Review of potential impact on water table from accidental LPG releases at Proposed LPG Depot, Kooragang, NSW

For Elgas Ltd

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Rev A	04-05-2017	Draft report for review	RR	JPM	RR
Rev 0	05-05-2017	Final issue	RR	PS	RR

Contents

Notation

Abbreviation	Description
AS	Australian Standard
DP&E	Department of Planning & Environment
ESD	Emergency Shutdown
K	Degrees Kelvin
kg	kilograms
kJ	Kilo-Joules
kL	Kilo-Litres
kPa	Kilo-Pascals
LPG	Liquefied Petroleum Gas
m	metres
m^3	Cubic metres
PHA	Preliminary Hazard Analysis
ppm (w/w)	Parts per million (by weight)
SEPP	State Environmental Planning Policy
v/v	Volume fraction

1 INTRODUCTION

1.1 Background

Elgas Ltd proposes to construct a Liquefied Petroleum Gas (LPG) storage and cylinder filling and small truck loading facility on Egret Street, Kooragang, NSW. The facility will be developed and leased to Elgas by Sovcheles Developments Pty Ltd.

The proposed site falls within the leased land in Kooragang, managed by the Port of Newcastle. Under the Three Ports SEPP, NSW (Ref.1), the Minister for Planning is the determining authority for the development.

During a discussion meeting between the NSW Department of Planning & Environment (DP&E) and the developer, the question of potential impact of accidental LPG spills on site on the high water table in the area was raised.

Elgas commissioned Arriscar Pty Ltd to review the physical effects of a pressurised propane (LPG) release on site and the measures undertaken to prevent potential ingress into soil.

This technical note summarises the results of the review.

1.2 Objective of the study

The objective of the present study is to conduct a review of the physical effects of an accidental release of pressurised LPG on the water table at proposed site.

2 OUTLINE OF PROPOSED DEVELOPMENT

The facility is to be located on Egret Street in Kooragang, NSW.

The LPG depot will consist of the following:

- One 50-tonne LPG tank, fireproofed with fendolite coating
- LPG loading/ unloading point (B-Double road tanker delivery and bobtail tanker loading)
- LPG pump supplying cylinder filling plant
- One 4.5 kL LPG tank for receiving residual LPG from returned cylinders before inspection and refill
- Cylinder filling and storage, loadout on flat top trucks.
- Overnight parking of laden bobtail tankers (1 x 6 tonne and 1 x 9 tonne) in a dedicated area

A site layout is shown in Figure 1.

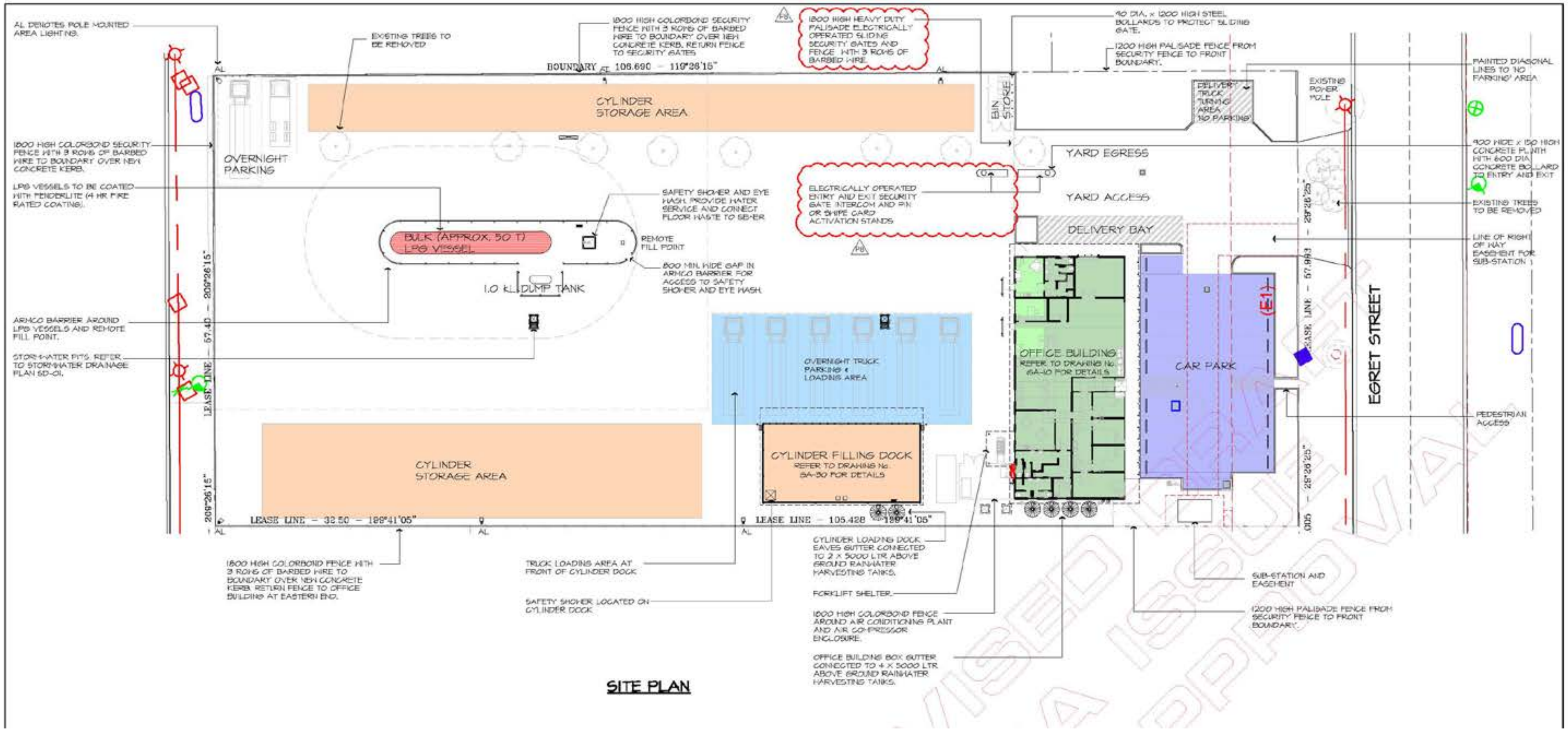

Figure 1: Site Layout

3 REGULATORY REQUIREMENTS

3.1 SEPP 33

The proposed development comes under NSW State Environmental Planning Policy (SEPP) No.33 (Ref.2), and will require a Preliminary Hazard Analysis (PHA) to accompany the Development Application.

3.2 Environmental Planning & Assessment Regulation

Under the Environmental Planning & Assessment Regulation 2000 (Ref.3), Schedule 3, Part 1.10, the following requirements apply:

Chemical storage facilities:

(a) that store or package chemical substances in containers, bulk storage facilities, stockpiles or dumps with a total storage capacity in excess of:

(i) 20 tonnes of pressurised gas, or

(ii) 200 tonnes of liquefied gases, or

(iii) 2,000 tonnes of any chemical substances, or

(b) that are located:

(i) within 40 metres of a natural waterbody or wetland, or

(ii) in an area of high water table or highly permeable soil, or

(iii) in a drinking water catchment, or

(iv) on a floodplain.

If any of the conditions are satisfied, then the development may be deemed a designated development.

3.3 Application of Schedule 3 to Proposed Development

Table 1 reviews the application of Schedule 3 requirements in Section 4.2 above with the proposed development.

Table 1: Review of Application of Schedule3, Part 1

No.	Schedule 3 Clause	Description	Applies to Proposed Development?
1	10 (a)(i)	Contains in excess of 20 tonnes of pressurised gas?	No.
2	10 (a)(ii)	Contains in excess of 200 tonnes of liquefied gas?	No. Maximum proposed quantity is 180 tonnes.
3	10 (a)(iii)	Contains in excess of 2000 tonnes of any chemical substance?	No.

No.	Schedule 3 Clause	Description	Applies to Proposed Development?
4	10 (b)(i)	Located within 40 metres of a natural waterbody or wetland?	No. Nearest coal loader berth is more than 100m away.
5	10 (b)(ii)	in an area of high water table or highly permeable soil?	Yes. The water table is at 2.2m depth and less than the 3m criteria for high water table.
6	10 (b)(iii)	Located in a drinking water catchment?	No
7	10(b) (iv)	Located on a floodplain?	No

Based on Item 5 in Table 1, the NSW Department of Planning has required that the development requires a review of the effects of potential spill of LPG and measures to prevent ingress into the soil and ultimately into the water table.

4 PHYSICAL PROPERTIES OF LPG

LPG can be either propane, butane, a mixture of both, or other liquefied hydrocarbon gases. In the proposed development, the LPG is odourised propane. No other products are stored.

The properties of propane are listed in Table 2 (Ref.4).

Table 2: Properties of Propane

Property	Value
Chemical formula	C_3H_8
Molecular weight	44.097
Atmospheric boiling point	-42^{O}C
Vapour pressure at 25^{O}C	954 kPa (abs)
Density of liquid at 25^{O}C	491 kg/m^3
Heat capacity of liquid	2.72kJ/kg-K
Upper flammability limit in air	9.5% (v/v)
Lower flammability limit in air	2.1% (v/v)
Heat of vaporisation at -42^{O}C	428 kJ/kg
Solubility in water at 20^{O}C and atmospheric pressure	93 ppm (w/w)*
Reactivity with water	Non-reactive

*As the temperature increases with solar heating, the propane degasses from the water.

5 EFFECTS OF PRESSURISED PROPANE RELEASE

5.1 Physical Effects following propane release

When propane liquid under pressure is release to atmosphere due to loss of containment, the following effects occur:

- Since the gas is kept as a liquid under pressure at ambient temperature, once the pressure is released, the propane tends to reach its equilibrium temperature of -42^{O}C at atmospheric pressure.
- The heat to vaporise the propane comes from the liquid itself as it gives out heat while cooling down from the storage temperature (about 25^{O}C) to -42^{O}C. The vaporised portion 'flashes' off and disperses downwind. This fraction is known as 'adiabatic flash' as it is a self-contained process with no external heat provided.
- The adiabatic flash is approximately 39% of the release quantity.
- Since there is expansion of the vapour as it flashes off, it traps significant amount of aerosols of propane, which immediately vaporise by heat transfer from ambient air. The aerosols trapped are conventionally taken as equivalent to the adiabatic flash. This is approximate, and detailed thermodynamic rainout calculations would have to be carried out to determine the aerosol fraction.
- Therefore, approximately 78% of the released propane becomes vapour and disperses.
- The remaining 22% of the liquid collects as a pool on the ground and quickly vaporises due to heat transfer initially from the ground and additional heat and mass transfer with warmer ambient air.
- Modelling pressurised propane releases using the software package Phast 7.2.1 in the Preliminary Hazard Analysis that will accompany the DA, it was found that only for downward releases from 20mm hole size or higher, impinging on the ground, a liquid pool would form on the ground.
- The liquid pool that stays on the ground for short periods until total vaporisation is the only source of potential ingress below ground.

5.2 Behaviour of propane liquid pool

The entire LPG depot surface is covered by a concrete surface. The propane liquid pool from 22% of the downward impinging release (=/> 20mm) behaves as follows:

1. The unflashed portion forming the pool would be at the atmospheric boiling point of propane, which is -42^{O}C (cryogenic).
2. Since the liquid is at -42^{O}C, as soon as it contacts the moisture trapped in the concrete pores, it freezes the water, thus blocking any penetration to sub-surface soil (Ref.5).
3. The pool vaporises into air due to two mechanisms: (a) heat transfer from air providing latent heat of vaporisation to the propane, and (b) diffusional mass transfer of propane to air under calm conditions and/ or convention mass transfer from propane to air, depending on the prevailing wind speed.

4. Initially, there is a large temperature difference between the spilled propane and ground surface. The initial evaporation rate of propane is rapid but will decrease as the ground temperature drops which results in a slower evaporation rate. The pool of propane would continue to evaporate until it completely vaporises.
5. The vaporised propane disperses into ambient air, and dilutes below the lower flammability limit, when it can no longer ignite.
6. It has been known from leaks of liquid propane from underground pipelines that the propane tends to rise to the land surface and disperses in air and does not remain in the soil (Ref.6). Therefore, a spill on the concrete surface would not affect the subsurface material.

Thus, little or no propane penetrates the ground.

There is a potential for the concrete surface to develop cracks over a period of time due to operational loads. Therefore, it is necessary that Elgas develops a schedule to inspect and maintain the integrity of the concrete surface.

5.3 Design and Operational measures to prevent propane ingress into the soil

The major design measures for preventing an LPG release or mitigating its effects are:

- Tank and pipework design to required Australian Standards for integrity (AS 1210 for vessel and AS 1596 for pipework)
- Emergency shutdown (ESD) system to minimise LPG releases.
- Concrete paving of the entire yard, which prevents LPG ingress into ground.
- Inspection and maintenance program to ensure mechanical integrity of the plant and equipment to minimise accidental releases.

6 CONCLUSIONS

The following conclusions are drawn from the above review:

1. Only large LPG releases that are downward oriented and impinge on the ground can form a liquid pool with a potential for ground penetration (approximately 22% of the release).
2. The ground is paved with concrete, which prevents ingress of LPG.
3. Any penetration though the pores of the concrete would result in the freezing of trapped moisture in the concrete (propane pool is at -42^{O}C) and block ingress.
4. The propane pool would vaporise and disperse into atmosphere.
5. There would be no adverse impact on the water table at the site, provided the concrete surface integrity is maintained.

7 REFERENCES

1. NSW Government, State Environmental Planning Policy (Three Ports) 2013.
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