Hazard Assessment of LPG Storage at Service Station on proposed Upgrade to Cammeray Public School

For NSW Department of Education

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Arriscar Risk Engineering Solutions

Arriscar Pty Limited
ACN 162 867 763
www.arriscar.com.au

Sydney
Level 26
44 Market Street
Sydney NSW 2000
T: +61 2 9089 8804

Melbourne
Level 2 Riverside Quay
1 Southbank Boulevard
Southbank VIC 3006
T: +61 3 9982 4535

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Notation

Abbreviation	Description
BLEVE	Boiling Liquid Expanding vapour Explosion
DoE	Department of Education
DP	Deposited Plan
ha	hectares
PS	Public School
kg	kilograms
kPa	Kilopascals
kW/m^2	Kilowatts per square metre
L	Litres
LFL	Lower Flammability Limit
LPG	Liquefied Petroleum Gas
m	metres
m/s	Metres per second
NSLEP	North Sydney Local Environmental Plan 2013
PTS	Permanent Teaching Space
VCE	Vapour Cloud Explosion
W/m^2	Watts per square metre

1 INTRODUCTION

This Hazard Assessment Report has been prepared to support a Review of Environmental Factors (REF) for the Department of Education (DoE) for the upgrade of the Cammeray Public School (CPS) (the activity). The purpose of the REF is to assess the potential environmental impacts of the activity prescribed by *State Environmental Planning Policy (Transport and Infrastructure) 2021* (T&I SEPP) as "development permitted without consent" on land carried out by or on behalf of a public authority under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The activity is to be undertaken pursuant to Chapter 3, Part 3.4, Section 3.37 of the T&I SEPP and in consideration of the stakeholder and community participation plan.

The proposed activity is for upgrades to the existing CPS at 68 Palmer Street, Cammeray NSW 2062 (the site).

The purpose of this report is to assess the potential impact of LPG releases from the Shell service station on the proposed school upgrades, and identify mitigation measures in the design, if required.

A service station operated by Shell Reddy Express (Shell) is located in the vicinity of the CPS on 447-483 Miller & Palmer Street, Cammeray. In addition to liquid fuels, the service station also stores LP Gas (LPG) in Swap 'n' Go LPG cylinders in cages.

Arriscar has undertaken a consequence analysis of the impact on the CPS upgrades from potential LPG releases at the service station.

This report contains details of the analysis and findings.

1.1 Landowner and Proponent

Proponent:

The Department of Education (DoE) is the proponent and determining authority pursuant to Section 5.1 of the *Environmental Planning and Assessment Act* 1979 (the Act).

Landowner

The NSW Minister for Education and Early Learning is the Landowner.

1.2 Site Location

CPS is located at 68 Palmer Street, Cammeray on the northern side of Palmer Road, bound by Palmer Street to the south, Bellevue Street to the east and Miller Street to the west. The site has an area of 1.36 ha and comprises 11 allotments, legally described as:

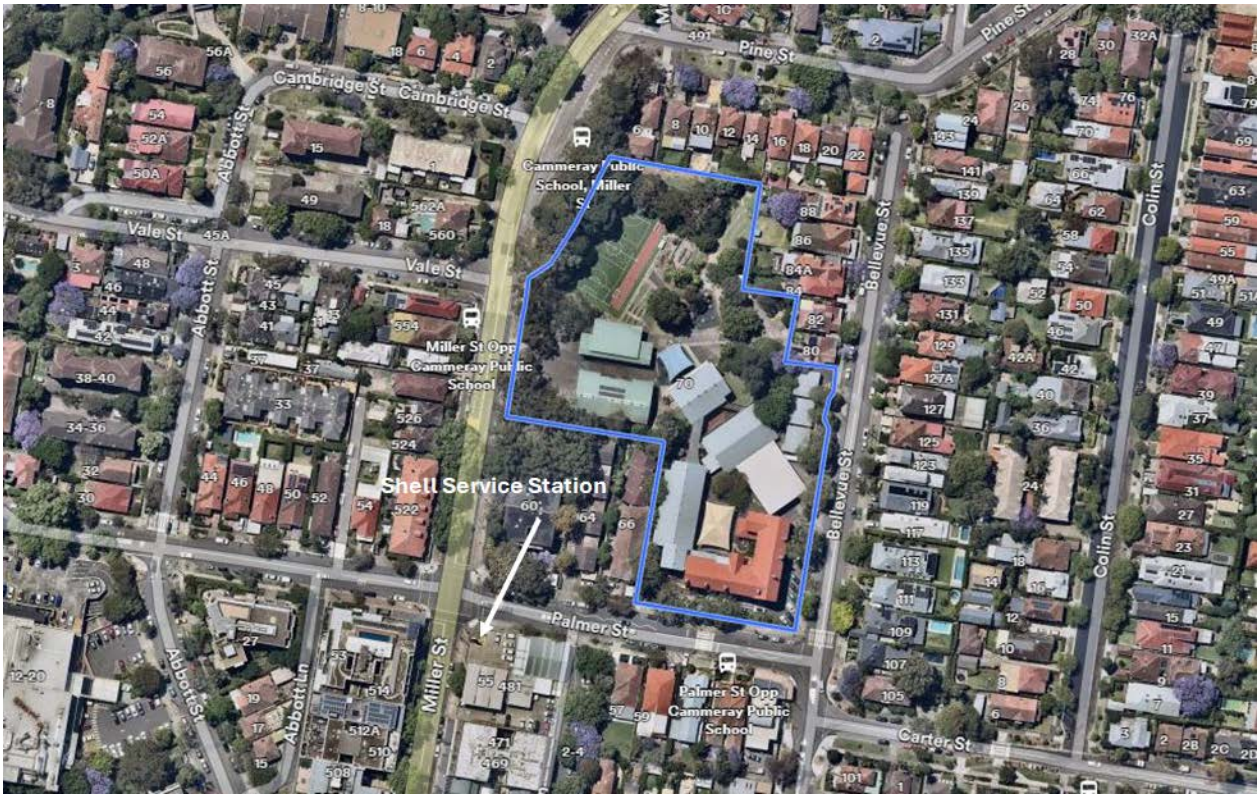
- Lot 11 DP 837836
- Lot 1 DP 316130
- Lot 1 DP 316706
- Lot 1 DP 123406
- Lot 2 DP 174370
- Lot 1 DP 174370
- Lot 4 Sec 35 DP 758790
- Lot 5 Sec 35 DP 758790
- Lot 66 DP 1049613

- Lot 3 DP 571310
- Lot 4 DP 571310

The site is identified as a locally listed heritage item (I0019) under Schedule 5 Environmental Heritage pursuant to the *North Sydney Local Environmental Plan 2013* (NSLEP). The school is listed on the DoE Section 170 Heritage Conservation Register as 'Cammeray Public School'. The site is approximately 115m from a State heritage item (I0004) being the electricity substation at 143 Bellevue Street and in close proximity to locally heritage listed items.

A location map of the site is shown in Figure 1, with the nearby Shell service station.

Figure 1: Cammeray PS Location Map



(Source: NearMap, taken 30 October 2024)

1.3 Existing School

The site currently comprises an existing co-education primary (K-6) public school with 6 permanent buildings, 3 demountable structures, covered walkways linked at multiple levels, play areas, on-grade parking, sports court, covered outdoor learning area (COLA) and vegetation/green spaces with mature trees.

The existing school buildings are clustered towards the southern portion of the site and comprise both single and 2 storey buildings. The northern portion of the site contains the sports court, vegetable garden and play equipment. The north-western portion of the site is heavily vegetated with trees of high landscape significance that are protected with fencing.

1.4 LPG Storage at Service Station

The LPG storage consists of the following:

Two (2) cages of Swap 'n' Go cylinders, each with a capacity of approximately 40 cylinders per cage with a maximum capacity of 340 kg of LPG in each cage. The Swap 'n' Go are supplied by the LPG supplier on flat top trucks. These cylinders are not opened and exchanged by customers by returning used cylinders. The LPG supplier replaces the empty cylinders with full cylinders.

The LPG storage location in the service station is shown in Figure 2. The LPG tank cylinders and the Swap 'n' Go cylinder cages are highlighted the figure.

Figure 2: LPG Storage at Service Station

1.5 Liquid Fuels at the Service Station

Liquid fuels stored for dispensing at the service station are gasoline and diesel. These liquids are stored in underground tanks and pose no risk to the school site.

If there is a spill of gasoline during bulk tanker deliveries to the service station, and ignition occurs, a pool fire would result with thermal radiation affecting the school site. Unloading is by gravity and a potential release source is a rupture of transfer hose.

1.6 Study Scope

The scope of the study included undertaking a consequence analysis of potential fires and explosions from the LPG storage at the Shell service station, and impact on the Cammeray PS upgrades.

This study mainly focuses on the following:

- Identification of LPG release hazards from the Shell service station at Cammeray;
- Development of appropriate and relevant representative gas release scenarios that may impact on the school site;
- Quantification of the consequences of harmful effects for each representative scenario (fires, explosions, exposure to unignited gas), including the potential for impact on the proposed school upgrades;
- Assess the fire and explosion effects on land use safety, suitability and any mitigation measures required to address potential impacts.

2 PROPOSED ACTIVITY AT CAMMERAY PS

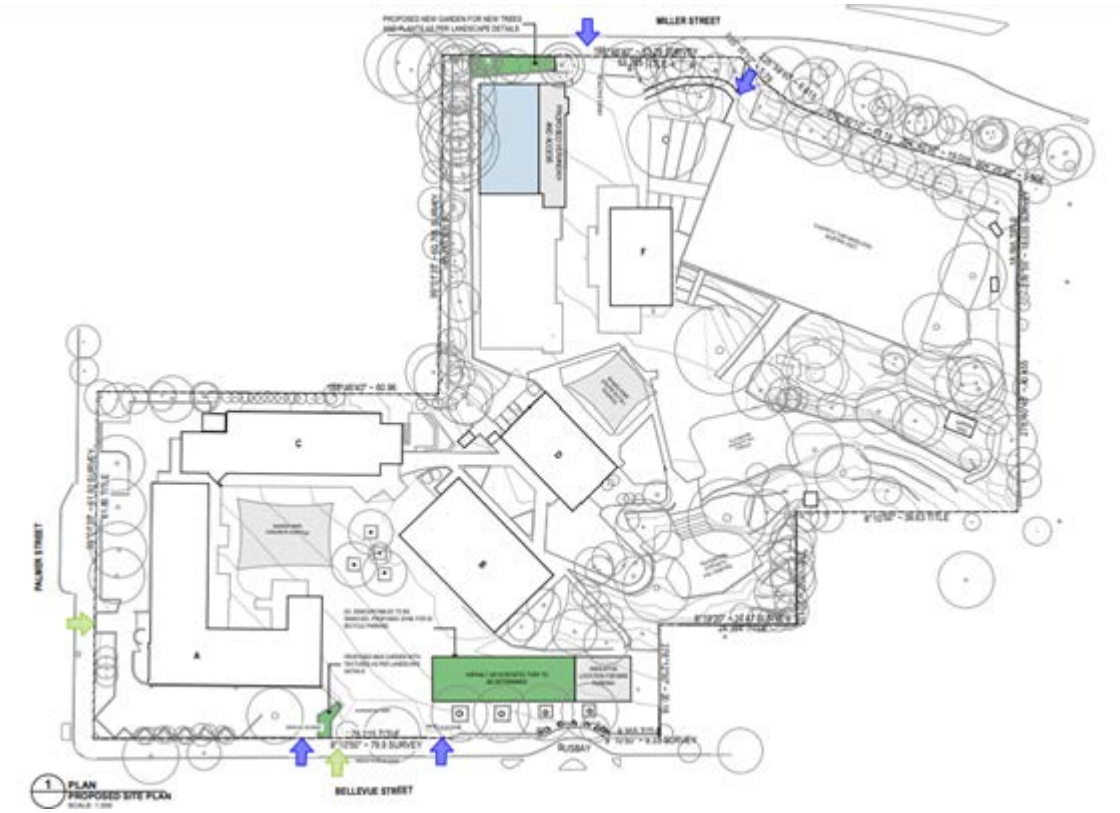
The proposed activity involves upgrades to the existing CPS, including the following [1]:

- Construction of 4 new permanent teaching spaces in a two-storey building incorporating 2 general learning spaces and 2 practical activity areas
- New egress lift and stairs for access to all building levels
- External covered walkways connecting the new building to the existing school network
- Landscaping and external works including compensatory planting
- Removal of 3 temporary (demountable) classrooms from the eastern side of the school
- Upgrades to site infrastructure and services to support the new buildings
- 50 bicycle parking spaces

The intent of the activity is to provide 4 permanent teaching spaces (PTS) plus 2 practical activity areas (PAA) across a two-storey addition, adjoining Building E. This will result in CPS retaining the capacity of a 'large' school (553-1,000 students) under EFSG (DoE Facilities Standards and Guidelines).

The scope of works for the proposed activity is shown in Figure 3 [2].

Figure 3: Proposed Scope of Works



(Source: Fulton Trotter Architects, Proposed Site Plan (Rev 6))

The proposed new building is to be located near the Miller Street entry to the school.

3 HAZARD IDENTIFICATION

3.1 LPG Inventory at the Shell Service Station

The maximum quantities of LPG stored at the petrol station are listed in Table 1 below. The actual quantities will vary depending on demand and deliveries.

Table 1: LPG Storage

No.	Description	Maximum Capacity kg
1	Swap 'n' Go cylinders (8.5kg cylinders x approximately 40 per cage) in 2 cages	680

There is no bulk LPG storage at the service station.

3.2 LPG Release Consequences

3.2.1 LPG Releases

An LPG release could occur from the following:

- A release from the cylinder nozzle from valve failure. This release is very small and confined within a few meters of the release.
- A rupture of the cylinder. The cylinders are certified pressure vessels. These are inspected before filling at the distribution centre and unlikely to fail. The Swap 'n' Go cylinders are also protected in a cage.

3.2.2 LPG Fires

Two types of fires are possible with LP Gas.

1 A jet fire. This could occur if a gas leak or a 2-phase leak from a pipe/ vessel/ equipment is ignited.

2 A flash fire. A flash fire is the result of ignition of a well mixed air-LPG cloud. An LPG leak would evaporate and disperse into atmosphere forming a flammable air-vapour mixture. If ignited, depending on the degree of congestion and confinement in the flame front, a vapour cloud explosion may result. In its absence, a flash fire would be the result.

3.2.3 Boiling Liquid Expanding Vapour Explosion (BLEVE)

BLEVE is a phenomenon experienced only with liquefied flammable gases such as LPG, stored under pressure above their atmospheric boiling points. A fire impinging on an LPG cylinder can weaken the tank wall, and allow the boiling LPG at high pressure to expand into the atmosphere generating high explosive energy, and resulting in a fireball. Even though the BLEVE is, by definition, an explosion, the thermal radiation effect of the fireball would have an impact at longer distances than the flying fragments from the explosion effects.

A BLEVE at stored LPG cylinders is possible if a jet fire impinges on an adjacent cylinder.

3.2.4 Vapour Cloud Explosion (VCE)

If a liquefied flammable gas is released to atmosphere, there is a possibility that the ignition of the flammable cloud may result in an explosion, and it is referred to as a Vapour Cloud Explosion (VCE). For a VCE to occur the cloud must have sufficient mass and confinement.

The partial confinement for LPG dispersion are the service station building itself, parked vehicles and refuelling bowsers.

3.3 LPG Release Scenarios Modelled

The focus in this study is the impact of LPG release from the cylinders on the proposed school building. Therefore, only the worst-case releases were modelled, as listed in Table 2.

Table 2: LPG Release Events

Event No.	Description	Maximum Release Quantity, kg
1	Rupture of 8.5 kg cylinder	8.5
2	BLEVE of 8.5 kg cylinder (from escalation of an ignited release)	8.5*

*At the time of BLEVE, the inventory would be lower as some gas would have escaped through the relieve valve. Full inventory was modelled as the worst case.

3.4 Gasoline Pool Fire

There is no release of gasoline from the underground storage tanks. The identified hazard is a leak from the transfer hose during unloading of fuel into the underground tanks by gravity from a bulk road tanker.

The maximum quantity of a potential spill is a single compartment in the road tanker, approximately 7000 Litres. The spill would spread as a pool and if ignited, a pool fire would result with thermal radiation to surrounds, including the LPG storage.

3.5 Meteorology

The wind speed and weather stability conditions applicable to the site are relevant as they influence the dispersion of an LPG release. Wind directional probabilities are not required for the study as these are required only for a risk assessment and this study focuses only on consequences of LPG release. The nearest weather station is located on Sydney Observatory Hill.

The weather conditions modelled are summarised in Table 3.

Table 3: Weather Conditions Applicable to the Site

Stability Class	Wind speed m/s	Notation	Average Temperature ^{O}C	Average Relative Humidity %	Average Solar Radiation W/m^2
B	2.0	B2	22.1	58	634
D	7.3	D7.3	17.7	63	300
D	4.2	D4.2	18.4	70	180
D	1.2	D1.2	15.1	76	85

E	3.3	E3.3	17.4	76	4
F	1.1	F1.1	17.7	79	4

Notes: E and F stability conditions occur only during twilight hours and nights when the school is unoccupied.

3.6 Consequence Analysis Results

Consequence calculations were made using the DNV software Safeti 9.0 (run in consequence mode).

3.6.1 LPG Flash Fires

LPG release dispersion calculations were carried out with the Safeti 9.0 software. LPG was modelled as propane. The lower flammability limit for propane is 2.1% (v/v) in air.

Three wind speed/ weather stability classes were analysed as the weather condition influences the dispersion distance. Distances to LFL were calculated at ground level as the gas is heavier than air and slumps to ground). The F stability occurs only at nighttime when the school is unoccupied.

The dispersion distances to LFL and ½ LFL are listed in Table 4.

Table 4: Flash Fire Results for 8.5 kg Cylinder Rupture

Weather Category	Distance to LFL, m	Distance to ½ LFL, m
B2	2.7	4.8
D7.3	4.5	11.9
D4.2	3.2	7.4
D1.2	1.3	3.8
F3.3	2.8	5.4
F1.1	2.5	3.5

The distances to LFL and ½ LFL for 8.5 kg LPG cylinder rupture is shown in Figure 4 for D7.3, which is the largest distance.

Figure 4: Flash Fire Contours for 8.5 kg Cylinder Rupture (D7.3)

The contours in Figure 4 represent the effect of the flashfire in all possible wind directions, known as the "Effects" contour. In reality, the actual contour would only be a fraction of the circle shown, in the downwind direction.

Flash fire would occur in the flammable cloud within the LFL envelope. The contour for ½ LFL is shown because there is a potential for ignition of the cloud within that contour, if an ignition source exists.

The following findings are made:

- The distances to LFL or ½ LFL from rupture of 8.5 kg LPG cylinder do not reach the school boundary.
- A flash fire from an 8.5 kg LPG cylinder rupture would have no impact on the school site.

3.6.2 LPG Cylinder BLEVE

The BLEVE (fire ball) thermal radiation consequences are summarised in Table 5.

Table 5: Consequence Results for LPG Cylinder BLEVE

No.	Event	Fireball Diameter m	Duration, s	Distance to thermal radiation, kW/m^2 (m)		
				4.7	12.5	23
1	8.5 kg cylinder rupture	11.5	1.5	30	18	13

BLEVE consequences were expressed as distances to lethality at different levels. These are summarised in Table 6.

Table 6: Distances to Lethality Levels from LPG Cylinder BLEVE

No.	Event	Distance to Lethality (m)		
		1%	10%	100%
1	8.5 kg cylinder rupture	2	N.R.	N.R.

Lethality contours for 1% and 10% lethality levels for 8.5 kg cylinder BLEVE are shown in Figure 5.

Figure 5: Lethality Contours for 8.5 kg LPG Cylinder BLEVE

- The distance to 10% lethality from an 8.5 kg LPG cylinder BLEVE is not generated.
- The distance to 1% lethality from an 8.5 kg LPG cylinder BLEVE is localised within the service station.
- A BLEVE of an 8.5 kg LPG cylinder rupture would have no impact on occupied areas of the proposed school site.

3.6.3 LPG Vapour Cloud Explosions

No explosion overpressure contours were generated for 8.5 kg cylinder rupture, indicating that there would be no impact on the school.

3.6.4 Gasoline Pool Fire

An analysis was undertaken to assess the impact of a gasoline pool fire from tanker unloading at the petrol station on the school site.

The pool fire thermal radiation distances are given in Table 7.

Table 7: Gasoline Delivery Pool Fire Consequences

Scenario	Pool diameter (m)	Flame emissive power (kW/m^2)	Distance to specified thermal radiation (m)		
			4.7 kW/m^2	12.5 kW/m^2	37.5 kW/m^2
Unloading Tanker Hose	12.0	107.0	31.0	17.9	9.7

The distance to 4.7 kW/m^2 thermal radiation level is 31m and does not reach the school site, and will have no impact on the school structures.

4 CONCLUSIONS AND MITIGATION STRATEGIES

4.1 Conclusions

The following conclusions were arrived at in the study:

1. A rupture of a Swap 'n' Go cylinder and fire/ explosion would have localised effects within the petrol station and not impact on CPS (existing and proposed buildings).
2. Thermal radiation from a gasoline pool fire from a hose leak during fuel deliveries from bulk fuel tanker does not reach the school site, and will have no impact on the school structures.

4.2 Mitigation Strategies

There are no mitigation strategies arising out of the study.

5 REFERENCES

[1] Gyde Consulting Pty Ltd, “Upgrade to Cammeray Public School: Standard Wording, Preamble and Reporting Requirements,” Sydney, October 2024.

[2] Fulton Trotters Architects, *Schematic Design of Cammeray Public School, Revision P5,* Document CPS-FTA-00-00-DR-A-1101 PROPOSED SITE PLAN [P5]: School Infrastructure NSW, 14 November 2024.