

Appendix 4

Preliminary Hazard Analysis (including a SEPP 33 Risk Screening)

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DUBBO ZIRCONIA PROJECT

PRELIMINARY HAZARD ANALYSIS

AUSTRALIA ZIRCONIA LIMITED

PREPARED FOR: R.W. Corkery & Co Pty Limited
on behalf of Australia Zirconia
Limited

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| Title: Dubbo Zirconia Project Preliminary Hazard Analysis | QA Verified: O. Alim |
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CONTENTS

| | |
|--|-------|
| ABBREVIATIONS | A4-9 |
| 1. EXECUTIVE SUMMARY | A4-10 |
| 1.1. PURPOSE AND SCOPE | A4-10 |
| 1.2. STUDY BASIS AND METHODOLOGY | A4-10 |
| 1.3. STATUS | A4-11 |
| 1.4. CONCLUSIONS | A4-11 |
| 1.5. RECOMMENDATIONS | A4-11 |
| 2. INTRODUCTION | A4-12 |
| 2.1. BACKGROUND | A4-12 |
| 2.2. STUDY OBJECTIVE | A4-12 |
| 2.3. STUDY SCOPE | A4-12 |
| 2.4. LIMITATIONS AND EXCLUSIONS | A4-12 |
| 3. DESCRIPTION OF THE PROPOSED DEVELOPMENT | A4-14 |
| 3.1. SITE LOCATION AND SURROUNDING LAND USE | A4-14 |
| 3.2. SITE LAYOUT | A4-14 |
| 3.3. PROCESS OVERVIEW | A4-19 |
| 4. METHODOLOGY | A4-21 |
| 4.1. STUDY OVERVIEW | A4-21 |
| 4.2. RISK CRITERIA | A4-22 |
| 4.3. SOCIETAL RISK | A4-23 |
| 5. HAZARD IDENTIFICATION | A4-24 |
| 5.1. HAZARDOUS MATERIALS | A4-24 |
| 5.2. POTENTIAL MAJOR HAZARDOUS INCIDENT SCENARIOS | A4-27 |
| 5.3. RULE SET AND ASSUMPTIONS FOR INCIDENT INCLUSION | A4-27 |
| 5.4. INCIDENT SCENARIOS ASSESSED IN QRA | A4-39 |
| 5.5. EXTERNAL EVENTS | A4-39 |
| 6. CONSEQUENCE ANALYSIS | A4-41 |
| 6.1. OVERVIEW | A4-41 |
| 6.2. ASSUMPTIONS | A4-42 |
| 6.3. DISPERSION MODEL | A4-44 |
| 6.4. RELEASE ORIENTATION | A4-44 |
| 6.5. METEOROLOGICAL DATA | A4-44 |
| 6.6. OTHER ENVIRONMENTAL FACTORS | A4-45 |
| 6.7. VULNERABILITY - TOXIC EFFECTS RULE SETS | A4-45 |
| 6.8. CONSEQUENCE ASSESSMENT RESULTS | A4-47 |
| 7. FREQUENCY ASSESSMENT | A4-48 |
| 7.1. OVERVIEW | A4-48 |
| 7.2. BASE FAILURE RATES FOR PROCESS EQUIPMENT | A4-48 |

| | |
|--|-------|
| 7.3. PARTS COUNT..... | A4-50 |
| 7.4. EVENT TREES | A4-50 |
| 8. RISK ASSESSMENT..... | A4-52 |
| 8.1. OVERVIEW | A4-52 |
| 8.2. RISK QUANTIFICATION..... | A4-52 |
| 8.3. RISK PRESENTATION | A4-52 |
| 8.4. RISK MODEL INPUT DATA SUMMARY..... | A4-52 |
| 9. RISK RESULTS AND FINDINGS | A4-54 |
| 9.1. INDIVIDUAL FATALITY RISK | A4-54 |
| 9.2. TOXIC INJURY/IRRITATION | A4-54 |
| 9.3. SOCIETAL RISK | A4-58 |
| 9.4. RISK TO BIOPHYSICAL ENVIRONMENT..... | A4-58 |
| 10. CONCLUSIONS AND RECOMMENDATIONS..... | A4-60 |
| 10.1. OFFSITE INDIVIDUAL FATALITY RISK | A4-60 |
| 10.2. TOXIC INJURY/IRRITATION RISK..... | A4-60 |
| 10.3. RECOMMENDATIONS | A4-60 |

| | |
|-------------|-----------------------------------|
| APPENDIX A. | HAZARDOUS MATERIALS |
| APPENDIX B. | CONSEQUENCE ANALYSIS |
| APPENDIX C. | METEOROLOGICAL DATA |
| APPENDIX D. | EVENT TREES AND EVENT FREQUENCIES |
| APPENDIX E. | RISKCURVES PARAMETERS |
| APPENDIX F. | RISKCURVES OUTPUT |
| APPENDIX G. | SEPP33 REPORT |
| APPENDIX H. | REFERENCES |

TABLES

| | |
|---|-------|
| Table 4.1: NSW Individual Fatality, Injury and Irritation Risk Criteria | A4-22 |
| Table 5.1: Hazardous Materials | A4-25 |
| Table 5.2: Potential Major Hazardous Incident Scenarios..... | A4-29 |
| Table 5.3: Scenarios Carried Forward for Assessment | A4-39 |
| Table 5.4: External Events | A4-40 |
| Table 6.1: Consequence Models..... | A4-42 |
| Table 6.2: Dispersion Model Inputs | A4-45 |
| Table 6.3: Toxicity Criteria..... | A4-47 |
| Table 7.1: Failure Frequencies, Pipework (Ref. 13) | A4-48 |
| Table 7.2: Failure Frequencies, Other Equipment..... | A4-49 |
| Table 7.3: Detection and Isolation Probabilities | A4-51 |
| Table 8.1: RiskCurves Input Data..... | A4-53 |
| Table 9.1: Comparison of Results with Risk Criteria | A4-58 |

FIGURES

| | |
|---|-------|
| Figure 3.1: Aerial View of DZP Site | A4-15 |
| Figure 3.2: DZP Site Layout | A4-16 |
| Figure 3.3: Processing Plant Layout (General Arrangement) | A4-17 |
| Figure 4.1: Basic Methodology for Preliminary Hazard Analysis | A4-21 |
| Figure 9.1: Individual Fatality Risk | A4-55 |
| Figure 9.2: Toxic Injury Risk | A4-56 |
| Figure 9.3: Toxic Irritation Risk | A4-57 |

ABBREVIATIONS

| | |
|-----------------|--|
| ADG | Australian Dangerous Goods |
| AEGL | Acute Exposure Guideline Level |
| AIHA | American Industrial Hygiene Association |
| AS | Australian Standard |
| AZL | Australian Zirconia Ltd |
| Cl ₂ | Chlorine |
| DG | Dangerous Goods |
| DoP(I) | Department of Planning and Infrastructure |
| DZP | Dubbo Zirconia Project |
| EIS | Environmental Impact Statement |
| EPL | Environmental Protection License |
| HAZOP | Hazard and Operability study |
| HCl | Hydrogen Chloride |
| HIPAP | (NSW) Hazardous Industry Planning Advisory Paper |
| LRSF | Liquid Residue Storage Facility |
| m | metres |
| m/s | metres per second |
| MGA | Map Grid of Australia |
| MHF | Major Hazards Facility |
| MSDS | Material Safety Data Sheet |
| NH ₃ | Ammonia |
| NOAEL | No-Observed-Adverse-Effect Level |
| NSW | New South Wales |
| OHS | Occupational Health and Safety |
| pa | per annum |
| PFD | Process Flow Diagram |
| PG | Packaging Group |
| PHA | Preliminary Hazard Analysis |
| PLS | Pregnant Leach Solution |
| ppm | Parts Per Million (usually vol/vol for gases) |
| QRA | Quantitative Risk Assessment |
| REEs | Rare Earth Elements |
| ROM | Run-of-Mine |
| RWC | R.W. Corkery |
| SDV | Shutdown Valve |
| SEPP | State Environmental Planning Policy |
| SRSF | Solid Residue Storage Facility |
| WHS | Work Health and Safety |
| SX | Solvent Extraction |
| UK HSE | United Kingdom Health and Safety Executive |
| VCE | Vapour Cloud Explosion |
| XSFV | Excess Flow Valves |

1. EXECUTIVE SUMMARY

1.1. Purpose and Scope

R.W. Corkery (RWC) has been engaged by Australian Zirconia Ltd (AZL) to prepare the Environmental Impact Statement (EIS) for the proposed development and operation of the Dubbo Zirconia Project (DZP, referred to as the Proposal).

As part of this process, Sherpa Consulting Pty Ltd (Sherpa) has been retained by RWC to prepare the Preliminary Hazard Analysis (PHA) for the Proposal. The PHA is required as a review against the 'State Environmental Planning Policy 33 – Hazardous and Offensive Development (SEPP33)' showed that the proposed hazardous material inventory exceed the screening thresholds and that the development is 'potentially hazardous' under SEPP33 (Ref. 1).

1.2. Study Basis and Methodology

The methodology in the NSW Department of Planning (DoP) guidelines, Hazardous Industry Planning Advisory Paper (HIPAP) No. 6, 'Hazard Analysis' (Ref. 3) was followed for this study. Risk criteria from HIPAP No. 4, 'Risk Criteria for Land Use Safety Planning', (Ref. 4) are adopted for the risk assessment.

The basic process for the study is as follows:

- Establish the context, including methodology of assessment and the relevant risk tolerability criteria.
- Perform hazard identification study to identify hazards and their controls throughout all development phases.
- Identify credible scenarios for carrying forward for quantification of consequences and likelihood in the operations phase.
- Consequence analysis for the identified credible scenarios. Where offsite impact was found to have the potential to occur, carry the scenario forward for frequency analysis.
- Frequency analysis to estimate the likelihood of hazardous events for the scenarios with the potential for offsite impact.
- Perform a Quantitative Risk Assessment (QRA) by combining the offsite scenario consequences and their associated frequency in order to generate risk contours for the development.
- Assess the offsite risk profile against the risk tolerability criteria outlined in the NSW DoP HIPAP No. 4.

This study is preliminary and based on proposed inventories and preliminary design basis information. As such, a conservative approach to modelling was adopted.

1.3. Status

This revision of the study (Rev. 0) has been updated to include revised information in relation to HCl storage, the sulphuric acid plant technology selection and address preliminary comments from NSW DoPI.

Whilst some technical inputs have been updated, the overall study conclusions remain unchanged compared to the previous issue (Rev. B).

1.4. Conclusions

Hazard analysis results demonstrate that the proposed processing plant complies with all NSW land use planning risk criteria as published in HIPAP No. 4. The relevant hazardous incidents which mainly contribute to offsite risk are the release and toxic dispersion of anhydrous ammonia from storage vessels.

Risk levels presented in this report are preliminary only, as the Proposal is in early stages of development. The risk contours would be refined in the Final Hazard Analysis (FHA, which is anticipated to be a condition associated with the development, if approved) once detailed design of the processing plant and final site layout is in place.

1.5. Recommendations

Based on the results and findings of the Preliminary Hazard Analysis (PHA), the following recommendations are made:

- The main contributor to risk is leaks from ammonia storage vessels, including instrument fittings and valves. The QRA is based on a conservative estimate of the number of leak points. It is recommended that the number of potential leak points in anhydrous ammonia service (transfer and storage area) be minimised to further reduce the risk. This includes minimising flanges and fittings in storage vessels and pipework. This can be further investigated in the detailed design stage and assessed in the FHA.
- It is also recommended that the number of potential leak points in the hydrochloric acid storage area be minimised to further reduce the risk. This includes minimising flanges and fittings in the acid storage tanks and pipework.
- A HAZOP should be undertaken to confirm that the likelihood of process upset scenarios that could result in loss of containment of toxic material is very low and that risk is acceptable. This includes, but not limited to scenarios such as breakthrough of sulphur dioxide from sulphuric acid production and breakthrough of ammonia from aqua ammonia manufacture.

2. INTRODUCTION

2.1. Background

Australian Zirconia Ltd (AZL), the Applicant, a wholly owned subsidiary of Alkane Resources Limited, is planning to submit a development application to develop and operate the Dubbo Zirconia Project (DZP, referred to as the Proposal). The mining and mineral processing plant for Zirconium, Niobium, Yttrium and Rare Earth Elements (REEs) is located near Toongi, approximately 25 km south of Dubbo. The Proposal incorporates complex industrial processing components involving dangerous goods (eg anhydrous ammonia, hydrochloric acid and caustic soda) to separate the rare metals and earth elements from the ore.

2.2. Study Objective

The objective of the study was to undertake a Preliminary Hazard Analysis (PHA) of the mineral processing plant in accordance with the guidelines for PHA by the NSW Department of Planning (DoP) and evaluate offsite risk levels.

2.3. Study Scope

The scope of the study (as per SEPP33 and PHA Study Brief, 31 July 2012) includes:

- Mineral processing activity
- Chemical storage and handling.

2.4. Limitations and Exclusions

The PHA does not cover:

- Transport of hazardous materials to and from site.
- Vehicle movements within the site.
- Onsite or employee risk.
- Process upset scenarios (eg breakthrough of ammonia from aqua ammonia production).
- Sensitivity analyses to determine the effect of any identified risk reduction measures.

The design of the Proposal is preliminary only. Hence the PHA is based on inventories and is a conservative estimate of typical process equipment and leak sources for similar plants.

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 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 Proposal is a designated Major Hazard Facility (MHF) under the NSW Work Health and Safety Regulation (WHS) 2011 (Ref. 2) as it will exceed the screening threshold of anhydrous ammonia given in Schedule 15. This PHA does not address the requirements of the safety report required under the WHS regulation.

3. DESCRIPTION OF THE PROPOSED DEVELOPMENT

3.1. Site Location and Surrounding Land Use

The proposed facility is located near Toongi, approximately 25 km south of Dubbo, NSW. DZP site is situated within the headwaters of the Macquarie River Catchment, in a transition zone between the tablelands of the Great Dividing Range to the east and the Darling Basin plains to the west.

The area around DZP site is predominantly used for agricultural purposes. Other land uses in the area include:

- Residential (Toongi village)
- Community hall at Toongi
- Waste transfer station at Toongi
- Recreational (sports field, tennis courts, camping ground) at Toongi
- Air strips.

There are also a small number of individual residences present around the site. There are no sensitive land uses (eg schools, hospitals, aged care facilities) in the area. The nearest residential use (Toongi Hall) is located approximately 270 m from the DZP site boundary and 750 m from the processing plant boundary.

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

3.2. Site Layout

The DZP site layout is shown in Figure 3.2. The mineral processing plant is located near the site main entrance. Layout of the processing plant is shown in Figure 3.3.

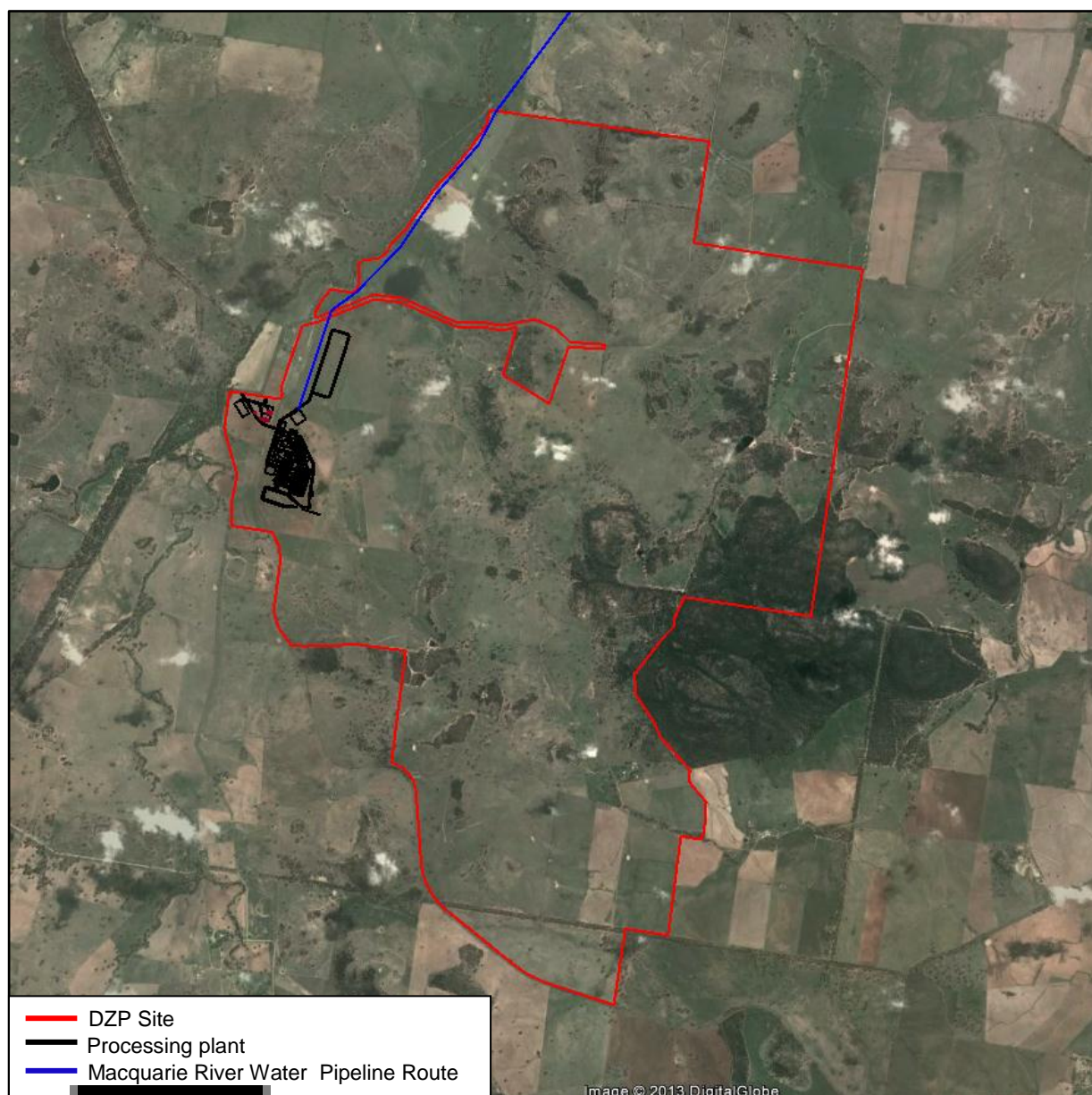


Figure 3.1: Aerial View of DZP Site

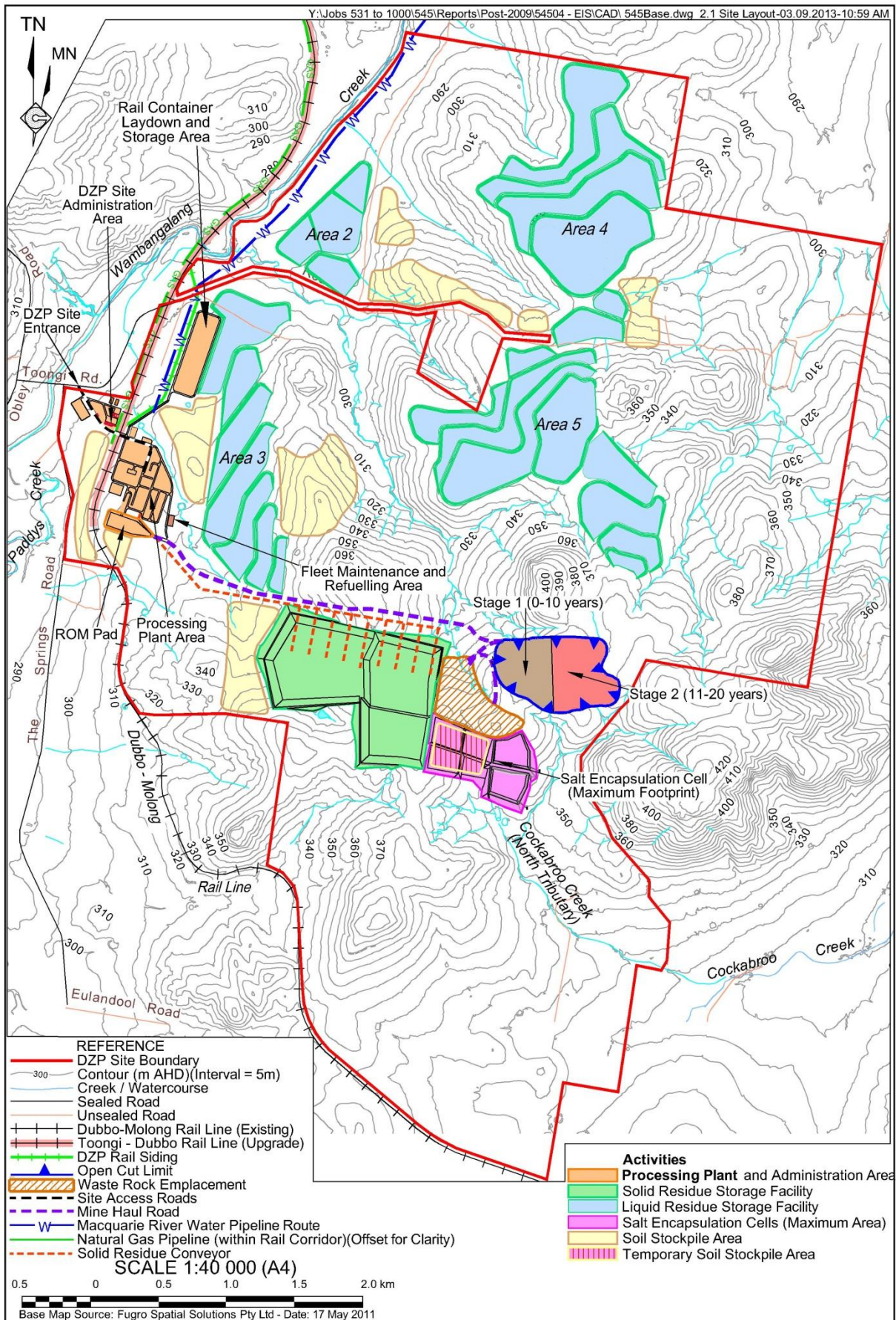


Figure 3.2: DZP Site Layout

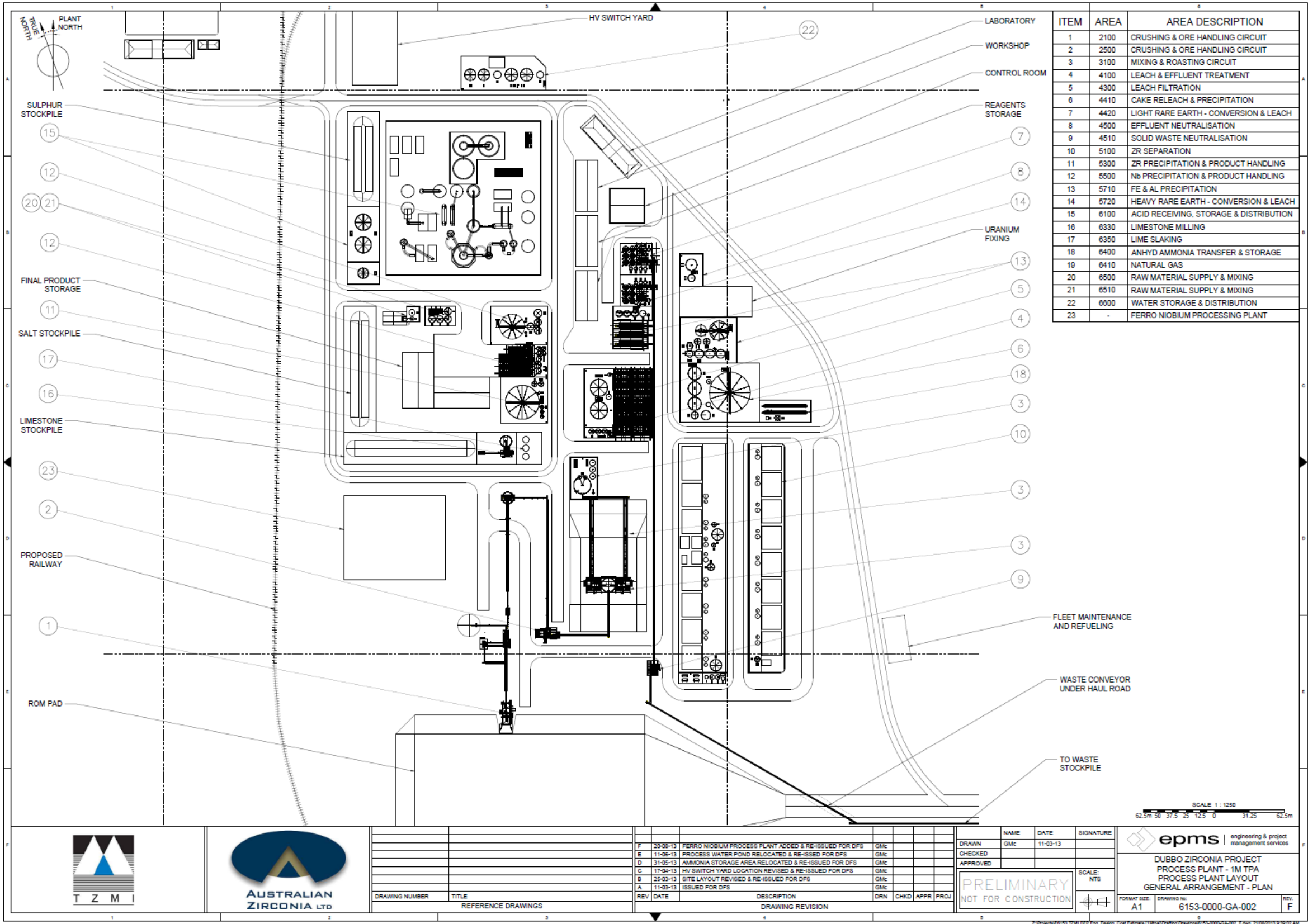


Figure 3.3: Processing Plant Layout (General Arrangement)

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3.3. Process Overview

The processing operations would include the following components:

- **Ore crushing and milling:** The mine ore would be loaded from the Run-of-Mine (ROM) pad into the primary crusher, followed by secondary and tertiary crushing stations to reduce the ore size to 6 mm (P_{80}). The 6 mm material would then be transferred to a dry grinding circuit to reduce the size to 75 μm (P_{80}).
- **Sulphuric acid production:** Sulphuric acid would be produced concurrently in a separate process. Sulphur from the stockpiles would be transferred to the sulphuric acid plant where it would be heated by natural gas burners to produce SO_2 , which would then be converted to SO_3 by oxidation in catalyst beds using vanadium oxide as the catalyst. The SO_3 would then be hydrated to form sulphuric acid.
- **Roasting:** Sulphuric acid and ground ore would be mixed and heated to convert the metals and Rare Earth Elements (REEs) to 'sulphated ore'. The sulphated ore would then be cooled in roaster coolers.

Acidic gases generated during the roasting process would be cooled using recovered water to less than 50°C and scrubbed to form dilute acid used in the metal and heavy REE leaching circuit. Remaining gas would be scrubbed with a limestone slurry to capture sulphuric acid mists, hydrofluoric gases and radionuclide particulates. The scrubbed gas would then flow through a 10 m high stack.

- **Leaching and filtration:** Sulphated ore from the coolers would be directed to leach tanks where water would be added to dissolve the sulphates compounds of the ore.

Remaining solids would be filtered to separate the pregnant leach solution (PLS) from the residue solids. Solids would be washed with recovered acid from the roaster scrubber to recover dissolved zirconium. The solid would then be dewatered using a filter press to produce a highly acidic, iron rich solution containing zirconium, hafnium, niobium, tantalum, yttrium and heavy REEs.

- **Light REE recovery and refining:** Filter cake residue from leach filtration would be mixed with water for light REE recovery. A thickener and filter press would then separate the light REE containing liquor from the solid residue. The solid residue would be transferred to a stabilisation area for neutralisation and disposal to the Solid Residue Storage Facility (SRSF). Light REEs would be precipitated, discharged to a neutralisation tank where the pH would be increased by adding a lime slurry, before being discharged to the Liquid Residue Storage Facility (LRSF).
- **Solvent extraction:** Filtered PLS solution would be directed to the solvent extraction (SX) cycle for the recovery of zirconium and hafnium, by neutralisation and selective precipitation. Raffinate from SX cycle would then be heated to recover niobium and tantalum products.

- **Heavy REE recovery and refining:** The remaining PLS would be directed to the Heavy REE recovery circuit. The pH of the liquid would be adjusted to neutral by dosing with lime slurry or residue from the sulphates light REE liquid as required and pumped to the LRSF for disposal. The solid residue (acidic in nature) would be transferred to the SRSF.
- **Solid neutralisation and SRSF:** Solid residues would be delivered to the neutralisation area via a long waste conveyor. Lime slurry would be added to produce a neutral pH cake, which would then be delivered to the SRSF via a conveyor. A sump pump would return any leachate to the LRSF.

4. METHODOLOGY

4.1. Study Overview

The methodology for undertaking the PHA was based on the NSW DoP guidelines, HIPAP No. 6, *Hazard Analysis* (Ref. 3) and HIPAP No. 4, *Risk Criteria for Land Use Safety Planning* (Ref. 4).

A PHA is required for an Environmental Impact Statement (EIS) for a potentially hazardous industrial development. The PHA is preliminary in the sense that detailed design information is usually not available at this stage. The PHA is part of the hazard and risk management process that continues through design, installation, operations and decommissioning.

The basic methodology for this PHA is shown in Figure 4.1, as reproduced from HIPAP No. 6.

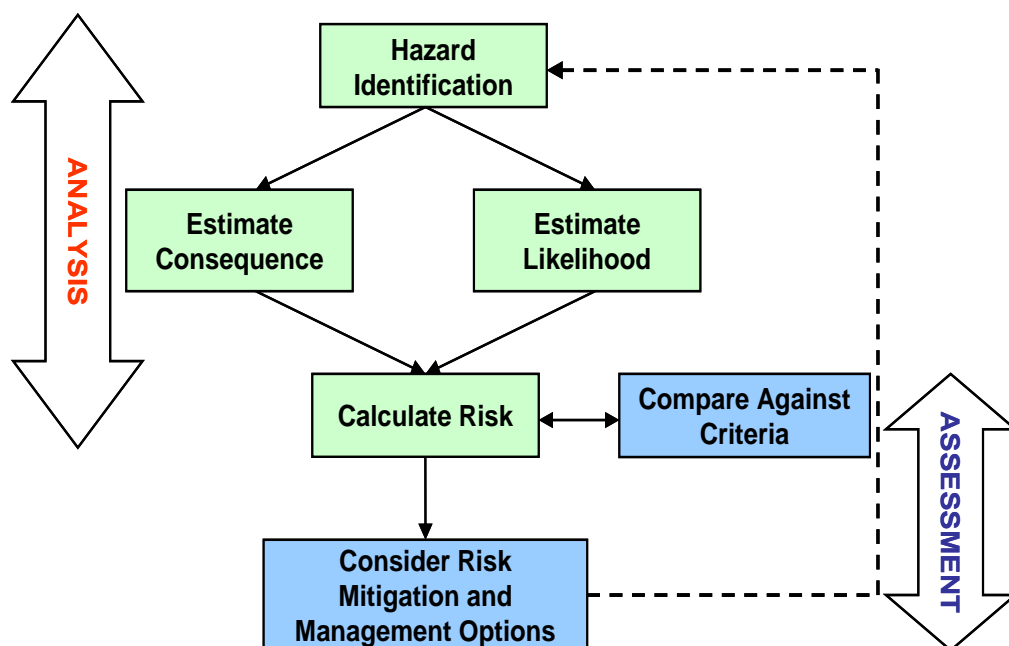


Figure 4.1: Basic Methodology for Preliminary Hazard Analysis

The stages of the study are given below:

- Establish the context, including methodology of assessment and the relevant risk tolerability criteria.
- Perform a hazard identification study to identify hazards and their controls throughout all development phases.
- Identify credible scenarios to carry forward for quantification of consequences and likelihood in the operations phase.

- Undertake a consequence analysis for the identified credible scenarios. Where offsite impact are found to have the potential to occur, carry the scenario forward for frequency analysis.
- Undertake a frequency analysis to estimate the likelihood of hazardous events for the scenarios with the potential for offsite impact.
- Undertake a quantitative risk assessment (QRA) by combining the offsite scenario consequences and their associated frequency in order to generate risk contours for the development.
- Assess the offsite risk profile against the risk tolerability criteria outlined in NSW DoP HIPAP No. 4.

4.2. Risk Criteria

Individual fatality risk criteria in NSW DoP HIPAP No. 4 (Ref. 4) were adopted for this study and are provided in Table 4.1.

Individual fatality risk represents the probability of fatality occurring to a theoretical individual located permanently at a particular location, assuming no mitigating action such as escape can be taken. It is considered to cover vulnerable individuals such as the very young, sick or elderly.

The injury and irritation contours show the likelihood of a threshold concentration being exceeded at a particular location. Similar to individual fatality risk, injury/irritation risk contours represent probability of injury or irritation experienced by a person located permanently at a particular location, assuming no mitigating action such as escape.

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

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

| Description | Risk criteria (per year) |
|--|--------------------------|
| Individual fatality risk | |
| Fatality to sensitive land uses, including hospitals, schools, aged care | 0.5×10^{-6} |
| Facility risk to residential and hotels | 1×10^{-6} |
| Facility 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 to be contained within the boundary of an industrial site | 50×10^{-6} |
| Injury (Fire/Explosion) | |

| Description | Risk criteria (per year) |
|---|--------------------------|
| 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} |
| <i>Injury/Irritation (Toxic impacts)</i> | |
| 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} |

4.3. 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

Potentially hazardous materials present at the site are listed below:

- Hydrochloric acid (33%)
- Sulphuric acid (98%)
- Sulphur
- Sodium sulphide
- Sodium hydroxide
- Anhydrous ammonia
- Chlorine (potable water treatment chemicals)
- SX organic
- Diesel fuel
- Aluminium powder
- Sodium fluoride
- Tributyl phosphate.

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 A.

Table 5.1: Hazardous Materials

| Material | State | DG Class | Description and hazards (Ref: Orica and SX MSDS) | Hazard Type |
|--|---|----------|---|---------------------|
| Hydrochloric acid (33 wt%) | 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 |
| Sulphuric Acid (98%) | Liquid | 8 PG II | Sulphuric acid is a strong mineral acid that is colourless and soluble in water at all concentrations. Although sulphuric acid is non-flammable, contact with metals in the event of a spillage can lead to the liberation of hydrogen gas. Sulphuric acid is extremely corrosive and skin contact may lead to serious burns. | Corrosive |
| Sulphur prills | Solid | Non DG | Sulphur is not subject to the provisions of the Australian Dangerous Goods Code when it has been formed to a specific shape (eg. prills, granules, pellets, pastilles or flakes). However, it is a combustible solid and may form combustible dust clouds in air. | Combustible |
| Sodium Sulphide (Na ₂ S) | Solid | 8 PG II | Red or yellowish solid with a rotten egg-like odour. It reacts with acids liberating hydrogen sulphide, a highly flammable toxic gas. It is a severe eye irritant, corrosive to eyes and skin. | Corrosive |
| Sodium hydroxide (NaOH) | Solid | 8 PG II | Sodium hydroxide is a colourless salt, which is soluble in water. It is corrosive and skin contact with the solution may result in severe pains and skin burns. Eye contact may result in serious permanent eye damage. | Corrosive |
| Anhydrous ammonia | Refrigerated liquid Pressurised liquefied gas Gas | 2.3 | Ammonia is a toxic gas. It is a powerful irritant to eyes and mucous membranes of the respiratory tract. Inhalation of high concentrations of the vapour may cause pulmonary oedema, which may be fatal. At low concentrations, ammonia vapour irritates the eyes, nose and throat. Ammonia can be detected in the atmosphere by smell at concentrations as low as 5 ppm. Ammonia is also flammable, however has a narrow flammability range (16 vol% to 25 vol%) and it requires a strong ignition source (compared to hydrocarbons). | Toxic/ Flammable |
| Chlorine (Potable water treatment chemicals) | Gas Liquid | 2.3 | Chlorine is a highly reactive gas with a pungent odour. It is greenish yellow in high concentration and colourless in low concentrations. It is heavier than air and forms explosive mixtures with alcohols, glycols, ammonia and its compounds. It is corrosive in the presence of moisture. It is a severe irritant to eyes, skin and mucous membranes of the respiratory tract. Exposure may lead to lung damage and overexposure may result in death. | Toxic |
| SX Organic (Alamine 336) | Liquid | 9 PG III | It is a light yellow liquid with an amine-like odour. It is not soluble in water. It is an irritant to eyes and skin and toxic to aquatic organisms. | Irritant |

| Material | State | DG Class | Description and hazards (Ref: Orica and SX MSDS) | Hazard Type |
|--------------------|----------------|------------|---|-----------------------------------|
| Diesel fuel | Liquid | 9 PG III | Diesel is a pale straw/colourless liquid which may ignite on surfaces above auto-ignition temperature (>220°C). Vapour in the headspace of tanks and containers may ignite and explode at temperatures above auto-ignition temperature, where vapour concentrations are within flammability range. Diesel is not a flammable but is a combustible with a flash point of 62°C (temperature above which it can form an ignitable mixture in air). Electrostatic discharge may cause fire. | Combustible |
| Aluminium powder | Solid powder | 4.1 | Dull grey to metallic silver in colour. Aluminium powder will react with water, acids, and alkalis to form highly flammable hydrogen gas and aluminium oxide. | Produces hydrogen (flammable gas) |
| Sodium fluoride | Solid crystals | 6.1 PG III | Sodium fluoride is a white or colourless solid which upon contact with acids, liberates very toxic gas (including hydrogen fluoride and sodium oxide fumes). It is an irritant to eyes and skin. | Irritant |
| Tributyl phosphate | Liquid | 2 | Tributyl phosphate is a colourless, combustible liquid. | Combustible |
| Automotive LPG | Liquid | 2.1 | Flammable gas stored in the form of pressurised liquefied gas (ie at ambient temperature and saturated vapour pressure). | Flammable |
| Petrol | Liquid | 3 PG II | Extremely flammable. Electrostatic charges may be generated during handling. Electrostatic discharge may cause fire. Liquid evaporates quickly and can ignite leading to a flash fire, or an explosion in a confined space. | Flammable |

5.2. Potential Major Hazardous Incident Scenarios

Potentially hazardous incident scenarios were identified based on a review of the facility Process Flow Diagrams (PFDs) and experience with hazard identification work undertaken previously for similar facilities. Table 5.2 outlines the potential major hazardous incident scenarios which were identified.

5.3. Rule Set and Assumptions for Incident Inclusion

The rule set and assumptions made for the inclusion of major incident scenarios in the Quantitative Risk Assessment (QRA) are given below:

- Hazardous incident scenarios involving only toxic and flammable materials were assessed quantitatively in the QRA. Corrosive materials, eg caustic soda, were not assessed as corrosive materials would be stored and handled as per *AS 3730: Storage and Handling of Corrosive Substances*. Scenarios such as spills and release of corrosives would be managed by site procedures and have limited impact only, hence do not contribute to offsite risk levels.
- Likelihood of reactions between incompatible materials (eg sodium sulphide, aluminium powder, acids, sulphur) would be low, due to dedicated separate storage areas provided onsite. Acid storage, handling and distribution would occur in a separate bunded concrete pad.
- Flammable effects of ammonia were not quantified in the QRA. The flammable effects of ammonia are secondary to any toxic effects. Additionally, aqueous ammonia has relatively localised toxic hazards and loss of containment impacts from aqueous ammonia were not quantified.
- Incidents involving combustibles (eg tributyl phosphate and diesel) were not included. Combustibles would be handled at ambient temperatures, hence would be difficult to ignite. Combustibles would be stored in accordance with *AS 1940: Storage and Handling of Flammable and Combustible liquids*.
- Flammable materials (LPG, petrol) would be stored in minor quantities only and would not be used in the processing plant operations. They were therefore excluded in the QRA.
- Generic consequence modelling was undertaken for fire incidents arising from natural gas used in burners and roasting circuits. Modelling results show that jet fires produce no significant offsite risk and do not present a risk of onsite escalation. Quantification of frequencies was not carried out and therefore not included in the QRA model.
- It was assumed that ammonia storage tanks would be designed as per *AS 2022: Anhydrous ammonia - Storage and Handling*. Safeguards required by AS 2022 which were specifically accounted for in the QRA are excess flow shut off valves which close at no more than 1.5 times the design flowrate on all liquid outlets from storage tanks unless they are less than 1.4 mm in diameter (Clauses 2.8, 3.4) and

emergency shutdown system with remote actuated shutoff valve on storage tank discharge liquid line (Clause 2.16). Additionally, it was assumed that instrument fittings on storage tanks would be restricted to 1.4 mm (avoiding the need for excess flow valves as per Clause 2.8/3.4.1), limiting the maximum leak rate from any fitting failure.

Table 5.2: Potential Major Hazardous Incident Scenarios

Page 1 of 5

| Plant Area Code | Area Description | Main materials present | Hazardous Impact? | | Scenario Description | Typical Causes | Controls and Safeguards | Consequences Modelled | Incorporated in PHA? | Further Assessment in FHA/HAZOP? |
|-----------------|---------------------------------------|---|-------------------|--|---|---|---|-----------------------|---|----------------------------------|
| | | | Flammable | Toxic | | | | | | |
| 2100 2500 | Crushing and ore handling circuit | <ul style="list-style-type: none"> ROM ore | No | No | - | - | - | - | No. No significant flammable and toxic impact. | No |
| 3100 | Mixing and roasting circuit | <ul style="list-style-type: none"> Milled ore Sulphuric acid Sulphated ore Acidic gases | No | Yes Sulphuric acid, Acidic gases | Release of sulphuric acid | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Sulphuric acid stored in tanks on bunded concrete pad Site spill procedures in place to contain leaks Attended operation (sulphuric acid addition) | - | No. It is considered that the effects of a release of sulphuric acid are likely to be localised and effectively managed and contained through implementation of the site spill procedures. | No |
| | | | | | Release of acidic gases (eg sulphur dioxide) | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) Scrubber failure modes eg breakdown | <ul style="list-style-type: none"> Materials of construction suitable Suitable design of scrubber to handle acidic gases The roaster would be operated under negative pressure and driven by the fan feeding the roaster scrubber unit. Design safeguards include shutdown of roaster in the event of fan stoppage or power failure. | - | No. Release of SO ₂ would be buoyant due to high process temperatures. The SO ₂ would rise and be diluted to below the toxic injury and toxic irritation end point concentrations prior to loss of buoyancy effects (0.75 ppm and 0.2 ppm respectively). SO ₂ releases are unlikely to impact sensitive community members and hence excluded from the risk model. Refer to APPENDIX B for SO ₂ release modelling inputs and results. Scrubber failure modes (eg breakdown scenarios) would be covered in the plant HAZOP. | Yes |
| | | | | | Reaction between components in vent gases (roasting circuit vents, hydrogen chloride) | <ul style="list-style-type: none"> Incompatible materials present in gases directed to the scrubber | <ul style="list-style-type: none"> Scrubber design to handle all acidic gas vents | - | No. The likelihood of reactions between incompatible materials would be low. Such scenarios would be covered in the plant HAZOP and reassessed as part of FHA. | Yes |
| 4100 | Leach and effluent treatment | <ul style="list-style-type: none"> Roasted ore Leach slurry | No | No | - | - | - | - | No. No significant flammable and toxic impact. | No |
| 4300 | Leach filtration | <ul style="list-style-type: none"> Pregnant leach solution (PLS) Residue solids | No | No | - | - | - | - | No. No significant flammable and toxic impact. | No |
| 4410 | Cake rewash and precipitation | <ul style="list-style-type: none"> Sodium sulphate solution Flocculent | No | No | - | - | - | - | No. No significant flammable and toxic impact. | No |
| 4420 | Light rare earth conversion and leach | <ul style="list-style-type: none"> Sodium sulphate solution Light REEs | No | No | - | - | - | - | No. No significant flammable and toxic impact. | No |

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Table 5.2: Potential Major Hazardous Incident Scenarios (Cont'd)

Page 2 of 5

| Plant Area Code | Area Description | Main materials present | Hazardous Impact? | | Scenario Description | Typical Causes | Controls and Safeguards | Consequences Modelled | Incorporated in PHA? | Further Assessment in FHA/HAZOP? |
|-----------------|--|---|-------------------|---|---|--|--|-----------------------|--|----------------------------------|
| | | | Flammable | Toxic | | | | | | |
| 4500 | Effluent neutralisation | <ul style="list-style-type: none"> Sulphuric acid Hydrochloric acid Effluent (caustic filter filtrates) HREC retentate Lime slurry | No | Yes Sulphuric acid, Hydrochloric acid | Release of sulphuric acid from distribution piping | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Sulphuric acid stored in tanks on bunded concrete pad Site spill procedures in place to contain leaks | - | No. It is considered that the effects of a release of sulphuric acid are likely to be localised and effectively managed and contained through implementation of the site spill procedures. | No |
| 4500 | Effluent neutralisation | <ul style="list-style-type: none"> Sulphuric acid Hydrochloric acid Effluent (caustic filter filtrates) HREC retentate Lime slurry | No | Yes Sulphuric acid, Hydrochloric acid | Release of hydrochloric acid from distribution piping | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Site spill procedures in place to contain leaks | - | No. Small hydrochloric acid releases from piping do not contribute to offsite risk. Small spills have localised impact only and are effectively managed and contained through implementation of site spill procedures. | No |
| 4510 | Solid waste neutralisation | <ul style="list-style-type: none"> Solid residues (from Fe, Al, HSL, LSL filters) | No | No | - | - | - | - | No. No significant flammable and toxic impact. | No |
| 5100 | Zirconium separation | <ul style="list-style-type: none"> PLS Recovered acid solution from scrubber Recovered heavy metals (Zr) Alamine 336 | No | Yes Recovered acid | Release of recovered acid from scrubber | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Site spill procedures in place to contain leaks | - | No. It is considered that the effects of a release of acid are likely to be localised and effectively managed and contained through implementation of the site spill procedures. | No |
| 5300 | Zirconium precipitation and product handling | <ul style="list-style-type: none"> Aqua ammonia Loaded strip liquor (containing Zr, Hf, Nb, Ta, Y, heavy REEs) Organics | No | Yes Aqua ammonia fumes | Release of aqua ammonia | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Mechanical design suitable for aqua ammonia service | - | Aqueous ammonia has relatively localised toxic hazards and therefore has not been included in QRA. | No |
| 5500 | Niobium precipitation and product handling | <ul style="list-style-type: none"> Zr raffinate Organics Recovered Nb | No | No | - | - | - | - | No. No significant flammable and toxic impact. | No |

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Table 5.2: Potential Major Hazardous Incident Scenarios (Cont'd)

Page 3 of 5

| Plant Area Code | Area Description | Main materials present | Hazardous Impact? | | Scenario Description | Typical Causes | Controls and Safeguards | Consequences Modelled | Incorporated in PHA? | Further Assessment in FHA/HAZOP? |
|-----------------|--|---|-------------------|---|---|--|---|-----------------------|--|----------------------------------|
| 5710 | Iron and aluminium precipitation | <ul style="list-style-type: none"> Calcium carbonate slurry Filtrates Sodium sulphide solution Soda ash Caustic solution | No | Yes Hydrogen sulphide | Reactions between sodium sulphide with acids, leading to formation and release of hydrogen sulphide | <ul style="list-style-type: none"> Inadvertent contact between sodium sulphide and acids during transfer and operation | <ul style="list-style-type: none"> Separation distance between Fe, Al precipitation (Area 5710) and Acid storage and distribution (Area 6100) Acid storage and distribution area is bunded, containing possible leaks within the area Controls assumed to be in place to prevent contact of sodium sulphide and acids Storage of sodium sulphide in accordance with AS 3730 | - | No. Likelihood of contact between sodium sulphide and acids is low, given the separation distance between acid handling and Fe, Al precipitation. Also, acid receiving, storage and distribution are in a separate bunded area. Any contact from abnormal plant operation would be covered in the plant HAZOP. | No |
| 5720 | Heavy rare earth - Conversion & leach | <ul style="list-style-type: none"> Liquor from HRC thickener Sulphuric acid Hydrochloric acid | No | Yes Sulphuric acid, Hydrochloric acid | Release of sulphuric acid | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Site spill procedures in place to contain leaks | - | No. It is considered that the effects of a release of sulphuric acid are likely to be localised and effectively managed and contained through implementation of the site spill procedures. | No |
| | | | | | Release of hydrochloric acid from distribution piping | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Site spill procedures in place to contain leaks | - | No. Small hydrochloric acid releases from piping do not contribute to offsite risk. Small spills have localised impact only and are effectively managed and contained through implementation of site spill procedures. | No |
| 6100 | Acid receiving, storage and distribution | <ul style="list-style-type: none"> Sulphur powder Sulphuric acid Sulphur dioxide Hydrochloric acid | No | Yes Sulphuric acid, Sulphur dioxide, HCl | Dust explosion of combustible sulphur powder | <ul style="list-style-type: none"> Material handling Generic mechanical failures | <ul style="list-style-type: none"> Separated area for sulphur, away from incompatibles (eg ammonia) Materials handling equipment designed for combustible dust | - | No. Releases of sulphur powder do not contribute significantly to offsite risk. Dust explosions can be very damaging in the immediate vicinity but no offsite impact or escalation potential – separation distances are approximately 420 m to ammonia storage and 510 m to site boundary. | No |
| | | | | | Release of sulphur dioxide gas in sulphuric acid production area | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Minimal inventory Low pressures (process at approximately atmospheric pressure and high temperatures, approximately 500° C) | - | No. A release of SO ₂ would be buoyant due to high process temperatures. The SO ₂ would rise and be diluted to below the toxic injury and toxic irritation end point concentrations prior to loss of buoyancy effects (0.75 ppm and 0.2 ppm respectively). SO ₂ releases are unlikely to impact sensitive community members and hence excluded from the risk model. Refer to APPENDIX B for SO ₂ release modelling inputs and results. | Yes |

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Table 5.2: Potential Major Hazardous Incident Scenarios (Cont'd)

Page 4 of 5

| Plant Area Code | Area Description | Main materials present | Hazardous Impact? | | Scenario Description | Typical Causes | Controls and Safeguards | Consequences Modelled | Incorporated in PHA? | Further Assessment in FHA/HAZOP? |
|-----------------|--|---|-------------------|-----|--|--|---|-----------------------|--|----------------------------------|
| | | | | | Release of hydrochloric acid from storage tanks | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Bunding in place | Toxic dispersion | Yes | Yes |
| | | | | | Release of hydrochloric acid from distribution piping | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Site spill procedures in place to contain leaks | - | No. Small hydrochloric acid releases from piping do not contribute to offsite risk. Small spills have localised impact only and are effectively managed and contained through implementation of site spill procedures. | No |
| 6330 | Limestone milling | <ul style="list-style-type: none"> Limestone | No | No | - | - | - | - | No. No significant flammable and toxic impact. | No |
| 6350 | Lime slaking | <ul style="list-style-type: none"> Quick lime | No | No | - | - | - | - | No. No significant flammable and toxic impact. | No |
| 6400 | Anhydrous ammonia transfer and storage | <ul style="list-style-type: none"> Anhydrous ammonia Aqua ammonia | Yes | Yes | Release of ammonia from storage vessels | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Storage vessel fitted with isolation valves, pressure relief valves in accordance with AS 2022 | Toxic dispersion | Yes | Yes |
| | | | | | Release of ammonia in anhydrous ammonia and transfer area | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | - | Toxic dispersion | Yes | Yes |
| | | | | | Breakthrough of ammonia from aqua ammonia production | <ul style="list-style-type: none"> Vapouriser breakdown Generic mechanical failures | <ul style="list-style-type: none"> Design controls in place | - | No. Scenarios related to ammonia breakthrough due to mechanical failures would be covered in the plant HAZOP. The inclusion of this scenario would be reassessed as part of final hazard analysis (FHA). | Yes |
| 6410 | Natural gas | <ul style="list-style-type: none"> Natural gas | Yes | No | Fires due to release of utility natural gas from piping to roasters, boilers and burners | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Design controls in place Burners are enclosed Emergency stop valves to cut-off gas supply Emergency gas shutdown | - | No. Generic consequence modelling for natural gas at 10 bar was undertaken and results show that fires resulting from natural gas leaks will not produce any offsite impact (Natural gas supply would typically be at lower pressures). Based on consequence modelling results and with separation distances and safeguards in place as required by the Australian Standard relating to fire equipment, there is no risk of jet fires leading to escalation events eg impact on ammonia bulk storage and failure leading to ammonia release. | No |

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Table 5.2: Potential Major Hazardous Incident Scenarios (Cont'd)

Page 5 of 5

| Plant Area Code | Area Description | Main materials present | Hazardous Impact? | | Scenario Description | Typical Causes | Controls and Safeguards | Consequences Modelled | Incorporated in PHA? | Further Assessment in FHA/HAZOP? |
|-----------------|--------------------------------|--|-------------------|--------------|--|---|--|-----------------------|--|----------------------------------|
| 6500, 6510 | Raw material supply and mixing | <ul style="list-style-type: none"> Salt Soda ash Caustic soda solution Coagulant Organics | No | No | - | - | - | - | - | No |
| 6600 | Water storage and distribution | <ul style="list-style-type: none"> Chlorine Caustic soda (50%) | No | Yes Chlorine | Release of chlorine from G cylinders (70 kg) | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) | <ul style="list-style-type: none"> Design controls in place Gas detection | Toxic dispersion | Yes | Yes |
| - | Ferro-Niobium smelting circuit | <ul style="list-style-type: none"> Iron scrap Ferrosilicon (75% Si) | No | No | - | - | - | - | No. No significant flammable and toxic impact. | No |
| - | Loading bay | <ul style="list-style-type: none"> Hydrochloric acid | No | Yes | Release of hydrochloric acid in loading bay | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) Leak from loading arm | <ul style="list-style-type: none"> Attended operation Remote ESD | Toxic dispersion | Yes | Yes |
| - | Loading bay | <ul style="list-style-type: none"> Ammonia | No | Yes | Release of ammonia in loading bay | <ul style="list-style-type: none"> Generic mechanical failures (including corrosion, impact, leaks from fittings and flanges) Leak from loading arm | <ul style="list-style-type: none"> Attended operation Remote ESD Excess flow valves in tanker and tank (as per AS 2022) | Toxic dispersion | Yes | Yes |

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5.4. Incident Scenarios Assessed in QRA

The potential major incident scenarios (as identified in Section 5.2) were assessed using the rule set and assumptions detailed in Section 5.3. Discrete scenarios were then developed to allow a quantitative model to be developed. The major incident scenarios carried forward for quantitative assessment mainly consist of impacts due to toxic dispersion and are listed in Table 5.3.

Table 5.3: Scenarios Carried Forward for Assessment

| Area description | Scenario ID | Scenario Description and Consequence |
|--|-------------|--|
| Anhydrous ammonia transfer and storage | AMS-01 | Release of ammonia from storage vessel 1 resulting in toxic dispersion |
| | AMS-02 | Release of ammonia from storage vessel 2 resulting in toxic dispersion |
| | AMS-03 | Release of ammonia from compressor systems (6400-PK-02) resulting in toxic dispersion |
| | AMS-04 | Release of ammonia from distribution piping (liquid) resulting in toxic dispersion |
| | AMS-05 | Release of ammonia from distribution piping (vapour) resulting in toxic dispersion |
| Acid receiving, storage and distribution | ACD-01 | Release of hydrochloric acid from 3 storage tanks leading to spills, resulting in toxic dispersion |
| Water distribution and storage | WDS-01 | Release of chlorine from G cylinders (70 kg) resulting in toxic dispersion |
| Loading/unloading bay | LDB-01 | Release of ammonia in unloading area (hardware) resulting in toxic dispersion |
| | LDB-02 | Release of ammonia in unloading area (operation) resulting in toxic dispersion |
| | LDB-03 | Release of hydrochloric acid in unloading area (hardware) resulting in toxic dispersion |
| | LDB-04 | Release of hydrochloric acid in unloading area(operation) resulting in toxic dispersion |
| | LDB-05 | Release of ammonia from tanker resulting in toxic dispersion |

5.5. External Events

As part of the hazard identification process, the potential for external events to affect the site was considered. Table 5.4 summarises the external events considered in the PHA.

Table 5.4: 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 | Site is located in a mining area. No major subsidence issues identified. |
| Cyclones | Facility structures assumed to be designed in accordance with relevant 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 located 5 km northwest of Dubbo town centre. Air strips present in land surrounding DZP site. However, 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 | Assumed that the facility will be a secure site with security regulations in place. |
| 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. |
| Bush fire | 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 frequency or consequence modelling approaches were made as part of the QRA.

6. CONSEQUENCE ANALYSIS

6.1. Overview

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

Based on the hazard identification outline in Section 5, toxic releases of ammonia, hydrogen chloride and chlorine were carried forward for consequence analysis. Generic consequence modelling results show that ignited events such as jet fires from natural gas would not produce significant offsite risk and was hence, excluded from the QRA.

Consequence calculations were carried out using commercially available risk and consequence assessment software, TNO EFFECTS and TNO RiskCurves v9.

TNO EFFECTS and RiskCurves are software packages that perform calculations to predict the physical effects (gas concentrations, heat radiation levels, peak overpressures) of the escape of hazardous materials. The consequence models used within EFFECTS and RiskCurves are documented in the TNO Yellow Book (Ref. 7).

Generally, for each scenario an appropriate release rate equation was selected based on the release situation and initial state of the material. Pool size and evaporation calculations were performed where necessary. For heavier than air gases such as ammonia and chlorine, a heavy gas dispersion model was used to model dispersion behaviour and estimate gas cloud sizes. Any inventory or flow restrictions were taken into consideration. For releases where the density of gas is close to that of air, a neutral gas dispersion model was selected.

Toxicity effects were then calculated from the consequence results and exposure times using probit equations to estimate the probability of fatality at a particular location.

The approach used for consequence modelling is summarised in Table 6.1. The scenarios modelled and associated input data assumptions are contained in APPENDIX B.

Table 6.1: Consequence Models

| Main Materials | Incident Type | | Model |
|-------------------|--------------------|------------------|--|
| | Fire/ Explosion | Toxic Release | |
| Ammonia | - | Y | Heavy gas dispersion or neutral gas depending on nature of release and physical behaviour (pool evaporation or jet release) Note: Flammability effects not assessed (much smaller impact area than toxicity effects). |
| Hydrogen chloride | - | Y | Evaporating pool (non-boiling) of hydrochloric acid, neutral gas dispersion of resulting hydrogen chloride gas. |
| Chlorine | - | Y | Heavy gas dispersion |

6.2. Assumptions

For each scenario modelled, representative release conditions for source term modelling were identified based on the PFDs and material balance datasheet. Inventories of storage tanks were taken to be the maximum tank storage quantities. For scenarios involving process equipment and/or piping, inventories were calculated based on estimates of vessel inventories and/or piping lengths, based on the site layout.

For scenarios where process information was not available, assumptions were made based on typical conditions and/or experience from other similar studies. The process conditions and inventories used in the study are summarised in APPENDIX B.

6.2.1. Release Sources

Continuous releases to atmosphere from piping or vessel failures have been modelled using hole sizes corresponding to the available frequency data (as described in Section 7). For this study, hole sizes reported in the generic data have been rationalised into the following sizes:

- 2.5 mm
- 10 mm
- 25 mm
- 50 mm
- 100 mm
- Rupture, which is modelled as either a leak through the piping diameter or the instantaneous release of the entire inventory of a section.

These generic failure cases are comparable to those used in a number of published risk assessment studies described in Lees (Ref.8).

6.2.2. Release Rates

Release rates were calculated using TNO EFFECTS from standard flow rate correlations based on the material state (gas or liquid), the process temperature and pressure and the defined hole size. Where a calculated release rate is greater than the maximum possible process flow rate, the release rate was specified as equal to the process flow rate.

6.2.3. Flash and Evaporation Rate

When a spill of volatile liquid or pressurised liquefied gas occurs (eg anhydrous ammonia), some material will initially flash off and evaporate, with the remaining liquid evaporating at a lower rate due to the cooling of the liquid spill.

Vapour evolution rate from a non-boiling liquid pool (eg hydrochloric acid) was calculated using the McKay and Matsugu method outlined in TNO Yellow Book (Ref. 7). A maximum pool spreading area was defined based on the bunding in place.

6.2.4. Release Inventory

Inventories available for release were generally taken as the maximum tank/vessel capacity for storage vessels, or the normal working inventory within an isolatable section for process systems.

6.2.5. Release Duration

In general, release durations were set to 900 seconds, on the basis that some form of mitigation action (such as manual shutdown and isolation) would be taken within 15 minutes of a release. The exception to this is in cases where the release cannot be effectively isolated, such as from a vessel, storage tank or large inventory pipeline. In such cases, the release duration was set equal to the time required to deplete the inventory in the section considered.

The release duration is calculated within RiskCurves and is determined from the release rate for the scenario. The release rate is determined by the type of release. For example a liquefied gas release could be a jet vaporising at a constant rate or could have an initial flash followed by an evaporating pool depending on the leak, type of material and process conditions. The maximum release duration (ie if isolation does not or cannot occur) for any scenario was set to 30 minutes as this is judged to be sufficient time to implement emergency response.

For releases during unloading operation, release durations were set to 300 seconds. This would be an attended operation and it was assumed that the operator would take five minutes to shutdown and/or isolate.

6.2.6. Exposure duration

The exposure duration is used in the calculation of toxicity fatality effects. It is adjusted within RiskCurves and is the lesser of the calculated release duration based on the release conditions and inventory, or the maximum exposure duration. In this case the maximum exposure duration was set to an hour as it was assumed that emergency

response action would have already occurred, particularly for toxic gases with good odour warning properties (ie ammonia and chlorine as covered in this analysis).

6.3. Dispersion Model

TNO RiskCurves was used for dense gas or neutral gas dispersion calculations.

Dense gas dispersion (for example from chlorine leaks) from a ground level evaporating pool, a horizontal or vertical jet, or an instantaneous release can be modelled. The model predicts dispersion behaviour by solving the conservation equations for mass, momentum and energy.

The resulting gas cloud is treated as a steady state plume, a transient 'puff' or a combination of the two, depending on the release duration. In the case of a finite duration release, cloud dispersion is initially described using a steady state plume model as long as the source is active. Once the source has been shut off, subsequent dispersion is calculated by the transient puff model. For instantaneous releases the transient puff model is used for the entire calculation.

Ammonia is unusual in that, depending on the release conditions, it may behave as either a dense gas or a neutral gas.

For a pressurised liquid ammonia release, a liquid pool may form due to rain-out from the jet release. Preliminary consequence modelling in TNO RiskCurves indicated that the evaporation rate from the liquid pool formed is generally much lower than the jet release rate (containing the flashed fraction and entrained liquid droplets which result in behaviour as a dense case as per Sung and Wheeler, Ref. 9). Consequently, the dense gas model in TNO RiskCurves was used for all pressurised liquid ammonia releases. For low pressure ammonia releases, dispersion is most appropriately modelled as neutral gas dispersion (Ref. 9).

6.4. Release Orientation

Release orientations were assumed to be horizontal for jet releases.

6.5. Meteorological Data

Meteorological data for the Dubbo site was obtained from the Bureau of Meteorology (Australian Government). Data from 2003 to 2013 was analysed and consolidated to six wind/weather combinations (wind speed/Pasquill stability category) and 12 directional categories. The data was presented in a format suitable for input to the dispersion model. In general, the most stable meteorological conditions (F stability) lead to the largest effect distances for toxic releases.

Refer to APPENDIX C for the dataset used for the Dubbo site. The dataset is characterised by moderate wind speeds and a relatively high proportion of D stability conditions.

6.6. Other Environmental Factors

Other environmental factors and modelling inputs used in the dispersion models are summarised in Table 6.2.

Table 6.2: Dispersion Model Inputs

| Item | Value | Comments |
|---------------------------|---------------------|---|
| Environment | | |
| Ambient temperature | 24.5 °C | Annual average (Bureau of Meteorology, Ref. 5) |
| Soil temperature | 24.5 °C | Assumed to be the same as ambient temperature |
| Relative Humidity | 67% | Annual average (Bureau of Meteorology, Ref. 5) |
| Solar radiation | 1 kW/m ² | Assumed average value used for evaporation calculations |
| Surface roughness factor | 0.1 m | Suitable for process sites with low crops and occasional large obstacles |
| Model inputs | | |
| Averaging time (toxics) | 600 sec | TNO Yellow Book (Ref. 7) |
| Exposures | | |
| Maximum exposure duration | 1 hour | Emergency response assumed to have occurred within 60 minutes. Stable dispersion conditions (ie steady state) established well within an hour. Note that if release durations are shorter than an hour, the release duration calculated by release model, not the maximum exposure duration is used in the risk calculations. |
| Receptor height | 1.5 m | Around face height |

6.7. Vulnerability - Toxic Effects Rule Sets

Table 6.3 summarises the criteria used for the assessment of acutely toxic materials considered in this QRA.

Fatality

In QRAs, probability of fatality is usually estimated from probit equations of the form:

$$Pr = A + b \ln(c^n t)$$

where:

- Pr : Probit value
- A, b : Constants specific to each material.
- c : concentration (ppm)

n : exposure exponent specific to each material.

t : time exposed to concentration (min)

erf : error function (mathematical)

These can then be converted to a probability of fatality using the error function transform:

$$\text{Probability} = 0.5 \left(1 + \operatorname{erf} \left(\frac{\text{Pr} - 5}{\sqrt{2}} \right) \right)$$

There are probits published for many common industrial toxic materials (eg ammonia, chlorine, hydrogen chloride) in the TNO Purple Book.

Table 6.3 contains the probit constants used in this QRA.

Injury/Irritation

Injury due to toxic exposure depends on the nature of the material, the concentration, the duration and mode of exposure and also on the sensitivity of the person exposed. It therefore follows that toxic criteria applicable to one chemical will not necessarily be appropriate for another chemical.

HIPAP No. 4 injury and irritation risk criteria for toxic gas exposure were given in Ref.4 as follows:

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."

Irritation: "Toxic concentrations in residential areas should not cause irritation to eyes or throat, coughing or other acute physiological response in sensitive members of the community over a maximum frequency of 50 in a million per year."

Establishing criteria for a particular chemical necessitates determination of the terms 'seriously injurious', 'sensitive', 'relatively short' and 'irritation'.

The quantitative risk assessment (QRA) makes the following interpretations:

Serious Injury: Occurs due to toxic exposure to the Acute Exposure Guideline Level 2 (AEGL-2) concentration. AEGL-2 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

Irritation: Occurs due to toxic exposure to the AEGL-1 concentration. AEGL-1 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL values are available for a range of exposure durations from 10 mins to 8 hours. Given the 'short duration' component in the definition, the 10 minute AEGL values have been selected.

Table 6.3 contains the values used in this QRA to assess toxic injury and irritation risks.

Table 6.3: Toxicity Criteria

| Material | Concentration | | | |
|-----------------------------|--|------|---------------------------------|-------------------------------------|
| | 1% Fatality at 15 mins exposure (See Note 1) | | Injury (AEGL-2, 10 min) Ref. 11 | Irritation (AEGL-1, 10 min) Ref. 11 |
| | Probit (Ref. 10) (ppm ⁿ min) | ppm | ppm | ppm |
| Chlorine (Cl ₂) | $-4.86 + 0.5 \ln (c^{2.75}t)$ | 89 | 2.8 | 0.5 |
| Hydrogen Chloride (HCl) | $-35.76 + 3.69 \ln (ct)$ | 2223 | 100 | 5 (See Note 2) |
| Ammonia (NH ₃) | $-16.29 + \ln (c^2t)$ | 3381 | 220 | 30 |
| Sulphur dioxide | $-16.846 + \ln (c^{2.4}t)$ | 1100 | 0.75 | 0.2 |

Notes:

1. The probability of fatality in the risk model uses the dose calculated from the estimated exposure calculated by the dispersion model. The 15 minute values in this table are for a continuous source term hence are examples only.
2. A concentration end-point of 5 ppm was chosen for **highly irritating** effects of hydrogen chloride. The AEGL-1 level for HCl (1.8 ppm) corresponds to a no-observed-adverse-effect level (NOAEL) in exercising asthmatic subjects (Ref. 19). This level was set for the most sensitive members of the community. It should be noted that specifying requirements that protect to most sensitive members is imposing a potentially unachievable requirement. If HCl criterion for 'Irritation' was set for truly the most sensitive members (eg asthmatic subjects), the end point concentration would be unworkable and therefore a practical limit was used.

6.8. Consequence Assessment Results

Consequence distances for toxic dispersion scenarios are presented in APPENDIX F. These distances represent the maximum distance to the 1% fatality endpoint for each scenario under the assessed meteorological conditions. As anticipated, the largest results (which extend to approximately 2.5 km) are associated with large releases of ammonia gas from storage vessels under the most stable F weather stability conditions.

7. FREQUENCY ASSESSMENT

7.1. Overview

The frequency of an event is defined as the number of occurrences of the event over a specified time period; with the period in risk analysis generally taken as one year.

The frequency of an event impacting a particular location takes into account:

- Leak frequencies from equipment and pipelines.
- Probabilities of detection and isolation.
- Probability of ignition.
- Probability of prevailing weather conditions at time of release.

The likelihood of hazardous events was estimated by combining generic failure frequency data and part counts of equipment.

7.2. Base Failure Rates for Process Equipment

The QRA uses generic data to estimate the likelihood of occurrence of the incident scenarios identified where the failure is related to mechanical failure of equipment.

For piping and equipment mechanical failures, base frequencies have been estimated either from data compiled and historically published for internal use by ICI (Mond data Ref. 12), from frequency estimates published by the Institution of Chemical Engineers, Cox, Lees and Ang (Ref. 13), the CCPS (Ref. 14), the Dutch Committee for the Prevention of Disasters (ie TNO Purple Book, Ref. 10) and UK HSE (Ref. 18). These are usually expressed on a per metre of pipe or per equipment item basis per year, or per million operating hours.

The failure frequency data for process pipework (interpolated from Cox, Lees and Ang) is summarised in Table 7.1 (interpolated from Cox, Lees and Ang). Table 7.2 contains failure frequency data for other process equipment.

Table 7.1: Failure Frequencies, Pipework (Ref. 13)

| Pipe diameter (mm) | Leak frequency (per m per year) | | |
|-----------------------|---------------------------------|----------------------|----------------------|
| | 3 mm leak | 20 mm leak | Full bore leak |
| 50 | 5×10^{-5} | 5×10^{-6} | 5×10^{-7} |
| 80 | 2×10^{-5} | 2×10^{-6} | 2×10^{-7} |
| 100 | 1.5×10^{-5} | 1.5×10^{-6} | 1.5×10^{-7} |
| 150 | 1×10^{-5} | 1×10^{-6} | 1×10^{-7} |
| 250 | 5×10^{-6} | 5×10^{-7} | 5×10^{-8} |

Table 7.2: Failure Frequencies, Other Equipment

| Type of Failure | Failure Rate (x 10 ⁻⁶ per year unless other units given) | Source |
|---|---|--|
| Piping | | |
| Bellows - fracture (full bore) | 4000/bellow | ICI Mond |
| Flange/gasket 13mm | 5 | ICI Mond |
| Instrument fittings | Included in process piping leak frequencies | |
| Valves | | |
| External leak | 10 | Cox, Lees, and Ang |
| Pressure Vessels (Storage and Process, except reactors) | | |
| 6 mm hole | 24 | All ICI Mond Consistent with UK HSE and Purple Book |
| 13 mm hole | 6 | |
| 25 mm hole | 3 | |
| 50 mm hole | 3 | |
| Catastrophic failure - Pressure Vessel | 1 | |
| Pressure Vessels (Reactors) | | |
| For reactors generic failure frequencies are increased by a factor of 10 | pressure vessel x 10 | Purple Book |
| Atmospheric Tanks (Full-containment atmospheric) | | |
| Catastrophic failure | 0.01 | Full containment tank data from Purple Book |
| Atmospheric Tanks | | |
| Catastrophic failure – Non-metallic atmospheric tanks | 58 | UK HSE |
| Catastrophic failure - atmospheric tank | 5 | Purple Book |
| Large leaks – atmospheric tank | 5 | |
| Small leaks – atmospheric tank | 10 | |
| Centrifugal Pumps | | |
| Seal failures - assume 13 mm hole at pump discharge pressure | 5000 (single mechanical seal) 2500 (double mechanical seal) 10000 (single mechanical seal below –20°C or above 100°C) 5000 (double mechanical seal below –20°C or above 100°C) | All ICI data (used in previous QRAs) |
| Shaft failure – assume 50 mm hole at pump discharge pressure | 100 | All ICI data (used in previous QRAs) Cox, Lees and Ang |
| Casing failure – equivalent to suction pipe rupture at pump | 5 | |
| Double diaphragm dosing pumps | | |

| Type of Failure | Failure Rate (x 10 ⁻⁶ per year unless other units given) | Source |
|---------------------------|---|---|
| Pump leak | 250 | Purple Book (“pumps with additional containment”) |
| Catastrophic pump failure | 50 | |
| Tanker loading | | |
| Hose failure | 4 per 10 ⁶ operating hours | Purple Book |
| Hose leak | 40 per 10 ⁶ operating hours | Purple Book |
| Container Handling | | |
| Liquid spills | 10 per 10 ⁶ container moves | Purple Book |
| Loading arm (marine) | | |
| External leak | 3 x 10 ⁻⁷ per operating hour | Purple Book |
| Full bore rupture | 3 x 10 ⁻⁸ per operating hour | Purple Book |

7.3. Parts Count

As the Proposal is still at early stages of design, a full parts count of equipment could not be performed. Therefore the piping lengths and numbers of fittings, valves etc. were estimated for each isolatable section. A conservative estimate of the number of other potential leak sources was made based on experience from previous risk assessments for other similar projects.

7.4. Event Trees

Following the calculation of the initiating release/leak frequencies, event tree analysis was used to define accident pathways and estimate the frequencies of likely outcomes such as toxic dispersion. A typical event tree together with the estimated event frequencies for each scenario used in the QRA are shown in APPENDIX D.

7.4.1. Detection and Isolation

The probabilities of detection and isolation assumed in this study are summarised in Table 7.3.

Table 7.3: Detection and Isolation Probabilities

| Parameter | Failure on demand | Source | Comments |
|-----------------------|----------------------|------------------------------|---|
| Gas detection (toxic) | 0.015 | CCPS, OREDA (Ref.14, Ref.15) | The probability of gas detection failure to operate on demand is calculated to be 1.53×10^{-2} per demand. This is based on gas detector, relay and circuit breaker failure rates of 3.34×10^{-6} per hour (Ref. 15), 1.94×10^{-6} per hour (Ref.14) and 1.71×10^{-6} per hour (Ref.14) respectively, with 6 monthly testing. Other testing periods may also be used depending on the system. |
| Isolation (EIV/SDV) | 0.017 | (Ref. 17) | The probability of emergency isolation or shutdown valve failure to operate on demand is taken to be 1.7×10^{-2} per demand. This comprises 8.3×10^{-3} for solenoid valve and 8.3×10^{-3} for isolation valve. Based on failure 0.1 t/yr fail to danger 1/3 of time and 6 monthly testing. |
| XSFV – clean service | 1.3×10^{-2} | UK HSE (Ref.16) | XSFV (excess flow shutoff valve) required by AS 2022 at all openings for ammonia storage. |

8. RISK ASSESSMENT

8.1. Overview

Risk models are presented as risk contours for the various facilities and infrastructure. Since the Proposal is in its early stages of development, detailed plot plans and plant design are yet to be finalised for the processing plant. As the Proposal develops, equipment layout and orientation will be optimised with respect to various factors including risk. In addition, the process equipment, inventories, operating conditions and safeguards will be better defined. The contours are therefore preliminary only, giving an indication of the risk. They should be revised as the detailed design progresses. It is anticipated that this would take the form of a Final Hazard Analysis (FHA).

8.2. Risk Quantification

Having established the consequence and frequency for each event of interest, risk quantification requires the following calculation (for individual incidents which are then summed for all potential recognised incidents).

$$\text{Risk} = \text{Frequency} \times \text{Consequence}$$

A separate summation is carried out for each consequence of interest (eg injury, individual fatality, etc). In this case the risk summation is done using RiskCurves, a software package developed by TNO to perform risk calculations.

8.3. Risk Presentation

For this QRA, the results of the risk calculations are presented in the following forms:

Individual Fatality Risk

This gives the likelihood of fatality to notional individuals at locations around the site, as a result of the defined fire/explosion and toxic gas release scenarios. This is shown as contours on a map of the area. The units for individual risk are probability (of fatality) per million per year.

By convention it is assumed that people are located outdoors, are always present and take no evasive action if an incident occurs. The results are presented cumulatively for all toxic impacts.

Injury and Irritation Risk

This gives the likelihood of injury or irritation to individuals at locations around the site as a result of the same scenarios used to calculate individual fatality risk. Similarly to individual fatality risk, injury/irritation risk contours represent probability of injury or irritation experienced by a person located permanently at a particular location, assuming no mitigating action such as escape.

8.4. Risk Model Input Data Summary

The basic input data used in the RiskCurves model is summarised in Table 8.1.

Table 8.1: RiskCurves Input Data

| Data Required | Source/Assumptions | Location in QRA Report |
|--|--|---|
| Limiting inventories/flows etc. | This data represents the upper limits assumed to develop RiskCurves input scenarios. | APPENDIX B |
| Physical conditions of material at the point of release | Processing plant PFDs, DG storage arrangements. | Input scenario tables in APPENDIX B |
| Wind/weather data | Site specific meteorological data consolidated to RiskCurves format | APPENDIX C |
| Frequency of each incident | Generic and fault tree estimates as per the assumptions described in Section 7 of this report. | Event tree results in APPENDIX D |
| Release coordinates | These were taken from the drawings of the site and processing plant layout. The coordinates are presented in MGA format. | APPENDIX E |
| Impact distance and effect area for each concentration/dose of concern | Toxic dispersion models as described in Section 6.3 of this report. | Calculated by RiskCurves and supplemented by TNO EFFECTS. |
| Probability of fatality corresponding to a particular location or scenario | Probit equations or other correlation as per the assumptions described in Section 6.7 of this report. | Calculated by RiskCurves. |

9. RISK RESULTS AND FINDINGS

9.1. Individual Fatality Risk

The individual risk contours represent the probability of fatality to a theoretical individual located permanently at a particular location, assuming no mitigating action such as escape.

Figure 9.1 shows the risk contours for the processing plant. The results indicate the following:

- The 0.5×10^{-6} per year contour is contained within DZP site and does not encroach into any sensitive land uses.
- The 1×10^{-6} per year risk contour, applicable for residential areas, is within the DZP site boundary, and does not encroach into residential areas.
- The 50×10^{-6} per year contour is small and contained within the processing plant. This contour is centred around the ammonia transfer and storage area. Hence, the 50×10^{-6} per year contour is also well within the DZP site boundary, satisfying the criterion that this contour be contained within the site for industrial land uses.

Therefore, the QRA shows that processing plant operations satisfy all HIPAP No. 4 quantitative criteria for individual fatality risk.

Upon analysis of risk results, it was found that ammonia releases from the ammonia storage vessels were the major contributors to risk.

9.2. Toxic Injury/Irritation

The injury and irritation contours show the likelihood of a threshold concentration being exceeded at a particular location. Similar to individual fatality risk, injury/irritation risk contours represent probability of injury or irritation experienced by a person located permanently at a particular location, assuming no mitigating action such as escape.

Figure 9.2 shows the injury risk contour and Figure 9.3 shows the irritation risk contour for the plant in relation to the nearest residence, Toongi Hall. The toxic injury and toxic irritation contours extend offsite from the western boundary, however, do not reach any residential or sensitive land uses (Toongi Hall, is located approximately 440 m and 130 m away from the toxic injury and toxic irritation contours respectively). Hence the plant satisfies HIPAP No. 4 criteria for toxic injury and toxic irritation risk.

Table 9.1 shows a summary of all categories of risk compared with the relevant criteria. It can be seen that the proposed plant complies with all individual fatality, toxic injury and toxic irritation risk criteria.

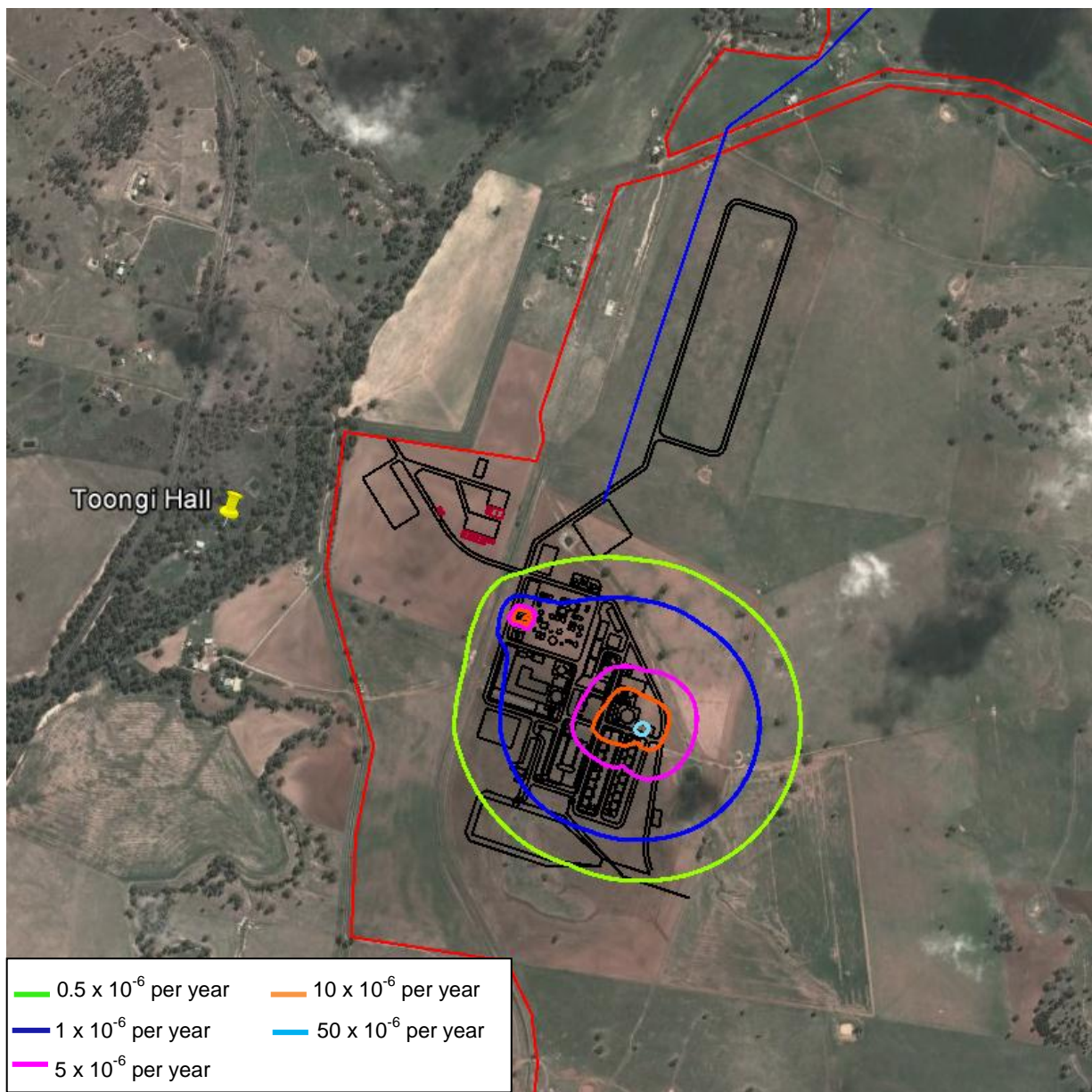


Figure 9.1: Individual Fatality Risk

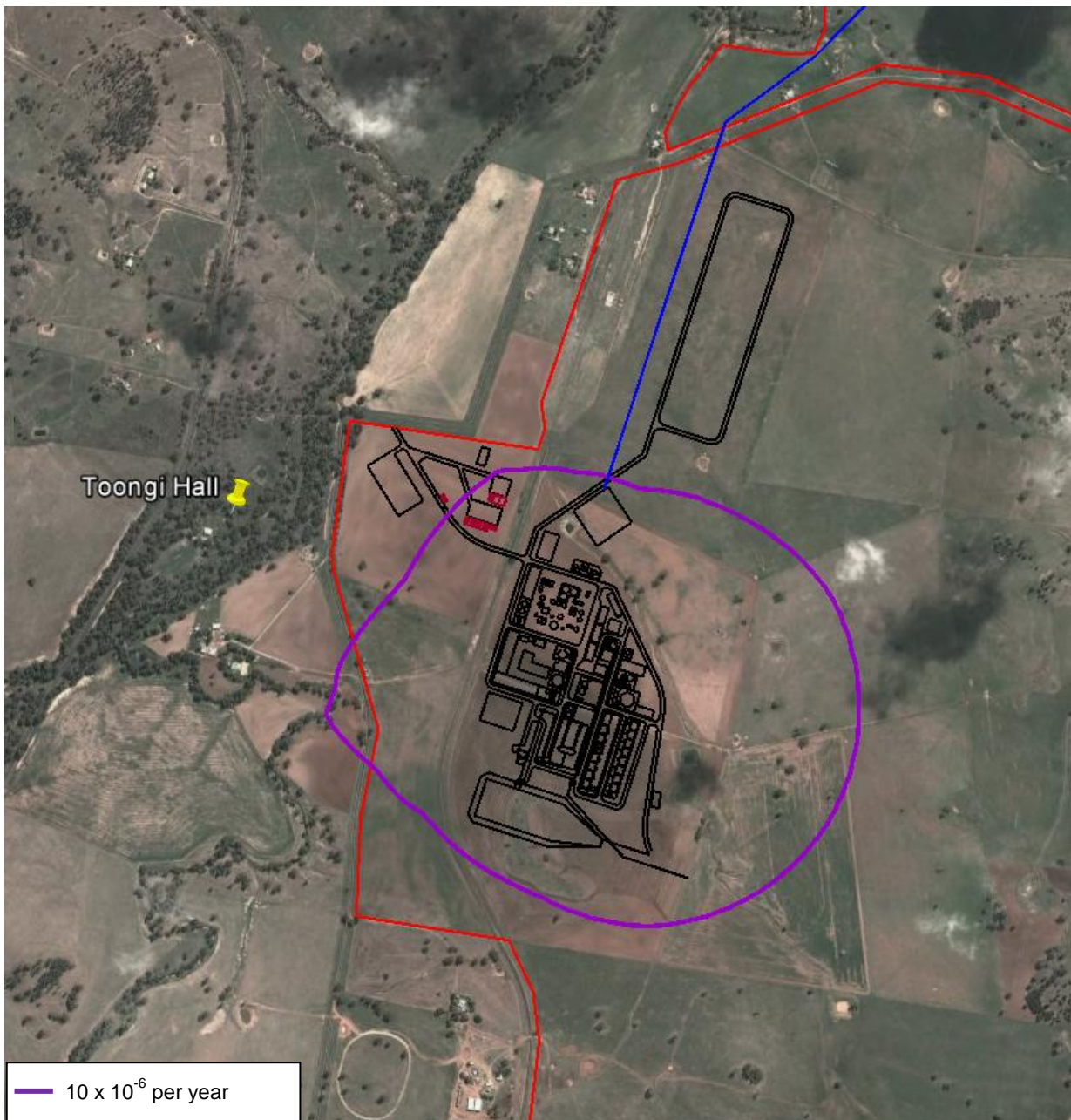


Figure 9.2: Toxic Injury Risk

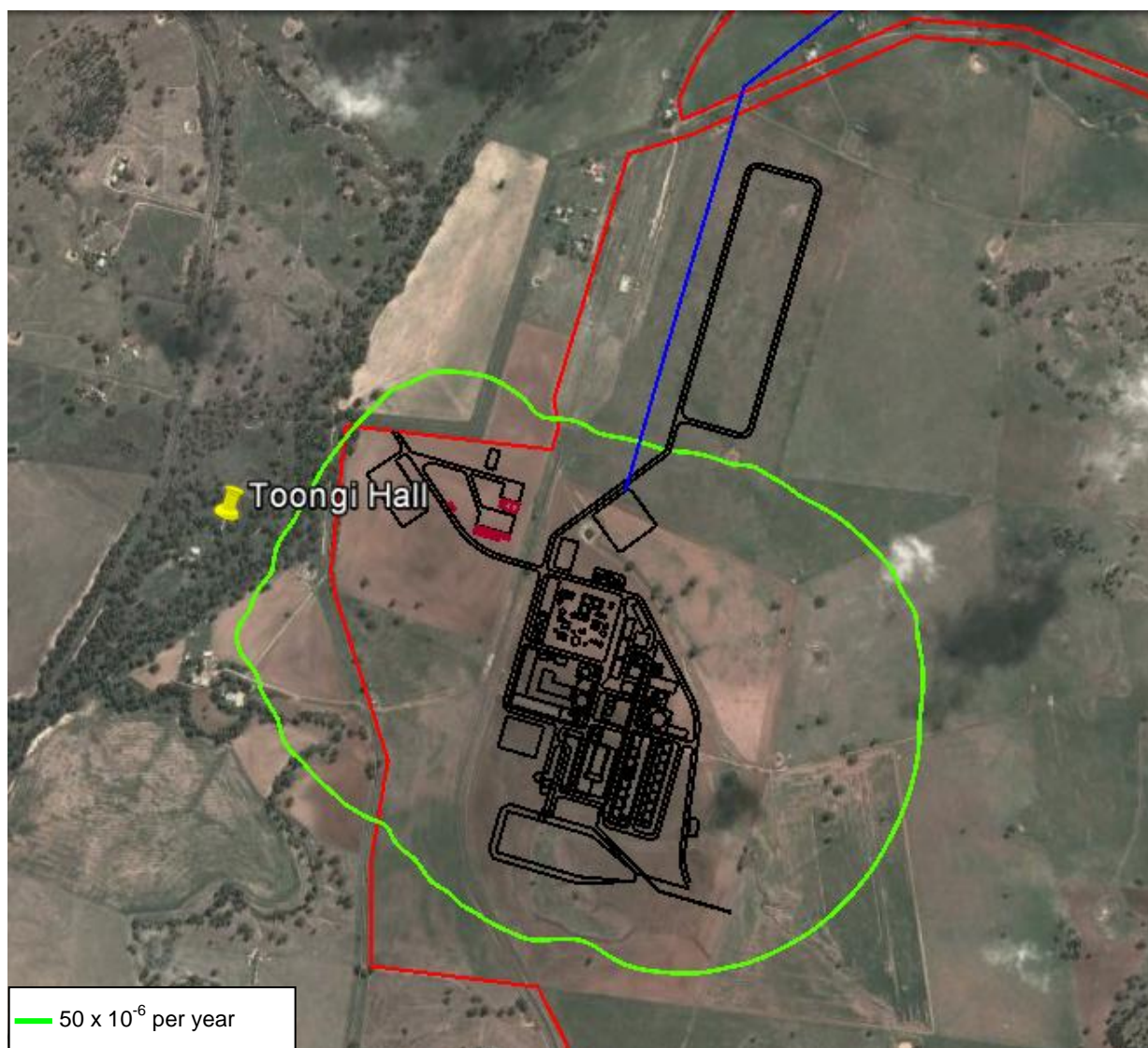


Figure 9.3: Toxic Irritation Risk

Table 9.1: Comparison of Results with Risk Criteria

| Description | Risk Criterion (per year) | Compliance | Comments |
|---|------------------------------|------------|--|
| Individual Fatality Risk | | | |
| Sensitive uses, including hospitals, schools, aged care | 0.5×10^{-6} | Complies | Contour is contained within DZP site boundary. It does not reach any sensitive uses. |
| Residential areas and hotels | 1×10^{-6} | Complies | Contour is contained within DZP site boundary and does not encroach on any residential uses. |
| Commercial areas, including offices, retail centres, warehouses | 5×10^{-6} | Complies | Contour within DZP site boundary and does not reach commercial developments. |
| Sporting complexes and active open spaces | 10×10^{-6} | Complies | Contour within DZP site boundary and does not reach any open space uses. |
| Contained within the boundary of an industrial site | 50×10^{-6} | Complies | Centred around anhydrous ammonia transfer, storage area. Does not extend beyond DZP site boundary. |
| Injury/Irritation Risk | | | |
| Injury (residential areas only) | 10×10^{-6} | Complies | Contour does not encroach on any residential uses. |
| Irritation (residential areas only) | 50×10^{-6} | Complies | Contour does not encroach on any residential uses. |

9.3. Societal Risk

As the individual fatality risk contours do not extend beyond the DZP site boundary, there are no significant offsite populations potentially affected by the proposal. Societal risk levels are therefore minimal and were not quantified.

9.4. Risk to Biophysical Environment

The main concern relating to environmental risk from accident events is generally with effects on whole systems or populations. HIPAP No. 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 ammonia, hydrogen chloride and chlorine. These releases have toxic impacts mainly on human health and safety. No accidental emissions were identified with the potential to threaten the long term viability of an ecosystem.

For completeness, 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.

9.4.1. Escape of Liquid Materials

Chemicals on the plant include various corrosives (eg NaOH) and acids. All chemicals would be stored within concrete bunded areas.

Tanker deliveries would occur over sealed areas with kerbing and a drainage design preventing any runoff to the environment if a spill occurs.

Spill kits would be provided as appropriate, 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 would also be very low due to the onsite containment devices and sealed surfaces.

9.4.2. Escape of Gaseous Materials

Gaseous or volatile materials handled at the processing plant (including ammonia, chlorine, hydrogen chloride fumes) have toxic effects that are primarily health and safety-related.

Long-term or continuous emissions that may arise from plant operations would be addressed via Environmental Protection Licenses (EPLs) and OHS management systems.

10. CONCLUSIONS AND RECOMMENDATIONS

A hazard analysis was undertaken for the processing plant at Dubbo. The study was based on preliminary engineering layouts and inventories. The results demonstrate that the proposed processing plant complies with all NSW land use planning risk criteria published in HIPAP No. 4. The relevant hazardous incidents which mainly contribute to offsite risk are the release and toxic dispersion of anhydrous ammonia from storage vessels.

10.1. Offsite Individual Fatality Risk

Individual fatality risk levels comply with the all HIPAP No. 4 criteria defined in the QRA. Risk levels presented in this report are preliminary only, as the Proposal is in early stages of development. The risk contours would be refined in the FHA once detailed design of the processing plant is in place.

10.2. Toxic Injury/Irritation Risk

Irritation and injury risk contours for the plant comply with the HIPAP No. 4 criteria.

The toxic injury and toxic irritation contours extend offsite from the western boundary, however, do not encroach on residential or sensitive land uses. The contours are contained within the site on the eastern boundary.

10.3. Recommendations

Based on the results and findings of the quantitative risk assessment, the following recommendations are made:

- The main contributor to risk is leaks from ammonia storage vessels, including instrument fittings and valves. The QRA is based on a conservative estimate of the number of leak points. It is recommended that the number of potential leak points in anhydrous ammonia service (transfer and storage area) be minimised to further reduce the risk. This includes minimising flanges and fittings in storage vessels and pipework. This can be further investigated in the detailed design stage and assessed in the FHA.
- It is also recommended that the number of potential leak points in the hydrochloric acid storage area be minimised to further reduce the risk. This includes minimising flanges and fittings in the acid storage tanks and pipework.
- A HAZOP should be undertaken to confirm that the likelihood of process upset scenarios that could result in loss of containment of toxic material is very low and that risk is acceptable. This includes, but not limited to scenarios such as breakthrough of sulphur dioxide from sulphuric acid production and breakthrough of ammonia from aqua ammonia manufacture.

APPENDIX A. Hazardous Materials

This appendix summarises the hazardous materials that would be used at the processing plant and their storage arrangements.

| Material | DG Class | Total Quantity (tonnes) ¹ | Storage Arrangements ¹ |
|--|----------|--------------------------------------|---|
| Hydrochloric acid wt (33 wt%) | 8 PG II | 1,600 | Road tankers pumped to bulk storage tanks |
| Sulphuric Acid (98%) | 8 PG II | 18,000 | Road tankers pumped to bunded four 2075 m ³ storage tanks |
| Sodium Sulphide (Na ₂ S) | 8 PG II | 220 | Containers stored on bunded concrete pad. Bulk bags undercover. |
| Sodium hydroxide (NaOH) | 8 PG II | 1,400 | Containers stored on bunded concrete pad. Bulk bags undercover. |
| Anhydrous ammonia | 2.3 | 200 | Onsite storage with a capacity of 200 tonnes. 2 tanks of 100 tonnes each |
| Potable water treatment chemicals (chlorine) | 2.3 | 0.43 | - |
| SX Organic (Alamine 336) | 9 PG III | 20 | Containers stored on bunded concrete pad. Totes undercover. |
| Diesel fuel | 9 PG III | 794 | - |

¹ Information provided by client (as per Ref. 1)

APPENDIX B. Consequence Analysis

B1. CONSEQUENCE MODELLING INPUTS

Input data used for consequence analysis are presented in Table B.1. The table details the material, phase, process conditions and associated assumptions for the scenarios modelled.

Table B.1: Consequence Analysis Inputs

Page 1 of 2

| ID | Description | Material released | Phase | Isolatable Inventory (tonne) | Method of Isolation | Operating Time (hrs /year) | Release conditions | | | | | Comments | Source/Reference | Hazardous Properties | |
|--------|---|--------------------|--------|---|---------------------|----------------------------|----------------------|----------------------------------|-----------|-----------------|-------------|--|---|----------------------|--------|
| | | | | | | | Stream no. (PFD ref) | Limiting Process Flowrate (kg/h) | Temp (°C) | Pressure (bara) | Conc. (wt%) | | | Flammable? | Toxic? |
| AMS-01 | Release of ammonia from storage vessel 1 | Ammonia | Liquid | 100.0 | None | 8760 | n/a | 0 | 28 | 11 | 100 | Storage vessel inventory assumed based on onsite storage capacity (total capacity of 200 tonnes, in 2 storage vessels). Ammonia stored at ambient temperature and under pressure of approximately 10 barg. | Reagent supply and usage information as provided by client. Process Flow Diagrams. Typical ammonia storage conditions | N | Y |
| AMS-02 | Release of ammonia from storage vessel 2 | Ammonia | Liquid | 100.0 | None | 8760 | n/a | 0 | 28 | 11 | 100 | As per AMS-01 | As per AMS-01 | N | Y |
| AMS-03 | Release of ammonia from compressor systems (6400-PK-02) | Ammonia | Liquid | 0.013 | Manual | 8760 | n/a | 1220 | 28 | 12 | 100 | Based on 1.22 tonnes/hr flow rate. Pressure assumed to be at a higher pressure than vapour pressure of ammonia at ambient temperature. Inventory assumed based on piping length of 10 m & density of approximately 670kg/m ³ (at process conditions). | Material balance flowsheet | N | Y |
| AMS-04 | Release of ammonia from distribution piping (liquid) | Ammonia | Liquid | 0.013 | Manual | 8760 | n/a | 1220 | 28 | 12 | 100 | Based on 1.22 tonnes/hr flow rate. Pressure assumed to be at a higher pressure than vapour pressure of ammonia at ambient temperature. | Material balance flowsheet | N | Y |
| AMS-05 | Release of ammonia from distribution piping (vapour) | Ammonia | Vapour | 0.013 | Manual | 8760 | n/a | 1220 | 150 | 6.2 | 100 | Based on 1.22 t/hr flow rate. Process conditions assumed based on typical ammonia vapourisation. | Material balance flowsheet | N | Y |
| ACD-01 | Release of hydrochloric acid from 3 storage tanks | Hydro-chloric acid | Liquid | Bunded surface area ≥280 m ² | None | 8760 | n/a | 0 | 40 | 1 | 33 | Hydrochloric acid storage tank dimensions – 8 m diameter, 10 m height. Volume of bund as per AS3780-2008 is 110% of volume of tank ≥560 m ³ . Bund height estimated to be 2m, giving a bund size of 280 m ² . | Information provided by client | N | Y |
| WDS-01 | Release of chlorine from G cylinders (70 kg) | Chlorine | Liquid | 0.070 | None | 8760 | n/a | 0 | 27 | 10 | 100 | Assumed - G cylinders for chlorine (in 70 kg cylinders) | Typical storage conditions assumed. | N | Y |

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Table B.1: Consequence Analysis Inputs (Cont'd)

Page 2 of 2

| ID | Description | Material released | Phase | Isolatable Inventory (tonne) | Method of Isolation | Operating Time (hrs /year) | Release conditions | | | | | Comments | Source/Reference | Hazardous Properties | |
|--------|--|--------------------|--------|----------------------------------|---------------------|----------------------------|----------------------|----------------------------------|-----------|-----------------|-------------|--|------------------------------------|----------------------|--------|
| | | | | | | | Stream no. (PFD ref) | Limiting Process Flowrate (kg/h) | Temp (°C) | Pressure (bara) | Conc. (wt%) | | | Flammable? | Toxic? |
| LDB-01 | Release of ammonia in unloading area (hardware) | Ammonia | Liquid | 0.026 | Attended | 480 | n/a | 1220 | 28 | 11 | 100 | Operating time based on ammonia delivery (480 times per year). Ammonia at ambient temperature and under pressure of approximately 10 barg. Inventory assumed based on piping length of 20 m & density of approximately 670kg/m ³ (at process conditions). | SEPP33 report (Ref. 1, APPENDIX G) | N | Y |
| LDB-02 | Release of ammonia in unloading area (operation) | Ammonia | Liquid | 0.026 | Attended | 480 | n/a | 1220 | 28 | 11 | 100 | As per LDB-01 | As per LDB-01 | N | Y |
| LDB-03 | Release of hydrochloric acid in unloading area (hardware) | Hydro-chloric acid | Liquid | Max pool size ~30 m ² | Attended | 144 | n/a | - | 40 | 1 | 33 | Pool size from leaks during unloading estimated to be 30 m ² (typical pool sizes for unloading scenarios). HCl delivery approximately 144 times per year | SEPP33 report (Ref. 1, APPENDIX G) | N | Y |
| LDB-04 | Release of hydrochloric acid in unloading area (operation) | Hydro-chloric acid | Liquid | Max pool size ~30 m ² | Attended | 144 | n/a | - | 40 | 1 | 33 | As per LDB-03 | As per LDB-03 | N | Y |
| LDB-05 | Release of ammonia from tanker | Ammonia | Liquid | 40.0 | Attended | 480 | n/a | 0.00000 | 28 | 11 | 100 | As per LDB-01 Assumed tanker inventory (typical case). | As per LDB-01 | N | Y |
| - | SO ₂ release | - | - | - | - | - | - | - | - | - | - | Not carried forward to QRA – No offsite effects | - | - | - |
| - | Natural gas | - | - | - | - | - | - | - | - | - | - | Not carried forward to QRA – No offsite or escalation effects | - | - | - |

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B2. CONSEQUENCE MODELLING – RELEASE OF SULPHUR DIOXIDE

A release of sulphur dioxide from the oxidation section was modelled as a positively buoyant plume using the Briggs plume model. The model describes the plume trajectory, along with the development of plume in the region of plume rise. Details of the Briggs plume model are outlined in TNO Yellow Book (Ref. 7).

Inputs, assumptions and results of the consequence modelling are tabulated below. Modelling was undertaken for typical sets of weather conditions – weather class D with a wind speed of 5 m/s (D5) and weather class F with a wind speed of 2 m/s (F2).

Concentration end points reported in AEGL are conservative in that SO₂ concentrations of 0.75 ppm and 0.2 ppm produce injury and irritation effects respectively in ‘exercising asthmatics’ (Ref. 20).

| Inputs | | | |
|----------------------------|---|------------------|--------------|
| Scenario | Release of SO ₂ gas in the event of ducting failure | | |
| Hole size | 250 mm | | |
| Discharge coefficient | 0.8 (typical for gases) | | |
| Pressure | Atmospheric release | | |
| Initial temperature | 1140°C (based on Chemetics Acid Plant proposal) | | |
| Density of gas | 0.26 kg/m ³ (~12% SO ₂ gas mixture, composition based on Chemetics Acid Plant proposal) | | |
| Results | | | |
| Concentration end point | Weather class/ Wind speed | Plume height (m) | Distance (m) |
| Toxic injury (0.75 ppm) | D, 5 m/s | 42 | 550 |
| | F, 2 m/s | 66 | 274 |
| Toxic irritation (0.2 ppm) | D, 5 m/s | 81 | 1,500 |
| | F, 2 m/s | 128 | 750 |

The results show that the gas plume would be well elevated, diluted to non-hazardous levels prior to loss of buoyancy effects and therefore unlikely to impact sensitive community members.

APPENDIX C. Meteorological Data

C1. METHODOLOGY OF WEATHER DATA CONVERSION TO REPRESENTATIVE CONDITIONS

The meteorological data used in the QRA is based on data from May 2003 to May 2013 that was obtained for Dubbo airport (weather station 065070) from the Bureau of Meteorology.

Weather stability classes, as defined by Gifford (1976) categorises atmospheric turbulence into six stability classes namely A, B, C, D, E and F, with class A being the most unstable or most turbulent class, and class F the most stable or least turbulent class. Table C.1 lists the published weather stability classes and provides the meteorological conditions that define each class.

Table C.1: Meteorological Conditions Defining the Pasquill-Gifford Stability Classes

| Surface wind speed, m/s | Daytime insolation* | | | Night time conditions | |
|-------------------------|---------------------|----------|--------|---------------------------------|------------------|
| | Strong | Moderate | Slight | Thin overcast or >4/8 low cloud | ≥ 3/8 cloudiness |
| <2 | A | A-B | B | F | F |
| 2-3 | A-B | B | C | E | F |
| 3-4 | B | B-C | C | D | E |
| 4-6 | C | C-D | D | D | D |
| >6 | C | C | D | D | D |

*Incoming Solar Radiation – These categories (strong, moderate and slight) are determined based on sky cover and solar elevation information.

For the purpose of the study and based on data analysis, weather data was recategorised into the following Pasquill-Gifford stability classes and wind speeds to represent the weather conditions at Dubbo:

- Pasquill Stability Class: B; wind speed 3 m/s (B3)
- Pasquill Stability Class: D; wind speed 5 m/s (D5)
- Pasquill Stability Class: F; wind speed 1.5 m/s (F1.5).

Applied meteorological conditions are shown in Table C.2.

Table C.2: Applied Meteorological Conditions Defining the Pasquill-Gifford Stability Classes

| Surface wind speed, m/s | Daytime Insolation | | | Night time Conditions | |
|-------------------------|--------------------|----------|--------|---------------------------------|------------------|
| | Strong | Moderate | Slight | Thin overcast or >4/8 low cloud | ≥ 3/8 cloudiness |
| <1.5 | B3 | B3 | B3 | F1.5 | F1.5 |
| 1.5-2 | B3 | B3 | B3 | F1.5 | F1.5 |
| 2-4 | B3 | B3 | B3 | D5 | D5 |
| 4-6 | D5 | D5 | D5 | D5 | D5 |
| >6 | D5 | D5 | D5 | D5 | D5 |

In the data analysis, any wind recording of wind speed = 0 and wind direction = 0 was categorised as F1.5 stability class during night time and categorised as B3 stability class during daytime (in accordance with the rule set in Table C.2). These records for calm readings were then allocated a direction consistent with the distribution for other non-calm records.

The distributions of representative weather conditions used in the QRA following weather data conversion is given in Figure C.1 and Table C.3.

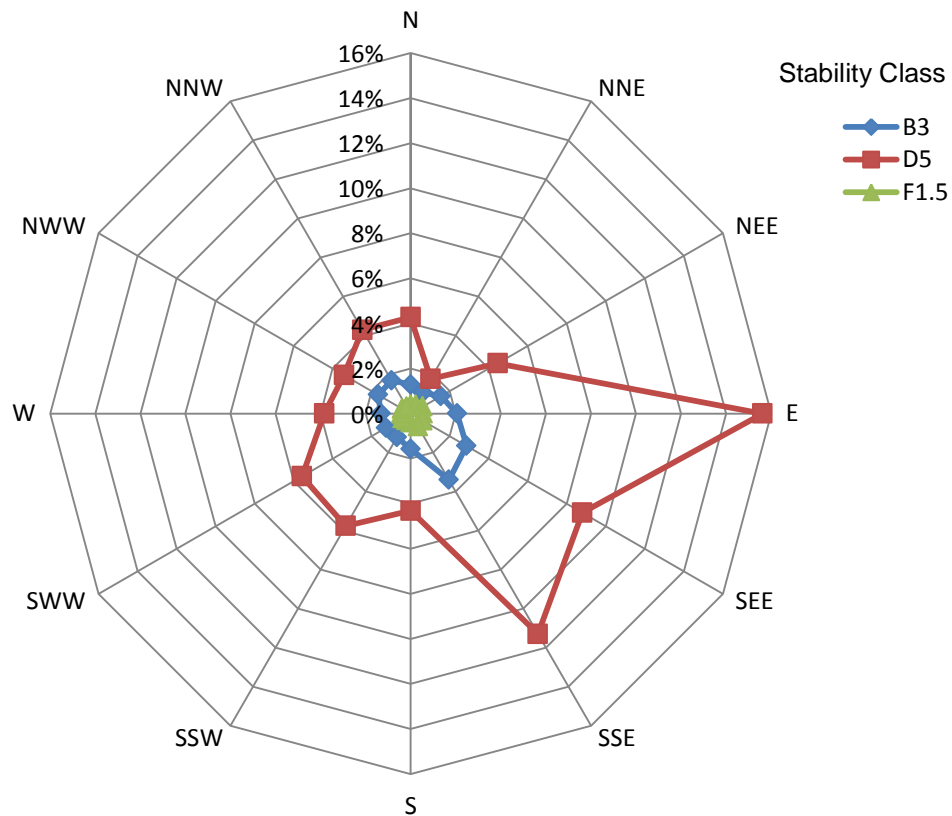


Figure C.1: Distribution of Representative Stability Classes for Weather Conditions at Dubbo Airport (BOM Weather Station 065070)

Table C.3: Dubbo Meteorological Data

| Stability | Avg wind speed (m/s) | Stability classes | Stability occurrence | Wind direction (from) | | | | | | | | | | | |
|-----------|-------------------------------|----------------------|-------------------------|-----------------------|------|-------|-------|-------|-------|------|------|------|------|------|------|
| | | | | N | NNE | NEE | E | SEE | SSE | S | SSW | SWW | W | NWW | NNW |
| B | 3 | B3 | 21.0% | 6.1% | 5.1% | 7.4% | 9.8% | 13.7% | 16.2% | 7.5% | 5.8% | 6.0% | 6.3% | 7.9% | 8.1% |
| D | 5 | D5 | 73.4% | 5.8% | 2.4% | 6.1% | 21.3% | 12.0% | 15.4% | 5.9% | 7.9% | 7.6% | 5.2% | 4.7% | 5.8% |
| F | 1.5 | F1.5 | 5.6% | 6.8% | 8.0% | 10.9% | 9.7% | 10.9% | 11.5% | 7.2% | 6.2% | 7.3% | 7.4% | 7.8% | 6.3% |

APPENDIX D. Event Trees and Event Frequencies

D1. OVERVIEW

When a release occurs, there are a number of different possible outcomes. These can be represented by an event tree which indicates the different outcomes and the probability of each outcome. The ultimate outcomes have a combined probability depending on the path. A sample event tree is given in Figure D.1.

Using such event trees, the outcome frequencies for the scenarios included in the risk model were calculated and are included in this appendix. The event trees cover scenarios developed from the generic failure rates. Event tree frequencies are contained in Table D.1.

The scenario tags in Table D.1 are of the form:

ABC-XX-YYY

where:

- ABC-XX designates the scenario ID as per Table 5.3.
- YYY designates the hole size modelled, as follows:
 - 025: 2.5 mm
 - 100: 10 mm
 - 250: 25 mm
 - 500: 50 mm
 - 999:100 mm
 - RUP: instantaneous release of section inventory.

The total release frequency shown in the following tables is the total leak frequency from a particular section. Not all hole sizes are relevant to all scenarios (ie some combinations will have a zero frequency).

It should be noted that consequences results for scenario LDB-03 (Release of hydrochloric acid in unloading area (hardware) resulting in toxic dispersion) were found to be insignificant, hence excluded from frequency analysis and QRA.

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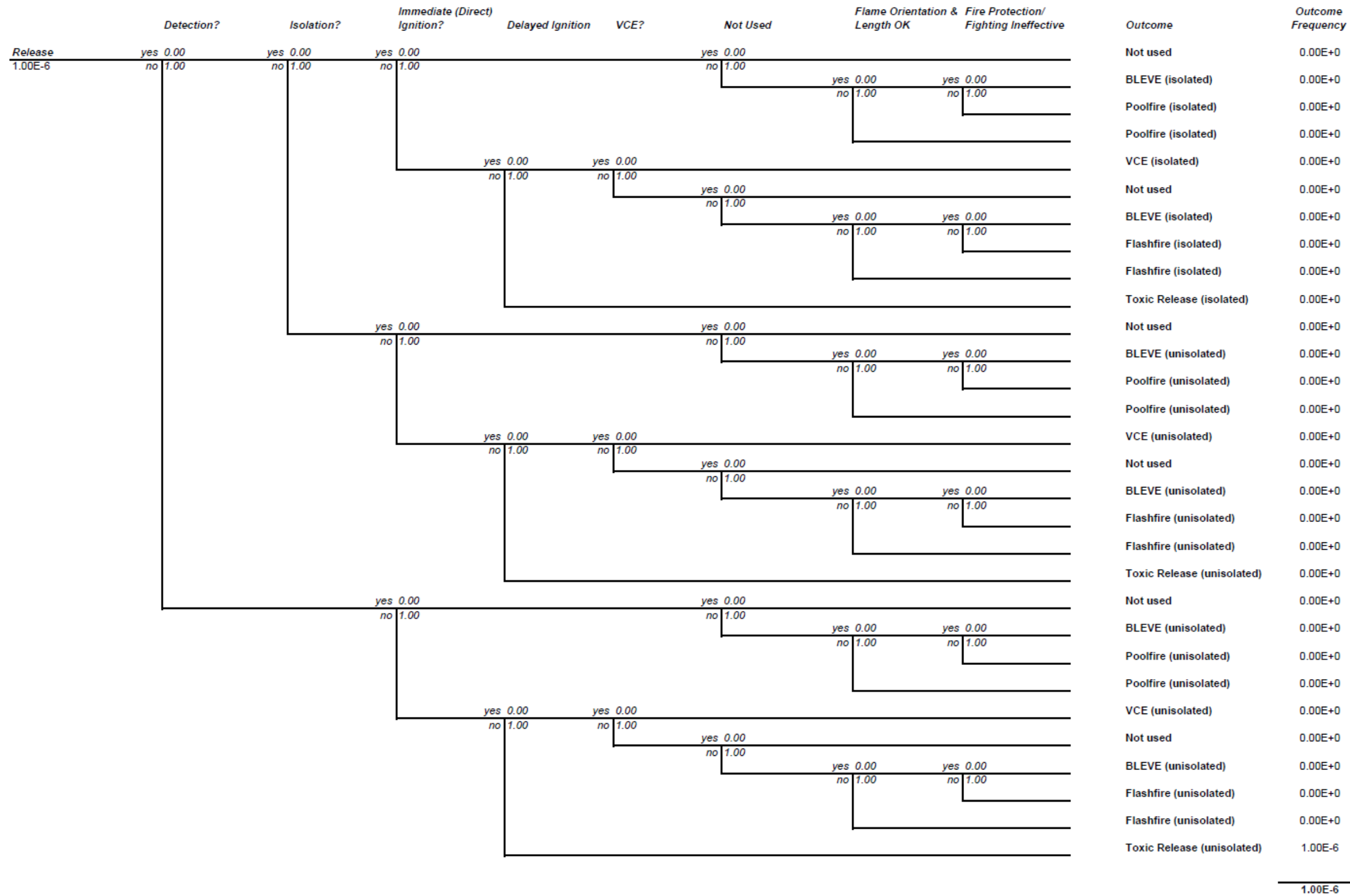


Figure D.1: Sample Event Tree

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Table D.1: Event Frequencies

| Scenario ID | Total Release Frequency (Toxic release) | Scenario ID | Total Release Frequency (Toxic release) |
|-------------|---|-------------|---|
| AMS-01_025 | 1.15E-03 | WDS-01_025 | 0.00E+00 |
| AMS-01_100 | 3.00E-04 | WDS-01_100 | 0.00E+00 |
| AMS-01_250 | 4.30E-05 | WDS-01_250 | 0.00E+00 |
| AMS-01_500 | 3.00E-06 | WDS-01_500 | 0.00E+00 |
| AMS-01_999 | 0.00E+00 | WDS-01_999 | 0.00E+00 |
| AMS-01_RUP | 1.00E-06 | WDS-01_RUP | 2.00E-07 |
| AMS-02_025 | 1.15E-03 | LDB-01_025 | 1.60E-04 |
| AMS-02_100 | 3.00E-04 | LDB-01_100 | 2.40E-05 |
| AMS-02_250 | 4.30E-05 | LDB-01_250 | 6.76E-06 |
| AMS-02_500 | 3.00E-06 | LDB-01_500 | 1.10E-06 |
| AMS-02_999 | 0.00E+00 | LDB-01_999 | 0.00E+00 |
| AMS-02_RUP | 1.00E-06 | LDB-01_RUP | 0.00E+00 |
| AMS-03_025 | 1.46E-03 | LDB-02_025 | 0.00E+00 |
| AMS-03_100 | 1.01E-03 | LDB-02_100 | 1.44E-04 |
| AMS-03_250 | 1.59E-04 | LDB-02_250 | 0.00E+00 |
| AMS-03_500 | 6.64E-05 | LDB-02_500 | 8.57E-04 |
| AMS-03_999 | 0.00E+00 | LDB-02_999 | 0.00E+00 |
| AMS-04_025 | 2.92E-03 | LDB-02_RUP | 0.00E+00 |
| AMS-04_100 | 5.44E-03 | LDB-04_025 | 0.00E+00 |
| AMS-04_250 | 4.34E-05 | LDB-04_100 | 0.00E+00 |
| AMS-04_500 | 1.20E-04 | LDB-04_250 | 0.00E+00 |
| AMS-04_999 | 0.00E+00 | LDB-04_500 | 8.29E-04 |
| AMS-05_025 | 1.46E-03 | LDB-04_999 | 0.00E+00 |
| AMS-05_100 | 2.49E-04 | LDB-04_RUP | 0.00E+00 |
| AMS-05_250 | 3.47E-05 | LDB-05_025 | 0.00E+00 |
| AMS-05_500 | 1.30E-05 | LDB-05_100 | 0.00E+00 |
| AMS-05_999 | 0.00E+00 | LDB-05_250 | 2.19E-06 |
| ACD-01_025 | 2.77E-03 | LDB-05_500 | 2.74E-08 |
| ACD-01_100 | 5.97E-04 | LDB-05_999 | 0.00E+00 |
| ACD-01_250 | 1.90E-04 | LDB-05_RUP | 2.74E-08 |
| ACD-01_500 | 0.00E+00 | | |
| ACD-01_999 | 0.00E+00 | | |
| ACD-01_RUP | 1.74E-04 | | |

APPENDIX E. RiskCurves Parameters

E1. CALCULATION INPUTS

Input parameters in RiskCurves include environment and vulnerability settings, which will be used in the software to perform the consequence and risk calculations. The inputs used for this QRA are summarised in Table E.1.

Table E.1: RiskCurves Input Parameters

| Environment | |
|---------------------------|-----------------------|
| Ambient temperature | 24.5 °C |
| Subsoil temperature | 24.5 °C |
| Water temperature | 24.5 °C |
| Ambient relative humidity | 67% |
| Ambient pressure | 1.0151 bar |
| Solar radiation flux | 1000 W/m ² |
| Vulnerability | |
| Receiver height | 1.5 m |
| Toxic exposure duration | 3600 s |

E2. LOCATION COORDINATES

Geographical location coordinates used in the QRA model for the scenarios are presented below.

| Scenario ID | Scenario description | Area description | MGA Location | |
|-------------|---|--|--|----------|
| | | | Easting | Northing |
| AMS-01 | Release of ammonia from storage vessel 1 (6400-PV-01) | Anhydrous ammonia transfer and storage | 649959 | 6408225 |
| AMS-02 | Release of ammonia from storage vessel 2 (6400-PV-04) | Anhydrous ammonia transfer and storage | 649959 | 6408225 |
| AMS-03 | Release of ammonia from compressor systems (6400-PK-02) | Anhydrous ammonia transfer and storage | 649954 | 6408218 |
| AMS-04 | Release of ammonia from distribution piping (liquid) | Anhydrous ammonia transfer and storage | Route: Pt 1- 649954 E, 6408218 N Pt 2- 649959 E, 6408225 N | |
| AMS-05 | Release of ammonia from distribution piping (vapour) | Anhydrous ammonia transfer and storage | Route: Pt 1- 649954 E, 6408218 N Pt 2- 649959 E, 6408225 N | |
| ACD-01 | Release of hydrochloric acid from 3 storage tanks | Acid receiving, storage and distribution | 649662 | 6408503 |

| Scenario ID | Scenario description | Area description | MGA Location | |
|-------------|---|--|--------------|----------|
| | | | Easting | Northing |
| ACD-02 | Release of sulphur dioxide gas in acid production area | Acid receiving, storage and distribution | 649662 | 6408503 |
| WDS-01 | Release of chlorine from G cylinders (70 kg) | Water distribution and storage | 649814 | 6408585 |
| LDB-01 | Release of ammonia in unloading area (hardware) | Loading/unloading bay | 649990 | 6408216 |
| LDB-02 | Release of ammonia in unloading area (operation) | Loading/unloading bay | 649990 | 6408216 |
| LDB-03 | Release of hydrochloric acid in unloading area (hardware) | Loading/unloading bay | 649627 | 6408466 |
| LDB-04 | Release of hydrochloric acid in unloading area(operation) | Loading/unloading bay | 649627 | 6408466 |
| LDB-05 | Release of ammonia from tanker | Loading/unloading bay | 649990 | 6408216 |

APPENDIX F. RiskCurves Output

F1. CONSEQUENCE DISTANCES TO THE 1% FATALITY LEVEL

The maximum consequence distance (in metres) and associated frequency for the scenarios is summarised in the RiskCurves result report below.

| Selection overview for Calculation set | Frequency | Max. Distance [year] |
|---|-----------|-------------------------|
| ACD-01_025_HCl release from tank | | |
| Neutral Gas Dispersion: Toxic dose | 2.77E-03 | 0 |
| ACD-01_100_HCl release from tank | | |
| Neutral Gas Dispersion: Toxic dose | 5.97E-04 | 0 |
| ACD-01_250_HCl release from tank | | |
| Neutral Gas Dispersion: Toxic dose | 1.90E-04 | 139 |
| ACD-01_RUP_HCl release from tank | | |
| Neutral Gas Dispersion: Toxic dose | 1.74E-04 | 231 |
| AMS-01_025_ Release of ammonia from storage vessel | | |
| Dense Gas Dispersion: Toxic dose | 1.15E-03 | 43 |
| AMS-01_100_ Release of ammonia from storage vessel | | |
| Dense Gas Dispersion: Toxic dose | 3.00E-05 | 313 |
| AMS-01_250_ Release of ammonia from storage vessel | | |
| Dense Gas Dispersion: Toxic dose | 4.30E-05 | 954 |
| AMS-01_500_ Release of ammonia from storage vessel | | |
| Dense Gas Dispersion: Toxic dose | 3.90E-08 | 1840 |
| AMS-01_RUP_ Release of ammonia from storage vessel | | |
| Dense Gas Dispersion: Toxic dose | 1.00E-06 | 2503 |
| AMS-02_025_ Release of ammonia from storage vessel | | |
| Dense Gas Dispersion: Toxic dose | 1.15E-03 | 43 |
| AMS-02_100_ Release of ammonia from storage vessel | | |
| Dense Gas Dispersion: Toxic dose | 3.00E-05 | 313 |
| AMS-02_250_ Release of ammonia from storage vessel | | |
| Dense Gas Dispersion: Toxic dose | 4.30E-05 | 954 |
| AMS-02_500_ Release of ammonia from storage vessel | | |
| Dense Gas Dispersion: Toxic dose | 3.90E-08 | 1840 |
| AMS-02_RUP_ Release of ammonia from storage | | |

| | | |
|---|----------|------|
| vessel | | |
| Dense Gas Dispersion: Toxic dose | 1.00E-06 | 1735 |
| AMS-05_025_Release of ammonia from compressor system | | |
| Dense Gas Dispersion: Toxic dose | 1.46E-03 | 18 |
| AMS-05_100_Release of ammonia from piping | | |
| Dense Gas Dispersion: Toxic dose | 1.01E-03 | 42 |
| AMS-05_250_Release of ammonia from piping | | |
| Dense Gas Dispersion: Toxic dose | 1.59E-04 | 42 |
| AMS-05_500(RUP)_Release of ammonia from piping | | |
| Dense Gas Dispersion: Toxic dose | 6.64E-05 | 42 |
| AMS-06_025_Release of ammonia from piping | | |
| Dense Gas Dispersion: Toxic dose | 2.92E-03 | 18 |
| AMS-06_100_Release of ammonia from piping | | |
| Dense Gas Dispersion: Toxic dose | 5.44E-03 | 38 |
| AMS-06_250_Release of ammonia from piping | | |
| Dense Gas Dispersion: Toxic dose | 4.34E-05 | 38 |
| AMS-06_500(RUP)_Release of ammonia from piping | | |
| Dense Gas Dispersion: Toxic dose | 1.20E-04 | 38 |
| AMS-07_025_Release of ammonia from piping (V) | | |
| Dense Gas Dispersion: Toxic dose | 1.46E-03 | 0 |
| AMS-07_100_Release of ammonia from piping (V) | | |
| Dense Gas Dispersion: Toxic dose | 2.49E-04 | 10 |
| AMS-07_250_Release of ammonia from piping (V) | | |
| Dense Gas Dispersion: Toxic dose | 3.47E-05 | 10 |
| AMS-07_500(RUP)_Release of ammonia from piping (V) | | |
| Dense Gas Dispersion: Toxic dose | 1.30E-05 | 58 |
| LDB-01_025_Ammonia release in unloading area | | |
| Dense Gas Dispersion: Toxic dose | 1.60E-04 | 10 |
| LDB-01_100_Ammonia release in unloading area | | |
| Dense Gas Dispersion: Toxic dose | 2.40E-05 | 27 |
| LDB-01_250_Ammonia release in unloading area | | |
| Dense Gas Dispersion: Toxic dose | 6.76E-06 | 26 |

| | | |
|---|----------|------|
| LDB-01_500_Ammonia release in unloading area | | |
| Dense Gas Dispersion: Toxic dose | 1.10E-05 | 26 |
| LDB-02_100_Ammonia release in unloading area | | |
| Dense Gas Dispersion: Toxic dose | 1.44E-04 | 26 |
| LDB-02_500_Ammonia release in unloading area | | |
| Dense Gas Dispersion: Toxic dose | 8.57E-04 | 20 |
| LDB-04_500_HCl release in unloading area | | |
| Neutral Gas Dispersion: Toxic dose | 8.29E-04 | 48 |
| LDB-05_250_Release of ammonia from tanker | | |
| Dense Gas Dispersion: Toxic dose | 2.19E-06 | 430 |
| LDB-05_500_Release of ammonia from tanker | | |
| Dense Gas Dispersion: Toxic dose | 2.74E-08 | 937 |
| LDB-05_RUP_Release of ammonia from tanker | | |
| Dense Gas Dispersion: Toxic dose | 2.74E-08 | 1539 |
| WDS-01 Release of chlorine_RUP | | |
| Dense Gas Dispersion: Toxic dose | 2.00E-07 | 332 |

APPENDIX G. SEPP33 REPORT



SEPP33 RISK SCREENING

DUBBO ZIRCONIA PROJECT

R.W. CORKERY

PREPARED FOR: Alex Irwin
R.W. Corkery

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CONTENTS

ABBREVIATIONS..... 5

1. INTRODUCTION..... 6

 1.1. Background.....6

 1.2. SEPP33 Applicability.....6

 1.3. Scope and Objectives.....6

 1.4. Method.....7

2. SEPP33 ASSESSMENT 8

 2.1. Potentially Hazardous Development8

 2.2. Potentially Offensive Development9

 2.3. Conclusion.....9

APPENDIX 1. REFERENCES 19



TABLES

| | | |
|------------|---|----|
| Table 2.1: | SEPP33 Hazardous Material Storage Screening Summary | 10 |
| Table 2.2: | SEPP33 Hazardous Material Transport Screening Summary | 12 |

FIGURES

| | | |
|-------------|---------------------|----|
| Figure 2.1: | Layout Drawing..... | 15 |
| Figure 2.2: | Site Boundary | 17 |

Document: J20663-001
Revision: B
Revision Date: 29 April 2013
Document ID: 54504_Appendix 4_ Report Appendix G from Sherpa_300813.docx

Page 4



ABBREVIATIONS

| | |
|-------------------|-------------------------------------|
| ADG | Australian Dangerous Goods |
| AZL | Australian Zirconia Ltd |
| DG | Dangerous Goods |
| DGR | Director-Generals Requirement |
| DoP | Department of Planning |
| DZP | Dubbo Zirconia Project |
| EIS | Environmental Impact Statement |
| EPL | Environmental Protection Licence |
| kW/m ² | kilo-Watts per square metre |
| m | metres |
| m/s | metres per second |
| MHF | Major Hazard Facility |
| MSDS | Material Safety Datasheet |
| NSW | New South Wales |
| PG | Packing Group |
| PHA | Preliminary Hazard Analysis |
| REEs | Rare Earth Elements |
| SEE | Statement of Environmental Effects |
| SEPP | State Environmental Planning Policy |
| WHS | Work Health and Safety |

Document: J20663-001
Revision: B
Revision Date: 29 April 2013
Document ID: 54504_Appendix 4_ Report Appendix G from Sherpa_300813.docx

Page 5



1. INTRODUCTION

1.1. Background

Australian Zirconia Ltd (AZL), a wholly owned subsidiary of Alkane Resources Limited, is planning to submit a development application to develop and operate the Dubbo Zirconia Project (DZP). The mining and mineral processing operation plant for Zirconium, Niobium, Yttrium and Rare Earth Elements (REEs) is located near Toongi, approximately 25 km south of Dubbo. The Proposal incorporates complex industrial processing components involving dangerous goods eg anhydrous ammonia, hydrochloric acid and caustic soda, to separate the rare metals and earth elements from the ore.

R.W. Corkery (RWC) has been commissioned by AZL to prepare the Environmental Impact Statement (EIS) for the DZP.

RWC has engaged Sherpa Consulting Pty Ltd (Sherpa) to carry out the hazards and risk component of the Director-Generals Requirements (DGR 642) under this proposed development. As part of this process, Sherpa is to review the proposed development using the *State Environmental Planning Policy 33 – Hazardous and Offensive Development* (SEPP 33) and determine whether it would be considered by SEPP 33 to be '*potentially hazardous industry*' or '*potentially offensive industry*'.

1.2. SEPP33 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 objectives of the SEPP33 review are to:

- Determine whether the Proposal is 'potentially hazardous', hence establish whether a PHA is required and document the basis for the decision.
- Determine whether the Proposal is 'potentially offensive', and document the basis for the decision.

Document: J20663-001
 Revision: B
 Revision Date: 29 April 2013
 Document ID: 54504_Appendix 4_ Report Appendix G from Sherpa_300813.docx

Page 6



1.4. Method

The screening process published in the NSW Department of Planning guideline *Hazardous & Offensive Development Application Guidelines – Applying SEPP33 (January 2011)* was used to establish whether the Proposal is 'potentially hazardous' or 'potentially offensive'.

Document: J20663-001
Revision: B
Revision Date: 29 April 2013
Document ID: 54504_Appendix 4_ Report Appendix G from Sherpa_300813.docx

Page 7



2. SEPP33 ASSESSMENT

2.1. Potentially Hazardous Development

SEPP33 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 SEPP33* 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 SEPP33* 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. Dangerous Goods

A list of the expected types and quantities of materials to be stored or handled at the proposed DG Store, together with the relevant SEPP33 screening threshold, is presented in Table 2.1.

A site layout showing the approximate location of these inventories is shown in Figure 2.1. Site boundary is indicated by the fenced area on the west of the site as shown in Figure 2.2.

Table 2.1 shows that:

- Class 2.3 goods on site:
 - have a total inventory of more than 200 tonnes of anhydrous ammonia
 - the SEPP33 threshold for anhydrous ammonia which contributes to the majority of the Class 2.3 inventory is 5 tonnes.
- Class 8 PG II goods on site:
 - have a total inventory of 21,220 tonnes
 - SEPP33 threshold for this class of DG is 25 tonnes.

Therefore, based on the screening thresholds for the dangerous goods listed above, the Proposal is 'potentially hazardous' and a Preliminary Hazard Analysis (PHA) is required.

Document: J20663-001
Revision: B
Revision Date: 29 April 2013
Document ID: 54504_Appendix 4_ Report Appendix G from Sherpa_300813.docx

Page 8



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 SEPP33 screening thresholds is presented in Table 2.2.

The transport screening thresholds are exceeded by the proposed numbers of hazardous material movements due to the number of ammonia truck movements hence a Transport Route Selection study is required.

2.1.3. Other Hazards

Additional hazards to be considered that are not explicitly covered by the *Applying SEPP33* guideline include:

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

A review of MSDS provided for the materials to be handled at the site was undertaken. As indicated in Table 2.1, any other potential hazards not specifically addressed by the *Applying SEPP33* screening process will be discussed further in a Preliminary Hazard Analysis to identify any significant offsite risk.

2.2. Potentially Offensive Development

SEPP33 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. Conclusion

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 SEPP33. The facility will also be a designated Major Hazard Facility (MHF) under the NSW Work Health and Safety Regulation (WHS) 2011 as it will exceed the screening threshold of anhydrous ammonia given in Schedule 15. Consequently, the Proposal is classified as 'potentially hazardous'. Therefore, a preliminary hazard analysis is required for the Proposal.

Document: J20663-001
Revision: B
Revision Date: 29 April 2013
Document ID: 54504_Appendix 4_Report Appendix G from Sherpa_300813.docx

Page 9

TABLE 2. 1: SEPP33 HAZARDOUS MATERIAL STORAGE SCREENING SUMMARY

| Material | DG Class | Total Quantity (tonnes) ¹ | Storage Arrangements ¹ | SEPP33 Threshold | SEPP33 Determination |
|--|----------------|--------------------------------------|---|---|---|
| Hydrochloric acid wt (33 wt%) | 8 PG II | 1,600 | Road tankers pumped to bulk storage tanks | Based on Table 3 (Ref 1) screening threshold: 25 tonnes of Class 8 PG II | Total Class 8 PG II storage exceeds SEPP 33 threshold. Proposal is potentially hazardous. |
| Sulphuric Acid (98%) | 8 PG II | 18,000 | Road tankers pumped to bundled four 2075 m ³ storage tanks | | |
| Sodium Sulphide Na ₂ S | 8 PG II | 220 | Containers stored on bundled concrete pad. Bulk bags undercover. | | |
| Sodium hydroxide NaOH | 8 PG II | 1,400 | Containers stored on bundled concrete pad. Bulk bags undercover. | | |
| TOTAL Class 8 PG II Store | 8 PG II | 21,220 | - | | |
| Anhydrous ammonia | 2.3 | 200 | Eight specialised 32 tonne storage tanks on crushed ROM pad. | Based on Table 3 (Ref 1) screening threshold: 5 tonnes of Class 2.3 (anhydrous ammonia kept in the same manner as for liquefied flammable gases and not kept for sale) | Total ammonia storage exceeds SEPP 33 threshold. Proposal is potentially hazardous. |
| Potable water treatment chemicals (chlorine) | 2.3 | 0.43 | - | Based on Table 3 (Ref 1) screening threshold: 1 tonne of Class 2.3 (chlorine and sulphur dioxide stored as liquefied gas in containers <100 kg | Total chlorine storage does not exceed SEPP 33 threshold. However Proposal is still potentially hazardous based on materials stored on site. |

¹ Information provided by client.

Document: J20663-001
Revision: B
Revision Date: 29 April 2013
Document ID: 54504_Appendix 4_Report Appendix G from Sherpa_300813.docx

| Material | DG Class | Total Quantity (tonnes) ¹ | Storage Arrangements ¹ | SEPP33 Threshold | SEPP33 Determination |
|--------------------------|----------|--------------------------------------|---|---|--|
| SX Organic (Alamine 336) | 9 PG III | 20 | Containers stored on bunded concrete pad. Totes undercover. | No threshold identified based on SEPP 33 | Figure 4 (Ref 1): Class 9 PG III not potentially hazardous material as per SEPP 33. |
| Diesel fuel | 9 PG III | 794 | - | No threshold identified based on SEPP 33 If diesel is stored in the same bund as gasoline (Class 3 PGII), total inventory of diesel will be classified as Class 3 PG II. | Figure 4 (Ref 1): Class 9 PG III not potentially hazardous material as per SEPP 33. |

TABLE 2. 2: SEPP33 HAZARDOUS MATERIAL TRANSPORT SCREENING SUMMARY

| Trip Type | Traffic generation | | Annual Delivery (ton) | DG Class | Comments | SEPP33 Threshold Vehicle Movements (Table 2) | | Threshold Exceeded? |
|----------------------------|--------------------------|---|--------------------------------|--|-----------------|--|-------------|---------------------|
| | Annually | Peak Weekly | | | | Annually | Peak Weekly | |
| Receipt of goods by trucks | Sodium sulphide | 144 | 3 | 2,817 | Class 8 PG II | >500 | >30 | No |
| | Anhydrous ammonia | 480 | 10 | 9,767 | Class 2.3 | >100 | >6 | Yes |
| | Aluminium powder | 144 | 3 | 1,700 | Class 4.1 PG II | >200 | >12 | No |
| | SX Organic (Alamine 336) | 48 (based on delivery once every 6 weeks) | Once every 6 weeks | 160 (based on 20 ton delivery every 6 weeks) | Class 9 PG III | >1,000 | >60 | No |
| | Sulphuric acid | No information given by client | No information given by client | No information given by client | Class 8 PG II | >500 | >30 | See comments |
| | Chlorine | No information given by client | No information given by client | No information given by client | Class 2.3 | >100 | >6 | See comments |
| | Diesel | No information given by client | No information given by client | No information given by client | Class 9 PG III | >100 | >6 | See comments |

Document: J20663-001
Revision: B
Revision Date: 29 April 2013
Document ID: 54504_Appendix 4_Report Appendix G from Sherpa_300813.docx

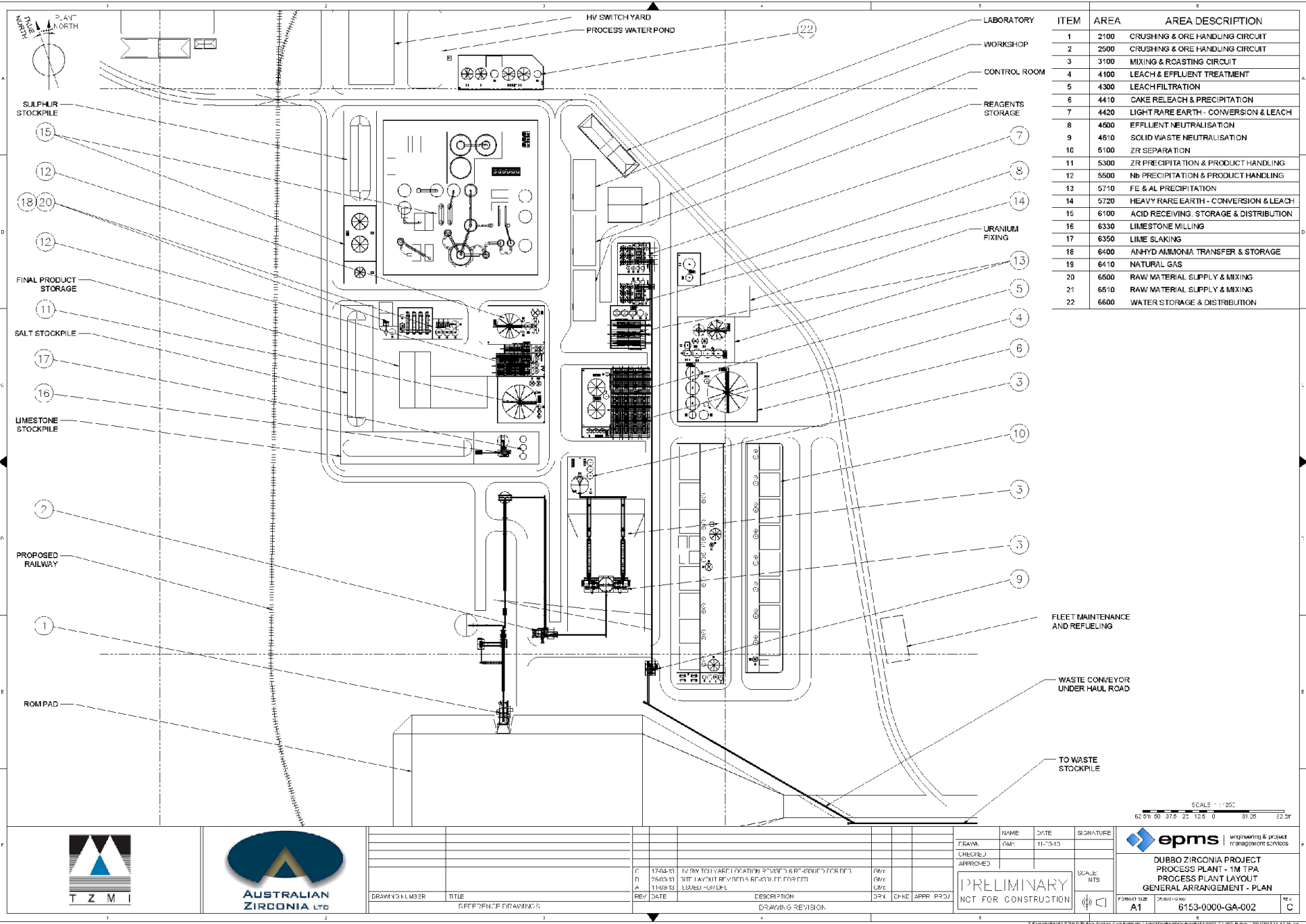
| Trip Type | Traffic generation | | Annual Delivery (ton) | DG Class | Comments | SEPP33 Threshold Vehicle Movements (Table 2) | | Threshold Exceeded? |
|---------------------------|--------------------|-------------|-----------------------|---------------|---|--|-------------|---------------------|
| | Annually | Peak Weekly | | | | Annually | Peak Weekly | |
| Receipt of goods by train | 144 | 3 | 42,403 | Class 8 PG II | Hazardous material deliveries by rail are not covered in the transportation screening threshold in SEPP33 | N/A | N/A | See comments |
| | 144 | 3 | 24,342 | Class 8 PG II | Hazardous material deliveries by rail are not covered in the transportation screening threshold in SEPP33 | N/A | N/A | See comments |



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FIGURE 2.1: LAYOUT DRAWING



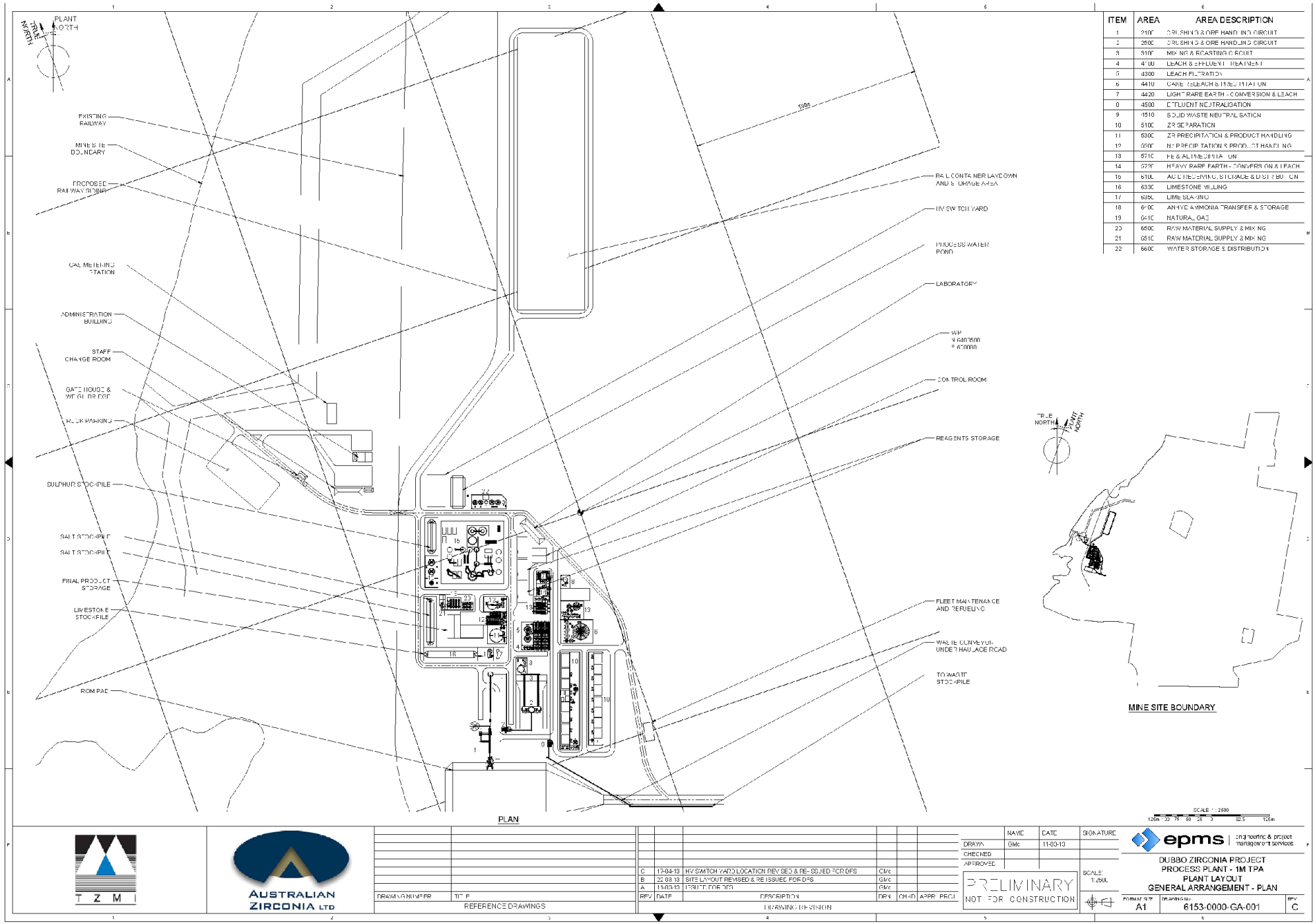
Document: J20663-001
Revision: B
Revision Date: 29 April 2013
Document ID: 54504_Appendix 4_Report Appendix G from Sherpa_300813.docx

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FIGURE 2.2: SITE BOUNDARY



Document: J20663-001
Revision: B
Revision Date: 29 April 2013
Document ID: 54504_Appendix 4_Report Appendix G from Sherpa_300813.docx

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Document: J20663-001
Revision: B
Revision Date: 29 April 2013
Document ID: 54504_Appendix 4_ Report Appendix G from Sherpa_300813.docx

Page 19

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