Appendix 17

Tomingley Gold Extension Project – SEPP 33 Risk Screening and Preliminary Hazard Analysis

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A17.1 Introduction

This *SEPP 33 Risk Screening and Preliminary Hazard Analysis* has been prepared for the Project by R.W. Corkery & Co. Pty Limited (RWC) on behalf of Tomingley Gold Operations Pty Ltd (The Applicant) for the Tomingley Gold Extension Project (the Project). The Project is fully described in Section 3 of the *Environmental Impact Statement*. In summary, however, the Project incorporates the following.

- Approved Tomingley Gold Operations (TGO) undertaken in accordance with State Significant Development consent (SSD) MP09_0155. The approved activities would continue under any new development consent and relevantly include transportation, storage and use of the following.
  - Explosives for blasting operations.
  - Reagents, including sodium cyanide, for ore processing and recovery of gold.
  - Diesel for use in mobile plant.
- The proposed San Antonio Roswell (SAR) operations would relevantly include transportation, storage and use of the following.
  - Explosives for blasting operations.
  - Diesel for use in mobile plant.

Previous assessments under *State Environmental Planning Policy 33 – Hazardous and Offensive Development* (SEPP 33) for TGO include the following.

- *TGO SEPP 33 Risk Screening and Preliminary Hazard Analysis* prepared by RWC and dated November 2011. That document was originally presented as Appendix 3 of the original *Environmental Assessment* for TGO Mine.
- *Tomingley Mine Site Final Hazard Analysis*, referred to hereafter as Sherpa (2013) and presented as **Annexure 1**. As Sherpa (2013) post-dates RWC (2011), reliance has been placed on the later document.
- *Tomingley Mine Site Risk Assessment Proposed Liquid Oxygen Storage*, referred to hereafter as Sherpa (2014) and presented as **Annexure 2**. Sherpa (2014) presents an updated Final Hazards Analysis taking into account the additional of a liquid oxygen storage tank within the TGO Mine Site.

Sherpa (2013 and 2014) were prepared by Sherpa Consulting Pty Limited (Sherpa) in accordance with Condition 47 of MP09_0155.

The SEARs issued for the Project identified "hazards and risks" as a key issue requiring assessment, including the following:

- a Preliminary Hazard Analysis, covering an assessment of the likely risks to public safety, paying particular attention to storage, handling, transport and use of any dangerous goods associated with the development; and
- consideration of all findings from the Preliminary Hazard Analysis and Final Hazard Analysis prepared for the MP 09_0155 development consent.

As a result, this Appendix considers whether the Project, including both the approved TGO and proposed SAR components, should be considered a hazardous or potentially hazardous industry under *State Environmental Planning Policy 33 – Hazardous and Offensive Development*

(SEPP 33). In accordance with the risk screening method provided by the *Hazardous and Offensive Development Application Guidelines – Applying SEPP 33* (NSW Government, 2011b), the following presents the details of the determination as to the classification of the Project under SEPP 33.

Industries or projects determined by the risk screening to be hazardous or potentially hazardous would require the preparation of a Preliminary Hazard Analysis in accordance with Clause 12 of SEPP 33. No further assessment under SEPP 33 is required for projects not considered potentially hazardous.

A17.2 Risk Screening

A17.2.1 Hazardous Materials within the Project Site

Hazardous materials are defined within the SEPP 33 Guidelines as substances falling within the classification of the *Australian Code for the Transportation of Dangerous Goods by Road and Rail* (Dangerous Goods Code) (Version 7.7) (National Transport Commission, 2020). Based on this definition, the hazardous materials to be stored within the Project Site, their quantities and storage location are summarised in **Table A17.1**. Threshold limit criteria are in accordance with Table 3 and Figure 5 of *Hazardous and Offensive Development Application Guidelines – Applying SEPP 33.*

A17.2.2 Risk Screening Results

Based on the risk screening results presented in **Table A17.1**, a Preliminary Hazard Analysis is required for the storage and use of the following hazardous materials within the TGO Mine Site.

- Class 1.1 explosives.
- Liquefied Petroleum Gas.
- Ammonium Nitrate Emulsion.
- Sodium cyanide.
- Hydrochloric acid.

It should be noted, no changes to the existing, assessed and approved transport, storage and/or use of any of the above hazardous materials for the TGO Mine Site are proposed as part of the Project. These hazardous materials were addressed by Sherpa (2013 and 2014) through detailed, quantitative assessments. The results of those assessments have been reviewed in consideration of current risk assessment methodologies and found to be in accordance with industry standards and with no significant changes to the risk profiles. In addition, the assumptions and modelling undertaken by Sherpa was found to be generally in accordance with current assessed and approved operations within the TGO Mine Site. Therefore, this Preliminary Hazard Analysis will only relate to the proposed hazardous materials with the SAR Mine Site.

Based on the risk screening results presented in **Table A17.1** a Preliminary Hazard Analysis is required for the storage and use of the Ammonium Nitrate Emulsion within the SAR Mine Site.

Table A17.1
Hazardous Materials Storage with the Project Site

Material	Class	Description	Actual / Proposed Storage Quantity	Storage Location	Distance to Site Boundary[1]	Threshold Limit	Threshold Triggered
TGO Mine Site (Source: Sherpa (2013) – Appendix F, Table 2.1)							
Diesel Fuel	C1	Combustible liquids: flashpoint above 61°C but not exceeding 150°C	2 x 77 500L	Self-bunded fuel bay in the vicinity of the TGO Mine Site workshop	>500m	10m	No
Explosives, blasting, type B. Explosives, blasting, type E. Booster Cord detonating. Detonators, Non-electric.	1.1	Pre-packaged and bulk explosives	7 530kg[2]	TGO Magazine	>28.5m	280	**Yes**[3]
Liquified Petroleum Gas (LPG)	2.1	Flammable Gas: Gases which ignite on contact with an ignition source	4 x 7 500L tanks (30 000L)	Bunded location adjacent to the Processing Plant within the Processing Plant and Office Area	600m	$16m^3$	**Yes**
Liquid Oxygen	2.2	Non-flammable, non-toxic	60 000L tank		>500m	Non-hazardous	
Ammonium Nitrate Emulsion	5.1 PG II	Oxidising agent	68t	TGO Magazine	>500m	5t	**Yes**
Sodium Cyanide (solution)	6.1 PG I	Solution mixed on site	2x 100 000L	Bunded location adjacent to the Processing Plant within the Processing Plant and Office Area	>500m	0.5t	**Yes**
Hydrochloric Acid	8 PG II	Concentrated liquid	30 000L (23.6t)			$25m^3$	**Yes**
Caustic Soda (Sodium Hydroxide) (Solution)	8 PG II	Concentrated liquid	20 000L			25t	No
Acetic Acid	8 PG III	Reagent	2 000L			$50m^3$	No
Copper Sulphate (Solution)	9 PG III	Catalyst in cyanide detoxification process	20 x $1m^3$ Intermediate Bulk Containers Tanks			Non-hazardous	
SAR Mine Site (Source: Tomingley Gold Operations Pty Ltd)							
Diesel Fuel	C1	Combustible liquids: flashpoint above 61°C but not exceeding 150°C	500 000L	Self-bunded fuel bay in the vicinity of the SAR Mine Site workshop	>500m	10m	No
Explosives, blasting, type B. Explosives, blasting, type E. Booster Cord detonating. Detonators, Non-electric	1.1	Pre-packaged and bulk explosives	20t[4]	SAR Magazine	800m	380[5]	**No**
Ammonium Nitrate Emulsion	5.1 PG II	Oxidising agent	200t[6]	SAR Magazine	800m	5t[7]	**Yes**

Note 1: Site Boundary = boundary of closest publicly accessible location, including public roads or surrounding private land.
Note 2: Total quantity of Class 1.1 explosives comprises 7 500 kg Class 1.1D explosive material and a nominal 30 kg for Class 1.1B detonators.
Note 3: The TGO Magazine was previously located within 28.5m of private land. However, the Applicant has now purchased surrounding land and the TGO Magazine is now >500m from publicly accessible land. Notwithstanding this, the previous Hazards Analysis completed by Sherpa (2013) remains valid.
Note 4: Assumed combined maximum total of Class 1.1D explosive material and Class 1.1B detonators.
Note 5: Based on Figure 5 of Applying SEPP33.
Note 6: Assumed maximum required storage capacity for SAR Mine Site during peak mining activity.
Note 7: Based on Table 3 of Applying SEPP33.

A17.2.3 Preliminary Hazard Analysis

A17.2.3.1 Introduction

This Preliminary Hazard Analysis has been conducted to evaluate the hazards associated with the use, storage and transport of Ammonium Nitrate Emulsion within the SAR Mine Site.

Preparation of this Preliminary Hazard Analysis addresses the requirements of *State Environmental Planning Policy (SEPP) No. 33 (Hazardous and Offensive Development)* and has been documented in general accordance with *Guidelines for Hazard Analysis: Hazardous Industry Planning Advisory Paper No. 6* (NSW Government, 2011e).

The Preliminary Hazard Analysis has been completed in accordance with the general principles of risk evaluation and assessment outlined in the NSW Governments' *Multi-Level Risk Assessment* (NSW Government, 2011c).

Assessed risks are compared to the qualitative risk assessment criteria developed in accordance with Australian Standard *Risk Management – Guidelines* (AS/ISO 31000:2018). Further, this Preliminary Hazard Analysis considers the qualitative criteria provided in *Risk Criteria for Land Use Planning: Hazardous Industry Planning Advisory Paper No. 4* (NSW Government, 2011d).

A17.2.3.2 Objectives and Scope

The objective of this Preliminary Hazard Analysis is to identify the risks posed by the Project-related use and storage of Ammonium Nitrate Emulsion (Class 5.1) to people, property and the environment surrounding the SAR Mine Site and assess the identified risks using applicable qualitative criteria. This assessment considers off-site risks to people, property and the environment (in the presence of controls) arising from atypical and abnormal hazardous events and conditions, i.e. equipment failure, operator error and external events. The assessment does not consider risks to the employees, property or business of the Applicant.

A17.2.3.3 Study Methodology

The *Multi-Level Risk Assessment* approach was used for this study. The approach considered the development in context of its location and its technical and safety management control. The *Multi-Level Risk Assessment is* 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.

The Multi-Level Risk Assessment approach is summarised in **Figure A17.1**. There are three levels of assessment, depending on the outcome of the preliminary screening. These are:

- Level 1 – Qualitative Analysis, primarily based on the hazard identification techniques and qualitative risk assessment of consequences, frequency and risk;
- Level 2 – Partially Quantitative Analysis, using hazard identification and the focused quantification of key potential offsite risks; and
- Level 3 – Quantitative Risk Analysis, based on the full detailed quantification of risks, consistent with *Hazardous Industry Planning Advisory paper No.6 – Guidelines for Hazard Analysis*.

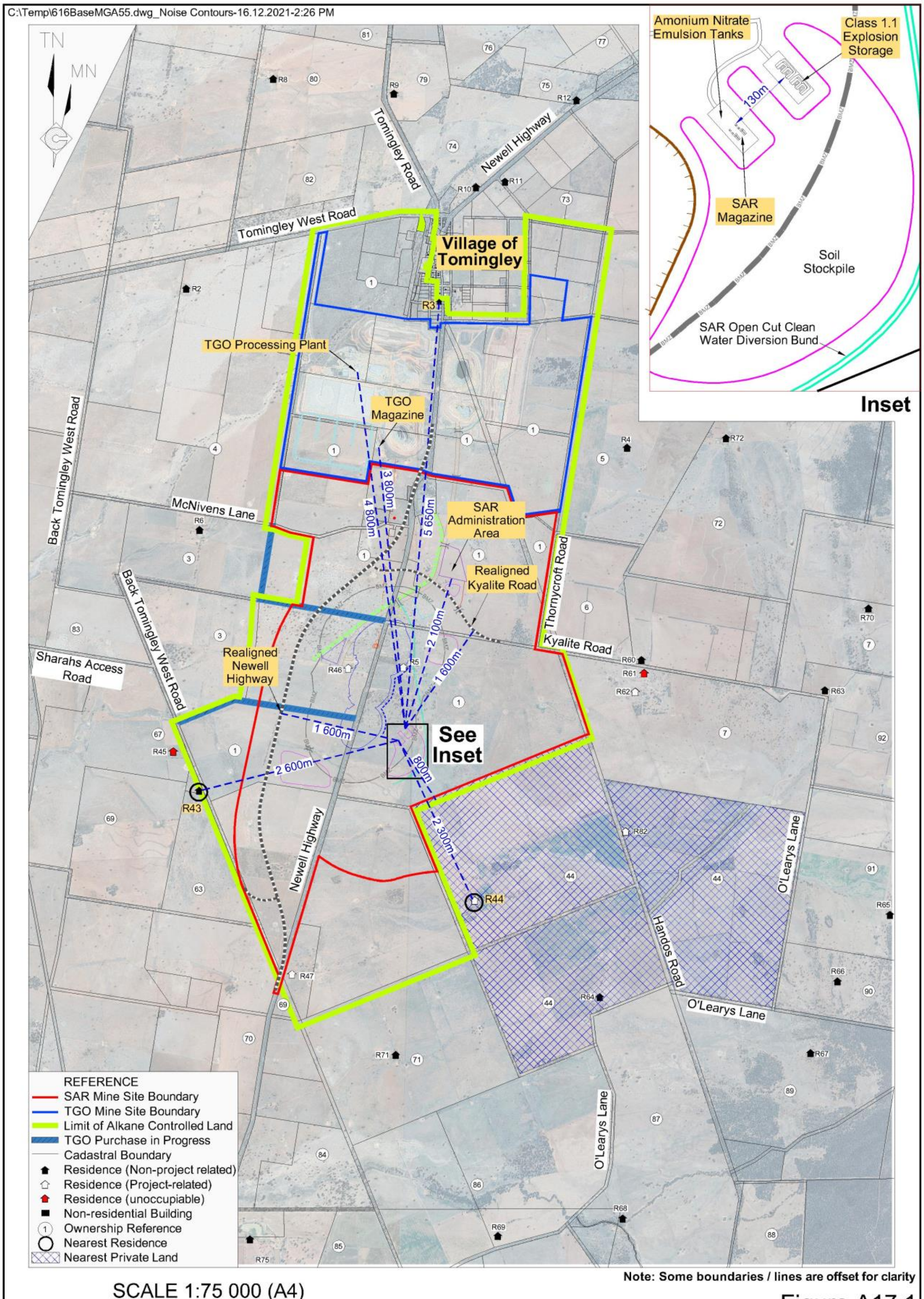

Figure A17.1
MINIMUM SEPARATION DISTANCE CRITERIA AND RECEIVERS

The Level 1 qualitative analysis methodology was employed during the preparation of this Preliminary Hazard Analysis as follows.

i) Identification of the hazards associated with the use and storage of Ammonium Nitrate Emulsion (Class 5.1).

ii) Examination of the maximum reasonable consequence of identified events, namely the worst-case consequence that could reasonably be expected, given the scenario and based upon previous experience.

iii) Qualitative estimation of the likelihood of events.

iv) Proposed risk treatment measures.

v) Qualitative assessment of risks to the environment, members of the public and their property arising from atypical and abnormal events and compare these to applicable qualitative criteria.

vi) Recommendation of further risk treatment measures if considered warranted.

vii) Qualitative determination of the residual risk assuming the implementation of the risk treatment measures.

A17.2.3.4 Risk Management Process

The Preliminary Hazard Analysis has been undertaken in general accordance with the risk management process described in *AS/ISO 31000:2018 – Risk management – Guidelines*. The risk management process includes but is not limited to the following components.

- Establish the risk assessment context – Sections A17.2.3.2 and A17.2.3.3
- Identify risks – Section A17.2.3.6.
- Analyse, evaluate and treat risks – Section A17.2.3.7.

A17.2.3.5 Qualitative Measures of Consequence, Likelihood and Risk Ranking Table

To undertake a qualitative risk assessment it is useful to define (in a descriptive sense) the various levels of consequence of a particular event, and the likelihood (or probability) of such an event occurring. Risk assessment criteria were developed in accordance with AS/ISO 31000:2018 which allowed the development of risk criteria to establish the risk context.

Tables A17.2, A17.3 and **A17.4** present the risk and consequence context for the Preliminary Hazard Analysis.

Table A17.2
Qualitative Consequence Ratings

Level	Descriptor	Description
1	Catastrophic	The potential to cause regional environmental impact/ecosystem damage or human health impact with impacts causing mine or business closure, e.g. major off-site release of a contaminant with long-term detrimental effects.
2	Major	The potential to cause substantial regional/local environmental damage or human health impacts which could result in major financial loss and/or prosecution, e.g. off-site release of a contaminant resulting in local ecosystem damage.
3	Moderate	The potential to cause substantial temporary or minor long-term damage, e.g. a minor water or large hydrocarbon off-site release with outside clean-up assistance required. May potentially result in a legal non-compliance.
4	Minor	The potential for a temporary or minor damage. No legal breach but may be non-compliant with internal environmental target, e.g. minor hydrocarbon spill.
5	Insignificant (I)	No detrimental effect, negligible environmental impact.

Table A17.3
Qualitative Likelihood Ranking

Level	Descriptor	Description
A	Almost Certain	Is expected to occur in most circumstances.
B	Likely	Will probably occur in most circumstances.
C	Possible	Could occur.
D	Unlikely	Could occur but not expected.
E	Rare	Occurs only in exceptional circumstances.

Table A17.4
Risk Rankings

		Likelihood				
		A - Certain	B - Likely	C - Possible	D – Unlikely	E - Rare
Consequence	1 – Catastrophic	1	2	4	7	11
	2 – Major	3	5	8	12	16
	3 – Moderate	6	9	13	17	20
	4 – Minor	10	14	18	21	23
	5 – Insignificant	15	19	22	24	25

Low	Medium	High	Extreme

Table A17.6 presents the identified risk sources and the potential consequences of the identified risk and the risk rankings assuming standard controls together with the assessed, existing and approved controls in accordance with the *Hazardous Materials Management Plan*.

The four risk rankings are defined as follows.

Low (L): requiring a basic assessment of proposed controls and residual impacts. Any residual impacts are unlikely to have any major impact on the local environment or stakeholders.

Medium (M): requiring a medium level assessment of proposed controls and residual impacts. It is unlikely to preclude the development of the Project but may result in impacts deemed unacceptable to some local or government stakeholders.

High (H): requiring in-depth assessment and high-level documentation of the proposed controls and mitigation measures. Ultimately, this level of risk may preclude the development of the Project.

Extreme (E): requiring in-depth assessment and high-level documentation of the proposed controls and mitigation measures and possible preparation of a specialised management plan. Unless considered to be adequately managed by the controls and/or management plan, this level of risk is likely to preclude the development of the Project.

A17.2.3.6 Hazard Identification

A17.2.3.6.1 Overview

The risk screening process undertaken in accordance with SEPP 33 identified potentially hazardous materials to be used and stored within the SAR Mine Site as Ammonium Nitrate Emulsion (Class 5.1), with up to 200t to be stored within the SAR Magazine.

The hazard (or risk) identification summary table (**Table A17.6**) provides a summary of the potential off-site risks and hazards identified for the Project and a qualitative assessment of the risks posed.

A17.2.3.6.2 Incident Classes and Predicted Level of Impact

Principal Risk

The principal risk from the use and storage of explosive compounds is that of an uncontrolled explosion. The following generic classes of incident that may lead to uncontrolled explosion include the following.

- Uncontrolled detonation via accident or environmental hazard.
- Unauthorised detonation via deliberate theft and/or sabotage.

These incident classes were applied to the component areas to identify scenarios for which control/mitigation measures were developed.

Level of Impact

The design of the SAR Magazine would be in accordance with *AS 2187.1 - Explosives—Storage, transport and use. Part 1: Storage*. In particular, the Applicant notes that there would be suitable separation between the Ammonium Nitrate Emulsion and Class 1.1 explosives. As a result, there would be minimal risk of sympathetic detonation and the cumulative impacts are therefore not required to be assessed. Notwithstanding this, for the purpose of this Preliminary Hazard Analysis, the cumulative impacts have been calculated.

In accordance with the methodology of Sherpa (2013), the potential impacts of an Ammonium Nitrate Emulsion explosion were assessed based on the equivalent amount of TNT, referred to as the Net Explosive Quantity. The TNT equivalence is a ratio of the blast energy produced by the explosive of interest to the blast energy produced by the same quantity of TNT. The TNT equivalence of Ammonium Nitrate Emulsion is 0.74.

The combined maximum Net Explosive Quantity value for the SAR Magazine would therefore be approximately 168t, based on an assumption of 200t of Ammonium Nitrate Emulsion with a Net Explosive Quantity of 148t and 20t of Class 1.1 Explosives.

Quantity Distance Rules

Minimum separation distances to protected works were assessed against the *Code of Practice Ammonium Nitrate Emulsions, Suspensions or Gels – Ammonium Nitrate Emulsions* (UN3375) (the ANE Code) (Australian Explosives Industry and Safety Group Inc, 2012) which states that the storage of Ammonium Nitrate Emulsions must either adopt the same quantity distances as explosives as per *AS 2187.1 - Explosives—Storage, transport and use. Part 1: Storage*, or must be able to be evacuated in the event of an emergency, which could potentially lead to an explosion.

The ANE Code specifies separation distances to various activities or occupied areas based on the Net Explosive Quantity at the magazine or works. The separation distances are based on consequence (i.e. overpressure level or impulse) developed by explosions of Net Explosive Quantities. The distances are set to:

- prevent propagation between explosives storages and associated works;
- reduce risk to acceptable level for people associated with the site; and
- minimise risk at protected works and vulnerable facilities.

Protected works are relevantly defined as follows:

- **Class A:** Public street, road or thoroughfare, open place where the public are accustomed to assemble or open place of work in another occupancy.
- **Class B:** A dwelling house, public building, other building or structure where the public are accustomed to assemble; a shop, store or building in which any person is employed in any trade or business or a depot for the keeping of flammable or dangerous goods.

Separation distances to 'vulnerable facilities' (including, but not restricted to schools, hospitals, major places of transport, significant public infrastructure) are also defined.

For the purpose of this assessment, the closest offset distances from the SAR Magazine to each of the above are as follows (**Figure A17.1**).

- Protected Works Class A
  – Property 44..minimum of 0.8km
  – Realigned Kyalite Road .... minimum of 1.5km
  – Realigned Newell Highway ....minimum of 1.5km

- Protected Works Class B
  - Residence R44 (Project-related)..minimum of 2.2km
  - Residence R43 (non-Project related)..................................minimum of 2.6km
  - SAR Administration Area ....minimum of 2.0km
  - TGO Processing Plant ....minimum of 4.9km
- Vulnerable facility – assumed to be in Tomingley village.........minimum of 5.7km

The ANE Code provides a minimum distance values for a range of Net Explosive Quantity levels, with the closest Net Explosive Quantity values with distances provided for 140t and 180t. In order to allow for a conservative assessment, for the purposes of this Preliminary Hazard Analysis, the minimum distances are based on the values provided by the ANE Code for a Net Explosive Quantity of 180t.

Table A17.5 present the minimum separation distances in accordance with the ANE Code. In summary, based on the maximum predicted volume of Ammonium Nitrate Emulsion and Class 1.1 Explosives that would be stored within the SAR Mine Site, the location of the SAR Magazine does not exceed any minimum distance criteria.

Table A17.5
Minimum Separation Distance Criteria

Receptor	Details	Approximate Separation Distance (m)[1]	SAR Magazine: Minimum Separation Distance (m)[2]	SAR Magazine: Separation Distance Acceptable?
Protected Works Class A				
Property 44	Nearest private property	800	840	Yes
Realigned Kyalite Road	Nearest public road	1 600		Yes
Realigned Newell Highway	Nearest significant infrastructure	1 500		Yes
Protected Works Class B				
Residence R44	Nearest Project-related residence	2 300	1 260	Yes
Residence R43	Nearest non-Project related residence	2 600		Yes
SAR Administration Area	Building in which a person is employed in any trade or business	2 100		Yes
TGO Processing Plant	Depot for LPG and other dangerous goods	4 800		Yes
Vulnerable Facility				
Tomingley Village	Relatively high density of vulnerable facilities/receptors	5 650[3]	2 320	Yes
Associated Facilities				
SAR Explosives and Detonator Storage	Distance between SAR Ammonium Nitrate Emulsion and Class 1.1 Explosives storages	130	105	Yes
TGO Explosives and Detonator Storage	TGO Magazine	3 800	105	Yes

Note 1: Measured from closest point of the SAR Magazine
Note 2: For 180t Net Explosive Quantity
Note 3: Measured from nearest Tomingley building (Residence R03)

A17.2.3.6.3 Project Risk Treatment Measures

For the purposes of hazard identification and assessment, the following risk controls were identified for the use and storage of Ammonium Nitrate Emulsion (and Class 1.1 Explosives) within the SAR Mine Site.

- The SAR Magazine would comply with all relevant engineering and safety standards, including *Australian Standard 2187 Explosives - Storage, transport and use*.
- The SAR Magazine and other landscape elements such as surrounding bunding and the southeast soil stockpile would provide barriers to suppress shrapnel or flying debris.
- The SAR Magazines would have a perimeter security fence with controlled access.
- All authorised employees managing explosives would have a Security Clearance issued in accordance with the *NSW Explosives Act 2003* & *Explosives Regulation 2013* and issued by SafeWork NSW.
- The use of explosives within the Project Site would be managed in accordance with a revised *Blast Management Plan*.

In addition, general hazard control measures would also be documented in the following management plans and strategies that would be revised following receipt of development consent.

- *Environmental Management Strategy.*
- *Emergency Management Plan*
- *Pollution Incident Response Management Plan.*
- *Blast Management Plan*

A17.2.3.7 Risk Management and Evaluation

Table A17.6 presents a qualitative assessment of risks associated with the storage and use, of both Ammonium Nitrate Emulsion. Hazard treatment measures are identified, where required, to produce a ‘low’ level of risk in accordance with the risk acceptance criteria described in Section A17.2.3.4. These measures are consistent with those identified in Section A17.2.3.6.3.

A17.3 Conclusion

The SEPP 33 screening study determined that the proposed storage and use of Ammonium Nitrate Emulsion within the SAR Mine Site has the potential for offsite impacts. The Project would also involve the storage and use of fuel and other hydrocarbons within the workshops of the SAR Administration Area, however based on the assumed volumes, storage and industry standard management and mitigation measures, no further assessment of those materials is required.

Table A17.6
Hazard Assessment – Ammonium Nitrate Emulsion

Project Component	Incident Type	Scenario	Proposed Control / Treatment	Likelihood	Consequence	Risk
Storage facilities within the Project Site	Accident / Fire / Explosion	Damage to SAR Magazine as a result of accident, fire or explosion	• Non-flammable storage containers and bunding. • Magazine and security provisions comply with *AS 2187 Explosives – Storage, Transport and Use* and ANE Code. • Isolate incompatible substances. • Develop and implement site-specific management plans: – *Hazardous Materials Management Plan*. – *Blast Management Plan*. – *Pollution Incident Response Management Plan*. – *Emergency Management Plan*.	E	4	Low
	Theft / Sabotage	Theft and malicious act/sabotage.	• Operational perimeter of SAR Mine Site would be fenced. • Operational perimeter of SAR Magazines would have security fence. • SAR Mine Site would have controlled access. • There is a single no through road access which requires vehicles to pass though heavily trafficked sections of the SAR Mine Site. • SAR Magazine and security provisions would comply with *AS 2187 Explosives – Storage, Transport and Use.* • Bunding to control access would be installed. • All authorised employees managing explosives would have a Security Clearance.	E	3	Low

This Preliminary Hazard Analysis considered a conservative cumulative impact scenario for the combined Net Explosive Quantity of a potential explosion of Ammonium Nitrate Emulsion at the SAR Magazine. A comparison of minimum and actual separation distances to key receptors showed compliance with the AEISG Code of Practice for Ammonium Nitrate Emulsions and consequently, *AS 2187.1 Explosives – Storage, transport and use Part 1 Storage*. Therefore, the offsite risks associated with hazardous materials located within the SAR Magazine are considered to be acceptable.

It should be noted that while the Project includes the use of the following hazardous materials within the TGO Mine Site, the risks associated with these materials has been assessed by previous hazard assessments. The assessed and approved hazardous materials within the TGO Mine Site are as follows.

- Class 1.1 Explosives.
- Liquefied Petroleum Gas.
- Ammonium Nitrate Emulsion.
- Sodium cyanide.
- Hydrochloric acid.

As no changes to the quantity in use and/or stored within the TGO Mine Site are proposed, these materials have not been included in this Preliminary Hazard Analysis. The results of Sherpa (2013) and Sherpa (2014) have been reviewed in consideration of current risk assessment methodologies and found to be in accordance with industry standards and with no significant changes to the risk profiles.

A17.4 References

Australian Explosives Industry and Safety Group Inc (2012). *Code of Practice Ammonium Nitrate Emulsions, Suspensions or Gels – Ammonium Nitrate Emulsions* (UN3375) (the ANE Code).

Australian Standard (AS/ISO 31000:2018). *Risk Management – Guidelines.*

National Transport Commission (2020). *Australian Code for the Transportation of Dangerous Goods by Road and Rail* (Dangerous Goods Code) (Version 7.7).

NSW Government (2011b). *Hazardous and Offensive Development Application Guidelines – Applying SEPP 33.*

NSW Government (2011c). *Multi-Level Risk Assessment.*

NSW Government (2011d). *Risk Criteria for Land Use Planning: Hazardous Industry Planning Advisory Paper No. 4.*

NSW Government, (2011e). *Guidelines for Hazard Analysis: Hazardous Industry Planning Advisory Paper No. 6.*

R.W. Corkery & Co. Pty Ltd (RWC 2011). *TGO SEPP 33 Risk Screening and Preliminary Hazard Analysis* dated November 2011.

Sherpa (2013), *Tomingley Mine Site Final Hazard Analysis.*

Sherpa (2014), *Tomingley Mine Site Risk Assessment Proposed Liquid Oxygen Storage.*

Annexure 1

Tomingley Mine Site Final Hazard Analysis

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TOMINGLEY MINE SITE

FINAL HAZARD ANALYSIS

TOMINGLEY GOLD OPERATIONS PTY LTD

PREPARED FOR:	**Simone Painter** **Tomingley Gold Operations Pty Ltd**

DOCUMENT NO:	**20783-RP-002**
REVISION:	**0**
DATE:	**2 December 2013**

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DOCUMENT REVISION RECORD

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A	17 October 2013	Issued for client comments	F. Wong	J. Polich	G. Peach	Email PDF
0	2 December 2013	Final issue incorporating client comments	F. Wong	J. Polich	G Peach	Email PDF

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Title: **Tomingley Mine Site** **Final Hazard Analysis**	**QA Verified:** J Polich **Date: 2 December 2013**

CONTENTS

TABLES

FIGURES

ABBREVIATIONS

ADG	Australian Dangerous Goods
AEGL	Acute Exposure Guideline Level
AEISG	Australian Explosives Industry And Safety Group Inc.
AIHA	America Industrial Hygiene Association
AN	Ammonium Nitrate
ANE	Ammonium Nitrate Emulsion
AS	Australian Standard
CIL	Carbon-in-leach
DG	Dangerous Goods
DoP(I)	Department of Planning and Infrastructure
EA	Environmental Assessment
ES	Exposed Site
EPL	Environmental Protection License
FHA	Final Hazard Analysis
HAZMAT	Hazardous Material
HCl	Hydrogen Chloride
HE	High Explosives
HIPAP	(NSW) Hazardous Industry Planning Advisory Paper
LEL	Lower Explosive Limit
LPG	Liquefied Petroleum Gas
MSDS	Material Safety Data Sheet
NEQ	Net Explosive Quantity
NOx	Nitrogen oxide
NSW	New South Wales
OHS	Occupational Health and Safety
Pa	per annum
PES	Potential Explosion Site
PFD	Process Flow Diagram
PG	Packaging Group
PHA	Preliminary Hazard Analysis
Ppm	Parts Per Million (usually vol/vol for gases)
PWA	Protected Works Class A
PWB	Protected Works Class B
ROM	Run-of-mine
RSF	Residue Storage Facility
SEPP	State Environmental Planning Policy
TGO	Tomingley Gold Operations Pty Ltd
TNT	Trinitrotoluene
WHS	Work Health and Safety
UK HSE	United Kingdom Health and Safety Executive
VCE	Vapour Cloud Explosion

1. EXECUTIVE SUMMARY

1.1. Purpose and Scope

Tomingley Gold Operations Pty Ltd (TGO) has engaged Sherpa Consulting Pty Ltd (Sherpa) to prepare the Final Hazard Analysis (FHA) for the development of a mine site near Tomingley (the Proposal).

Due to the significant differences between the inventories coved in the Preliminary Hazard Analysis (PHA) and the proposed final Dangerous Goods (DG) storage, a review against the 'State Environmental Planning Policy 33 – *Hazardous and Offensive Development* (SEPP 33)' was conducted prior to the FHA to identify materials to be covered in the FHA.

1.2. Study Basis and Methodology

The assessment followed the methodology given in the NSW Department of Planning (DoP) guidelines, Hazardous Industry Planning Advisory Paper (HIPAP) No. 6, 'Hazard Analysis' (Ref. 1) and Multi-Level Risk Assessment (Ref. 2). Risk criteria from HIPAP No. 4, 'Risk Criteria for Land Use Safety Planning', (Ref. 3) were adopted for the risk assessment.

The basic process is as follows:

- Identification of hazards and description of potential incident scenarios. Based on the hazard identification exercise, scenarios with potential offsite impact were identified for further analysis.
- Analysis of the consequences of these incidents on people, property and the biophysical environment.
- Compare risk levels with appropriate risk criteria as detailed in HIPAP 4.

As suggested in the Multi-Level Risk Assessment guidelines, the consequence and risk analysis can be carried out either qualitatively or quantitatively, or using a combination of techniques.

For this study, sufficient quantitative analysis was undertaken to identify the events with the potential to have an offsite impact on people or property. Qualitative analysis was used to determine whether the project will comply with the risk criteria published in HIPAP 4. This approach is known as a Level 2 risk assessment.

1.3. Conclusions

Hazard analysis results are described below.

- Hydrochloric acid and sodium cyanide releases in the processing plant and storage were found to have limited offsite impact with the implementation of proper spill management procedures, adequate bunding around tanks and process equipment and adherence to the relevant Australian Standards (as is included in the design and covered in the Hazardous Materials Management Plan).

- Consequence analysis involving LPG fire and BLEVE scenarios showed that heat radiation levels causing injury (4.7 kW/m^2) and fatality (23 kW/m^2) did not extend offsite hence there is no significant offsite risk from these materials.
- The explosion risk for Class 1.1 explosives storage was found to be acceptable by satisfying the minimum separation distances (quantity distance rules) to receptors according to AS 2187.1 *Explosives – Storage, transport and use*.
- Ammonium Nitrate Emulsion (ANE) explosion overpressure distances extend offsite. Further analysis against HIPAP 4 risk criteria found that overpressure thresholds for injury/fatality or third party building damage did not reach the relevant land use categories. Therefore, there is no significant risk to these land use categories defined in HIPAP 4. In addition, a comparison of minimum and actual separation distances to sensitive receptors showed compliance with the industry guideline, Australian Explosives Industry and Safety Group Inc (AEISG) *Code of Practice for Ammonium Nitrate Emulsions, Suspensions or Gels*.

Overall, it can be concluded that the only hazardous events to have a potential impact outside the site boundary are explosions involving Class 1.1 explosives and Class 5.1 ANE. However, the effect distances do not extend to sensitive, residential or any other land uses or critical infrastructure. Hence the risk levels meet the risk criteria in HIPAP 4.

Risk to the biophysical environment from releases of dilute cyanide solutions from the process water dam or Residue Storage Facility (RSF) is minimised by design and construction the dams with very low permeability and liners (as specified in the project conditions of approval reference 09_0155) to prevent leakage, and also managing the levels the in the dams with sufficient freeboard operationally to prevent overflows. The design (which was subject to HAZOP) includes level interlocks preventing additional inflow to dams if the level is high, supplemented by an independent high level alarm.

1.4. Recommendations

The separation distance to various receptors currently satisfies the requirements in AS 2187.1. It is recommended that throughout the life of the mine site operation, Project monitor changes in land uses adjacent to the ANE compound. If there are changes, ensure that the ANE separation distances to potential receptors continue to comply with AS 2187.1.

2. INTRODUCTION

2.1. Background

Tomingley Gold Operations Pty Ltd (TGO), a wholly owned subsidiary of Alkane Resources Limited, is developing a mine site near Tomingley (the Proposal). The project is in the final stages of design and preparing to commence operations.

In 2011, RW Corkery & Co Pty Limited was retained by the Project to develop the Environmental Assessment (EA) for the mine site. The EA included a Preliminary Hazard Analysis (PHA), which incorporated a screening of the site hazardous materials against the criteria in *State Environmental Planning Policy 33 – Hazardous and Offensive Development* (SEPP 33).

TGO has engaged Sherpa Consulting Pty Ltd (Sherpa) to update the PHA of the project to a Final Hazard Analysis (FHA) as per the Conditions of Approval (Application No. 09_0155) shown below.

Final Hazard Analysis

47. The Proponent shall prepare a Final Hazards Analysis (FHA) for the project to the satisfaction of the Director-General, in accordance with the Department's *Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis.*

Note: If the project design is no different from that assessed in the Preliminary Hazard Analysis (PHA), then the Director-General will accept the PHA as the FHA.

A number of significant differences between the hazardous materials storage assessed in the PHA and the proposed final storage arrangements were identified. Consequently, an update of the SEPP 33 screening was carried out. The SEPP 33 screening concluded that the following Dangerous Goods (DG) must be considered in the FHA for potential offsite impacts:

- Class 1.1 explosives
- Liquefied Petroleum Gas (LPG)
- Ammonium Nitrate Emulsion (ANE)
- Sodium cyanide
- Hydrochloric acid.

This report summarises the results of the FHA undertaken for the Tomingley mine site.

2.2. Study Objective

The objective of the study was to undertake a Final Hazard Analysis (FHA) of the mineral processing plant in accordance with the guidelines for FHA by the NSW Department of Planning (DoP).

The objective of the FHA is to determine whether the offsite risks associated with the proposal are acceptable according to the NSW DoP land use planning criteria.

2.3. Study Scope

The scope of the study includes:

- DG storage and handling associated with the proposed mine operations.

2.4. Limitations and Exclusions

The FHA does not cover:

- Transport of hazardous materials to and from site
- Vehicle movements within the site
- Onsite or employee risk.

The study focuses on the acute effects of potential accident scenarios. It does not cover long-term or continuous emissions, or occupational health and safety (OHS) issues that may arise from routine plant operations. These are addressed via other mechanisms such as OHS regulations, OHS management systems and Environmental Protection Licenses (EPLs).

3. DESCRIPTION OF THE PROPOSED DEVELOPMENT

3.1. Site Location and Surrounding Land Use

The proposed facility is located immediately south of the village of Tomingley and approximately 60 km south-west of Dubbo, NSW. The site comprises a total area of approximately 776 hectares including the mining, processing, waste rock management and related activities. The site is located northwest of the Herveys Range on the western slopes of the Great Dividing Range, and is within the catchment of the Bogan River.

Land uses within and surrounding the mine site include the following:

- Residential and rural residential
- Agriculture
- Transportation (Newell Highway)
- Recreational (Tomingley race course in Tomingley town)
- Former mining operations, namely the McPhail Mine Tailings Dam and associated underground workings.

There are no identified sensitive land uses in the vicinity of the site (eg schools, hospitals, aged care facilities). The nearest sensitive land uses are in Tomingley town 2 km away from the Ammonium Nitrate Emulsion (ANE) storage. The nearest residential use (private residential) is located in Tomingley town approximately 240 m from the mine site boundary and 1,300 m from the processing plant boundary. The Newell Highway runs from north to south of the site, along the centre of the mine site in between the open cut mines.

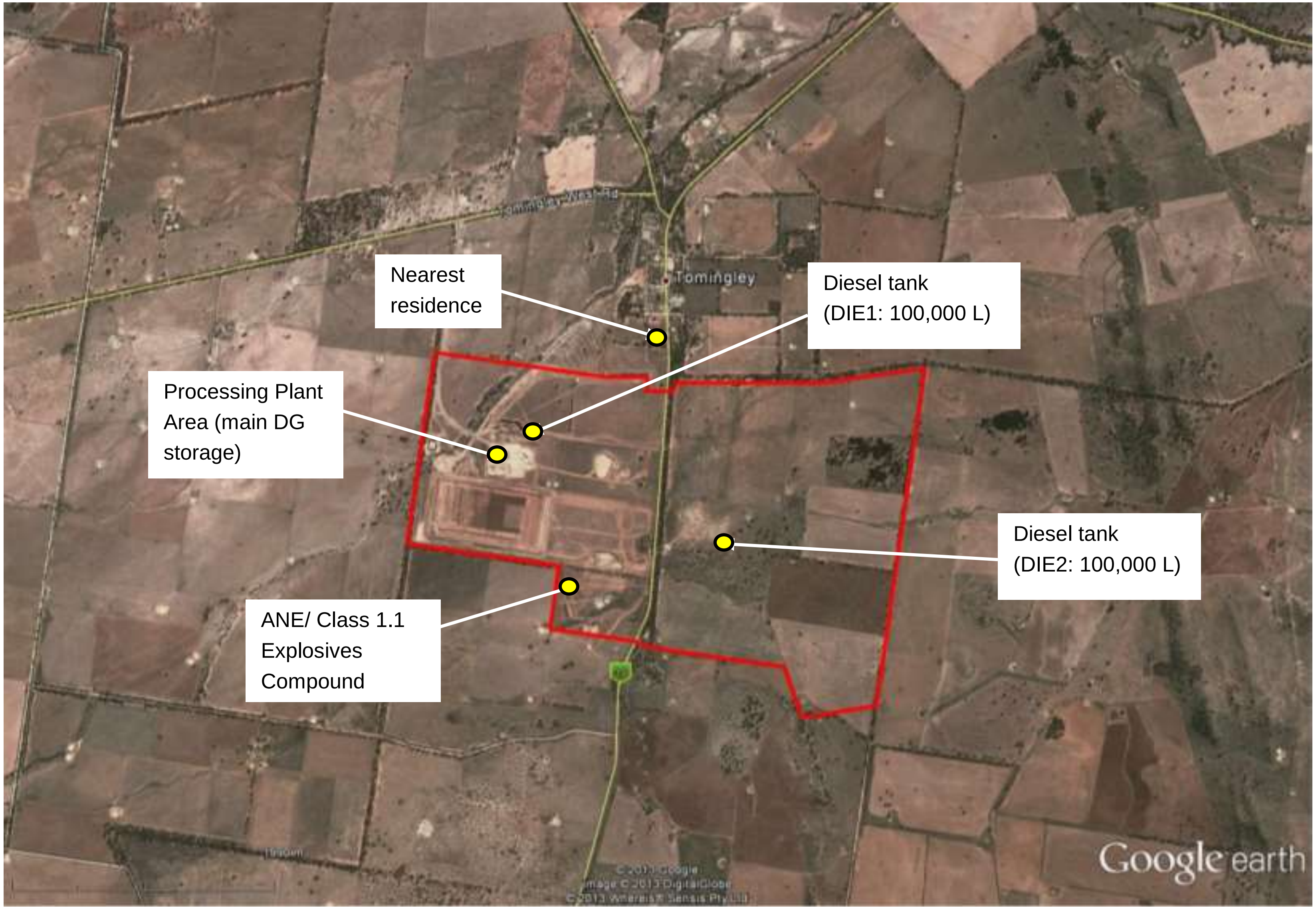
3.2. Site Layout

An aerial view of the site is shown in Figure 3.1.

The processing plant and office area is located near the site main entrance from Tomingley West Road. The processing plant, which contains the majority of the DG storage is located approximately 1,000 m from the ANE/explosives compound.

APPENDIX A contains additional drawings of the site and processing plant layout.

Figure 3.1: Aerial Photo of Mine Site



3.3. Process Overview

Ore will be extracted from within the Caloma, Wyoming Three and Wyoming One Open Cuts. Drill and blast methods would be used to fragment material that cannot be excavated using a bulldozer or excavator alone. The blasting operation will use ANE or explosives in a controlled manner.

Recovery of gold from the run-of-mine (ROM) ore material involves the following process operations.

- **ROM Stockpiling, Crushing and Grinding –** The mine ore would be loaded from the ROM pad into the primary and secondary crusher to reduce the size of the material to smaller than 23 mm in diameter. The product is then conveyed to a grinding circuit to further reduce the size of the ore to less than 106 microns.
- **Gravity and Leach Circuit** – The ore is passed through a series of cyclones and separated based on density. Denser material would flow to the gravity concentrator to continue separating based on density. The dense material goes to an intensive leach processing to extract the gold and the less dense material goes back to the grinding circuit. Less dense cyclone overflow material would flow to the standard carbon-in-leach (CIL) process.
- **Standard CIL Process –** The standard CIL leach circuit recovers gold by adding sodium cyanide, lime and air to the slurry of ground ore and water in a series of agitated tanks containing activated carbon. The gold, dissolved with sodium cyanide, would be recovered from the solution through adsorption onto pores of carbon granules. The gold-loaded carbon would be collected and transferred to an elution column which would contain a strong solution of caustic and cyanide heated by a Liquefied Petroleum Gas (LPG) gas-fired heater. This reverses the adsorption process. The gold would be removed from the solution by electrowinning.
- **Intensive Leach Process –** The concentrate from the gravity concentrator is exposed to a high cyanide and caustic solution in a tank. The cyanide dissolves the gold into solution. The solids are recovered and the pregnant solution would be pumped to the electrowinning circuit for gold recovery.
- **Gold Production –** Gold sludge, a product from the electrowinning cells, would be smelted onsite in a gas-fired furnace to produce gold doré, stored briefly and then collected by a security company for transportation to a gold refinery.
- **Residue Management –** The remaining slurry exiting the leaching processes would be concentrated in the leach tails thickener. In the thickener, the excess water will be removed for re-use and the slurry would be pumped to the cyanide destruct tank. The residual cyanide in the tailings stream is treated with Sodium Metabisulphite (SMBS) and air to reduce the cyanide concentration to less than 20ppm before being pumped to the residue storage facility (RSF). Excess water will be directed to the process water dam.

4. METHODOLOGY

4.1. Study Overview

The methodology for undertaking the FHA was based on the NSW DoP guidelines, HIPAP No. 6 Hazard Analysis (Ref. 1), HIPAP No. 4 Risk Criteria for Land Use Safety Planning (Ref. 2) and Multi-Level risk assessment guidelines (Ref. 3).

A Preliminary Hazard Analysis (PHA) (Ref. 4) was conducted as part of the Environmental Assessment (EA) for the submission of the development application in November 2011. The FHA usually develops from the PHA as more design information becomes available. However, the final quantities and locations of DG storage have changed significantly since the PHA and the findings from the PHA had minimal input to the FHA.

The main steps in this FHA are:

- Identification of hazards and description of potential incident scenarios. Based on the hazard identification exercise, scenarios with potential offsite impact were identified for further analysis.
- Analysis of the consequences of these incidents on people, property and the biophysical environment.
- Comparison of risk levels with risk criteria as detailed in HIPAP 4.

As suggested in the Multi-Level Risk Assessment guidelines, the consequence and risk analysis can be carried out either qualitatively or quantitatively, or using a combination of techniques.

For this study, sufficient quantitative analysis was undertaken to identify the events with the potential to have an offsite impact on people or property. Qualitative analysis was used to determine whether the project will comply with the risk criteria published in HIPAP 4. This approach is known as a Level 2 risk assessment.

4.2. Australian Standard Separation Distances

Explosives facilities are generally sited and designed in accordance with AS 2187.1-1998 *Explosives – Storage, Transport and Use Part 1: Storage* and ANEs in accordance with a Code of Practice (Ref. 10) which has been developed by the Australian Explosives Industry and Safety Group Inc (AEISG), *Code of Practice Ammonium Nitrate Emulsions, Suspensions or Gels – ANEs (UN3375) 2012*. Separation distance requirements are explained in the following sections.

The quantity distance rules in AS 2187.1 have been based on UK standards which were in turn based on the observed effects of damage occurring in accidental explosions that have occurred throughout the world up until the mid 20th century. It is generally accepted by the explosives industry and regulators that compliance with

AS 2187.1 and the AEISG Code will ensure that there will be minimal offsite consequences or escalation effects from explosion events (ie the risk is negligible).

4.2.1. Class 1.1 Explosives

AS 2187.1 contains quantity distance rules which specify separation distances to various activities or occupied areas based on the Net Explosive Quantity (NEQ) at the magazine or works. The separation distances are based on consequence (ie overpressure level or impulse) developed by explosions of NEQs. The distances are set to:

- Prevent propagation between explosives storages and associated works.
- Reduce risk to acceptable level for people associated with the site.
- Minimise risk at protected works and vulnerable facilities. (Vulnerable facilities are generally large populations who would be difficult to evacuate).

Protected works are defined as follows:

> (a) **Class A:** Public street, road or thoroughfare, railway, navigable waterway, dock, wharf, pier or jetty, market place, public recreation and sports ground or other open place where the public are accustomed to assemble, open place of work in another occupancy, river-wall, seawall, reservoir, above ground water main, radio or television transmitter or main electrical substation, a private road which is a principal means of access to a church, chapel, college, school, hospital or factory.
>
> (b) **Class B:** A dwelling house, public building church, chapel, college, school, hospital, theatre, cinema or other building or structure where the public are accustomed to assemble; a shop, factory, warehouse, store or building in which any person is employed in any trade or business; a depot for the keeping of flammable or dangerous goods; major dam.

Separation distances to ‘vulnerable facilities’ (including, but not restricted to schools, hospitals, major places of transport, significant public infrastructure) are also defined. Vulnerable facilities require the largest separation distances, with Protected Works B (PWB) the next largest distance and Protected Works A (PWA) the smallest distance. The nearest vulnerable facility is in Tomingley town, a minimum of 2 km away from the explosives compound. The nearest PWB is the site processing facility 1 km away from the explosives compound, and the nearest PWA is the Newell highway, with a minimum distance of 700 m.

4.2.2. Ammonium Nitrate Emulsion (ANE)

Since they are not explosives (UN3375) ANEs are outside the scope of AS 2187.1. However, the code of practice (the AEISG code) covering ANEs has been accepted by the majority of Australian jurisdictions, including NSW. Under the AEISG Code, storages of ANE either adopt the same quantity distances as explosives as per AS 2187.1, or must be able to be evacuated in the event of an emergency, which could potentially lead to an explosion.

4.3. Risk Criteria

Risk criteria in NSW DoP HIPAP 4 (Ref. 2) were adopted for this study and are provided in Table 4.1.

The risk criteria given in Table 4.1 are expressed in terms of individual fatality risk or likelihood of exposure to threshold values of overpressure, heat radiation or toxicity.

Table 4.1: NSW Individual Fatality, Injury, Irritation and Property Damage Risk Criteria

Description	Risk criteria (per year)
Individual fatality risk	
Fatality to sensitive land uses, including hospitals, schools, aged care	0.5×10^{-6}
Fatality risk to residential and hotels	1×10^{-6}
Fatality risk to commercial areas, including offices, retail centres, warehouses	5×10^{-6}
Fatality risk to sporting complexes and active open spaces	10×10^{-6}
Fatality risk should, as a target, be contained within the boundary of an industrial site where applicable	50×10^{-6}
Injury (Fire/Explosion)	
Fire/explosion injury risk – Incident heat flux radiation at residential areas should not exceed 4.7 kW/m^2 at frequencies of more than 50 chances in a million per year or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year	50×10^{-6}
Injury/Irritation (Toxic impacts)	
Toxic injury – Toxic concentrations in residential areas should not exceed a level which would be seriously injurious to sensitive members of the community following a relatively short period of exposure at a maximum frequency of 10 in a million per year.	10×10^{-6}
Toxic irritation – Toxic concentrations in residential areas should not exceed cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community over a maximum frequency of 50 in a million per year.	50×10^{-6}
Risk of Property Damage and Accident Propagation	
Explosion overpressure at neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings should not exceed a risk of 50 in a million per year for the 14 kPa explosion overpressure level.	50×10^{-6}

4.4. Societal Risk

Societal risk provides a mechanism by which the number of people exposed can be taken into account as well as the magnitude of the individual risk to each of those people. It is used to ensure that the risk impact on the community as a whole is not excessive.

Societal risk considers risk to offsite populations only. The risk calculations are undertaken if individual fatality risk contours extend into areas with significant population.

5. HAZARD IDENTIFICATION

5.1. Hazardous Materials

The complete list of hazardous materials located on the Tomingley Mine Site were analysed in the SEPP 33 screening study (Ref. 5). The outcome of the SEPP 33 review (extract as shown in APPENDIX B) indicated that the following hazardous materials should be considered in the FHA:

- Class 1.1 Explosives (Type B and Type E) and detonators
- Liquefied Petroleum Gas (LPG)
- Ammonium Nitrate Emulsion (ANE)
- Sodium cyanide solution
- Hydrochloric acid.

The main hazards associated with these materials (taken from Material Safety Data Sheets) are summarised in Table 5.1. Additional information on hazardous materials, inventories and storage arrangements is provided in APPENDIX B.

The remaining hazardous materials (eg caustic soda, diesel), were not considered in the FHA because the SEPP 33 study showed that the quantities are such that they were unlikely to present an offsite impact.

Table 5.1: Hazardous Materials

Material	State	DG Class	Description and hazards (Ref: MSDS)	Hazard Type
Explosives (Type B and E) and detonators	Solid	1.1	Explosives storage has the potential risk of explosion caused by shock, friction, fire or other sources of ignition.	Explosive
Liquefied Petroleum Gas (LPG)	Liquid	2.1	LPG is a highly flammable gas stored in the form of pressurised liquefied gas (ie at ambient temperature and saturated vapour pressure). Excessive heating of pressurised tanks may result in Boiling Liquid Expanding Vapour Explosion (BLEVE).	Flammable
Ammonium Nitrate Emulsion (ANE)	Liquid	5.1 PG II	ANE is an oxidising agent that will sustain combustion even in the absence of an external source of oxygen. The main hazard of ANE is excessive heating which can cause accelerating decomposition to the point where explosion or detonation can occur, if the decomposition gases are sufficiently confined. The presence of contaminants (eg acids, alkalis) or energetic sensitising materials increases decomposition/detonation. Toxic nitrogen oxide (Nox) gases are formed during decomposition.	Toxic/Explosive
Sodium cyanide solution	Liquid	6.1 PG I	Sodium cyanide is brought onsite as a solid and mixed with water to create sodium cyanide solution (30%). Sodium cyanide solution is corrosive when in contact with metals and skin and toxic when ingested or inhaled. Sodium cyanide decomposes when heated to produce toxic hydrogen cyanide and ammonia gases. There would be a significant environmental hazard if cyanide spills into waterways.	Corrosive/Toxic
Hydrochloric acid	Liquid	8 PG II	Hydrochloric acid is a colourless, corrosive liquid and evolves hydrogen chloride (HCl) fumes (eg from tank vents, spills, etc). HCl is an irritant gas that attacks the respiratory system.	Corrosive/Toxic

5.2. External Events

As part of the hazard identification process, the potential for external events to affect the site was considered. Table 5.2 summarises the external events considered in the FHA.

Table 5.2: External Events

External Event	Comments
External flooding	Likelihood of flooding would be low and not considered significant.
Earthquakes	According to GeoScience Australia, this area is classified as a moderate earthquake hazard (Ref. 6). It is assumed that the equipment and facility is designed accordingly.
Land slip/subsidence	Mine site subsidence issues covered as part of project design.
Cyclones	Not a cyclone area. Facility structures assumed to be designed in accordance with relevant wind/loading codes.
Tsunami/storm surge tides	Located inland. Not a potential hazard for proposed facility.
Lightning	Assumed that systems will comply with relevant Australian Standards to be installed to manage the risks associated with lightning.
Plane crash	Dubbo airport is located 60 km northeast of Tomingley town. Parkes airport is located 70 km south of Tomingley. There are no air strips present in land surrounding Tomingley Mine Site. Therefore, likelihood of a plane crash would be low and not considered significant.
Vehicle crash	Assumed that site speed limits and plant protection for structures are installed to prevent vehicle impact on critical equipment.
Sabotage/vandalism	The TGO mine site is perimeter man proof fenced and will be manned and operational 24 hours a day with restricted access. Security plan for site as per regulatory requirements for Class 1.1 explosives and ANE (Ref. 7).
Utilities failure	Assumed that power failure will result in 'fail safe' condition and plant operations are not possible in the event of loss of power.
Bushfire	Site is located in an open area. Fires may be possible, however risk is not considered significant. It is assumed that a cleared buffer zone will be in place separating processing plants and any vegetation.

No external events were identified as a significant or unmanaged potential concern, hence no specific adjustment to modelling approaches were made as part of the FHA.

5.3. Potential Major Hazardous Incident Scenarios

Potentially hazardous incident scenarios were identified based on a review of the site facility layout, the SEPP 33 screening study and experience with hazard identification work undertaken previously for similar facilities. Table 5.3 outlines the potential major hazardous incident scenarios which were identified.

5.4. Rule Set and Assumptions for Scenario Inclusion

The rule set and assumptions made for the inclusion of major incident scenarios in the Final Hazard Analysis (FHA) are given below:

- Hazardous incident scenarios involving flammable and potentially explosive materials were assessed quantitatively in the consequence analysis. Corrosive and toxic materials (ie sodium cyanide and hydrochloric acid) were not assessed quantitatively as these substances have limited offsite impact on humans and do not contribute to offsite fatality or injury risk levels. Spills within the processing plant would be managed by site procedures such as spill kits for small releases and bunding for larger releases. They would be stored and handled as per the relevant Australian Standards. Offsite risks on the biophysical environment due to liquid spills are discussed qualitatively in Section 8.2.
- Vapour Cloud Explosions (VCE) consequences were not considered because the open spaces around the LPG tanks allow for the dispersion of LPG into the surrounding environment (ie no confinement identified).
- Impact of vapour releases of LPG (ie liquid LPG not present) was not quantified in the consequence analysis of this FHA. Liquid LPG releases, having a higher mass release rate, were modelled as this is the worst case scenario.

Table 5.3: Potential Major Hazardous Incident Scenarios

Plant Area	Area Description	Main materials present	Hazardous Impact?			Scenario Description	Typical Causes	Controls and Safeguards	Carried forward for analysis in FHA?
			Flammable	Toxic	Explosive				
LPG1, LPG2, LPG3, LPG4	LPG tanks	• LPG	Yes	No	No	Piping/tank leak causes loss of containment of LPG liquid and/or vapour leading to fire or BLEVE if impingement occurs on storage vessel or delivery tanker	• Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) • Leak during loading (hose failure, driveaway etc)	• Storage and unloading area designed to AS NZS 1596:2008 *The storage and handling of LP Gas* • Preventive maintenance and routine vessel inspection • Attended operation during loading • Safe Working Procedure for LPG transfer from tanker to Mine Site storage tank • Control of ignition sources • Remote ESD at loading bay • Operator trained in emergency response and/or HAZMAT • Emergency Management Plan	Yes.
LPG1, LPG2, LPG3, LPG4	LPG tanks	• LPG	Yes	No	No	Tank rupture causes loss of containment of LPG liquid and vapour leading to fire	• Generic mechanical failures (including impact)	• Tank designed to AS NZS 1596:2008 *The storage and handling of LP Gas* • Preventive maintenance and routine vessel inspection • Control of ignition sources • Operator trained in emergency response and/or HAZMAT • Emergency Management Plan	Yes.
Process Plant	LPG combustion and energy generation	• LPG	Yes	No	No	Leak from distribution piping causes loss of containment of LPG vapour leading to fire	• Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges)	• Preventive maintenance and routine piping inspection • Control of ignition sources • Operator trained in emergency response and/or HAZMAT • Emergency Management Plan	No. Refer to Section 5.4.
ANE1/ ACE1	Magazine	• Explosives, blasting (Type B) • Explosives, blasting (Type E) • Booster • Cord detonating • Detonators, non-electric	No	No	Yes	Explosion	• Sabotage of explosives • Unauthorised access to explosives	• Entire site has perimeter man proof fence • Site is monitored 24 hours a day (including ongoing boundary surveillance) • Single no through road access • Magazine and security provisions comply with AS 2187 Explosives – Storage, Transport and Use • Bunding to suppress shrapnel or flying debris • All authorised employees will have a Unsupervised Handling License	Yes.
ANE1	ANE tank	• ANE	No	Yes	Yes	Contamination causes decomposition in ANE storage leading to explosion.	• Contaminated ANE delivered to site	• Product specification and quality assurance. • Tank has a 3 inch breather system to prevent confinement of decomposition gases which may lead to an explosion. • Low melt point inspection hatch for pressure relief	Yes

Plant Area	Area Description	Main materials present	Hazardous Impact?			Scenario Description	Typical Causes	Controls and Safeguards	Carried forward for analysis in FHA?
			Flammable	Toxic	Explosive				
ANE1	ANE tank	• ANE	No	Yes	Yes	Missile or high energy shock wave causes decomposition in ANE storage leading to explosion.	• Explosion in magazine • Arson/sabotage	• Magazine and security provisions comply with AS 2187 Explosives – Storage, Transport and Use (including personnel security checks, security fencing, access control, alarms and security monitoring) • Separation distance between ANE storage area and LPG/fired heaters in processing plant (minimum 1,000 m away) • Separation distance and mounding between ANE tank and Class 1.1 explosives magazine (50 m away)	Yes
ANE1	ANE tank	• ANE	No	Yes	Yes	External fire causes decomposition in ANE storage. Toxic fume emission and eventual explosion.	• Electrical fire • Vehicle fire • Human failure • Chemical decomposition followed by failure to control fire • Bushfire	• Minimal fuel/combustible material in the area – sustained fire extremely unlikely • Asset protection zone (cleared area) on site and to boundary around ANE tank • Tank has a 3 inch breather system to prevent confinement of decomposition gases which may lead to an explosion. • Low melt point inspection hatch for pressure relief	Yes
CN01, CN02	Sodium cyanide tanks	• Sodium cyanide solution	No	Yes	No	Tank leak/rupture leading to loss of containment of sodium cyanide	• Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges)	• Bunding constructed to AS NZS 4452:1997 *The storage and handling of toxic substances* (impermeable material) • Preventative maintenance • Routine inspections • Operator trained in emergency response and/or HAZMAT • Hazardous Materials Management Plan • Emergency Management Plan	No. Refer to Section 5.4.
Process plant	Ore treatment and processing	• Sodium cyanide solution	No	Yes	No	Leak from distribution piping leading to loss of containment of sodium cyanide	• Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges)	• Site spill procedures in place to contain leaks • Contained within bunded area capable of retaining spill • Preventative maintenance • Routine inspections • Operator trained in emergency response and/or HAZMAT • Hazardous Materials Management Plan • Emergency Management Plan	No. Small sodium cyanide releases from distribution piping do not contribute to offsite risk. Small spills have localised impact only and are managed and contained through implementation of site spill procedures.

Plant Area	Area Description	Main materials present	Hazardous Impact?			Scenario Description	Typical Causes	Controls and Safeguards	Carried forward for analysis in FHA?
			Flammable	Toxic	Explosive				
Process plant	Residue and process water management	• Sodium cyanide solution (dilute < 20ppm)	No	Yes	No	Leak from or rupture of tailings pipeline leading to loss of containment of sodium cyanide	• Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges)	• Inspections and reporting completed regularly • Pumping ceased immediately on identification of leak (two flow meters at either end of pipeline leads to automatic pump shutdown) • Preventative maintenance • Routine inspection • Pumping only to recommence following repair of leak • All tailings material excavated and manually placed within the RSF • Emergency Management Plan	No. Refer to Section 5.4.
Process plant	Residue and process water management	• Sodium cyanide solution (dilute < 20ppm)	No	Yes	No	Leak from Residue Storage Facility (RSF) leading to loss of containment of sodium cyanide	• Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges)	• RSF constructed in accordance with NSW Dams Safety Committee requirements • Regular inspections of structural integrity of RSF walls • Specific operating procedures during construction of each lift • RSF lined with impermeable clay (1×10^{-9} m/sec) • RSF designed for 1 in 100 yr, 72 hr rainfall event • Monitoring of peizometer to detect leakage	No. Refer to Section 5.4.
Process plant	Residue and process water management	• Sodium cyanide solution (dilute < 20ppm)	No	Yes	No	Overflow or leak from Process Water Dam	• Heavy rain • Excess water generated from process	• Dam designed with suitable freeboard to retain rainfall from design storm event and diversion structures to prevent inflow of surface waters (Designed for 1 in 100 yr, 72 hr rainfall event) • Process Water Dam is HDPE lined • Ultrasonic level sensor activates an alarm in the control room. Decant return and raw water pumps (make-up water sources) are interlocked with this level sensor and shuts down pumps on high alarm. • Floating ball high high level switch in process water dam. When activated it alarms in the control room and an audible alarm sounds in the field. • Contaminated material to be excavated and manually placed within the RSF • Overflow from the process water pond report to Sediment pond 1. The pond is constructed of 1×10^{-9} m/sec low permeability clay and fitted with a hard wired pump to allow any inflows to be recovered quickly to the RSF.	No. Refer to Section 5.4.

Plant Area	Area Description	Main materials present	Hazardous Impact?			Scenario Description	Typical Causes	Controls and Safeguards	Carried forward for analysis in FHA?
			Flammable	Toxic	Explosive				
HCL1	Hydrochloric acid storage tank	• Hydrochloric acid	No	Yes	No	Piping/tank leak/rupture leading to loss of containment of hydrochloric acid	• Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) • Leak during loading (hose failure, driveaway etc)	• Bunding constructed to AS3780 *The storage and handling of corrosive substances* • Preventative maintenance • Routine inspections • Attended operation during loading • Operator trained in emergency response and/or HAZMAT • Hazardous Materials Management Plan • Emergency Management Plan	No. Refer to Section 5.4.

6. CONSEQUENCE ANALYSIS

6.1. Scenarios Modelled

Consequence analysis involves qualitative and/or quantitative review of the identified hazardous scenarios to estimate the potential to cause injury/fatality.

Based on the hazard identification outlined in Section 5, the following scenarios were carried forward for consequence analysis:

- LPG fires (jet fire, flash fire, BLEVE), in the event of ignition of a tank or piping leak.
- LPG fires (flash fire, fireball), in the event of ignition following a tank rupture.
- ANE explosion, in the event of ANE decomposition arising from contamination, missile/high energy shock wave or an external fire.

Table 6.1 is a summary of the scenarios which were carried forward for consequence analysis.

Table 6.1: Scenarios Carried Forward for Consequence Analysis

Area description	Scenario Description	Scenario ID	Consequence Modelled	Comments
LPG storage	Piping/tank leak from LPG1 or LPG2 or LPG3 or LPG4	LPG-01.1	Jet Fire	Immediate ignition of LPG when released from a leak
		LPG-01.2	Flash Fire	Delayed ignition of dispersed LPG from a leak
		LPG-01.3	BLEVE	A jet fire from a nearby LPG tank impinges on another LPG tank resulting in a BLEVE
	Tank rupture of LPG1 or LPG2 or LPG3 or LPG4	LPG-02.1	Fireball	Immediate ignition of the entire LPG tank contents
		LPG-02.2	Flash Fire	Delayed ignition of dispersed LPG (entire tank contents)
ANE storage	Contamination, missile/high energy shock wave or external fire causes decomposition in ANE storage	ANE-01	Explosion	

Consequence calculations were carried out using commercially available consequence assessment software, TNO Effects, and spreadsheet models for explosion scenarios. TNO Effects is a software package that performs calculations to predict the physical effects (gas concentrations, heat radiation levels) of the escape of hazardous materials.

The approach used for consequence modelling is summarised in Table 6.2.

Table 6.2: Consequence Models

Main Materials	Incident Type		Model
	Fire/ Explosion	Toxic Release	
LPG	Y	-	The jet fire consequences were modelled using the Chamberlain model in TNO Effects. The flash fire from a leak uses a gas turbulent free jet model in TNO Effects, and flash fire from a tank rupture uses a dense gas dispersion (explosive mass) model. The BLEVE and fireball consequences were modelled from the fireball model in TNO Yellow Book (Ref. 8).
ANE	Y	-	The TNT equivalence model and Kingery-Bulmash correlation were used to estimate the explosion overpressure effects from an ANE explosion.

6.2. Consequence Assessment Criteria

To determine the impact of fire and explosion on people, it is necessary to relate the physical effects (eg heat radiation and overpressure) to different impacts (ie injury or probabilities of fatality). The consequence assessment criteria for fires and explosions used in this study are discussed below.

6.2.1. Fire Effects

The consequence criteria (ie levels of harm) for various fire scenarios used in this study is shown in Table 6.3. These criteria are based on the levels given in HIPAP 4.

Table 6.3: Fire Consequence Criteria

Phenomenon	Levels Assessed	Impact/Comment
Fireball/ BLEVE	Injury	Due to the short duration of a fireball, the probability of fatality is dependent on the thermal dose from the fireball, which is calculated based on the heat radiation, fireball size and duration.
	1% fatality	
	100% fatality	
Jet fire	4.7 kW/m^2	Will cause pain in 15-20 seconds and injury after 30 seconds exposure, or 1% chance of fatality
	23 kW/m^2	100% fatality for short exposure. Unprotected steel will reach thermal stress temperature which can cause failures. Property damage.

Phenomenon	Levels Assessed	Impact/Comment
Flash fire	Within Lower Explosive Limit (LEL)	100% probability of fatality

6.2.2. Overpressure

Overpressure levels are equated to different impacts (ie injury or probabilities of fatality) as summarised in Table 6.4. These criteria are based on the levels given in HIPAP 4 (Ref. 2). The probability of fatality is higher for a person inside a building because of the potential structural failure of the building and hence, impact on the person.

Table 6.4: Fatality/Overpressure Correlation

Overpressure (kPa)	HIPAP 4 Description	Probability of Fatality Assumed in Consequence Analysis	
		Inside Building	Outside
7	Damage to internal partitions and joinery but can be repaired. Probability of injury is 10%. No fatality.	-	-
14	Houses uninhabitable and badly cracked.	1%	0.1%
21	Reinforced structures distort. Storage tanks fail. 20% chance of fatality for a person in a building.	20%	1%
35	House uninhabitable. Wagons and plant items overturned. Threshold of eardrum damage. 50% chance of fatality for a person in buildings and 15% chance of fatality for a person in open.	50%	15%
70	Threshold of lung damage. 100% chance of fatality for a person in a building or in the open. Complete demolition of houses.	100%	100%

6.3. Consequence Assessment of Fire Scenarios

The BLEVE/fireball scenario was assessed using the fireball model in the TNO Yellow Book (Ref. 8).

The impact of a jet fire and flash fire were assessed using the following methodology:

1. Estimating the LPG release rate (for a leak scenario).
2. Estimating the distances to the consequence criteria (as defined in Section 6.2.1) using an appropriate model.

There are four LPG tanks that have the same capacity (7,500 L), dimensions and are in the same location. Therefore, one scenario was modelled for a leak from a LPG tank, but may apply to any of the four tanks. The minimum distance to site boundary

(554 m) was used as a conservative estimate to determine whether offsite impact was possible.

The MSDS states that LPG supplied to the mine site may be either propane or butane. The LPG tanks containing either 100% propane or 100% butane scenarios were analysed. There were no significant differences in the consequence distances. The outcome reported in Section 6.4 is for 100% propane.

6.4. Consequence Results of Fire Scenarios

Table 6.5 shows the summary of the distances to injury and fatality for all possible LPG fire scenarios. The worst case scenario is a LPG tank rupture potentially leading to a flash fire.

The results in Table 6.5 indicate that there are no offsite impacts for any LPG tank/piping leak or rupture leading to a fire or BLEVE, hence these scenarios do not contribute to offsite risk and are not considered further.

APPENDIX C outlines the fire consequence modelling methodology and results in further detail.

Table 6.5: Summary of Consequence Distances For LPG Tank Fire Scenarios

Scenario ID	Scenario description	Distances to injury/fatality (m)			Offsite impact?
		Injury	1% fatality	100% fatality	
LPG 01.1	Piping/tank leak leading to jet fire	-	140	100	No
LPG 01.2	Piping/tank leak leading to flash fire	-	-	Length: 20 Width: 2	No
LPG 01.3 LPG 02.1	Piping/tank leak leading to BLEVE Tank rupture leading to fireball	160	56	47	No
LPG 02.2	Tank rupture leading to flash fire	-	-	Length: 167 Width: 154	No

6.5. Consequence Assessment of Explosion Scenarios

The TNT equivalence model was used to estimate explosion overpressure effects. This method involves:

1. Equating the material of interest to an equivalent mass of TNT. This is known as the Net Explosive Quantity (NEQ).
2. Estimating the distance to the overpressure levels of interest using a scaling law known as the TNT overpressure versus scaled distance relationship.

6.5.1. TNT Equivalent Mass

To equate ANE to an equivalent mass of TNT, the following relationship is used:

$$NEQ = e\ Mass_{ANE}$$

- **TNT equivalence (e)**: This parameter is essentially a ratio of the blast energy produced by the explosive of interest to the blast energy produced by the same quantity of TNT. The value provided by the Class 5.1 ANE supplier is 0.74.

6.5.2. Overpressure versus Scaled Distance Equations

Overpressure versus scaled distance relationships are presented as equations or graphs. In this case a modified Kingery and Bulmash correlation is used to estimate the scaled distance (Z) from the overpressure of interest (Ref. 9). The Kingery and Bulmash correlation is as follows:

$$P = \exp(A + B.X_o + C.X_o^2 + D.X_o^3 + E.X_o^4)$$

$$X_o = \ln(Z_o)$$

$$Z_o = d / NEQ^{0.333}$$

Where:

Z_o is scaled distance ($m/kg^{0.333}$)

d is distance at a particular overpressure level (m)

P is overpressure (kPa)

NEQ is Net Explosive Quantity (kg)

Refer to APPENDIX E for the Kingery and Bulmash coefficients (A, B, C, D and E), the overpressure (P) levels of interest and solutions to the equation, as these coefficients vary depending on Z_o.

6.6. Consequence Results for Explosion Scenarios

Overpressure results for the scenarios identified for the proposed facility are shown in Table 6.6. The results show that:

- Distance to the 70 kPa level (100% probability of fatality to individuals located outside – ie not in a building) is 142 m and extend 114 m beyond the site boundary (minimum distance to the site boundary is 28 m from the ANE storage). However, the ANE storage area is approximately 2 km away from the nearest residential building in the town of Tomingley and hence, will not to impact any offsite populations.

- Similarly, distance to 21 kPa level is 291 m. The scenario is capable of causing fatality (1%) within this radius and presents an offsite risk to individuals. Again, this overpressure level does not reach the nearest residence.
- Distances to 7 kPa and 14 kPa levels can cause some form of injury for an individual in the open and damage to houses. The distances to these levels are 664 m and 387 m respectively, which again does not reach the nearest residence.

Similar analysis can be applied to Class 1.1 explosives to determine distances to explosion overpressure levels. The NEQ for the Class 1.1 explosives is five times less than the NEQ for ANE and consequently the distances to overpressure levels would be less. Results for ANE were taken to be the worst case scenario of an explosion in the ANE/Class 1.1 explosives compound.

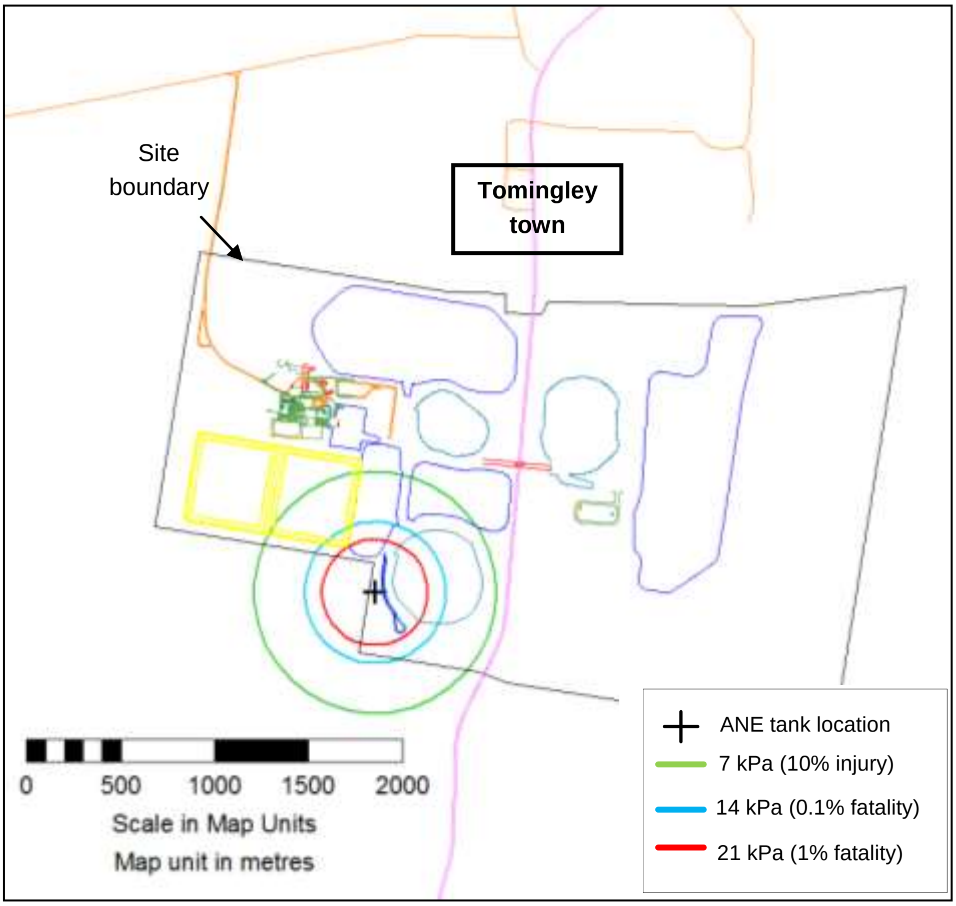
Due to proximity to the site boundary and hence the potential offsite impacts, this scenario was carried forward for assessment against the HIPAP 4 injury, fatality and property damage risk criteria.

Figure 6.1 shows the distances to the 7, 14 and 21 kPa overpressure levels on the mine site layout.

Table 6.6: Consequence Analysis Results – Explosion Overpressure Scenarios

Scenario ID	Scenario Description	Max storage quantity (T)	Equivalence	NEQ (kg)	Distance to Overpressure (kPa) (m) (% fatality)					Minimum distance to site boundary (m)	Offsite impact?
					70 (100%)	35 (15%)	21 (1%)	14 (0.1%)	7 (-)		
ANE-01	Explosion in ANE tanks due to contamination, external fire or missile/high energy shock wave	68	0.74	50,320	142	210	291	387	664	28	Yes

Figure 6.1: ANE Explosion Overpressure Overlays on Site Layout



6.7. Toxic Effects

An external fire involving ANE or ANE contamination would lead to ANE decomposition followed by nitrogen oxide gas (NOx) emissions and an eventual explosion if gases are confined. Nitrogen oxide gas toxic dispersion was not assessed quantitatively. NOx evaluation is a precursor to an explosion event and evolved gases are at elevated temperature, hence buoyant, and would not have a significant impact at ground level. The likelihood of the causes leading to a decomposition of ANE is given in Section 7.1.3.

7. EXPLOSION RISK

7.1. Overview

Based on the potential for offsite impact, the following scenarios has been carried forward for further analysis:

- ANE explosion, in the event of ANE decomposition arising from contamination, missile/high energy shock wave or an external fire.
- Class 1.1 explosives detonation.

7.1.1. Quantity Distance Rules

The explosion risk has been assessed in two ways:

1. By comparison against the quantity distance rules in AS 2187.1 and the AEISG Code of Practice.
2. Against threshold impact and risk criteria in HIPAP 4.

For the Class 1.1 explosives detonation, minimum separation distances to protected works were assessed against AS 2187.1 *Explosives – Storage, transport and use Part 1 Storage*. The AEISG has developed a Code of Practice for ANE (Ref. 10) which adopts the same quantity distance rules given in AS 2187.1. It is generally accepted by the explosives industry and regulators that compliance with AS 2187.1 and the AEISG Code will ensure that there will be minimal offsite consequences or escalation effects from explosion events, ie the risk is negligible.

The NEQ values used to determine the minimum separation distances are shown in Table 7.1. The mounded explosives magazine and ANE tank are adequately separated according to AS 2187.1, hence there is minimal risk of sympathetic detonation and the inventories (NEQs) do not require cumulating. The worst case scenario would be an explosion in the ANE tank as this has the higher NEQ value.

Table 7.1: NEQ For ANE and Class 1.1 Explosives

Explosive Material	Net Explosive Quantity (NEQ)	Comment
Ammonium Nitrate Emulsion (ANE) tank	50,320 kg	68,000 kg of ANE NEQ calculation in Section 6.5.1
Class 1.1 explosives (HE) magazine and detonators magazine	10,000 kg	Actual storage is 7,500 kg of Class 1.1 Explosives and 30,000 units of detonators (30 kg). TGO Security Plan uses 10,000 kg NEQ.

7.1.2. HIPAP 4 Explosion Overpressure Guidelines

HIPAP 4 specifies individual fatality risk criteria based on different types of land uses and the property damage risk to offsite public buildings. The HIPAP4 overpressure thresholds were used (Ref. 2) to determine if there was a potential consequence in the land uses covered by the HIPAP4 risk criteria.

Table 7.2 compares the injury, fatality or property damage threshold overpressure to actual distances for land use categories of concern in HIPAP 4. Since the overpressure thresholds were not exceeded at the HIPAP 4 land use categories, the consequence impacts do not reach these land uses, hence the risk levels are acceptable.

Table 7.2: Overpressure Threshold for HIPAP 4 Land Uses

Land Uses	Distance to Overpressure Threshold (m)		Receptors	Minimum Distance to Nearest Receptors (m)	Separation Distance Acceptable?
	7 kPa (Injury)	14 kPa (Fatality or Property Damage)			
Sensitive land uses, including hospitals, schools, aged care	664	387	Tomingley town (assumed to be in town, if any)	2,000	Yes
Residential and hotels	664	387	Tomingley town (houses, hotel)	2,000	Yes
Commercial areas including offices, retail centres, warehouses	664	387	Tomingley town (assumed to be in town, if any)	2,000	Yes
Sporting complexes and active open spaces	664	387	Tomingley town (horse race track)	2,000	Yes

7.1.3. Boundary Risk

As per HIPAP 4, the individual fatality risk to be contained within the boundary of the industrial site is set as a target.

There have been few known ANE explosions in the industry and very limited frequency data is available. ANE is very insensitive to overheating and shock and very difficult to initiate (Ref. 10). The three main causes of an ANE explosion are very unlikely at the Tomingley site as discussed below:

- External fire can cause decomposition of ANE and lead to formation of toxic fumes and an eventual explosion. There are no flammable or combustible materials stored in the vicinity of the ANE tank with the potential for fire. The site is located in an open area and the land in the vicinity of the compound is cleared of bush and vegetation, hence bushfire risk is regarded as low.
- Missile/high energy shock wave to the ANE tank would be caused by an explosion in the Class 1.1 explosives magazine. However, the explosives magazines are mounded and the separation distance between the ANE and magazine was found to be greater than the minimum specified in AS 2187.1 (see Table 7.4).
- Contamination of ANE material can also lead to toxic emissions and eventual explosion. It would be caused by contaminated material delivered by the supplier. This is very unlikely considering there are strict specifications associated with ANE quality delivered onsite and there is no actual mixing or manufacturing of ANE done onsite.

Therefore, the risk of an ANE explosion is considered to be very low. The risk at the boundary of the mine site is considered acceptable as there are no receptors or land uses close to the boundary nearest the ANE storage.

Societal Risk

As the overpressure distance sufficient to cause fatality (14 kPa) does not reach significant populations, societal risk levels are minimal and were not quantified.

Table 7.3 shows the summary of compliance with the HIPAP 4 fatality and property damage risk criteria to land use categories.

Table 7.3: Summary of Compliance With Risk Criteria

Land Uses	**Max Risk (per year)**	**Comments**	**TGO Mine Site Complies with HIPAP 4 Criteria?**
Individual Fatality Risk			
Sensitive uses	0.5×10^{-6}	No fatality impacts in this land use	Yes
Residential areas	1×10^{-6}	No fatality impacts in this land use	Yes
Commercial developments, retail centres, offices, entertainment centres	5×10^{-6}	No fatality impacts in this land use	Yes
Sporting complexes and active open space	10×10^{-6}	No fatality impacts in this land use	Yes

Land Uses	Max Risk (per year)	Comments	TGO Mine Site Complies with HIPAP 4 Criteria?
Remain within boundary of an industrial site	50 x 10^{-6}	Very low event likelihood. ANE/Class 1.1 explosions only scenarios with potential offsite impacts. No receptors within area potentially affected by overpressure.	Yes
Property Damage Risk			
Overpressure at neighbouring potentially hazardous installations or the nearest public building should not exceed a risk of 50 per million per year for the 14 kPa overpressure contour.	50 x 10^{-6}	No neighbouring installations potentially within 14kPa consequence area.	Yes

7.2. Quantity Distance Rules

Table 7.4 compares the minimum required and actual distance of the ANE storage and explosives compound to receptors as defined in AS 2187.

The required separation distances in the AS 2187 standard are more conservative than those to overpressure impact levels from the HIPAP 4 guidelines. For example, the correlation used to determine the separation distance to vulnerable facilities is equivalent to a separation distance to 2 kPa, which is lower than the HIPAP 4 injury threshold (7 kPa) for sensitive populations.

Table 7.4 shows that the actual distances for the ANE tank and Class 1.1 explosives to all receptors comply and exceed the minimum distances required by AS 2187.1. Based on compliance with the more conservative quantity distance rules, the offsite risk level of ANE and explosives storage is acceptable.

It is recommended that throughout the life of the mine site operation, the Project should keep track of changes in land uses adjacent to the ANE compound. If there are changes, ensure that the ANE separation distances to the potential receptors continue to satisfy AS 2187.1.

Figure D.1 in APPENDIX D shows the location of the ANE and explosives compound to the receptors on a Google Earth image. Figure D.2 in APPENDIX D shows the location of the ANE tank relative to the explosives magazine.

Table 7.4: Separation Distances Comparison From ANE and Explosives Storage to Receptors

Receptor	Receptor Group	Details	Actual Separation Distance (m)	Ammonium Nitrate Emulsion (ANE)		Class 1.1 Explosives	
				Minimum Separation Distance (m) from AS 2187.1	Separation Distance Acceptable?	Minimum Separation Distance (m) from AS 2187.1	Separation Distance Acceptable?
Newell Highway	Protected works – Class A	Nearest public road	700	550	Yes	320	Yes
Tomingley Town	Vulnerable facilities	Vulnerable facilities would be in town	2,000	1,640	Yes	960	Yes
Site Administration Offices	Protected works – Class B	Building in which a person is employed in any trade or business	1,200	820	Yes	480	Yes
Processing Facility > 10 people[(a)]	Protected works – Class B	Depot for LPG and other DGs	1,000	820	Yes	270	Yes
Explosives and Detonator Storage	Associated works	Mounded storage (Note 5 in Table 3.2.3.2 in AS 2187.1)	50	20	Yes	-	-

(a) Processing Facility is not related to manufacture or storage of explosives. This is considered to be typical of a place of work involving DGs and is assessed against Protected Works – Class B.

8. RISK TO BIOPHYSICAL ENVIRONMENT

The main concern relating to environmental risk from accident events is generally with effects on whole systems or populations. HIPAP 4 provides the following qualitative guidance for assessment of environmental risk due to accident events:

- *Industrial developments should not be sited in proximity to sensitive natural environmental areas where the effects (consequences) of the more likely accidental emission may threaten the long-term viability of the ecosystem or any species within it.*
- *Industrial developments should not be sited in proximity to sensitive natural environmental areas where the likelihood (probability) of impacts that may threaten the long-term viability of the ecosystem or any species within it is not substantially lower than the background level of threat to the ecosystem.*

Potential hazardous incident scenarios identified for the processing plant were toxic releases of nitrogen dioxide gas, hydrochloric acid and sodium cyanide solution.

Potential risks to the biophysical environment due to loss of containment events and control measures in place to prevent or reduce any impacts are briefly summarised in the following sections.

8.1. Explosion Events Resulting In Bushfire

Overpressures associated with an ANE or Class 1.1 explosion event may damage some vegetation and fauna in the vicinity, however are unlikely to affect the long-term viability of the ecosystem or any species within it. It is possible that an explosion could result in a bushfire with resulting adverse effects on the environment. This scenario is unlikely as the site is located in an open area and the land in the vicinity of the explosives compound is cleared of bush and vegetation.

8.2. Escape of Liquid Materials

Chemicals on the plant include sodium cyanide and hydrochloric acid. Hydrochloric acid is corrosive but has no long term environmental impacts. Sodium cyanide solution release is very toxic and has acute impact on aquatic life. Concentrated sodium cyanide solution is used for processing and is also stored as a very dilute solution (less than 20ppm) as waste water in the RSF and process water dam. The impact on the biophysical environment will be dependent on the leak location ie processing plant or RSF/process water dam.

8.2.1. Processing plant

On the processing plant, all cyanide solids and liquids will be stored within bunded areas. Spill kits will be provided enabling recovery of small quantities of spilt materials. A spill of any of these chemicals would have very localised impacts. The likelihood of any spill reaching the environment will also be very low due to the onsite containment devices and sealed surfaces.

A site specific Hazardous Materials Management Plan has been prepared that covers these materials (refer to http://www.alkane.com.au/index.php/projects/current-projects/tomingley-gold-operations).

8.2.2. RSF / Process Water Dam

Sodium cyanide levels in waste water are reduced (using a sodium metabisulfite / air stripping treatment process) to less than 20ppm before reaching the RSF/Process Water Dam. However releases from the RSF or process water dam may lead to offsite environmental impact. The risk of sodium cyanide release from these areas were assessed qualitatively in the PHA (Ref. 4) as tolerable based on design controls, management actions and contingency plans implemented by the Proposal.

Review of the detailed design confirms that the primary (preventative) control reducing the risk of dilute cyanide leaking or overflowing from the dams is the design and construction of the RSF and Process Water Dam (as specified in the project conditions of approval, ref NSW DoP, 09_0155, 24 July 2012):

- The RSF will be lined with a compacted clay liner with a permeability of $<1\times10^{-9}$ m/s and operated with a sufficient freeboard to prevent overflow. The RSF is designed for 1 in 100 year, 72 hour rainfall event.
- The Process Water Dam is HDPE lined with freeboard levels designed for a 1 in 100 year, 72 hour event.

On the Process Water Dam, an ultrasonic level sensor activates an alarm in the control room. The decant return pumps and raw water pump (make-up water sources) are interlocked with this level sensor and automatically shut down the pumps on high level. A backup independent floating ball high high level switch activates alarms in the control room and audible alarms in the field. The overflow from the dam is sent to Sediment pond 1, which is also constructed of low permeability clay (1×10^{-9} m/s). This pond is fitted with a hard wired pump to allow any inflows to be recovered quickly to the RSF. The process water system level management was covered in the HAZOP (Ref *HAZOP Minutes Process Water Pond 18/11/2013*).

The operational controls for preventing overflow from the RSF are as follows:

- Maintain free board levels
- Maintain small decant pond area
- Conduct monthly geotech inspections
- Deposition plan to correct rate of rise
- Allow tailings time to dry before construction.

Secondary (mitigative) controls are the implementation of a shallow groundwater bore monitoring program to confirm there is no leaching of contaminated water from the RSF or Process Water Dam and regular monitoring of the area for fauna mortality.

8.3. Escape of Gaseous Materials

Nitrogen dioxide gas have toxic effects that are primarily health and safety-related. This is only produced in the event of an external fire or contamination of ANE.

9. CONCLUSIONS AND RECOMMENDATION

The SEPP 33 screening study determined that the following hazardous materials stored on TGO mine site had the potential for offsite impact:

- Class 1.1 explosives
- Liquefied Petroleum Gas (LPG)
- Ammonium Nitrate Emulsion (ANE)
- Sodium cyanide
- Hydrochloric acid.

9.1. Conclusions

Overall the following conclusions can be drawn from hazard analysis:

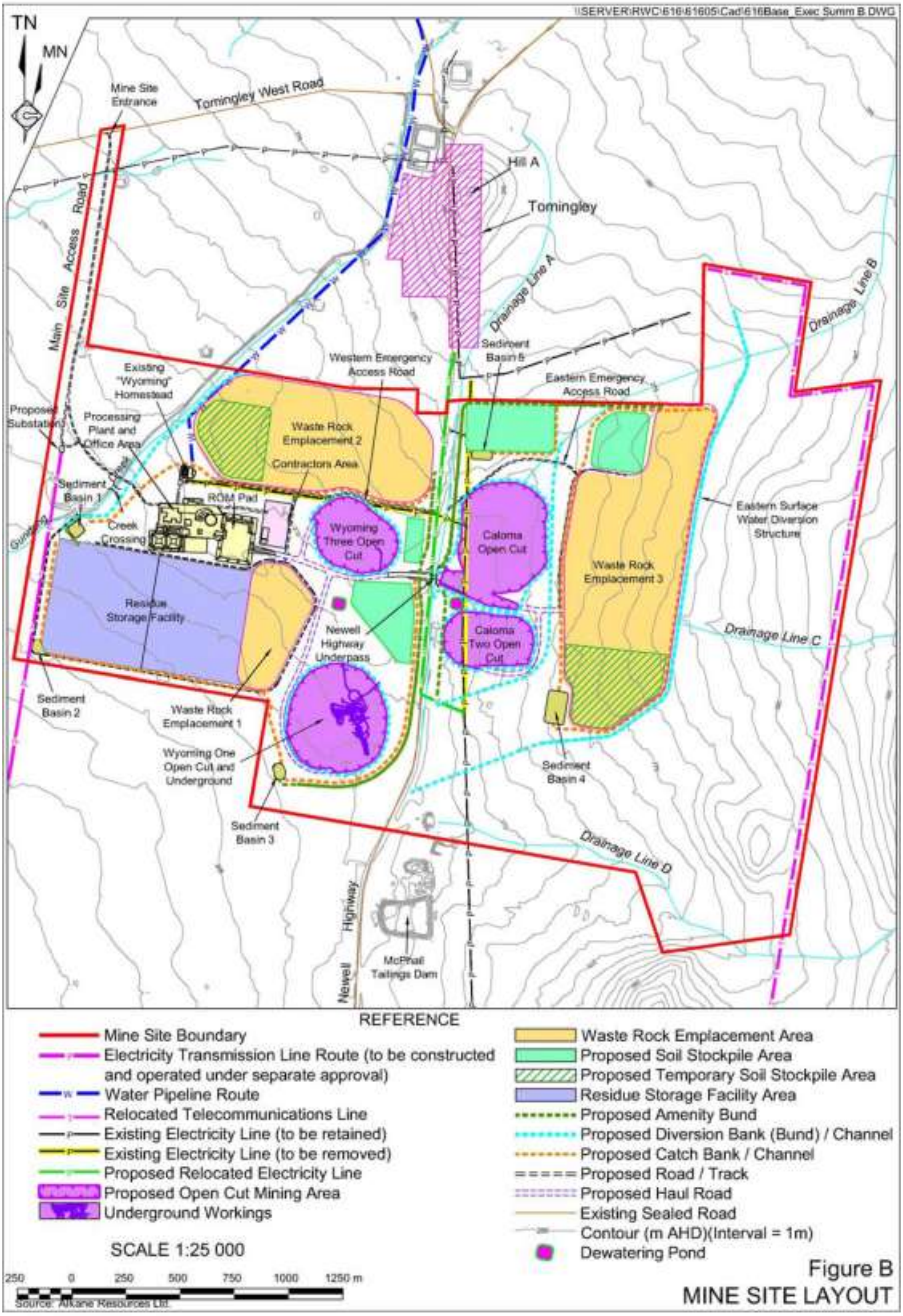
- Class 1.1 explosives: The explosion risk for Class 1.1 explosives storage was found to be acceptable by satisfying minimum separation distances to receptors according to AS 2187.1 Explosives – Storage, transport and use Part 1 Storage.
- Hydrochloric acid: Acid spills on the processing plant or storage have limited offsite impact with the implementation of spill management procedures, adequate bunding and storage and handling according to appropriate Australian standards.
- LPG: Quantitative consequence assessment found that distances to heat radiation generated by LPG fires or BLEVEs causing 1% fatality (4.7 kW/m2) and 100% fatality (23 kW/m2) did not extend offsite.
- ANE: Quantitative consequence assessment found that ANE explosion overpressure distances to 1% fatality (21 kPa) extend offsite. Assessment against HIPAP 4 risk criteria showed that offsite injury, fatality and property damage overpressure thresholds (7 and 14 kPa) did not reach the relevant land use categories. A comparison of minimum and actual separation distances to certain receptors showed compliance with the AEISG Code of Practice for ANEs and consequently, AS 2187.1. Therefore, the offsite risks associated with ANE explosions are acceptable.
- Risk to the biophysical environment from releases of dilute cyanide solutions from the process water dam or Residue Storage Facility (RSF) is minimised by design and construction the dams with very low permeability and liners (as specified in the project conditions of approval reference 09_0155) to prevent leakage, and also managing the levels the in the dams with sufficient freeboard operationally to prevent overflows. The design (which was subject to HAZOP) includes level interlocks preventing additional inflow to dams if the level is high, supplemented by an independent high level alarm.

9.2. Recommendation

The separation distance to various receptors currently satisfies the requirements in AS 2187.1. It is recommended that throughout the life of the mine site operation, Project should monitor changes in land uses adjacent to the ANE compound. If there are changes, ensure that the ANE separation distances to the potential receptors continue to satisfy AS 2187.1.

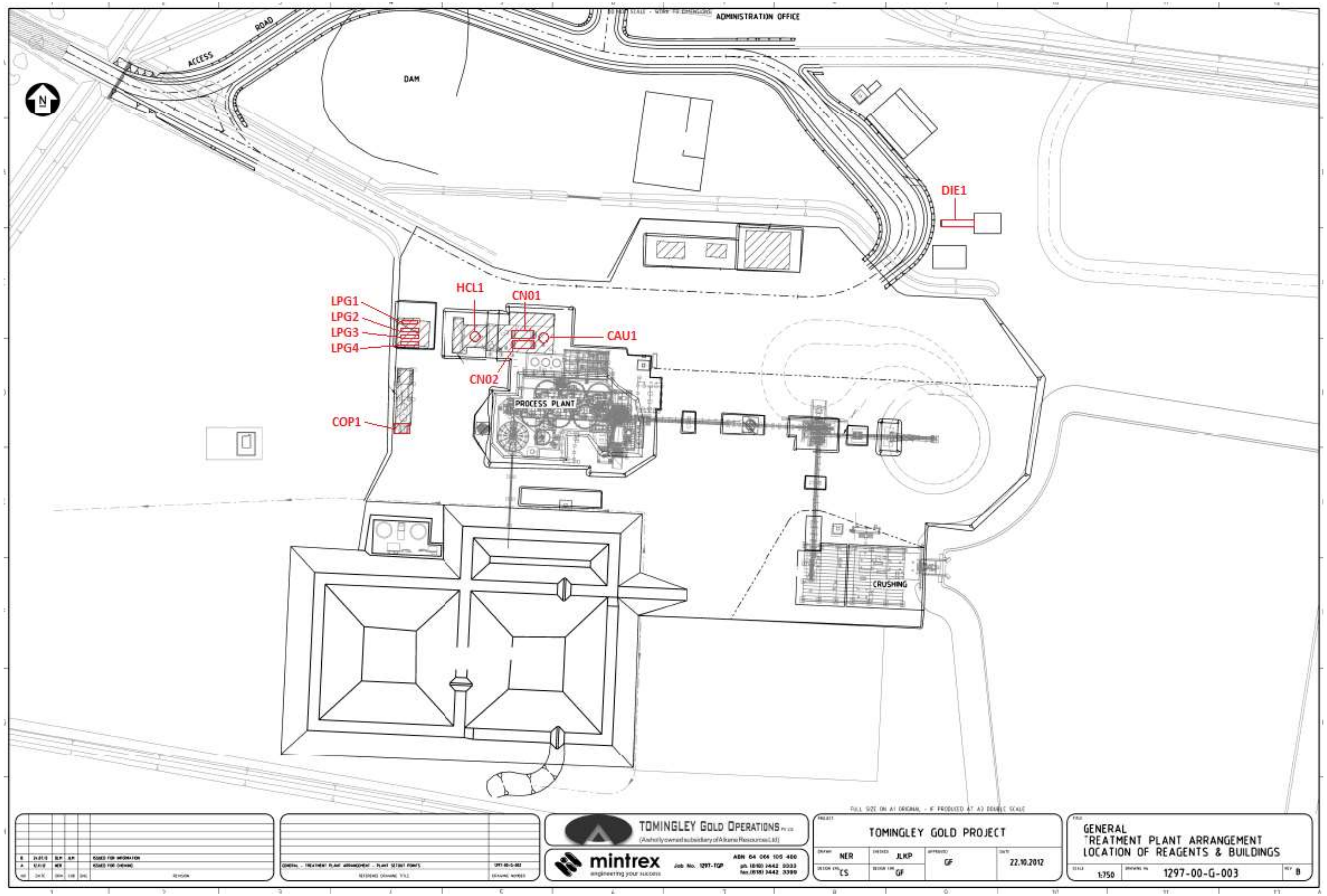
APPENDIX A. SITE LAYOUT

Figure A.1: Tomingley Mine Site Layout (Ref. 12)



Note. The existing "Wyoming" homestead has been converted into exploration or training offices for the site.

Figure A.2: Storage Tank Location On Processing Plant Layout



APPENDIX B. HAZARDOUS MATERIALS

The table below summarises the storage arrangements and the SEPP 33 screening study of the hazardous materials on the Tomingley Mine Site.

Material	DG class	Total quantity (L) [1]	Storage arrangements [1]	Storage facility ID	SEPP 33 threshold	Threshold exceeded?
Explosives, blasting, type B Explosives, blasting, type E Booster Cord detonating Detonators, non-electric	1.1	(7,530 kg) [2]	Magazine	ACE1/ANE1	Based on Figure 5 (Ref. 11) screening threshold: For 7.5 tonne of Class 1.1, proposal is potentially hazardous if distance to site boundary is less than approximately 280 m. Closest distance to site boundary is 28.5 m [1].	Yes
Liquefied Petroleum Gas (LPG)	2.1	30,000	4 above ground tanks (7,500 L each)	LPG1, LPG2, LPG3 & LPG4	Based on Table 3 (Ref. 11) screening threshold: 16 m^3 of Class 2.1 (LPG only – excluding automotive retail outlets) if stored above ground	Yes
Ammonium Nitrate Emulsion (ANE)	5.1 PG II	46,800 (68 tonne)	Above ground tank	ANE1	Based on Table 3 (Ref. 11) screening threshold: 5 tonne of Class 5.1 (any other Class 5.1)	Yes
Sodium cyanide solution	6.1 PG I	200,000 (320 tonne)	2 above ground tanks (100,000 L each)	CN01 & CN02	Based on Table 3 (Ref. 11) screening threshold: 0.5 tonne of Class 6.1 PG I	Yes
Hydrochloric acid	8 PG II	30,000	Above ground tank	HCL1	Based on Table 3 (Ref. 11) screening threshold: 25 m^3 of Class 8 PG II	Yes

Material	DG class	Total quantity (L) [1]	Storage arrangements [1]	Storage facility ID	SEPP 33 threshold	Threshold exceeded?
Caustic soda (sodium hydroxide solution)	8 PG II	20,000	Above ground tank	CAU1	Based on Table 3 (Ref. 11) screening threshold: 25 m^3 of Class 8 PG II	No
Acetic acid solution	8 PG III	2,000	Tank - Intermediate Bulk Container (IBC)	ACE1	Based on Table 3 (Ref. 11) screening threshold: 50 m^3 of Class 8 PG II	No
Copper sulphate solution	9 PG III	20,000	Tank - IBC	COP1	No threshold identified based on SEPP 33. Class 9 PG III not potentially hazardous material as per SEPP 33.	N/A
Diesel fuel	Combustible Class C1	110,000	Above ground tank	DIE1	No threshold identified based on SEPP 33. If diesel is stored in the same bund as gasoline (Class 3 PG II), total inventory of diesel will be classified as Class 3 PG II. No other flammables stored with diesel.	N/A
Diesel fuel	Combustible Class C1	110,000	Above ground tank	DIE2	No threshold identified based on SEPP 33. If diesel is stored in the same bund as gasoline (Class 3 PG II), total inventory of diesel will be classified as Class 3 PG II. No other flammables stored with diesel.	N/A

Notes:

1. Information provided by client.
2. Total quantity of Class 1.1 explosives comprises 7,500 kg Class 1.1D explosive material and a nominal 30 kg for Class 1.1B detonators.

APPENDIX C. CONSEQUENCE ANALYSIS

C1. Consequence Analysis Methodology

The following parameters were assumed in all LPG fire cases:

Parameter	Value	Source
Chemical	Propane	MSDS. To be conservative, 100% propane was assumed.
Ambient temperature	24 ^{o}C	Annual average (Ref. 13)
Stability/windspeeds (m/s)	B3, D5 and F2	Typical sets of weather conditions
Surface roughness	0.1 m	Assumed to be low crops, occasional large obstacles

The MSDS for LPG states that LPG may also be supplied as butane. A sensitivity analysis was conducted by analysing all LPG fire scenarios with 100% butane. Modelling parameters and results are for 100% propane unless stated otherwise.

C1.1. Jet Fire

Jet fires result from the ignition of a high-pressure release of gas from a leak in a pipe or vessel. Depending on the liquid level in the tank and the location of the leak, LPG can be released as a vapour (if hole is located on the vapour space of tank) or a liquid, but instantaneously flashes on release. If this gas ignites, a jet fire would result. A liquid LPG release will be the worst case scenario as it gives a higher mass release rate. A liquid release rate as used for the consequence analysis.

Storage conditions were used as input parameters to determine the release rate from a leak in the LPG tank/piping. This release rate from a hole in the tank/piping was used to determine the distances to injury/fatality. TNO Effects uses the Chamberlain model to assess a jet fire scenario.

Table C.1 shows the storage conditions parameters used for the jet fire and flash fire consequence/release rate modeling. The LPG release rate was calculated to be 34 kg/s.

C1.2. Flash Fire

A flash fire occurs when a cloud of vapour accumulates and spreads until the edge of the cloud reaches a source of ignition. A flame at the edge then passes rapidly through the cloud. If a person is within the cloud when it ignites, the resultant injury may be serious or fatal.

There are two extents of flash fire considered in this consequence analysis. One is caused by a LPG piping/tank leak and the other is a full tank rupture. The flash fire consequence distances from a leak were modelled using the ‘gas turbulent free jet’. The tank rupture case results in an instantaneous release of LPG and the consequence distances were determined using a dense gas dispersion model since LPG vapour is denser than air.

Table C.1: Modelling Input Parameters – Jet Fire and Flash Fire Scenarios

Parameter	Value	Source/Comment
Input Data		
Capacity per vessel	7,500 L	TGO ‘Summary of Dangerous Goods’
Leak size	50 mm	Assumption
Release Orientation	Horizontal	Assume worst case scenario
Vessel filling degree	100 %	Assume maximum filling degree
Vessel temperature	24°C	Assume LPG stored at ambient temperature
Vessel pressure	9.3 bara	Assume LPG stored at vapour pressure
Findings		
Release rate	34 kg/s	TNO Effects output

C1.3. BLEVE/fireball

The fireball scenario was modelled using the fireball model described in the TNO Yellow Book (Ref. 8).

The BLEVE and fireball scenarios for a LPG tank were modelled using the same fireball model. This is because the causes are different but the consequences are the same.

A summary of the modeling input data is given in Table C.2. Atmospheric conditions were not relevant in the model due to the high energy and short duration of the fireball.

Table C.2: Modelling Input Parameters – Fireball/BLEVE Scenario

Parameter	Value	Comments
Capacity per vessel	7,500 L	As provided in ‘Summary of Dangerous Goods’
	3,716 kg	Based on a density of 485 kg/m^3 (taken from TNO Effects)
Vessel filling degree	100 %	Assume maximum filling degree
Vessel temperature	24°C	Assume LPG stored at ambient temperature

Parameter	Value	Comments
Vessel pressure	9.3 bara	Assume LPG stored at vapour pressure

C2. Consequence Results of Fire Scenarios

The consequence distances to for the jet fire, flash fire and fireball scenarios are shown in Table C.3, Table C.4 and Table C.5 respectively. These tables report results for F2 conditions as it produced the worst consequence distances.

The results show that the worst LPG fire scenario is a flash fire in the event of a full tank rupture. The distance to LEL is 167 m for 100% propane. The distance is well within the site boundary, which is 554 m from LPG storage tanks. This indicates that there are no offsite impacts for any LPG tank/piping leak or LPG tank rupture scenarios, and was not considered further for the FHA.

The results in Table C.3 to Table C.5 include the consequence results for LPG containing 100% butane. The worst consequence distance for a tank containing 100% butane was also caused by a tank rupture leading to a flash fire.

Table C.3: Consequence Analysis Results – Jet Fire Scenarios

Scenario ID	Scenario	Material	Hole size (mm)	Release Rate (kg/s)	Flame length (m)	Flame width (m)	Distance (m) to heat radiation levels		Minimum distance to site boundary (m)	Offsite impact ?
							4.7 kW/m^2	23 kW/m^2		
LPG-01.1	Jet fire from LPG1/LPG2/LPG3/LPG 4 tank/piping leak	Propane	50	34	72	26	140	100	554	No
LPG-01.1	Jet fire from LPG1/LPG2/LPG3/LPG 4 tank/piping leak	Butane	50	16	53	23	106	77	554	No

Table C.4: Consequence Analysis Results – Flash Fire Scenarios

Scenario ID	Scenario	Material	Hole size (mm)	Release Rate (kg/s)	Distance (m) to LEL		Minimum distance to site boundary (m)	Offsite impact?
					Length	Width		
LPG-01.2	Flash fire due to LPG1/LPG2/ LPG3/LPG4 tank/piping leak	Propane	50	34	20	2	554	No
LPG-01.2	Flash fire due to LPG1/LPG2/ LPG3/LPG4 tank/piping leak	Butane	50	16	10	1	554	No
LPG-02.2	Flash fire due to LPG1/LPG2/ LPG3/LPG4 tank rupture	Propane	Rupture	Instantaneous	167	154	554	No
LPG-02.2	Flash fire due to LPG1/LPG2/ LPG3/LPG4 tank rupture	Butane	Rupture	Instantaneous	173	160	554	No

Table C.5: Consequence Analysis Results – Fireball/BLEVE Scenarios

Scenario ID	Scenario	Material	Fuel mass (kg)	Fireball radius (m)	Fireball duration (s)	Distance (m) to following fatality probabilities/injury			Minimum distance to site boundary (m)	Offsite impact?
						100%	1%	Injury		
LPG-01.3 LPG-02.1	BLEVE due to LPG1/LPG2/LPG3/ LPG4 tank/piping leak or Fireball due to LPG1/LPG2/LPG3/ LPG4 tank rupture	Propane	3,716	47	7	47[(a)]	56	160	554	No
LPG-01.3 LPG-02.1	BLEVE due to LPG1/LPG2/LPG3/ LPG4 tank/piping leak or Fireball due to LPG1/LPG2/LPG3/ LPG4 tank rupture	Butane	4,310	49	8	49[(a)]	-[(b)]	134	554	No

(a) Distance to 100% fatality was assumed to be equal to the fireball radius

(b) Does not reach the heat radiation level (and hence fatality probability) at target location

APPENDIX D. ANE AND EXPLOSIVES STORAGE SEPARATION DISTANCES

Figure D.1: Class 1.1 Explosives Separation Distances to Protected Works

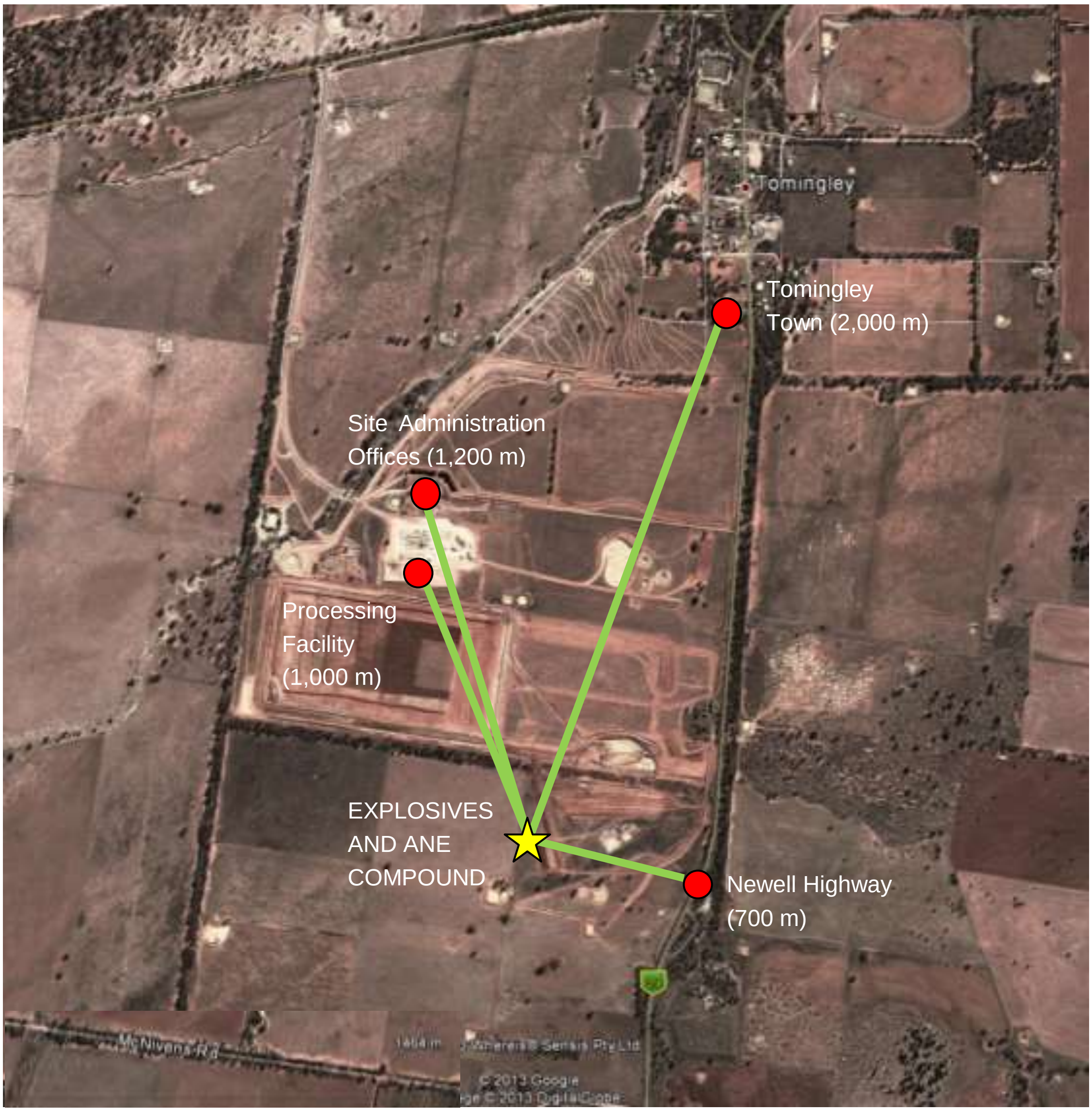
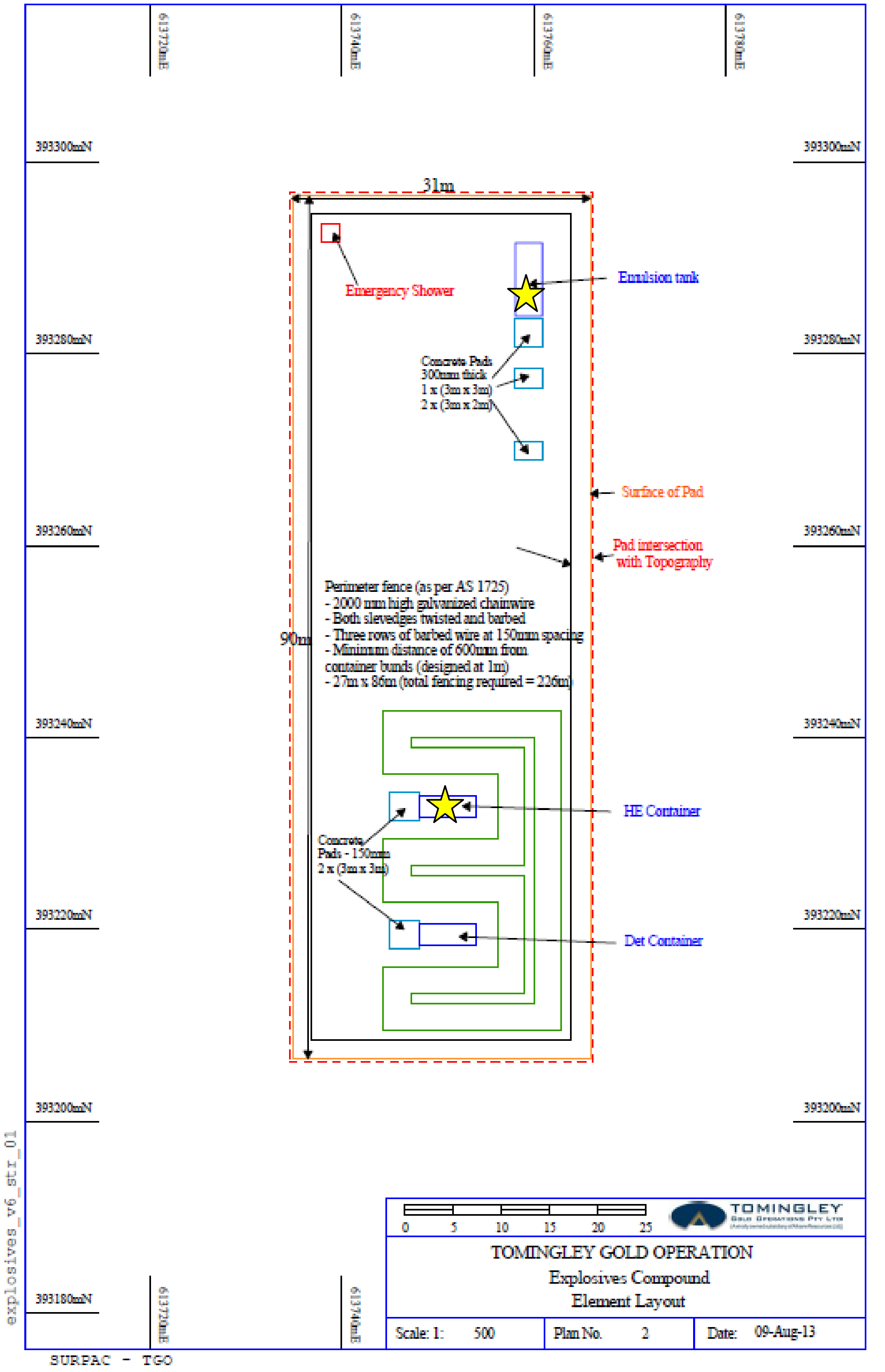


Figure D.2: Class 1.1 Explosives Separation Distances to ANE Tank



APPENDIX E. EXPLOSION OVERPRESSURE CONSEQUENCE MODELLING METHODOLOGY

References:	Department of Defense Explosives Safety Board Alexandria, VA 2 February 2007						
	TP no 14 Rev 3 APPROVED METHODS AND ALGORITHMS FOR DOD RISK-BASED EXPLOSIVES SITING						
Objective:	Use Kingery-Bulmarsh TNT correlation to estimate effect distances to defined overpressure levels for explosions						
Method:	This worksheet solves the K-B equations for a range of overpressure levels to determine the equivalent effective hazard factor (Z_o)						
	The estimated Z is then used to calculate impact distance from the NEQ on worksheets "Conseq distances".						
P	psi						
d	feet						
Y	pounds						
Z	ft/lbs$^{1/3}$						
Z_o =	d/NEQ $^{0.333}$						
X_o =	ln (Z_o)						
Ref: pg 22, and pg A-3, Table A-3							
P =	e ($A + B.X_o + C.X_o^2 + D.X_o^3 + E.X_o^4$)						
Z (ft/lbs$^{1/3}$)		A	B	C	D	E	
0.5 - 7.25		6.9137	-1.4398	-0.2815	-0.1416	0.0685	
7.25 - 60		8.8035	-3.7001	0.2709	0.0733	-0.0127	
60 - 500		5.4233	-1.4066	0	0	0	
P (kpa)		**70**	**35**	**21**	**14**	**7**	**2**
P (psi)		10.15	5.075	3.045	2.03	1.015	0.29
ln(P) psi		2.317473705	1.624326525	1.113500901	0.708035793	0.014888612	-1.237874356
Use Excel Solver to solve for Xo (ft):							
Upper X							
1.9810		**2.2937**	**2.8903**	**2.8903**	**2.8903**	**2.8903**	**2.8903**
4.0943		2.2715	2.6585	2.9852	3.2728	3.8112	4.7304
6.2146		**2.2080**	**2.7008**	**3.0640**	**3.3522**	**3.8450**	**4.7357**
Excel solver ln(P) recalc		2.3175	1.7621	1.7621	1.7621	1.7621	1.7621
		2.3175	1.6243	1.1135	0.7080	0.0149	-1.2379
		2.3175	1.6243	1.1135	0.7080	0.0149	-1.2379
solver check		0.0000	**0.1377**	**0.6486**	**1.0540**	**1.7472**	**3.0000**
(aim: diff in ln(P) ~ 0)		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Z (ft/lbs$^{1/3}$)	Z range						
	0.5 - 7.25	9.911749761	17.99867379	17.99867379	17.99867379	17.99867379	17.99867379
	7.25 - 60	9.69395392	14.27442447	19.79003169	26.38421589	45.20409957	113.3426499
	60 - 500	9.097840801	14.89193904	21.41266832	28.56670039	46.75979466	113.9381186
Z (m/kg$^{1/3}$)	Z range						
	2.882924057	3.941354735	7.157077196	7.157077196	7.157077196	7.157077196	7.157077196
	23.85868185	**3.854749374**	**5.676149199**	**7.869401165**	**10.49154355**	**17.9751705**	**45.07010373**
	198.8223487	3.617708153	5.921700595	8.514634015	11.35939694	18.5937844	45.30688868
Conversion:		0.397644697					
ft/lb^.333 to m/kg^.333							

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Calculation of consequence distances

QRA Scenario			Consequence Model Parameters							Distance to Overpressure (kPa) (m) probability of fatality						Distance to nearest boundary (m)
Scenario ID	**Area**	**Scenario Description**	**Material**	**Max storage quantity (te)**	**proportion AN**	**Theoretical Mass Avail for Explosion (te)**	**Equivalence**	**Efficiency**	**NEQ (kg)**	**70**	**35**	**21**	**14**	**7**	**2**	
ANE-01	ANE Storage	Explosion in ANE tanks due to contamination, external fire or missile/high energy shock wave	ANE	68	1	68	0.74	1	50320	142	210	291	387	664	1664	28

APPENDIX F. SEPP33 REPORT

SEPP 33 RISK SCREENING

TOMINGLEY MINE SITE

TOMINGLEY GOLD OPERATIONS PTY LTD

PREPARED FOR:	**Simone Painter**
	Tomingley Gold Operations Pty Ltd

DOCUMENT NO:	**20783-RP-001**
REVISION:	**A**
DATE:	**18 September 2013**

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Title: **SEPP 33 Risk Screening** **Tomingley Mine Site**	**QA Verified:** **M LIU**
	Date: 18 September 2013

CONTENTS

TABLES

FIGURES

ABBREVIATIONS

ADG	Australian Dangerous Goods
ANE	Ammonium Nitrate Emulsion
DG	Dangerous Goods
EIS	Environmental Impact Statement
EPL	Environmental Protection Licence
FHA	Final Hazard Analysis
IBC	Intermediate Bulk Container
LPG	Liquefied Petroleum Gas
MSDS	Material Safety Data Sheet
NSW	New South Wales
PG	Packing Group
PHA	Preliminary Hazard Analysis
SEPP	State Environmental Planning Policy
TGO	Tomingley Gold Operations Pty Ltd

1. INTRODUCTION

1.1. Background

Tomingley Gold Operations Pty Ltd (TGO), a wholly owned subsidiary of Alkane Resources Limited, is developing a mine site near Tomingley (the Proposal). The project is in the final stages and preparing to commence operations.

RW Corkery & Co Pty Limited was retained by the project to develop the Environmental Impact Statement (EIS) for the mine site. The EIS included a Preliminary Hazard Analysis (PHA), which incorporated a screening of the site hazardous materials against the criteria in *State Environmental Planning Policy 33 – Hazardous and Offensive Development* (SEPP 33).

TGO has engaged Sherpa Consulting Pty Ltd (Sherpa) to update the PHA of the project to a Final Hazard Analysis (FHA). It is noted that there are a number of significant differences between the hazardous materials storage assessed in the PHA and the proposed final storage arrangements. Consequently, an update of the SEPP 33 screening is required as an input to the FHA.

This report summarises the results of the review undertaken for the Tomingley mine site to determine whether it would be considered by SEPP 33 to be a *'potentially hazardous industry'* and/or *'potentially offensive industry'*, and will be incorporated into the FHA to be developed.

1.2. SEPP 33 applicability

SEPP 33 links the permissibility of an industrial development to its offsite safety and environmental risks. Developments that involve storage, handling or processing materials which, in the absence of locational, technical or operational controls, may create an offsite risk or offence to people, property or the environment are defined by SEPP 33 as *'potentially hazardous industry'* or '*potentially offensive industry'.*

Development proposals that are classified as potentially hazardous industry must undergo a Preliminary Hazard Assessment (PHA) to determine the risk to people, property and the environment. If the residual risk exceeds the acceptability criteria, the development is 'hazardous industry' and may not be permissible within NSW.

Developments that have the potential to emit contaminants to the environment and which require an Environmental Protection Licence (EPL) are 'potentially offensive'.

1.3. Scope and objectives

The normal objective of a SEPP 33 review is to determine whether the proposed dangerous goods store/facility operations is considered *Hazardous* or *Potentially Hazardous* (and therefore requiring a PHA to be prepared) within the meaning of SEPP 33.

Since a FHA is required for the Tomingley mine site, the objective of this SEPP 33 review is to identify the hazardous materials that need to be carried forward for assessment in the FHA, based on the SEPP 33 screening guidelines.

1.4. Method

The screening process published in the NSW Department of Planning guideline *Hazardous & Offensive Development Application Guidelines – Applying SEPP 33 (January 2011)* (Ref. 1) was used to establish whether the Proposal is 'potentially hazardous' or 'potentially offensive'.

2. SEPP 33 ASSESSMENT

2.1. Potentially hazardous development

SEPP 33 defines potentially hazardous industry as follows:

> *'Potentially hazardous industry'* means a development for the purposes of an industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality:
>
> (a) to human health, life or property; or
>
> (b) to the biophysical environment, and:
>
> includes a hazardous industry and a hazardous storage establishment.

To determine whether a proposed development is potentially hazardous, the risk screening process in the *Applying SEPP 33* guideline considers the type and quantity of hazardous materials to be stored on the site and the distance of the storage area to the nearest site boundary, as well as the expected number of transport movements.

'Hazardous materials' are defined within the *Applying SEPP 33* guideline as substances that fall within the classification of the Australian Dangerous Goods Code (ADG), ie have a Dangerous Goods (DG) classification.

2.1.1. Storage and handling

A list of the expected types and quantities of hazardous materials to be stored or handled at the Tomingley mine site, together with the relevant SEPP 33 screening threshold, is presented in Table 2.1. Site layouts showing the approximate locations of these inventories are shown in Figure 2.1 and Figure 2.2.

Table 2.1 shows that the SEPP 33 thresholds are exceeded for the following materials:

- Explosives (Class 1.1)
- Liquefied Petroleum Gas (LPG) (Class 2.1)
- Ammonium Nitrate Emulsion (ANE) (Class 5.1)
- Sodium cyanide solution (Class 6.1)
- Hydrochloric acid (Class 8).

Therefore, the Proposal is 'potentially hazardous' and the FHA should take account of the above materials.

2.1.2. Transport

A list of the expected types and quantities of hazardous materials transport movements to and from the site together with the relevant SEPP 33 screening thresholds is presented in Table 2.2.

A route evaluation study is required due to the movements of trucks carrying sodium cyanide. In addition, the NSW Department of Planning should be contacted for advice on the transport of explosives.

2.1.3. Other hazards

Additional hazards to be considered that are not explicitly covered by the *Applying SEPP 33* guideline include:

- Reactions/incompatibilities between materials
- Dust explosion hazards
- Hazardous processing conditions (eg high temperatures and pressures).

A review of the Material Safety Data Sheets (MSDSs) provided for the materials to be handled at the site was undertaken. Other potential hazards not specifically addressed by the *Applying SEPP 33* screening process will be discussed further in the FHA to identify any significant off-site risk.

2.2. Potentially offensive development

SEPP 33 defines potentially offensive industry as follows:

> *'Potentially offensive industry'* means a development for the purposes of an industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would emit a polluting discharge (including, for example, noise) in a manner which would have a significant adverse impact in the locality or on the existing or likely future development on other land, and includes an offensive industry and an offensive storage establishment.

In the absence of controls, the Proposal has the potential to cause pollutants to be discharged to water, air and soil. The Proposal is considered 'potentially offensive industry' and will require an Environmental Protection Licence (EPL).

2.3. Conclusions

The screening risk assessment demonstrates that the quantities of hazardous materials proposed to be stored and handled at the site are well above the screening thresholds nominated in SEPP 33. Consequently, the Proposal is classified as 'potentially hazardous'.

The following DG must be considered in the FHA:

- Class 1.1 explosives
- LPG
- ANE
- Sodium cyanide
- Hydrochloric acid.

A route evaluation study is required due to the movements of trucks carrying sodium cyanide. In addition, the NSW Department of Planning should be contacted for advice on the transport of explosives.

Table 2.1: SEPP 33 hazardous material storage screening summary

Material	DG class	Total quantity (L) [1]	Storage arrangements [1]	Storage facility ID	SEPP 33 threshold	Threshold exceeded?
Explosives, blasting, type B Explosives, blasting, type E Booster Cord detonating Detonators, non-electric	1.1	(7,530 kg) [2]	Magazine	ACE1/ANE1	Based on Figure 5 (Ref 1) screening threshold: For 7.5 tonne of Class 1.1, proposal is potentially hazardous if distance to site boundary is less than approximately 280 m. Closest distance to site boundary is 28.5 m [1].	Yes
Liquefied Petroleum Gas (LPG)	2.1	30,000	4 above ground tanks (7,500 L each)	LPG1, LPG2, LPG3 & LPG4	Based on Table 3 (Ref 1) screening threshold: 16 m^3 of Class 2.1 (LPG only – excluding automotive retail outlets) if stored above ground	Yes
Ammonium Nitrate Emulsion (ANE)	5.1 PG II	46,800 (68 tonne)	Above ground tank	ANE1	Based on Table 3 (Ref 1) screening threshold: 5 tonne of Class 5.1 (any other Class 5.1)	Yes
Sodium cyanide solution	6.1 PG I	200,000 (320 tonne)	2 above ground tanks (100,000 L each)	CN01 & CN02	Based on Table 3 (Ref 1) screening threshold: 0.5 tonne of Class 6.1 PG I	Yes
Hydrochloric acid	8 PG II	30,000	Above ground tank	HCL1	Based on Table 3 (Ref 1) screening threshold: 25 m^3 of Class 8 PG II	Yes

Material	DG class	Total quantity (L) [1]	Storage arrangements [1]	Storage facility ID	SEPP 33 threshold	Threshold exceeded?
Caustic soda (sodium hydroxide solution)	8 PG II	20,000	Above ground tank	CAU1	Based on Table 3 (Ref 1) screening threshold: 25 m^3 of Class 8 PG II	No
Acetic acid solution	8 PG III	2,000	Tank - Intermediate Bulk Container (IBC)	ACE1	Based on Table 3 (Ref 1) screening threshold: 50 m^3 of Class 8 PG II	No
Copper sulphate solution	9 PG III	20,000	Tank - IBC	COP1	No threshold identified based on SEPP 33. Class 9 PG III not potentially hazardous material as per SEPP 33.	N/A
Diesel fuel	Combustible Class C1	110,000	Above ground tank	DIE1	No threshold identified based on SEPP 33. If diesel is stored in the same bund as gasoline (Class 3 PG II), total inventory of diesel will be classified as Class 3 PG II. No other flammables stored with diesel.	N/A
Diesel fuel	Combustible Class C1	110,000	Above ground tank	DIE2	No threshold identified based on SEPP 33. If diesel is stored in the same bund as gasoline (Class 3 PG II), total inventory of diesel will be classified as Class 3 PG II. No other flammables stored with diesel.	N/A

Notes:

1. Information provided by client.
2. Total quantity of Class 1.1 explosives comprises 7,500 kg Class 1.1D explosive material and a nominal 30 kg for Class 1.1B detonators.

Table 2.2: SEPP 33 hazardous material transport screening summary

Trip type		DG class	Traffic generation [1]		Quantity per load (tonne) [1]	SEPP 33 threshold vehicle movements (Table 2)		Threshold exceeded?
			Annually	Peak weekly		Annually	Peak weekly	
Receipt of goods by trucks	Explosives, blasting, type B Explosives, blasting, type E Booster Cord detonating Detonators, non-electric	1.1	From note to Table 2 (Ref 1), the Department of Planning should be contacted for advice where proposals include materials of Class 1.					
	LPG	2.1	12	Once per month	20	>500	>30	No
	ANE	5.1 PG II	104	2	23	>500	>30	No
	Sodium cyanide (briquettes)	6.1 PG I	52	1	22	all	all	Yes
	Hydrochloric acid	8 PG II	7	Once every 7 weeks	25	>500	>30	No
	Caustic soda (sodium hydroxide solution)	8 PG II	4	Once every 3 months	25	>500	>30	No
	Acetic acid solution	8 PG III	12	Once per month	1	>500	>30	No
	Copper sulphate solution	9 PG III	12	Once per month	12	>1000	>60	No
	Diesel	9 PG III	365	52	37	>1000	>60	No

Note:
1. Information provided by client.

Figure 2.1: Locations of DG stored (in vicinity of treatment plant)

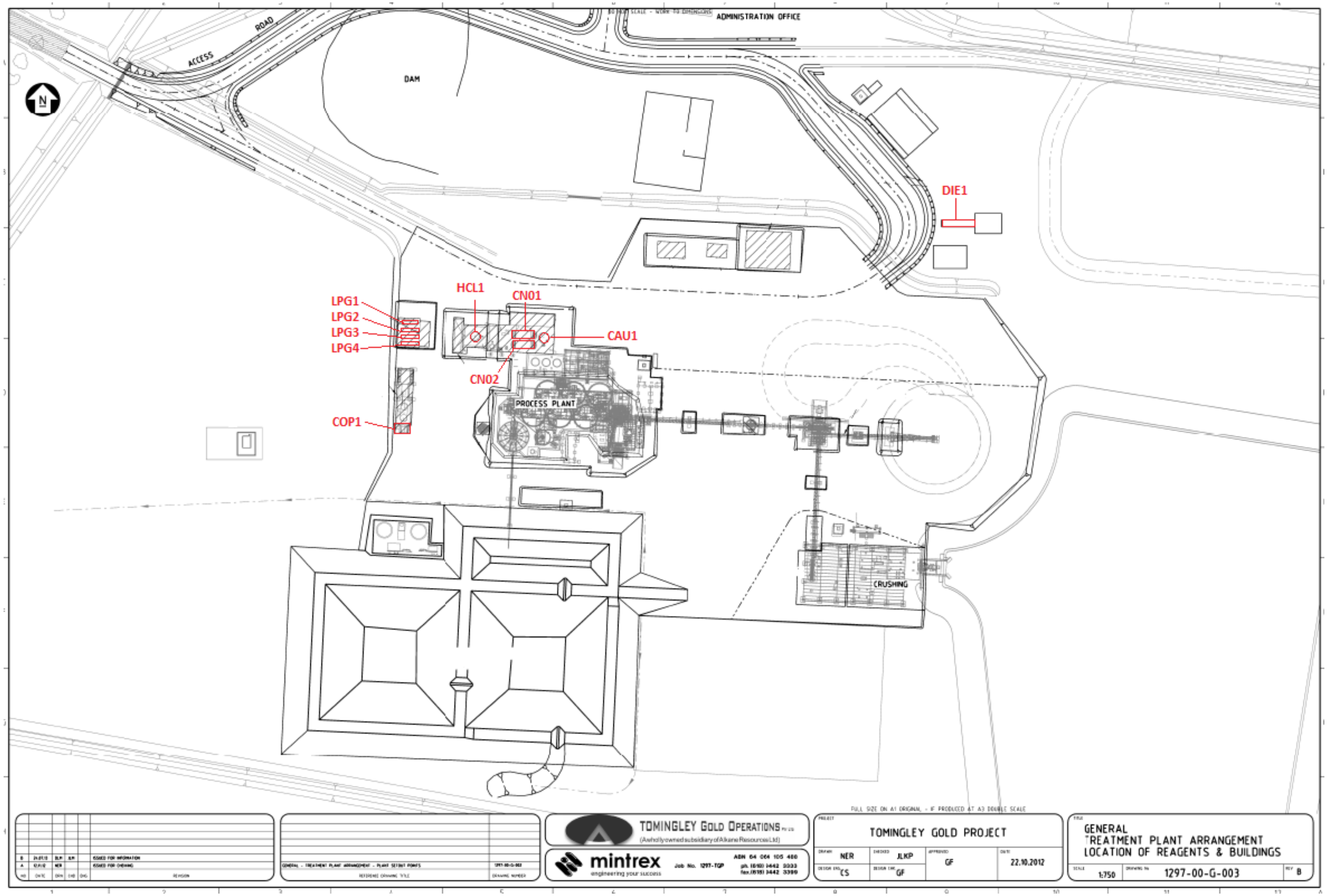
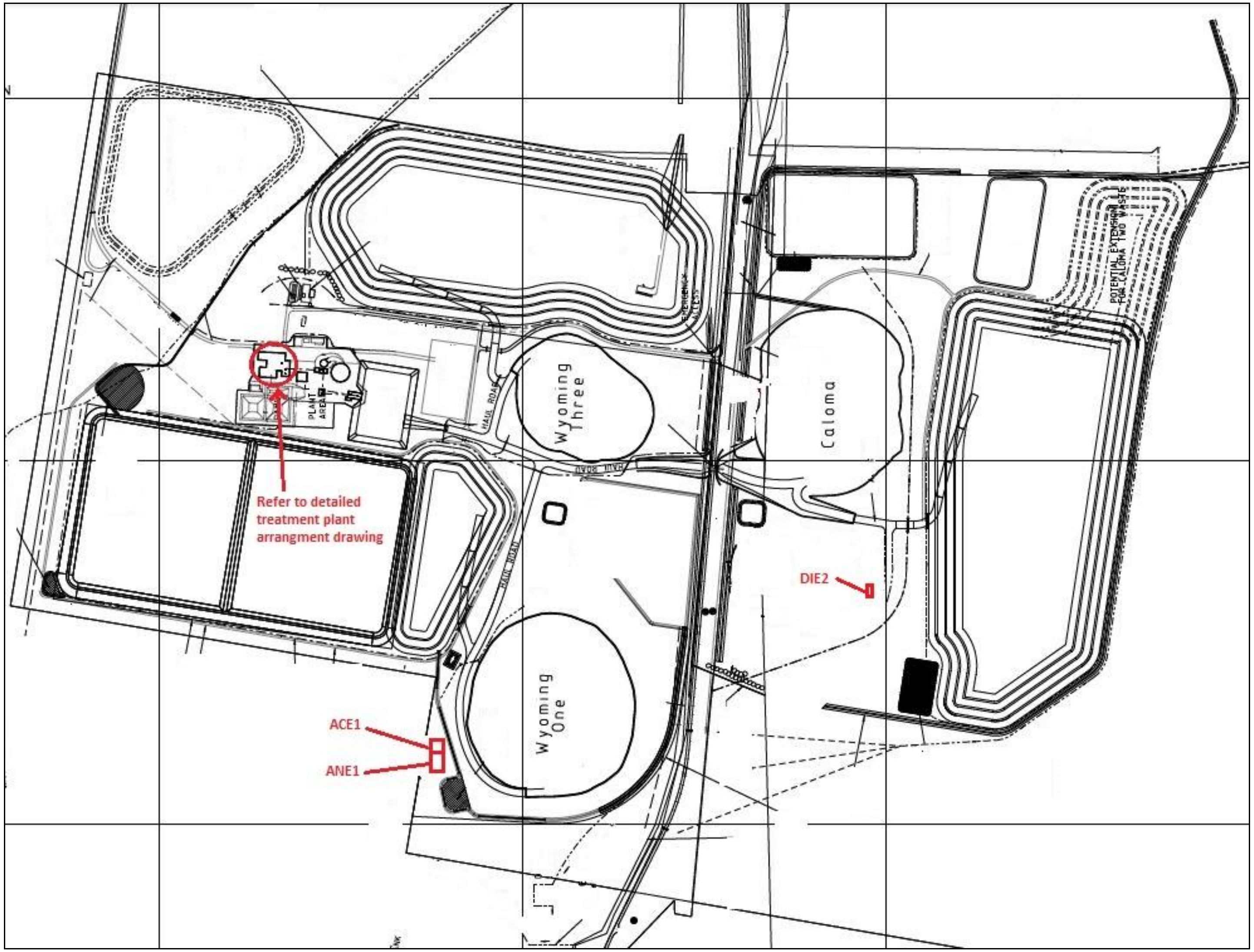


Figure 2.2: Locations of DG stored (overall site layout)



APPENDIX 1. REFERENCES

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APPENDIX G. REFERENCES

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Annexure 2

Tomingley Mine Site Risk Assessment Proposed Liquid Oxygen Storage

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TOMINGLEY MINE SITE

RISK ASSESSMENT PROPOSED LIQUID OXYGEN STORAGE

TOMINGLEY GOLD OPERATIONS PTY LTD

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Title: Tomingley Mine Site RISK ASSESSMENT PROPOSED LIQUID OXYGEN STORAGE	QA Verified: M Liu
	Date: 1 December 2014

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ABBREVIATIONS

ADG	Australian Dangerous Goods
ANE	Ammonium Nitrate Emulsion
AS	Australian Standard
DG	Dangerous Goods
DPI	(NSW) Department of Planning and Infrastructure
EA	Environmental Assessment
EPL	Environmental Protection License
FHA	Final Hazard Analysis
HAZID	Hazard Identification
HIPAP	Hazardous Industry Planning Advisory Paper
LOX	Liquid Oxygen
MSDS	Material Safety Data Sheet
NSW	New South Wales
O_2	Oxygen
OHS	Occupational Health and Safety
pa	per annum
PG	Packaging Group
ppm	Parts Per Million (usually vol/vol for gases)
QRA	Quantitative Risk Assessment
TGO	Tomingley Gold Operations Pty Ltd
WHS	Workplace Health and Safety

1. SUMMARY

1.1. Purpose and Scope

Tomingley Gold Operations Pty Ltd (TGO), a wholly owned subsidiary of Alkane Resources Limited, has recently commenced operations at a mine site near Tomingley, NSW.

To satisfy conditions attached to the planning approval for the project, TGO retained Sherpa Consulting Pty Ltd (Sherpa) to prepare a Final Hazard Analysis (FHA) for the project. The FHA was submitted prior to commencement of operations and approved by the NSW Department of Planning and Infrastructure (DPI).

The FHA reviewed the Dangerous Goods (DGs) associated with site operations to establish offsite risk levels from the mine site and determine the risk acceptability compared with the land use planning risk criteria defined in HIPAP No. 4, *Risk Criteria for Land Use Safety Planning* (Ref 1). The FHA concluded that the only hazardous events to have a potential impact outside the site boundary were explosions involving Class 1.1 explosives or Class 5.1 Ammonium Nitrate Emulsion (ANE). However, the effect distances did not extend to sensitive, residential or any other land uses, hence the project complied with the HIPAP No. 4 criteria.

TGO is proposing to introduce a change to the process that requires storage and use of liquid oxygen (LOX), and has requested that Sherpa prepare a hazard analysis for the change to determine if there are any significant effects on the offsite risk levels.

1.2. Study Basis and Methodology

Similarly to the FHA, the study included the following steps:

- Hazard identification to identify potential hazardous incidents involving oxygen, including identification of safeguards proposed.
- Consequence assessment - dispersion modelling for oxygen leaks to determine zone of oxygen enrichment.
- Qualitative risk assessment to determine if the change will result in any significant effects on offsite risk levels.

1.3. Conclusions

The following hazardous incident scenarios associated with the storage and handling of oxygen were identified

1. Leak of liquid oxygen causing oxygen enrichment
2. Leak of gaseous oxygen causing oxygen enrichment
3. Release of oxygen due to process venting causing oxygen enrichment

4. Ignition of oxygen piping causing significant asset damage and localised very intense heat

Consequence modelling shows that the zone of oxygen enrichment in either a liquid oxygen or gaseous oxygen release remains well within the mine site boundary hence there is no effect on the offsite risk from the facility. Oxygen enrichment zones do not reach the nearest flammable storage (LPG) within the site boundary or the Class 1.1 or 5.1 store (around 1 km away), hence does not increase the severity or likelihood of an ignited event involving an existing flammable or explosive inventory on the site.

Overall, it can be concluded that the introduction of LOX does not result in the potential for hazardous incidents with effect distances that extend offsite or to any sensitive, residential or any other land uses or critical infrastructure. Hence the risk levels continue to meet the offsite land use planning risk criteria defined in HIPAP No. 4 as per the conclusions in the FHA.

1.4. Recommendations

To ensure that the likelihood of an incident involving oxygen is low, the following recommendations are made:

1. Update the site emergency plan to cover a leak of oxygen.
2. Ensure that personnel are made aware of the hazards of oxygen.
3. Implement an ignition control policy around the oxygen area.
4. Ensure that specialist maintenance procedures are in place for working on oxygen systems that cover material compatibility and oxygen cleanliness.

2. INTRODUCTION

2.1. Background

Tomingley Gold Operations Pty Ltd (TGO), a wholly owned subsidiary of Alkane Resources Limited has recently commenced operations at a mine site near Tomingley.

As part of the approval process for the development a Final Hazard Analysis (FHA) for the project was prepared and approved by the NSW Department of Planning and Infrastructure (DPI). The FHA reviewed the Dangerous Goods associated with site operations to establish offsite risk levels from the project and determine the risk acceptability compared with the land use planning risk criteria defined in HIPAP No. 4, *Risk Criteria for Land Use Safety Planning* (Ref 1).

The FHA concluded that the only hazardous events to have a potential impact outside the site boundary were explosions involving Class 1.1 explosives and Class 5.1 ANE. However, the effect distances did not extend to sensitive, residential or any other land uses, hence the project complied with the HIPAP No. 4 criteria.

TGO is now proposing to introduce a change to the process that requires storage and use of liquid oxygen (LOX), and has requested that Sherpa prepare a hazard analysis for the change to determine the effect on offsite risk.

This report summarises the hazard analysis for the storage and use of oxygen.

2.2. Scope and Objectives

The objectives of the risk assessment of the LOX storage and handling facilities are to:

- develop a comprehensive understanding of the hazards, risks and the adequacy of the safeguards associated with the proposed change.
- identify whether (current) offsite risk levels would be affected by introduction of LOX.

The results are for internal use by TGO. A risk assessment report for the planning authority is not required.

The scope of the study includes:

- LOX storage and handling.

2.3. Limitations and Exclusions

The study focuses on the acute effects of potential accident scenarios. It does not cover long-term or continuous emissions, or occupational health and safety (OHS) issues that may arise from routine plant operations. These are addressed via other mechanisms such as OHS regulations, OHS management systems and Environmental Protection Licenses (EPLs).

The study did not cover transport of oxygen to the site.

3. DESCRIPTION OF THE PROPOSED CHANGE

3.1. Description

Bulk liquid oxygen will be stored on site in a single 60,000 litre capacity cryogenic tank, vapourised and injected into the process.

The system will be designed and installed by BOC Limited, specialist industrial gas providers, and the installation will be in accordance with the relevant Australian Standard AS1894-1997: *The storage and handling of non-flammable cryogenic and refrigerated liquid.* Piping will be largely pre-fabricated and will be site fitted by specialist tradesmen sub-contracted to BOC. All equipment and materials will be cleaned for oxygen service.

Oxygen will be withdrawn as required through two vaporisers (one duty, one standby) and piped into the cyanide destruction process tank (detox tank). The two vaporisers will be swapped over automatically every 8 hours to prevent the build-up of ice on the units.

The delivery of oxygen to the process will be controlled to maintain a measured concentration of dissolved oxygen in the process slurry. The oxygen flow rate will be controlled by an inline vortex flow meter and an automatic control valve.

3.2. Site Layout

The LOX system will be located on the edge of the existing processing area within the mine site. The nearest mine site boundary is approximately 450 m away from the processing area. An aerial view of the site showing the location of the proposed LOX system in the processing area is shown in Figure 3.1.

The layout of the processing area including the proposed LOX system is shown in Figure 3.2.

The processing plant is a gold leaching process handling various toxic, corrosive materials (aqueous alkaline cyanide solutions). There are no flammable materials within the gold leaching process area.

The nearest inventory of flammable material is the LPG storage (4 above ground bullets, 7,500 L each). The LPG is used for fuelling fired appliances and furnaces in the gold recovery process and is located in a well separated storage compound around 60 m away from the proposed LOX area as shown in Figure 3.2. Note that the separation distance significantly exceeds the requirement of 15m in AS1894 from LOX storage to a flammable liquefied gas storage of less than 60 m^3 capacity.

The explosive (Class 1.1) and ANE inventories are approximately 1 km away from the proposed LOX location.

Figure 3.1: Aerial Photo of Mine Site

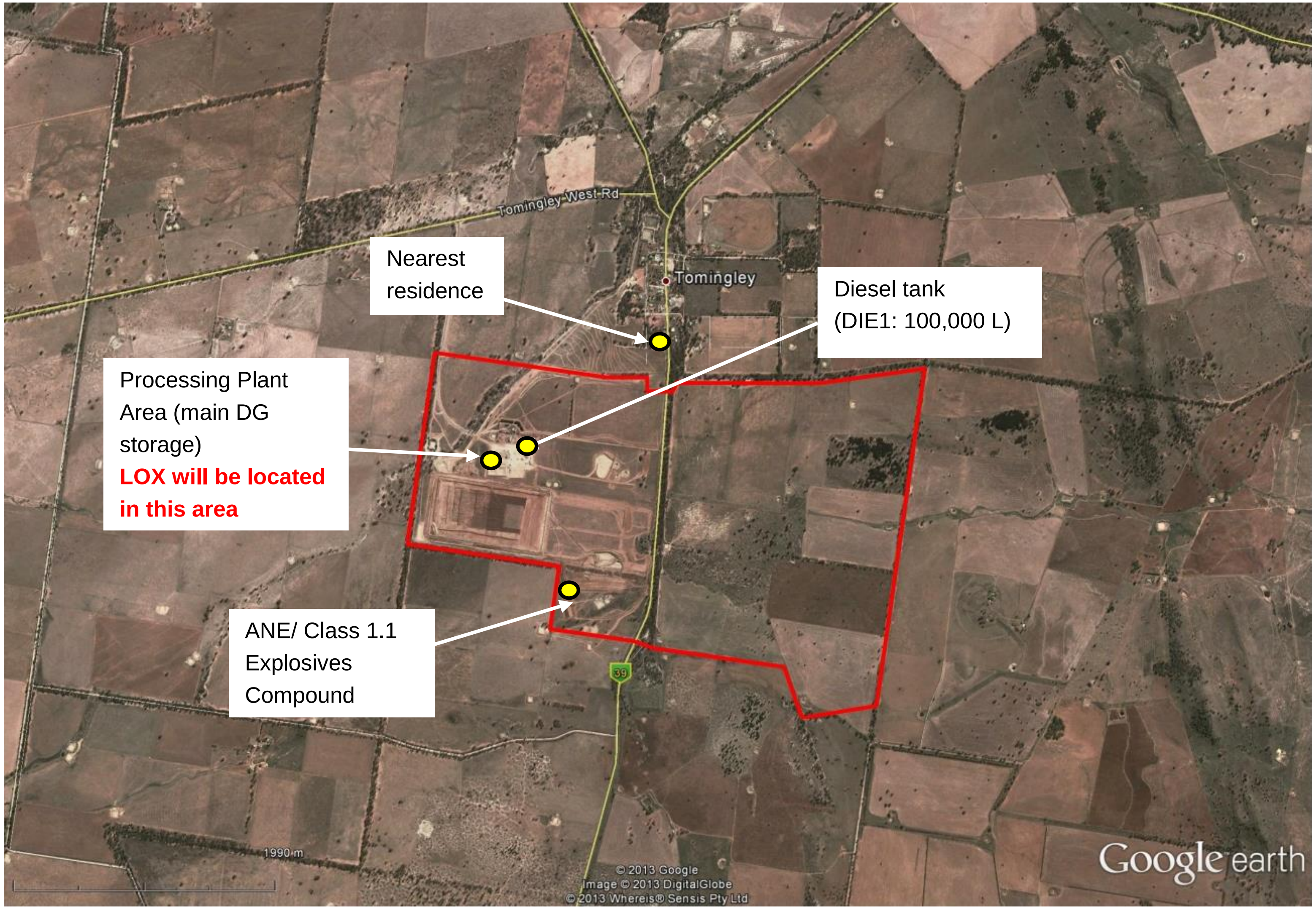
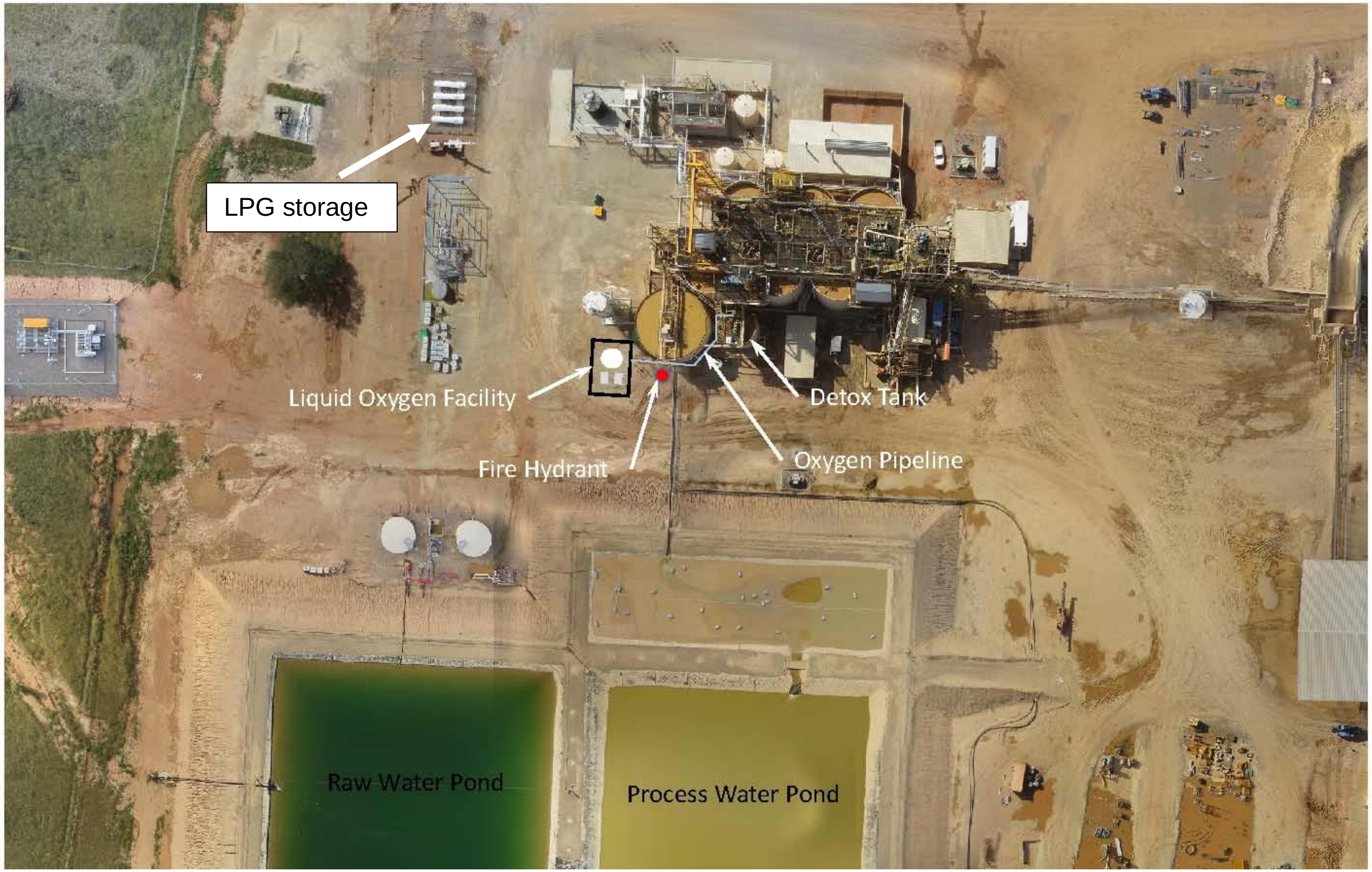


Figure 3.2: Oxygen System Layout



4. METHODOLOGY

As for the FHA, the following steps were included in the hazard analysis for the LOX system:

1. Review hazardous properties of oxygen
2. Identify potential incident scenarios involving oxygen.
3. Analysis of the consequences of these incidents on people, property and the biophysical environment.
4. Comparison of risk levels with risk criteria as detailed in HIPAP No. 4 (Ref.1) as given in Table 4.1.

The risk criteria given in Table 4.1 are expressed in terms of individual fatality risk or likelihood of exposure to threshold values of overpressure, heat radiation or toxicity.

Table 4.1: NSW Individual Fatality, Injury, Irritation and Property Damage Risk Criteria

Description	**Risk criteria (per year)**
Individual fatality risk	
Fatality risk to sensitive land uses, including hospitals, schools, aged care	0.5×10^{-6}
Fatality risk to residential and hotels	1×10^{-6}
Fatality risk to commercial areas, including offices, retail centres, warehouses	5×10^{-6}
Fatality risk to sporting complexes and active open spaces	10×10^{-6}
Fatality risk should, as a target, be contained within the boundary of an industrial site where applicable	50×10^{-6}
Injury (Fire/Explosion)	
Fire/explosion injury risk – Incident heat flux radiation at residential areas should not exceed 4.7 kW/m^2 at frequencies of more than 50 chances in a million per year or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year	50×10^{-6}
Injury/Irritation (Toxic impacts)	
Toxic injury – Toxic concentrations in residential areas should not exceed a level which would be seriously injurious to sensitive members of the community following a relatively short period of exposure at a maximum frequency of 10 in a million per year.	10×10^{-6}

Description	Risk criteria (per year)
Toxic irritation – Toxic concentrations in residential areas should not exceed cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community over a maximum frequency of 50 in a million per year.	50×10^{-6}
Risk of Property Damage and Accident Propagation	
Explosion overpressure at neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings should not exceed a risk of 50 in a million per year for the 14 kPa explosion overpressure level.	50×10^{-6}

5. HAZARD ANALYSIS

5.1. Hazardous Material Properties

The main hazard associated with oxygen is oxygen enrichment as summarised in Table 5.1. Oxygen enrichment is a generic name for the hazards associated with gases and liquids containing oxygen concentrations greater than the normal oxygen concentration in air of 21 vol% (Ref 2).

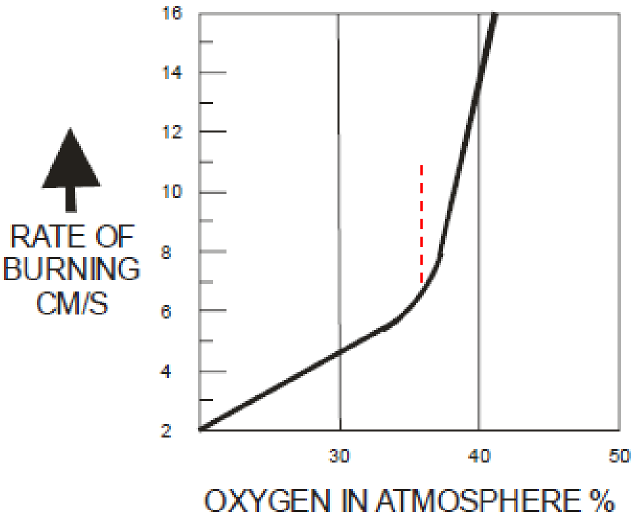
Oxygen is a colourless, odourless gas about 1.1 times heavier than air. Liquid oxygen has a clear, pale-blue colour. It is a cryogenic liquid with a boiling point of -180ºC. It is naturally occurring in air at about 21 vol%. Oxygen itself is not flammable or combustible. However, it is an oxidiser and readily supports combustion of other substances. It presents a fire hazard in that combustible materials that come in contact with oxygen may ignite spontaneously. Additional presence of oxygen gas can also intensify an ordinary fire or explosion.

As per AS2865 *Confined Spaces,* an oxygen enriched atmosphere that is the onset of potentially hazardous conditions is an atmosphere with 23.5 vol% oxygen or above. The risk of ignition starts to increase and strength of ignition source resulting in ignition decreases. At around 35 vol% oxygen concentration, there is a very steep rise in the rate of combustion in most materials. An example for clothing material made of cotton is shown in Figure 5.1. Similar curves, showing the same kind of behaviour, can be drawn for other clothing materials, plastic and elastomers.

Since most materials can react with oxygen, materials used in contact with oxygen must be carefully selected to be the least reactive under the conditions of service.

Oxygen is not acutely toxic.

Figure 5.1: Relationship Between O_2 concentration in atmosphere and rate of burning for cotton, Ref 2.



5.2. Incident Scenario

Potential incidents involving oxygen were identified by review of industry guidance (eg Refs 2, 3, 4, 5 and 6) and based on previous similar hazard analyses conducted by Sherpa for oxygen systems.

These include:

1. Leak of liquid oxygen causing oxygen enrichment
2. Leak of gaseous oxygen causing oxygen enrichment
3. Release of oxygen due to process venting causing oxygen enrichment
4. Ignition of oxygen piping causing significant asset damage and localised very intense heat
5. Fire or explosion in another plant area affecting oxygen storage area.

Additional details are given in the hazard identification word diagram in Table 5.2.

Table 5.1: Oxygen Hazardous Properties

Hazardous Material	State	DG Class	Description of Properties	Materials of construction incompatibilities	Events		
					Ignited events	**Acute Toxicity**	**Other**
Oxygen	Cryogenic liquid	2.2	Oxygen is a colourless and odourless gas about 1.1 times heavier than air. Naturally occurring oxygen gas is present in the atmosphere at about 21 vol%. Oxygen itself is not flammable or combustible. However, it is a fire hazard as combustible materials that come in contact with oxygen may catch fire spontaneously due to reduced ignition temperatures and expanded flammability ranges in oxygen enriched environments. Additional presence of oxygen gas can intensify an ordinary fire or explosion. Compared with a fire in air, a fire in an enriched oxygen atmosphere is: ♦ more intense ♦ with higher temperatures, and ♦ has a greater heat output rate. Under most circumstances, an oxygen fire cannot be extinguished until any source of oxygen feeding the fire has been isolated Continuous inhalation of oxygen enriched air (>75%) may cause nausea, dizziness, respiratory difficulty and convulsion.	Oils, grease, many elastomers Mild steel at velocity exceeding industry guidance	Y	-	-

Table 5.2: Potential Hazardous Incident Scenarios

Area Description	Scenario Description	Typical Causes	Consequence	Controls and Safeguards	Quantitative consequence model? (see Section 5.3)
Liquid oxygen storage tank	Piping/tank leak/rupture leading to oxygen leak and oxygen enrichment Vent left open during filling	Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) Leak during loading (hose failure, driveaway etc)	Spill of liquid oxygen creates a dense cloud of oxygen enriched air when evaporating. In an open space hazardous oxygen concentration usually exists only within the visible cloud associated with the spill (Ref 2).	Design in accordance with industry standards by BOC Preventative maintenance Routine inspections Attended operation during loading Located in well ventilated area Impact protection (bollards) as per AS1984-1997 App D provided around tank and vaporisers.	Yes

Area Description	Scenario Description	Typical Causes	Consequence	Controls and Safeguards	Quantitative consequence model? (see Section 5.3)
Oxygen vapourisers	Piping failure leading to oxygen leak and oxygen enrichment	Low temperature embrittlement and line failure downstream of vapouriser due to low temp liquid oxygen breakthrough from vapouriser (flowrate too high, vapouriser icing up etc)	Spill of liquid oxygen creates a dense cloud of oxygen enriched air when evaporating in an open space hazardous oxygen concentration usually exists only within the visible cloud associated with the spill (Ref 2)	Design in accordance with industry standards by BOC Materials of construction to suit low temperatures Auto changeover of duty /standby vapourisers to prevent icing up with low temperature shutdown. Flow controller sized to prevent excessively high flow exceeding vapouriser capacity Preventative maintenance Routine inspections Located in well ventilated area	Yes
	Venting or pressure relief leading to pressurised oxygen release around vent	High pressure in system due to process upset Vent valve sticks open	Dispersion of gaseous oxygen, oxygen enrichment	Located in well ventilated area	Yes

Area Description	Scenario Description	Typical Causes	Consequence	Controls and Safeguards	Quantitative consequence model? (see Section 5.3)
Oxygen piping to detox tank	Ignition in gaseous oxygen supply piping	Introduction of incompatible material eg oil, grease, gasket material during maintenance High velocity in piping and particle impingement	Asset damage Potential burn injury to anyone in immediate vicinity of equipment	Materials of construction to suit service Maintenance procedures specific to oxygen equipment Flow controller sized to prevent excessively high flow exceeding piping velocity limits Two inline filters (100 µm) to remove any particles in the gas stream.	No. Incidents show localised but very intense fire. No impact offsite as site boundary is 450m away. eg Refs 7 8,
Detox tank	High oxygen concentration in tank	Failure of oxygen dosing control / metering resulting in overdosing of detox tank	Potential oxygen enriched atmosphere in the gas space in the top of the tank.	Process alarms and interlocks	No
LPG	Fire / explosion in LPG area	Leak of LPG	Damage to LOX equipment, release of oxygen, escalated event / increased fire intensity	Separation distance between LOX and LPG is approximately 60 m. Consequence modelling in FHA shows only very large releases of LPG) (50 mm hole size or above) may cause radiant heat levels capable of causing damage to about 100m away which may impact LOX.	No. No impact offsite even in more intense fire event as site boundary is 450 m away.
ANE / Class1 .1 storage area	Explosion	Instability of Class5.1 or Class 1.1 stored materials	Damage to LOX equipment, release of oxygen, escalated event	Separation distance is approximately 1 km from LOX. Not credible - no damage potential based on consequence modelling for ANE in FHA which shows potentially damaging overpressure effects to 387 m	No

5.3. Consequence Analysis

Consequence analysis involves qualitative and/or quantitative review of the identified hazardous scenarios to estimate the potential to cause injury/fatality, in this case outside the site boundary

5.3.1. Scenarios Modelled

TNO Effects software v9.0.19 was used to estimate the potential zone of oxygen enrichment.

Dispersion model input parameters are the same as those used in the FHA and are summarised in Table 5.3.

Table 5.3: Dispersion Model Input Parameters

Parameter	Value	Source
Ambient temperature	24 ^{o}C	Annual average
Receptor height	1.5 m	Typical face height
Stability/windspeeds (m/s)	F2	Worst case for dense gas dispersion
Surface roughness	0.1 m	Assumed to be low crops, occasional large obstacles

Table 5.4 provides a summary of the oxygen leak scenarios included in the quantitative consequence analysis including the input assumptions. These are representative and do not cover every possible scenario – they are intended to obtain an estimate of the range of oxygen enriched areas that could occur in the event of a leak of liquid or gaseous oxygen, and hence determine:

1. whether these can affect areas outside the site boundary and result in an increased risk of an ignited event due to ignition of combustible materials (that would not normally pose a risk without a strong ignition source) .
2. whether these can affect any flammable or combustible storages within the site boundary (ie increasing the severity or likelihood of an ignited event involving these).

5.3.2. Endpoints

The oxygen enrichment thresholds considered for injury and fatality (due an ignited vent caused by oxygen enrichment) were set to correspond to 23.5% and 35% respectively based on the information provided in Section 5.1.

Since oxygen is normally present in air in concentrations up to 21%, the scenarios were assessed by determining whether the oxygen release can generate additional oxygen concentration of 2.5% and 14%.

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5.3.3. Consequence Results

Consequence results are summarised in Table 5.5.

It can be seen that the oxygen enrichment zones do not reach the site boundary more than 450 m away hence there is no offsite risk impact.

It can also be seen that the 35% oxygen enrichment zone does not reach the nearest flammable storage (LPG). Although it should be noted that in any case for oxygen enrichment to result in an escalated event, a simultaneous release of LPG and oxygen would need to occur which is extremely unlikely.

Separation distances to the LPG area and Class 1.1 and ANE area are large and based on the consequence modelling for these areas carried out as part of the FHA:

- The ANE / Class 1.1 area is more than 1km away and an explosion will not affect the LOX area.
- The LPG area is more than 60m away. Heat radiation from a worst case jet fire from a hole size 50mm or larger may affect the LOX area, with any oxygen released potentially increasing the intensity of the LPG fire. However this does not significantly change the offsite risk level associated with the LPG area as the LPG release and fire would still need to occur first and the nearest site boundary is 450m away.

5.4. Likelihood Analysis

As described in industry literature (eg Refs 5, 8) there have been very few major accidents world wide reported with significant consequences off site involving liquid oxygen spills. This is attributed to the high standards adopted for cryogenic liquid storage installations. There are only a relatively small number of companies involved in the industrial gases industry; they work closely on safety issues (through trade associations such as British Compressed Gas Association (BCGA), the European Industrial Gases Association (EIGA), the American Compressed Gases Association (CGA), etc.) resulting in high standards throughout the industry.

The instances where there were multiple loss of life have involved some form of confinement, ie. ship's compartment, car, building. There have been no major releases of LOX where people exposed in the open air have received serious injuries.

The LOX installation at Tomingley will be designed and installed by a reputable industrial gases supplier and comply with relevant industry guidelines. It is in a well ventilated area and well separated from other DG inventories. Deliveries will be made by a reputable industrial gases supplier. Any maintenance will also be contracted to an industry specialist. Hence it is regarded as extremely unlikely that a significant release of LOX would occur.

Table 5.4: Scenarios for Consequence Analysis

Material Released	Equipment	Release Scenario	Source term	Consequence
Oxygen - liquid	1. LOX tank and vapouriser inlet piping	Release of liquid oxygen and pool evaporation	50mm hole 10mm hole LOX at -180degC Atmospheric pressure Pool spreading constrained to $1500m^2$	Oxygen-enriched atmosphere due to pool evaporation followed by dense gas dispersion
Oxygen – gaseous	2. Oxygen venting / pressure relief	Release from vent	50mm vertical discharge 6m high 500kPag $20^{o}C$	Oxygen-enriched atmosphere due to turbulent jet followed by neutral dispersion
Oxygen – gaseous	3. Oxygen piping to detox tank	Pipe rupture or leak from pipe rack to detox tank – 50mm hole	50mm horizontal discharge 500kPag $20^{o}C$ 3 m above grade	Oxygen-enriched atmosphere due to turbulent jet followed by neutral dispersion

Table 5.5: Consequence Analysis Results

Release Scenario	Description	Distance (m) to (at 1.5 m above grade) :		23.5 vol% O_2 exceeded 450m away at site boundary?	35 vol% O_2 exceeded at LPG storage – 60m away?
		23.5 % O_2	35% O_2		
1. LOX tank and vapouriser inlet piping	50mm leak Average oxygen evaporation rate of 23kg/s with a maximum equivalent pool diameter of approximately 25m	110m	Immediately above pool only	No	No
	10mm leak Average oxygen evaporation rate of 14kg/s with a maximum equivalent pool diameter of approximately 10m	34m	Immediately above pool only	No	No
2. Oxygen venting / pressure relief	Oxygen enriched air is limited to 1-2 m horizontally or vertically from the release point. In both cases, the maximum oxygen concentration at ground level is 21.3% (ie 0.3% above background oxygen level of 21%).	n/a at 1.5m above grade	n/a at 1.5m above grade	No	No
3. Oxygen piping to detox tank	Oxygen enriched air is limited to around 5 - 6 m horizontally or vertically from the release point. In both cases, the maximum oxygen concentration at ground level is around 27% (ie 6% above background oxygen level of 21%).	6 m	n/a at 1.5m above grade	No	No
NOTE: Dispersion results are reasonably similar to those reported in Ref 4 BCGA *Technical Report 1, A Method For Estimating The Offsite Risks From Bulk Storage Of Liquefied Oxygen*					

5.5. Boundary Risk

There is no change in the individual fatality or injury risk as the predicted oxygen enrichment zones remain well within the mine site boundary.

Hence the introduction of the LOX system does not affect the offsite risk and HIPAP 4 criteria are complied with.

5.6. Risk to Biophysical Environment

The main concern relating to environmental risk from accident events is generally with effects on whole systems or populations. HIPAP 4 provides the following qualitative guidance for assessment of environmental risk due to accident events:

- *Industrial developments should not be sited in proximity to sensitive natural environmental areas where the effects (consequences) of the more likely accidental emission may threaten the long-term viability of the ecosystem or any species within it.*
- *Industrial developments should not be sited in proximity to sensitive natural environmental areas where the likelihood (probability) of impacts that may threaten the long-term viability of the ecosystem or any species within it is not substantially lower than the background level of threat to the ecosystem.*

Oxygen does not have any environmentally harmful properties, hence a release will not result in any significant impact on the biophysical environment.

6. CONCLUSIONS AND RECOMMENDATIONS

Overall the following conclusions can be drawn from hazard analysis:

- Introduction of the LOX system introduces a new risk of oxygen enrichment occurring if a leak of oxygen occurs.
- Consequence modelling shows that the zone of oxygen enrichment in either a liquid oxygen or gaseous oxygen release remains well within the mine site boundary hence there is no effect on the offsite risk from the facility. The HIPAP No 4 criteria continue to be met as per the conclusions of the original FHA.

To ensure that the likelihood of an incident involving oxygen is low, the following recommendations are made:

1. Update the site emergency plan to cover a leak of oxygen
2. Ensure that personnel are made aware of the hazards of oxygen
3. Implement an ignition control policy around the oxygen area
4. Ensure that specialist maintenance procedures are in place for working on oxygen systems that cover material compatibility and oxygen cleanliness.

APPENDIX A. REFERENCES

1 NSW Department of Planning (2011): *Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning*.

2 AIGA 005/04 *Fire Hazards Of Oxygen And Oxygen Enriched Atmospheres*

3 Emilio Palazzi et al, Journal of Process Safety and Environmental Protection Vol 92 (2014), *Development of a theoretical framework for the evaluation of risk connected to accidental oxygen releases*

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6 EIGA (2005) SAG NL 79/04/E *The hazards of oxygen enriched atmospheres*

7 AIGA 021/05 *Oxygen Pipeline Systems (AIGA Globally Harmonised Document)*

8 NASA Oxygen incident summary, http://wiki.nasa.gov/oxygen-fire-incidents/wiki/home/