities	• Storage area and cylinder to comply with 4332-2004 (Ref. [6]) • Very minor quantity stored – 1x0.25 kg cylinder • Hospital is well ventilated, such that toxic gas will not accumulate above toxic concentration. • Staff are trained in DG handling	No Compliant design, including minor quantity stored, is considered appropriate for containing potential impacts onsite	• No
7	Storage of flammable liquids (Class 3)	• Loss of containment of flammable liquid package • Ignition source in presence of flammable liquids	• Ignition of flammable liquids • Fire resulting in potential injuries and property damage	• Storage areas to comply with AS 1940-2017 (Ref. [10]) • Fire protection in accordance with the standard • Area to be well ventilated in accordance with the standard • Mostly minor quantities stored, in small packages (1-20 L) • Packages are mostly cleaning products which do not contain 100% flammable liquid • Staff are trained in DG handling • HAC in accordance with AS/NZS 60079.10.1:2009 (Ref. [7])	No Compliant design is considered appropriate for containing potential impacts onsite	• No

ID	Hazard	Hazard Cause	Hazard Consequence	Safeguards	Potential for offsite impacts?	Carried forward?
8	Storage of flammable liquids (Class 3)	• Loss of containment of flammable liquids • Ignition source in presence of flammable liquids	• Accumulation of flammable vapour cloud • Delayed ignition of flammable liquids • Flash fire or explosion	• Storage areas to comply with AS 1940-2017 (Ref. [10]) • Fire protection in accordance with the standard • Area to be well ventilated in accordance with the standard • Mostly minor quantities stored, in small packages (1-20 L) • Packages are mostly cleaning products which do not contain 100% flammable liquid • Staff are trained in DG handling • HAC in accordance with AS/NZS 60079.10.1:2009 (Ref. [7])	No. Compliant design is considered appropriate for containing potential impacts onsite	• No
9	Storage of flammable solids (Class 4)	• Loss of containment of flammable solid package • Ignition source in presence of flammable solid	• Ignition of flammable solids • Fire resulting in potential injuries and property damage	• Storage areas to comply with AS/NZS 5026:2012 (Ref. [11]) • Fire protection in accordance with the standard • Minor quantities stored (Total 100 kg), in small packages (0.5-5 kg) • Staff are trained in DG handling	No Compliant design is considered appropriate for containing potential impacts onsite	• No
10	Storage of oxidising substances (Class 5.1)	• Oxidising Agents and Organic Peroxides Release and Environmental Incident	• Minor environmental release • Potential for spills to enter drains and surrounding environment	• Storage areas to comply with AS 4326-2008 (Ref. [12]) • Fire protection in accordance with the standard • Minor quantities stored (100 kg), in small packages (0.01-2 L)	No Compliant design is considered appropriate for containing potential impacts onsite	• No

ID	Hazard	Hazard Cause	Hazard Consequence	Safeguards	Potential for offsite impacts?	Carried forward?
				• Staff are trained in DG handling / spill response • Spill kits		
11	Storage of oxidising substances (Class 5.1)	• Loss of containment of oxidising substances / organic peroxides packages • Dropped/damaged packages • Inadequate spill containment •	• Exacerbation of fire and / or explosion incidents onsite • Potential for injuries and / or fatalities	• Storage areas to comply with AS 4326-2008 (Ref. [12]) • Fire protection in accordance with the standard • Minor quantities stored (100 kg), in small packages (0.01-2 L) • Staff are trained in DG handling / spill response • Spill kits	No Compliant design is considered appropriate for containing potential impacts onsite	• No
12	Storage of organic peroxides (Class 5.2)	• Loss of containment of organic peroxides packages • Dropped/damaged packages • Inadequate spill containment	• Minor environmental release • Potential for spills to enter drains and surrounding environment	• Storage areas to comply with AS 2714-2008 (Ref. [13]) • Fire protection in accordance with the standard • Minor quantities stored (50 L), in small packages (0.1-20 L) • Staff are trained in DG handling / spill response • Spill kits	No Compliant design is considered appropriate for containing potential impacts onsite	• No
13	Storage of organic peroxides (Class 5.2)	• Loss of containment of organic peroxides packages • Dropped/damaged packages • Ignition sources in the presence of packages	• Ignition of organic peroxides • Fire resulting in potential injuries and property damage	• Storage areas to comply with AS 2714-2008 (Ref. [13]) • Fire protection in accordance with the standard • Area to be well ventilated in accordance with the standard	No Compliant design is considered appropriate for containing potential impacts onsite	• No

ID	Hazard	Hazard Cause	Hazard Consequence	Safeguards	Potential for offsite impacts?	Carried forward?
				• Minor quantities stored (50 L), in small packages (0.1-20 L) • Staff are trained in DG handling		
14	Storage of toxic substances (Class 6.1)	• Loss of containment of toxic substances packages • Dropped/damaged packages • Inadequate spill containment	• Minor environmental release - Potential for spills to enter drains and surrounding environment • Potential for injuries	• Storage to comply with AS 4452–1997 (Ref. [14]) • Minor quantities (20 L) stored in small packages (0.01-10 L) • Spill containment for storage areas • Staff are trained in DG handling / spill response • Spill kits	No. Compliant design is considered appropriate for containing potential impacts onsite	• No
15	Storage of corrosive substances (Class 8)	• Loss of containment of corrosive substances packages • Dropped/damaged packages • Inadequate spill containment	• Minor environmental release - Potential for spills to enter drains and surrounding environment • Potential for injuries/property damage	• Storage to comply with AS 3780-2008 (Ref. [15]) • Segregation between incompatible materials • Materials of construction for storage area to be compatible with corrosive substances • Mostly minor quantities stored in small packages (1-20 L) • Staff are trained in DG handling / spill response • Spill kits	No. Compliant design is considered appropriate for containing potential impacts onsite	• No
16	Storage of Miscellaneous DGs (Class 9) (not including diesel tanks)	• Loss of containment of Class 9 packages • Dropped/damaged packages	• Minor environmental release – Potential for spills to enter drains and	• Storage to comply with AS/NZS 4921:2000 (Ref. [16]) • Mostly minor quantities stored in small packages (0.01-16 L)	No. Compliant design is considered appropriate for containing	• No

ID	Hazard	Hazard Cause	Hazard Consequence	Safeguards	Potential for offsite impacts?	Carried forward?
		• Inadequate spill containment	surrounding environment	• Staff are trained in DG handling / clean up • Spill kits	potential impacts onsite	
17	Diesel storage (generator tanks, and underground tank)	• Loss of containment of diesel storage tank • Loss of containment during fuel transfers • Ignition sources in vicinity of diesel storage tank	• Ignition of diesel • Fire resulting in potential injuries and property damage	• Storage area to comply with AS 1940-2017 (Ref. [10]) • Fire protection in accordance with AS 1940-2017 • Storage tank to comply with AS 1692-2006 (Ref. [18]) • Spill containment for delivery vehicles • Tanks are integrally bunded • Separation distances to comply with AS 1940-2017 • Diesel is classified as 'combustible' and therefore not considered a significant ignition risk • Area to be well ventilated in accordance with AS 1940-2017	No. Compliant design is considered appropriate for containing potential impacts onsite	• No
18	Diesel storage	• Loss of containment of diesel fuel during fuel transfers • Loss of hose connections during fuel transfers • Loss of containment of diesel storage tank • Overfilling of tank	• Release of diesel to surrounding environment resulting in potential environmental damage	• Storage area to comply with AS 1940-2017 (Ref. [10]) • Spill containment in accordance with AS 1940-2017 • Trained and supervised fuel transfers • Tank inspections • Tank overfill protection	No. Compliant design is considered appropriate for containing potential impacts onsite	• No

ID	Hazard	Hazard Cause	Hazard Consequence	Safeguards	Potential for offsite impacts?	Carried forward?
19	Storage of Mixed Classes of Dangerous Goods	• Dropped/damaged packages • Loss of containment of incompatible dangerous goods	• Potential for incompatible DGS to come into contact with each other, resulting in exothermic reactions • Potential for injuries/property damage	• Storage to comply AS/NZS 3833:2007 (Ref. [17]) • Segregation between incompatible materials • Mostly minor quantities stored in small packages (0.01-20 L) – minor reactions • Spill containment for storage area • Staff are trained in DG handling / spill response • Spill kits	No Compliant design is considered appropriate for containing potential impacts onsite	• No