

NSW Health Infrastructure
Coffs Harbour Hospital Expansion
SSD Application No. 8981
SEPP 33 Assessment Report

Issue 1 | 23 May 2018

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Arup
Arup Pty Ltd ABN 18 000 966 165



Arup
Level 17
1 Nicholson Street
East Melbourne VIC 3002
Australia
www.arup.com

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HAZOP Register

1 Executive Summary

Coffs Harbour Hospital is preparing an expansion proposal to enable it to provide additional services as outlined in the MNCLHD Clinical Services Plan 2016-2026.

As part of the development it is expected that following the completion of the Coffs Harbour Hospital Expansion project there will be a total of six (6) on-site LPG tanks (total volume approximately 45 kL) to meet gas supply requirements. There is also existing storages of oxygen, nitrous oxide and compressed air on-site.

An assessment of the proposed expanded LPG storage facility has been undertaken to meet the requirements of SEPP 33 for potentially hazardous industry has been conducted.

The review has demonstrated that the design complies with the requirements of the following Australian Standards:

- AS1596:2014 *The storage and handling of LP Gas*;
- AS 1894 1997 *The storage and handling of non-flammable cryogenic and refrigerated liquids*; and
- AS 4332-2004: *The storage and handling of gases in cylinders*

Consequence modelling of LPG events have been undertaken (jet fire, vapour cloud explosions and BLEVEs) have been undertaken. An event tree for failure of the tanks has also been completed. These studies have shown that in the very unlikely event of a large jet fire becoming established in the eastern most tank (currently existing) that it is possible for direct flame impingement on the hospital main building.

Consideration should be given to installing a fire wall on the eastern side of the LPG storage area to reduce risk so far as reasonably practicable.

2 Introduction

2.1 Project Background

Coffs Harbour Health Campus is a major non-metropolitan referral hospital in the Coffs Clinical Network, operated under the Mid North Coast Local Health District (MNCLHD). Coffs Harbour Hospital provides services at role delineation level 4 and 5. The proposed expansion will provide additional service demands as outlined in the MNCLHD Clinical Services Plan 2016-2026 and as endorsed by the NSW Ministry of Health.

The objectives of the Coffs Harbour Hospital Expansion are:

- better Health Value benefits are identified, developed and achieved;
- service capacity is increased to meet future demand;
- self-sufficiency of acute medical and surgical care is achieved to the required level for the catchment area;
- service access and patient flows are improved;
- service integration is optimised especially between home, and ambulatory and acute services;
- future proofing is incorporated to enable the necessary changes over a defined time to operational practice; and
- Coffs Harbour Health Campus will be identified as a preferred employer in regional NSW.

The hospital is located adjacent to the Pacific Highway 3 km south-west of central Coffs Harbour with direct highway access. The broader context is shown in Figure 1 and the site location in Figure 2.

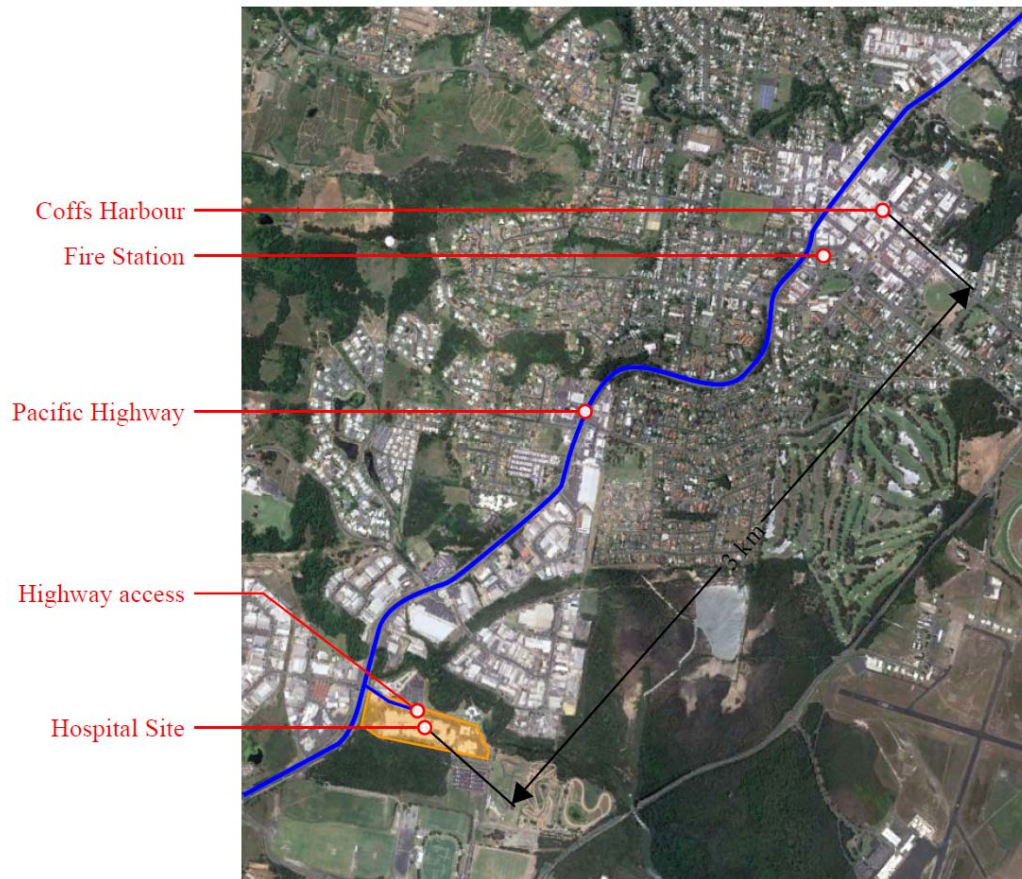


Figure 1: Coffs Harbour Health Campus Location

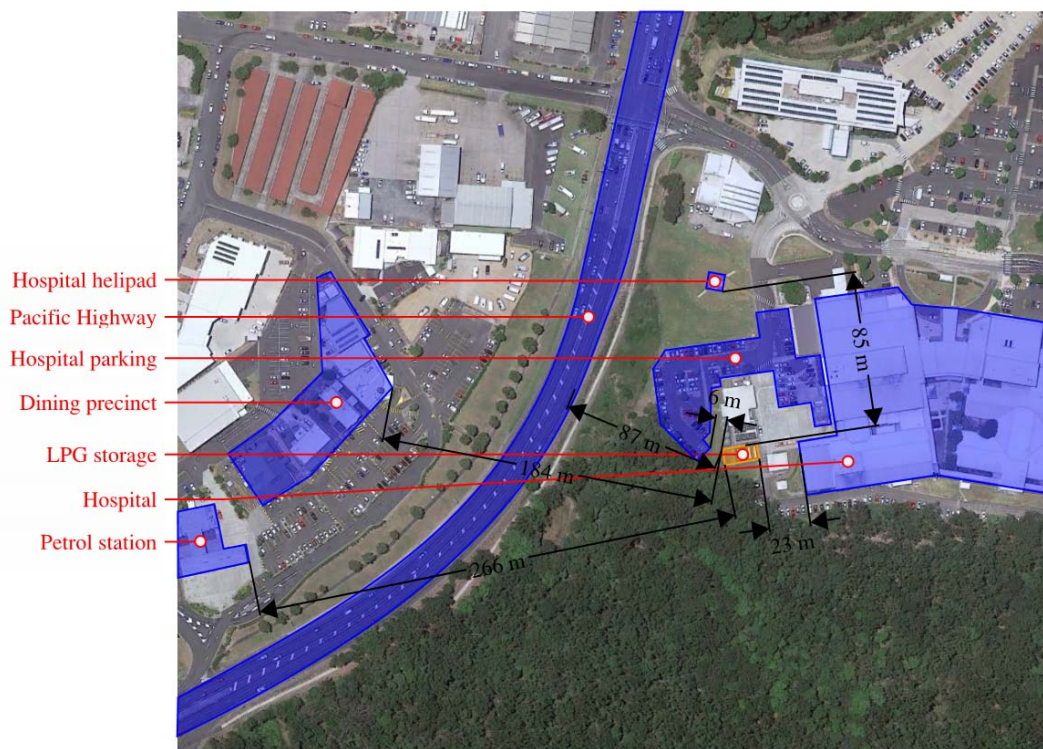


Figure 2: LPG storage Location at Coffs Harbour Health Campus

The site has existing water and sewer services provided by Coffs Harbour City Council. Gas requirements are currently met by four (4) on-site liquefied petroleum gas (LPG) tanks (total storage volume 29.2 kL) and the expansion project is expected to include an increase to the LPG storage capacity by the addition of further storage tanks. It is expected that following the completion of the Coffs Harbour Hospital Expansion project there will be a total of six (6) on-site LPG tanks (total volume approximately 45 kL).

2.2 SEPP 33

State Environmental Planning Policy No. 33 Hazardous and Offensive Development (SEPP 33) is used in New South Wales to regulate the planning approval process for developments in hazardous and offensive industries, and potentially hazardous and potentially offensive industries. The SEPP 33 process is shown in Figure 3.

A key part of the SEPP 33 process is the preliminary hazard analysis (PHA). If the development application includes dangerous goods (DGs) with quantities or transport frequencies above defined thresholds, a PHA must be performed as part of the SEPP 33 process.

This report assesses the Coffs Harbour Hospital Expansion Project site against the SEPP 33 guidelines to determine whether a PHA must be undertaken.

Figure 1: The SEPP 33 Process

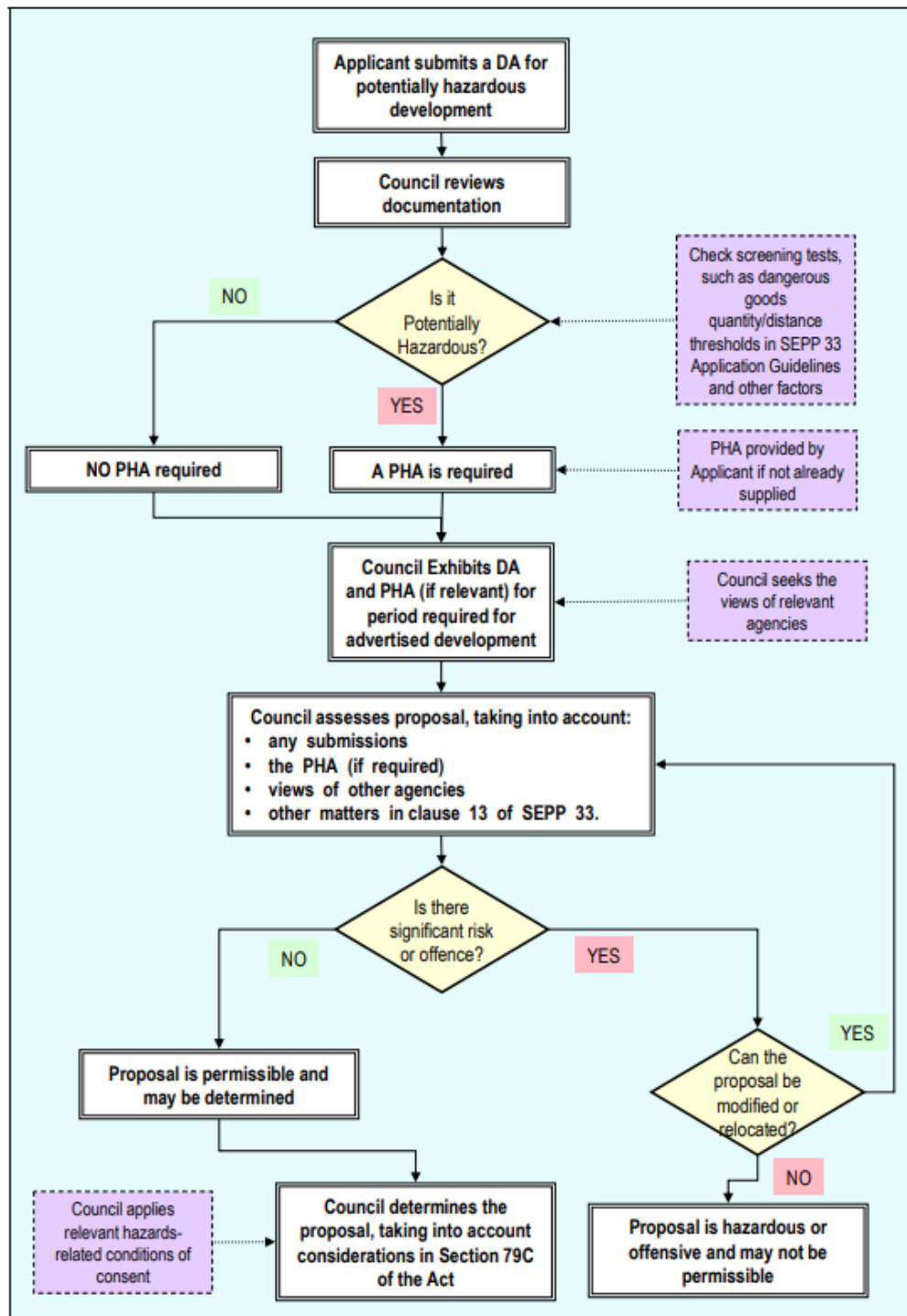


Figure 3: The SEPP 33 Process

3 Applicability of SEPP 33

3.1 Dangerous Goods on site

The following DGs are to be stored on site:

Dangerous Good	Class	Subsidiary Risk	Quantity
LPG	2.1	-	45000 L
Liquid Oxygen	2.2	5.1	18000 L
Nitrous oxide	2.3	5.1	9 “G” size cylinders (450 L water capacity)
Tool Air	2.2		15 “G” size cylinders (750 L water capacity)

A layout of the existing storage areas and the expanded LPG tank farm provides details of the storage locations for each of these hazardous goods in Figure 4: Medical Gases and LPG Storage locations.

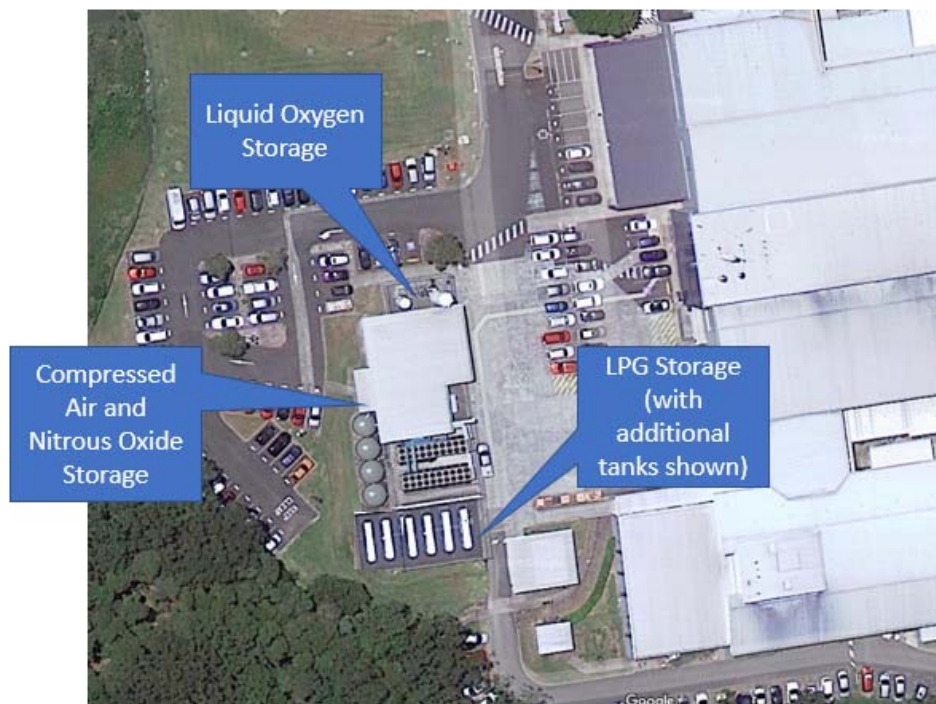


Figure 4: Medical Gases and LPG Storage locations

Together, Table 1 and Table 3 of the NSW Department of Planning *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* define the threshold quantities for each class of DG on site. These are as follows:

DG Class	Threshold Quantity	Threshold Exceeded?
2.1	16 m3 / 10 tonne ¹	Yes (in total with existing 29200 L)
2.2	N/A	No
2.3	100kg	Yes
5.1	5000kg	Yes

Notes:

1 Threshold for aboveground storage of LPG only

3.2 Dangerous Goods transportation

Table 2 of the NSW Department of Planning *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* defines the transportation screening thresholds for each class of DG being delivered to the site. These are as follows:

DG Class	Expected Annual Movements	Threshold Annual Movements	Threshold Exceeded?
2.1	52	> 500	No
2.3	52	>100	No
5.1	52	>500	No

None of the expected transportation frequencies exceed the screening thresholds under SEPP 33.

4 Risk Classification and Prioritisation

In order to complete the classification process a review has been completed of the following matters to assess the need for more rigorous assessment:

- Likelihood of tank failure
- Consequences of tank failure
- Offsite populations
- Risk of fatality.

4.1 Likelihood of LPG tank failure

The UK USE Failure Rate and Event Data for use in Risk Assessments gives the following tank failure rate information for holes in LPG tanks [1].

Type of Release	Failure rate (per vessel year)
50 mm diameter hole	5×10^{-6}
25 mm diameter hole	5×10^{-6}
13 mm diameter hole	1×10^{-5}

4.2 Consequences of tank failure

Consequence modelling was undertaken using DNV GL's Phast v8.0 software. Based on guidance from the Elgas website [2], the proposed 971,550 MJ of LPG was modelled as 3265.9 kg of propane per tank (based on a conversion of 49.58 MJ/kg). The propane was taken to be at its bubble point at 20°C (736.2 kPa(g)).

4.2.1 Jet fire

The most significant release which would result in a jet fire described in the HSE Failure Rate guidance is a 50 mm diameter hole. A 50 mm orifice size was therefore used for analysis in Phast v8.0.

The jet fire consequence was considered at wind speeds of 1.5 m/s and 5 m/s.

The results are summarised in Table 1 and the heat radiation contours for the 1.5 m/s wind speed are shown in Figure 5.

	1.5 m/s wind speed	5 m/s wind speed
Flame length (m)	68.4	49.7
Distance to 35 kW/m ² contour (m)	81.9	66.6
Distance to 23 kW/m ² contour (m)	88.1	72.8
Distance to 12.6 kW/m ² contour (m)	98.5	83.4
Distance to 4.7 kW/m ² contour (m)	121.7	107.5

Table 1: Jet fire heat radiation contours

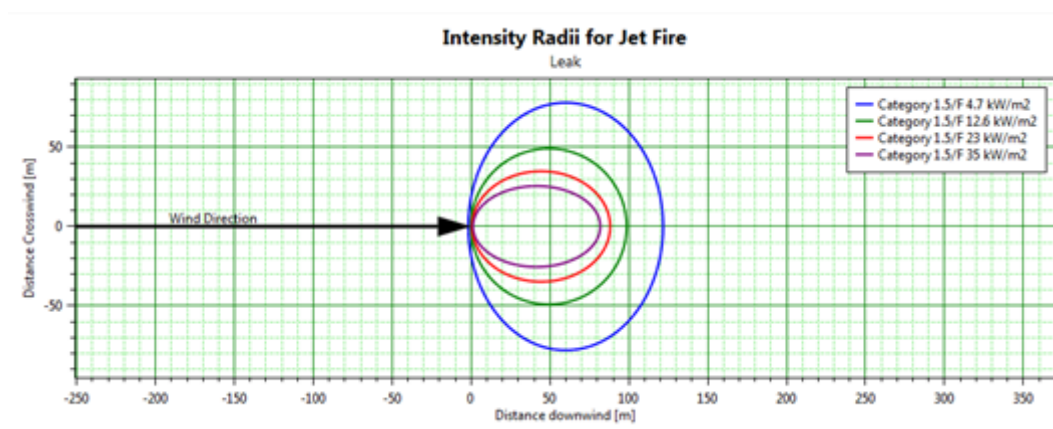


Figure 5: Jet fire heat radiation contours

The jet fire scenario can also lead to flame impingement on other LPG tanks, causing a boiling liquid expanding vapour explosion (BLEVE, discussed below).

The flame length in both weather conditions studied indicates that direct flame impingement on the hospital is a plausible consequence of a large jet fire from the eastern tank. It is recommended that consideration is given to installing a firewall on the eastern side of the LPG storage area to prevent direct flame impingement on the hospital.

The results of a jet fire resulting from a hole in the western side of the westernmost tank are shown in Figure 6. This is the scenario with the most widespread heat radiation consequences; if the jet fire is directed towards the firewall, the ground or upwards, the heat radiation is contained in close proximity to the tanks. If the jet fire is directed at another tank, the potential consequence is a BLEVE.

The offsite fatality risk from a jet fire is for people using the footpath along Pacific Hwy. If a pedestrian is in the direct line of a jet fire, it is likely that a fatality would result. If a pedestrian is in the vicinity, but the jet fire is not directed

at them, fatality is unlikely. People in vehicles on Pacific Hwy are not likely to be fatally affected by a jet fire.

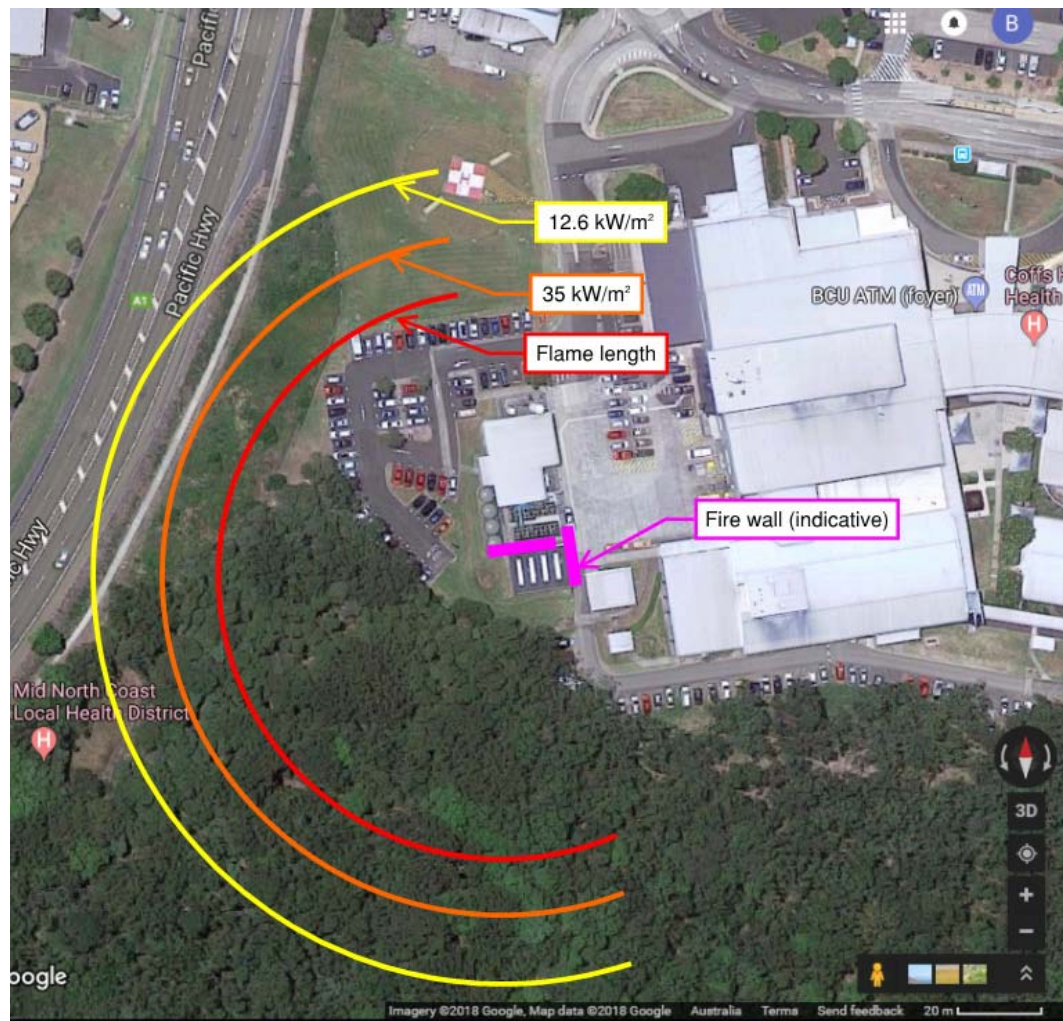


Figure 6: Jet fire from western side of westernmost LPG tank

4.2.2 Flash fire

The downwind distances to the lower flammability limit (LFL) and half the LFL in the event of a release are shown in Table 2. It is likely that an ignition source would be found before the cloud reaches these sizes, resulting in a much smaller flash fire.

Table 2: Flash fire results

Wind Speed	Downwind distance to LFL	Downwind distance to 50% LFL
1.5 m/s	100.0 m	178.1 m
5 m/s	112.2 m	208.9 m

4.2.3 Vapour cloud explosion (VCE)

A vapour cloud explosion (VCE) was modelled, based on the accumulation of propane vapour in the confined area (shown in yellow) in Figure 7. The confined area is 625 m². A cloud height of 3 m was taken, given a cloud volume of 1875 m³.

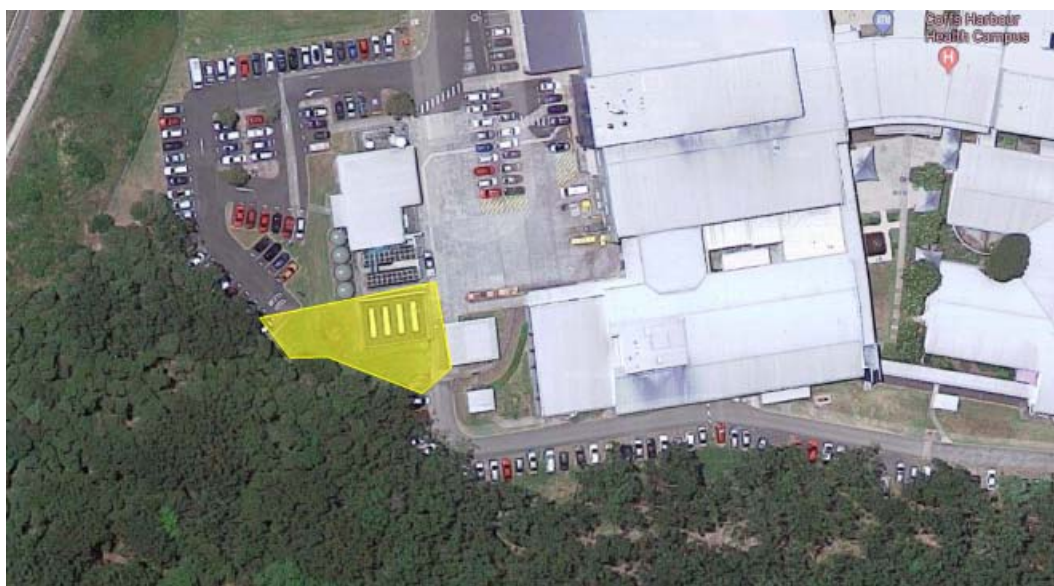


Figure 7: Potential vapour cloud confined area

In order to simulate the worst-case VCE scenario, propane was assumed to be in the optimal stoichiometric ratio to air of 1:23.8. This value is an output from Phast v8.0. The volume of propane is 78.8 m³, which at 20°C and atmospheric pressure is 144.4 kg.

The Dutch Yellow Book [3] defines the modelling parameter known as the “blast strength” based on three conditions:

- Obstruction (i.e obstacles within the cloud);

- Parallel plane confinement; and
- Ignition strength.

Obstruction within the cloud was classified as **low** (less than 30% of cloud volume) and ignition strength was classified as **low** (spark, flame etc.). Parallel plane confinement could be classified as either **yes** or **no** depending on the effectiveness of the bushland to the south of the tanks at confining the cloud. Both options were carried forward for further analysis.

Table 5.3 of the Yellow Book, reproduced below in Figure 8, defines the blast strength based on these parameters. As highlighted in Figure 8, the blast strength category could be either 9 or 10 (depending on whether parallel plane confinement events occur), giving a blast strength of 3-5 or 2-3 respectively.

Based on experience, a blast strength of 3 was deemed to be appropriate based of the site layout.

Table 5.3 Initial blast strength index

Blast strength category	Ignition energy		Obstruction			Parallel plane confinement	Multi-Energy Unconfined	Class
	Low	High	High	Low	No			
	(L)	(H)	(H)	(L)	(N)	(C)	(U)	
1		H	H			C		7-10
2		H	H				U	7-10
3	L	H	H			C		5-7
4		H		L		C		5-7
5		H		L			U	4-6
6		H			N	C		4-6
7	L		H				U	4-5
8		H			N			4-5
9	L			L		C		3-5
10	L			L			U	2-3
11	L				N	C		1-2
12	L				N		U	1

Figure 8: Blast Strength Index

Incident overpressure is graphed against distance based on the inputs above, and is shown in Figure 9 below. The incident overpressure decays below 3.5 kPa after 38m. Pulse duration is 0.24 s after 22 m. There are not expected to be any fatality consequences off site, or in the hospital building itself.

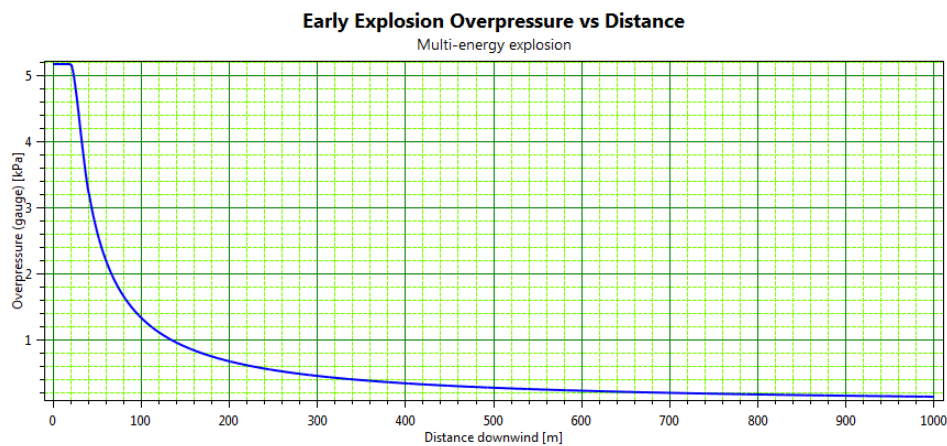


Figure 9: Early Explosion overpressure

4.2.4 BLEVE (boiling liquid expanding vapour explosion)

A boiling liquid expanding vapour explosion (BLEVE) could occur as a result of fire heating one of the LPG tanks. This could occur as a result of escalation of a jet fire event, or as a result of a bushfire.

The results of the BLEVE are summarised in Table 3. Incident overpressure contours are shown in Figure 10.

Incident overpressure (kPa)	Distance from source (m)
35	22.0
21	30.4
14	40.5
7	64.4
3.5	109.0

Table 3: BLEVE incident overpressures

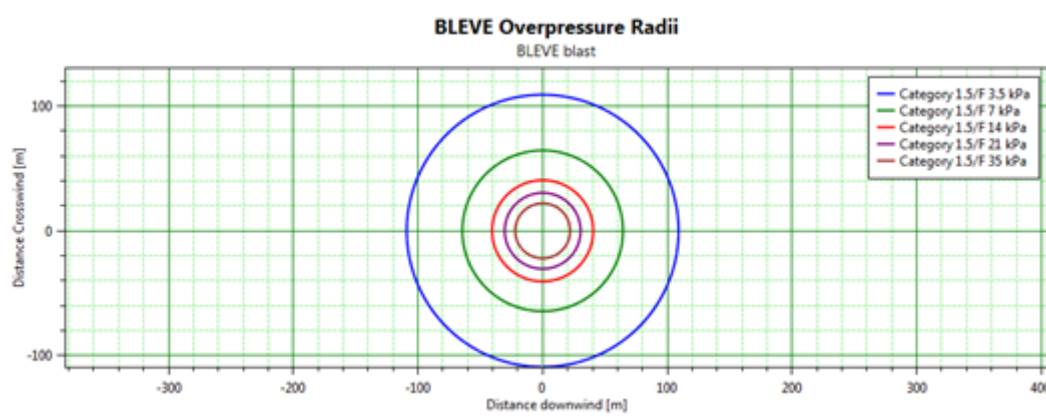


Figure 10: BLEVE Incident overpressure contours

In the event of a BLEVE, the hospital building is likely to be heavily damaged in the immediate vicinity of the tanks. The nearest building contains storerooms at the closest point to the tanks, with offices and labs approximately 20 m further away. There exists the risk that the damage to the hospital building in the event of a BLEVE will result in fatalities occurring in the offices and labs due to extensive building damage.

The BLEVE scenario is contingent on a jet fire impinging on another tank for an extended period of time to allow the contents of the second tank to heat sufficiently. This can be mitigated by a firefighting response in the event of a jet fire, specifically, the application of cooling water to the neighbouring tanks to prevent the contents of these tanks becoming too hot. Further, the recommended firewall would allow the fire brigade to safely approach the tanks and apply cooling water. It is assumed that the firefighting response is 90% effective at preventing a BLEVE (one order of magnitude).

4.2.5 Onsite locations of interest

The LPG storage is located at approximately the following distances from key on-site locations:

- 6 m from carpark
- 23 m from hospital (nearest point)
- 85 m from the hospital helipad

4.2.6 Offsite populations

The hospital is located in an industrial zone south-west of Coffs Harbour. The nearest residential dwelling is lodge 390 m east of the LPG tank farm.

The Pacific Highway passes within approximately 85 m of the LPG storage at its nearest point.

On the other side of the highway there is a petrol station which is approximately 266 m from the LPG storage and a public dining/restaurant precinct which is approximately 184 m from the LPG storage at its nearest point.

4.2.7 Offsite Risk of Fatality

The societal risk is shown in the f-N curve in Figure 11. The risk was quantified using the bowtie diagram shown in Figure 12.

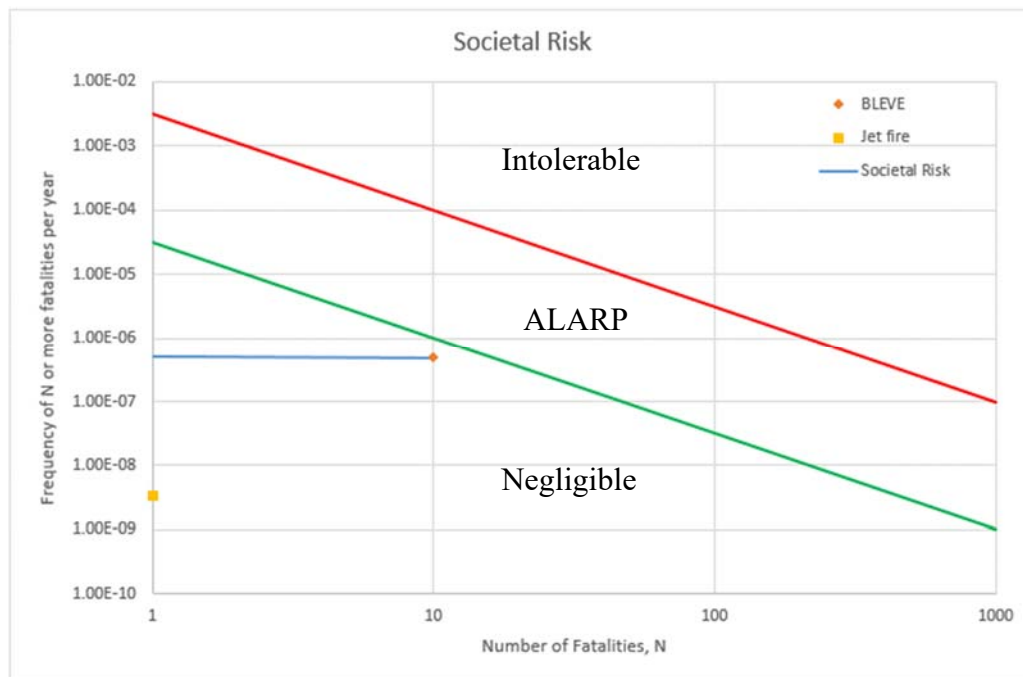
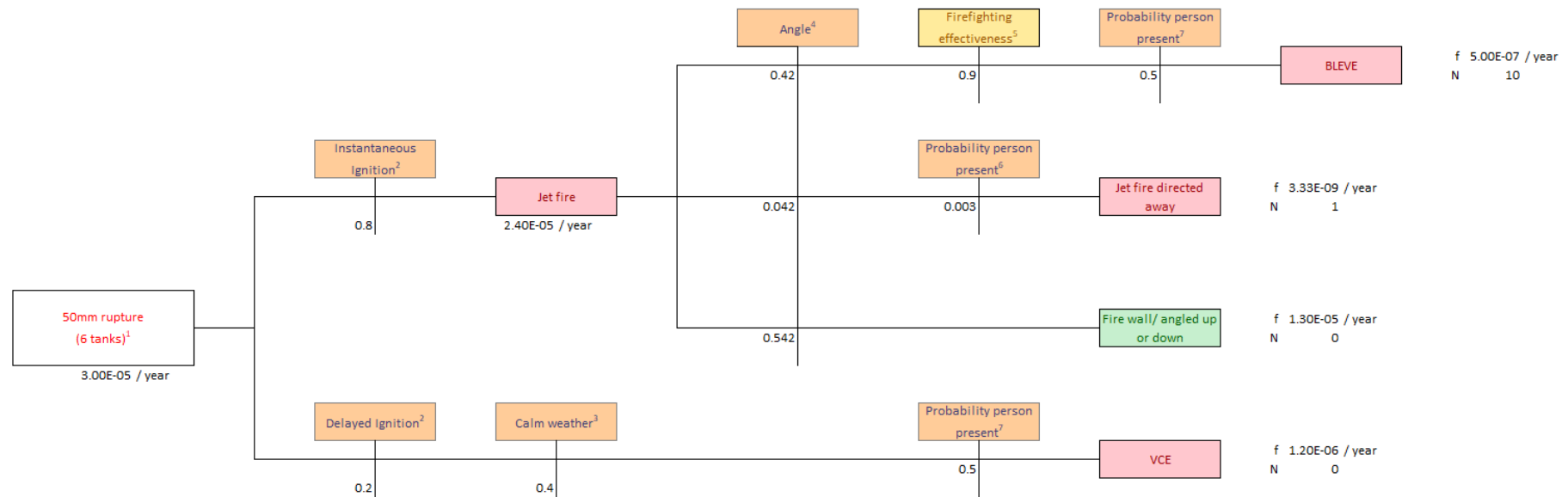


Figure 11: f-N curve

The results show that the societal risk associated with the LPG tanks is broadly acceptable. It should be noted that the results of this analysis are contingent on the construction of a firewall to protect the hospital buildings from direct flame impingement in the result of a jet fire angled towards the building.



1 <http://www.hse.gov.uk/landuseplanning/failure-rates.pdf>

2 Dutch Purple Book

3 http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/windrose_selector.cgi?period=Annual&type=9&location=59040

4 The location of the hole determines the consequence; 10/24 the fire will point towards another tank (BLEVE), 1/24 the fire will point to the road (jet fire), 13/24 the fire will point up, down or to the fire wall (no fatality consequence)

5 Order of magnitude effectiveness

6 If a pedestrian is in the 10m either side of the direction of a jet fire, fatality likely to occur. Assume 20 pedestrians per day (low traffic area), 5 km/h walking speed

7 Assume lab and/or offices occupied for 12 hours per day. 10 people killed due to BLEVE (order of magnitude)

Figure 12: Bowtie diagram (societal risk)

4.3 Controlling the risk

A HAZOP study was performed to show the risks and associated safeguards related to the tank farm. The register can be found in Appendix A.

In the event of a large tank jet fire from the eastern most tank (existing), it is plausible for flame impingement on the main hospital building. Consideration should be given to the installation of a fire wall FRR (240/240/240) on the eastern side of the LPG storage area.

5 Dangerous Goods Requirements

The requirements for storage of Dangerous Goods are defined in guidance materials and standards. The applicable Australian Standards for this development include:

- AS/NZS 1596-2014: The storage and handling of LP Gas
- AS 1894 1997 The storage and handling of non-flammable cryogenic and refrigerated liquids
- AS 4332-2004: The storage and handling of gases in cylinders

The primary management of offsite risks is by locating goods in appropriate places from the boundary and separated from other reactive or incompatible goods. These requirements for LPG storages are detailed below.

5.1 LPG Storage

Gas requirements are currently met by four (4) on-site LPG tanks (total storage volume 29.2 kL). It is expected that following the completion of the Coffs Harbour Hospital Expansion Project there will be a total of six (6) on-site LPG tanks (total volume approximately 45kL).

The LPG storage tanks shall be located a minimum of 6 m from a protected place. (Table 6.1 of AS1596). Most notably this is the hospital itself. It shall also be located a minimum of 4 m from the boundary. These requirements are satisfied.

The LPG storage tanks shall be located at least 6m from the Nitrous Oxide cylinder storage area, which they are.

5.2 Liquid Oxygen

The combined 18000L liquid oxygen storage requirements are detailed in Tables 4.1 and 4.2 of AS 1894.

The oxygen separation distance shall be determined by risk assessment. The specific requirements are not stated. However, the greatest concern will be direct impingement of a jet fire on the oxygen tanks which could lead to a BLEVE. To achieve this requires either a separation distance greater than 68m (as determined in Table 1) or a fire wall to prevent this. As the location of the oxygen tanks is on the opposite side of the plant room, direct impingement is not possible. It is concluded that separation has been met.

The oxygen shall be at least 10m from where people are confined to bed, which they are.

The oxygen shall be at least 3m from the hospital building structure, which it is.

The oxygen shall be at least 2m from the CO2 and N2O cylinder storage area, which it is.

References

- [1] Health and Safety Executive, “Failure Rate and Event Data for use within Risk Assessments (28/06/2012),” 28 June 2012. [Online]. Available: <http://www.hse.gov.uk/landuseplanning/failure-rates.pdf>.
- [2] Elgas, “LPG (propane) Conversions,” [Online]. Available: <http://www.elgas.com.au/blog/389-lpg-conversions-kg-litres-mj-kwh-and-m3>.
- [3] Committee for the Prevention of Disasters, Methods for the calculation of physical effects: due to releases of hazardous materials (liquids and gases) - ("Yellow Book"), The Hague, 1996.

Appendix A

HAZOP Register

Coffs Harbour Hospital LPG Storage

Risk Register

Coffs Harbour Hospital

LPG Storage

Project No. 256261-06

Revision 1

Project: Coffs Harbour Hospital LPG Storage Risk Assessment				RISK RATING					
Node Description Tank Farm incorporating manifold and pipework to isolation valve.									
ID	GUIDEWORD	CAUSE	CONSEQUENCE	Likelihood	Severity	Risk	SAFEGUARD	REC #	RECOMMENDATION
1.1	Low flow	Low levels of gas in tanks	Interruption to operation, not enough gas	2	1	L	Keep tanks full Flow monitors Usage monitoring		
1.2	High level	Overfill	Icing resulting in loss of instrument functionality	2	1	L	Elgas procedures Dead man switches Truck controls		
1.3	Low level	Pipe leak	Difficult to locate leak	2	2	L	Pipework position markers for underground pipes		
1.4	High pressure	High ambient temperature External fire Fire from adjacent tank	Vapour leak from weakest joint	3	2	L	Relief valves Hazardous area classifications		
1.5	High pressure	Fire in adjacent tank or external fire impinging on tank	BLEVE causing property damage and or injury/death in hospital, nearby Pacific Highway and users, fuel station and restaurant precinct	1	5	H			

1.6	High pressure	Vapour leak from tank	Vapour cloud explosion causing property damage and or injury/death in hospital, nearby Pacific Highway and users, nearby fuel station and restaurant precinct	3	4	M		
1.7	High flow	High ambient temperature External fire Fire from adjacent tank	Relief from relief valve	4	2	L	Ullage allowance for expansion based on Coffs Harbour conditions	
1.8	High temperature	Tank failure	Jet fire from tank	1	5	H		1. Consider installing a firewall at Eastern side on LPG storage area
1.9	High temperature	High ambient temperature Fire from tank	Flame impingement on bushland south of tank storage area causing a bushfire, potentially with further impacts on hospital site	1	4	M		
1.10	Impurities	Delivery of wrong grade of product	Possible damage to gas-fired equipment, downtime to empty, clean and refill	2	1	L	Elgas procedures Contract specification	
1.11	Change in components	Replacement parts during service or breakdown	Unexpected leak	2	2	M	Regular testing	
1.12	Change in components	Change out regulator	No gas supply for services	2	1	L	Parallel regulator arrangement	
1.13	Unloading	Unloading tanker can block other delivery trucks and activity in loading dock area	Traffic stopped Accident hazard	2	3	M		
1.14	Settlement	Underlying ground conditions	Relative movement results in pipework failure	2	3	M		
1.15	Emergency response	Delays in response can lead to small events becoming larger	Uncontrolled events can lead to catastrophic events like large fires or BLEVEs	1	4	M	Onsite hydrants Fire department quick response time (3-5 minute drive away)	
1.16	Traffic	Trucks and other traffic impacting tanks	Rupture of tank or pipework	1	4	M	Barriers / walls / bollards	

Project: Coffs Harbour Hospital LPG Storage Risk Assessment				RISK RATING					
Node Description Pipework from Tank farm isolation valve to building and into services.									
ID	GUIDEWORD	CAUSE	CONSEQUENCE	Likelihood	Severity	Risk	SAFEGUARD	REC #	RECOMMENDATION
2.1	Commissioning	Insecure joints or fittings	Leaks during commissioning	5	2	M	Line and equipment testing procedures and certification		
2.2	High flow	Control equipment failure	Loss of operational equipment	4	3	M	Overpressure protection including LPG supply shutoff		
2.3	Low flow	Control equipment failure	Loss of operational equipment	4	3	M	Underpressure protection on steam boilers		
2.4	Plant equipment	Contact with exposed pipework causes mechanical damage	Fractured pipes resulting in leaks	4	2	L	SWMS Risk assessments Competent operatives		
2.5	Impurities	Impurities in pipework	Blockage leading to low flow and/or low pressure	4	2	L	Filters Gas supply from vapour side		
2.6	Change in components	Replacement parts during service or breakdown	Unexpected leak	3	2	L	SWMS Risk assessments Competent operatives		
2.7	Testing	Human error can lead to unexpected events	Vapour release	4	3	M	Line and equipment testing procedures and certification		
2.8	Electrical equipment	Is a potential ignition source	Any vapour present will be ignited	3	4	M	Line and equipment testing procedures and certification		
2.9	Emergency procedures	General building fire	LPG can add fuel to a fire	3	5	H	Automatic smoke detection provided in building, linked to Fire Indicator Panel and automated shutdown of LPG supply		