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Subject: **Integrated Waste Management Facility, Pinkenba, Qld – Response to Brisbane City Council RFI**

1 INTRODUCTION

1.1 Background

Little Resources Pty Ltd (Little Resources) is has lodged a development application (Reference: A006676436) to Brisbane City Council (the Council) to construct an Integrated Waste Management Facility at 164 Main Beach Road, Pinkenba, Queensland.

As part of the assessment process The Council issued a request for information (RFI) [1], requiring a Hazard Analysis Report in accordance with PO3 of the Industry code [2] and Industrial Hazard and Risk Assessment Planning Scheme Policy (PSP) [3].

A hazard analysis report was prepared by Arriscar Pty Ltd (Arriscar) in in response to the RFI, and submitted to Council by Little Resources [4]. Since the submission, Little Resources had made some changes to the design of the Thermal waste Treatment Plant (TWTP). The State Assessment and Referral Agency (SARA) had advised that appropriate amendments to the supporting documentation by Little Resources be updated to address the proposed changes [5].

An updated report was prepared by Arriscar [6], which was submitted to Council by Little Resources. The Council has responded with a request for additional information [7].

This technical note has been prepared by Arriscar in response to the RFI in Ref. [7].

1.2 Council's Request for Further Advice

The following information has been requested by the Council in the ongoing assessment of the Little Resources Application A006676436.

In accordance with PO3 of the Industry code, provide additional risk assessment to address the following:

- (i) Liquid Oxygen (LOX) release scenarios – with risk implication contours (fatality risk)
- (ii) LPG BLEVE and fireball scenarios – with quantified fatality, injury, property damage and accident propagation risk
- (iii) Molten metal-water explosion scenarios – with quantified overpressure and injury risk zones

- (iv) ALARP justification – for scenarios with potential off-site impact.

2 RISK IMPLICATIONS OF LIQUID OXYGEN (LOX) RELEASE SCENARIOS

2.1 LOX Releases

When a loss of containment (LOC) of LOX occurs, the following potential impacts can occur.

- Cold burns on exposure to skin of cold oxygen enriched air as the LOX is released at a temperature close to -170°C.
- No health effects have been observed in people exposed to concentrations up to 50% oxygen at one atmosphere pressure for 24 hours or longer [8].
- Inhalation of 80 per cent oxygen at one atmosphere for more than 12 hours can cause irritation of the respiratory tract, nausea, dizziness, muscle twitching, vision loss, coughing, nasal stuffiness, sore throat and chest pain [8].
- Oxygen does not directly cause a fire, but around 34% oxygen in air, there is a significant increase in flame spread rate in combustible materials (fabrics and polymers), and above 40%, there is a decrease in ignition temperature of combustible fabrics and sheeting, thus promoting a fire, if started by other mechanisms.
- The potential for fatality is very low as it requires exposure to high oxygen enriched atmosphere for a long time.

2.2 LOX Release Consequence Analysis

The maximum oxygen inventory is 20,000 Litres (L), and kept at 2000 kPa and -170°C.

The representative release scenarios modelled are presented in Table 1. Hole sizes were based on Ref. [9].

Table 1: Representative Release Scenarios for LOX

| Description | Inventory kg | Release Case ID | Hole Size (mm) | Release Rate kg/s | Release Duration, min |
|-------------|--------------|-----------------|----------------|-------------------|-----------------------|
| LOX Tank | 20000 | 27-LOX-TANK-25 | 25 | 19.5 | 17.1 |
| | | 27-LOX-TANK-75 | 75 | 175.6 | 1.9 |
| | | 27-LOX-TANK-RUP | Rupture | - | Instantaneous |

The duration of release of the entire tank contents of LOX is of the order of 2-17 minutes, and prolonged exposure is not credible.

LOX releases form a cryogenic pool on the ground and vaporise. The oxygen vapour disperses in surrounding air downwind. Oxygen enriched air forms in the dispersing plume until the atmospheric concentration of 21% is reached.

Dispersion calculations were carried out to 35% oxygen concentration for various weather categories (wind speeds and Pasquill atmospheric stability), using the Phast 9.11 software. The weather categories resulted from processing the meteorological data for the Port of Brisbane into annualised averages.

Tracking was specified in Phast for an oxygen concentration of 17.8%, which is equivalent to oxygen enriched air of 35%.

The distances downwind to 35% oxygen level in air are summarised in Table 2, for the three release cases.

Table 2: Oxygen Dispersion Distances to 35% Concentration Level

| Weather Stability | Wind Speed m/s | Distance to 35% O ₂ , m | | |
|-------------------|----------------|------------------------------------|-----------|---------|
| | | 25mm Hole | 75mm Hole | Rupture |
| B | 3.6 | 12 | 48 | 51 |
| D | 2.0 | 13 | 53 | 44 |
| D | 4.3 | 12 | 52 | 58 |
| D | 7.5 | 11 | 51 | 68 |
| E | 3.1 | 12 | 53 | 53 |
| F | 1.5 | 12 | 51 | 43 |

The maximum distance reached is 68m from the tank, and is confined within the industrial area. It is necessary to keep the area around the oxygen tank free of flammable or combustible materials as part of housekeeping.

The 35% enriched air contours are shown in Figure 1 to Figure 3. Two sets of curves are shown in the figures. The ellipses are the actual plumes for wind direction oriented east. These ellipses would appear in the direction of release. The full circles cover the ‘effect zone’, i.e. the area that could be potentially covered taking into account all possible directions of release.

Figure 1: Oxygen Dispersion Contour to 35% Level for 25mm Hole Release



Figure 2: Oxygen Dispersion Contour to 35% Level for 75mm Hole Release

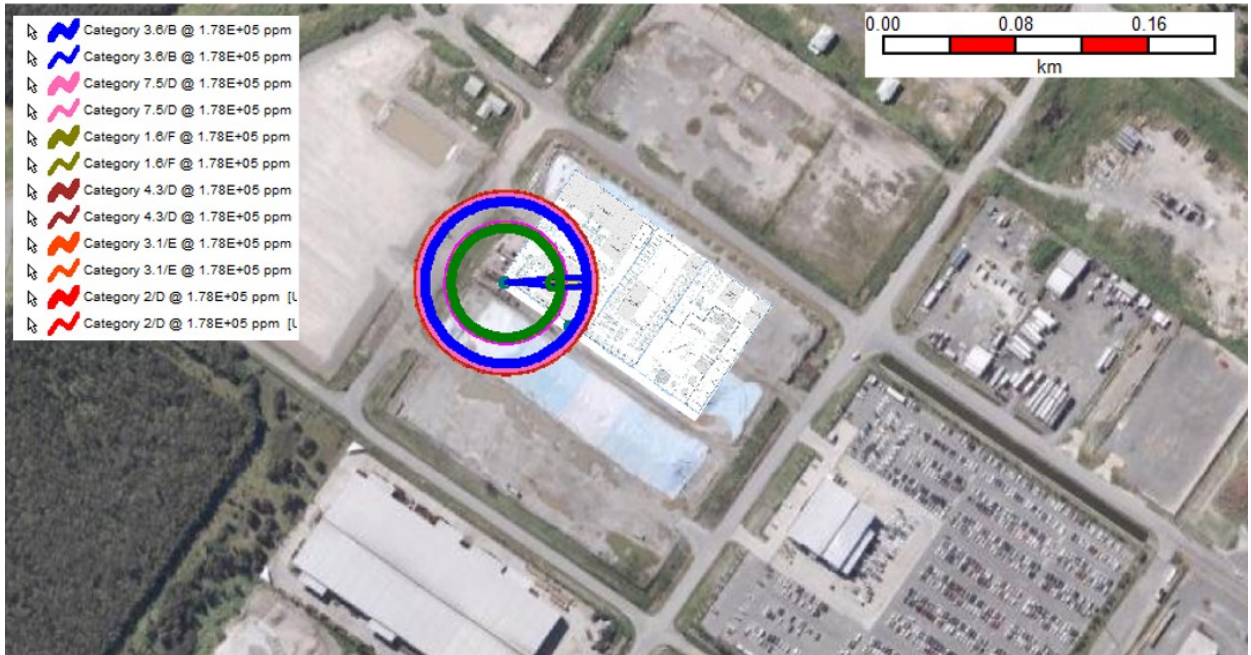
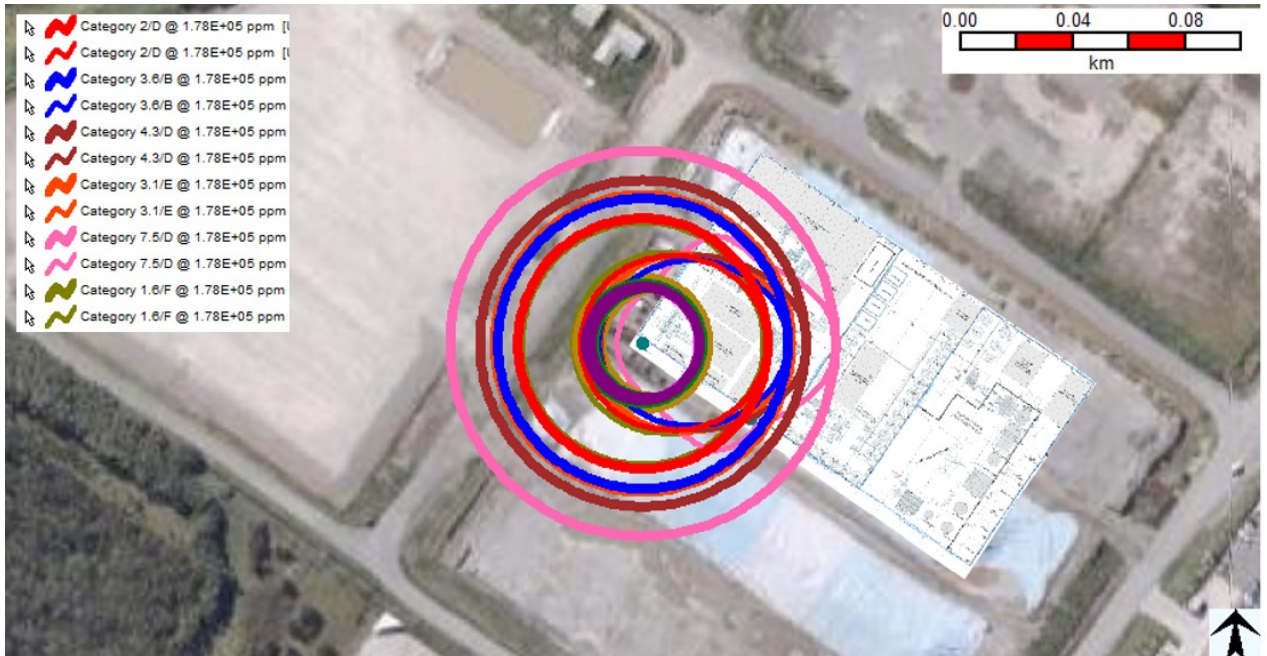


Figure 3: Oxygen Dispersion Contour to 35% Level for Tank Rupture



The contours represent the potential areas that could be subject to a 35% concentration level in the event of a loss of containment.

The following conclusions were drawn:

- There is no fatality potential from LOX releases as the duration of release for a 25mm hole is only 17 minutes, and much less for larger hole sizes.

- The plume itself is narrow (the ellipses in the figures above) in the direction of the wind.
- Within the plume, should fire occur, the oxygen enriched air promotes combustion and increases the flame speed of the combusting material.

The safeguards in preventing a LOC of LOX are discussed in Section 3.

2.3 LPG Release Consequences

2.3.1 LPG Tank BLEVE

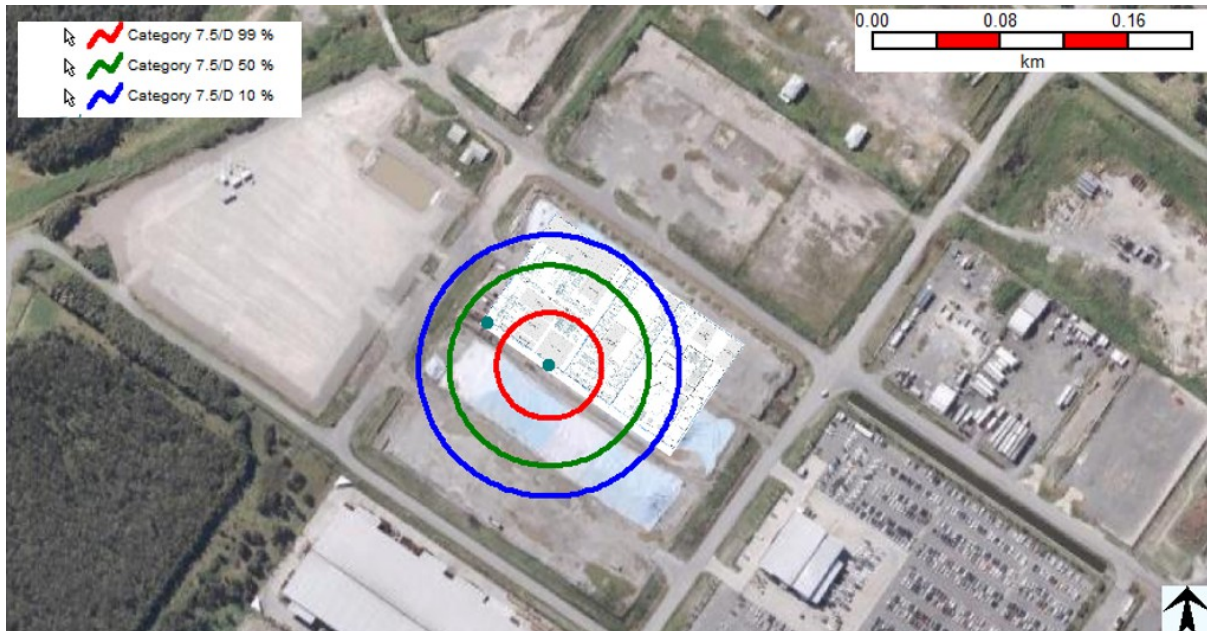
The BLEVE consequence distances are listed in the hazard assessment report in Ref. [6] and reproduced in Table 3, based on 5000 kg inventory in the tank.

Table 3: BLEVE/ Fireball Consequences

| Incident Description | Fireball Diameter (m) | Fireball Duration (sec) | Distance to Fatality | | | |
|----------------------|-----------------------|-------------------------|----------------------|-----|-----|------|
| | | | 1% | 10% | 50% | 100% |
| LPG tank BLEVE | 99.2 | 7.6 | 96 | 82 | 59 | 29 |

The lethality contours are shown in Figure 4. The weather category has no impact on the BLEVE consequence.

Figure 4: Lethality Contours for LPG BLEVE



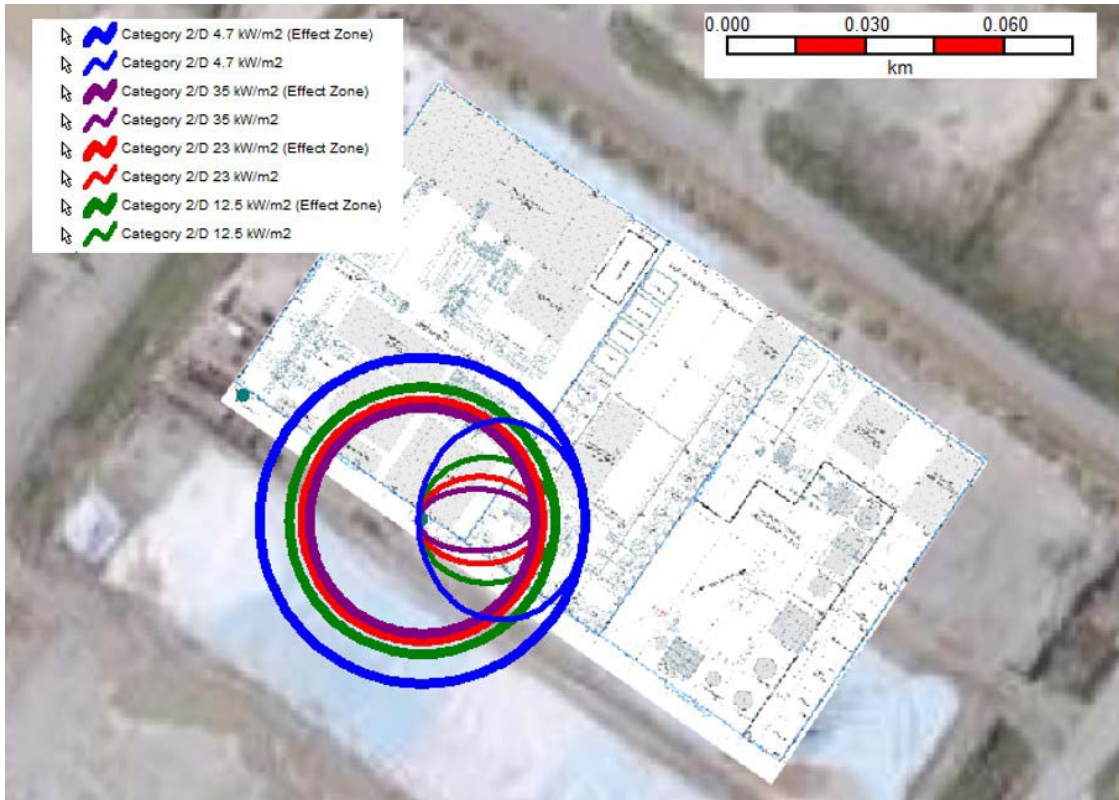
The 10% chance of fatality distance extends 80m to the south of the site. Personnel within the building would receive protection from thermal radiation, but the building itself would be damaged. Further, there is potential for escalation to the adjacent LPG tank.

The prevention and protection measures against a BLEVE are described in Ref. [6] and elaborated under the ALARP discussion in Section 3.

2.3.2 LPG Jet Fires

The jet fire radiation contours for 4.7 kW/m², 12.5 kW/m², 23 kW/m² and 35 kW/m² are shown in Figure 5. Both shape and effects contours are shown.

Figure 5: LPG 13mm release Jet Fire Radiation Contours



The 23 kW/m² contour reaches the adjacent industrial facility site to the south, depending on the flame orientation.

The contours in Figure 5 indicate that for releases above 13mm, the 23 kW/m² thermal radiation contours for jet fires would go offsite.

2.3.3 LPG Vapour Cloud Explosions

Vapour cloud explosion contours for 13mm LPG leak are shown in Figure 6. The TNO multi-energy model in Phast 9.11 was used, with a conservative assumption of Curve No.5 for blast impact.

The following observations can be made:

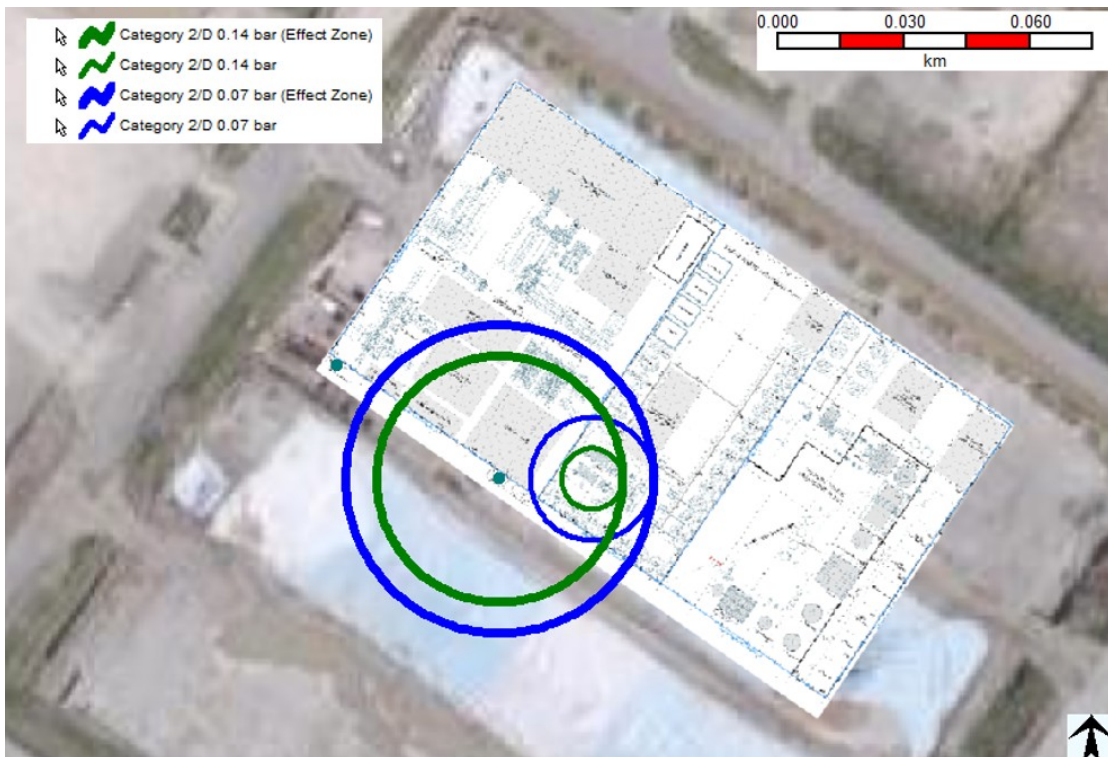
- Overpressures above 14 kPa were not generated.
- An overpressure of 7 kPa would reach the adjoining industrial site to the south.
- An overpressure of 14 kPa would reach up to the boundary of the adjacent industrial site to the south.
- The effects contours are based on the assumption of wind direction from the north, orienting cloud towards adjacent industrial site to the south, but this is unlikely due to the waste treatment site building obstructing the wind from the north.

Figure 6: LPG 13mm release VCE Overpressure Contours



The corresponding VCE contours for a 25mm release are shown in Figure 7.

Figure 7: LPG 25mm release VCE Overpressure Contours



The 14 kPa overpressure reaches the neighbouring facility for a 25mm release and higher.

2.4 Molten Metal Explosion

A molten metal-water explosion can be caused by contact of molten lead or slag from the smelting furnace with water.

The consequence calculations are provided in Ref. [6] and not repeated here. The explosion overpressures for exposure to 1,10 and 100 mL water are summarised in Table 4.

Table 4: Distance to overpressures from molten metal explosions

| Overpressures (kPa) | Distance to Overpressure (m) | | |
|---------------------|------------------------------|------|--------|
| | 1ml | 10ml | 100 mL |
| 7 | 2.8 | 5.9 | 7.0 |
| 14 | 1.5 | 3.2 | 4.3 |
| 21 | 0.9 | 1.9 | 3.3 |
| 35 | 0.5 | 1.1 | 2.4 |
| 70 | 0.3 | 0.7 | 1.6 |

The distances are close to the smelting furnace and too small to represent as contours on a plant layout map. The following conclusions are drawn:

- The molten metal explosion impact is localised with no offsite effects.
- The injury potential (14 kPa) extends from 1.5m to 4.3m from the spill location, depending on amount of water contacted.
- There would be localised damage to equipment, but no escalation to other operating areas is expected.

The prevention and protection measures are elaborated under the ALARP discussion in Section 3.

3 ALARP ASSESSMENT

ALARP justification has been required by Council for events with potential offsite effects. The following sections discuss the prevention and protection safeguards provided.

3.1 ALARP Demonstration Methods

There are several methods of demonstrating ALARP. The generally accepted definition by regulators in Australia has been:

- Residual risk is balanced against the cost of averting or mitigation;
- Further risk reduction measures are technically feasible and effective i.e. practicable;
- However, if cost of further risk reduction is grossly disproportionate to the benefits, the occupier “discharges the burden of proving that compliance is not reasonably practicable” [10].

3.2 Adopted Method for ALARP Demonstration

The following method has been adopted for Little resources, for demonstration of ALARP. It broadly consists of four components.

1. Regulatory Compliance
 - Compliance with relevant Design Codes in Regulations
 - Risk assessment and compliance with risk criteria in Brisbane City Council Industry Code [11].
2. Effective barriers for prevention and mitigation of a hazardous incident. These include robust design, control of ignition, fire protection, emergency response, safe operating and maintenance procedures and training etc.
3. An effective Safety Management System to maintain the integrity of the prevention barriers and mitigation control measures.
4. Identification of additional practicable risk reduction measures, if Item 2 above is not complied with.

3.3 Demonstration of ALARP

ALLRP is said to be achieved when:

- 1) The facility meets the requirements of established codes and standards.
- 2) The facility designed and operated to good industry practice.
- 3) The assessed risks from the operations involving LOX, LPG and molten metal satisfy the Brisbane City Plan Industry Code risk criteria [2].
- 4) Adequate and effective layers of protection for incident prevention and consequence mitigation are in place. Identify reasonably practicable additional control measures where these are inadequate.
- 5) Personnel can escape to a place of safety in an emergency.
- 6) There is an effective Safety Management System including an on-site and off-site emergency response plan.

3.4 Council Risk Criteria

The risk criteria in the Brisbane City Plan 2014 Industry Code is the same as in the NSW Hazardous Industry Planning Advisory Paper (HIPAP) No.4 [12], and listed below:

Table 5: Individual Fatality Risk Criteria

| Land Use | Risk [per million per year] |
|--|-----------------------------|
| Hospital, educational establishment, childcare centre, community care centre, health care service, residential care facility and retirement facility | 0.5 |
| Community residence, dwelling house, dual occupancy, multiple dwelling, relocatable home park, rooming accommodation, short-term accommodation and tourist park. | 1 |
| Commercial developments including food and drink outlet, office, shop, shopping centre, theatre and tourist attraction | 5 |
| Indoor sport and recreation, outdoor sport and recreation | 10 |
| Industrial activities | 50 |

risk criteria for injury risk (specified thermal radiation intensities and explosion overpressures at residential areas) are listed in Table 6.

Table 6: Injury Risk Criteria

| Impact | Risk [per million per year] |
|---|-----------------------------|
| Exceeding 4.7 kW/m ² thermal radiation intensity | 50 |
| Exceeding 7 kPa explosion overpressure | 50 |

Table 7: Property Damage and Accident Propagation Risk Criteria

| Impact | Risk [per million per year] |
|--|-----------------------------|
| Exceeding 23 kW/m ² thermal radiation intensity at neighbouring potentially hazardous installations or at land zoned to accommodate such installations | 50 |
| Exceeding 14 kPa explosion overpressure at neighbouring potentially hazardous installations, at land zoned to accommodate such installations, or at nearest public buildings | 50 |

3.5 LOX Releases

3.5.1 Designed to Codes and Standards

LOX releases have offsite consequences in the sense that 35% oxygen concentration can reach outside the site boundary, depending on wind direction.

The following safeguards are provided to prevent an LOC event.

1. LOX tank construction: The LOX tank is a double skinned vacuum insulated tank. The inner tank is made of stainless steel to handle cryogenic temperatures. The outer tank is made of

carbon steel. The annular space is filled with perlite insulation material, and sealed after creating a vacuum in that space to provide effective insulation.

2. The tank is constructed to gas industry standards and installed/ maintained by the LOX supply company, e.g. AS 1894-1997 [13] and the design codes referred to, as used by supplier.
3. The inner tank is protected by pressure relief devices to prevent overpressuring.
4. Outer jacket is fitted with a device to relieve pressure increase in the event of a leak from the inner vessel. This also serves as a leak detection device.
5. All materials used in the installation, including tank, fittings, valves, flange gaskets, pipework are oxygen compatible.
6. In-service inspection and maintenance will be carried out by the LOX supplier. Tools used for maintenance of oxygen equipment are degreased to ensure they are fit for oxygen service. Tools are provided by LOX supplier.
7. The tank is located in a well-ventilated area to assist dispersion.
8. Separation distances from the tank provided in the layout in accordance with AS 1894:1997 [13].
9. Site operates under a hot work permit and applies to any work in the vicinity of the oxygen tank.

3.5.2 LOX Releases Consequence assessment

The consequence analysis of oxygen releases described in Section 2.2 above.

There are no offsite fatality or injury risk identified from oxygen releases and therefore, individual fatality risk criteria in Table 5 and injury criteria in Table 6 do not apply.

There is a potential for 35% oxygen concentration to reach adjoining industrial facility, and depending on the activities in the adjoining facility, may promote a fire. The duration of oxygen release for the worst case is low and is estimated to be 17 minutes.

The frequency of an oxygen release exceeding a 25mm hole (offsite effect) is reported as 1.6E-05 p.a. [14]. The oxygen vessel is designed as a pressure vessel and hence pressure vessel failure frequency is used.

Assuming that a person could be present in the open near the southern border of Little Resources site for 10% of the time, there is a 10% chance that injury could result in the neighbouring industrial area, the risk is 1.6E-06 p.a., and is an order of magnitude less than the injury criterion of 5×10^{-5} p.a.

3.5.3 Prevention and Mitigation Measures

The prevention measures are:

- Storage tank and pipework design safeguards listed in Section 3.5.1
- Safe operating procedures and driver training by supply company.
- Inspection and maintenance by supply company.
- Housekeeping measures to keep area clear of flammables and combustibles.

Mitigation Measures:

- Use of PPE as recommended in the Safety Datasheet for liquid oxygen.

- Emergency response – first aid for cold burns (safety shower available), and medical treatment if required.

3.6 LPG Releases

3.6.1 Designed to Codes and Standards

The design safeguards are:

- LPG vessels designed to AS 1210-2010 [15]
- Pipework and valves designed to AS 1596-2026 [16]
- Dedicated area for LPG supply tanker parking and fill point
- Hazardous area classification to AS 60079.10.1-2022 [17] and electrical equipment/instrumentation to conform.

3.6.2 LPG Releases Risk Assessment

LPG releases and ignition could result in thermal radiation of 23 kW/m² reaching the adjacent industrial site to the south. Similarly, a vapour cloud explosion from delayed ignition could also exceed 14 kPa on the site to the south of Little Resources.

The contributors to this risk are:

- Thermal radiation - 13mm, 25mm, 50mm holes and tank rupture, followed by early ignition.
- Explosion overpressure – 25mm, 50mm holes and tank rupture, followed by delayed ignition.

The risk assessment is summarised in Table 8 below. Ignition probabilities were obtained from Table 5 of Ref. [18], and interpolated for the corresponding release rate.

The ignition probability is split 50:50 between early and delayed ignition.

The risk of exceeding the thermal radiation and explosion overpressure offsite is calculated as follows:

$$\text{Risk} = \text{Release frequency} \times \text{Early ignition probability} \times \text{Number of vessels (2)}$$

Table 8: Offsite Risk from LPG Releases

| Release size | Release rate, kg/s | Total Ignition probability | Release frequency, p.a. | Risk of jet fire p.a. | Risk of explosion, p.a. |
|--------------|--------------------------|----------------------------|-------------------------|-----------------------|-------------------------|
| 13mm | 2.27 | 0.009 | 1.0E-05 | 9.00E-08 | - |
| 25mm | 8.39 | 0.0312 | 5.0E-06 | 1.56E-07 | 1.56E-07 |
| 50mm | 33.55 | 0.0791 | 5.0E-06 | 3.96E-07 | 3.96E-07 |
| Rupture | 5000 kg (tank inventory) | 0.6 | 2.0E-06 | 1.20E-06 | 1.20E-06 |
| Total | | | | 1.84E-06 | 1.75E-06 |

The target risk criterion is 5.0E-05 p.a. which is not exceeded. Therefore, the risk from the LPG installation satisfies the risk criteria in Table 6 and Table 7.

3.6.3 Prevention and Mitigation Measures

The prevention measures include:

- Pressure vessel designed to AS 1210-2010 [15] and certified after pressure testing.
- Installation to comply with AS 1596-2026 [16]
- Tank and pipework protected by barricades or bollards from mechanical damage
- Dedicated location for fill point and supply tanker parking.
- Hazardous area classification for the installation
- Hot work permit for maintenance work.

The mitigation measures are as follows:

- Gas detection by smell as the gas is odourised
- ESD valve fitted to the liquid connections in the tanks as required by AS 1596-2026 [16] and activated by the driver
- Ignition control measures
- Emergency response procedures

Recommendations:

1. *Install protection barriers around the LPG tanks and pipework to prevent accidental mechanical damage*
2. *Include informing the neighbour south of the facility and response to an LPG release emergency (i.e. stop work and evacuate personnel away from Little resources boundary.*

3.7 Molten Metal releases

The molten metal explosion has no offsite effect, and the discussion provided in Ref. [6] covers the safeguards.

4 REFERENCES

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- [3] Brisbane City Council, *SC6.15 Industrial hazard and risk assessment planning scheme policy*, 3 July 2017.
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- [5] Queensland State Assessment and Referral Agency (SARA), “SARA advice notice—164 Main Beach Road, Pinkenba,” Brisbane, 30 October 2025.
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- [17] Standards Australia, “AS/NZS IEC 60079.10.1 - Explosive atmospheres Classification of areas - Explosive gas atmospheres,” 2026.

- [18] International Oil and Gas Producers Association (IOGP), *Risk Assessment Data Directory 434-06: Ignition Probabilities*, Version 1.1, May 2021.
- [19] Hazardous Industry Planning Advisory Paper No.4, "Risk Criteria for Land Use Safety Planning", Sydney: NSW Department of Planning & Environment, 2011.
- [20] Standards Australia, *AS 1596-2014: The Storage and Handling of LP Gas*, 2014.

5 NOTATION

| Abbreviation | Description |
|-------------------|----------------------------------|
| ALARP | As Low As Reasonably Practicable |
| AS | Australian Standard |
| ESD | Emergency Shutdown |
| kg | kilograms |
| kg/s | kilograms per second |
| kPa | Kilopascals |
| kW/m ² | Kilowatts per square metre |
| LOC | Loss of Containment |
| LOX | Liquid Oxygen |
| LPG | Liquefied Petroleum Gas |
| m | metre |
| m/s | metres per second |
| mm | millimetres |
| PO | Performance Outcome |
| PPE | Personal Protection Equipment |
| RFI | Request for Information |
| SARA | State Assessment referral Agency |
| TWTP | Thermal Waste Treatment Plant |