



**AUSTRALIAN  
ZIRCONIA LTD**

(A wholly owned subsidiary of Alkane Resources Ltd)

# **Dubbo Zirconia Project**

## **Air Quality and Greenhouse Gas Assessment**

**Prepared by**

**Pacific Environment Limited**

**August 2013**

**Specialist Consultant Studies Compendium  
Volume 1, Part 2**

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# Air Quality and Greenhouse Gas Assessment

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# CONTENTS

	<b>Page</b>
<b>EXECUTIVE SUMMARY.....</b>	<b>2-9</b>
<b>1. INTRODUCTION.....</b>	<b>2-11</b>
<b>2. PROJECT DESCRIPTION.....</b>	<b>2-12</b>
2.1 OVERVIEW .....	2-12
2.2 SITE ESTABLISHMENT AND CONSTRUCTION.....	2-13
2.3 MINING OPERATIONS .....	2-13
2.4 PROCESSING PLANT .....	2-15
2.5 TRANSPORT .....	2-15
<b>3. LOCAL SETTING .....</b>	<b>2-16</b>
<b>4. LEGISLATIVE SETTING .....</b>	<b>2-17</b>
4.1 INTRODUCTION .....	2-17
4.2 DIRECTOR-GENERAL'S REQUIREMENTS .....	2-17
4.3 ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979.....	2-18
4.4 AIR QUALITY ISSUES AND EFFECTS .....	2-19
4.4.1 Introduction .....	2-19
4.4.2 Particulate Matter .....	2-19
4.4.3 Oxides of Nitrogen (NO <sub>x</sub> ) .....	2-20
4.4.4 Sulphur Dioxide (SO <sub>2</sub> ).....	2-21
4.4.5 Hydrogen Chloride (HCl).....	2-21
4.4.6 Odour .....	2-21
4.4.7 Radon.....	2-21
<b>5. AIR QUALITY ASSESSMENT CRITERIA .....</b>	<b>2-23</b>
5.1 PARTICULATE MATTER ASSESSMENT CRITERIA.....	2-23
5.2 GASEOUS AIR QUALITY PARAMETERS ASSESSMENT CRITERIA .....	2-24
5.3 IN-STOCK CONCENTRATIONS .....	2-24
5.4 ODOUR ASSESSMENT CRITERIA .....	2-25
5.4.1 Measuring Odour Concentration .....	2-25
5.4.2 Odour Performance Criteria .....	2-26
<b>6. CLIMATE AND METEOROLOGY .....</b>	<b>2-28</b>
6.1 INTRODUCTION .....	2-28
6.2 TEMPERATURE .....	2-28
6.3 RELATIVE HUMIDITY .....	2-28
6.4 RAINFALL .....	2-28
6.5 DISPERSION METEOROLOGY .....	2-29
6.5.1 Wind Speed and Wind Direction .....	2-29

# CONTENTS

	Page
<b>7. EXISTING AIR QUALITY .....</b>	<b>2-30</b>
7.1 INTRODUCTION.....	2-30
7.2 DUST DEPOSITION .....	2-30
7.3 TOTAL SUSPENDED PARTICULATE (TSP).....	2-31
7.4 PARTICULATE MATTER LESS THAN 10 MICRONS IN AERODYNAMIC DIAMETER (PM <sub>10</sub> ) .....	2-32
7.5 PARTICULATE MATTER LESS THAN 2.5 MICRONS IN AERODYNAMIC DIAMETER (PM <sub>2.5</sub> ) .....	2-32
7.6 OTHER AIR QUALITY PARAMETERS .....	2-33
7.6.1 Sulphur Dioxide .....	2-33
7.6.2 Nitrogen Dioxide.....	2-33
7.6.3 Hydrogen Chloride and Fluoride .....	2-33
7.7 SUMMARY OF BACKGROUND DATA .....	2-34
<b>8. METHODOLOGY .....</b>	<b>2-35</b>
8.1 APPROACH TO ASSESSMENT .....	2-35
8.2 TAPM .....	2-35
8.3 CALMET .....	2-36
8.4 WIND SPEED AND DIRECTION.....	2-37
<b>9. EMISSIONS TO AIR .....</b>	<b>2-38</b>
9.1 INTRODUCTION.....	2-38
9.2 PARTICULATE MATTER.....	2-38
9.2.1 Emissions from proposed operations.....	2-38
9.2.2 Fugitive Particulate Matter Emission Estimates .....	2-38
9.2.3 Consideration of Cumulative Emissions.....	2-39
9.3 CONSTRUCTION PARTICULATE .....	2-41
9.4 ODOUR.....	2-41
9.5 RADON .....	2-43
9.6 OTHER AIR QUALITY PARAMETERS .....	2-43
9.6.1 Emissions Sources.....	2-43
9.6.2 Determination of nitrogen dioxide concentrations .....	2-45
<b>10. IMPACT ASSESSMENT .....</b>	<b>2-46</b>
10.1 INTRODUCTION.....	2-46
10.2 PARTICULATE MATTER.....	2-46
10.2.1 Introduction.....	2-46
10.2.2 Annual average TSP, PM <sub>10</sub> , PM <sub>2.5</sub> and dust deposition predictions .....	2-47
10.2.3 Incremental 24-hour average PM <sub>10</sub> and PM <sub>2.5</sub> concentrations .....	2-50
10.2.4 Cumulative 24-hour average PM <sub>10</sub> concentrations .....	2-52
10.3 SULPHUR DIOXIDE .....	2-54
10.4 NITROGEN DIOXIDE .....	2-54

# CONTENTS

	<b>Page</b>
10.5 HYDROGEN CHLORIDE .....	2-57
10.6 RADON IMPACT ASSESSMENT .....	2-58
10.7 ODOUR IMPACT ASSESSMENT .....	2-59
<b>11. MITIGATION .....</b>	<b>2-61</b>
11.1 INTRODUCTION .....	2-61
11.2 FUGITIVE DUST .....	2-61
11.2.1 Construction Dust Controls .....	2-61
11.2.2 Operations .....	2-61
11.2.3 Real-Time Dust Monitoring .....	2-62
11.3 PROCESSING PLANT .....	2-63
<b>12. GREENHOUSE GAS ASSESSMENT .....</b>	<b>2-64</b>
12.1 INTRODUCTION .....	2-64
12.2 GREENHOUSE GAS EMISSION ESTIMATES .....	2-65
12.3 SUMMARY OF GHG EMISSIONS .....	2-66
12.4 IMPACT ASSESSMENT .....	2-66
12.5 GREENHOUSE GAS MANAGEMENT .....	2-69
<b>13. CONCLUSIONS .....</b>	<b>2-70</b>
<b>14. REFERENCES .....</b>	<b>2-71</b>
<b>15. FIGURES .....</b>	<b>2-73</b>

## APPENDICES

Appendix 1	Detailed receptor information .....	2-123
Appendix 2	CALMET and TAPM input file parameters .....	2-127
Appendix 3	Emission Inventory Calculations .....	2-131
Appendix 4	DZP Odour Monitoring Report .....	2-139
Appendix 5	Greenhouse gas emission calculations .....	2-155

## FIGURES

Figure 1	DZP Site Layout .....	2-75
Figure 2	Processing plant layout .....	2-76
Figure 3	Regional setting of the Proposal .....	2-77
Figure 4	Land ownership in the vicinity of the DZP Site .....	2-78
Figure 5	Pseudo three-dimensional plot of the DZP Site .....	2-79
Figure 6	Particle Deposition within the Respiratory Track .....	2-80
Figure 7	Annual and seasonal windroses for Toongi Met Station (2003) .....	2-81

# CONTENTS

	<b>Page</b>
Figure 8 Annual and seasonal windroses for Toongi Met Station (2005).....	2-82
Figure 9 Annual and seasonal windroses for Toongi Met Station (2006).....	2-83
Figure 10 Annual and seasonal windroses for Toongi Met Station (2007).....	2-84
Figure 11 Annual and seasonal windroses for Toongi Met Station (2008).....	2-85
Figure 12 Annual and seasonal windroses for Toongi Met Station (2010).....	2-86
Figure 13 Annual and seasonal windroses for Toongi Met Station (2011).....	2-87
Figure 14 Annual and seasonal windroses for Toongi Met Station (2011).....	2-88
Figure 15 Annual and seasonal windroses for Dubbo Airport AWS (2008) .....	2-89
Figure 16 Location of monitoring stations.....	2-90
Figure 17 Historical dust deposition data.....	2-91
Figure 18 Monitoring data for 24 hour average PM <sub>10</sub> concentrations.....	2-92
Figure 19 CALMET/CALPUFF modelling system.....	2-93
Figure 20 Annual and seasonal windroses for Toongi weather station and CALMET (2008).....	2-94
Figure 21 Source locations Year 5 .....	2-96
Figure 22 Source locations Year 15 .....	2-97
Figure 23 LRSF – Year 15.....	2-98
Figure 24 Predicted cumulative annual average TSP concentrations – Year 5.....	2-99
Figure 25 Predicted cumulative annual average PM <sub>10</sub> concentrations – Year 5.....	2-100
Figure 26 Predicted cumulative annual average PM <sub>2.5</sub> concentrations – Year 5 .....	2-101
Figure 27 Predicted cumulative annual average dust deposition – Year 5 .....	2-102
Figure 28 Predicted cumulative annual average TSP concentrations – Year 15.....	2-103
Figure 29 Predicted cumulative annual average PM <sub>10</sub> concentrations – Year 15.....	2-104
Figure 30 Predicted cumulative annual average PM <sub>2.5</sub> concentrations – Year 15 .....	2-105
Figure 31 Predicted cumulative annual average dust deposition – Year 15 .....	2-106
Figure 32 Predicted maximum incremental 24 hour average PM <sub>10</sub> concentrations – Year 5 .....	2-107
Figure 33 Predicted maximum incremental 24 hour average PM <sub>10</sub> concentrations – Year 15 ....	2-108
Figure 34 Predicted maximum incremental 24 hour average PM <sub>2.5</sub> concentrations – Year 5.....	2-109
Figure 35 Predicted maximum incremental 24 hour average PM <sub>2.5</sub> concentrations – Year 15.....	2-110
Figure 36 Year 15 Receptors 4, 7, 10, 22, 40 and 46 – Frequency distribution of cumulative 24-hr PM <sub>10</sub> concentration using Monte Carlo Simulation .....	2-111
Figure 37 Selected receptors for 24 hour PM <sub>10</sub> cumulative analysis.....	2-112
Figure 38 Predicted cumulative maximum 10 minute SO <sub>2</sub> concentrations – Year 15.....	2-113
Figure 39 Predicted cumulative maximum 1 hour SO <sub>2</sub> concentrations – Year 15 .....	2-114
Figure 40 Predicted cumulative maximum 24 hour SO <sub>2</sub> concentrations – Year 15 .....	2-115
Figure 41 Predicted cumulative annual average SO <sub>2</sub> concentrations – Year 15 .....	2-116
Figure 42 Predicted HCl concentrations – Year 15 .....	2-117
Figure 43 Predicted Radon concentrations – Year 15.....	2-118
Figure 44 Predicted Odour concentrations – Year 15 .....	2-119

# CONTENTS

	<b>Page</b>
<b>TABLES</b>	
Table 1	ROM ore extracted and overburden removed over the life of the Proposal ..... 2-14
Table 2	Indicative Mining Fleet..... 2-14
Table 3	Director-General's Requirements and government agency requirements..... 2-18
Table 4	EPA Air Quality Criteria for Particulate Matter Concentrations ..... 2-23
Table 5	EPA Advisory Reporting Standards for PM <sub>2.5</sub> ..... 2-23
Table 6	EPA Criteria for Dust (Insoluble Solids) Fallout ..... 2-24
Table 7	Air quality criteria for gaseous air quality parameters (EPA, 2005) ..... 2-24
Table 8	In-Stack Concentration Criteria under the POEO (Clean Air) Regulation, 2010..... 2-25
Table 9	Odour Performance Criteria for the Assessment of Odour ..... 2-27
Table 10	Climate Statistics for Dubbo Airport AWS BoM Station ..... 2-28
Table 11	Rainfall for Toongi Met Station 2001-2012 (mm) ..... 2-29
Table 12	Dust deposition sampling collected during 2012 for baseline radiation purposes ..... 2-31
Table 13	TSP Monitoring Results for March 2001- February 2002 ..... 2-31
Table 14	Annual Average PM <sub>10</sub> Concentration for Rural NSW ..... 2-32
Table 15	1 hour maximum SO <sub>2</sub> concentrations for Bargo (µg/m <sup>3</sup> )..... 2-33
Table 16	Annual Average and 1 hour maximum NO <sub>2</sub> concentrations for Bargo (µg/m <sup>3</sup> )..... 2-33
Table 17	Adopted background contributions..... 2-34
Table 18	Estimated TSP emissions for each stage of the Proposal (kg TSP/year)..... 2-40
Table 19	Odour monitoring results ..... 2-42
Table 20	Odour model inputs ..... 2-42
Table 21	Radon emission rates for the Proposal ..... 2-43
Table 22	Processing Plant source characteristics ..... 2-44
Table 23	Processing Plant air quality parameter emission rate (g/s)..... 2-44
Table 24	Predicted incremental and cumulative annual average results for TSP, PM <sub>10</sub> , PM <sub>2.5</sub> and dust deposition – Year 5..... 2-47
Table 25	Predicted incremental and cumulative annual average results for TSP, PM <sub>10</sub> , PM <sub>2.5</sub> and dust deposition – Year 15 ..... 2-49
Table 26	Predicted incremental maximum 24 hour average results for PM <sub>2.5</sub> and PM <sub>10</sub> concentrations for Year 5 and Year 15 ..... 2-51
Table 27	Predicted incremental and cumulative results for SO <sub>2</sub> ..... 2-55
Table 28	Predicted incremental results for NO <sub>2</sub> ..... 2-56
Table 29	Predicted incremental concentrations of HCl ..... 2-58
Table 30	Predicted incremental and cumulative results for Radon..... 2-59
Table 31	Predicted incremental and cumulative results for odour ..... 2-60
Table 32	Summary of GHG Emissions (t CO <sub>2</sub> -e) ..... 2-66
Table 33	Projected Changes in Annual Temperature (relative to 1990) ..... 2-67
Table 34	Comparison of Greenhouse Gas Emissions ..... 2-68

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## **EXECUTIVE SUMMARY**

This report has been prepared by Pacific Environment for R.W. Corkery & Co. Pty Ltd (RWC) on behalf of Australian Zirconia Ltd (the Applicant; wholly owned subsidiary of Alkane Resources Ltd). The purpose of this study is to assess the likely air quality impacts of the proposed Dubbo Zirconia Project (hereafter referred to as the Proposal) located near Toongi, NSW.

The Proposal would include the development, mining and processing of Zirconium, Niobium and Rare Earth Elements (REEs) resources located near Toongi, approximately 25km south of Dubbo.

This assessment has been prepared to form part of an Environmental Impact Statement (EIS) being prepared by RWC to support an application for State Significant Development Consent under Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the Proposal.

The assessment follows the procedures outlined by the NSW Environment Protection Authority (EPA) in their document titled "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (EPA, 2005) (hereafter referred to as the "Approved Methods"). The Approved Methods specify how assessments based on the use of air dispersion models should be undertaken. They include guidelines for the preparation of meteorological data, emissions data and relevant air quality criteria.

Two operating scenarios over the life of the Proposal have been assessed to represent the potential worst case air quality impacts that the Proposal would have on private and Applicant-owned receptors in the proximity of the DZP Site.

The air quality parameters investigated include particulate matter (TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, dust deposition), SO<sub>2</sub>, NO<sub>2</sub>, HCl, Radon and Odour.

Dispersion modelling was conducted to predict the ground level concentrations for potential air impacts for Year 5 and Year 15 (particulate matter only) impacts and Year 15 for the remaining air quality parameters. Cumulative impacts were also considered, taking into account the Proposal and other non-mining sources.

The modelling results showed that during operation, the Proposal would be compliant with all of the NSW EPA air quality criteria for the relevant averaging periods for TSP, PM<sub>10</sub>, dust deposition, SO<sub>2</sub>, NO<sub>2</sub>, HCl, Odour and also the NEPM advisory reporting standards for PM<sub>2.5</sub>. Several Applicant-owned receptors located to the immediate west of the processing plant are predicted to be impacted for SO<sub>2</sub> only.

Monte Carlo simulation was completed to determine the probability of six selected private receptors located around the DZP Site of exceeding the EPA Criterion for cumulative PM<sub>10</sub> 24 hour averages. Monitored PM<sub>10</sub> 24-hour concentrations recorded at Bathurst and Tamworth were used to create a daily background data set which was then randomly added to predictions made from the Proposal alone. Results indicate that all of the most affected receptors are predicted to experience cumulative PM<sub>10</sub> 24-hour impacts over the criterion on two days in the modelled year 2015. However, given that the background data set contains two exceedances of the EPA 24-hour criterion, the Proposal is not anticipated to contribute to any *additional* exceedances, and thus are anticipated to satisfy the EPA criterion.

It is further highlighted that the adoption of background data sets from Bathurst and Tamworth is considered conservative.

The potential for construction air quality impacts were assessed qualitatively. Emissions from construction activities account for a relatively small percentage compared to the potential emissions during the operation of the Proposal. Construction particulate matter emissions are considered short lived and able to be effectively managed via a *Construction Dust Management Plan*.

The processing plant emission rates comply with the in-stack concentration limits prescribed under the Protection of the Environment Operations (Clean Air) Regulation (2010).

A GHG assessment indicates that average annual scope 1 and 2 emissions from the Proposal (0.26 Mt CO<sub>2</sub>-e) would represent approximately 0.04% of Australia's commitment under the *Kyoto Protocol* (591.5 Mt CO<sub>2</sub>-e) and a very small portion of global greenhouse emissions.



## **1. INTRODUCTION**

This report has been prepared by Pacific Environment for R.W. Corkery & Co. Pty Ltd (RWC) on behalf of Australian Zirconia Ltd (the Applicant; wholly owned subsidiary of Alkane Resources Ltd). The purpose of this study is to assess the likely air quality impacts of the proposed Dubbo Zirconia Project (DZP) (hereafter referred to as the 'Proposal').

The Proposal would include the development, mining and processing of Zirconia, Niobium and Rare Earth Elements (REEs) resources located near Toongi, approximately 25km south of Dubbo.

The purpose of the assessment is to form part of an Environmental Impact Statement (EIS) being prepared by RWC to support an application for State Significant Development Consent under Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to facilitate the Proposal.

The assessment follows the procedures outlined by the NSW Environment Protection Authority (EPA) in their document titled "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (EPA, 2005) (hereafter referred to as the "Approved Methods"). The Approved Methods specify how assessments based on the use of air dispersion models should be undertaken. They include guidelines for the preparation of meteorological data, emissions data and relevant air quality criteria.

Additionally, the Proposal will require approval from the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities (SEWPaC) in relation to impacts on matters protected by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The need for an approval under the EPBC Act was established following the referral of the Project to SEWPaC (8 November 2012) which subsequently determined it to be a Controlled Action on the basis of potential impacts on threatened species (4 January 2013). SEWPaC has indicated that assessment of the Proposal will be undertaken bi-laterally with the NSW State Significant Development assessment process being undertaken by the NSW Department of Planning and Infrastructure (DP&I).

The objectives of the air quality and greenhouse gas assessment are as follows.

- To understand meteorological conditions of the DZP Site.
- To characterise current air quality and baseline air quality issues.
- To estimate the emissions of:
  - particulate matter (PM) (as PM<sub>10</sub>, PM<sub>2.5</sub>, total suspended particulates (TSP) and depositional dust) for representative worst case stages of the Proposal;
  - other air quality parameters released from the processing plant including sulphur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>) and hydrogen chloride (HCl) for a worst case stage of the Proposal;
  - odour for a representative worst case stage of the Proposal; and
  - radon for a representative worst case stage of the Proposal.
- To apply regulatory dispersion models to predict future ambient air quality at the site for two representative stages of the Proposal's development.
- To recommend air quality management measures.
- To estimate greenhouse gas emissions and evaluate the potential impact of the Proposal to future climate change.

## 2. PROJECT DESCRIPTION

### 2.1 OVERVIEW

**Figure 1** shows the proposed layout of the DZP Site and the following provides an overview of the various activities to be undertaken.

- Ore would be mined by standard drill and blast, load and haul methods from a shallow Open Cut.
- Waste rock from the margins of the ore body would be transferred to a small Waste Rock Emplacement (WRE) to the southwest of the Open Cut.
- The ore would be transferred to a processing plant where it would be crushed and ground before the various metals and REEs are separated by sulphation leach, solvent extraction and precipitation processes.
- A Rail Siding would be constructed as a spur from the Toongi-Dubbo Rail Line along with a Rail Container Laydown and Storage Area for the unloading and temporary storage of reagents and loading of products for despatch.
- The solid waste residue produced by the processing of the ore would be mixed with lime (to neutralise the residue) and transported on a conveyor to a Solid Residue Storage Facility (SRSF).
- Water which cannot be recycled through the processing plant would be pumped to a Liquid Residue Storage Facility (LRSF) comprising a series of terraced cells within four separate areas of the DZP Site from which the liquid would be evaporated.
- Salt which accumulates within the LSRF (approximately 6.7Mt) would be excavated at the completion of the Project and disposed of within a series of Salt Encapsulation Cells which would adjoin the WRE and SRSF.
- Other features of the DZP Site illustrated on **Figure 1** and critical to the development and operation of the Proposal include:
  - DZP Site Administration Area;
  - internal haul roads;
  - contractor management area;
  - water diversion and storage structures; and
  - soil stockpile areas.
- A small basalt quarry may be developed to the south of the open cut within the footprint of the WRE and operated during the construction period of the Proposal. The extraction of basalt, crushing and operation of a concrete batching plant would be restricted to the construction period.

## **2.2 SITE ESTABLISHMENT AND CONSTRUCTION**

Complete site establishment, i.e. complete construction of all DZP Site infrastructure and facilities, is anticipated to take between 18 months and 2 years although it is noted that mining and processing would be undertaken concurrently for a period towards the end of the site establishment phase. Construction activities are proposed to occur seven days a week during daylight hours only. Construction activities for the Proposal would include (at least):

- construction of a water supply line between the DZP Site and an off-take from the Macquarie River on the “Mia Mia” property (Macquarie River Water Pipeline), a distance of approximately 7.5km;
- construction of a natural gas pipeline developed as a spur line between the Central West Pipeline (of APA Group) at Purvis Lane, Dubbo, and the processing plant;
- construction of the Toongi-Dubbo Rail Line;
- construction of the DZP Site Entrance, Access Road and intersection with Toongi Road;
- upgrades to the public road network between the DZP Site Entrance and Newell Highway; and
- construction of a range of surface water diversion and retention structures.

Site establishment would also include the construction of various infrastructure and facilities associated with processing operations, processing residue management and storage, other site facilities and services.

## **2.3 MINING OPERATIONS**

The Applicant seeks approval for open cut mining sequentially for a total period of 20 years with a production rate of up to 1.1 Mtpa of ore.

An indicative ore production schedule for the conceptual staged years of the Proposal is provided in **Table 1**. These years were chosen as representative of different stages of the project as well as worst-case operational years in terms of potential for air quality impacts.

Project Approval is sought for the extraction of ore and waste rock from a single open pit.

The proposed Open Cut would be developed in two stages, each of approximately 10 years duration. During the first ten years of operation only the western half of the ore body will be mined. The initial Open Cut would cover an area of approximately 20 hectares (ha). During the second ten years of operation the eastern half of the ore body would be mined.

Drill and blast methods would be used to fragment all material that is to be excavated from the Open Cut. Blast holes would be drilled using one or more hydraulic drill rigs equipped with dust suppression equipment.

Following completion of each blast, boundaries between ore and waste rock material would, if required, be identified and marked on the ground using paint, tape or similar materials. Fragmented material would then be loaded into haul trucks using a front-end loader and transported to the WRE or the ROM pad.

**Table 2** presents an overview of the indicative mining fleet that would be used during mining operations. In addition to the equipment identified in **Table 2**, a number of light and other vehicles would be used during mining operations.

**Table 1**  
**ROM ore extracted and overburden removed over the life of the Proposal**

Year	Ore (t)	Waste Rock (t)	Total (t)	Strip Ratio (ore : waste rock)
-1	74,598	1,869	76,466	1 : 0.025
1	753,362	41,016	794,378	1 : 0.054
2	813,254	67,398	880,652	1 : 0.083
3	905,797	88,888	994,685	1 : 0.098
4	1,000,444	118,254	1,118,697	1 : 0.118
5	1,008,330	116,829	1,125,159	1 : 0.116
6	989,570	113,171	1,102,742	1 : 0.114
7	1,005,179	82,212	1,087,391	1 : 0.082
8	991,605	77,541	1,069,147	1 : 0.078
9	1,002,201	78,917	1,081,118	1 : 0.079
10	1,005,807	149,356	1,155,163	1 : 0.148
11	1,004,671	669,556	1,674,227	1 : 0.666
12	995,891	262,944	1,258,836	1 : 0.264
13	1,003,319	271,753	1,275,072	1 : 0.271
14	1,001,169	285,565	1,286,734	1 : 0.285
15	998,558	268,212	1,266,771	1 : 0.269
16	995,185	186,425	1,181,610	1 : 0.187
17	1,006,494	188,543	1,195,037	1 : 0.187
18	991,207	149,643	1,140,850	1 : 0.151
19	1,004,666	148,007	1,152,673	1 : 0.147
20	904,566	92,642	997,208	1 : 0.102
<b>Total</b>	<b>19,455,875</b>	<b>3,458,740</b>	<b>22,914,615</b>	<b>1 : 0.178</b>

Source: Alkane Resources Ltd

**Table 2**  
**Indicative Mining Fleet**

Indicative Mining Fleet			
Equipment No	Indicative Number	Use	Proposed Hours of Operation
Major Equipment – Open Cut Mining			
Cat 980G Front End Loader or equivalent	1	Extraction of ore material and waste rock	10 - 11 hours per day, 5 - 5.5 days per week, 48 weeks per year
Articulated Truck (Cat 740) 38t or equivalent	5	Transportation of ore material and waste rock	
Support Equipment			
Cat D8R Dozer	1	Stripping soil, shaping of waste rock emplacements, clearing of benches, general site maintenance	10 - 11 hours per day, 5 - 5.5 days per week, 48 weeks per year
Cat 14H Grader	1		
Service Truck	1	Equipment servicing and refuelling	
Water cart	1	Dust suppression	
Diesel Generators	variable	Power supply as required	
Blast Hole Drill Rig	1	Drilling blast/grade control holes	10 - 11 hours per day, 5 – 5.5 days per week, 32 weeks per year
Explosives Delivery Vehicle	1	Explosives delivery	
Source: Alkane Resources Ltd			

Source: Alkane Resources Ltd

## **2.4 PROCESSING PLANT**

The processing plant is a unique development using novel process technology that has been developed for the specific characteristics of the Toongi ore body. The process is based on a sulphuric acid roast, water leach, and solvent extraction recovery and refining process to produce high purity zirconium chemical products. Niobium concentrate is recovered from the waste stream of the zirconia extraction, and refined using acid leaching.

The processing plant site layout is shown in **Figure 2** and includes the following components:

- ROM pad and crushing circuit.
- Dry grinding (ball) mill.
- Sulphur stockpiles and sulphuric acid plant.
- Acid mixing & roasting circuit (roasting kilns).
- Leach filtration circuit.
- Solid residue precipitation circuit.
- Solid residue neutralisation area.
- Solvent extraction, precipitation and product handling circuits.
- Refining and metal / rare recovery circuits.
- Major reagent storage and stockpile areas.
- Minor reagents stores.
- Limestone stockpiles, (wet) mill and slurry tank.
- Neutralised waste stockpile.
- Water storage & treatment facilities.
- Process water pond.
- Final product storage.
- Laboratory and control room.

## **2.5 TRANSPORT**

The Applicant's preferred method of transporting reagents and other materials to and products from the DZP Site would involve a combination of road and rail operations. However, considering the high capital cost associated with the upgrade of the rail line between Dubbo and Toongi, three options for transport are identified and may be implemented.

### **Option A – Road / Rail (Toongi)**

This option assumes the rail transport of Sulphur, Caustic Soda and Hydrogen Chloride all the way to the DZP Site at Toongi. Three trains would be operated on the Toongi-Dubbo Rail Line per week. The road transport of all other reagents, fuels and materials would be by road, however, this volume of road traffic would be reduced by the use of rail.

### **Option B – Rail (Dubbo) / Road**

This option assumes some reagents are transported by rail to a rail terminal operated by Fletcher International Exports Pty Ltd on the Merrygoen (Newcastle) Rail Line from which they would be unloaded and transferred to trucks for delivery to Toongi. From the Fletcher Rail Terminal trucks would travel to the DZP Site using an existing heavy haulage route.

### **Option C – Road Only**

The road only option assumes that the rail line is not constructed, construction of the rail line is scheduled for later in the life of the Proposal, or construction is delayed. In this case, all reagents, fuel, other materials and products would be delivered to and despatched from the DZP Site by road registered trucks. This the preferred option for the Proposal.

### 3. LOCAL SETTING

The Proposal is a greenfield development. The DZP Site is located in the Central West of New South Wales, approximately 25km south of Dubbo.

The regional setting of the Proposal is shown in **Figure 3**. Significant geographic features in the area include the Goobang National Park to the southwest and other parks and forest in the wider area surrounding the DZP Site.

Land use comprises of mixed agricultural activities including sheep and cattle grazing and grain crops. The land within the DZP Site is gently undulating and has been affected by disturbances commonly associated with livestock grazing operations.

Further afield there are several small quarries located near Dubbo and the Tomingley Gold Mine is located approximately 40km to the southwest of the DZP Site. These sources are anticipated to have negligible contributions to the air quality in the vicinity of the DZP Site and any impacts would be reflected in the background data.

The land within the DZP Site is either owned by the Applicant, or the Applicant holds a contractual arrangement with the current owner to purchase the land on approval of the Proposal. A sensitive receptor is defined as a location where people are likely to work or reside, and may include a dwelling, school, hospital office or public recreational area in addition to known or likely future locations (DEC, 2005). Private freehold landholders are considered sensitive receptors and are located to the north, north-east and south of the DZP Site boundary as shown in the land ownership map provided in **Figure 4**. Three receptors located within the DZP Site are Applicant owned while two are on land on which the Applicant holds a call option to purchase. These receptors have been considered part of this assessment as workers may reside within these existing houses. A detailed list of the receptors investigated in this assessment, including ownership and location coordinates, is provided in **Appendix 1**.

Topography is gently undulating across the DZP Site and surrounding area, ranging from topographic highs associated with Dowds Hill (425m) to the lows across the plains to the northwest (~275m). Gently undulating cleared grasslands (approximately 310m above sea level) dominate the central and western portions of the DZP Site.

**Figure 5** shows a pseudo three dimensional representation of the local topography in the DZP Site and surrounds.

## **4. LEGISLATIVE SETTING**

### **4.1 INTRODUCTION**

The proposed activities described in Section 2 have the potential to generate fugitive dust emissions in the form of particulate matter described as total suspended particulate matter (TSP), particulate matter with an equivalent aerodynamic diameter of 10 micrometres ( $\mu\text{m}$ ) or less ( $\text{PM}_{10}$ ), particulate matter with an equivalent aerodynamic diameter of 2.5  $\mu\text{m}$  or less ( $\text{PM}_{2.5}$ ), and deposited dust emissions. Activities at the processing plant would also result in the potential release of particulate matter as described above, in addition to other air quality parameters generated through the ore processing include sulphur dioxide ( $\text{SO}_2$ ), nitrogen dioxide ( $\text{NO}_2$ ) and hydrogen chloride (HCl). To a lesser extent, there may also be potential for emissions of sulphur trioxide ( $\text{SO}_3$ ), hydrogen sulphide ( $\text{H}_2\text{S}$ ) and hydrogen fluoride (HF).

Odour emissions have the potential to be released from the by-product solid and liquid waste residues after ore processing. It is anticipated that some odour emissions may potentially arise from the release of ammonia from the ammonia scrubber vent.

Potential emissions of the radionuclides radon and thoron may also be released from the solid and liquid storage facilities and to a very limited extent, other ore material handling related activities. Thoron has a half-life of approximately 1-minute and therefore emissions are not considered to be of significance. The radon emissions have been assessed in the radiation assessment (JRHC Enterprises, 2013).

In addition, combustion engines within generators and vehicles release emissions through engine exhausts including carbon monoxide (CO), minor quantities of  $\text{SO}_2$  and  $\text{NO}_2$ . Diesel combustion also results in the emission of fine particulate matter which is accounted for in the estimates of fugitive emissions presented in this report.

Other potential emissions to air from the Proposal include greenhouse gases (GHG) such as carbon dioxide ( $\text{CO}_2$ ) from the combustion of fuel in combustion engines and blasting of the ore and overburden. GHG emissions are assessed in Section 12.

The following sections provide information on the air quality criteria used to assess the impact of dust and particulate emissions, odour and radon. To assist in interpreting the significance of predicted concentration and deposition levels some background discussion is also provided.

### **4.2 DIRECTOR-GENERAL'S REQUIREMENTS**

The Air Quality and Greenhouse Gas Assessment has been prepared in accordance with the Director-General's Requirements (DGRs) provided in **Table 3**, as well as the Approved Methods.

**Table 3**  
**Director-General's Requirements and government agency requirements**

Discipline	Requirement	Section addressed
<b>Director General's Requirements</b>		
Air	<p>Including a quantitative assessment of potential:</p> <ul style="list-style-type: none"> <li>• construction and operational impacts, with a particular focus on dust emissions (including PM<sub>2.5</sub> and PM<sub>10</sub> emissions) and processing emissions;</li> <li>• reasonable and feasible mitigation measures to minimise dust and processing emissions, including evidence that there are no such measures available other than those proposed;</li> <li>• monitoring and management measures, in particular real-time air quality monitoring.</li> </ul>	<p>Section 8 to 10</p> <p>Section 11</p> <p>Section 11.1.2</p>
Greenhouse gases	<ul style="list-style-type: none"> <li>• a quantitative assessment of the potential Scope 1, 2 and 3 greenhouse gas emissions;</li> <li>• a qualitative assessment of the potential impacts of these emissions on the environment; and</li> <li>• an assessment of the reasonable and feasible measures to minimise the greenhouse gas emissions and ensure energy efficiency.</li> </ul>	<p>Section 12</p> <p>Section 12.2 to 12.4</p> <p>Section 12.5</p>
<b>Government agency requirements (NSW EPA)</b>		
Air	<ul style="list-style-type: none"> <li>• The goal should be to maintain existing rural air quality and protect sensitive receptors, both on and off site, from adverse impacts of dust and odour in particular and other relevant air pollutants</li> </ul>	Section 9 to 11
Greenhouse gases	<ul style="list-style-type: none"> <li>• an assessment of, and report on, the project's predicted greenhouse gas emissions (tCO<sub>2</sub>e)</li> </ul>	Section 12

### 4.3 ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979

The EP&A Act requires that consideration be given to environmental impacts as part of the land use planning process. In NSW, environmental impacts are interpreted as including impacts to air quality.

Upon repeal of Part 3A of the EP&A Act on 1 October 2011, the *Environmental Planning and Assessment Amendment (Part 3A Repeal) Act 2011* inserted a new Division 4.1 into Part 4 of the EP&A Act.

Division 4.1 provides for a new planning assessment and determination regime for State Significant Development (SSD). Section 89C of the EP&A Act stipulates that a development will be considered SSD if declared to be such by the new *State Environmental Planning Policy (State and Regional Development) 2011* (SEPP SRD).

Under Clause 8(1) of SEPP SRD, a development is declared to be State Significant Development if:

- the development on the land concerned is, by the operation of an environmental planning instrument, permissible with development consent under Part 4 of the EP&A Act; and
- the development is specified in Schedule 1 or 2 of SEPP SRD.



The Proposal is SSD as it meets both of these criteria, namely:

- it is permissible with development consent on the land on which it is located; and
- it is development that is specified in Schedule 1 of SEPP SRD.

This impact assessment has been prepared in accordance with Division 4.1 of Part 4 of the EP&A Act. The EP&A Act requires that environmental impacts including air quality impacts be assessed and mitigated where necessary.

## **4.4 AIR QUALITY ISSUES AND EFFECTS**

### **4.4.1 Introduction**

From an air quality perspective, it is important to consider the potential emissions that may occur during the operation of the Proposal. During operation of the Proposal, the key air quality parameters will be those associated with dust generating mining operations, SO<sub>2</sub> and NO<sub>2</sub> from the processing plant, odour from the solid waste residue, radon from material handling and processing activities and GHG emissions from diesel vehicle exhaust and blasting activities.

### **4.4.2 Particulate Matter**

Particulate matter has the capacity to affect health and to cause nuisance effects, and is categorised by size and/or by chemical composition. The potential for harmful effects depends on both. The particulate size ranges are commonly described as:

- TSP – refers to all suspended particles in the air.
- PM<sub>10</sub> – refers to all particles with equivalent aerodynamic diameters of less than 10 µm, that is, all particles that behave aerodynamically in the same way as spherical particles with diameters less than 10µm and with a unit density. PM<sub>10</sub> are a sub-component of TSP.
- PM<sub>2.5</sub> – refers to all particles with equivalent aerodynamic diameters of less than 2.5µm diameter (a subset of PM<sub>10</sub>). These are often referred to as the fine particles and are a sub-component of PM<sub>10</sub>.
- PM<sub>2.5-10</sub> – defined as the difference between PM<sub>10</sub> and PM<sub>2.5</sub> mass concentrations. These are often referred to as coarse particles.

Evidence suggests that health effects from exposure to airborne particulate matter are predominantly related to the respiratory and cardiovascular systems. The human respiratory system has in-built defensive systems that prevent larger particles from reaching the more sensitive parts of the respiratory system. The size of particles determine their behaviour in the respiratory system, including how far the particles are able to penetrate, where they deposit, and how effective the body's clearance mechanisms are in removing them. This is demonstrated in **Figure 6**, which shows the relative deposition by particle size within various regions of the respiratory tract.

Particles larger than 10µm, while not able to affect health, can soil materials and generally degrade aesthetic elements of the environment. For this reason air quality goals make reference to measures of the total mass of all particles suspended in the air, this is referred to as TSP. In practice particles larger than 30 to 50µm settle out of the atmosphere too quickly to be regarded as air quality parameters. The upper size range for TSP is usually taken to be 30µm.

Both natural and anthropogenic processes contribute to the atmospheric load of particulate matter. Coarse particles (PM<sub>2.5-10</sub>) are derived primarily from mechanical processes resulting in the suspension of dust, soil, or other crustal<sup>1</sup> materials from roads, farming, mining and dust storms. Coarse particles also include sea salts, pollen, mould, spores, and other plant parts. Mining dust is likely to be composed of predominantly coarse particulate matter (and larger).

Fine particles or PM<sub>2.5</sub> are derived primarily from combustion processes, such as vehicle emissions, wood burning, coal burning for power generation and natural processes such as bush fires. Fine particles also consist of transformation products, including sulphate and nitrate particles, and secondary organic aerosol from volatile organic compound emissions. PM<sub>2.5</sub> may penetrate beyond the larynx and into the thoracic respiratory tract and evidence suggests that particles in this size range are more harmful than the coarser component of PM<sub>10</sub>.

For these reasons, particle size is a key consideration in assessing exposure.

The health-based assessment criteria used by the EPA have, to a large extent, been developed by reference to epidemiological studies undertaken in urban areas with large populations where the primary pollutants are the products of combustion (EPA, 1998; National Environment Protection Council [NEPC], 1998a; NEPC, 1998b). This means that, in contrast to dust of crustal origin, the particulate matter from urban areas would be composed of smaller particles and would generally contain acidic and carcinogenic substances that are associated with combustion.

Total suspended particulate matter can also impact amenity when coarse fractions of the material deposit onto surfaces, resulting in the spoiling of surfaces and fabrics, known as deposited dust. Furthermore, the deposition of dust onto house roofs can result in the transport of dust from roofs into water tanks during periods of rainfall.

#### **4.4.3 Oxides of Nitrogen (NO<sub>x</sub>)**

Oxides of nitrogen (NO<sub>x</sub>) are produced when fossil fuels are combusted in internal combustion engines (e.g. motor vehicles, mine equipment). NO<sub>x</sub> emitted by fossil fuel combustion are comprised mainly of nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). NO is much less harmful to humans than NO<sub>2</sub> and is not generally considered an air quality parameter at the concentrations normally found in urban environments. In open-cut mining, such as that proposed by the Proposal, there is also potential for NO<sub>2</sub> to form as a result of the oxidation of ammonium nitrate during blasting.

NO<sub>2</sub> is the regulated oxide of nitrogen in NSW and effects of exposure to NO<sub>2</sub> include irritation of the lungs and lower resistance to respiratory infections such as influenza. The effects of short-term exposure are still unclear, however, continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children. Concern with NO is related to its transformation to NO<sub>2</sub> and its role in the formation of photochemical smog.

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<sup>1</sup> Crustal dust refers to dust generated from materials derived from the earth's crust.

#### **4.4.4 Sulphur Dioxide (SO<sub>2</sub>)**

The plant includes a double absorption contact process to manufacture sulphuric acid. This involves burning sulphur to produce the intermediates, SO<sub>2</sub> gas, SO<sub>3</sub> gas and finally oleum liquid, which is diluted with water to produce concentrated sulphuric acid. Trace emissions of SO<sub>2</sub> gas and H<sub>2</sub>SO<sub>4</sub> mist are expected from the acid plant stack, particularly during start up.

Sulphur dioxide (SO<sub>2</sub>) belongs to the family of sulphur oxide gases (SO<sub>x</sub>). These gases are formed when for instance fuel containing sulphur (mainly coal and oil) is burned. The major health concerns associated with exposure to high concentrations of SO<sub>2</sub> include effects on breathing, respiratory illness, alterations in pulmonary defences, and aggravation of existing cardiovascular disease. SO<sub>2</sub> is a major precursor to acid rain, which is associated with the acidification of lakes and streams, accelerated corrosion of buildings and monuments, and reduced visibility.

Emissions of SO<sub>2</sub> from diesel have been progressively declining in Australia as more stringent sulphur fuel standards have been introduced. Under the Fuel Quality Standards Act (2000) the current sulphur content in diesel fuel is now 10ppm, which is just 2% of what it was less than 10 years ago. Therefore SO<sub>2</sub> is not considered to be a key indicator air quality parameter for this assessment.

#### **4.4.5 Hydrogen Chloride (HCl)**

Hydrochloric acid (HCl) is commonly known as stomach acid. It is not readily formed in the ambient environment, with the most significant source of ambient contributions derived from anthropogenic emissions released during industrial processes. Hydrochloric acid contributes to the processes that form photochemical smog. It is also responsible for the decay of sandstone buildings.

Hydrochloric acid has a high acute toxic effect on all form of life. Exposure to concentrated HCl can result in serious health impacts which can lead to death in extreme cases. In a less concentrated form, HCl can also cause inflammation and irritation of the respiratory tract and skin, among a number of other health effects.

#### **4.4.6 Odour**

An odour is perceived when chemicals in gaseous form stimulate the human olfactory system. Due to the diversity of the receptors within the nose, intensity of odour impacts can vary as reactions to odour are highly subjective.

Odour is affected by climatic and seasonal conditions, with impacts increasing in intensity during calm conditions. Typically, odour has the potential to become an issue in situations of conflicting land uses. This typically occurs when residential areas encroach on established odour generating activities, or in the reverse scenario; when odour generating activities are established close to residential areas.

#### **4.4.7 Radon**

The target ore for the Proposal contains low levels of naturally occurring uranium, which when mined can result in the release of radon gas.

Radon is an inert gas and a radioactive decay product of uranium. Radon itself is not a significant source of radiation exposure, however, it is a transport mechanism for potentially more hazardous decay products. There is a direct relationship between the radon concentration and the decay product concentration, therefore an understanding of the radon concentration from the air quality modelling provides a basis for calculating the potential decay product concentrations, which will be used to assess the impact to people and the environment. While the dispersion of radon is addressed within this report, it is noted that a full assessment of radiation impacts is provided within a stand-alone technical assessment (JRHC Enterprises, 2013).

## 5. AIR QUALITY ASSESSMENT CRITERIA

### 5.1 PARTICULATE MATTER ASSESSMENT CRITERIA

The Approved Methods specify air quality assessment criteria relevant for assessing impacts from air pollution (EPA, 2005). The impact assessment criteria refer to the total pollutant load in the environment and consideration of background dust levels needs to be made when using these goals to assess potential impacts. These criteria are health-based (i.e. they are set at levels to protect against health effects).

These criteria are consistent with the National Environment Protection Measures for Ambient Air Quality (referred to as the Ambient Air-NEPM) (NEPC, 1998a). However, the EPA's criteria includes averaging periods which are not included in the Ambient Air-NEPM, and also references other measures of air quality, namely dust deposition and TSP.

**Table 4** summarises the air quality goals for concentrations of particulate matter that are relevant to this assessment. It is important to note that the criteria are applied to the cumulative impacts due to the Proposal and other sources.

**Table 4**  
**EPA Air Quality Criteria for Particulate Matter Concentrations**

Air quality parameter	Averaging period	Standard/Goal	Agency
TSP	Annual mean	90 $\mu\text{g}/\text{m}^3$	National Health and Medical Research Council
PM <sub>10</sub>	24-hour maximum	50 $\mu\text{g}/\text{m}^3$	EPA impact assessment criteria. Ambient Air-NEPM reporting goal, allows five exceedances per year for bushfires and dust storms.
	Annual mean	30 $\mu\text{g}/\text{m}^3$	EPA impact assessment criteria.

Notes:  $\mu\text{g}/\text{m}^3$  – micrograms per cubic metre.

In May 2003, the NEPC released a variation to the Ambient Air-NEPM (NEPC, 2003) to include advisory reporting standards (ARS) for particulate matter with an equivalent aerodynamic diameter of  $2.5\mu\text{m}$  or less (PM<sub>2.5</sub>), as shown in **Table 5**. The purpose of the variation was to gather sufficient data nationally to facilitate the review of the Ambient Air-NEPM, which is currently underway. The variation includes a protocol setting out monitoring and reporting requirements for PM<sub>2.5</sub>.

It is noted that the Ambient Air-NEPM PM<sub>2.5</sub> advisory reporting standards are not impact assessment criteria.

Notwithstanding the above, in the absence of any other relevant standard/goal, the advisory reporting standards have been used in this report for comparison against dispersion modelling results (Section 10).

**Table 5**  
**EPA Advisory Reporting Standards for PM<sub>2.5</sub>**

Air quality parameter	Averaging period	Standard/Goal	Agency
PM <sub>2.5</sub>	Annual mean	8 $\mu\text{g}/\text{m}^3$	Ambient Air-NEPM Advisory Reporting Standard
	24-hour average	25 $\mu\text{g}/\text{m}^3$	

Notes:  $\mu\text{g}/\text{m}^3$  – micrograms per cubic metre.

In addition to health impacts, airborne dust also has the potential to cause nuisance effects by depositing on surfaces, including vegetation. Larger particles do not tend to remain suspended in the atmosphere for long periods of time and will deposit relatively close to the source. Dust deposition can soil materials and generally degrade aesthetic elements of the environment, and are assessed for nuisance or amenity impacts.

**Table 6** shows the maximum acceptable increase and accumulation with other sources in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust deposition levels are set to protect against nuisance impacts (DEC, 2005).

**Table 6**  
**EPA Criteria for Dust (Insoluble Solids) Fallout**

Air quality parameter	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level (cumulative)
Deposited dust	Annual	2 g/m <sup>2</sup> /month	4 g/m <sup>2</sup> /month

Notes: g/m<sup>2</sup>/month – grams per square metre per month.

## 5.2 GASEOUS AIR QUALITY PARAMETERS ASSESSMENT CRITERIA

**Table 7** summarises the air quality criteria for concentrations of gaseous air quality parameters that are relevant to this assessment in the diesel fume and blast assessments.

**Table 7**  
**Air quality criteria for gaseous air quality parameters (EPA, 2005)**

Air quality parameter	EPA Impact assessment criteria	Averaging Period
Sulphur Dioxide	712 µg/m <sup>3</sup> (0.25 ppm)	10-minute
	570 µg/m <sup>3</sup> (0.2 ppm)	1-Hour
	228 µg/m <sup>3</sup> (0.08 ppm)	24-Hour
	60 µg/m <sup>3</sup> (0.02 ppm)	Annual
Nitrogen Dioxide	246 µg/m <sup>3</sup> (0.12 ppm)	1-Hour
	62 µg/m <sup>3</sup> (0.03 ppm)	Annual
Hydrogen Chloride	0.14 mg/m <sup>3</sup> (0.09 ppm)	1 hour

## 5.3 IN-STOCK CONCENTRATIONS

The Protection of the Environment Operations (Clean Air) Regulation, 2010 specifies in-stack concentration criteria relevant to the emissions from the stacks at the processing plant. The release of air quality parameters from the processing plant must operate within these limits. **Table 8** summarises the in-stack concentration limits for particulate matter and other air quality parameters that are relevant to this assessment. The Proposal would be subject to the prescribed limits for Group 6 activities as it would commence after 1 September 2005.

**Table 8**  
**In-Stack Concentration Criteria under the POEO (Clean Air) Regulation, 2010**

Air quality parameter	Source	Limit (mg/m <sup>3</sup> )	
		Group 5	Group 6
Solid Particles (TSP)	Clean Air Regulation – Schedule 4 “Any plant used for heating metals”	100	50
	Clean Air Regulation – Schedule 4 “Any crushing, grinding, separating or materials handling activity”	100	20
NO <sub>2</sub> or NO or both as NO <sub>2</sub> equivalent	Clean Air Regulation – Schedule 4 “Any boiler operating on gas”	2,000	350
SO <sub>2</sub>	Clean Air Regulation – Schedule 4 “Sulphuric acid manufacture using elemental sulphur”	2,800	1,000
SO <sub>3</sub>	Clean Air Regulation – Schedule 4 “Any activity or plant”	100	100
HCl	Clean Air Regulation – Schedule 4 “Any activity, other than the manufacture of glazed terracotta roofing tiles”	100	100

Notes: mg/m<sup>3</sup> – milligrams per cubic metre. Group 5 refers to those activities that commenced on or after 1 August 1997. Group 6 refers to those activities that commenced on or after 1 September 2005.

## **5.4 ODOUR ASSESSMENT CRITERIA**

### **5.4.1 Measuring Odour Concentration**

There are no instrument-based methods that can measure an odour response in the same way as the human nose. Therefore “dynamic olfactometry” is typically used as the basis of odour measurement and subsequent management by regulatory authorities.

Dynamic olfactometry is the measurement of odour by presenting a sample of odorous air diluted to the point where a trained panel of assessors cannot detect a change between the odour free air and the diluted sample. The concentration is then doubled until the difference is observed with certainty. The correlations between the dilution ratios and the panellists’ responses are then used to calculate the number of dilutions of the original sample required to achieve the odour detection threshold. The units for odour measurement using dynamic olfactometry are “odour units” (ou) which are dimensionless and are effectively “dilutions to threshold”. The detectability of an odour (i.e. whether someone smells it or not) is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. However, we note that the panellists used for this work are specially selected based on a reference odorant, n-butanol.

The theoretical minimum concentration is referred to as the “odour threshold” and is the definition of 1 odour unit (ou). Therefore, an odour concentration of less than 1 ou would theoretically mean that no odour would be detected.

## 5.4.2 Odour Performance Criteria

### 5.4.2.1 Introduction

The determination of air quality goals for odour and their use in the assessment of odour impacts is recognised as a difficult topic in air pollution science. The topic has received considerable attention in recent years and the procedures for assessing odour impacts using dispersion models have been refined considerably. There is still some debate in the scientific community about appropriate odour goals as determined by dispersion modelling.

The EPA has developed odour goals and the way in which they should be applied with dispersion models to assess the likelihood of nuisance impact arising from the emission of odour.

There are two factors that need to be considered:

1. what "level of exposure" to odour is considered acceptable to meet current community standards in NSW; and
2. how can dispersion models be used to determine if a source of odour meets the goals which are based on this acceptable level of exposure.

The term "level of exposure" has been used to reflect the fact that odour impacts are determined by several factors the most important of which are (the so-called FIDOL factors):

- the Frequency of the exposure;
- the Intensity of the odour;
- the Duration of the odour episodes;
- the Offensiveness of the odour; and
- the Location of the source.

In determining the offensiveness of an odour it needs to be recognised that for most odours the context in which an odour is perceived is also relevant. Some odours, for example the smell of sewage, hydrogen sulphide, butyric acid, landfill gas etc., are likely to be judged offensive regardless of the context in which they occur. Other odours such as the smell of jet fuel may be acceptable at an airport, but not in a house, and diesel exhaust may be acceptable near a busy road, but not in a restaurant.

In summary, whether or not an individual considers an odour to be a nuisance will depend on the FIDOL factors outlined above and although it is possible to derive formulae for assessing odour annoyance in a community, the response of any individual to an odour is still unpredictable. Odour goals need to take account of these factors.

### 5.4.2.2 New South Wales Odour Criteria

The Approved Methods include ground-level concentration (glc) criterion for complex mixtures of odorous air compounds. They have been refined by the EPA to take account of population density in the area. **Table 9** lists the odour glc criterion to be exceeded not more than 1% of the time, for different population densities.



The difference between odour criteria is based on considerations of risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area.

**Table 9**  
**Odour Performance Criteria for the Assessment of Odour**

<b>Population of affected community</b>	<b>glc criterion for complex mixtures of odorous air quality parameters (OU)</b>
~2	7
~10	6
~30	5
~125	4
~500	3
Urban (2000) and/or schools and hospitals	2
Source: Approved Methods	

A conservative approach has been adopted in the determination of the odour impact assessment criteria by basing the criteria on the most densely populated area within the vicinity of the Proposal. There are five sensitive receptors located within a square kilometre area that are located to the immediate west of the DZP Site. Therefore, in accordance with **Table 9**, it is appropriate to adopt an impact assessment glc criterion of 6 OU.

#### **5.4.2.3 Peak-to-Mean Ratios**

It is common practice to use dispersion models to determine compliance with odour criteria. This introduces a complication because Gaussian dispersion models are only able to directly predict concentrations over an averaging period of 3-minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a 3-minute period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source.

To determine more rigorously the ratio between the one-second peak concentrations and longer period average concentrations (referred to as the peak-to-mean ratio) that might be predicted by a Gaussian dispersion model, the EPA commissioned a study by Katestone Scientific Pty Ltd (1995, 1998). This study recommended peak-to-mean ratios for a range of circumstances. The ratio is also dependent on atmospheric stability and the distance from the source. For this assessment we have assumed a peak-to-mean ratio (ratio of peak 1-second average concentrations to mean 1-hour average concentrations; P/M60) of 2.3 for all stability classes. The EPA odour criteria take account of this peaking factor and the goals shown in **Table 9** are based on nose-response time, which is effectively assumed to be 1 second.

## 6. CLIMATE AND METEOROLOGY

### 6.1 INTRODUCTION

This section describes the local dispersion meteorology and local climatic conditions in the area. The closest Bureau of Meteorology (BoM) site that collects climatic information is located at Dubbo Airport, approximately 30km north of the DZP Site. The data are summarised in **Table 10** which presents information on temperature, relative humidity and rainfall.

**Table 10**  
**Climate Statistics for Dubbo Airport AWS BoM Station**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
<b>9am Mean Temperature (°C) and Relative Humidity (%)</b>													
Temp	23.8	22.4	19.6	17.0	12.2	8.6	7.5	9.6	14.0	17.9	20.3	22.8	16.3
Humidity	56	62	64	64	76	86	86	76	67	56	56	52	67
<b>3pm Mean Temperature (°C) and Relative Humidity (%)</b>													
Temp	31.6	30.2	27.6	23.7	19.2	15.4	14.5	16.5	19.9	23.5	27.0	29.7	23.2
Humidity	32	36	36	37	47	57	55	47	43	36	35	30	41
<b>Daily Maximum Temperature (°C)</b>													
Mean	33.0	31.8	28.7	24.6	19.9	16.2	15.4	17.4	21.0	24.5	28.2	30.8	24.3
<b>Daily Minimum Temperature (°C)</b>													
Mean	18.1	17.7	14.4	10.1	6.5	4.3	3.1	3.4	6.2	9.3	13.5	15.7	10.2
<b>Rainfall (mm)</b>													
Monthly mean	52.4	49.7	48.9	35.6	41.1	43.2	41.0	39.4	42.3	49.2	70.5	62.0	576.2
<b>Rain days (Number)</b>													
Mean no. of rain days	4.7	4.8	4.9	3.1	4.1	5.2	5.3	4.2	5.1	5.3	6.0	5.1	57.8
Station number: 065070; Commenced 1946; Currently Operating; Elevation: 284m AHD; Latitude: 32.22; Longitude: 148.58													
Source: Bureau of Meteorology (2012).													

### 6.2 TEMPERATURE

January is typically the warmest month with mean daily maximum temperature of 33°C. July is typically the coolest month with a mean daily minimum temperature of 3.1°C.

### 6.3 RELATIVE HUMIDITY

Relative humidity is highest in June and July at 86% (observed at 9am), and the lowest in December at 30% (observed at 3pm).

### 6.4 RAINFALL

November is the wettest month with a maximum mean monthly rainfall of 70.5mm recorded at Dubbo, coinciding with the maximum number of monthly rain days. The minimum rainfall and number of rain days occurs in April.

Rainfall data collected at meteorological station maintained by the Applicant on the “Whychitella” property and provided by RWC was also analysed for the years 2001-2012 and presented in **Table 11**.

The year of highest rainfall occurred in 2010. The annual average rainfall at Toongi is consistent with the historical BoM data recorded at the Dubbo Airport.

**Table 11**  
**Rainfall for Toongi Met Station 2001-2012 (mm)**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
<b>2001</b>	No Data	No Data	2.02	2.07	2.00	2.05	1.94	0.72	1.38	2.05	2.17	0.77	426
<b>2002</b>	1.0	3.8	0.7	0.9	0.9	0.2	0.2	0.2	1.4	0.0	0.6	1.3	158
<b>2003</b>	1.4	2.5	0.3	1.4	0.1	2.3	0.9	3.3	0.3	2.0	1.3	0.9	507
<b>2004</b>	1.8	0.7	0.4	0.7	1.8	1.3	1.6	0.8	0.8	1.7	2.3	2.5	n/a
<b>2005</b>	1.6	1.4	1.5	0.1	0.1	3.0	1.3	0.8	3.4	2.8	3.7	1.0	623
<b>2006</b>	2.8	1.4	0.7	0.4	0.0	1.1	2.9	0.1	0.3	0.1	2.0	2.6	353
<b>2007</b>	0.5	0.9	1.2	0.9	2.3	3.2	0.4	0.6	0.0	0.1	1.8	5.1	520
<b>2008</b>	2.1	2.6	1.0	0.0	0.6	1.3	0.7	1.1	1.7	1.7	2.7	1.7	481
<b>2009</b>	0.3	1.7	0.5	1.1	0.3	2.4	0.7	0.3	1.4	1.3	0.4	4.3	n/a
<b>2010</b>	0.6	4.8	3.1	2.1	1.5	0.8	2.0	1.6	2.0	1.6	5.4	5.0	919
<b>2011</b>	0.4	1.1	1.4	1.2	1.6	2.3	No Data	No Data	No Data	No Data	No Data	No Data	181 <sup>a</sup>
<b>2012</b>	59.0	71.6	122.8	3.0	66.6	34.6	51.4	2.8	24.2	3.8	25.2	3.2	468

<sup>a</sup> Data available to July only

## **6.5 DISPERSION METEOROLOGY**

### **6.5.1 Wind Speed and Wind Direction**

**Figure 7** to **Figure 14** present the annual and seasonal wind roses generated from the wind data provided by the Applicant’s Met Station for 2003, 2005-2008 and 2010-2012. **Figure 15** shows the annual and seasonal wind roses for Dubbo Airport AWS for 2008, located 25km north of the DZP Site.

The wind distribution patterns at Toongi across all years are dominant by winds from the south-southwest and northeast. The prevailing winds at Toongi during summer are from the northeast and north-northeast. During autumn and winter the prevailing wind direction originates from the south-southwest. The prevailing wind during spring is a transition between winter and summer.

The annual and seasonal wind roses for the data measured at Dubbo Airport AWS years indicate that the area is dominated by winds from the east for all seasons.

The Dubbo Airport, located north of Dubbo has terrain features to the north, east and southeast, relative to the meteorological station location, creating a wind channelling effect in an easterly direction. Toongi experiences southwest wind due to the channelling effect created by terrain features to the south and west of the location.

## 7. EXISTING AIR QUALITY

### 7.1 INTRODUCTION

Air quality criteria refer to cumulative air quality parameter levels which include existing and proposed sources. To fully assess impacts against all the relevant air quality criteria (detailed in Section 5) it is necessary to have information on existing dust concentration and deposition levels in the vicinity of the DZP Site.

Historical dust deposition and TSP monitoring has been conducted in the Toongi area by the Applicant between 2001 and 2003. The historical monitoring network comprised of nine dust deposition gauges (DDGs) and a single High Volume Air Sampler (HVAS) fitted with a sample head for TSP. Dust deposition monitoring was recommenced in November 2012. The current and historical monitoring locations are shown in **Figure 16**.

As there is limited monitoring data available for the DZP Site, EPA monitoring stations from further afield have been referenced. It is acknowledged that these monitoring locations are geographically distant from the DZP Site, however, the data is considered to be useful in providing an indicative (but conservatively high) estimate of background air quality for rural areas in NSW.

The EPA sites selected are based on distance from the DZP Site, land use in the vicinity of the monitoring station and site representation.

The following sources have been referenced to establish baseline air quality:

- current dust deposition monitoring (DZP Site);
- historical dust deposition monitoring (DZP Site);
- historical TSP monitoring (DZP Site);
- PM<sub>10</sub> data from Bathurst, located 140km southeast of the DZP Site.;
- PM<sub>10</sub> data from Tamworth, located 260km northeast of the DZP Site;
- SO<sub>2</sub> data from Bargo, located 280km southeast of the DZP Site; and
- NO<sub>2</sub> data from Bargo, located 280km southeast of the DZP Site.

### 7.2 DUST DEPOSITION

Dust deposition monitoring, commenced in September 2012 as part of a baseline radiation monitoring program, is currently being undertaken. Dust deposition data is collected bi-monthly at ten locations (prefaced as EML-). To date, only two months of data are available and is presented in **Table 12**.

Historical dust deposition was monitored at nine dust deposition gauges (DG1-DG9) surrounding the DZP Site, from March 2001 to February 2003 and the results are presented in **Figure 17**, with the contaminated results, such as those containing leaves or bird droppings, removed. With the exception of November and December 2002, the monitored locations have reported dust deposition levels below the 4g/m<sup>2</sup>/month dust fallout goal. The high dust levels recorded for November and December of 2002 is consistent with the low rainfall recorded for these months in the area (**Table 11**).

A background dust deposition level of 2 g/m<sup>2</sup>/month (annual average) has been adopted for this assessment.

**Table 12**  
**Dust deposition sampling collected during 2012 for baseline radiation purposes**

Site ID	Site Name	Start Date	End Date	# Days	Mass Dust (mg)	Daily Dust Mass (mg/day)
EML-LB	Lifestyle Blocks	13/09/2012	29/11/2012	77	30	0.39
EML-MB	Malcolm Bye's	13/09/2012	29/11/2012	77	51	0.66
EML-TV	Toongi Valley	13/09/2012	29/11/2012	77	15	0.19
EML-W	Wychitella	13/09/2012	29/11/2012	77	75	0.97
EML-CC	Cockeshell Corner	13/09/2012	29/11/2012	77	27	0.35
EML-K	Karingle	13/09/2012	29/11/2012	77	37	0.48
EML-OB	Ore Body	13/09/2012	29/11/2012	77	30	0.39
EML-GI	Glen Idol	13/09/2012	29/11/2012	77	84	1.09
EML-G	Grandale	13/09/2012	29/11/2012	77	77	1.00
EML-MM	Mia Mia	27/09/2012	29/11/2012	63	31	0.49

<sup>a</sup> Calculated based on 30 days per month.

### 7.3 TOTAL SUSPENDED PARTICULATE (TSP)

The recorded 24-Hour TSP concentrations for the period from March 2001 to April 2002 are presented in **Table 13**. The annual average TSP concentration of 19µg/m<sup>3</sup> for the monitored year is below the EPA criterion of 90µg/m<sup>3</sup> and has been adopted as the background for this assessment.

The highest TSP concentration measured was in January 2002 measuring 63µg/m<sup>3</sup>, below the EPA criteria of 90µg/m<sup>3</sup>. The higher TSP concentrations experienced during the summer months are likely the result of reduced rainfall to suppress dust emissions during this period.

**Table 13**  
**TSP Monitoring Results for March 2001- February 2002**

Averaged Period	Average TSP Concentration (µg/m3)
Mar-01	14
Apr-01	19
May-01	12
Jun-01	5
Jul-01	6
Aug-01	4
Sep-01	10
Oct-01	12
Nov-01	24
Dec-01	41
Jan-02	63
Feb-02	17
<b>Annual Average (Mar 2001- Feb 2002)</b>	<b>19</b>

## 7.4 PARTICULATE MATTER LESS THAN 10 MICRONS IN AERODYNAMIC DIAMETER (PM<sub>10</sub>)

There are no site specific PM<sub>10</sub> monitoring data available in the vicinity of the DZP Site. As indicated in Section 7.1, reference can be made to available monitoring data collected by the EPA in rural NSW. A time series of the 24-hour PM<sub>10</sub> concentrations recorded at Tamworth and Bathurst from January 2008 to February 2013 are presented in **Figure 18**. The annual average PM<sub>10</sub> for each site is shown in **Table 14**.

For scaling purposes, the 24 hour average PM<sub>10</sub> concentrations measured on the day of a significant dust storm that impacted much of the east of Australia on 23 September 2009 has been removed from the dataset. All other significant weather events have been included in the datasets.

**Table 14**  
**Annual Average PM<sub>10</sub> Concentration for Rural NSW**

Year	Tamworth (µg/m <sup>3</sup> )	Bathurst (µg/m <sup>3</sup> )
2008	16	14
2009	22	17
2010	12	9
2011	13	11
2012	16	13
2013 <sup>a</sup>	14	16
Average	16	13

<sup>a</sup> Data available to 20 February 2013

The annual average data show that 2009 experienced the highest annual average PM<sub>10</sub> concentration at both monitoring stations. This result is likely due to the prevailing drought conditions across NSW during this period. The average across both data sets is 16µg/m<sup>3</sup> and has been adopted as the annual average PM<sub>10</sub> background for this assessment.

## 7.5 PARTICULATE MATTER LESS THAN 2.5 MICRONS IN AERODYNAMIC DIAMETER (PM<sub>2.5</sub>)

As with PM<sub>10</sub>, there are no site specific PM<sub>2.5</sub> monitoring data available in the vicinity of the DZP Site. The closest and most similar in environment to the DZP Site are the PM<sub>2.5</sub> concentration data measured at Wagga Wagga North.

Data from this site is considered highly conservative and would provide a site representative dataset for the Proposal due to ongoing air quality issues in the area. The annual average PM<sub>2.5</sub> concentration ranges between 7µg/m<sup>3</sup> and 9µg/m<sup>3</sup>. The NEPM advisory reporting standard is 8µg/m<sup>3</sup>. An annual average PM<sub>2.5</sub> concentration of 7µg/m<sup>3</sup> has been conservatively adopted for this assessment.

## **7.6 OTHER AIR QUALITY PARAMETERS**

### **7.6.1 Sulphur Dioxide**

The 1 hour maximum SO<sub>2</sub> concentrations measured at the EPA's Bargo monitoring site between 2009 and 2012 are presented in **Table 15**. The maximum recorded 1 hour average concentration was 31µg/m<sup>3</sup>, well below the EPA criterion of 570µg/m<sup>3</sup>.

**Table 15**  
**1 hour maximum SO<sub>2</sub> concentrations for Bargo (µg/m<sup>3</sup>)**

<b>Year</b>	<b>1 hour maximum</b>
<b>EPA criterion</b>	<b>570</b>
2008	31
2009	23
2010	29
2011	26
2012	27

### **7.6.2 Nitrogen Dioxide**

The annual average and 1 hour maximum NO<sub>2</sub> concentrations measured at the EPA's Bargo monitoring site between 2009 and 2012 are presented in **Table 16**. The annual average NO<sub>2</sub> concentrations range between 10µg/m<sup>3</sup> and 12µg/m<sup>3</sup>, with the average across all years being 11µg/m<sup>3</sup>. The maximum recorded 1 hour average concentration was 126µg/m<sup>3</sup>, well below the EPA criterion of 246µg/m<sup>3</sup>. The daily varying values within this data set have been adopted for this assessment.

**Table 16**  
**Annual Average and 1 hour maximum NO<sub>2</sub> concentrations for Bargo (µg/m<sup>3</sup>)**

<b>Year</b>	<b>Annual average</b>	<b>1 hour maximum</b>
<b>EPA criterion</b>	<b>62</b>	<b>246</b>
2008	12	83
2009	10	103
2010	10	126
2011	10	98
2012	10	94
Average	11	101

### **7.6.3 Hydrogen Chloride and Fluoride**

There are no available monitoring data for hydrogen chloride or hydrogen fluoride in the vicinity of the DZP Site or as part of the EPA monitoring network. In consideration of the predominantly agricultural surrounding land use distinct lack of industry that would likely contribute to background HCl and HF baseline levels, it has been assumed that the respective air quality parameters would be present at very low levels, if not trace concentrations.

It is noted that in any event, the Approved Methods require that only the incremental (as opposed to the cumulative) impact of hydrogen chloride is required to be evaluated.

## 7.7 SUMMARY OF BACKGROUND DATA

The following background concentrations are adopted for the assessment, based on the available monitoring data described above are presented in **Table 17**.

**Table 17**  
**Adopted background contributions**

Air quality parameter	Averaging period	EPA criteria	Adopted background concentration
Dust deposition	Annual	4g/m <sup>2</sup> /month	2g/m <sup>2</sup> /month
TSP annual	Annual	90µg/m <sup>3</sup>	19µg/m <sup>3</sup>
PM <sub>10</sub>	Annual	30µg/m <sup>3</sup>	16µg/m <sup>3</sup>
	24 hour	50µg/m <sup>3</sup>	Daily varying
PM <sub>2.5</sub>	Annual	8µg/m <sup>3</sup>	7µg/m <sup>3</sup> <sup>b</sup>
	24 hour	25µg/m <sup>3</sup>	n/a
SO <sub>2</sub>	Annual <sup>a</sup>	60µg/m <sup>3</sup>	3µg/m <sup>3</sup>
	24 hour <sup>a</sup>	228µg/m <sup>3</sup>	11µg/m <sup>3</sup>
	1 hour	570µg/m <sup>3</sup>	27µg/m <sup>3</sup>
	10 minute <sup>a</sup>	712µg/m <sup>3</sup>	34µg/m <sup>3</sup>
NO <sub>2</sub>	Annual	62µg/m <sup>3</sup>	Daily varying
	1 hour	246µg/m <sup>3</sup>	Daily varying

<sup>a</sup> Pro-rated in accordance with the 1 hour monitoring data for SO<sub>2</sub>

<sup>b</sup> In considerations of the relatively higher PM<sub>10</sub> concentrations measured at Wagga Wagga and Wagga Wagga North, the annual average PM<sub>2.5</sub> background contribution has been assumed.



## 8. METHODOLOGY

### 8.1 APPROACH TO ASSESSMENT

The overall approach to the assessment follows the Approved Methods (EPA, 2005) using the Level 2 assessment methodology. The Approved Methods specify how assessments based on the use of atmospheric dispersion models should be completed. They include guidelines for the preparation of meteorological data to be used in dispersion models and the relevant air quality criteria for assessing the significance of predicted concentration and deposition rates from the Proposal. The approach taken in this assessment follows as closely as possible the approaches suggested by the guidelines.

The atmospheric dispersion modelling conducted for this assessment is based on an advanced modelling system using the models TAPM and CALMET/CALPUFF (see **Figure 19**). This system overcomes some of the limitations of steady-state Gaussian plume models such as AUSPLUME and ISC.

The modelling system works as follows:

- TAPM is a prognostic meteorological model that generates gridded three-dimensional meteorological data for each hour of the model run period.
- CALMET, the meteorological pre-processor for the dispersion model CALPUFF, calculates fine resolution three-dimensional meteorological data based upon observed ground and upper level meteorological data, as well as observed or modelled upper air data generated for example by TAPM.
- CALPUFF then calculates the dispersion of plumes within this three-dimensional meteorological field.

Output from TAPM, plus regional observational weather station data were entered into CALMET, a meteorological pre-processor endorsed by the US EPA and recommended by the NSW EPA for use in non-steady state conditions. From this, a 1-year representative meteorological dataset suitable for use in the 3-dimensional plume dispersion model, CALPUFF, was compiled. Details on the model configuration and data inputs are provided in the following sections.

A summary of the TAPM and CALMET model set up and inputs can be found in **Appendix 2**.

### 8.2 TAPM

The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. Detailed description of the TAPM model and its performance can be found in Hurley 2008 and Hurley, Edwards *et al.*, 2009.

TAPM utilises fundamental fluid dynamics and scalar transport equations to predict meteorology and (optionally) air quality parameter concentrations. It consists of coupled prognostic meteorological and air pollution concentration components. The model predicts airflow important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

For the this Assessment, TAPM was set up with 3 domains, composed of 25 grids along both the X and the Y axes, centred on -32° 26.5' Latitude and 148° 37' Longitude (651.500 km, 6409.000 km), to capture both the inner and outer modelling domains (further discussed below). Each nested domain had a grid resolution of 30 km, 10 km and 3 km respectively.

Default TAPM terrain values are based on a global 30-second resolution (approximately 1 km) dataset provided by the US Geological Survey, Earth Resources Observation Systems (EROS). Default land use and soils data sets for TAPM were used.

TAPM was used to generate gridded prognostic data (3D.dat) for the CALMET modelling domain.

### **8.3 CALMET**

The choice of the CALMET/CALPUFF modelling system for this assessment is based on the fact that simple Gaussian dispersion models such as ISC assumes that the meteorological conditions are uniform spatially over the entire modelling domain for any given hour. While this may be valid for some applications, in complex flow situations, such as areas with complex terrain, the meteorological conditions may be more accurately simulated using a wind field model such as CALMET.

CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are utilised in the CALPUFF dispersion model. CALMET was configured with a domain covering a 25 km x 34km area, with the origin (SW corner) at 640 km Easting and 6400 km Northing (UTM Zone 55S). This consisted of 100 x 136 grid points, with a 0.25 km resolution along both the X and Y axes.

The year 2008 was selected as a representative year for the dispersion modelling. The annual and seasonal wind roses presented in **Figure 7** to **Figure 14** indicate a good correlation between the available years of meteorological data measured at the Applicant's Met Station.

Observed hourly surface data were incorporated into the modelling from meteorological stations including:

- Applicant's Met Station; and
- Dubbo Airport AWS.

Meteorological parameters such as wind speed, wind direction, temperature and relative humidity were sourced from Toongi weather station. Cloud amount and cloud height data were sourced from the BoM Dubbo Airport AWS station with any gaps in the data supplemented by TAPM.

Upper air information was incorporated through the use of prognostic three dimensional data extracted from TAPM. The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. A detailed description of the TAPM model and its performance is provided elsewhere, (Hurley, 2002a, 2002b; Hurley *et al.*, 2002a, 2002b; Hibberd *et al.*, 2003; Luhar & Hurley, 2003).

Detailed mine plan terrain data was incorporated into the modelling as the terrain of the DZP Site will vary over time. A separate CALMET wind field was then generated for each mine plan scenario. Land use for the domain was determined by aerial photography from Google Earth.

Terrain for this area was derived from 90m DEM data sourced from the NASA Shuttle Radar Topography Mission (SRTM) data set.

#### **8.4 WIND SPEED AND DIRECTION**

The CALMET generated winds are compared with the measured data from Applicant's Met Station and presented in **Figure 20**.

The CALMET wind roses are extracted for a single point at the approximate location of Applicant's Met Station.

The CALMET wind roses extracted at Applicant's Met Station displays very similar characteristics to the measured data from Applicant's Met Station with the prevailing wind directions dominated by those originating from the south-southeast and to a lesser extent the east-northeast. The average wind speed from CALMET is 3.2 m/s which is similar to the annual average wind speed of 3.3 m/s observed at Applicant's Met Station. The percentage occurrence of calm conditions (defined as wind speeds <0.5m/s) are also similar with 1.5% recorded at Applicant's Met Station compared with 0.8% predicted by CALMET.

Further details on model set up are provided in **Appendix 2**.

## 9. EMISSIONS TO AIR

### 9.1 INTRODUCTION

This section discusses the calculation of the emission estimates for the assessment. Emissions have been calculated for the following.

- Particulate matter from the surface operations from the Proposal.
- Odour emissions from the solid and liquid waste storage.
- Radon emissions from ore handling activities and exposed areas.
- Other air emissions released from the processing plant (SO<sub>2</sub>, NO<sub>2</sub> and HCl).

### 9.2 PARTICULATE MATTER

#### 9.2.1 Emissions from proposed operations

The proposed operations have been analysed and estimates of dust emissions for the key dust generating activities have been made. Emission factors developed both in Australia, and by the US EPA, have been applied to estimate the amount of dust produced by each activity. The emission factors applied are considered to be the most reliable, contemporary methods for determining dust generation rates.

The mine plans for the Proposal have been analysed and detailed dust emissions inventories have been prepared for two key operating scenarios, being Year 5 and Year 15 following the commencement of operations (following site establishment). These modelled years are considered to be representative of worst-case operations; for example where ore and waste production are highest, where extraction or wind erosion areas are largest or where operations are located closest to receptors.

Detailed calculations are provided in **Appendix 3** which provide information on the equations used, the basic assumptions about material properties (e.g. moisture content, silt content etc.), information on the way in which equipment would be used to undertake different mining operations and the quantities of materials that would be handled in each scenario.

It is important to note that there would also be particulate matter emissions released from the processing plant during operations. Details on the emissions rates and source characteristics are provided in Section 9.

#### 9.2.2 Fugitive Particulate Matter Emission Estimates

Estimates of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions for each source were developed on an hourly time step taking into account the activities that would take place at that location. Thus, for each source, for each hour, an emission rate was determined which depended upon the level of activity and the wind speed. Dust generating activities were represented by a series of volume sources situated according to the location of activities for the modelled scenarios, shown in **Figure 21** and **Figure 22**.

To model the effect of pit retention for emissions within the Open Cut, detailed mine plan terrain data has been incorporated into the modelling. Mining activities have been restricted to the proposed hours of operation between 7am and 6pm, with the exception of blasting that would be scheduled between 9am and 5pm. Wind erosion emissions have been modelled for 24 hour per day.

For both scenarios and in accordance with **Figure 21** and **Figure 22**, a corresponding emissions inventory has been developed. The information used for developing the inventories has been based on the operational descriptions and mine plan drawings which were used to determine haul road distances and routes, stockpile and pit areas, activity operating hours, truck sizes and other details that are necessary to estimate dust emissions. Onsite dust mitigation strategies have been included in estimating the emissions and include:

- adopting a Level 2 watering to achieve 75% control of dust from haul roads;
- water injection during drilling of ore and overburden;
- the stockpiling of material is watered to maintain a relatively high moisture content for the prevention of wind erosion;
- the use of water curtains at all crushers and miscellaneous transfer points; and
- the implementation of a bag house at the grinding mill.

**Table 18** summarises the quantities of TSP estimated to be released by each activity of the Proposal. Detailed calculations for the estimation of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> are provided in **Appendix 3**.

### **9.2.3 Consideration of Cumulative Emissions**

There are currently no major dust generating operations (particularly mining operations) located in the vicinity of the DZP Site.

Further afield there are several small quarries located near Dubbo and the Tomingley Gold Mine located approximately 40km to the southwest of the DZP Site. These sources are anticipated to have negligible contributions to the air quality in the vicinity of the DZP Site and any impacts would be reflected in the background data.

Estimating the dust from other non-mining sources is complicated and depends on local land use and the associated emission sources, as well as climate, soil type, farming practice etc. The adopted background concentrations detailed in Section 7.7 are considered to conservatively capture contributions of other sources in the data set.

**Table 18**  
**Estimated TSP emissions for each stage of the Proposal (kg TSP/year)**

<b>ACTIVITY</b>	<b>TSP emission for Year 5 (kg/y)</b>	<b>TSP emission for Year 15 (kg/y)</b>
Topsoil Removal - Stripping topsoil - in waste rock emplacement area	1,244	-
Topsoil Removal - Stripping topsoil at salt encapsulation cell	-	4,000
Topsoil Removal - Stripping topsoil at waste rock emplacement area	-	1,474
OB - Drilling	792	792
OB - Blasting	239	239
OB - Sh/Ex/FELs loading OB to trucks at Pit	95	219
OB - Hauling OB from Pit to emplacement area	1,956	4,491
OB - Trucks emplacing OB at emplacement area	95	219
OB - Dozers on D1 north dump	5,024	5,024
OB - Dozers on SRSF	5,024	5,024
Ore - Dozers ripping/pushing/clean-up in pit	1,057	1,057
Ore - Drilling	6,833	6,833
Ore - Blasting	2,066	2,066
Ore - Loading ore from Pit to trucks	376	372
Ore - Hauling ore from Pit to ROM Pad	123,811	122,612
Ore - Unloading ore from truck to ROM pad	376	372
Ore - Primary crushing	10,083	9,986
Ore - Secondary crushing	30,250	29,957
Ore - Tertiary crushing	30,250	29,957
Ore - Quaternary crushing	30,250	29,957
Ore - Dry grinding	205,699	203,706
Ore - Miscellaneous transfers	20,167	19,971
WE - Stripped topsoil area at new LRSF in north	-	-
WE - Stripped topsoil area at salt encapsulation cell	-	18,308
WE - Waste emplacement	8,935	14,804
WE - Pit	15,856	34,690
WE - Stockpiles other - SRSF	17,599	28,882
WE - ROM stockpiles	108,610	108,610
WE - Stockpiles other - soil stockpiles	-	-
WE - Stockpiles other - Salt encapsulation cells	-	7,709
Grading roads	11,439	11,439
<b>Total TSP emissions (kg/yr)</b>	<b>638,126</b>	<b>702,768</b>

Notes: - OB – overburden; ORE – ore; WE – wind erosion.  
 - denotes no emissions from that source are predicted for that scenario.  
 - Totals do not add up exactly due to rounding errors.

### **9.3 CONSTRUCTION PARTICULATE**

Complete site establishment, i.e. construction of all DZP Site infrastructure and facilities, is anticipated to take between 18 months and 2 years although it is noted that mining and processing would be undertaken concurrently for a period towards the end of the site establishment phase. Construction activities are proposed to occur seven days a week during daylight hours only. Construction activities for the Proposal would include (at least):

- construction of a water supply line to the DZP Site;
- construction of a natural gas pipeline developed as a spur line between the Central West Pipeline at Purvis Lane, Dubbo, and the processing plant;
- construction of the Toongi-Dubbo Rail Line;
- construction of the DZP Site Entrance, Access Road and intersection with Toongi Road;
- upgrades to the public road network between the DZP Site Entrance and Newell Highway; and
- construction of a range of surface water diversion and retention structures

Experience has shown that emissions from construction activities account for a relatively small percentage of the overall emissions over the life of a mining project. This is largely associated with the short lived and highly variable nature and effective management of fugitive construction dust emissions. Given the predicted dust levels during operations, dust generated during construction is likely to be less and thus comply with the EPA criteria and NEPM advisory reporting standards. Furthermore, construction dust may be effectively managed through the implementation of *Construction Environmental Management Plans* (CEMPs).

### **9.4 ODOUR**

Odour emissions are anticipated to be released from the wastes produced as part of the ore processing operations. It is anticipated that odour emissions may be released from the liquid/solid waste streams that are to be deposited as part of the Proposal.

The liquid waste stream would be pumped to Liquid Residue Storage Facility (LRSF) at a rate of approximately 2.5GL per year. The liquid waste stream may contain residues containing ammonia.

The solid (compound) waste stream would comprise a complex mixture of odorous compounds that may include H<sub>2</sub>S, and would be conveyed to the Solid Residue Storage Facility (SRSF).

To determine the potential odour impacts from the Proposal, odour samples from each waste stream (ALZN cake) were collected from a pilot processing plant operated by ANSTO at Lucas Heights, NSW on 6 December 2012 and 12 February 2013. Odour monitoring was then undertaken, results have been reproduced in **Table 19**. The odour monitoring report and laboratory analysis are provided in **Appendix 4**.

**Table 19**  
**Odour monitoring results**

Sample	Sample Description	Date / Time	Odour Concentration (OU)	Specific Odour Emission Rate (SOER) (OU.m <sup>3</sup> /m <sup>2</sup> /s)	Odour Character
Liquid Waste Stream	Prepared immediately prior to sampling	6/12/2012 15:10	256	0.15	Musty / Stale Water
Compound Waste Stream	Prepared immediately prior to sampling	12/02/2013 11:28	128	0.08	Musty / Stale Water

It was also established from the odour monitoring undertaken on the 'fresh' and 'aged' ALZN cake (see **Appendix 4**) that the odour emissions decrease rapidly with time. As such, not factoring in the decrease of odour emissions from all LRSF would be a gross overestimation of the potential odour levels at sensitive receptors. Accordingly, a more realistic approach was adopted and includes the following assumptions:

- the total volume of liquid residue to be evaporated is 2.5GL each year;
- liquid waste would only be odorous for 7 days after being introduced to the LRSF;
- liquid waste would be pumped to only one cell of the LRSF at a time. Odour emissions would be released from only one LRSF cell at a time;
- LRSF – Area 3 (**Figure 23**) would provide the worst case locations for odour impacts;
- the average depth of LRSFs for Year 15 is assumed to be 0.9 metres (2.5GL / 292 ha);
- a dilution factor was applied to odour emission rate for LRSF – Area 3; and
- 100% diffusion of the liquid was assumed through the LRSF- Area 3 cell.

The odour emissions from the two waste streams have been modelled as area sources with a vertical spread of 0.5 metres. It has been assumed that the temperature of the liquid waste would be close to ambient when it is released into the LRSF and SRSF. It is understood that the liquid waste would enter the cells at a temperature of approximately 50°C, however, CALPUFF model does not account for buoyant area or volume sources. It has been assumed that the odour character is the same for the LRSF and SRSF areas based on the hedonic tone described by the odour panel (see **Table 19**).

The areas of the respective sources are based on the site layout for Year 15, the worst case year in terms of potential for air quality impacts. The Odour Emission Rates (OERs) for the solid waste stream and diluted liquid waste stream are presented in **Table 20**.

**Table 20**  
**Odour model inputs**

Sample	Area (ha) <sup>a</sup>	Specific Odour Emission Rate (SOER; OU.m <sup>3</sup> /m <sup>2</sup> /s)	Diluted (OU.m <sup>3</sup> /m <sup>2</sup> /s)	Total odour emission (OU.m <sup>3</sup> /s)
LRSF3	75.6	0.15	0.01	5,095
SRSF	34.0	0.08	0.08	27,189



It is acknowledged that there is potential for some odour emissions to be released from the ammonia scrubber vent at the processing plant. Given the low concentrations of ammonia anticipated to be realised, in conjunction with appropriate mitigation (through use of ammonia scrubbing), the ammonia emissions from the vent are considered to be negligible and have not been addressed further.

## 9.5 RADON

The potential radon emissions that would be released during the operations of the Proposal have been assessed for Year 15. It was established that Year 15 would result in the worst case radon emission based on the anticipated area of the LRSF that would be in use.

The radon emission rates have been determined as part of the radiation assessment (JRHC Enterprises, 2013). All radon emissions have been modelled as area sources, with the exception of emissions that would potentially be released from the processing plant. It has been assumed that all radon emissions from the processing plant would be released from the Ore Mill Exhaust Vent (point source emission).

The adopted radon emissions rates and source characteristics are presented in **Table 21**.

**Table 21**  
**Radon emission rates for the Proposal**

Source term	Radon emission factor	Unit	Area (ha)	Total Radon emission (Bq/s)
Open Cut	0.6	Bq/m <sup>2</sup> /s	396,000	237,600
ROM Stockpiles	3.00	Bq/m <sup>2</sup> /s	21,000	6,300
Waste rock	0.26	Bq/m <sup>2</sup> /s	169,000	43,940
SRSF	1.13	Bq/m <sup>2</sup> /s	471,000	532,230
LRSF – Area 2	0.0002	Bq/m <sup>2</sup> /s	267,679	54
LRSF – Area 3	0.0002	Bq/m <sup>2</sup> /s	755,934	151
LRSF – Area 4	0.0002	Bq/m <sup>2</sup> /s	851,507	170
LRSF – Area 5	0.0002	Bq/m <sup>2</sup> /s	1,046,225	209
Processing plant	50	Bq/s	n/a	50

<sup>a</sup> Radon emissions from the Ore Mill Exhaust Vent has been modelled as a point source. Source characteristics are provided in **Table 22**.

## 9.6 OTHER AIR QUALITY PARAMETERS

### 9.6.1 Emissions Sources

Other air quality parameters anticipated to be released during the operation of the Proposal include SO<sub>2</sub>, NO<sub>2</sub>, HCl, PM<sub>10</sub> and PM<sub>2.5</sub> and limited concentrations of SO<sub>3</sub>. For the purposes of this assessment, SO<sub>2</sub>, NO<sub>2</sub>, HCl, PM<sub>10</sub> and PM<sub>2.5</sub> are considered the principal air quality parameters of concern and have been included in the dispersion modelling. All of the respective modelled air quality parameters would be released from various stacks and vents at the processing plant.

The source characteristics and stack locations are provided in **Table 22**. The corresponding air quality parameter emission rates are provided in **Table 23**.

**Table 22**  
**Processing Plant source characteristics**

Source	Exit temperature (K)	Stack height (m)	Stack diameter (m)	Exit velocity (m/s)	Easting (m)	Northing (m)
Fe Precipitation vent 1	323	20	0.6	2.5	649839	6408330
Fe Precipitation vent 2	323	20	0.6	2.5	649857	6408324
Sulphuric Acid Plant stack	353	80	2.1	6.4	649647	6408471
Roaster heater exhaust vent - Roaster 1	548	30	1.0	3.5	649770	6408221
Roaster heater exhaust vent - Roaster 2	548	30	1.0	3.5	649790	6408214
Gas Boiler stack	423	30	1.2	12.3	649808	6408210
Roaster Scrubber Stack	323	30	0.6	9.8	649763	6408205
Ore Mill exhaust vent	383	20	1.2	12.3	649788	6408201
Ore Preheater exhaust vents Roaster 1	473	20	1.0	8.8	649808	6408194
Ore Preheater exhaust vents Roaster 2	473	20	1.0	8.8	649763	6408183
Ammonia scrubber vent	303	20	0.3	3.9	649647	6408400
Zr Dryer vent	383	20	1.0	7.1	649743	6408306
Nb Dryer vent	383	20	0.6	9.8	649759	6408330
Ferro-niobium Process stack	323	30	0.6	9.8	649865	6408353

The emission rates provided in **Table 23** comply with the in-stack concentration limits prescribed under the Protection of the Environment Operations (Clean Air) Regulation (2010) described in Section 5.3.

**Table 23**  
**Processing Plant air quality parameter emission rate (g/s)**

Source	SO <sub>2</sub>	NO <sub>2</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	HCl
Fe Precipitation vent 1	-	-	-	-	-
Fe Precipitation vent 2	-	-	-	-	-
Sulphuric Acid Plant stack	17.78	0.67	-	-	-
Roaster heater exhaust vent - Roaster 1	-	0.97	-	-	-
Roaster heater exhaust vent - Roaster 2	-	0.97	-	-	-
Gas Boiler stack	-	4.86	-	-	-
Roaster Scrubber Stack	0.39	-	-	-	-
Ore Mill exhaust vent	-	0.42	0.28	0.28	-
Ore Preheater exhaust vents Roaster 1	-	2.43	0.14	0.14	-
Ore Preheater exhaust vents Roaster 2	-	2.43	0.14	0.14	-
Ammonia scrubber vent	-	-	-	-	-
Zr Dryer vent	-	-	0.28	0.28	-
Nb Dryer vent	-	-	0.14	0.14	-
Ferro-niobium Process stack	0.14	0.14	0.14	0.14	0.28

The particle size distribution of the particulate matter released from the stacks at the processing plant is not known at the time of the assessment. For conservatism it has been assumed that the particulate matter released from the stack would comprise both PM<sub>10</sub> and PM<sub>2.5</sub> at the whole emission rate for the respective air quality model runs.

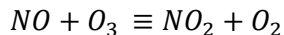
### **9.6.2 Determination of nitrogen dioxide concentrations**

Oxides of nitrogen (NO<sub>x</sub>) from combustion sources are emitted as both nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). NO<sub>x</sub> is typically emitted from combustion sources as greater than 90% NO (**MoE, 2004**), with atmospheric transformation to NO<sub>2</sub> taking place over a number of hours, rather than instantaneously.

The EPA documents a number of methods that can be applied to account for atmospheric transformation of NO to NO<sub>2</sub> within Section 8 of the Approved Methods. The US-EPA's Ozone Limiting Method (OLM) was applied in this assessment and is further detailed in Section 4.4.3.

The OLM assumes that all available O<sub>3</sub> in the atmosphere will react with NO in the plume until either all O<sub>3</sub> or all NO is used up. This approach is conservative, particularly in the case of the current near-field assessment, as the transformation is assumed to occur instantly, whereas in reality, transformation will occur over a period of hours.

Typically, at the point of emission (i.e. trucks and locomotives), NO<sub>x</sub> would consist of approximately 90-95% of NO and 5-10% of NO<sub>2</sub>. The dominant short term conversion is NO to NO<sub>2</sub> through oxidation with atmospheric ozone (O<sub>3</sub>) as the plume travels from source.



Therefore, to predict the ground level concentration of NO<sub>2</sub> it is important to account for the transformation of NO<sub>x</sub> to NO<sub>2</sub>.

The transformation of NO<sub>x</sub> to NO<sub>2</sub> in this report is derived using the US EPA's Ozone Limiting Method (OLM) which assumes that all the available ozone in the atmosphere will react with the NO in the plume until either all the O<sub>3</sub> or all the NO is used up.

Using the OLM, NO<sub>2</sub> concentrations are derived as follows:

$$[NO_2]_{total} = \{0.1 \times [NO_x]_{predicted}\} + MIN\{(0.9) \times [NO_x]_{predicted} \text{ or } (46/48) \times [O_3]_{background}\} + [NO_2]_{background}$$

The OLM is generally considered a conservative approach and is therefore appropriate for this assessment (Tikvart, 1996).

## **10. IMPACT ASSESSMENT**

### **10.1 INTRODUCTION**

Modelling results are presented for the following air quality parameters and averaging periods.

- TSP - annual average.
- Deposited dust - annual average.
- PM<sub>10</sub> - 24 hour and annual average.
- PM<sub>2.5</sub> - 24 hour and annual average.
- SO<sub>2</sub> - 10 minute, 1 hour, 24 hour and annual average.
- NO<sub>2</sub> - 1 hour and annual average.
- HCl – 1 hour average.
- Radon - annual average.
- Odour - 99<sup>th</sup> percentile and 1-second average.

Dust impacts have been assessed for both Year 5 and Year 15. Impacts for Odour, Radon, SO<sub>2</sub>, NO<sub>2</sub> and HCl have been presented for Year 15 only as it is considered the worst case year in terms of potential for air quality impact.

Contour figures of air quality parameter concentrations and particulate matter deposition levels show where different concentrations of the various air quality parameters are predicted to occur spatially. It is important to note that the contour figures are presented to provide a visual representation of the predicted impacts. To produce the contours it is necessary to make interpolations, and as a result the contours will not always match exactly with predicted impacts at any specific location.

The actual predicted particulate concentrations/levels at nearby receptors are presented in tabular form, with those that are predicted to experience levels above the EPA's impact assessment criteria or NEPM advisory reporting goals bolded.

### **10.2 PARTICULATE MATTER**

#### **10.2.1 Introduction**

The following sections examine predicted annual average TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition impacts, and maximum 24-hour average PM<sub>10</sub> and PM<sub>2.5</sub> impacts. A separate cumulative assessment of 24-hour average PM<sub>10</sub> is provided in Section 10.2.3.

It is important to note that there are currently no impact assessment criteria for PM<sub>2.5</sub>. The predicted impacts have been compared with the NEPM advisory reporting standards for PM<sub>2.5</sub>.

The EPA impact assessment criteria and the NEPM advisory reporting standards for PM<sub>2.5</sub> are provided in Section 5.

## 10.2.2 Annual average TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition predictions

### 10.2.2.1 Operational Year 5

**Table 24** presents a summary of the Year 5 predicted annual average concentrations at each of the nearby receptors, due to the operation of the Proposal alone and cumulatively with other sources/background predictions.

**Figure 24** to **Figure 27** show the corresponding predicted annual average TSP, PM<sub>10</sub>, PM<sub>2.5</sub> concentrations and dust deposition levels in Year 5 due to the operation of the Proposal and cumulatively with other sources/background predictions.

**Table 24**  
**Predicted incremental and cumulative annual average results for TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition – Year 5**

Page 1 of 2

	Incremental prediction				Cumulative prediction			
Air quality parameter	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Dust deposition	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Dust deposition
Unit	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	g/m <sup>2</sup> /month	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	g/m <sup>2</sup> /month
<b>Assessment criterion</b>	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>	<b>2</b>	<b>90</b>	<b>30</b>	<b>8<sup>e</sup></b>	<b>4</b>
<b>Adopted background</b>	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>	<b>19</b>	<b>16</b>	<b>7</b>	<b>2</b>
1 <sup>a</sup>	2.6	1.1	0.5	0.15	21.6	17.1	7.5	2
2 <sup>a</sup>	4.7	1.4	0.5	0.26	23.7	17.4	7.5	2
3 <sup>a</sup>	0.5	0.2	0.1	0.05	19.5	16.2	7.1	2
4	0.2	0.1	0.0	0.01	19.2	16.1	7.0	2
6	0.3	0.1	0.1	0.01	19.3	16.1	7.1	2
7	0.3	0.2	0.1	0.01	19.3	16.2	7.1	2
8A	0.4	0.2	0.1	0.02	19.4	16.2	7.1	2
8B	0.2	0.1	0.1	0.01	19.2	16.1	7.1	2
10	1.7	0.8	0.4	0.07	20.7	16.8	7.4	2
18	0.2	0.1	0.1	0.01	19.2	16.1	7.1	2
19	0.7	0.4	0.3	0.06	19.7	16.4	7.3	2
20	1.0	0.6	0.5	0.08	20.0	16.6	7.5	2
21	0.3	0.3	0.3	0.01	19.3	16.3	7.3	2
22	1.1	0.6	0.4	0.04	20.1	16.6	7.4	2
23	1.0	0.6	0.4	0.04	20.0	16.6	7.4	2
24	0.9	0.6	0.4	0.03	19.9	16.6	7.4	2
25	0.9	0.6	0.4	0.03	19.9	16.6	7.4	2
26	0.4	0.4	0.3	0.01	19.4	16.4	7.3	2
27	0.1	0.1	0.1	0.00	19.1	16.1	7.1	2
28A	0.1	0.1	0.1	0.00	19.1	16.1	7.1	2
28B	0.1	0.1	0.1	0.00	19.1	16.1	7.1	2
30A	0.1	0.1	0.1	0.01	19.1	16.1	7.1	2
30B	0.1	0.1	0.1	0.00	19.1	16.1	7.1	2
31A	0.1	0.1	0.1	0.00	19.1	16.1	7.1	2
31B	0.1	0.1	0.1	0.00	19.1	16.1	7.1	2
32	0.1	0.1	0.1	0.00	19.1	16.1	7.1	2

**Table 24 (Cont'd)**  
**Predicted incremental and cumulative annual average results for TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition – Year 5**

Page 2 of 2

Air quality parameter	Incremental prediction				Cumulative prediction			
	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Dust deposition	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Dust deposition
Unit	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	g/m <sup>2</sup> /month	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	g/m <sup>2</sup> /month
35A	0.1	0.1	0.1	0.00	19.1	16.1	7.1	2
35B	0.1	0.1	0.1	0.00	19.1	16.1	7.1	2
38	0.1	0.1	0.1	0.00	19.1	16.1	7.1	2
36	0.1	0.1	0.1	0.01	19.1	16.1	7.1	2
40	0.1	0.1	0.1	0.01	19.1	16.1	7.1	2
42	0.1	0.1	0.0	0.00	19.1	16.1	7.0	2
43	0.1	0.1	0.0	0.01	19.1	16.1	7.0	2
46	0.2	0.1	0.0	0.01	19.2	16.1	7.0	2
48 <sup>a</sup>	0.5	0.2	0.1	0.02	19.5	16.2	7.1	2
49A <sup>a</sup>	0.4	0.2	0.1	0.03	19.4	16.2	7.1	2
49B <sup>a</sup>	0.4	0.1	0.1	0.02	19.4	16.1	7.1	2
51 <sup>b</sup>	1.5	0.7	0.4	0.07	20.5	16.7	7.4	2
54 <sup>a</sup>	2.4	1.2	0.6	0.09	21.4	17.2	7.6	2
55 <sup>c</sup>	2.1	1.1	0.6	0.08	21.1	17.1	7.6	2
56 <sup>a</sup>	2.9	1.4	0.7	0.11	21.9	17.4	7.7	2
58 <sup>c</sup>	1.7	0.9	0.5	0.07	20.7	16.9	7.5	2
61	0.1	0.0	0.0	0.00	19.1	16.0	7.0	2
50 <sup>d</sup>	0.9	0.3	0.2	0.05	19.9	16.3	7.2	2

<sup>a</sup> Applicant owned residence; <sup>b</sup> Agreed contract (call option); <sup>c</sup> Agreed contract (put option); <sup>d</sup> Potential future residence, <sup>e</sup> This is not an assessment criterion but rather an advisory reporting standard set by the NEPM.

Modelling results for Year 5 show no exceedances of the annual average TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition EPA criteria and NEPM advisory reporting standards, either for the Proposal alone (incremental prediction) or when considering the adopted background (cumulative prediction).

The incremental contributions of the proposed operations to the local air quality are relatively low compared to the contribution of background sources.

Review of the contour plots for TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition indicate that those areas predicted to experience the greatest particulate levels are the receptors located to the west of the DZP Site, at the Village of Toongi.

Incremental and cumulative particulate concentrations and deposition levels during the operation of the Proposal are thus not anticipated to result in adverse impacts at any of the receptors investigated in this assessment on an annual basis.

#### 10.2.2.2 Operational Year 15

**Table 25** presents a summary of the Year 15 predicted annual average TSP, PM<sub>10</sub>, PM<sub>2.5</sub> concentrations and deposition at each of the nearby receptors, due to the operations of the Proposal alone and cumulatively with other sources/background predictions.

**Figure 30 to Figure 31** show the corresponding predicted annual average TSP, PM<sub>10</sub>, PM<sub>2.5</sub> concentrations and dust deposition levels in Year 15 due to the operations of the Proposal and cumulatively with other sources/background predictions.

**Table 25**  
**Predicted incremental and cumulative annual average results for TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition – Year 15**

Page 1 of 2

	Incremental prediction				Cumulative prediction			
Air quality parameter	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Dust deposition	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Dust deposition
Unit	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	g/m <sup>2</sup> /month	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	g/m <sup>2</sup> /month
<b>Assessment criterion</b>	<b>n/a</b>	<b>n/a</b>	<b>n/a</b>	<b>2</b>	<b>90</b>	<b>30</b>	<b>8<sup>e</sup></b>	<b>4</b>
<b>Adopted background</b>	<b>n/a</b>	<b>n/a</b>	<b>n/a</b>	<b>n/a</b>	<b>19</b>	<b>16</b>	<b>7</b>	<b>2</b>
1 <sup>a</sup>	8.4	2.2	0.7	0.5	27.4	18.2	7.7	2
2 <sup>a</sup>	11.3	2.9	0.8	0.6	30.3	18.9	7.8	3
3 <sup>a</sup>	1.8	0.6	0.3	0.2	20.8	16.6	7.3	2
4	0.6	0.2	0.1	0.0	19.6	16.2	7.1	2
6	0.6	0.2	0.1	0.0	19.6	16.2	7.1	2
7	0.8	0.3	0.1	0.0	19.8	16.3	7.1	2
8A	1.0	0.3	0.2	0.1	20.0	16.3	7.2	2
8B	0.4	0.1	0.1	0.0	19.4	16.1	7.1	2
10	4.9	1.4	0.5	0.2	23.9	17.4	7.5	2
18	0.6	0.2	0.1	0.0	19.6	16.2	7.1	2
19	2.7	0.9	0.4	0.2	21.7	16.9	7.4	2
20	3.9	1.3	0.7	0.3	22.9	17.3	7.7	2
21	0.8	0.4	0.3	0.0	19.8	16.4	7.3	2
22	3.2	1.0	0.5	0.1	22.2	17.0	7.5	2
23	2.9	1.0	0.4	0.1	21.9	17.0	7.4	2
24	2.6	0.9	0.5	0.1	21.6	16.9	7.5	2
25	2.6	0.9	0.5	0.1	21.6	16.9	7.5	2
26	1.2	0.6	0.4	0.0	20.2	16.6	7.4	2
27	0.4	0.2	0.1	0.0	19.4	16.2	7.1	2
28A	0.4	0.2	0.1	0.0	19.4	16.2	7.1	2
28B	0.3	0.2	0.1	0.0	19.3	16.2	7.1	2
30A	0.4	0.2	0.1	0.0	19.4	16.2	7.1	2
30B	0.3	0.2	0.1	0.0	19.3	16.2	7.1	2
31A	0.3	0.2	0.1	0.0	19.3	16.2	7.1	2
31B	0.3	0.1	0.1	0.0	19.3	16.1	7.1	2
32	0.3	0.2	0.1	0.0	19.3	16.2	7.1	2

**Table 25 (Cont'd)**  
**Predicted incremental and cumulative annual average results for TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition – Year 15**

Page 2 of 2

Air quality parameter	Incremental prediction				Cumulative prediction			
	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Dust deposition	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Dust deposition
Unit	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	g/m <sup>2</sup> /month	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	g/m <sup>2</sup> /month
35A	0.3	0.2	0.1	0.0	19.3	16.2	7.1	2
35B	0.3	0.1	0.1	0.0	19.3	16.1	7.1	2
38	0.3	0.1	0.1	0.0	19.3	16.1	7.1	2
36	0.4	0.2	0.1	0.0	19.4	16.2	7.1	2
40	0.4	0.2	0.1	0.0	19.4	16.2	7.1	2
42	0.3	0.1	0.1	0.0	19.3	16.1	7.1	2
43	0.4	0.1	0.1	0.0	19.4	16.1	7.1	2
46	0.5	0.2	0.1	0.0	19.5	16.2	7.1	2
48 <sup>a</sup>	1.2	0.4	0.2	0.1	20.2	16.4	7.2	2
49A <sup>a</sup>	1.3	0.4	0.2	0.1	20.3	16.4	7.2	2
49B <sup>a</sup>	1.1	0.4	0.2	0.1	20.1	16.4	7.2	2
51 <sup>b</sup>	4.8	1.5	0.6	0.3	23.8	17.5	7.6	2
54 <sup>a</sup>	8.1	2.4	0.9	0.3	27.1	18.4	7.9	2
55 <sup>c</sup>	7.2	2.2	0.8	0.3	26.2	18.2	7.8	2
56 <sup>a</sup>	9.9	2.9	1.0	0.4	28.9	18.9	8.0	2
58 <sup>c</sup>	5.9	1.8	0.7	0.3	24.9	17.8	7.7	2
61	0.2	0.1	0.0	0.0	19.2	16.1	7.0	2
50 <sup>d</sup>	2.2	0.7	0.3	0.1	21.2	16.7	7.3	2

<sup>a</sup> Applicant owned residence; <sup>b</sup> Agreed contract (call option); <sup>c</sup> Agreed contract (put option); <sup>d</sup> Potential future residence, <sup>e</sup> This is not an assessment criterion but rather an advisory reporting standard set by the NEPM.

Modelling results for Year 15 show no exceedances of the annual average TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition EPA criteria and NEPM advisory reporting standards, either for the Proposal alone (incremental prediction) or when considering the adopted background (cumulative prediction).

The incremental contributions of the Proposal's operations to the local air quality are relatively low compared to the contribution of background sources.

Review of the contour plots for TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition indicate that those areas predicted to experience the greatest particulate levels are the receptors located to the west of the DZP Site, at the Village of Toongi.

Incremental and cumulative particulate concentrations and deposition levels during the operation of the Proposal are thus not anticipated to result in adverse impacts at any of the receptors investigated in this assessment on an annual basis.

### 10.2.3 Incremental 24-hour average PM<sub>10</sub> and PM<sub>2.5</sub> concentrations

**Table 26** presents the predicted maximum 24-hour PM<sub>10</sub> and PM<sub>2.5</sub> concentrations due to the Proposal alone at the receptors investigated in this assessment. **Figure 32** through **Figure 35** show the corresponding contour plots. The 24-hour PM<sub>10</sub> and PM<sub>2.5</sub> contours do not represent



a single worst case day, but rather represent the potential worst case 24-hour average concentration that could be reached at any particular location across the entire modelling year.

**Table 26**  
**Predicted incremental maximum 24 hour average results for PM<sub>2.5</sub> and PM<sub>10</sub> concentrations for Year 5 and Year 15**

Page 1 of 2

	Year 5		Year 15	
Air quality parameter	PM <sub>10</sub>	PM <sub>2.5</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>
Assessment criteria	50	25 <sup>e</sup>	50	25 <sup>e</sup>
1 <sup>a</sup>	13	5	33	8
2 <sup>a</sup>	17	7	34	10
3 <sup>a</sup>	3	3	18	5
4	2	2	6	2
6	2	2	4	2
7	3	3	4	3
8A	3	3	5	3
8B	1	2	2	2
10	11	4	20	5
18	1	2	3	2
19	3	2	8	4
20	5	4	10	5
21	4	4	5	4
22	18	3	34	6
23	11	5	18	6
24	10	5	17	6
25	7	6	12	6
26	6	6	9	6
27	3	3	3	3
28A	3	3	3	3
28B	3	3	3	3
30A	2	2	4	2
30B	2	1	2	1
31A	3	3	4	3
31B	3	2	4	2
32	2	2	3	2
35A	2	2	3	2
35B	2	1	2	2
38	1	1	2	1
36	2	2	3	2
40	1	1	3	2
42	1	1	2	1
43	1	1	2	1
46	1	1	2	1
48 <sup>a</sup>	3	2	4	2

**Table 26 (Cont'd)**  
**Predicted incremental maximum 24 hour average results for PM<sub>2.5</sub> and PM<sub>10</sub> concentrations for Year 5 and Year 15**

Page 2 of 2

	Year 5		Year 15	
Air quality parameter	PM <sub>10</sub>	PM <sub>2.5</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>
Assessment criteria	50	25 <sup>e</sup>	50	25 <sup>e</sup>
49A <sup>a</sup>	3	2	4	3
49B <sup>a</sup>	2	2	3	2
51 <sup>b</sup>	7	4	17	6
54 <sup>a</sup>	14	10	25	10
55 <sup>c</sup>	8	4	18	6
56 <sup>a</sup>	15	11	31	11
58 <sup>c</sup>	11	5	23	8
61	2	1	4	2
50 <sup>d</sup>	4	3	8	4

<sup>a</sup> Applicant owned residence; <sup>b</sup> Agreed contract (call option); <sup>c</sup> Agreed contract (put option); <sup>d</sup> Potential future residence, <sup>e</sup> This is not an assessment criterion but rather an advisory reporting standard set by the NEPM.

The predicted PM<sub>10</sub> and PM<sub>2.5</sub> concentrations during Year 5 and Year 15 indicate that there would not be any exceedances of the EPA criteria (50µg/m<sup>3</sup> for PM<sub>10</sub>) or NEPM advisory report standard (25µg/m<sup>3</sup> for PM<sub>2.5</sub>) due to the Proposal alone.

In general, the incremental PM<sub>10</sub> and PM<sub>2.5</sub> concentrations are predicted to be higher in Year 15 than in Year 5. Receptor 22 is predicted to experience the highest PM<sub>10</sub> concentrations for both years, predicted to experience up to 34µg/m<sup>3</sup> expressed as a 24 hour average in Year 15. For PM<sub>2.5</sub>, the receptor that is predicted to experience the highest PM<sub>2.5</sub> concentrations is Receptor 56 with 11µg/m<sup>3</sup> during both Year 5 and Year 15.

The contour plots indicate that those areas predicted to experience the greatest maximum 24 hour average PM<sub>10</sub> and PM<sub>2.5</sub> concentrations are the receptors located to the west of the DZP Site, at the Village of Toongi.

Incremental PM<sub>10</sub> and PM<sub>2.5</sub> concentrations during the operation of the Proposal are thus not anticipated to result in adverse impacts at any of the receptors investigated in this assessment on a 24-hour basis.

#### 10.2.4 Cumulative 24-hour average PM<sub>10</sub> concentrations

It is not straightforward to accurately predict the cumulative 24-hour PM<sub>10</sub> concentrations using dispersion modelling due to the difficulties in resolving (on a day to day basis) the varying intensity, duration and precise locations of activities for mining developments, the weather conditions at the time of an activity, or combination of activities.

The difficulties in predicting cumulative 24-hour impacts are compounded by the day to day variability in ambient particulate levels and the spatial and temporal variation in any other anthropogenic activity e.g. agricultural activity, bushfires etc., including mining in the future. Experience shows that the worst-case 24-hour PM<sub>10</sub> concentrations are often strongly influenced by other sources such as bushfires and dust storms, which are both unpredictable and beyond the control of any given project.

Cumulative air quality impacts have been evaluated using a statistical approach known as a Monte Carlo Simulation. This approach has been provided to achieve the objectives of a Level 2 Assessment (see Section 11.2 of [EPA, 2005]). The cumulative assessment focuses on the receptors predicted to be most affected by particulate according to the modelling.

Six private receptors were selected for cumulative analysis based on their proximity to the proposed operations, spatial variability and also the magnitude of their Proposal-only predictions. The location of these receptors is shown in **Figure 37**.

The Monte Carlo Simulation is an approach that combines the frequency distribution of one data set (in this case the measured background 24-hour PM<sub>10</sub> concentrations) with the frequency distribution of another data set (modelled impacts at a given point). This is achieved by repeatedly randomly sampling and combining values within the two data sets to create a third, 'cumulative' data set and associated frequency distribution.

As discussed in Section 7.4, there are no site specific PM<sub>10</sub> monitoring data available for this assessment. The monitoring data sets adopted are from the EPA monitoring stations at Bathurst and Tamworth. To account for year to year variation in PM<sub>10</sub> concentrations, data collected between January 2008 and February 2013 was adopted.

Individual 24-hour predictions for the Proposal were then added to a random value from the above data set. This process is repeated many thousands of times yielding the 'cumulative' data set, which is then presented as a frequency distribution. Project-only predictions for six selected receptors for Year 15 have been assessed as it provides the worst case predicted PM<sub>10</sub> concentration contributions from the Proposal.

The process assumes that a randomly selected background value would have a chance equal to that of any other background value from the data set of occurring on the given 'model day'. Over sufficient repetitions, this yields a good statistical estimate of the combined and independent effects of varying background and Proposal contributions to total PM<sub>10</sub>.

To generate greater confidence in the robustness of the results, the Monte Carlo Simulation was repeated 250,000 times for each of the six receptors. In other words, the same 1-year set of predicted (modelled) 24-hour PM<sub>10</sub> concentrations due to the Proposal were added to 250,000 variations of the randomly selected background concentrations (i.e. a different random background concentration is selected each time).

The results of this analysis are presented graphically in **Figure 36**. The plots show the statistical probability of 24-hour PM<sub>10</sub> concentrations being above the EPA 24-hour PM<sub>10</sub> criterion of 50µg/m<sup>3</sup> and also compares the cumulative probability with the measured background.

**Figure 36** shows that Receptor 10 is predicted to be the most affected by Proposal-only operations as it is furthest from the background (dotted line) as shown on the graph. The graph indicates that all receptors are predicted to experience cumulative PM<sub>10</sub> 24-hour impacts over the criterion on 2 days in the modelled year 2015. However, given that the background contains two exceedances of the EPA 24-hour criterion, the Proposal is not anticipated to contribute to any *additional* exceedances, and thus are anticipated to satisfy the EPA criterion.

Finally, it is noted that the line representing the background data set does not deviate from the lines representing cumulative impact to any great degree. The inference is therefore that the Proposal-related increment does not contribute significantly to the overall cumulative impact.

### 10.3 SULPHUR DIOXIDE

The dispersion modelling results for the predicted incremental and cumulative impacts for SO<sub>2</sub> for Year 15 are presented in **Table 27** for the maximum 10 minute average, maximum 1 hour average, maximum 24 hour average and annual average averaging periods, respectively.

Contour plots for the maximum 1 hour cumulative SO<sub>2</sub> impacts for year 15 are shown in **Figure 38** through **Figure 41**.

Receptor 10 (Toongi Hall) is predicted to be the most impacted private receptor for all of the SO<sub>2</sub> averaging periods for both the incremental and cumulative results. Receptor 10 is located immediately to the west of the DZP Site.

Exceedances of the 10 minute and 1 hour SO<sub>2</sub> criteria are predicted at Receptor 1. This is a Applicant-owned property and not a private receptor. Given the Applicant-owned status, it is anticipated that any occupants of this receptor will be made fully aware of the potential for elevated SO<sub>2</sub>. Further, it is recommended that if this residence is occupied, that ambient monitoring be conducted to establish if model predictions will occur in reality.

The contour plots of the modelled results indicate that for the shorter term averaging periods (i.e. 10 minute, 1 hour and 24 hour) the most impacted areas are located closest to the processing plant. There are some areas close to the processing plant and outside of the Project boundary that are predicted to exceed the 10 minute EPA averaging period but will not impact at any privately owned receptors. For the annual averaging period, the areas predicted to experience the greatest SO<sub>2</sub> concentrations are predicted to be to the west of the DZP Site boundary.

### 10.4 NITROGEN DIOXIDE

The dispersion modelling results for NO<sub>2</sub> are presented in **Table 28** for the maximum 1 hour average and annual average averaging periods. As discussed in Section 9.6.1, the OLM method has been applied for the prediction of NO<sub>2</sub> concentrations surrounding the DZP Site taking the maximum daily NO<sub>2</sub> and O<sub>3</sub> monitoring data combined with the maximum daily NO<sub>x</sub> prediction for each receptor. This approach provides an added level of conservatism estimate in determining the NO<sub>x</sub> to NO<sub>2</sub> conversion.

Receptor 25 is predicted to be the most impacted private receptor for the maximum 1 hour average NO<sub>2</sub>, predicted to experience up to 200µg/m<sup>3</sup>, which is below the EPA criterion of 246µg/m<sup>3</sup>. Receptor 22 is predicted to experience the highest annual average NO<sub>2</sub> concentration with results indicating an annual average concentration of 48µg/m<sup>3</sup>, which is also below the EPA criteria of 62µg/m<sup>3</sup>.

There are no assessed receptors that are predicted to experience NO<sub>2</sub> concentration above the maximum 1 hour or annual average EPA criteria.

Predicted NO<sub>2</sub> concentrations during the operation of the Proposal are thus not anticipated to result in adverse impacts at any of the receptors investigated in this assessment.

**Table 27**  
**Predicted incremental and cumulative results for SO<sub>2</sub>**

Receptor ID	Incremental prediction				Cumulative prediction			
Averaging period	10 minute	1 hour	24 hour	Annual	10 minute	1 hour	24 hour	Annual
<b>EPA Criterion</b>	<b>712</b>	<b>570</b>	<b>220</b>	<b>60</b>	<b>712</b>	<b>570</b>	<b>220</b>	<b>60</b>
<b>Adopted background</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>34</b>	<b>27</b>	<b>11</b>	<b>3</b>
1 <sup>a</sup>	971	679	29	1	1,005	706	40	3.9
2 <sup>a</sup>	274	192	11	1	308	219	22	3.9
3 <sup>a</sup>	141	98	9	0	175	125	20	3.3
4	100	70	7	0	134	97	18	3.2
6	67	46	6	0	101	73	17	3.2
7	58	41	5	0	92	68	16	3.2
8A	56	39	6	0	90	66	17	3.3
8B	37	26	4	0	71	53	15	3.2
10	610	426	18	1	644	453	29	3.7
18	59	41	5	0	93	68	16	3.3
19	57	40	7	1	91	67	18	3.7
20	110	77	11	1	144	104	22	4.0
21	56	39	12	1	90	66	23	3.7
22	124	87	9	1	158	114	20	3.8
23	182	127	8	1	216	154	19	3.8
24	285	199	9	1	319	226	20	3.8
25	255	178	13	1	289	205	24	3.7
26	316	221	16	1	350	248	27	3.5
27	70	49	5	0	104	76	16	3.2
28A	56	39	5	0	90	66	16	3.2
28B	64	45	5	0	98	72	16	3.2
30A	75	53	4	0	109	80	15	3.2
30B	59	41	3	0	93	68	14	3.2
31A	40	28	4	0	74	55	15	3.2
31B	62	43	4	0	96	70	15	3.2
32	66	46	4	0	100	73	15	3.2
35A	132	92	5	0	166	119	16	3.3
35B	94	66	6	0	128	93	17	3.3
38	58	41	3	0	92	68	14	3.2
36	79	55	3	0	113	82	14	3.3
40	72	50	5	0	106	77	16	3.3
42	34	24	4	0	68	51	15	3.2
43	80	56	3	0	114	83	14	3.2
46	33	23	4	0	67	50	15	3.2
48 <sup>a</sup>	91	63	7	0	125	90	18	3.3
49A <sup>a</sup>	53	37	6	0	87	64	17	3.3
49B <sup>a</sup>	45	32	6	0	79	59	17	3.3
51 <sup>b</sup>	214	149	8	1	248	176	19	3.9
54 <sup>a</sup>	261	182	12	1	295	209	23	4.0
55 <sup>c</sup>	249	174	10	1	283	201	21	4.1
56 <sup>a</sup>	303	212	11	1	337	239	22	4.1
58 <sup>c</sup>	582	407	18	1	616	434	29	4.1
61	27	19	2	0	61	46	13	3.1
50 <sup>d</sup>	83	58	8	1	117	85	19	3.5

<sup>a</sup> Applicant owned residence; <sup>b</sup> Agreed contract (call option); <sup>c</sup> Agreed contract (put option); <sup>d</sup> Potential future residence.

**Table 28**  
**Predicted incremental results for NO<sub>2</sub>**

Page 1 of 2

Receptor ID	Project and background	
Averaging period	1 hour	Annual
<b>EPA Criterion</b>	<b>246</b>	<b>62</b>
1 <sup>a</sup>	208	50
2 <sup>a</sup>	179	47
3 <sup>a</sup>	107	33
4	96	32
6	139	34
7	151	35
8A	190	37
8B	146	34
10	162	48
18	179	36
19	173	46
20	188	48
21	164	45
22	200	48
23	148	46
24	205	47
25	200	48
26	161	46
27	132	37
28A	153	37
28B	138	37
30A	123	37
30B	114	36
31A	110	36
31B	111	35
32	129	36
35A	97	36
35B	92	36
38	102	34
36	103	35
40	111	34
42	91	33
43	110	32
46	111	32
48 <sup>a</sup>	123	35
49A <sup>a</sup>	152	34
49B <sup>a</sup>	149	34
51 <sup>b</sup>	157	49

**Table 28 (Cont'd)**  
**Predicted incremental results for NO<sub>2</sub>**

Page 2 of 2

Receptor ID	Project and background	
Averaging period	1 hour	Annual
EPA Criterion	246	62
54 <sup>a</sup>	201	55
55 <sup>c</sup>	197	55
56 <sup>a</sup>	198	57
58 <sup>c</sup>	218	51
61	100	31
50 <sup>d</sup>	141	40

<sup>a</sup> Applicant owned residence; <sup>b</sup> Agreed contract (call option); <sup>c</sup> Agreed contract (put option); <sup>d</sup> Potential future residence.

## 10.5 HYDROGEN CHLORIDE

The dispersion modelling results for the predicted incremental impacts for HCl in Year 15 are presented in **Table 29** for the maximum 1 hour averaging period. No background HCl monitoring data was available for this assessment. In consideration of the remote location of the Proposal it is anticipated that cumulative contributions from other sources would not be of significance.

Contour plots for the maximum 1 hour HCl predictions in year 15 are shown in **Figure 42**.

Receptor 25 is predicted to be the most impacted private receptor for the maximum 1 hour average HCl concentrations predictions. Receptor 25 is located just to the west of the DZP Site boundary. Receptor 55, which holds a contractual arrangement for purchase with the Applicant, is predicted to experience the highest HCl concentrations.

The contour plots of the modelled results indicate that the most impacted area is located closest to the processing plant.

The predicted HCl concentrations during the operation of the Proposal would not result in an exceedance of the EPA criterion of 0.14mg/m<sup>3</sup> (140µg/m<sup>3</sup>) at any of the receptors investigated in this assessment.

**Table 29**  
**Predicted incremental concentrations of HCl**

Receptor ID	1 hour maximum HCl prediction ( $\mu\text{g}/\text{m}^3$ )	Receptor ID	1 hour maximum HCL prediction ( $\mu\text{g}/\text{m}^3$ )
<b>EPA Criterion</b>	<b>140</b>	<b>EPA Criterion</b>	<b>140</b>
1 <sup>a</sup>	15	30B	3
2 <sup>a</sup>	16	31A	3
3 <sup>a</sup>	4	31B	3
4	3	32	5
6	7	35A	2
7	8	35B	2
8A	5	38	2
8B	4	36	2
10	5	40	2
18	15	42	2
19	9	43	1
20	7	46	2
21	4	48 <sup>a</sup>	4
22	10	49A <sup>a</sup>	6
23	11	49B <sup>a</sup>	6
24	15	51 <sup>b</sup>	15
25	16	54 <sup>a</sup>	31
26	10	55 <sup>c</sup>	35
27	5	56 <sup>a</sup>	28
28A	5	58 <sup>c</sup>	14
28B	4	61	3
30A	3	50 <sup>d</sup>	12

<sup>a</sup> Applicant owned residence; <sup>b</sup> Agreed contract (call option); <sup>c</sup> Agreed contract (put option); <sup>d</sup> Potential future residence.

## 10.6 RADON IMPACT ASSESSMENT

The dispersion modelling results for the predicted annual average radon concentrations in Year 15 for the Proposal are presented in **Table 30** for the receptors investigated in this assessment. There is currently no EPA criterion for radon, with the results being interpreted within the stand-alone radiation assessment (JRHC Enterprises, 2013). The cumulative impacts of radon were not considered for this assessment and are further discussed in the radiation assessment (JRHC Enterprises, 2013).

Contour plots showing the annual average predictions for year 15 are shown in **Figure 43**.



**Table 30**  
**Predicted incremental and cumulative results for Radon**

Receptor ID	Annual average Radon prediction (Bq/m <sup>3</sup> )	Receptor ID	Annual average Radon prediction (Bq/m <sup>3</sup> )
1 <sup>a</sup>	0.11	30B	0.02
2 <sup>a</sup>	0.31	31A	0.02
3 <sup>a</sup>	0.04	31B	0.02
4	0.02	32	0.02
6	0.03	35A	0.02
7	0.03	35B	0.02
8A	0.03	38	0.02
8B	0.02	36	0.03
10	0.08	40	0.02
18	0.09	42	0.02
19	0.09	43	0.02
20	0.03	46	0.02
21	0.01	48 <sup>a</sup>	0.05
22	0.07	49A <sup>a</sup>	0.06
23	0.08	49B <sup>a</sup>	0.05
24	0.08	51 <sup>b</sup>	0.16
25	0.09	54 <sup>a</sup>	0.20
26	0.07	55 <sup>c</sup>	0.20
27	0.03	56 <sup>a</sup>	0.22
28A	0.03	58 <sup>c</sup>	0.19
28B	0.02	61	0.01
30A	0.03	50 <sup>d</sup>	0.19

<sup>a</sup> Applicant owned residence; <sup>b</sup> Agreed contract (call option); <sup>c</sup> Agreed contract (put option); <sup>d</sup> Potential future residence.

The highest annual average Radon concentrations for private receptors are predicted to occur at Receptor 18, Receptor 19 and Receptor 25, predicting a Radon concentration of 0.09Bq/m<sup>3</sup>. The Proposal related receptors located closer to or within the DZP Project Site are predicted to experience higher radon concentrations.

The contour plots of the modelled results indicate that higher radon concentrations are predicted to the west and south of the DZP Site.

## 10.7 ODOUR IMPACT ASSESSMENT

The dispersion modelling results for the 1 second (nose response) average 99<sup>th</sup> percentile odour predictions for Year 15 of the Proposal are presented in **Table 31**. The cumulative impacts of odour were not considered for this assessment and are further discussed in Section 9.2.3.

Contour plots for the 1 second 99<sup>th</sup> percentile predictions for year 15 are shown in **Figure 44**.

**Table 31**  
**Predicted incremental and cumulative results for odour**

Receptor ID	99 <sup>th</sup> percentile prediction odour concentration (OU)	Receptor ID	99 <sup>th</sup> percentile prediction odour concentration (OU)
<i>Adopted peak to mean</i>	<b>2.3</b>	<i>Adopted peak to mean</i>	<b>2.3</b>
<i>NSW EPA criterion</i>	<b>6</b>	<i>NSW EPA criterion</i>	<b>6</b>
1 <sup>a</sup>	0.4	30B	0.2
2 <sup>a</sup>	0.9	31A	0.2
3 <sup>a</sup>	0.3	31B	0.2
4	0.1	32	0.2
6	0.2	35A	0.2
7	0.2	35B	0.2
8A	0.2	38	0.1
8B	0.1	36	0.2
10	0.4	40	0.2
18	0.4	42	0.1
19	0.4	43	0.1
20	0.2	46	0.1
21	0.1	48 <sup>a</sup>	0.3
22	0.4	49A <sup>a</sup>	0.5
23	0.4	49B <sup>a</sup>	0.4
24	0.5	51 <sup>b</sup>	1.0
25	0.5	54 <sup>a</sup>	0.6
26	0.4	55 <sup>c</sup>	0.7
27	0.2	56 <sup>a</sup>	0.6
28A	0.2	58 <sup>c</sup>	0.8
28B	0.2	61	0.1
30A	0.2	50 <sup>d</sup>	1.2

<sup>a</sup> Applicant owned residence; <sup>b</sup> Agreed contract (call option); <sup>c</sup> Agreed contract (put option); <sup>d</sup> Potential future residence.

The highest 1-second 99<sup>th</sup> percentile odour concentration is at a private receptor is predicted to be 0.5ou at Receptors 24 and 25. This is well below the adopted odour criterion of 6ou and also below the most stringent EPA odour criterion of 2ou, typically applied to urban areas, schools and hospitals.

All Proposal related receptors are also predicted to experience odour levels well below the odour criterion. The most impacted receptors would be Receptor 51, both predicted to experience odour levels of up to 1.0ou.

The contour plots of the modelled results indicate that higher odour concentrations are predicted to the west and south of the DZP Site. The contour plots also show that the SRSF is the most significant source of odour emissions.

The 1 second 99<sup>th</sup> percentile predicted odour concentrations during the operation of the Proposal are thus not anticipated to result in adverse impacts at any of the receptors investigated in this assessment.

## **11. MITIGATION**

### **11.1 INTRODUCTION**

There are no adverse air quality impacts predicted at any of the receptors investigated in this assessment. Nevertheless, mitigation strategies have been included in the modelling of fugitive dust emissions and emissions from the processing plant with further detail provided in **Appendix 3**. The adopted mitigation strategies are included below, along with recommendations to the ongoing management of air quality parameters anticipated to be released on site.

### **11.2 FUGITIVE DUST**

#### **11.2.1 Construction Dust Controls**

It is important to consider the potential emissions that would occur during construction. While dust emissions from construction activities can have impacts on local air quality, impacts are typically of a short duration and relatively easy to manage through commonly applied dust control measures.

During unfavourable meteorological conditions, such as when it is dry and windy, dust emissions may be higher requiring specific corrective measures. A *Construction Dust Management Plan* (CDMP) would be prepared prior to construction and would identify triggers and procedures for dealing with these conditions.

Procedures for controlling dust impacts during construction will include, but not necessarily be limited to the following.

- Watering haul roads – 75% control.
- Application of gravel to disturbed areas where possible.
- Rehabilitation / cover crops where possible and on exposed areas.
- Modifying working practices by limiting excavation during periods of high winds.
- Limiting the extent of clearing of vegetation and topsoil to the designated footprint required for construction and appropriate staging of any clearing.
- Confining all vehicles on-site to designated routes with speed limits enforced.
- Controlling and reducing trips and trip distances where possible, for example by coordinating delivery and removal of materials to avoid unnecessary trips.

#### **11.2.2 Operations**

There are no predicted exceedances of any of the particulate matter (TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and deposited dust) air quality criteria or NEPM advisory reporting standards.

The predicted dust levels incorporated several dust mitigation strategies in estimating the dust emissions during operations of which include:

- adopting a Level 2 watering to achieve 75% control of dust from haul roads.
- Water injection during drilling of ore and overburden.
- Prevention of wind erosion of stockpiled material.

Air quality will need to be managed to ensure that emissions from mining does not contribute to exceedances of the EPA criteria. This may involve the implementation of dust controls to minimise emissions and the implementation of modifications to mining under dry conditions when winds are carrying dust from mining activities to occupied receptors.

A detailed operational *Air Quality Management Plan* (AQMP) should be developed in consultation with the relevant regulatory authorities as part of the conditions of consent. This plan should be dynamic and reviewed and updated regularly and include details of an *Air Quality Monitoring Plan*.

### **11.2.3 Real-Time Dust Monitoring**

An additional aspect of the AQMP for the Proposal could be a real-time dust management system. If adopted, full details of the dust management measures should be outlined in the AQMP, which would be prepared prior to the commencement of the operational phase of the Proposal.

The real-time monitoring system would require a minimum of one real-time dust monitor, such as a Tapered Element Oscillating Microbalance (TEOM) or Beta Attenuated Mass Monitor (BAMM) used in conjunction with a weather station. The real-time monitor would be located in the proximity of most impacted private receptors, such as those receptors to the west of Toongi. Additional real-time boundary monitoring may also be installed as required during the operational phase of the Project.

The real-time monitor would continuously log short-term dust concentrations (15-minute, 30-minute and 1-hour averages) and report the data via GPS/GRSM modem to a web based recording system. When certain short-term trigger levels are reached / exceeded, a message is delivered to the appropriate personnel, alerting them to the high dust levels. The on-site weather station could also report wind conditions at the time.

A short-term average performance indicator (approximately 1-hour) would be set at a level that allows proactive dust management if dust levels are expected to approach the 24-hour PM<sub>10</sub> impact assessment criteria in the upcoming 24 hours. During the life of the Proposal, should more suitable technology become available, this system may be modified and enhanced if required.

A procedural response would facilitate the day-to-day management of dust emissions triggered if the performance indicator is exceeded. The procedure would include identifying the source of excessive dust, determining the controls used to minimise dust, implementing such controls and reviewing the effectiveness of controls.

### **11.3 PROCESSING PLANT**

The following mitigation measures would be put in place to minimise emissions to atmosphere from the processing plant:

- The use of spray curtains would be adopted at all crushers and miscellaneous transfers (not already located within enclosures).
- A bag house would be used to capture particulate matter from the grinding mill.
- Emissions from the stacks and vents would be regulated by operating within the prescribed in-stack concentrations limits. This would be initially determined through the detailed design phase and verified by in-stack monitoring.
- Periodic extractive monitoring would be undertaken to demonstrate compliance with in-stack limits. This may be required to be completed every 3 months for the first year of operation and then annually if compliance is easily achieved.
- A regular and documented maintenance and inspection program would be implemented for all plant items where emissions to air is deemed likely.

## 12. GREENHOUSE GAS ASSESSMENT

### 12.1 INTRODUCTION

Greenhouse Gas (GHG) emissions have been estimated based on the methods outlined in the following documents:

- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) *Greenhouse Gas Protocol The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition* (WRI/WBCSD, 2004).
- *National Greenhouse and Energy Reporting (Measurement) Determination 2008*.
- The Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) *National Greenhouse Accounts (NGA) Factors 2012* (DCCEE, 2012).

The *GHG Protocol* establishes an international standard for accounting and reporting of GHG emissions. The *GHG Protocol* has been adopted by the International Standard Organisation, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes.

Three 'scopes' of emissions (scope 1, scope 2 and scope 3) are defined for GHG accounting and reporting purposes, as described below. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment.

#### Scope 1: Direct Greenhouse Gas Emissions

Direct GHG emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct GHG emissions are those emissions that are principally the result of the following types of activities undertaken by an entity:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources.
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials (e.g. the manufacture of cement, aluminium, etc.).
- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources (e.g. trucks, trains, ships, aeroplanes, buses and cars).
- Fugitive emissions. These emissions result from intentional or unintentional releases (e.g. equipment leaks from joints, seals, packing, and gaskets; CH<sub>4</sub> emissions from coal mines and venting); hydrofluorocarbon emissions during the use of refrigeration and air conditioning equipment; and CH<sub>4</sub> leakages from gas transport.

#### Scope 2: Energy Product Use Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that account for GHG emissions from the generation of purchased energy products (principally, electricity, steam/heat and reduction materials used for smelting) by the entity.

Scope 2 in relation to a project typically covers purchased electricity, defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity.

### **Scope 3: Other Indirect Greenhouse Gas Emissions**

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of scope 3 activities provided in the *GHG Protocol* are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

In the case of the Proposal, scope 3 emissions will include emissions associated with the extraction, processing and transport of fuels. The *GHG Protocol* notes that reporting scope 3 emissions is optional. If an organisation believes that scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with scope 1 and scope 2. However, the *GHG Protocol* notes that reporting scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult because reporting is voluntary. Double counting needs to be avoided when compiling national (country) inventories under the *Kyoto Protocol*. The *GHG Protocol* also recognises that compliance regimes are more likely to focus on the “point of release” of emissions (i.e. direct emissions) and/or indirect emissions from the purchase of electricity.

## **12.2 GREENHOUSE GAS EMISSION ESTIMATES**

Inventories of GHG emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as global warming potentials) and emission factors take into account the global warming potentials of the gases created during combustion. The estimated emissions are referred to in terms of carbon dioxide equivalent, or CO<sub>2</sub>-e, emissions by applying the relevant global warming potential. The greenhouse gas assessment has been conducted using the NGA Factors, published by the DCCEE (2012).

Proposal-related GHG sources included in the assessment are as follows:

- Fuel consumption (diesel) during mining operations – scope 1.
- Indirect emissions associated with on-site electricity use – scope 2.
- Indirect emissions associated with the production of transport fuels – scope 3.
- Indirect emissions associated with the production of electricity – scope 3.

The operational phase is assumed to be 20 years in accordance with data provided by the Applicant. The Applicant has indicated that diesel and electricity usage would not vary significantly between years of operation.

Emissions from the shipping of product ore are not included in this assessment due to the uncertainties in emission estimates, including uncertainty in future export destinations and limited data on emission factors and/or fuel consumption for ocean going vessels.

Detailed information on the calculation of greenhouse gas emissions from the Proposal are provided in **Appendix 5**.

## 12.3 SUMMARY OF GHG EMISSIONS

A summary of the total GHG emissions associated with the Proposal are presented in **Table 32**. The data has been presented for the average operational year and for the life of the Proposal. Of the transport options assessed (see Section 2.4), Option A would result in the greatest CO<sub>2</sub>-e emissions.

**Table 32**  
**Summary of GHG Emissions (t CO<sub>2</sub>-e)**

	Scope 1 Emissions (t CO <sub>2</sub> -e)	Scope 2 Emissions (t CO <sub>2</sub> -e)	Scope 3 Emissions (t CO <sub>2</sub> -e)	Total (Scope 1 and Scope 2)	Total (All scopes)
<b>Average operational year</b>					
<i>Option A</i>	140,040	120,560	1,107	260,600	262,101
<i>Option B</i>	140,040	120,560	1,126	260,600	261,727
<i>Option C</i>	140,040	120,560	1,501	260,600	261,707
<b>Life of Proposal</b>					
<i>Option A</i>	2,800,807	2,411,200	1,277,650	5,212,007	6,497,532
<i>Option B</i>	2,800,807	2,411,200	1,278,032	5,212,007	6,490,040
<i>Option C</i>	2,800,807	2,411,200	1,285,525	5,212,007	6,489,657

## 12.4 IMPACT ASSESSMENT

According to the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report, global surface temperature has increased  $0.74 \pm 0.18^{\circ}\text{C}$  during the 100 years ending 2005 (IPCC, 2007a). The IPCC has determined *"most of the observed increase in globally averaged temperatures since the mid-twentieth century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations"*. "Very likely" is defined by the IPCC as greater than 90% probability of occurrence (IPCC, 2007).

Climate change projections specific to Australia have been determined by the CSIRO, based on the following global emissions scenarios predicted by the IPCC (CSIRO, 2007):

- A1F1 (high emissions scenario) – assumes very rapid economic growth, a global population that peaks in mid-century and technological change that is fossil fuel intensive.
- A1B (mid emissions scenario) – assumes the same economic and population growth as A1F1, with a balance between fossil and non-fossil fuel intensive technological changes.
- B1 (low emissions scenario) – assumes the same economic and population growth as A1F1, with a rapid change towards clean and resource efficient technologies.

For the global emissions scenarios described above, the projected changes in annual temperature relative to 1990 levels for Australian cities for 2030 and 2070 are presented in **Table 33** as determined by the CSIRO (2007). The towns/cities presented in **Table 33** are those closest to the DZP Site for which results are available.



**Table 33**  
**Projected Changes in Annual Temperature (relative to 1990)**

Location	2030 - A1B (mid-range emissions scenario)	2070 - B1 (low emissions scenario)	2070 - A1F1 (high emissions scenario)
<b>Temperature (°C)</b>			
Brisbane	0.7 - 1.4	1.1 - 2.3	2.1 - 4.4
Dubbo	0.7 - 1.5	1.2 - 2.5	2.2 - 4.8
St George (Queensland)	0.7 - 1.6	1.2 - 2.7	2.4 - 5.2
Sydney	0.6 - 1.3	1.1 - 2.2	2.1 - 4.3

Notes: Range of values represents the 10<sup>th</sup> and 90<sup>th</sup> percentile results.

For 2030, only A1B results are shown as there is little variation in projected results for the global emission scenarios A1B, B1 and A1F1 (CSIRO, 2007).

Source: CSIRO (2007) *Climate Change in Australia – Technical Report 2007*, Commonwealth Scientific and Industrial Research Organisation.

The CSIRO also details projected changes to other meteorological parameters (for example rainfall, potential evaporation, wind speed, relative humidity and solar radiation) and the predicted changes to the prevalence of extreme weather events (for example droughts, bush fires and cyclones).

The potential social and economic impacts of climate change to Australia are detailed in the Garnaut Climate Change Review (Garnaut, 2008), which draws on IPCC assessment work and the CSIRO climate projections. The Garnaut review details the negative and positive impacts associated with predicted climate change with respect to:

- agricultural productivity;
- water supply infrastructure;
- urban water supplies;
- buildings in coastal settlements;
- temperature related deaths;
- ecosystems and biodiversity; and
- geopolitical stability and the Asia-Pacific region.

The Proposal's contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global GHG emissions. Average annual scope 1 and scope 2 emissions from the Proposal (0.26 million tonnes [Mt] CO<sub>2</sub>-e) would represent approximately 0.04% of Australia's commitment for annual emissions under the *Kyoto Protocol* (591.5 Mt CO<sub>2</sub>-e/annum) and a very small portion of global greenhouse emissions, given that Australia contributed approximately 1.5% of global GHG emissions in 2005 (Commonwealth of Australia, 2011).

A comparison of predicted annual GHG emissions from the Proposal with global, Australian and NSW emissions inventories are presented in **Table 34**.

**Table 34**  
**Comparison of Greenhouse Gas Emissions**

<b>Geographic coverage</b>	<b>Source coverage</b>	<b>Timescale</b>	<b>Emission Mt CO<sub>2</sub>-e</b>	<b>Reference</b>
Proposal	Scope 1 and 2	Average annual	0.26	This report.
Global	CO <sub>2</sub> -e emissions	2005	35,000	Based on Australia representing 1.5% of global emissions (Commonwealth of Australia, 2011). Australian National Greenhouse Gas Inventory (2005) taken from <a href="http://www.ageis.greenhouse.gov.au/">http://www.ageis.greenhouse.gov.au/</a>
Global	CO <sub>2</sub> -e emission increase 2004 to 2005	2005	733	IPCC (2007a). From tabulated data presented in Table 7.1 on the basis of an additional 733 Mt/a. Data converted from Carbon unit basis to CO <sub>2</sub> basis.
Australia	1990 Base	1990	547.7	Taken from the National Greenhouse Gas Inventory (2009) <a href="http://www.ageis.greenhouse.gov.au/">http://www.ageis.greenhouse.gov.au/</a>
Australia	Kyoto target	Average annual 2008 - 2012	591.5	Based on 1990 net emissions multiplied by 108% Australia's Kyoto emissions target.
Australia	Total	2009	564.5	Taken from the National Greenhouse Gas Inventory (2009) <a href="http://www.ageis.greenhouse.gov.au/">http://www.ageis.greenhouse.gov.au/</a>
NSW	Total	2009	160.5	Taken from the National Greenhouse Gas Inventory (2009) <a href="http://www.ageis.greenhouse.gov.au/">http://www.ageis.greenhouse.gov.au/</a>

The commitment from the Australian Government to reduce GHG emissions is proposed to be achieved through the introduction of the Australian Government's carbon pricing mechanisms. From 1 July 2012, a fixed price on GHG emissions has been introduced (currently \$23/tonne CO<sub>2</sub>-e), with no cap on Australia's GHG emissions, or emissions from individual facilities (Commonwealth of Australia, 2011).

From 1 July 2015 an emissions trading scheme is proposed to be implemented. As such, Australia's GHG emissions, inclusive of emissions associated with the Proposal, would be capped at a level specified by the Australian Government.

It is expected that the Proposal would exceed the facility threshold of 25,000 t CO<sub>2</sub>-e per annum for participation in the carbon pricing mechanisms, and as such scope 1 and scope 2 GHG emissions from the Proposal would be subject to the carbon pricing mechanism. As such, AZL would directly contribute to the revenue generated by the carbon pricing mechanism, which is to be used to fund the following initiatives designed to reduce Australia's GHG emissions (Commonwealth of Australia, 2011):

- \$1.2 billion Clean Technology Program to improve energy efficiency in manufacturing industries and support research and development in low-pollution technologies;
- \$10 billion Clean Energy Finance Corporation to invest in renewable energy, low-pollution and energy efficiency technologies; and
- \$946 million Biodiversity Fund (over the first six years) to protect biodiverse carbon stores and secure environmental outcomes from carbon farming.

## **12.5 GREENHOUSE GAS MANAGEMENT**

The following measures are recommended to minimise GHG emissions from the Proposal:

- maximise energy efficiency as a key consideration in the development of the Proposal. For example, significant savings of GHG emissions (through increased energy efficiency) can be achieved by mine planning decisions which minimise haul distances for ore and waste rock transport, and therefore fuel use;
- improving energy use and efficiency;
- considering the use of alternative fuels where economically and practically feasible;
- the review of mining practices to minimise double handling of materials and ensuring that ore and overburden haulage is undertaken using the most efficient routes;
- ongoing scheduled and preventative maintenance to ensure that diesel and electrically powered plants operate efficiently;
- developing targets for greenhouse gas emissions and energy use, and monitor and report against these;
- implementing a detailed energy monitoring programme. This would include monitoring the electricity and diesel usage on-site to identify the main sources of greenhouse gas emissions and apply appropriate reduction mechanisms where possible;
- regular maintenance of diesel powered equipment to ensure operation at peak efficiency;
- dedicating a number of trucks for each digging unit to minimise truck wait times;
- ensuring that dump trucks are fully loaded to maximise productivity and efficiency;
- conducting a baseline study of energy use; and
- assessing lighting plant efficiency;

The Applicant should also consider joining relevant state and Federal energy efficiency programs in place at the commencement of operations (for example, the federal Energy Efficiency Opportunities or *NSW Energy Savings Action Plan* programs). Joining such programs are intended to minimise energy usage and GHG emissions from the Proposal's operations, and will include objectives, commitments, procedures and responsibilities as described above.

The effectiveness of these reasonable and feasible measures to reduce GHG emissions (and energy consumption) should be monitored, as AZL would annually estimate GHG emissions and energy consumption in accordance with its commitments under the National Greenhouse and Energy Reporting (NGER) scheme.

### 13. CONCLUSIONS

Pacific Environment has completed an air quality impact assessment for the construction and operation of the Dubbo Zirconia Project in central-west NSW. The Proposal is for an open cut mine to operate over a period of 20 years and includes open cut mining, a processing plant, rail loading and ore stockpiling areas, waste rock emplacement areas and associated infrastructure.

Two operating scenarios over the life of the Proposal have been assessed to represent the potential worst case air quality impacts that the Proposal would have on private and Proposal related receptors on and surrounding the DZP Site.

The air quality parameters investigated include particulate matter (TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, dust deposition), SO<sub>2</sub>, NO<sub>2</sub>, HCl, radon and odour.

Dispersion modelling was conducted to predict the ground level concentrations for potential air impacts for Year 5 and Year 15 (particulate matter only) impacts and Year 15 for the remaining air quality parameters. Cumulative impacts were also considered where appropriate, taking into account the Proposal and other non-mining sources.

The modelling results showed that during operation, the Proposal would be compliant with all of the EPA air quality criteria for the relevant averaging periods for TSP, PM<sub>10</sub>, dust deposition SO<sub>2</sub>, NO<sub>2</sub>, HCl, odour and also the NEPM advisory reporting standards for PM<sub>2.5</sub> at all privately owned receptors. Several Applicant-owned receptors located to the immediate west of the processing plant are predicted to be impacted for SO<sub>2</sub> only.

Monte Carlo simulation was completed to determine the probability of six selected receptors located around the DZP Site of exceeding the EPA Criterion for cumulative PM<sub>10</sub> 24 hour averages. Monitored PM<sub>10</sub> 24-hour concentrations recorded at Bathurst and Tamworth were used to create a daily background data set which was then randomly added to predictions made from the Proposal alone. Results indicate that most affected private receptors were already predicted to exceed the EPA assessment criteria of 50µg/m<sup>3</sup> due to existing sources for up to two days, and that no additional exceedances are anticipated associated with Proposal operations.

The potential for air quality exceedances during construction were assessed qualitatively. Emissions from construction activities account for a relatively small percentage compared to the overall emissions of the operation of the Proposal. Construction particulate matter emissions are considered short lived and able to be effectively managed.

The processing plant emission rates comply with the in-stack concentration limits prescribed under the Protection of the Environment Operations (Clean Air) Regulation (2010).

A GHG assessment indicates that average annual scope 1 and 2 emissions from the Proposal (0.26 Mt CO<sub>2</sub>-e) would represent approximately 0.04% of Australia's commitment under the *Kyoto Protocol* (591.5 Mt CO<sub>2</sub>-e) and a very small portion of global greenhouse emissions.

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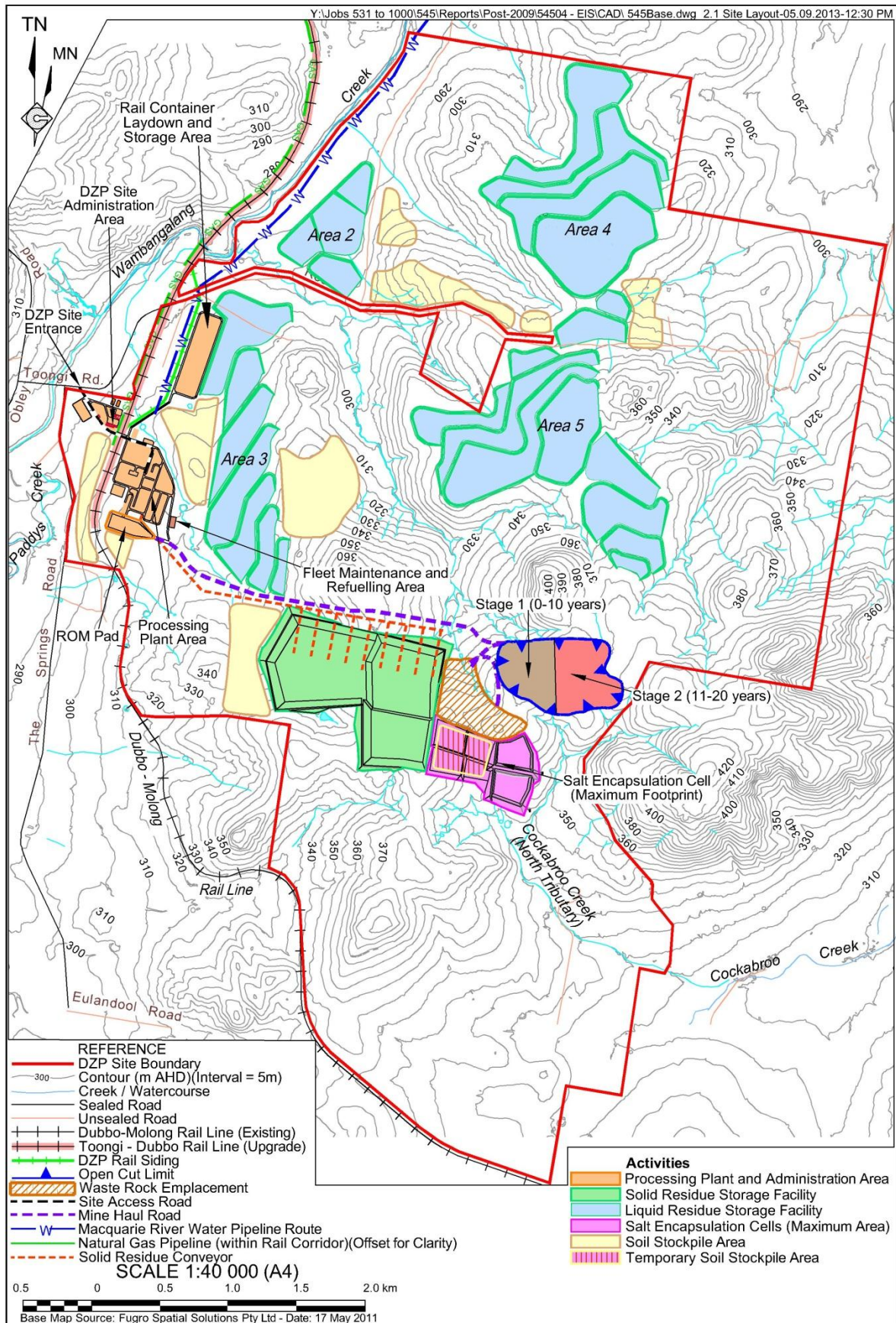
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## **15. FIGURES**

**\*Note: 'Mine-owned' refers to those Receptors either owned by Australian Zirconia Ltd or which are under contract for purchase by Australian Zirconia Ltd**

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**Figure 1 DZP Site Layout**



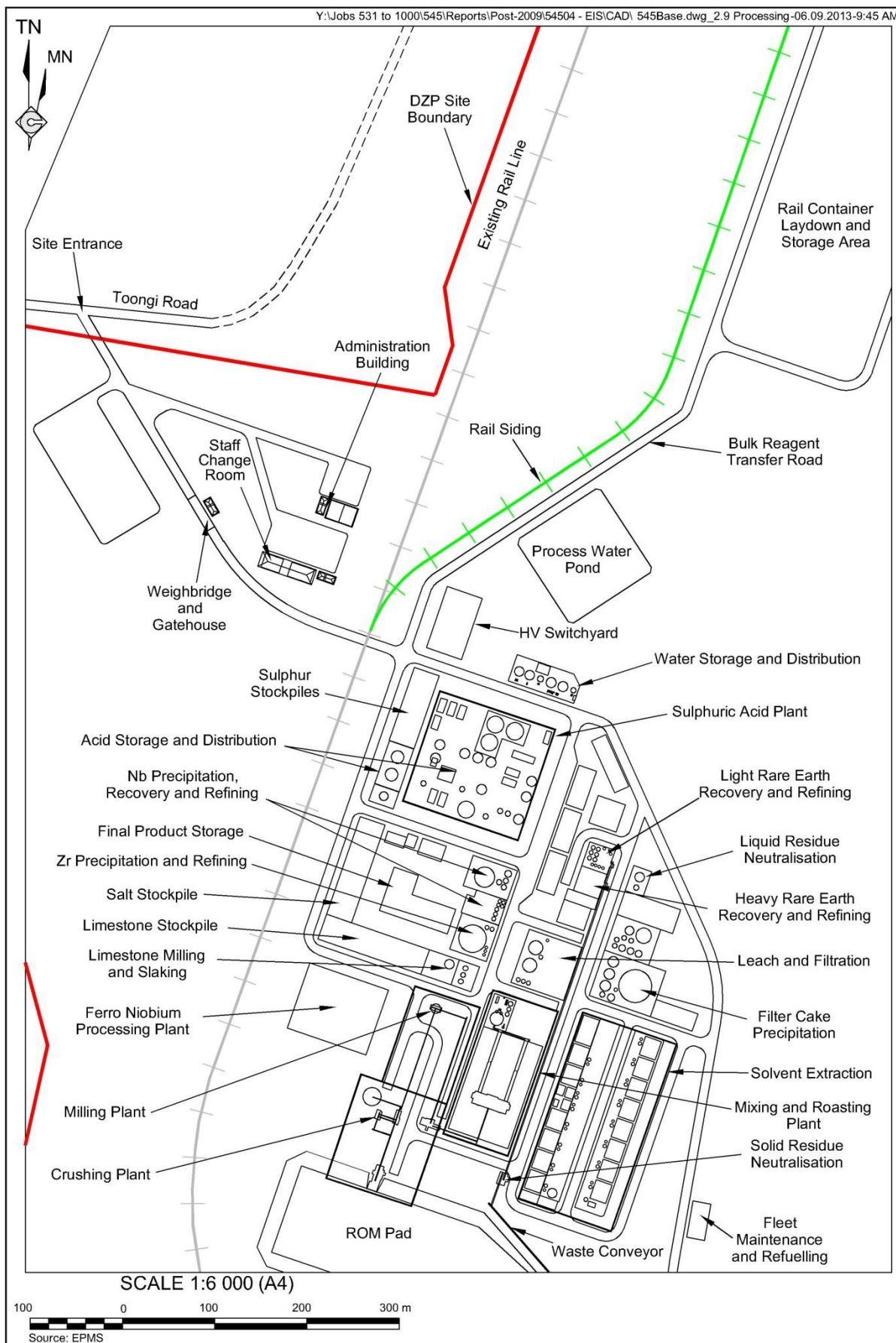


Figure 2 Processing plant layout



**Figure 3 Regional setting of the Proposal**



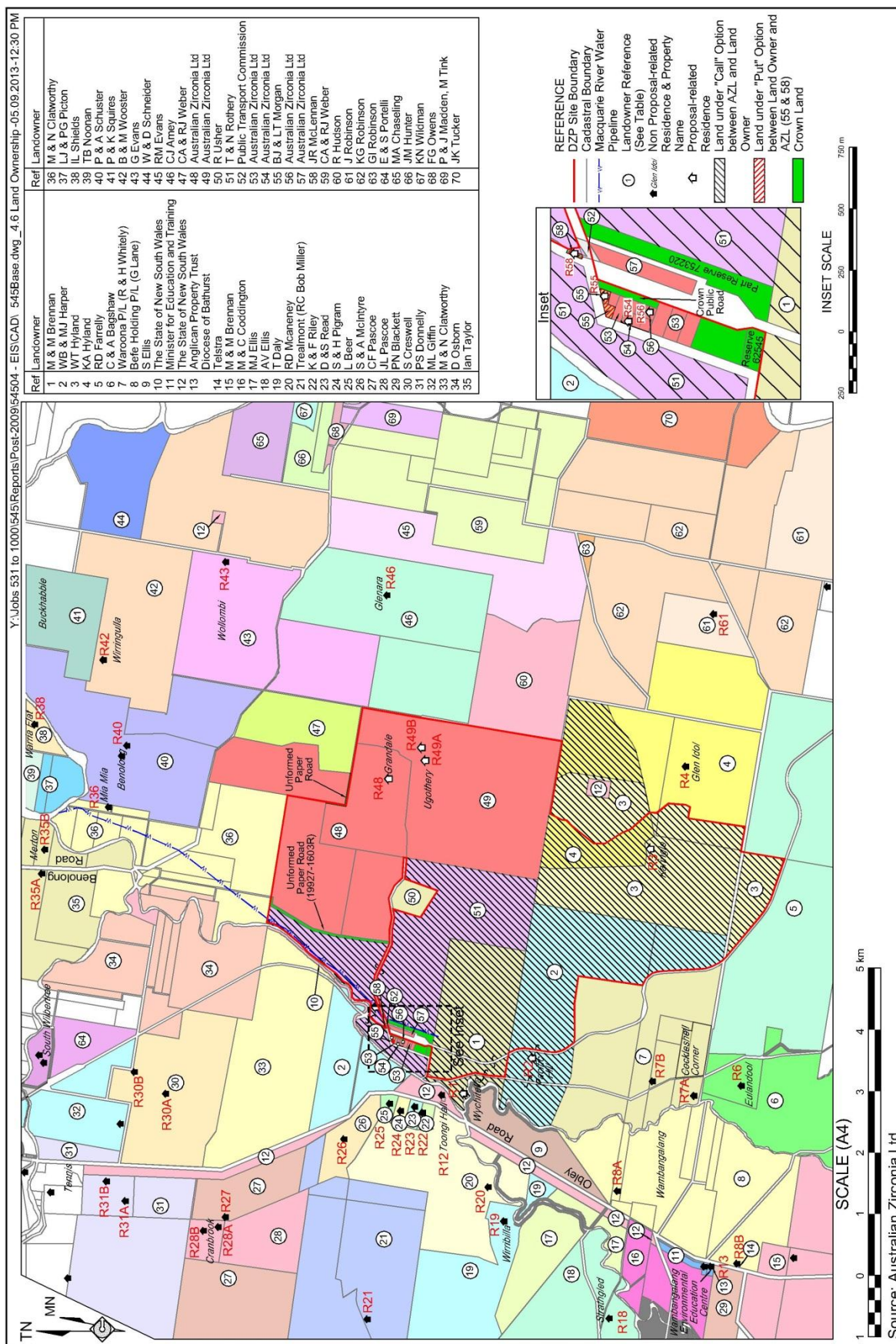
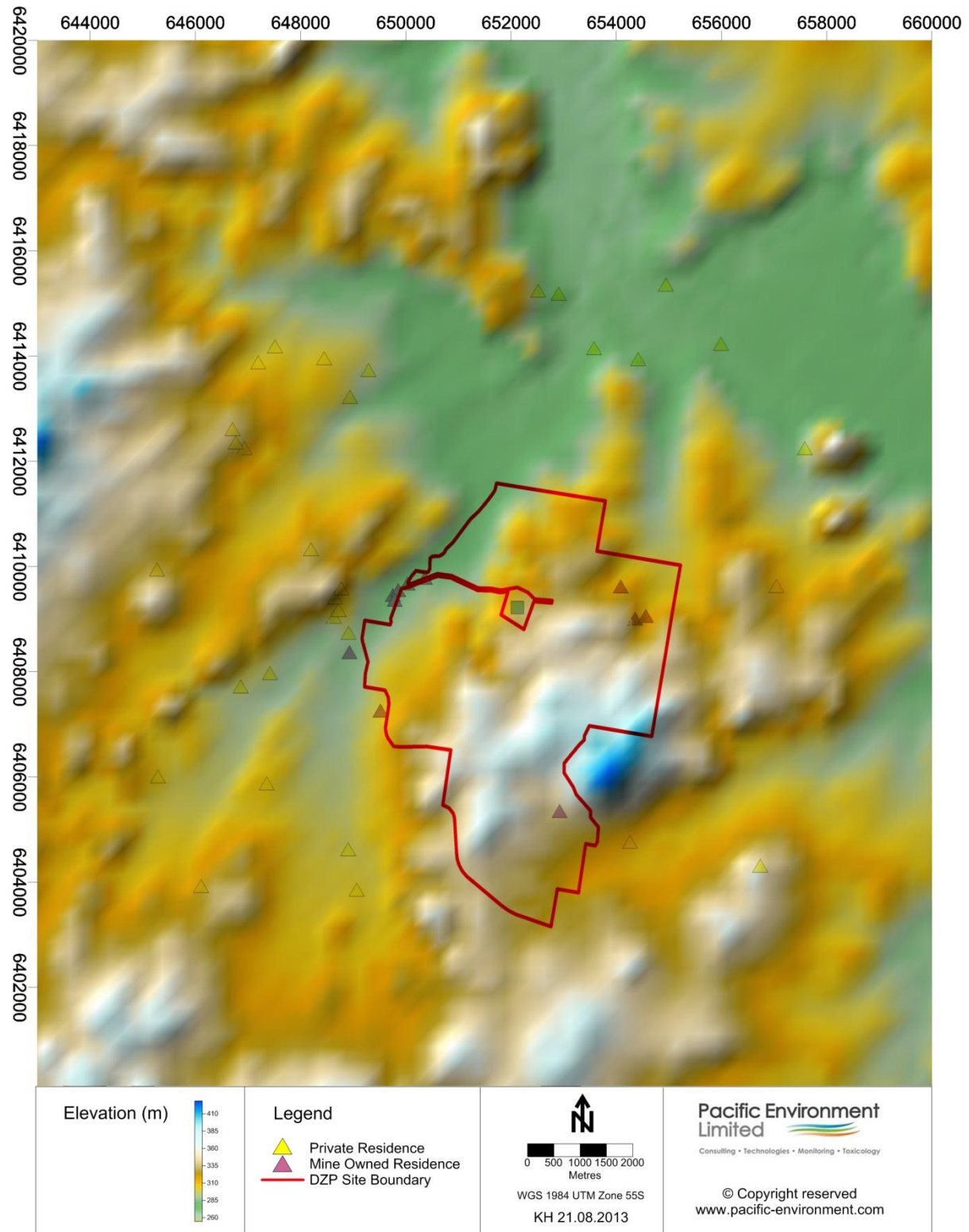
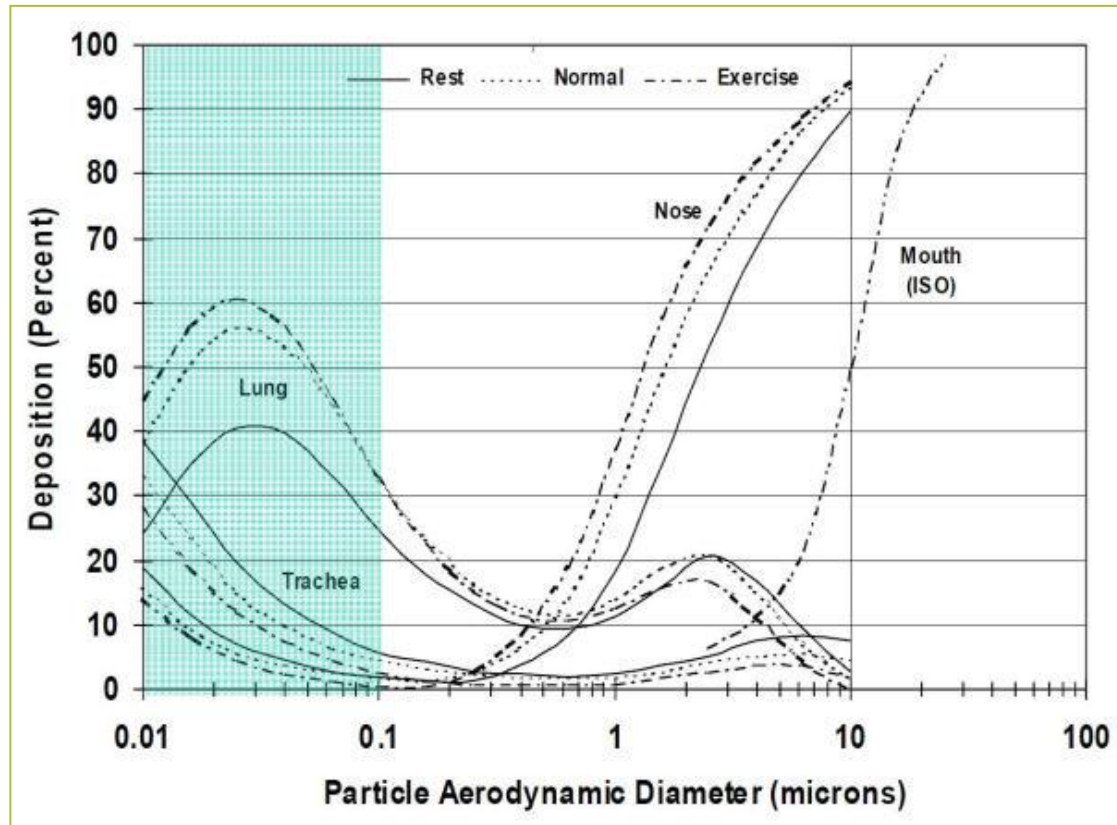


Figure 4 Land ownership of the DZP Site and surrounds



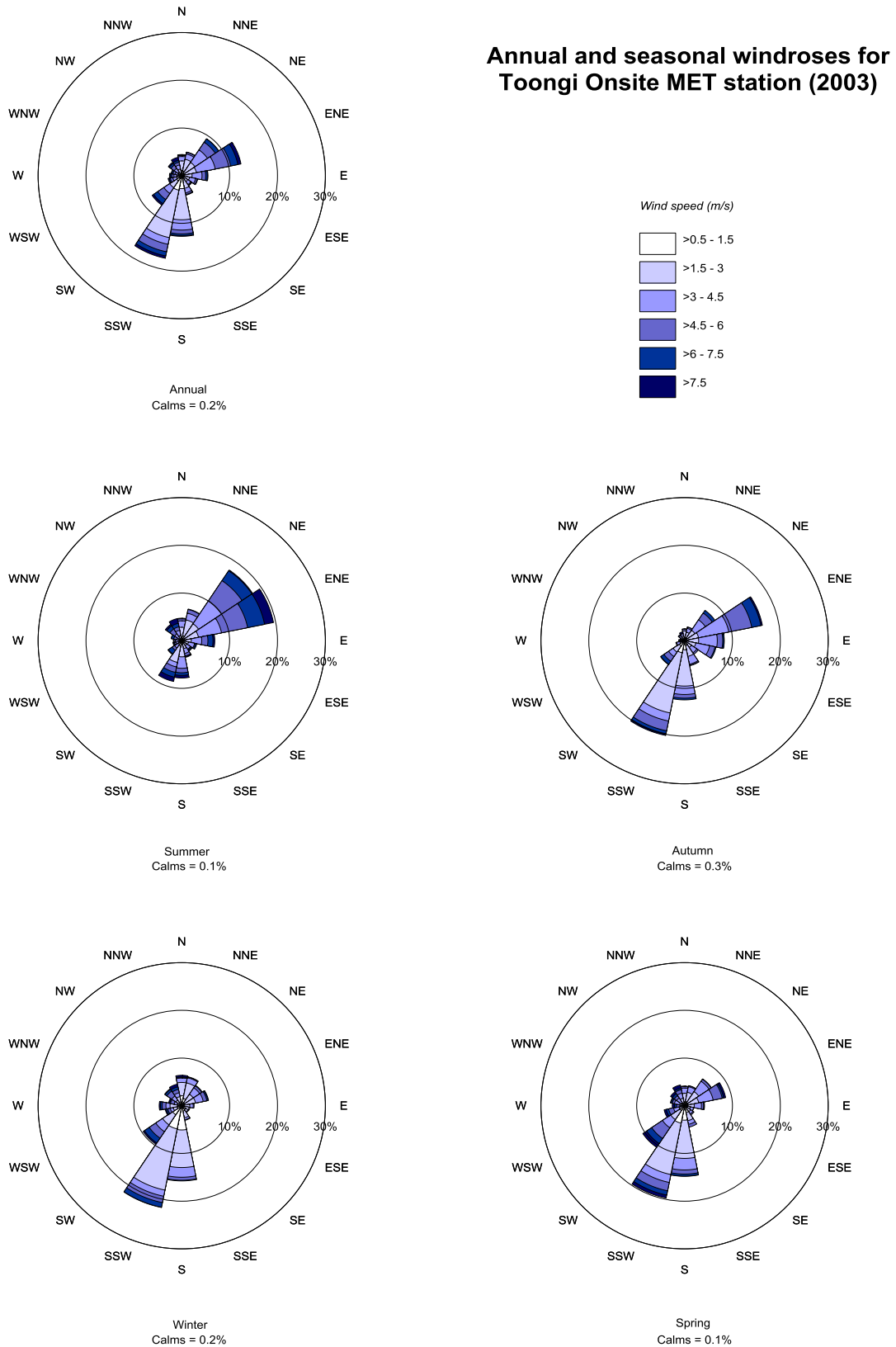
**Figure 5 Pseudo three-dimensional plot of the DZP Site**





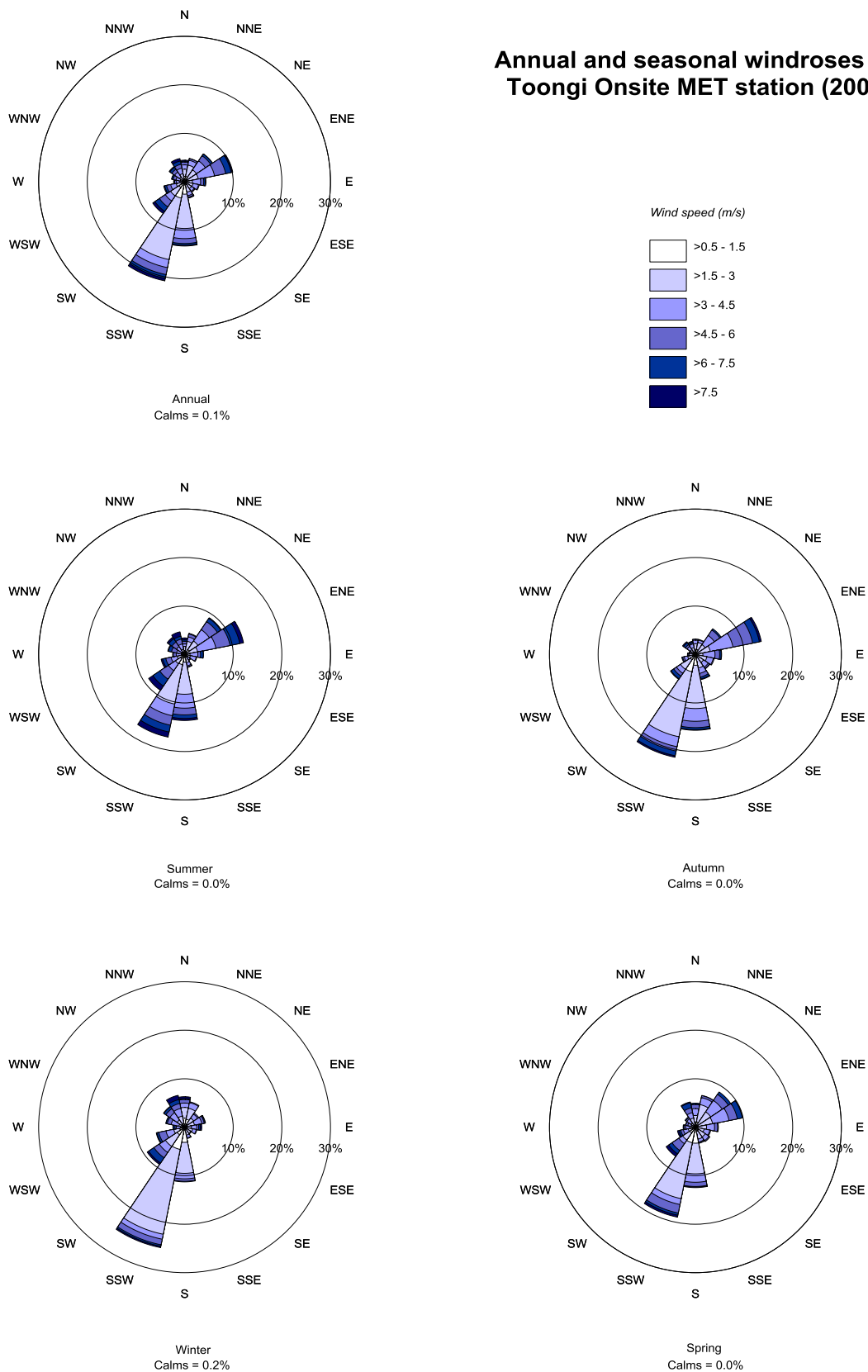
Source: Chow, 1996

**Figure 6** Particle Deposition within the Respiratory Track



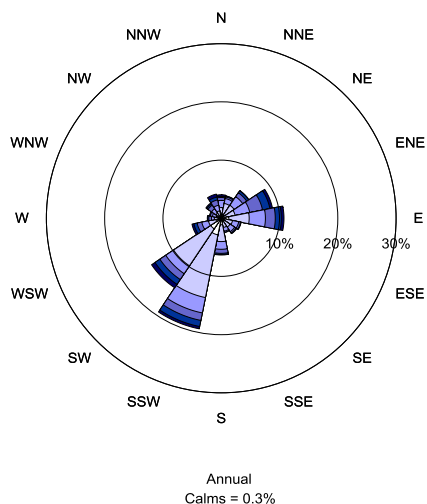
**Figure 7 Annual and seasonal wind roses for Toongi Met Station (2003)**

**Annual and seasonal windroses for Toongi Onsite MET station (2005)**



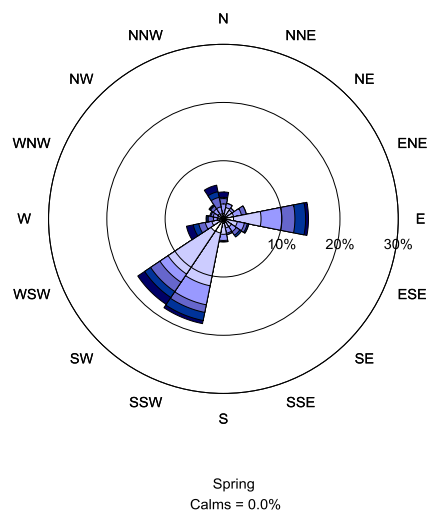
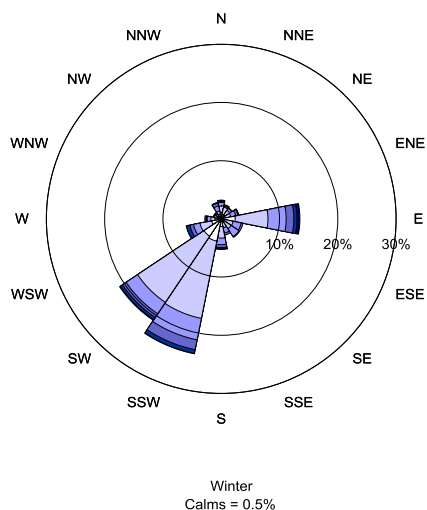
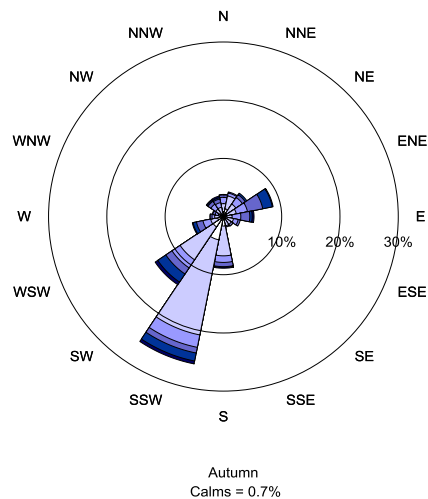
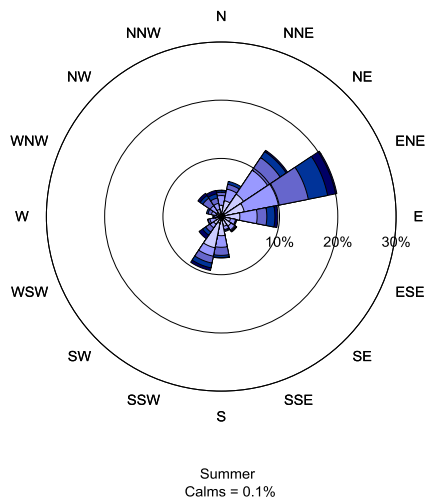
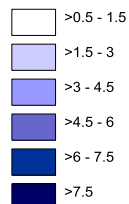
**Figure 8 Annual and seasonal wind roses for Toongi Met Station (2005)**





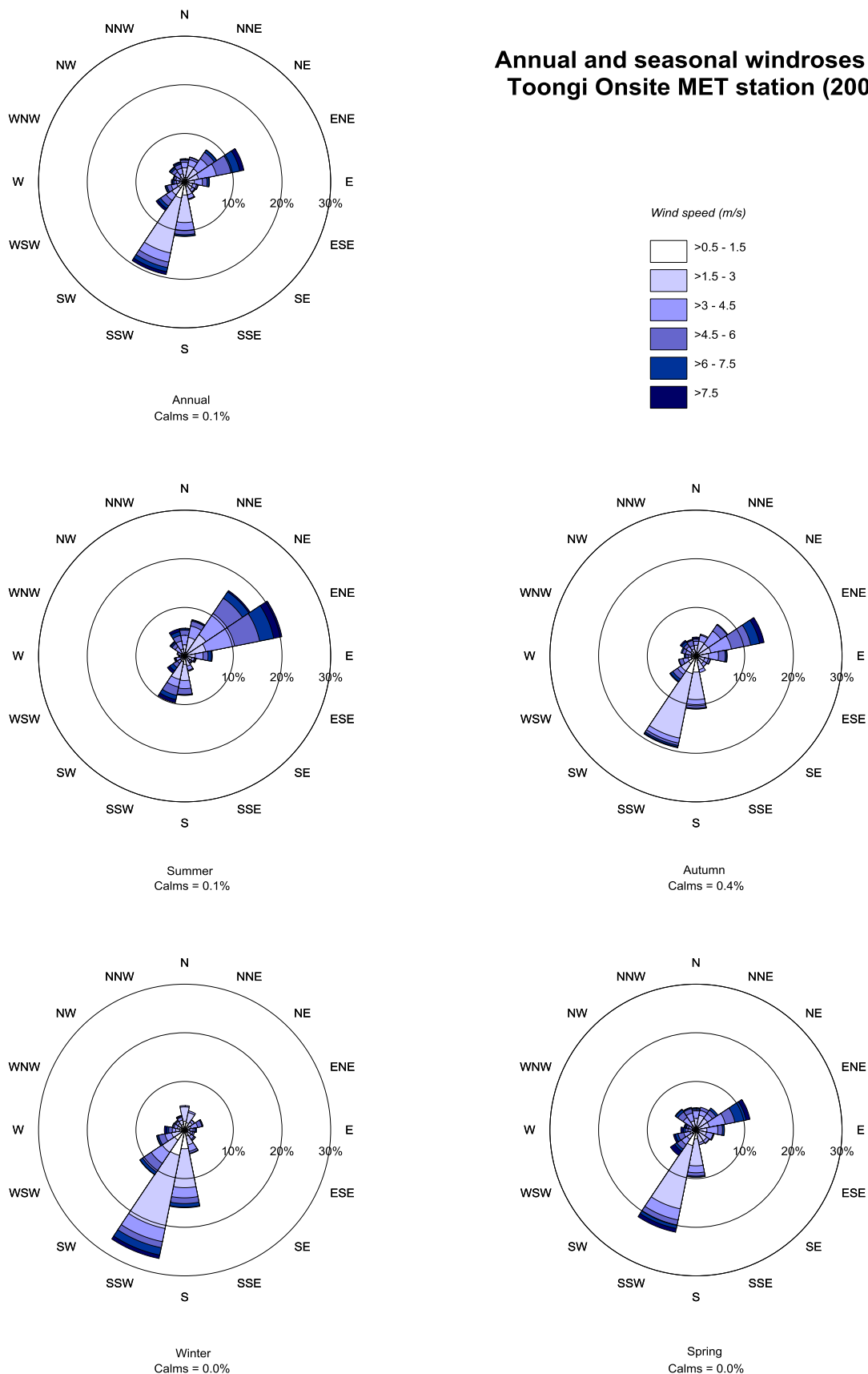
### Annual and seasonal windroses for Toongi Onsite MET station (2006)

Wind speed (m/s)

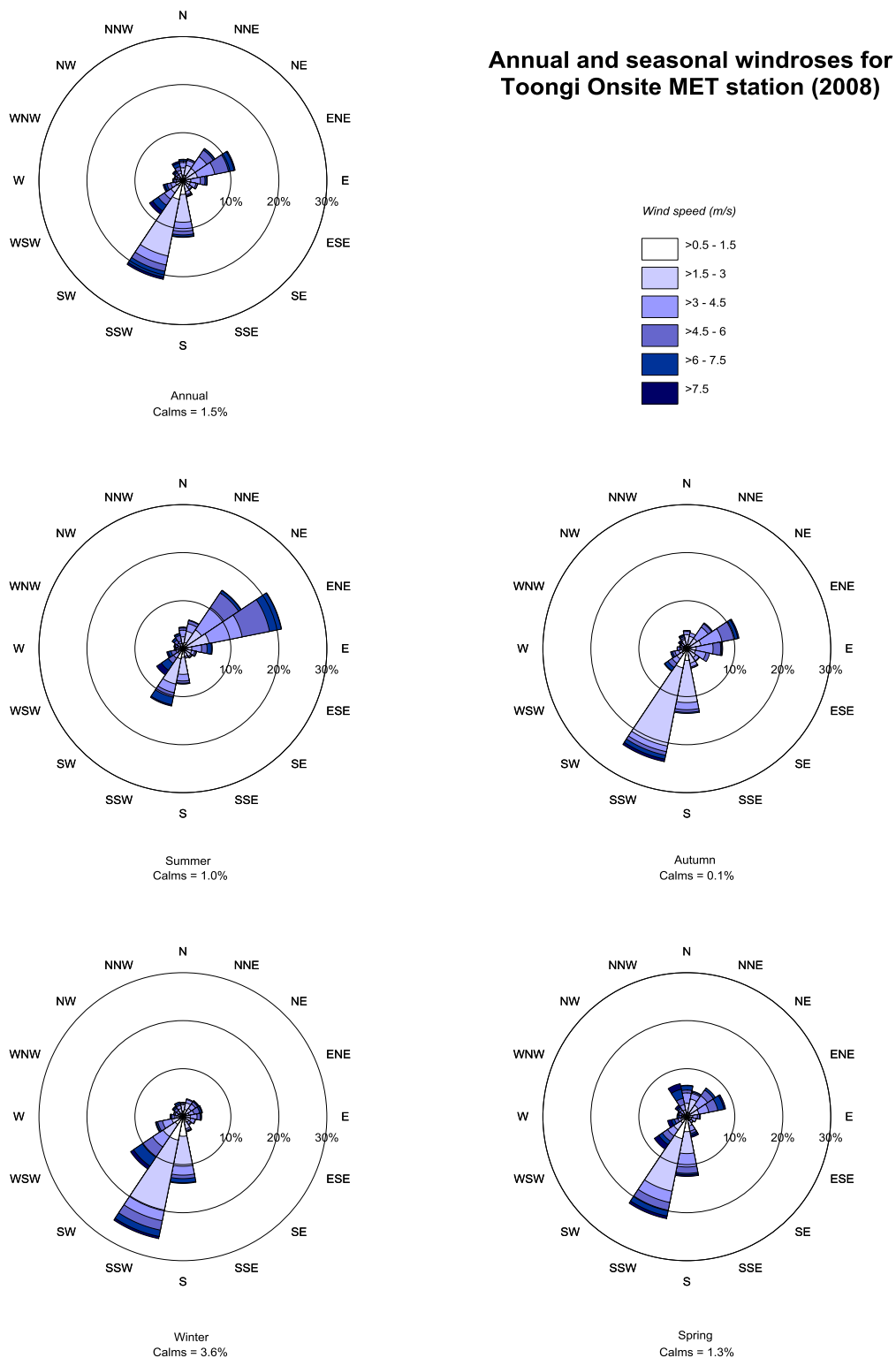


**Figure 9** Annual and seasonal wind roses for Toongi Met Station (2006)

**Annual and seasonal windroses for  
 Toongi Onsite MET station (2007)**



**Figure 10 Annual and seasonal wind roses for Toongi Met Station (2007)**



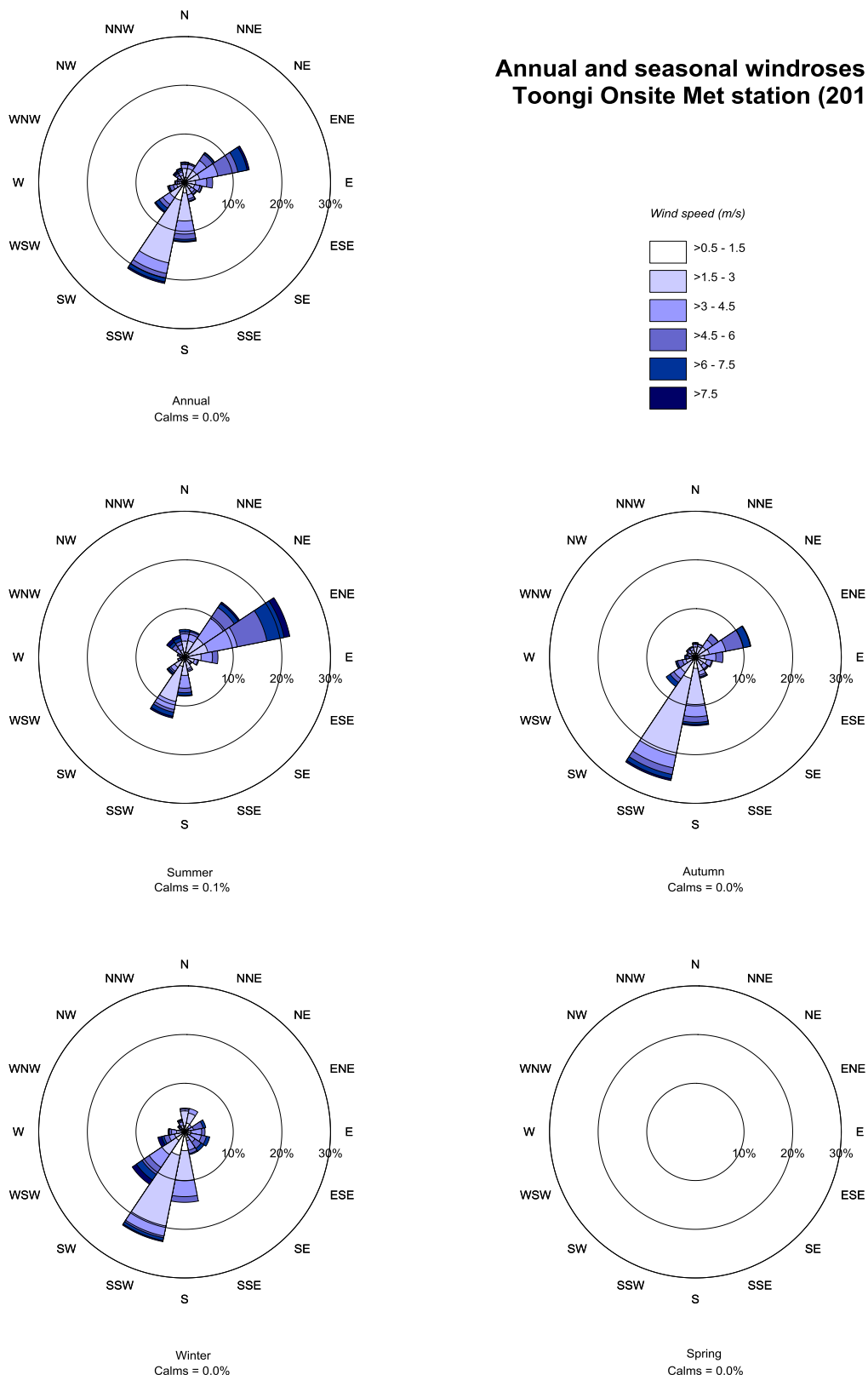
**Figure 11 Annual and seasonal wind roses for Toongi Met Station (2008)**

**Annual and seasonal windroses for  
 Toongi Onsite MET station (2010)**



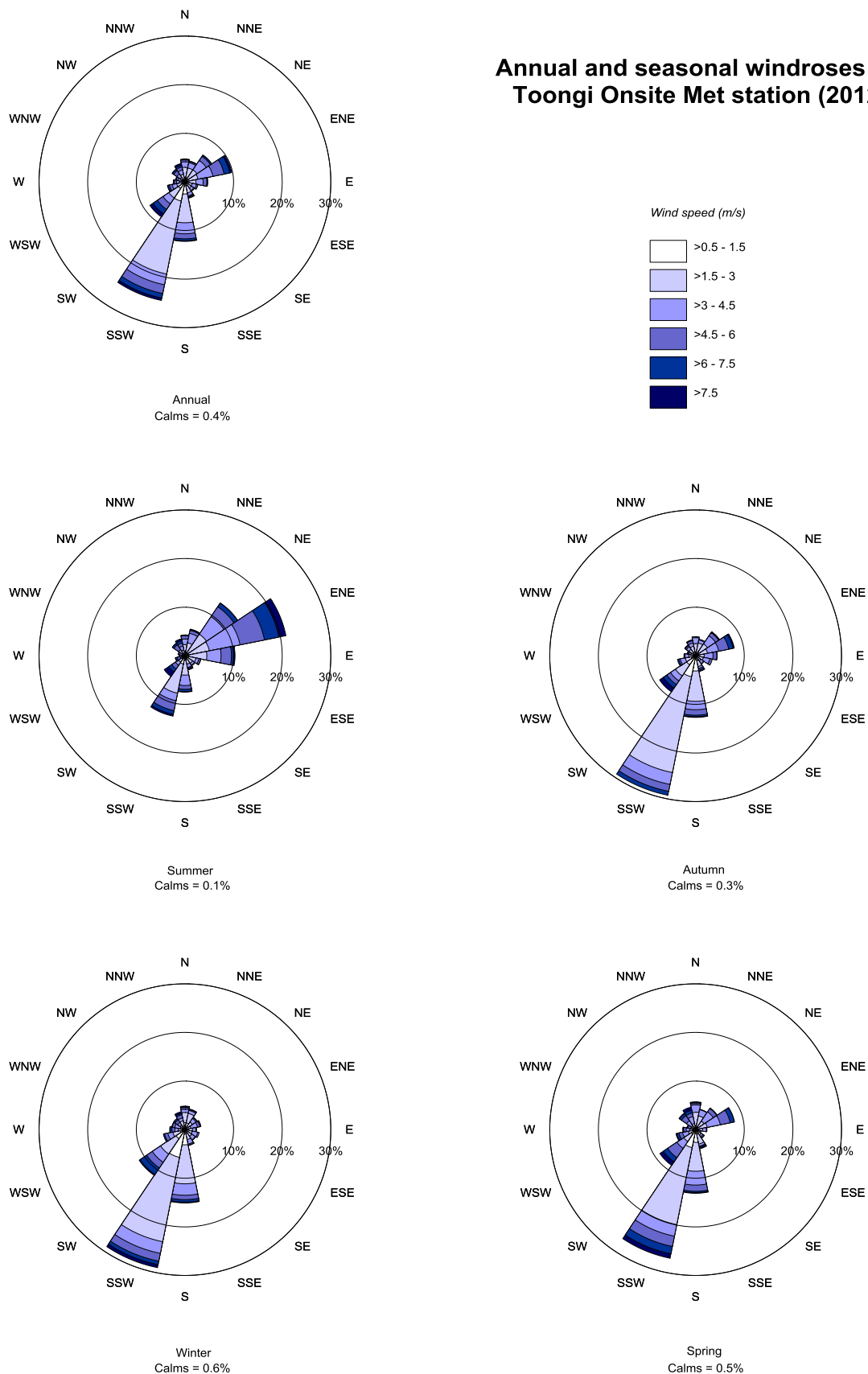
**Figure 12 Annual and seasonal wind roses for Toongi Met Station (2010)**

**Annual and seasonal windroses for  
Toongi Onsite Met station (2011)**

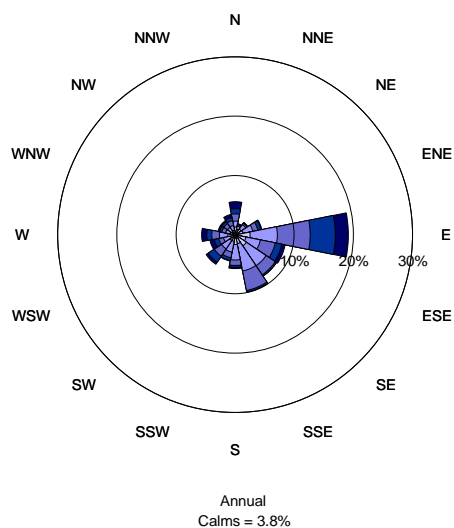


**Figure 13 Annual and seasonal wind roses for Toongi Met Station (2011)**

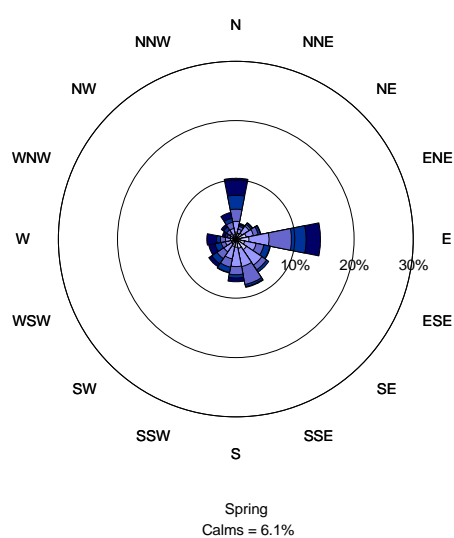
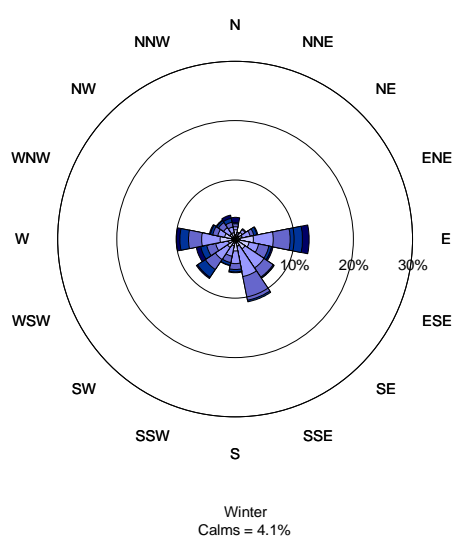
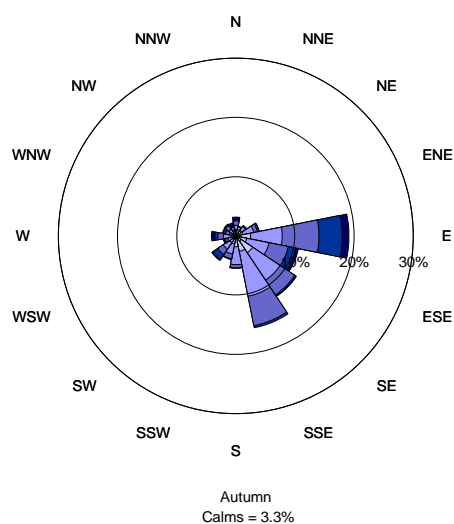
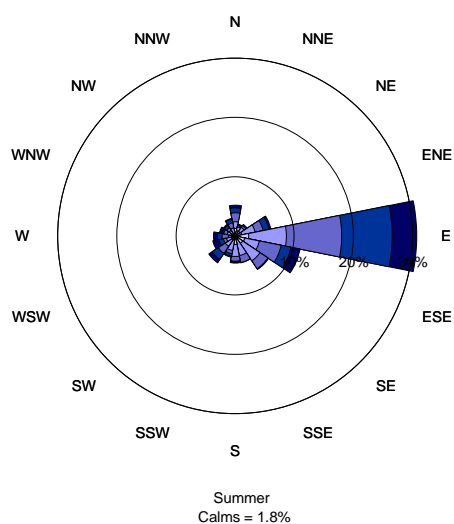
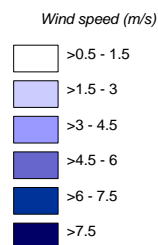
### Annual and seasonal windroses for Toongi Onsite Met station (2012)



**Figure 14 Annual and seasonal wind roses for Toongi Met Station (2011)**

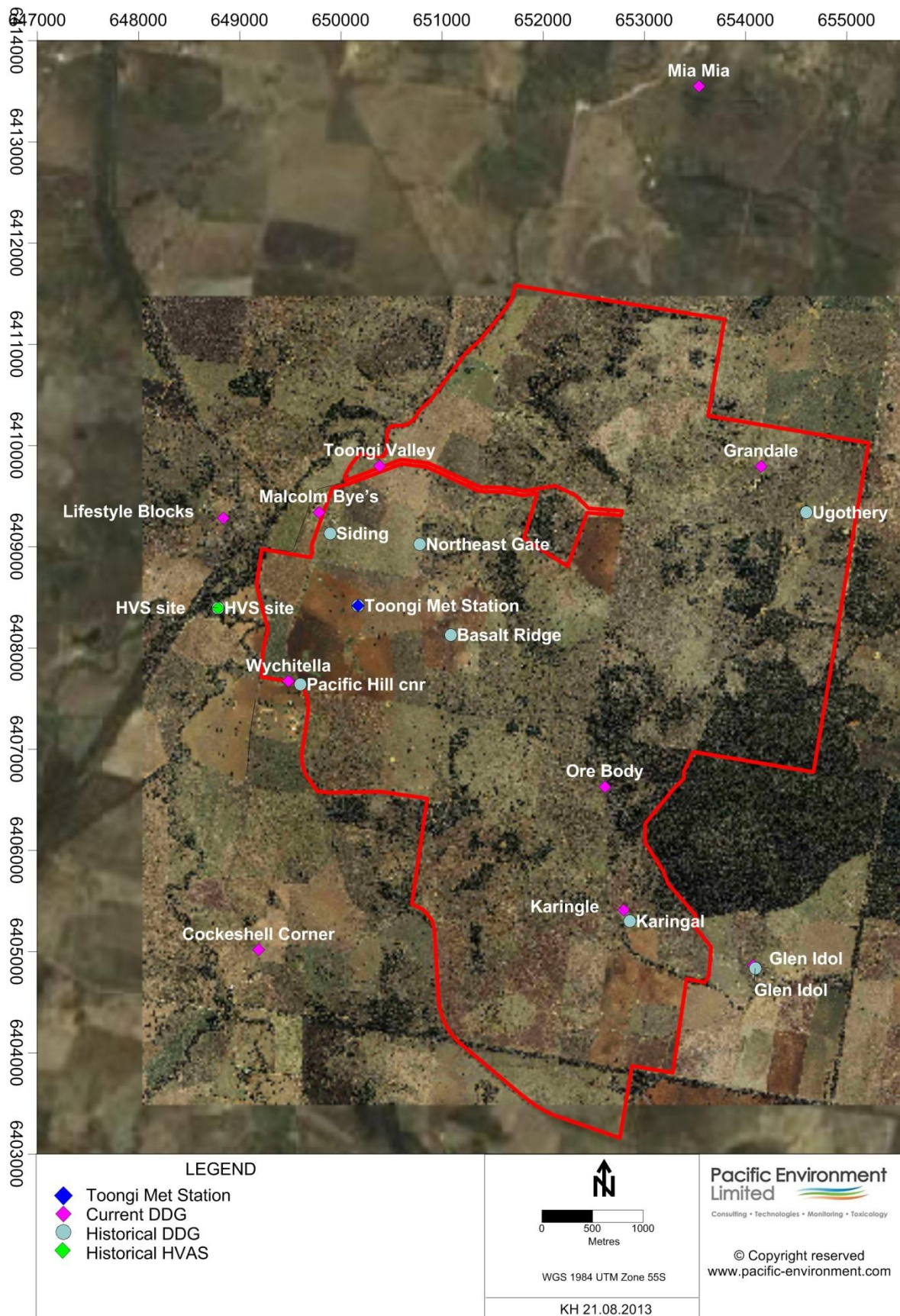


**Annual and seasonal windroses for  
Dubbo Airport AWS (2008)**



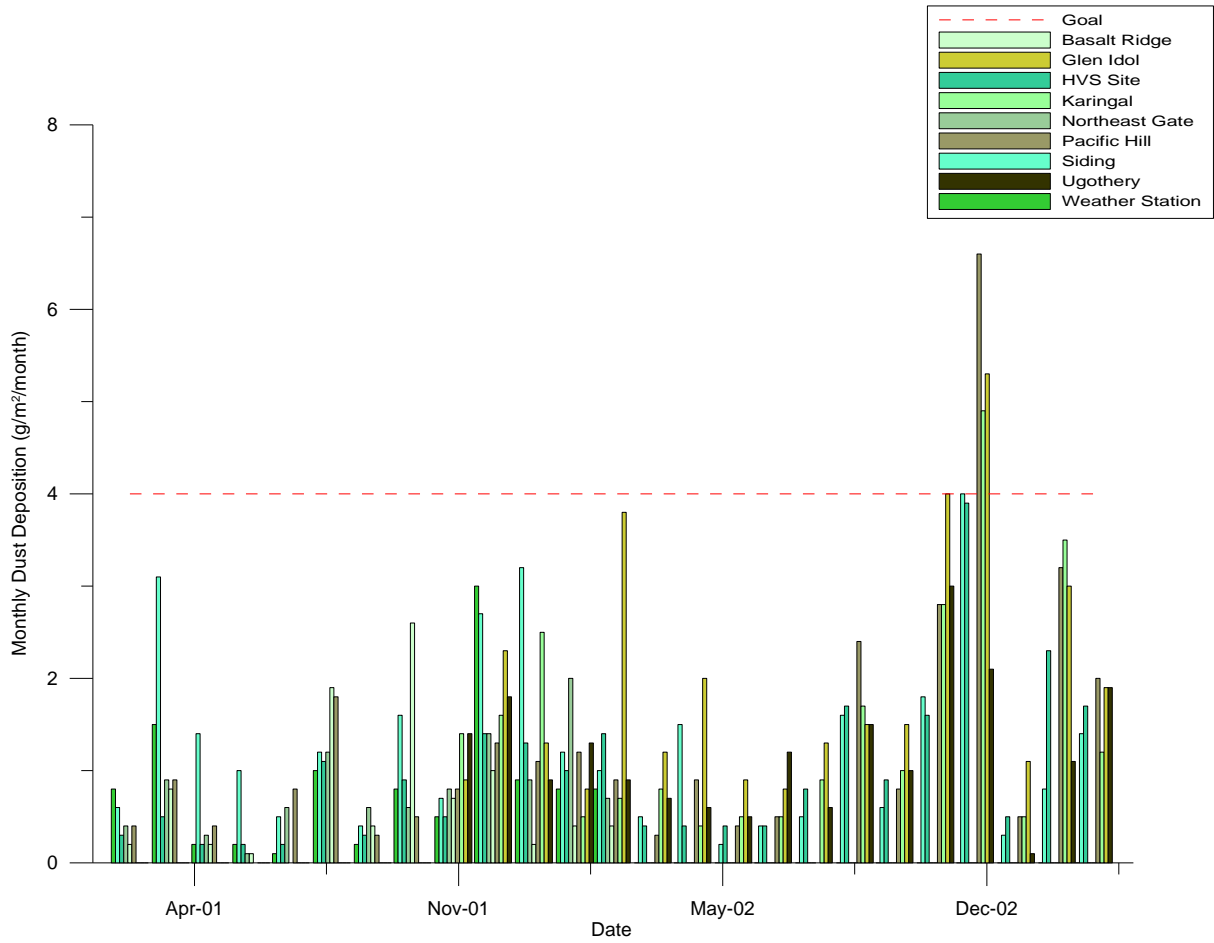
**Figure 15** Annual and seasonal wind roses for Dubbo Airport AWS (2008)



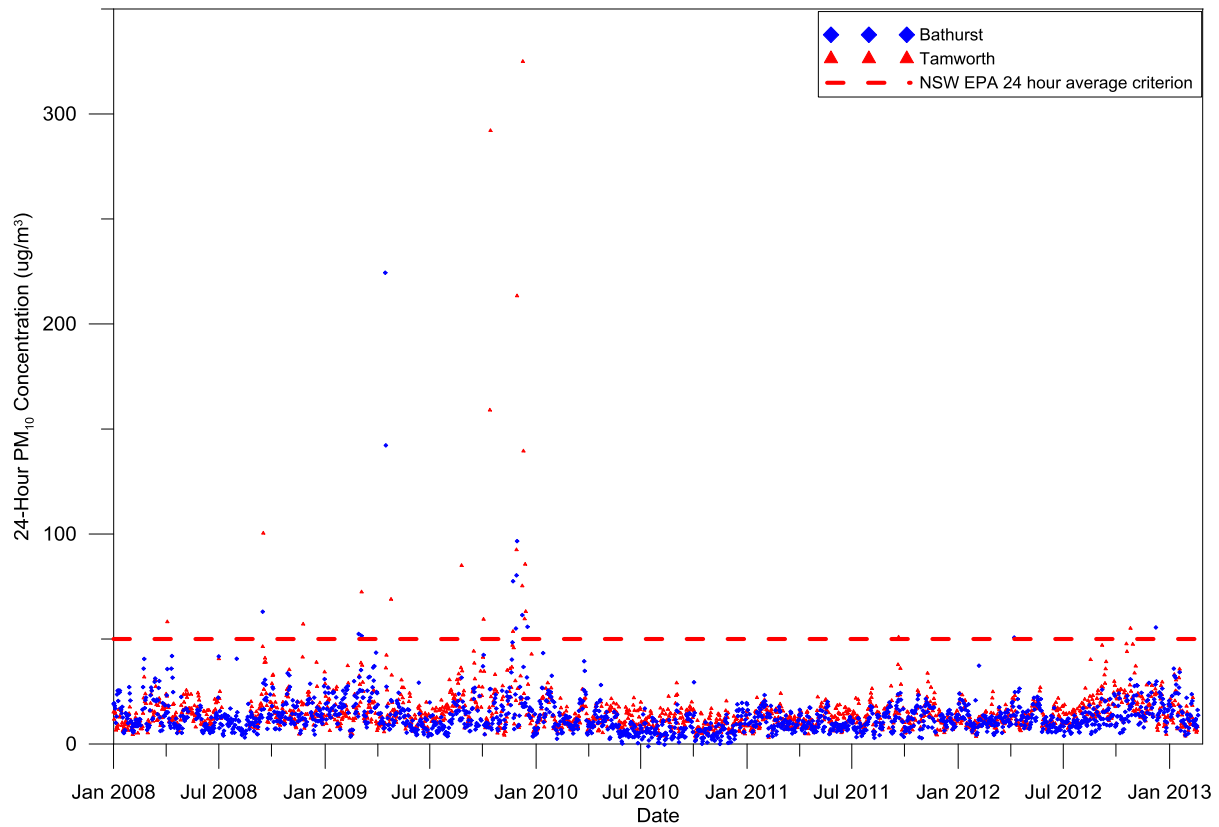


**Figure 16 Location of monitoring stations**

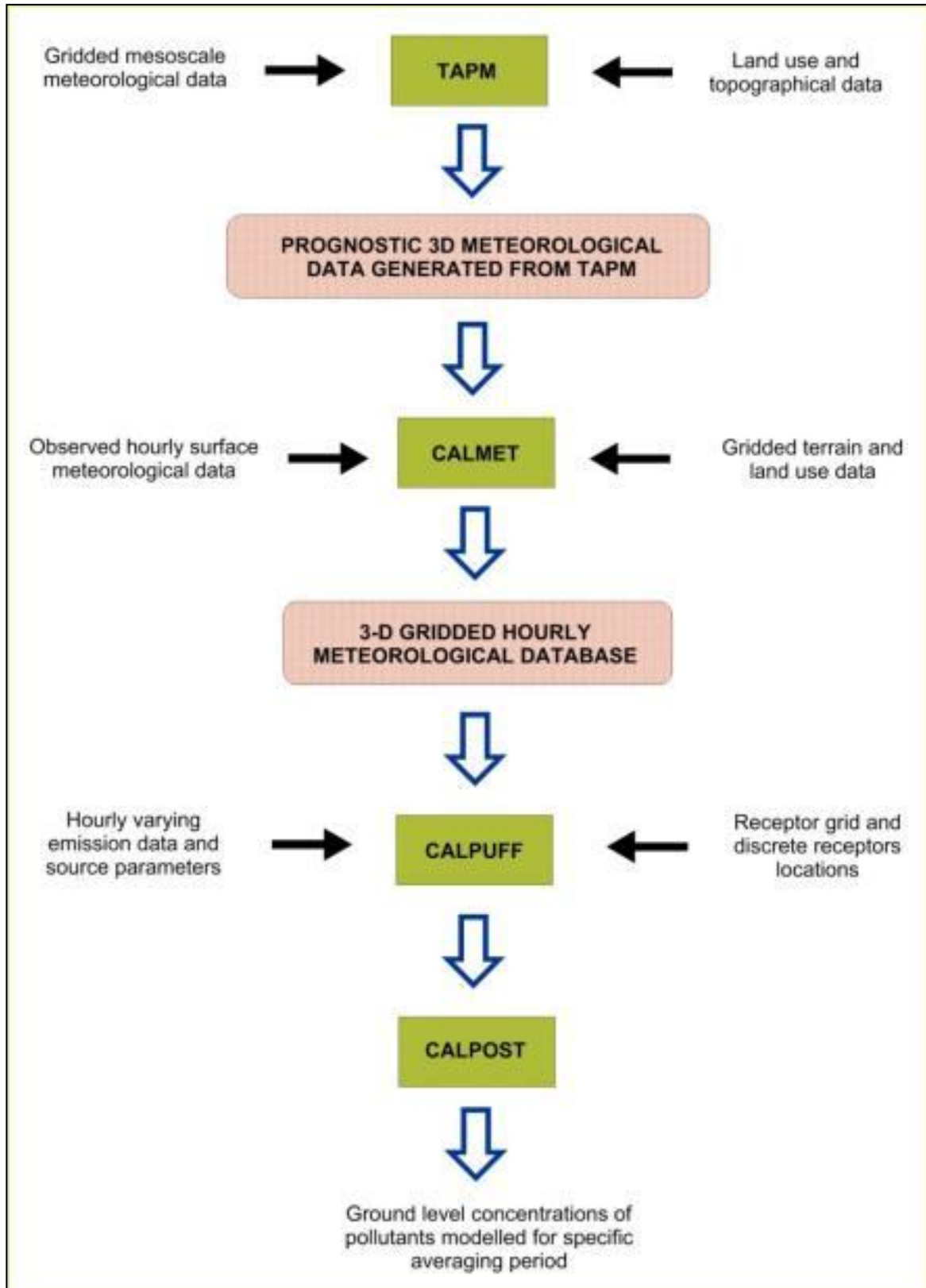




**Figure 17**      **Historical dust deposition data**

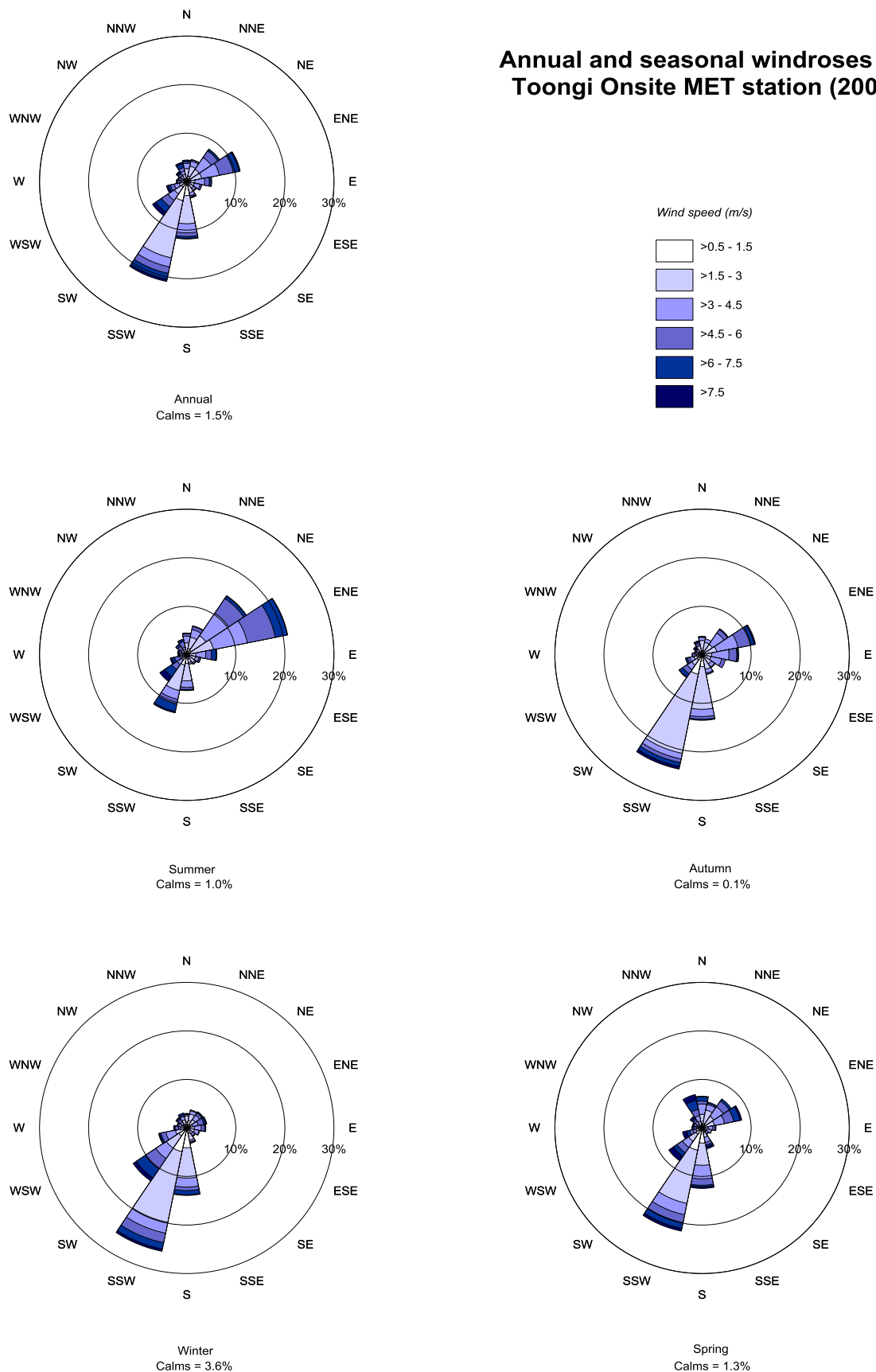


**Figure 18** Monitoring data for 24 hour average PM<sub>10</sub> concentrations



**Figure 19** CALMET/CALPUFF modelling system

### Annual and seasonal windroses for Toongi Onsite MET station (2008)



**Figure 20** Annual and seasonal wind roses for Toongi weather station and CALMET (2008)

### Annual and seasonal windroses for CALMET extract at Toongi Met Station (2008)



**Figure 20** Annual and seasonal wind roses for Toongi weather station and CALMET (2008)



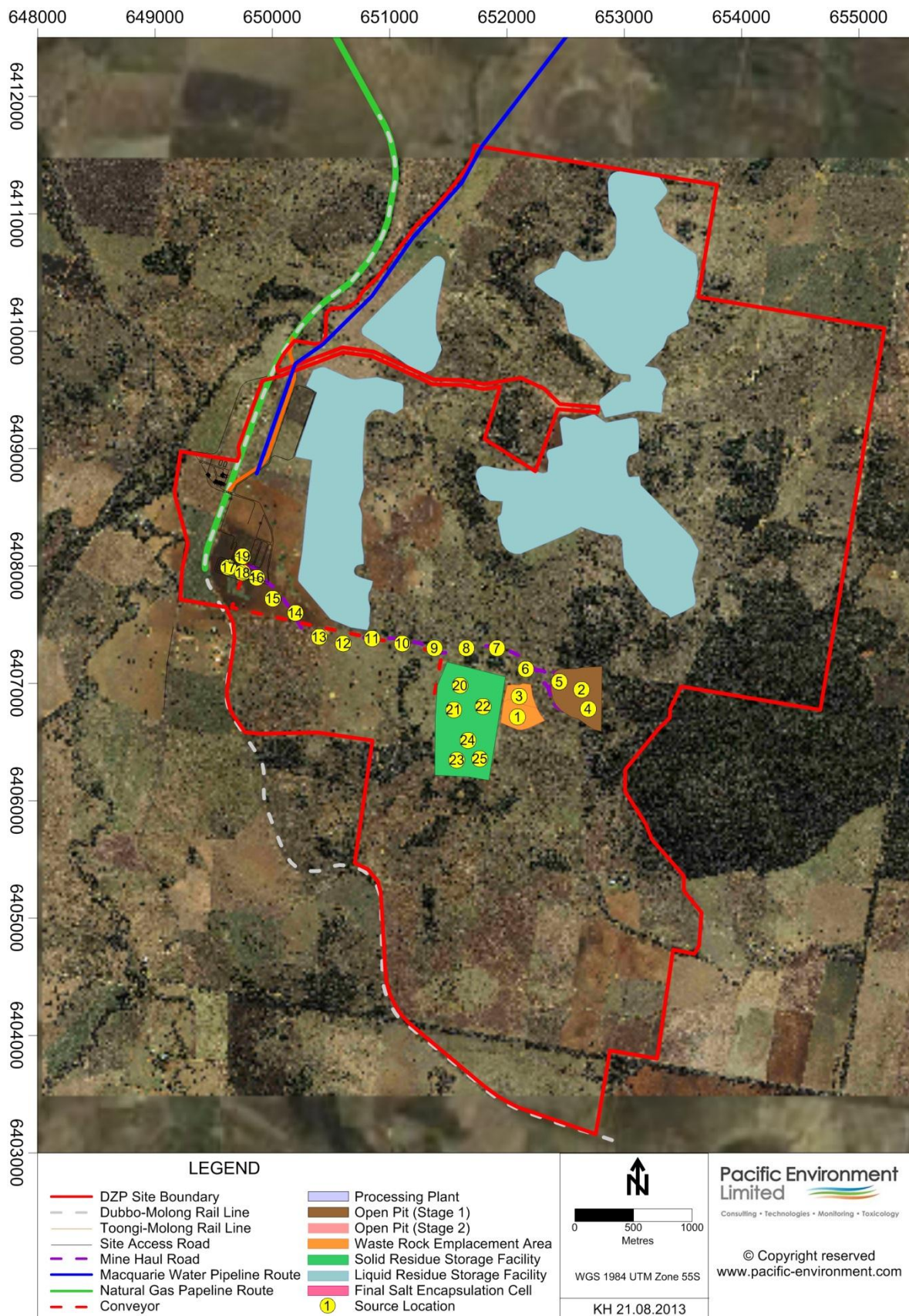
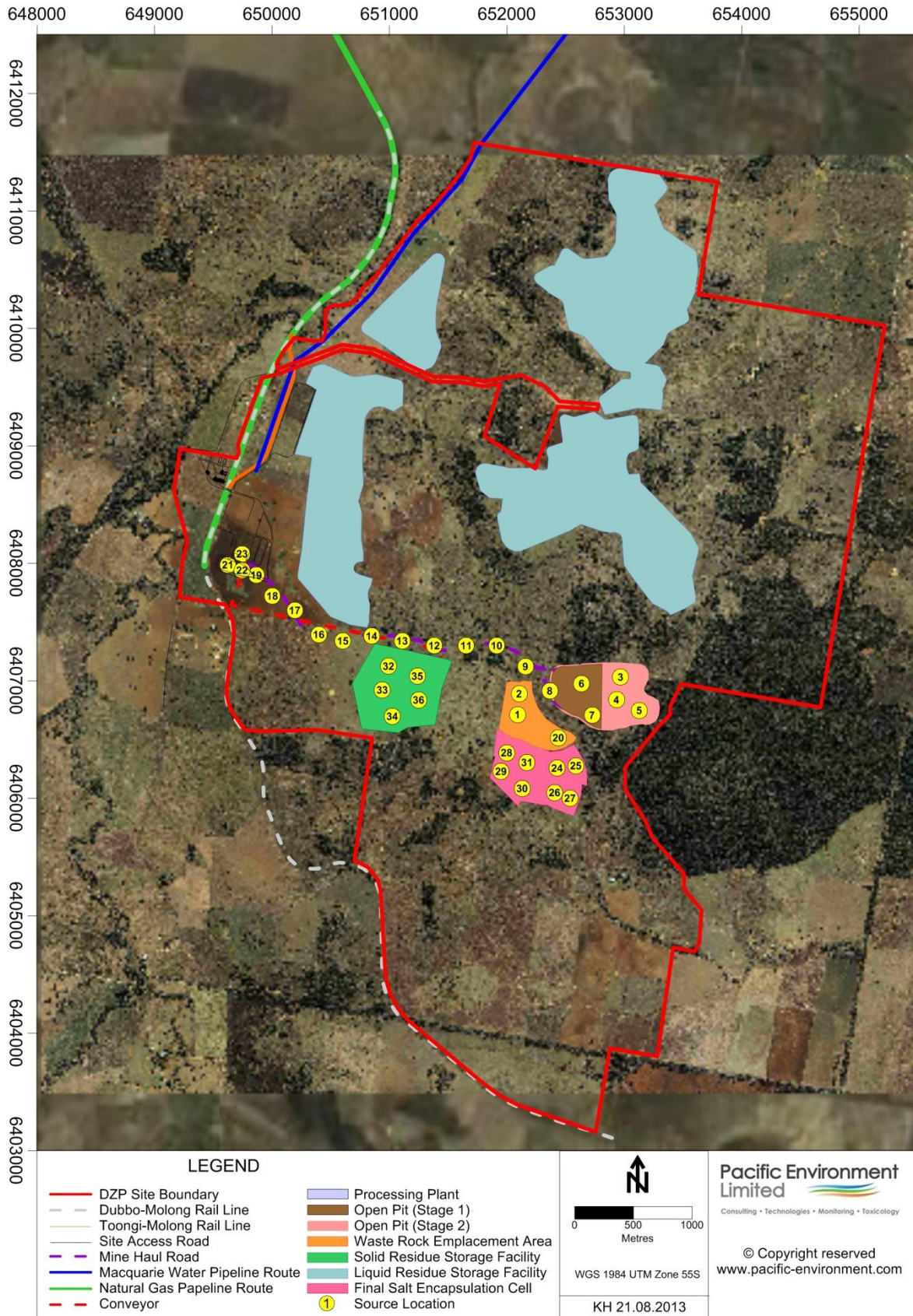


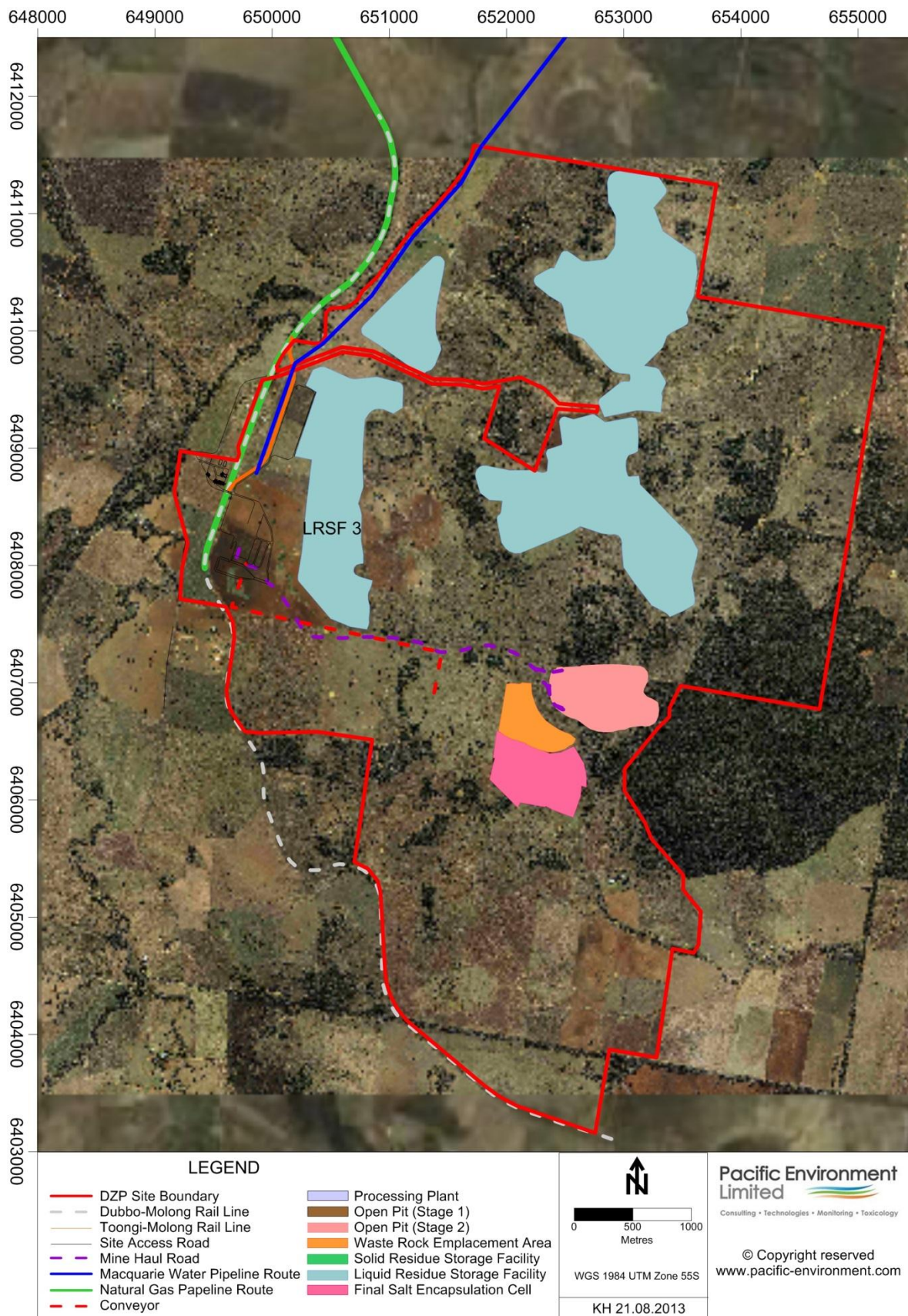
Figure 21 Source locations Year 5





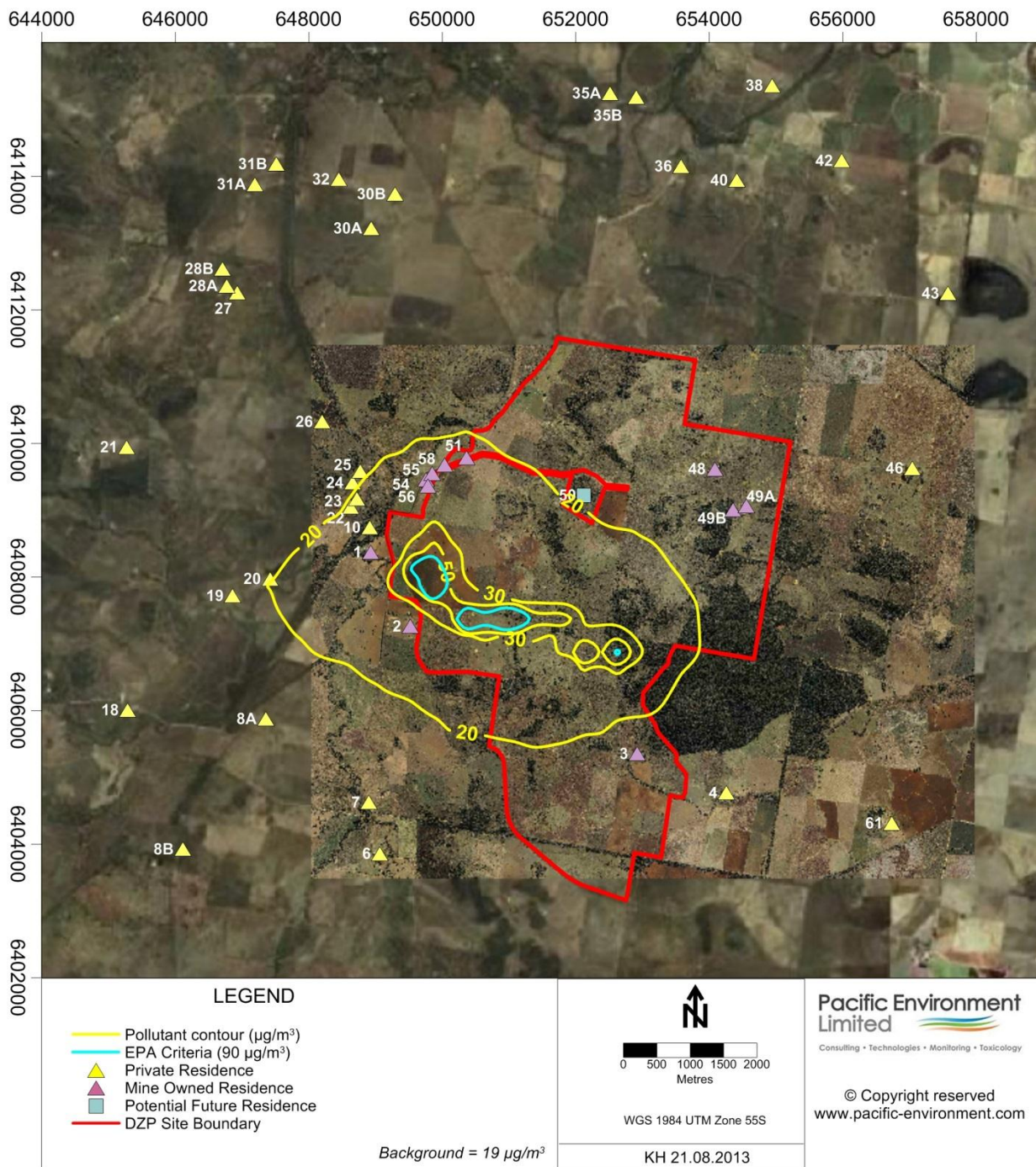
**Figure 22 Source locations Year 15**





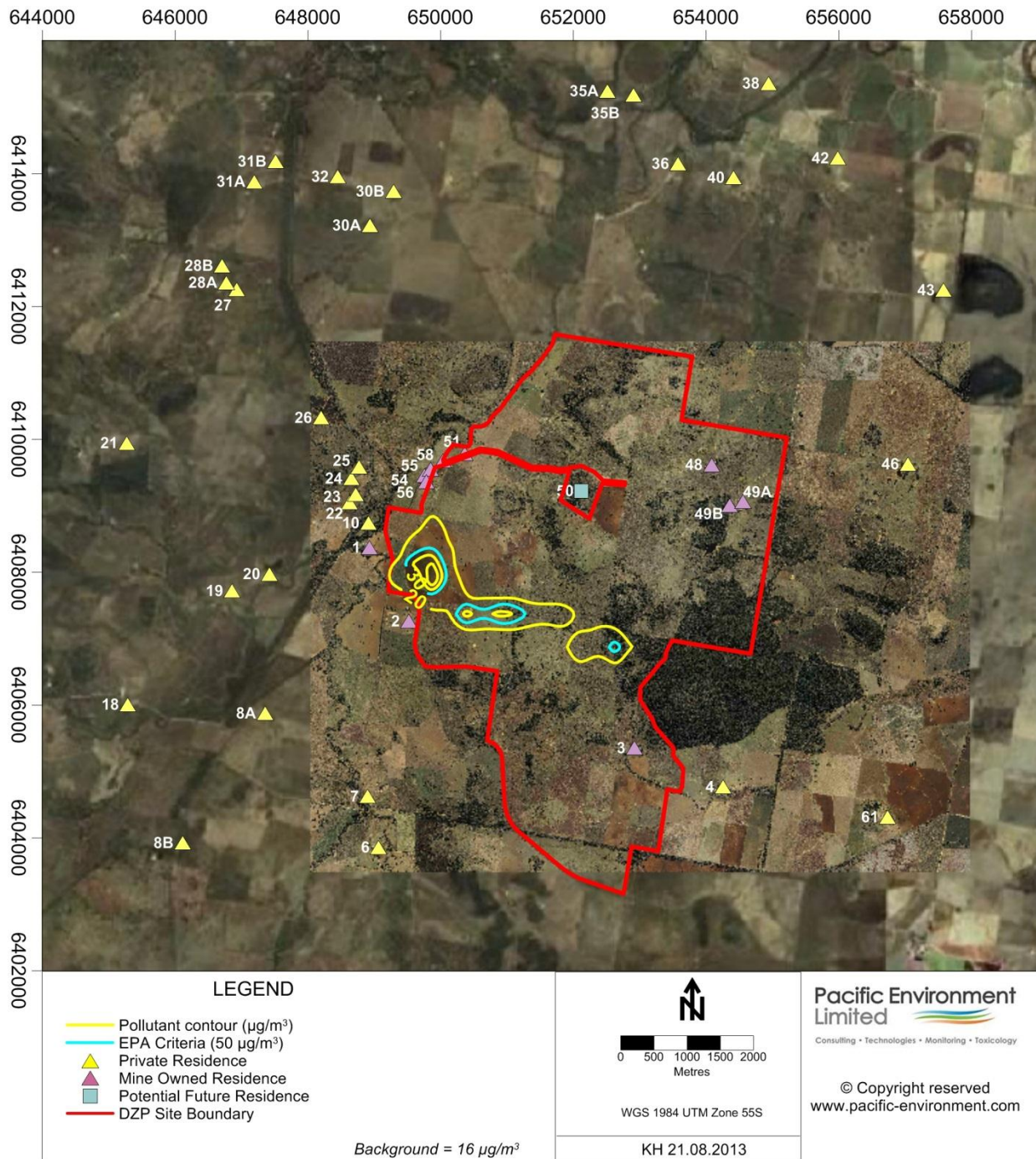
**Figure 23 LRSF – Year 15**





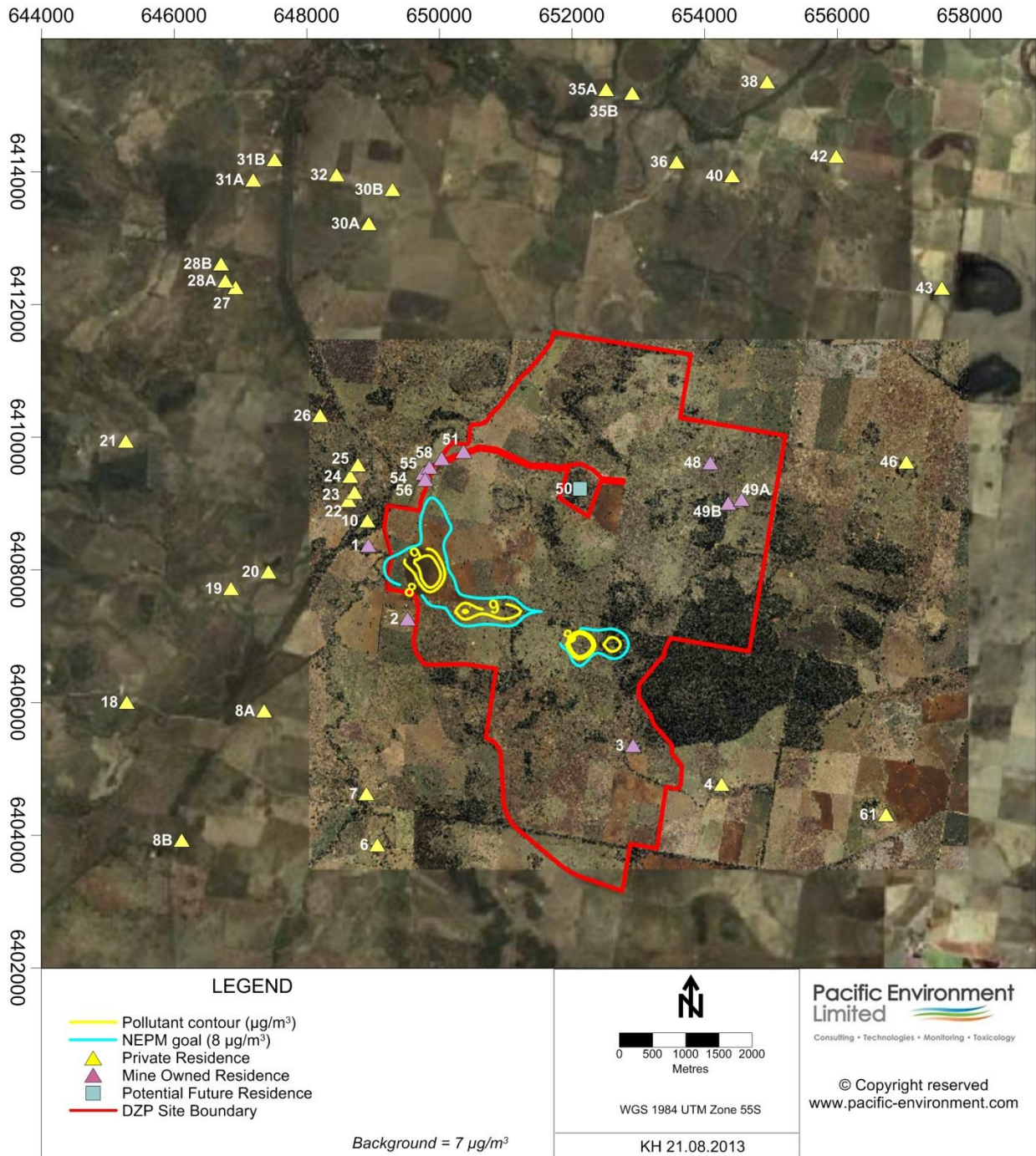
**Figure 24 Predicted cumulative annual average TSP concentrations – Year 5**





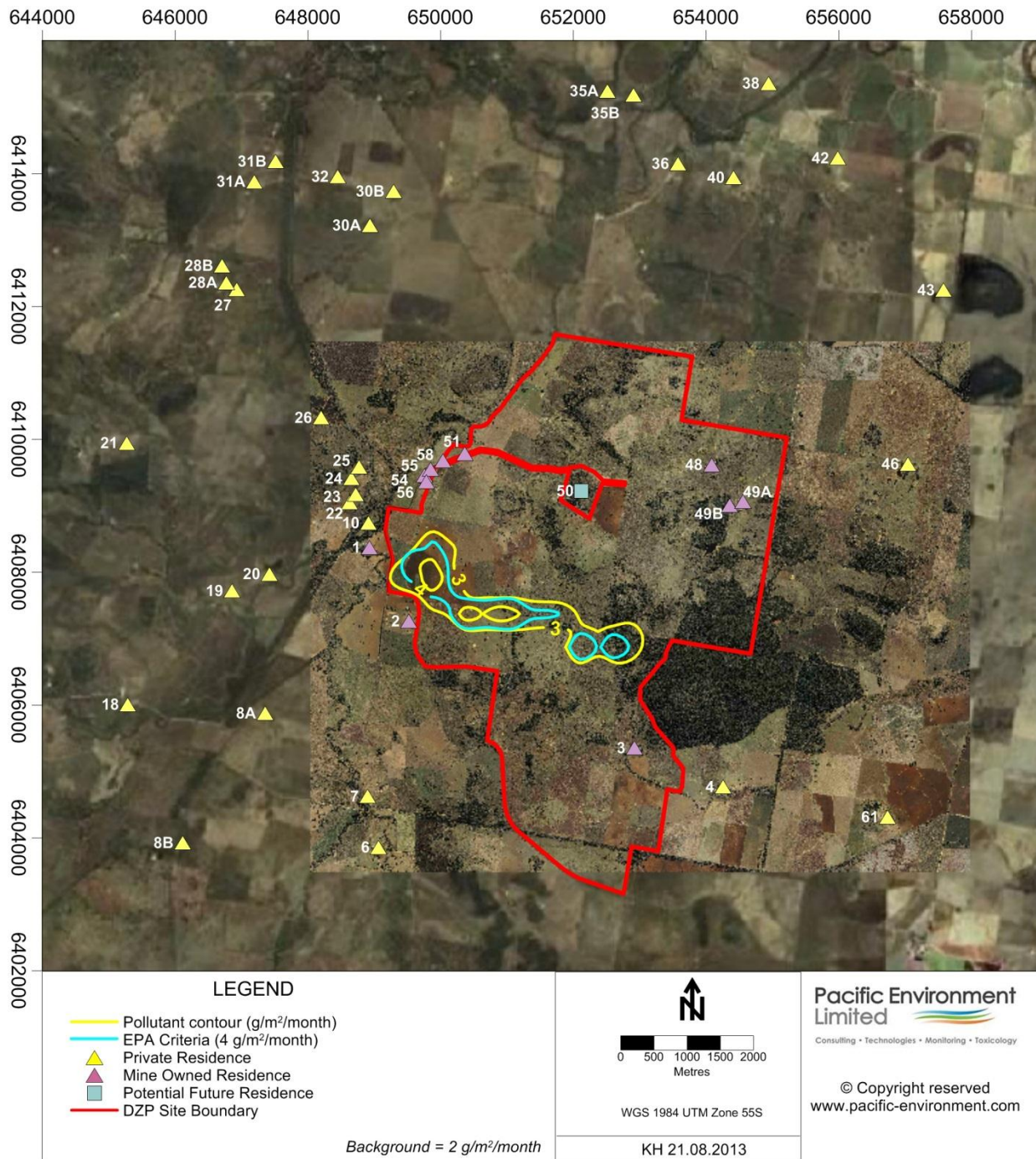
**Figure 25 Predicted cumulative annual average PM<sub>10</sub> concentrations – Year 5**





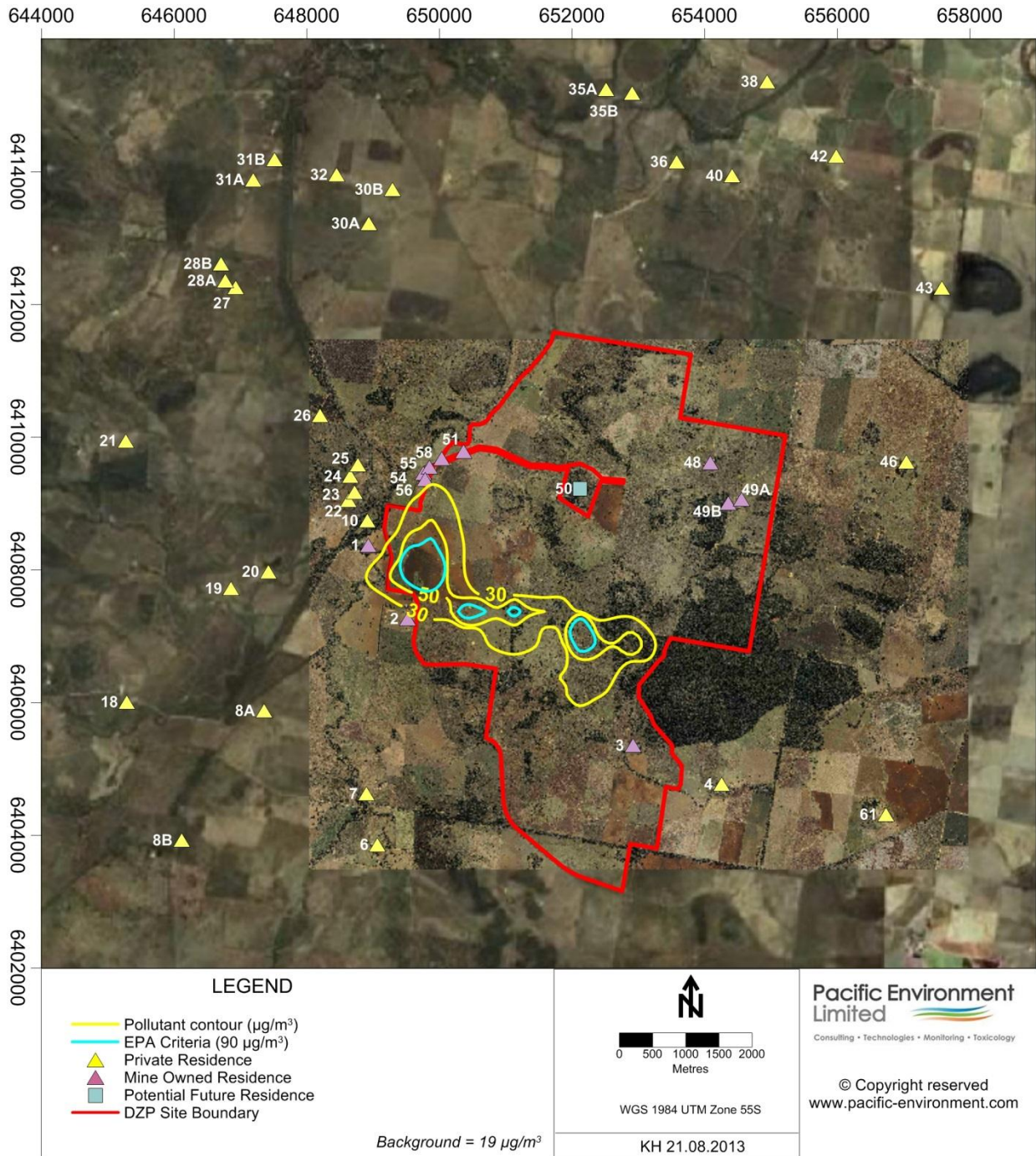
**Figure 26 Predicted cumulative annual average  $\text{PM}_{2.5}$  concentrations – Year 5**





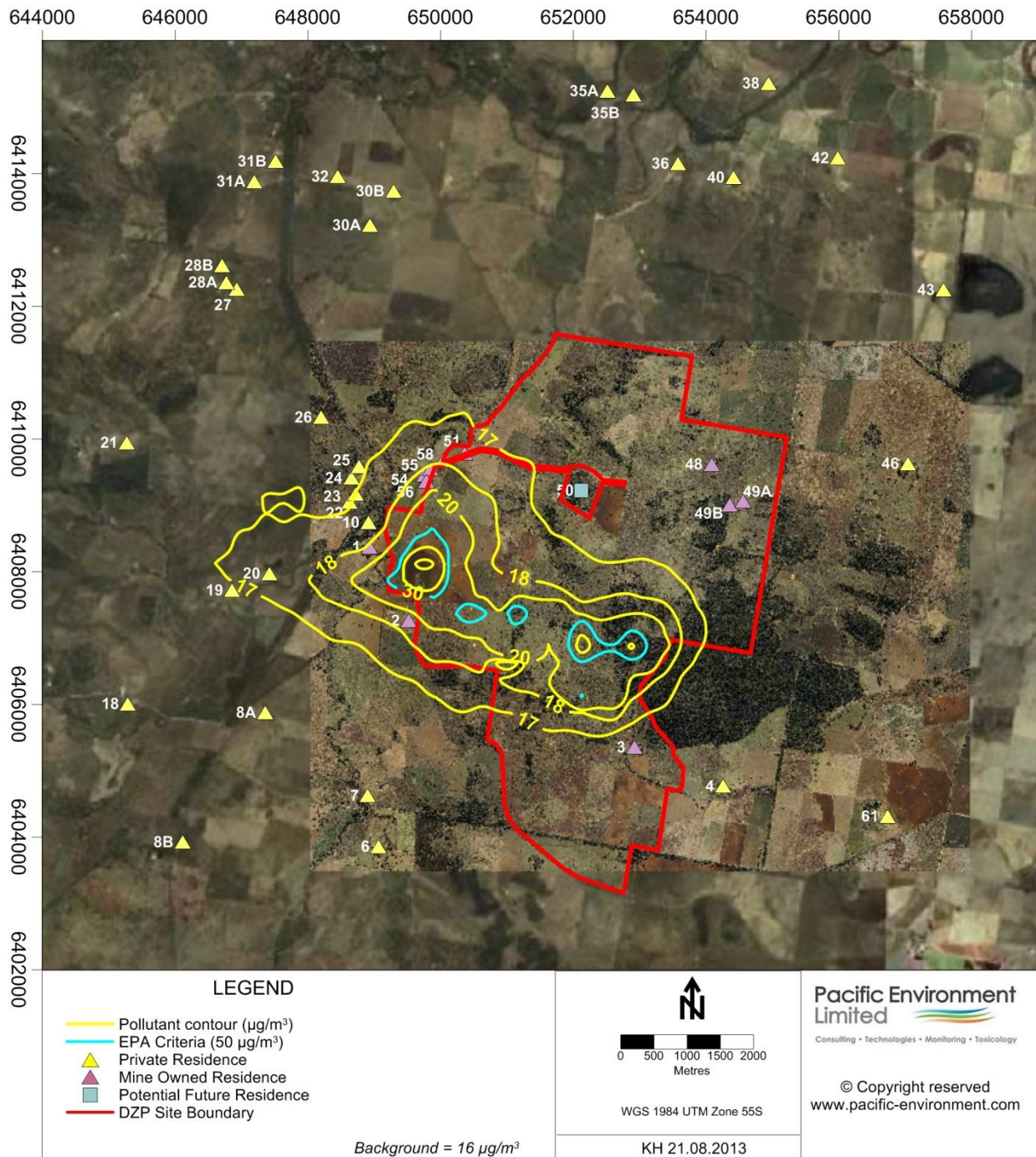
**Figure 27 Predicted cumulative annual average dust deposition – Year 5**





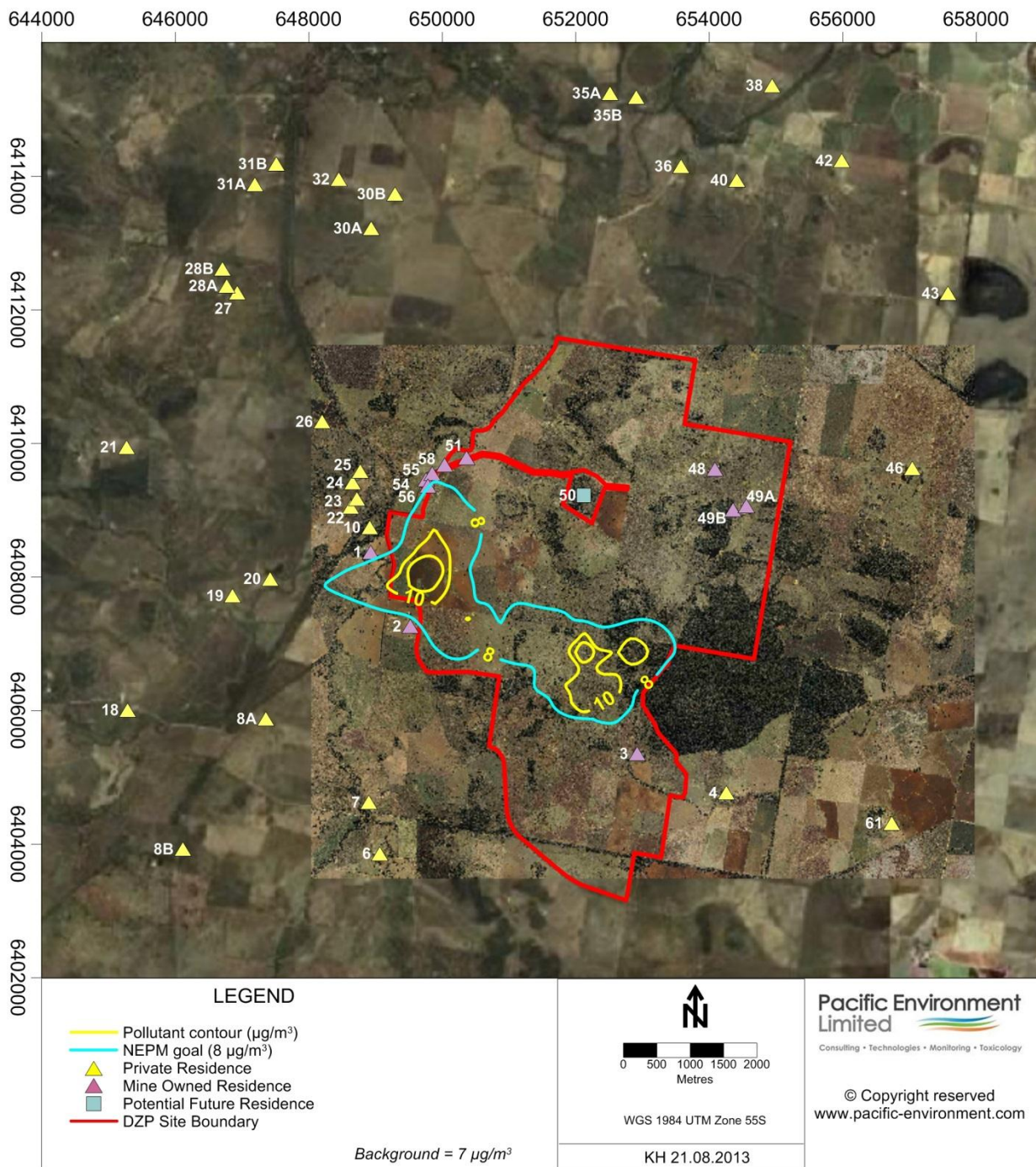
**Figure 28 Predicted cumulative annual average TSP concentrations – Year 15**





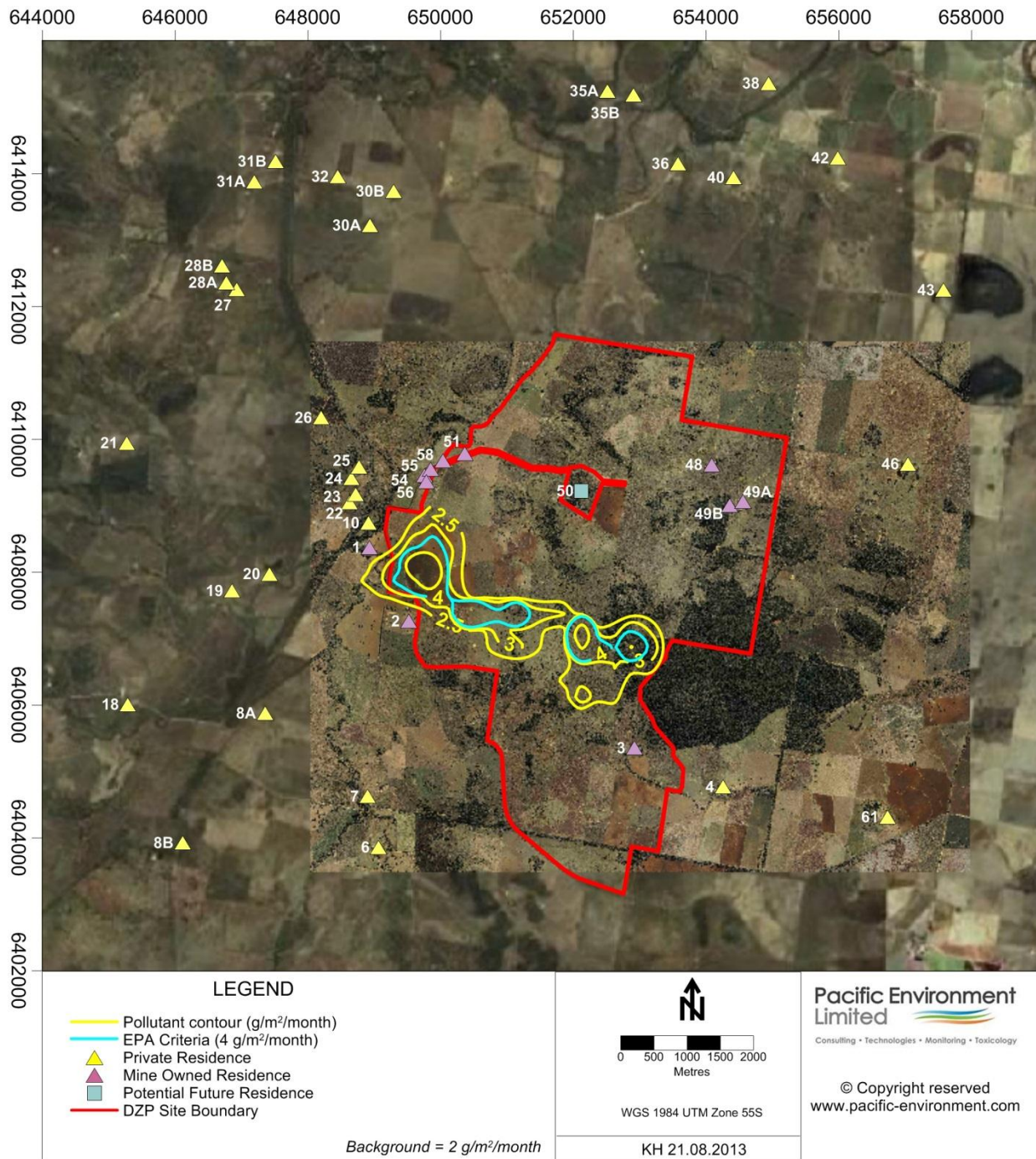
**Figure 29 Predicted cumulative annual average  $\text{PM}_{10}$  concentrations – Year 15**





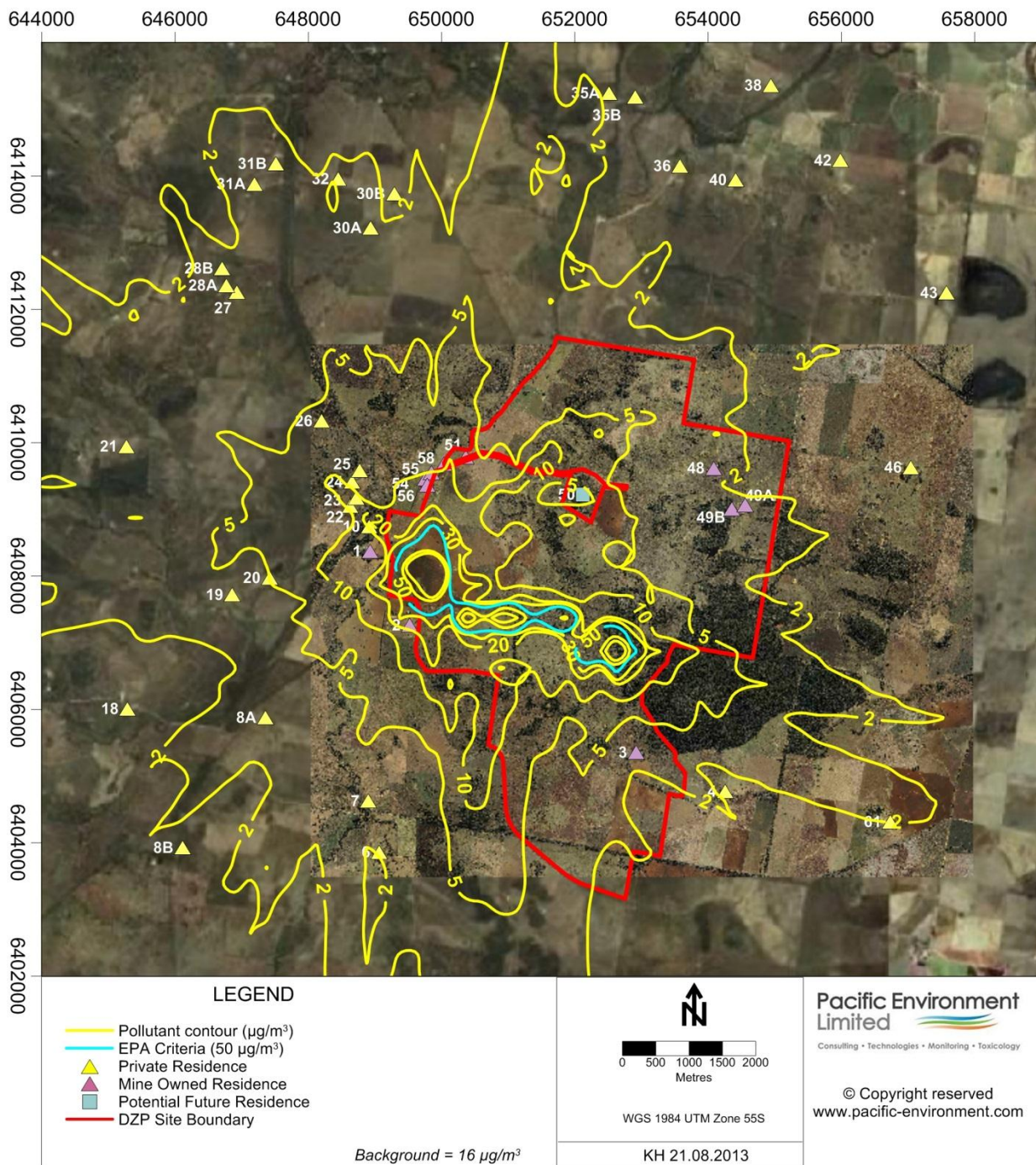
**Figure 30 Predicted cumulative annual average PM<sub>2.5</sub> concentrations – Year 15**





**Figure 31 Predicted cumulative annual average dust deposition – Year 15**





**Figure 32 Predicted maximum incremental 24 hour average  $\text{PM}_{10}$  concentrations – Year 5**



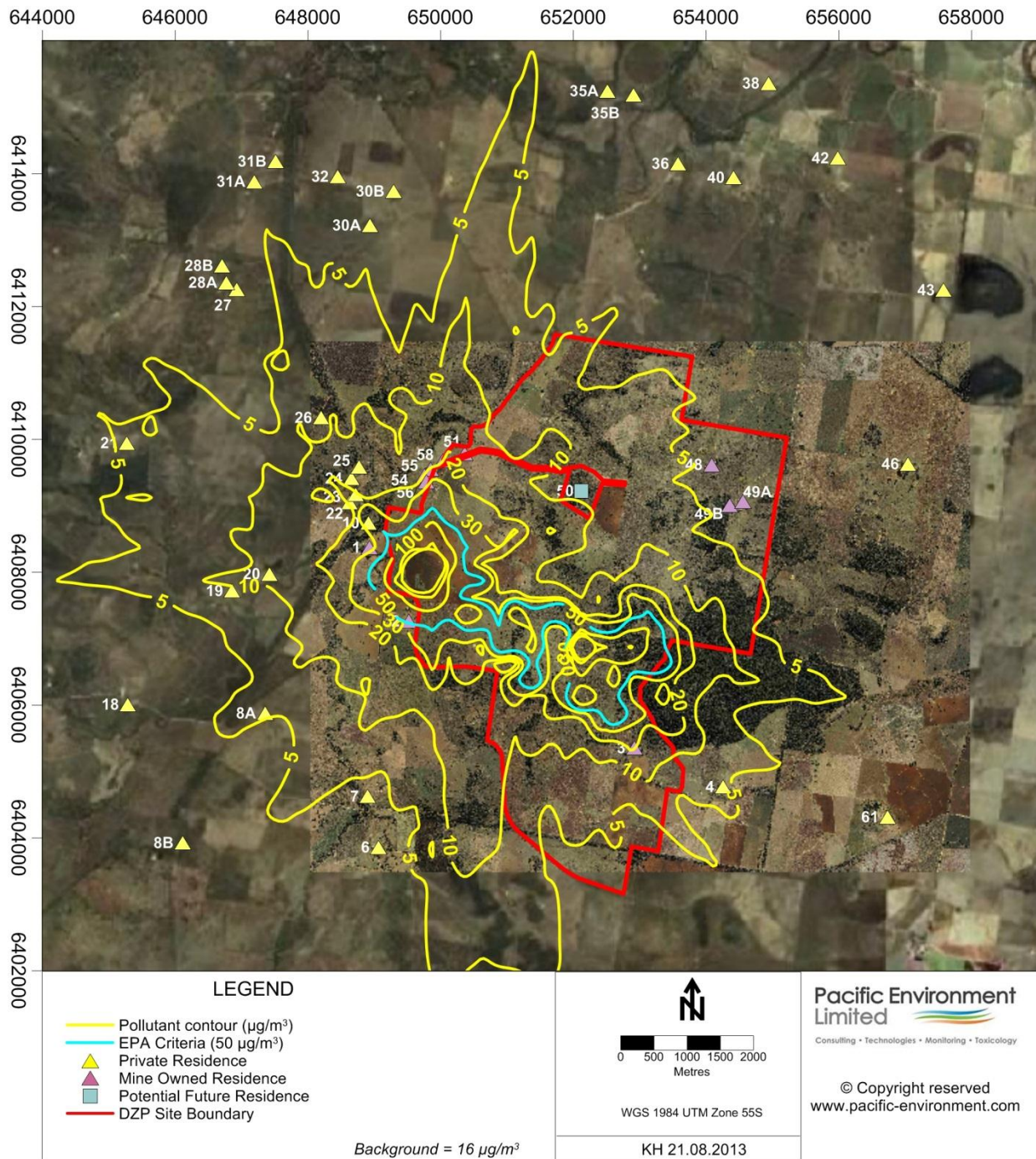
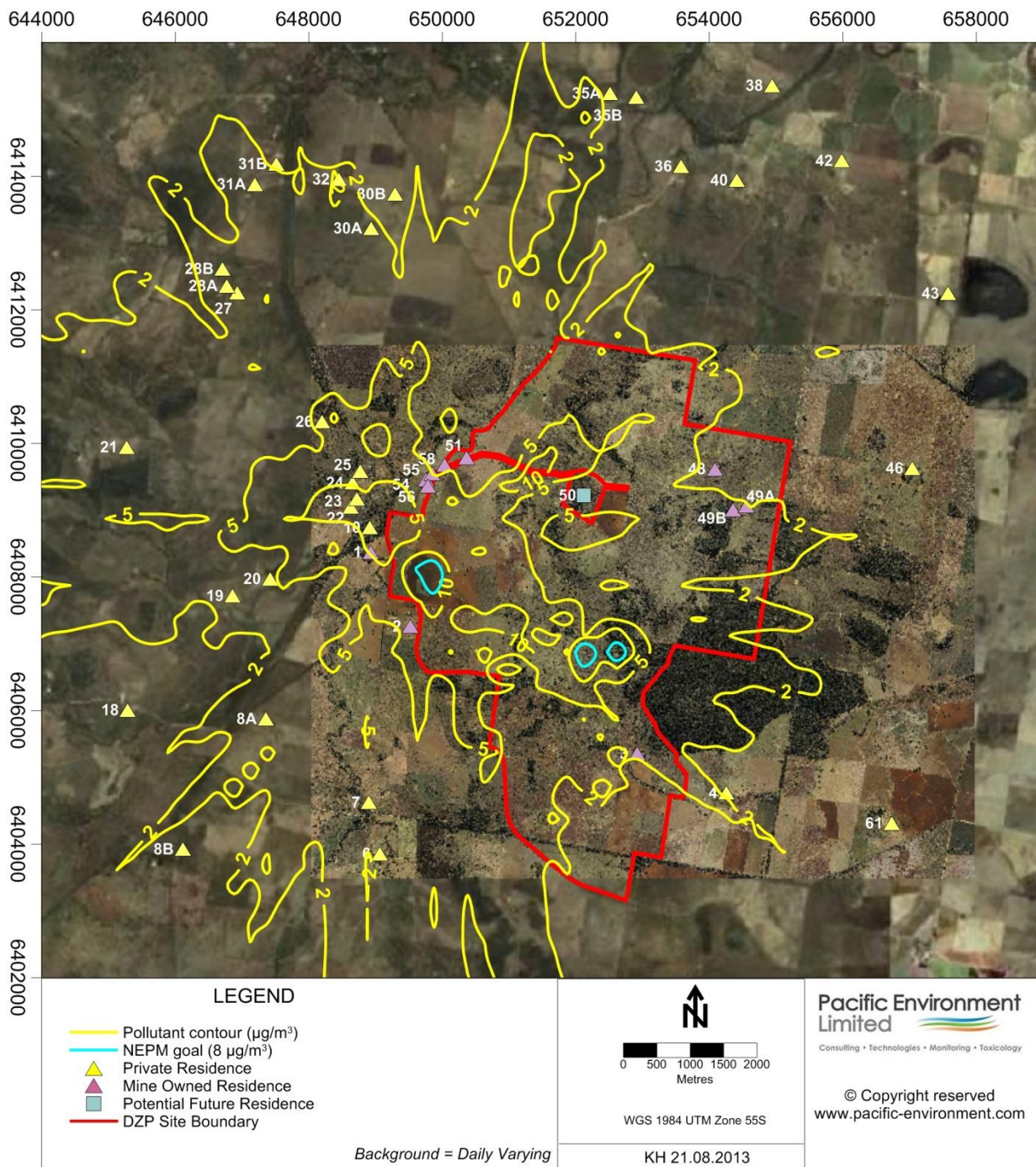


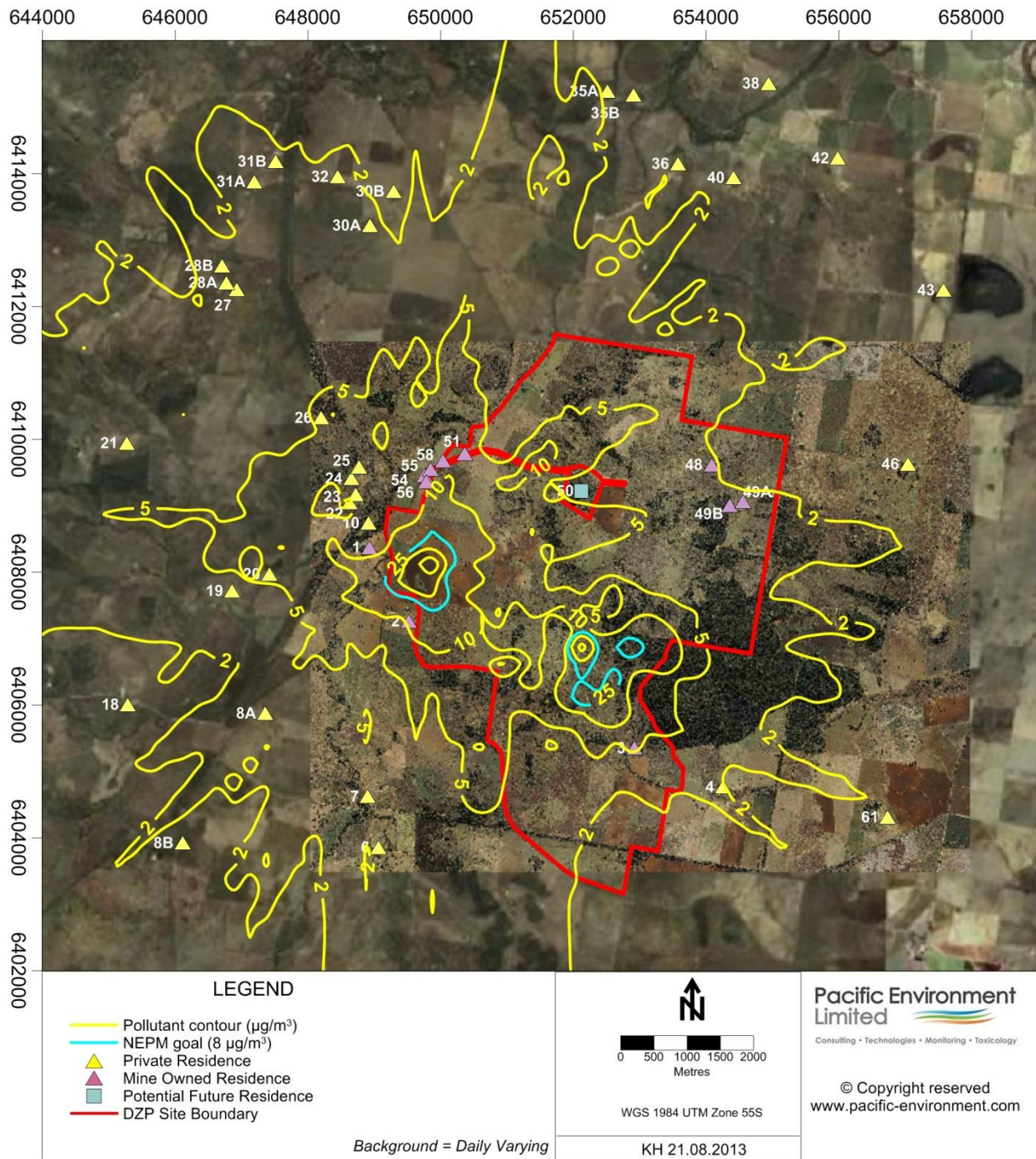
Figure 33 Predicted maximum incremental 24 hour average  $\text{PM}_{10}$  concentrations – Year 15



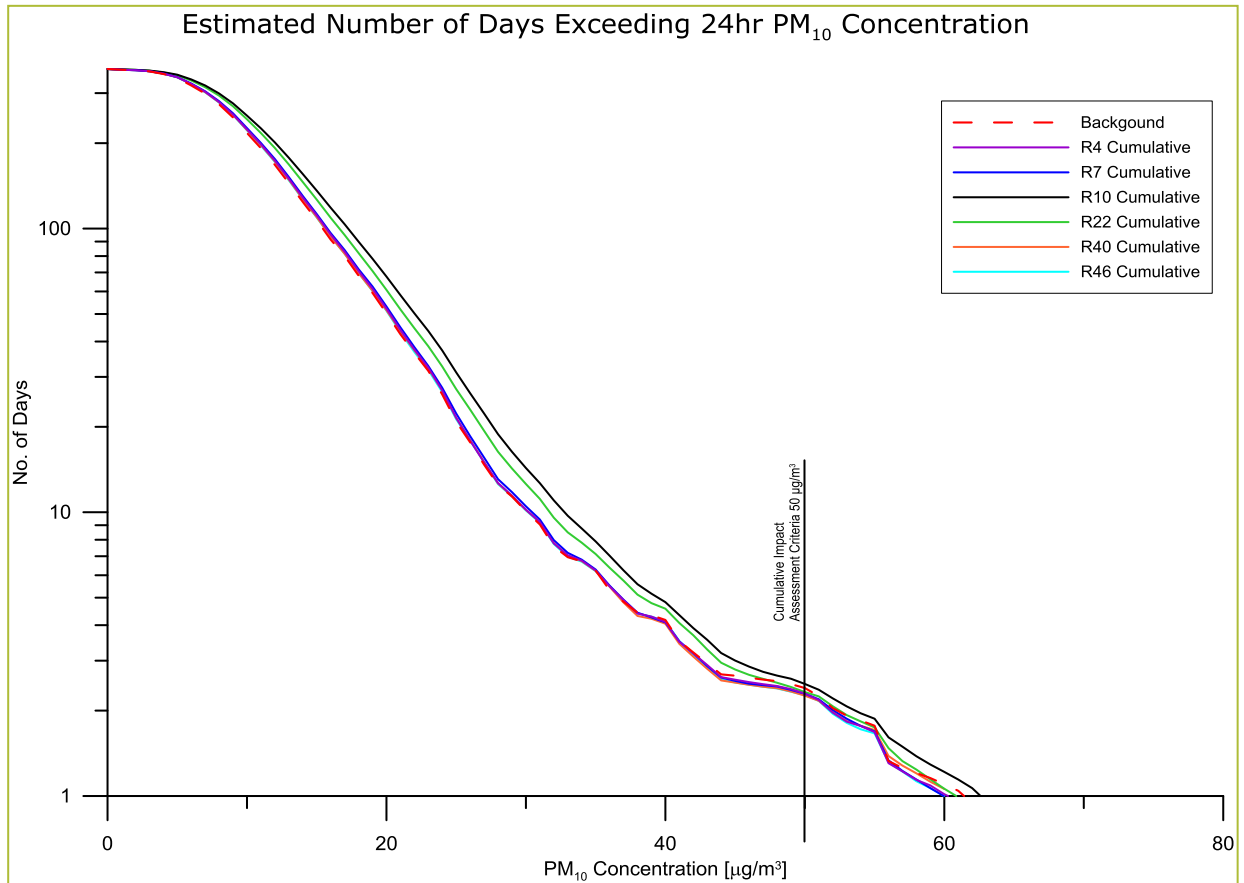


**Figure 34** Predicted maximum incremental 24 hour average  $\text{PM}_{2.5}$  concentrations – Year 5



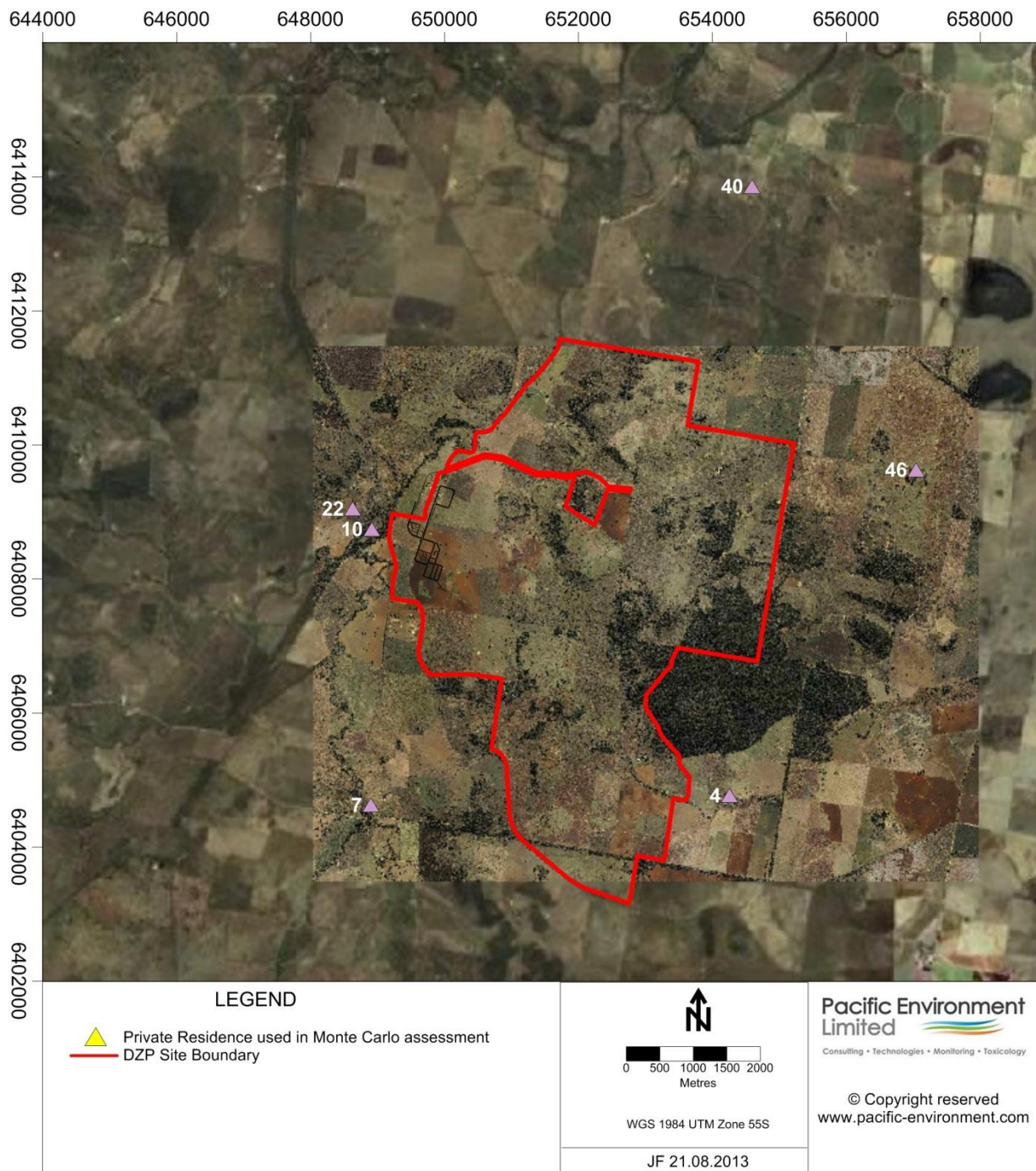


**Figure 35** Predicted maximum incremental 24 hour average  $\text{PM}_{2.5}$  concentrations – Year 15



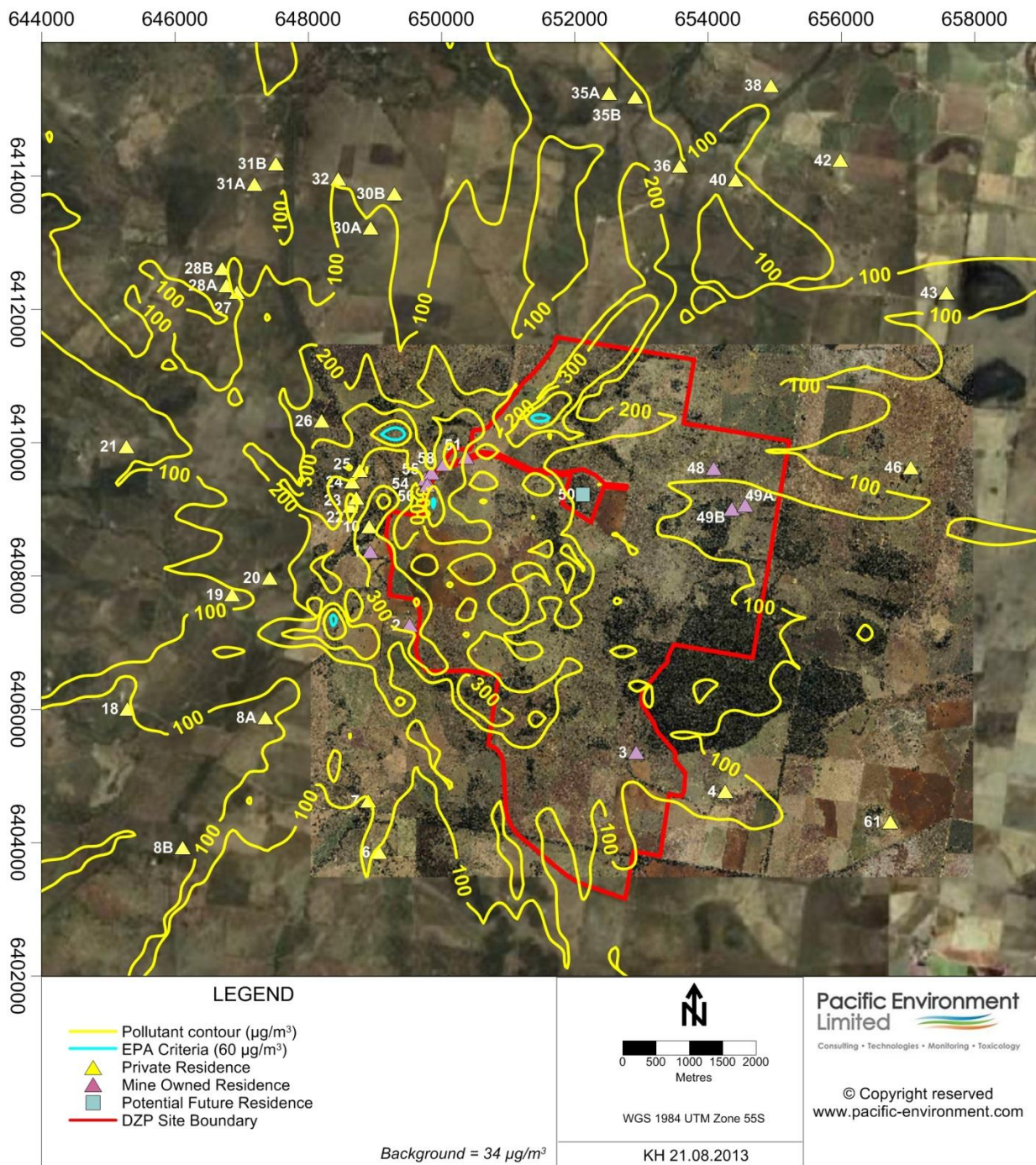
**Figure 36 Year 15 Receptors 4, 7, 10, 22, 40 and 46 – Frequency distribution of cumulative 24-hr PM<sub>10</sub> concentration using Monte Carlo Simulation**





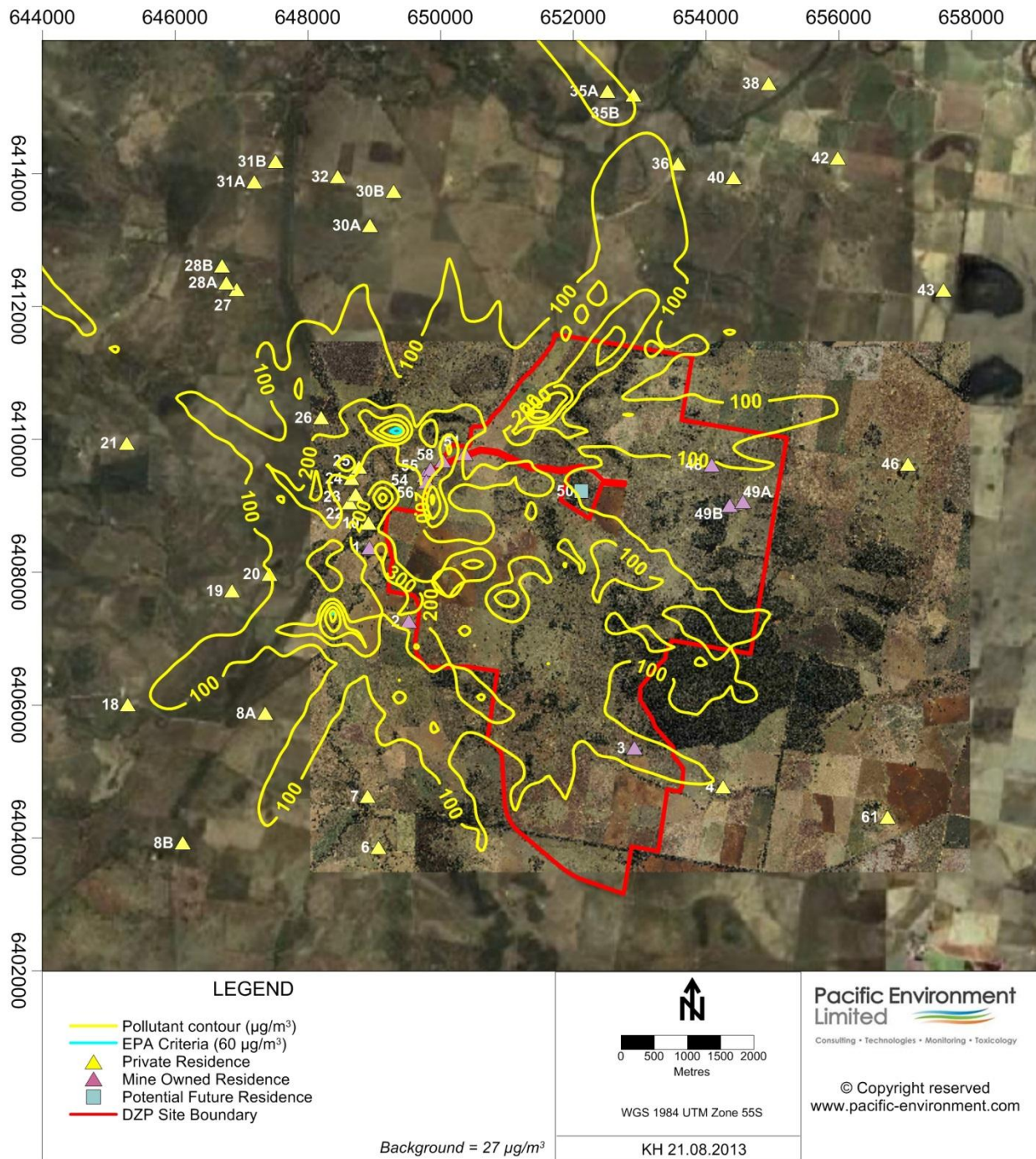
**Figure 37** Selected Receptors for 24 hour PM<sub>10</sub> cumulative analysis





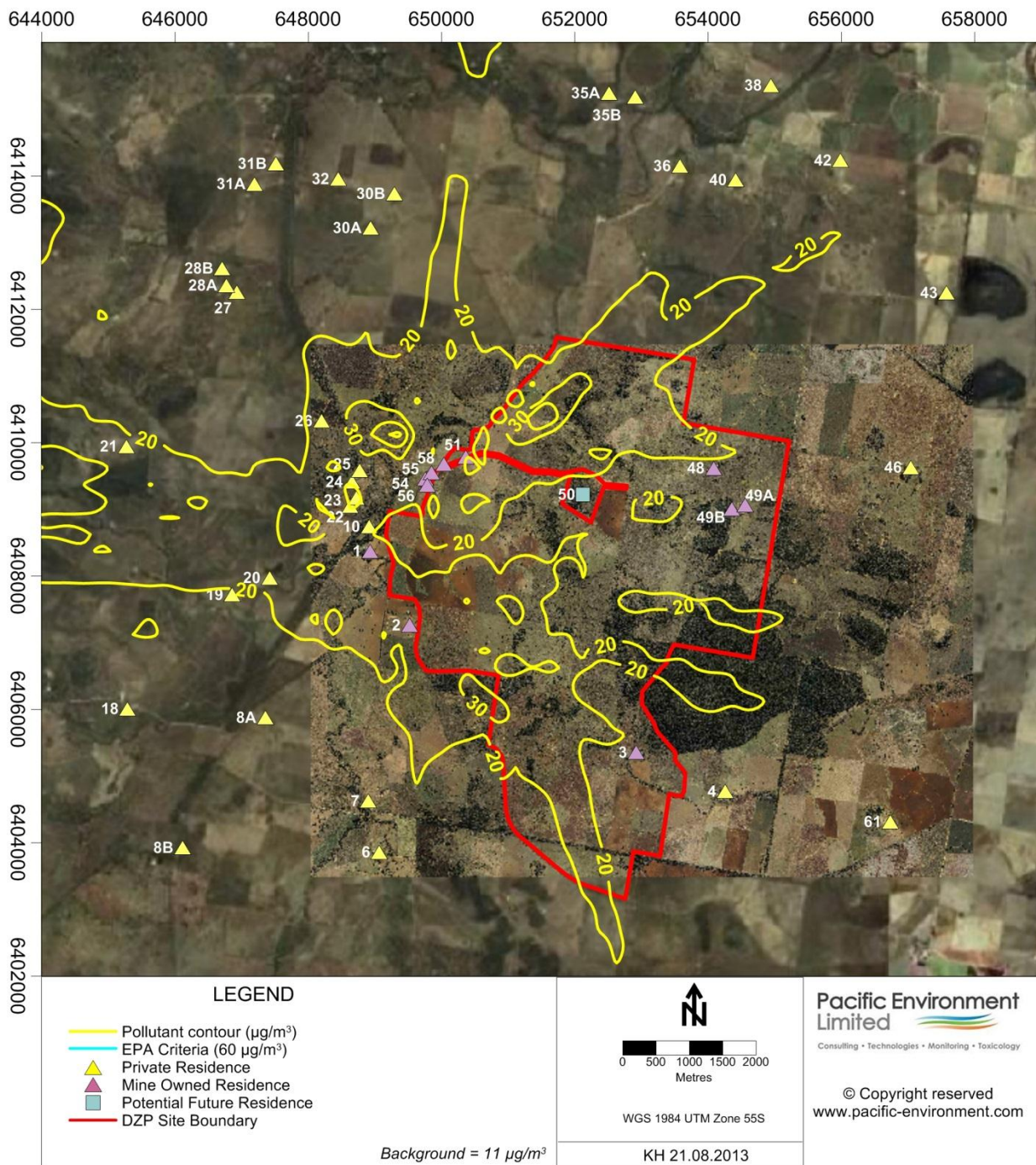
**Figure 38 Predicted cumulative maximum 10 minute SO<sub>2</sub> concentrations – Year 15**





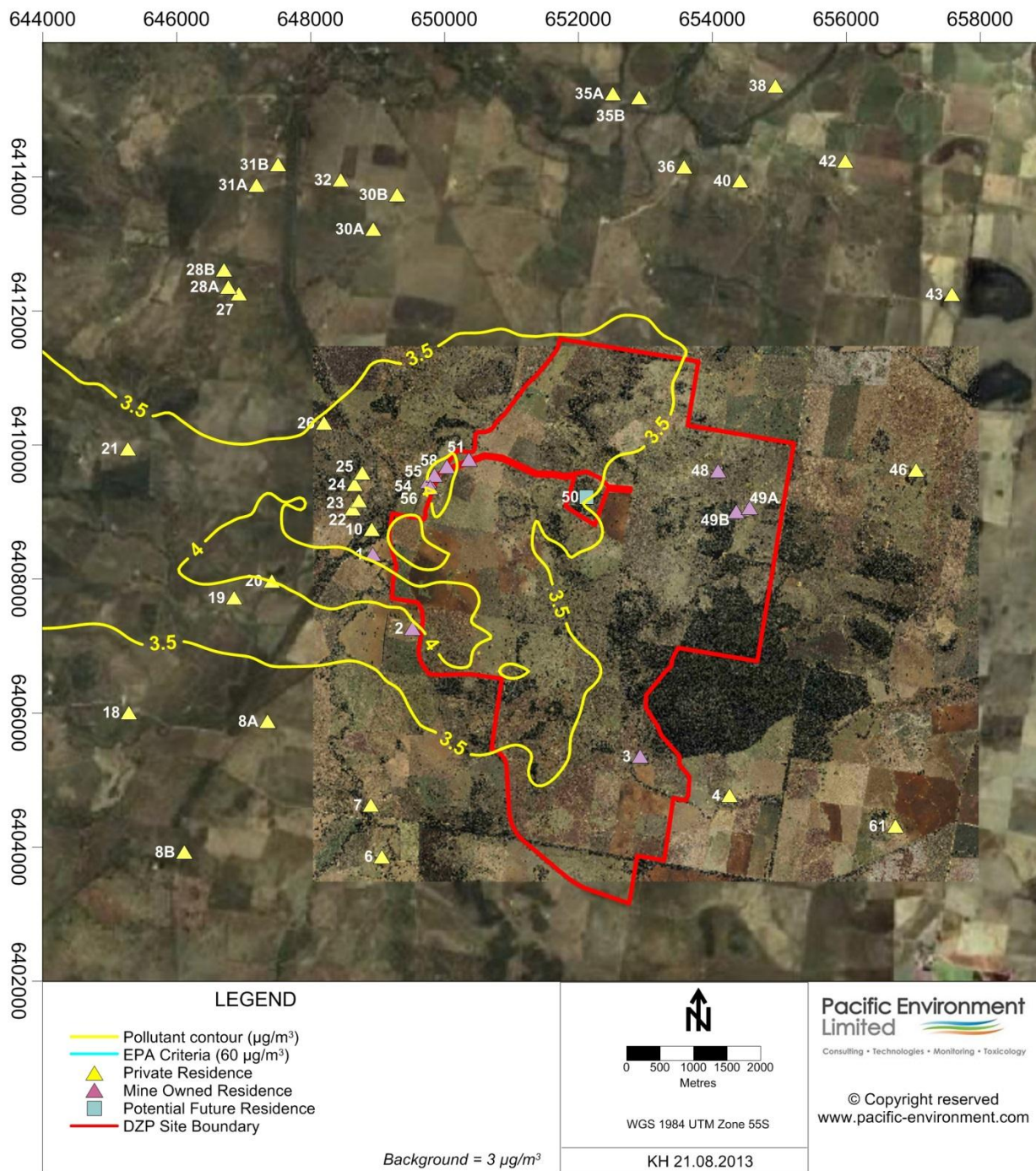
**Figure 39 Predicted cumulative maximum 1 hour SO<sub>2</sub> concentrations – Year 15**





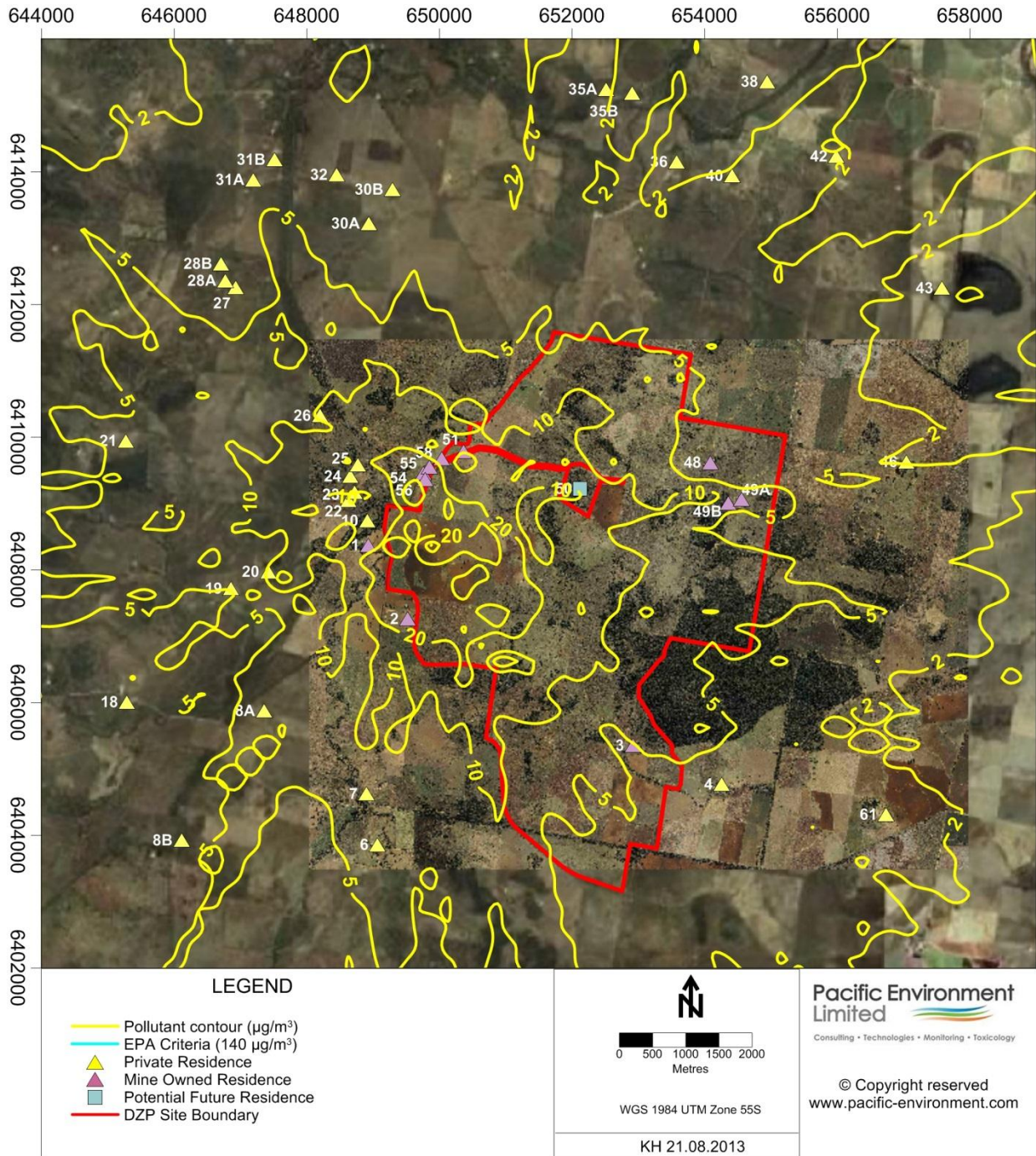
**Figure 40 Predicted cumulative maximum 24 hour  $\text{SO}_2$  concentrations – Year 15**





**Figure 41 Predicted cumulative annual average SO<sub>2</sub> concentrations – Year 15**





**Figure 42 Predicted HCl concentrations – Year 15**



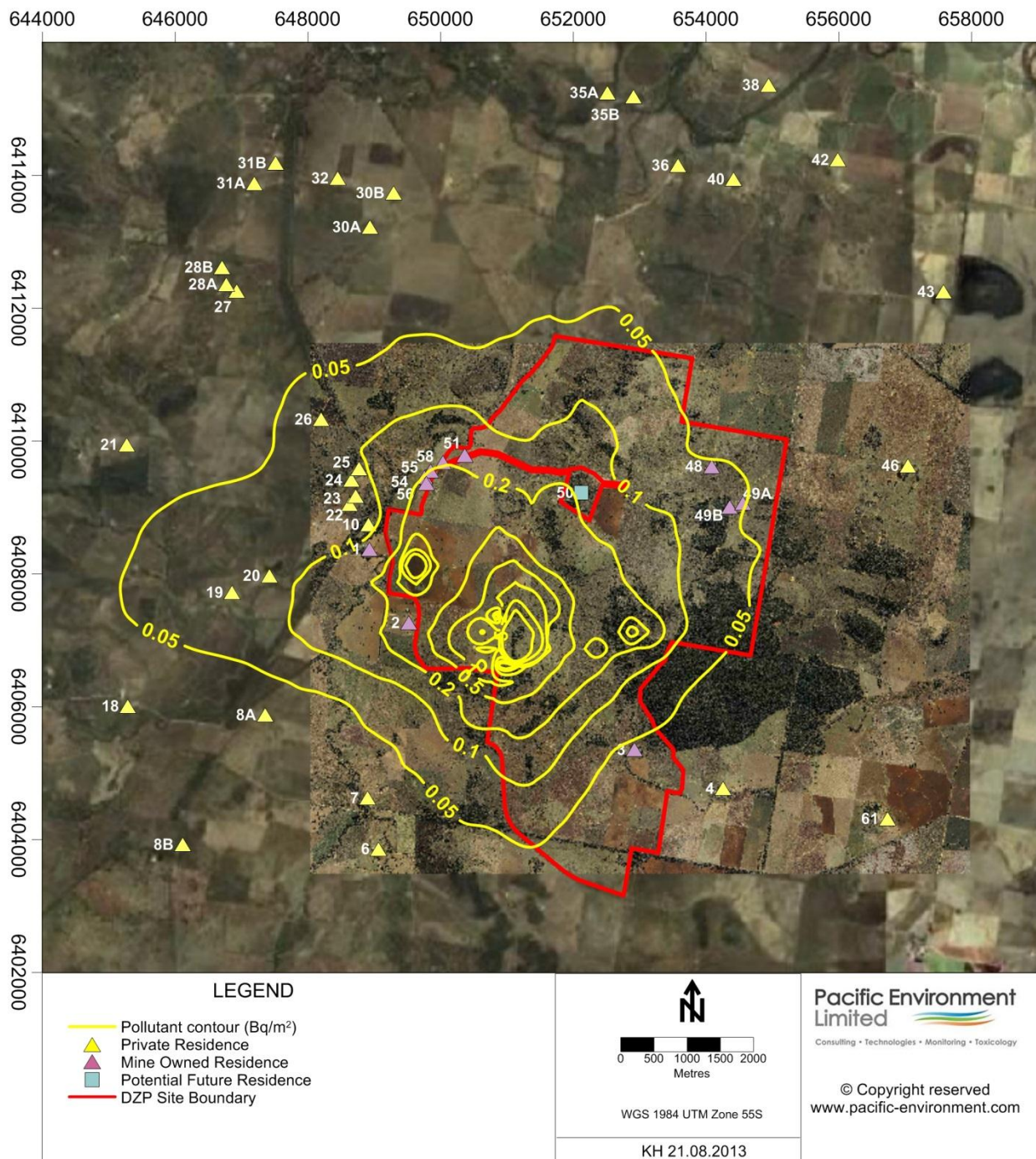
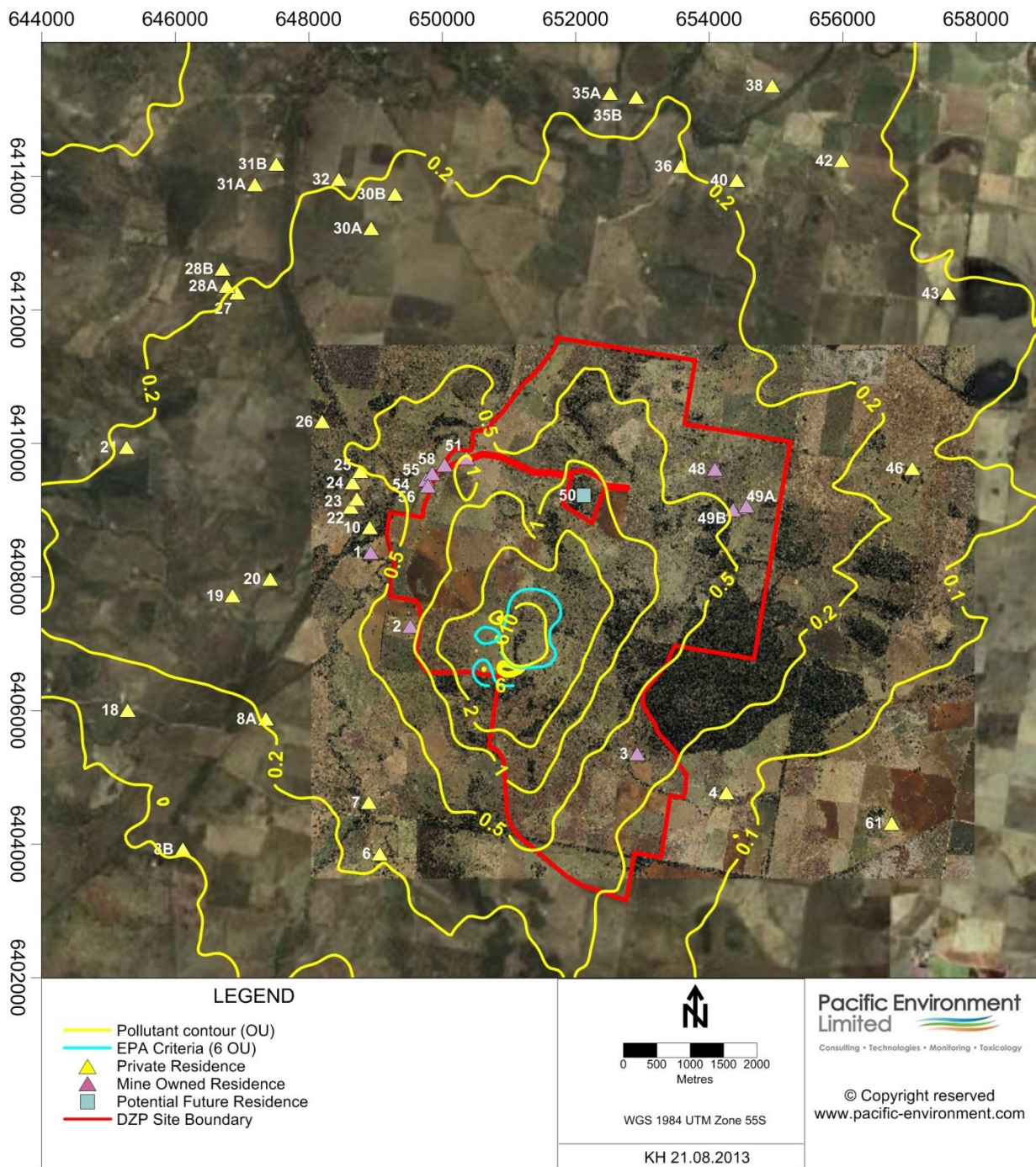


Figure 43 Predicted Radon concentrations – Year 15





**Figure 44 Predicted Odour concentrations – Year 15**

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# ***APPENDICES***

(No. of pages excluding this page = 40)

- |                   |   |
|-------------------|---|
| <b>Appendix 1</b> | <b>Detailed receptor information</b>          |
| <b>Appendix 2</b> | <b>CALMET and TAPM input file parameters*</b> |
| <b>Appendix 3</b> | <b>Emission Inventory Calculations*</b>       |
| <b>Appendix 4</b> | <b>DZP Odour monitoring report*</b>           |
| <b>Appendix 5</b> | <b>Greenhouse gas emission calculations*</b>  |

**\*Note: A copy of these appendices are available on the Project CD**

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# Appendix 1

## Detailed receptor information

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Receptor ID	MGA (mE)	MGA (mN)	Ownership
1	648928	6408374	Agreed Contract (Call Option)
2	649518	6407265	Agreed Contract (Call Option)
3	652919	6405355	Agreed Contract (Call Option)
4	654256	6404770	Private
6	649063	6403861	Private
7	648900	6404627	Private
8A	647353	6405878	Private
8B	646110	6403927	Private
10	648912	6408743	Private
18	645287	6406011	Private
19	646858	6407722	Private
20	647417	6407975	Private
21	645269	6409946	Private
22	648629	6409049	Private
23	648720	6409174	Private
24	648654	6409412	Private
25	648771	6409589	Private
26	648196	6410327	Private
27	646929	6412257	Private
28A	646768	6412362	Private
28B	646708	6412616	Private
30A	648935	6413224	Private
30B	649289	6413736	Private
31A	647191	6413882	Private
31B	647510	6414186	Private
32	648447	6413958	Private
35A	652513	6415246	Private
35B	652904	6415188	Private
38	654940	6415361	Private
36	653575	6414152	Private
40	654414	6413943	Private
42	655986	6414235	Private
43	657580	6412249	Private
46	657040	6409630	Private
48	654081	6409619	Applicant owned
49A	654356	6409008	Applicant owned
49B	654559	6409064	Applicant owned
50	652119	6409225	Potential future residence
51	650362	6409786	Agreed Contract (Call Option)
54	649753	6409460	Applicant owned
55	649851	6409552	Agreed Contract (Put Option)
56	649784	6409367	Applicant owned
58	650031	6409679	Agreed Contract (Put & Call Option)
61	656734	6404316	Private

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# **Appendix 2**

## **CALMET and TAPM input file parameters**

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**Table 1: Meteorological Parameters used for TAPM and CALMET**

TAPM (v 4.0.4)	
Number of grids (spacing)	3 (30 km, 10 km, 3 km)
Number of grid points	25 x 25 x 35
Year of analysis	January 2008 to December 2008
Centre of analysis	Project Boundary (32°26.5' S, 148°37.0' E)
CALMET (v. 6.327)	
Meteorological inner grid domain	25 km x 34 km
Meteorological inner grid resolution	0.25 km (fine resolution)
Surface meteorological stations	Toongi Met station - Wind speed - Wind direction - Temperature - Relative humidity Dubbo Airport AWS (Bureau of Meteorology, Station No.065070) - Wind speed - Wind direction - Temperature - Relative humidity - Cloud Amount - Cloud Height - Sea Level Pressure
Upper air	Prognostic three dimensional data file extracted from TAPM at 3 km grid

**Table 2: CALMET Model Options**

Flag	Descriptor	Default	Value Used
IEXTRP	Extrapolate surface wind observations to upper layers	Similarity theory	Similarity theory
BIAS (NZ)	Relative weight given to vertically extrapolated surface observations vs upper air data	NZ * 0	-1 for first layer, -0.5 for second layer, 0.25 for third layer. 0 for all other layers.
TERRAD	Radius of influence of terrain	No default (typically 5-15km)	5 km
RMAX1 and RMAX2	Maximum radius of influence over land for observations in layer 1 and aloft	No Default	2 km
R1 and R2	Distance from observations in layer 1 and aloft at which observations and Step 1 wind fields are weighted equally	No Default	1 km

**Table 3: CALPUFF Model Options used**

Flag	Flag Descriptor	Value Used	Value Description
MCHEM	Chemical Transformation	0	Not modelled
MDRY	Dry Deposition	1	Yes
MTRANS	Transitional plume rise allowed?	1	Yes
MTIP	Stack tip downwash?	1	Yes
MRISE	Method to compute plume rise	1	Numerical plume rise
MSHEAR	Vertical wind Shear	0	Vertical wind shear not modelled
MPARTL	Partial plume penetration of elevated inversion?	1	Yes
MSPLIT	Puff Splitting	0	No puff splitting
MSLUG	Near field modelled as slugs	0	Not used
MDISP	Dispersion Coefficients	3	PG coefficient for rural areas
MPDF	Probability density function used for dispersion under convective conditions	0	No
MROUGH	PG sigma y,z adjusted for z	0	No
MCTADJ	Terrain adjustment method	3	Partial Plume Adjustment
MBDW	Method for building downwash	1	Prime method

# **Appendix 3**

## **Emission Inventory Calculations**

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## **Dubbo Zirconia Project**

The dust emission inventories have been prepared using the operational description of the Dubbo Zirconia Project (the Proposal).

Estimated emissions are presented for all significant dust generating activities associated with the operations. The relevant emission factors used for the assessment are described below for TSP only. The same assumptions have been adopted in the PM<sub>10</sub> and PM<sub>2.5</sub> emission estimate equations. A copy of the emissions inventory for each modelled scenario and particulate matter parameter is provided at the end of this Appendix.

Mining activities have been restricted to the proposed hours of operation between 7am and 6pm, with the exception of blasting that would operate between 9am and 5pm.

Dust from wind erosion is assumed to occur over 24-hours per day, however, wind erosion is also assumed to be proportional to the third power of wind speed. This will mean that most wind erosion occurs during the day when wind speeds are highest.

### **Scraper stripping topsoil**

Emissions from scrapers stripping topsoil have been calculated using the US Environmental Protection Authority (EPA) emission factor equation given in Equation 1 (US EPA, 1985 and updates).

#### **Equation 1**

$$E_{TSP} = 0.029 \text{ kg/tonne}$$

### **Drilling overburden and ore**

The emission factor used for drilling has been taken to be 0.59 kg/hole (US EPA, 1985 and updates).

### **Blasting overburden and coal**

TSP emissions from blasting were estimated using the US EPA (1985 and updates) emission factor equation given in Equation 3.

#### **Equation 3**

$$E_{TSP} = 0.00022 \times A^{1.5} \quad \text{kg/blast}$$

Where,

A = area to be blasted in m<sup>2</sup>

The area to be blasted for overburden and ore is 1,400m<sup>2</sup>.

### **Loading material / dumping overburden and ore**

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. Equation 4 shows the relationship between these variables.

#### **Equation 4**

$$E_{TSP} = k \times 0.0016 \times \left( \frac{\left( \frac{U}{2.2} \right)^{1.3}}{\left( \frac{M}{2} \right)^{1.4}} \right) \text{ kg/t}$$

Where: k = 0.74 for TSP

U = wind speed (m/s)

M = moisture content (%)

(where  $0.25 \leq M \leq 2.8$ )

The moisture content of overburden was given to be 10% for overburden and 5% for ore.

#### **Hauling material / product on unsealed surfaces**

The emission estimate of wheel generated dust is based on the US EPA AP42 emission factor for unpaved surfaces at industrial sites shown below in Equation 5:

#### **Equation 5**

$$E_{TSP} = 0.2819 \times \left[ 4.9 \times \left( \frac{s}{12} \right)^{0.7} \times \left( \frac{\frac{W}{1.1023}}{3} \right)^{0.45} \right] (kg/VKT)$$

Where:

$EF_{TSP}$  = TSP emission factor from wheel generated dust

s = silt content of road surface

W = mean vehicle weight

The adopted silt content (s) for the Project was 3%.

The mean vehicle weight used in the emissions estimates is an average of the loaded and unloaded gross vehicle mass, to account for one empty trip and one loaded trip. A capacity of 61 t was used for haulage of materials.

A control factor of 75 % has been applied for watering and the use of water sprays on unpaved roads.

#### **Dozers working on overburden**

Emissions from dozers on overburden have been calculated using the US EPA emission factor equation given in Equation 1 (US EPA, 1985 and updates).

A conservative estimate was adopted in assuming the silt content for the overburden was 10% and 5% for ore. The respective moisture contents were assumed to be 4% and 7%.

#### **Crushing of ore**

Four stages of crushing are included at the processing plant. The emission factor used for crushing of metallic minerals has been taken from US EPA (1985 and updates). The following list the adopted emissions factors for TSP:

- Primary crushing: 0.01 kg/tonne
- Secondary crushing: 0.03 kg/tonne



- Tertiary crushing: 0.03 kg/tonne
- Quaternary crushing: 0.03 kg/tonne

It has been assumed that the moisture content of greater than 4% would be achieved through use of spray curtains.

### **Dry grinding**

The emission factor used for dry grinding of metallic minerals has been taken from US EPA (1985 and updates). The adopted TSP emission factor for dry grinding is 1.2 kg/tonne of ore processed. It has been assumed that the moisture content of greater than 4% would be achieved through use of spray curtains.

### **Miscellaneous transfers**

The emission factor used for miscellaneous transfers has been taken from US EPA (1985 and updates). The adopted TSP emission factor for dry grinding is 0.005 kg/tonne of ore processed. It has been assumed that there would be three miscellaneous transfers.

### **Wind erosion from exposed areas**

The latest wind erosion equation made available from the US EPA (1985 and updates) requires information on the threshold frictional velocity for the surface of the exposed area.

As this information is not available the default emission factor of 0.1 kg/ha/h (US EPA (1985 and updates)) has been used to estimate TSP emissions for wind erosion. For active stockpiles a TSP emission rate of 5.9 kg/ha/h has been calculated.

A control factor of 30% has been applied to the SRSF to account for the high moisture level of the solid waste that would be deposited at the site.

### **Grading roads**

Estimates of TSP emissions from grading roads have been made using the US EPA (1985 and updates) emission factor equation (Equation 8).

#### **Equation 8**

$$E_{\text{TSP}} = 0.0034 \times S^{2.5} \quad \text{kg/VKT}$$

Where,

S = speed of the grader in km/h (taken to be 8 km/h)

The following tables present the calculated emissions for each modelled year of the project and which correspond to the sources allocations as represented in **Table 21** and **Table 22**.

ACTIVITY	TSP emission for Year 5 (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Variable 6	Units
Topsoil Removal - Stripping topsoil - in waste rock emplacement area	1,244	42,900	t/yr	0.029	kg/t											0	% control
Topsoil Removal - Stripping topsoil at new LRSF in north	-	-	t/yr	0.029	kg/t											0	% control
OB - Drilling	792	4,473	holes/y	0.59	kg/hole											70	% Control
OB - Blasting	239	21	blasts/y	12	kg/blast	1,400	Area of blast in square metres									0	% Control
OB - Sh/Ex/FELs loading OB to trucks at Pit	95	116,829	t/y	0.0008	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							0	% Control
OB - Hauling OB from Pit to emplacement area	1,956	116,829	t/y	0.066976	kg/t	38	t/load	61	Vehicle gross mass (t)	1.2	km/return trip	2.1	kg/VKT	3	% silt content	75	% control
OB - Trucks emplacing OB at emplacement area	95	116,829	t/y	0.0008	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							0	% control
OB - Dozers on D1 north dump	5,024	739	h/y	6.8	kg/h	10	silt content in %	4	moisture content in %							0	% control
OB - Dozers on SRSF	5,024	739	h/y	6.8	kg/h	10	silt content in %	4	moisture content in %							0	% control
ORE - Dozers ripping/pushing/clean-up in pit	1,057	739	h/y	1.4	kg/h	5	silt content in %	7	moisture content in %							0	% control
ORE - Drilling	6,833	38,604	holes/y	0.6	kg/hole											70	% Control
ORE - Blasting	2,066	179	blasts/y	12	kg/blast	1,400	Area of blast in square metres									0	% Control
ORE - Loading ore from Pit to trucks	376	1,008,330	t/y	0.0004	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	7	moisture content in %							0	% Control
ORE - Hauling ore from Pit to ROM Pad	123,811	1,008,330	t/y	0.4912	kg/t	38	t/load	61	Vehicle gross mass (t)	8.8	km/return trip	2.1	kg/VKT	3	% silt content	75	% control
ORE - Unloading ore from truck to ROM pad	376	1,008,330	t/y	0.0004	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	7	moisture content in %							0	% Control
Ore - Primary crushing	10,083	1,008,330	t/y	0.01	kg/t											0	% control
Ore - Secondary crushing	30,250	1,008,330	t/y	0.03	kg/t											0	% control
Ore - Tertiary crushing	30,250	1,008,330	t/y	0.03	kg/t											0	% control
Ore - Quaternary crushing	30,250	1,008,330	t/y	0.03	kg/t											0	% control
Ore - Dry grinding	205,699	1,008,330	t/y	1.20	kg/t											83	% control
Ore - Miscellaneous transfers	20,167	4,033,320	t/y	0.005	kg/t											0	% control
WE - Stripped topsoil area at new LRSF in north	8,935	10.2	ha	0.1	kg/ha/h	8,760	h/y									0	% Control
WE - Waste emplacement	-	-	ha	0.1	kg/ha/h	8,760	h/y									0	% Control
WE - Pit	15,856	18.1	ha	0.1	kg/ha/h	8,760	h/y									0	% Control
WE - Stockpiles other - SRSF	17,599	28.7	ha	0.1	kg/ha/h	8,760	h/y									30	% Control
WE - ROM stockpiles	108,610	2.1	ha	5.9	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	% Control
WE - Stockpiles other - soil stockpiles	-	-	ha	5.9	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	% Control
WE - Stockpiles other - Salt encapsulation cells	-	-	ha	5.9	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	% Control
Grading roads	11,439	37,171	km	0.62	kg/km	8	speed of graders in km/h	4,646	grader hours							50	% Control
Total TSP emissions for Year 5 (kg/yr)	638,126																

ACTIVITY	TSP emission for Year 5 (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Variable 6	Units
Topsoil Removal - Stripping topsoil at salt encapsulation cell	4,000	137,940	t/yr	0.029	kg/t											0	
Topsoil Removal - Stripping topsoil at waste rock emplacement	1,474	50,820	t/yr	0.029	kg/t											0	
OB - Drilling	792	4,473	holes/y	0.59	kg/hole											70	
OB - Blasting	239	21	blasts/y	12	kg/blast	1,400	Area of blast in square metres									0	
OB - Sh/Ex/FELs loading OB to trucks at Pit	219	268,212	t/y	0.0008	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							0	
OB - Hauling OB from Pit to emplacement area	4,491	268,212	t/y	0.066976	kg/t	38	t/load	61	Vehicle gross mass (t)	1.2	km/return trip	2.1	kg/VKT	3	% silt content	75	
OB - Trucks emplacing OB at emplacement area	219	268,212	t/y	0.0008	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							0	
OB - Dozers on D1 north dump	5,024	739	h/y	6.8	kg/h	10	silt content in %	4	moisture content in %							0	
OB - Dozers on SRSF	5,024	739	h/y	6.8	kg/h	10	silt content in %	4	moisture content in %							0	
ORE - Dozers ripping/pushing/clean-up in pit	1,057	739	h/y	1.4	kg/h	5	silt content in %	7	moisture content in %							0	
ORE - Drilling	6,833	38,604	holes/y	0.6	kg/hole											70	
ORE - Blasting	2,066	179	blasts/y	12	kg/blast	1,400	Area of blast in square metres									0	
ORE - Loading ore from Pit to trucks	372	998,558	t/y	0.0004	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	7	moisture content in %							0	
ORE - Hauling ore from Pit to ROM Pad	122,612	998,558	t/y	0.4912	kg/t	38	t/load	61	Vehicle gross mass (t)	8.8	km/return trip	2.1	kg/VKT	3	% silt content	75	
ORE - Unloading ore from truck to ROM pad	372	998,558	t/y	0.0004	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	7	moisture content in %							0	
Ore - Primary crushing	9,986	998,558	t/y	0.01	kg/t											0	
Ore - Secondary crushing	29,957	998,558	t/y	0.03	kg/t											0	
Ore - Tertiary crushing	29,957	998,558	t/y	0.03	kg/t											0	
Ore - Quaternary crushing	29,957	998,558	t/y	0.03	kg/t											0	
Ore - Dry grinding	203,706	998,558	t/y	1.20	kg/t											83	
Ore - Miscellaneous transfers	19,971	3,994,232	t/y	0.01	kg/t											0	
WE - Stripped topsoil area at salt encapsulation cell	18,308	20.9	ha	0.1	kg/ha/h	8,760	h/y									0	
WE - Waste emplacement	14,804	16.9	ha	0.1	kg/ha/h	8,760	h/y									0	
WE - Pit	34,690	39.6	ha	0.1	kg/ha/h	8,760	h/y									0	
WE - Stockpiles other - SRSF	28,882	47.1	ha	0.1	kg/ha/h	8,760	h/y									30	
WE - ROM stockpiles	108,610	2.1	ha	5.9	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	
WE - soil stockpiles	-	-	ha	0.1	kg/ha/h	8,760	h/y									0	
WE - Salt encapsulation cells	7,709	8.8	ha	0.1	kg/ha/h	8,760	h/y									0	
Grading roads	11,439	37,171	km	0.62	kg/km	8	speed of graders in km/h	4,646	grader hours							50	
Total TSP emissions for Year 5 (kg/yr)	702,768																

# SPECIALIST CONSULTANT STUDIES

## Part 2: Air Quality and Greenhouse Gas Assessment

# AUSTRALIAN ZIRCONIA LTD

## Dubbo Zirconia Project

Report No. 545/05

ACTIVITY	TSP emission for Year 5 (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Variable 6	Units
Topsoil Removal - Stripping topsoil - in waste rock emplacement area	1,244	42,900	t/yr	0.029	kg/t											0	% control
Topsoil Removal - Stripping topsoil at new LRSF in north	-	-	t/yr	0.029	kg/t											0	% control
OB - Drilling	412	4,473	holes/y	0.31	kg/hole											70	% Control
OB - Blasting	124	21	blasts/y	6.0	kg/blast	1,400	Area of blast in square metres									0	% Control
OB - Sh/Ex/FELs loading OB to trucks at Pit	45	116,829	t/y	0.0004	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s									0	% Control
OB - Hauling OB from Pit to emplacement area	454	116,829	t/y	0.0155	kg/t	38	t/load	61	Vehicle gross mass (t)	1.2	km/return trip	0.5	kg/VKT	3	% silt content	75	% control
OB - Trucks emplacing OB at emplacement area	45	116,829	t/y	0.0004	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s									0	% control
OB - Dozers on D1 north dump	1,133	739	h/y	1.5	kg/h	10	silt content in %									0	% control
OB - Dozers on SRSF	1,133	739	h/y	1.5	kg/h	10	silt content in %									0	% control
ORE - Dozers ripping/pushing/clean-up in pit	183	739	h/y	0.2	kg/h	5	silt content in %									0	% control
ORE - Drilling	3,553	38,604	holes/y	0.31	kg/hole											70	% Control
ORE - Blasting	1,074	179	blasts/y	6	kg/blast	1,400	Area of blast in square metres									0	% Control
ORE - Loading ore from Pit to trucks	178	1,008,330	t/y	0.0002	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s									0	% Control
ORE - Hauling ore from Pit to ROM Pad	28,724	1,008,330	t/y	0.1139	kg/t	38	t/load	61	Vehicle gross mass (t)	8.8	km/return trip	0.5	kg/VKT	3	% silt content	75	% control
ORE - Unloading ore from truck to ROM pad	178	1,008,330	t/y	0.0002	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s									0	% Control
Ore - Primary crushing	4,033	1,008,330	t/y	0.004	kg/t											0	% control
Ore - Secondary crushing	12,100	1,008,330	t/y	0.012	kg/t											0	% control
Ore - Tertiary crushing	10,083	1,008,330	t/y	0.010	kg/t											0	% control
Ore - Quaternary crushing	10,083	1,008,330	t/y	0.010	kg/t											0	% control
Ore - Dry grinding	27,427	1,008,330	t/y	0.160	kg/t											83	% control
Ore - Miscellaneous transfers	8,067	4,033,320	t/y	0.002	kg/t											0	% control
WE - Stripped topsoil area at new LRSF in north	-	-	ha	0.1	kg/ha/h	8,760	h/y									0	% Control
WE - Waste emplacement	4,468	10.2	ha	0.1	kg/ha/h	8,760	h/y									0	% Control
WE - Pit	7,928	18.1	ha	0.1	kg/ha/h	8,760	h/y									0	% Control
WE - Stockpiles other - SRSF	8,799	28.7	ha	0.1	kg/ha/h	8,760	h/y									30	% Control
WE - ROM stockpiles	54,305	2.1	ha	3.0	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	% Control
WE - Stockpiles other - soil stockpiles	-	-	ha	3.0	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	% Control
WE - Stockpiles other - Salt encapsulation cells	-	-	ha	3.0	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	% Control
Grading roads	3,997	37,171	km	0.22	kg/km	8	speed of graders in km/h	4,646	grader hours							50	% Control
Total PM10 emissions for Year 5 (kg/yr)		189,769															

ACTIVITY	TSP emission for Year 5 (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Variable 6	Units
Topsoil Removal - Stripping topsoil at salt encapsulation cell	4,000	137,940	t/yr	0.029	kg/t											0	% control
Topsoil Removal - Stripping topsoil at waste rock emplacement area	1,474	50,820	t/yr	0.029	kg/t											0	% control
OB - Drilling	412	4,473	holes/y	0.31	kg/hole											70	% Control
OB - Blasting	124	21	blasts/y	6.0	kg/blast	1,400	Area of blast in square metres									0	% Control
OB - Sh/Ex/FELs loading OB to trucks at Pit	104	268,212	t/y	0.0004	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s									0	% Control
OB - Hauling OB from Pit to emplacement area	1,042	268,212	t/y	0.015538	kg/t	38	t/load	61	Vehicle gross mass (t)	1.2	km/return trip	0.5	kg/VKT	3	% silt content	75	% control
OB - Trucks emplacing OB at emplacement area	104	268,212	t/y	0.0004	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s									0	% control
OB - Dozers on D1 north dump	1,133	739	h/y	1.5	kg/h	10	silt content in %									0	% control
OB - Dozers on SRSF	1,133	739	h/y	1.5	kg/h	10	silt content in %									0	% control
ORE - Dozers ripping/pushing/clean-up in pit	183	739	h/y	0.2	kg/h	5	silt content in %									0	% control
ORE - Drilling	3,553	38,604	holes/y	0.31	kg/hole											70	% Control
ORE - Blasting	1,074	179	blasts/y	6	kg/blast	1,400	Area of blast in square metres									0	% Control
ORE - Loading ore from Pit to trucks	176	998,558	t/y	0.0002	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s									0	% Control
ORE - Hauling ore from Pit to ROM Pad	28,446	998,558	t/y	0.1139	kg/t	38	t/load	61	Vehicle gross mass (t)	8.8	km/return trip	0.5	kg/VKT	3	% silt content	75	% control
ORE - Unloading ore from truck to ROM pad	176	998,558	t/y	0.0002	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s									0	% Control
Ore - Primary crushing	3,994	998,558	t/y	0.004	kg/t											0	% control
Ore - Secondary crushing	11,983	998,558	t/y	0.012	kg/t											0	% control
Ore - Tertiary crushing	9,986	998,558	t/y	0.010	kg/t											0	% control
Ore - Quaternary crushing	9,986	998,558	t/y	0.010	kg/t											0	% control
Ore - Dry grinding	27,161	998,558	t/y	0.160	kg/t											83	% control
Ore - Miscellaneous transfers	7,988	3,994,232	t/y	0.002	kg/t											0	% control
WE - Stripped topsoil area at salt encapsulation cell	9,154	20.9	ha	0.1	kg/ha/h	8,760	h/y									0	% Control
WE - Waste emplacement	7,402	16.9	ha	0.1	kg/ha/h	8,760	h/y									0	% Control
WE - Pit	17,345	39.6	ha	0.1	kg/ha/h	8,760	h/y									0	% Control
WE - Stockpiles other - SRSF	14,441	47.1	ha	0.1	kg/ha/h	8,760	h/y									30	% Control
WE - ROM stockpiles	54,305	2.1	ha	3.0	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	% Control
WE - soil stockpiles	-	-	ha	0.1	kg/ha/h	8,760	h/y									0	% Control
WE - Salt encapsulation cells	3,854	8.8	ha	0.1	kg/ha/h	8,760	h/y									0	% Control
Grading roads	3,997	37,171	km	0.22	kg/km	8	speed of graders in km/h	4,646	grader hours							50	% Control
Total PM10 emissions for Year 5 (kg/yr)		224,728															

ACTIVITY	TSP emission for Year 5 (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Variable 6	Units
Topsoil Removal - Stripping topsoil - in waste rock emplacement area	1,244	42,900	t/yr	0.029	kg/t											0	% control
Topsoil Removal - Stripping topsoil at new LRSF in north	-	-	t/yr	0.029	kg/t											0	% control
OB - Drilling	24	4,473	holes/y	0.02	kg/hole											70	% Control
OB - Blasting	7	21	blasts/y	0.3	kg/blast	1,400	Area of blast in square metres									0	% Control
OB - Sh/Ex/FELs loading OB to trucks at Pit	7	116,829	t/y	0.0001	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							0	% Control
OB - Hauling OB from Pit to emplacement area	45	116,829	t/y	0.001554	kg/t	38	t/load	61	Vehicle gross mass (t)	1.2	km/return trip	0.0	kg/VKT	3	% silt content	75	% control
OB - Trucks emplacing OB at emplacement area	7	116,829	t/y	0.0001	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							0	% control
OB - Dozers on D1 north dump	528	739	h/y	0.7	kg/h	10	silt content in %	4	moisture content in %							0	% control
OB - Dozers on SRSF	528	739	h/y	0.7	kg/h	10	silt content in %	4	moisture content in %							0	% control
ORE - Dozers ripping/pushing/clean-up in pit	111	739	h/y	0.2	kg/h	5	silt content in %	7	moisture content of coal in %							0	% control
ORE - Drilling	205	38,604	holes/y	0.0177	kg/hole											70	% Control
ORE - Blasting	62	179	blasts/y	0.35	kg/blast	1,400	Area of blast in square metres									0	% Control
ORE - Loading ore from Pit to trucks	27	1,008,330	t/y	0.0000	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	7	moisture content in %							0	% Control
ORE - Hauling ore from Pit to ROM pad	2,872	1,008,330	t/y	0.0114	kg/t	38	t/load	61	Vehicle gross mass (t)	8.8	km/return trip	0.0	kg/VKT	3	% silt content	75	% control
ORE - Unloading ore from truck to ROM pad	27	1,008,330	t/y	0.0000	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	7	moisture content in %							0	% Control
Ore - Primary crushing	302	1,008,330	t/y	0.0003	kg/t											0	% control
Ore - Secondary crushing	907	1,008,330	t/y	0.0009	kg/t											0	% control
Ore - Tertiary crushing	907	1,008,330	t/y	0.0009	kg/t											0	% control
Ore - Quaternary crushing	907	1,008,330	t/y	0.0009	kg/t											0	% control
Ore - Dry grinding	6,171	1,008,330	t/y	0.0360	kg/t											83	% control
Ore - Miscellaneous transfers	605	4,033,320	t/y	0.0002	kg/t											0	% control
WE - Stripped topsoil area at new LRSF in north	-	-	ha	0.0	kg/ha/h	8,760	h/y									0	% Control
WE - Waste emplacement	670	10.2	ha	0.0	kg/ha/h	8,760	h/y									0	% Control
WE - Pit	1,189	18.1	ha	0.0	kg/ha/h	8,760	h/y									0	% Control
WE - Stockpiles other - SRSF	1,320	28.7	ha	0.0	kg/ha/h	8,760	h/y									30	% Control
WE - ROM stockpiles	8,146	2.1	ha	0.4	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	% Control
WE - Stockpiles other - soil stockpiles	-	-	ha	0.4	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	% Control
WE - Stockpiles other - Salt encapsulation cells	-	-	ha	0.4	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	% Control
Grading roads	355	37,171	km	0.02	kg/km	8	speed of graders in km/h	4,646	grader hours							50	% Control
Total PM2.5 emissions for Year 5 (kg/yr)																	
27,174																	

ACTIVITY	TSP emission for Year 5 (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Variable 6	Units
Topsoil Removal - Stripping topsoil at salt encapsulation cell	4,000	137,940	t/yr	0.029	kg/t											0	% control
Topsoil Removal - Stripping topsoil at waste rock emplacement area	1,474	50,820	t/yr	0.029	kg/t											0	% control
OB - Drilling	24	4,473	holes/y	0.02	kg/hole											70	% Control
OB - Blasting	7	21	blasts/y	0.3	kg/blast	1,400	Area of blast in square metres									0	% Control
OB - Sh/Ex/FELs loading OB to trucks at Pit	16	268,212	t/y	0.0001	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							0	% Control
OB - Hauling OB from Pit to emplacement area	104	268,212	t/y	0.001554	kg/t	38	t/load	61	Vehicle gross mass (t)	1.2	km/return trip	0.0	kg/VKT	3	% silt content	75	% control
OB - Trucks emplacing OB at emplacement area	16	268,212	t/y	0.0001	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							0	% control
OB - Dozers on D1 north dump	528	739	h/y	0.7	kg/h	10	silt content in %	4	moisture content in %							0	% control
OB - Dozers on SRSF	528	739	h/y	0.7	kg/h	10	silt content in %	4	moisture content in %							0	% control
ORE - Dozers ripping/pushing/clean-up in pit	111	739	h/y	0.15	kg/h	5	silt content in %	7	moisture content of coal in %							0	% control
ORE - Drilling	205	38,604	holes/y	0.018	kg/hole											70	% Control
ORE - Blasting	62	179	blasts/y	0.35	kg/blast	1,400	Area of blast in square metres									0	% Control
ORE - Loading ore from Pit to trucks	27	998,558	t/y	0.0000	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	7	moisture content in %							0	% Control
ORE - Hauling ore from Pit to ROM pad	2,845	998,558	t/y	0.0114	kg/t	38	t/load	61	Vehicle gross mass (t)	8.8	km/return trip	0.0	kg/VKT	3	% silt content	75	% control
ORE - Unloading ore from truck to ROM pad	27	998,558	t/y	0.0000	kg/t	1.82	average of (wind speed/2.2)^1.3 in m/s	7	moisture content in %							0	% Control
Ore - Primary crushing	300	998,558	t/y	0.000	kg/t											0	% control
Ore - Secondary crushing	899	998,558	t/y	0.001	kg/t											0	% control
Ore - Tertiary crushing	899	998,558	t/y	0.001	kg/t											0	% control
Ore - Quaternary crushing	899	998,558	t/y	0.001	kg/t											0	% control
Ore - Dry grinding	6,111	998,558	t/y	0.036	kg/t											83	% control
Ore - Miscellaneous transfers	599	3,994,232	t/y	0.000	kg/t											0	% control
WE - Stripped topsoil area at salt encapsulation cell	1,373	20.9	ha	0.0	kg/ha/h	8,760	h/y									0	% Control
WE - Waste emplacement	1,110	16.9	ha	0.0	kg/ha/h	8,760	h/y									0	% Control
WE - Pit	2,602	39.6	ha	0.0	kg/ha/h	8,760	h/y									0	% Control
WE - Stockpiles other - SRSF	2,166	47.1	ha	0.0	kg/ha/h	8,760	h/y									30	% Control
WE - ROM stockpiles	8,146	2.1	ha	0.4	kg/ha/h	8,760	h/y	3.28	m/s (annual average ws)							0	% Control
WE - soil stockpiles	-	-	ha	0.0	kg/ha/h	8,760	h/y									0	% Control
WE - Salt encapsulation cells	578	8.8	ha	0.0	kg/ha/h	8,760	h/y									0	% Control
Grading roads	355	37,171	km	0.02	kg/km	8	speed of graders in km/h	4,646	grader hours							50	% Control
Total PM2.5 emissions for Year 5 (kg/yr)																	
36,007																	

# **Appendix 4**

## **DZP Odour Monitoring Report**

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# Pacific Environment Limited



Consulting • Technologies • Monitoring • Toxicology

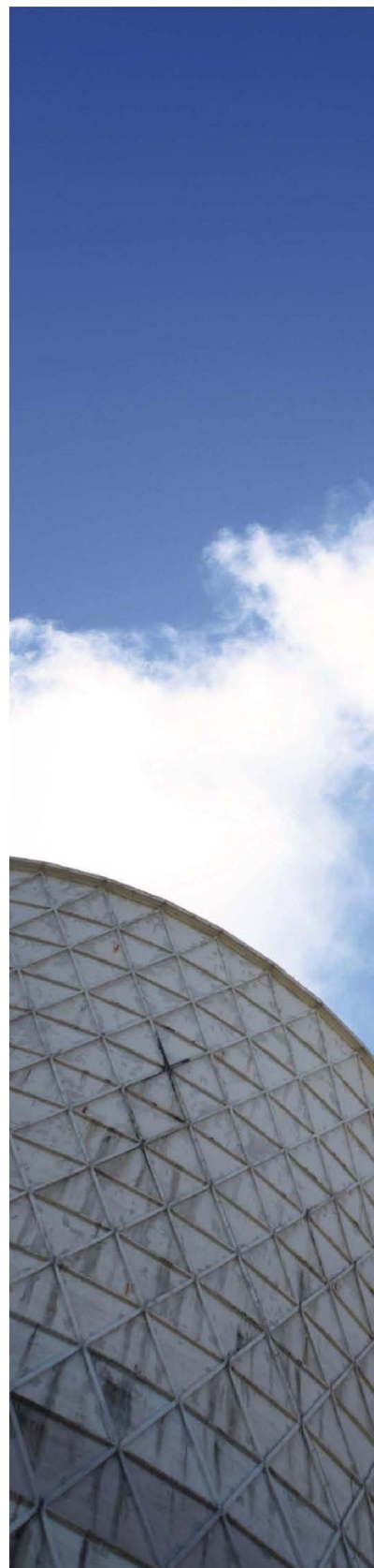
## REPORT

### ODOUR MONITORING FOR THE PROPOSED DUBBO ZIRCONIA PROJECT

**R.W. Corkery & Co. Pty Limited**

Job No: 6622

26 February 2013



[www.pacific-environment.com](http://www.pacific-environment.com)



PROJECT TITLE:	ODOUR MONITORING FOR THE PROPOSED DUBBO ZIRCONIA PROJECT
JOB NUMBER:	6622
PREPARED FOR:	R.W. CORKERY & CO. PTY LIMITED
PREPARED BY:	Ronan Kellaghan
APPROVED FOR RELEASE BY:	Damon Roddis
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VERSION	DATE	PREPARED BY	REVIEWED BY
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**CONTENTS**

1	INTRODUCTION	4
2	METHODOLOGY	5
3	RESULTS	6
4	CONCLUSION	6
5	REFERENCES	6
	APPENDIX A – MONITORING CERTIFICATES	A-1

**LIST OF TABLES**

Table 3.1:	Odour Monitoring Results	6
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## 1 INTRODUCTION

Australian Zirconia Ltd (AZL), a wholly owned subsidiary of Alkane Resources Ltd, are seeking approval for the development, mining and processing of Zirconium, Yttrium, Rare Earth Elements (REEs) and Niobium resources at a site located near Toongi, approximately 25km south of Dubbo.

Pacific Environment has been commissioned by R.W. Corkery & Co. Pty Ltd (RWC) to complete an Air Quality Impact Assessment (AQIA) for proposed Dubbo Zirconia Project.

As part of the AQIA for the project, an assessment of the potential for odour impacts from the waste streams is required. To facilitate this assessment, Pacific Environment have completed odour monitoring on 6 December 2012 and 12 February 2013 on samples of the waste streams generated by process.

The waste streams were obtained from a pilot processing plant operated by ANSTO at Lucas Heights, NSW and are described as:

- A solid residue which may contain specific wastes with elevated sulphide concentration.
- A liquid residue stream which may contain some residues containing ammonia.
- A compound waste stream.

The objective of the monitoring is to derive site specific odour emission rates (OERs) for input into an atmospheric dispersion model, allowing assessment of potential for off-site odour impact from the full scale facility.

The intent is to emulate conditions that could occur onsite and as such the potential exists for both fresh waste and previously placed (aged) waste to be stored at the site. Monitoring has therefore been conducted on both fresh and aged waste.

Sampling and analysis is conducted in accordance with:

- "Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales" (NSW DEC, 2005).
- Australian Standard AS/NZS 4323.4:2009 "Stationary source emissions. Method 4 Area Source sampling – Flux chamber method".
- Australian Standard AS/NZS 4323.3:2001 "Determination of Odour Concentration by Dynamic Olfactometry".

## 2 METHODOLOGY

Solid and liquid waste streams from the pilot plant were prepared by ANSTO.

For sampling on 6 December 2012, the solid waste was prepared in advance and stored in a sealed drum at ANSTO prior to sampling. The liquid waste was prepared immediately prior to sampling.

For sampling on 12 February 2013, a fresh solid waste sample was prepared immediately prior to sampling. The sample of the previously prepared solid waste was left exposed in a ventilated space, and used to characterise 'aged' waste.

Additionally, an odour sample was taken for a compound waste stream prepared immediately prior to sampling.

All waste streams were transferred to plastic trays to facilitate samples being collected. The potential for odour contamination from the sample trays was considered to be minimal. A sufficient volume of waste material was transferred to the trays to ensure adequate surface area cover for monitoring.

Representative odour samples from the surface of the solid and liquid waste streams were taken using an isolation flux hood (IFH). Samples are measured in accordance with Australian Standard AS/NZS 4323.4:2009 "Area source sampling – Flux chamber technique" and the method described in the US EPA technical report "EPA/600/68-86/008".

A seal is formed between the IFH and each waste stream and odour-free air or nitrogen is forced into the hood via odour free Teflon tubing until it has reached equilibrium. The nitrogen flow (5 L/min) purges the flux hood with a residence time of 4 times the chamber volume occurring before sampling begins (24 minutes). The odorous sample is then drawn at a sample rate of approximately 2-3 L/min over a period of 30 minutes into a single use, odour-free Nalophan sample bag, secured inside a drum kept under vacuum using a pump.

Following collection, odour samples are analysed at a NATA accredited laboratory using dynamic olfactometry<sup>□</sup> in accordance with AS/NZS 4323.3:2001 "Determination of Odour Concentration by Dynamic Olfactometry".

---

<sup>□</sup> There are no instrument-based methods that can measure an odour response in the same way as the human nose and "dynamic olfactometry" is therefore the preferred method for odour analysis. Dynamic olfactometry is the measurement of odour by presenting a sample of odorous air to a panel of people with decreasing quantities of clean odour-free air. The panellists then note when the smell becomes detectable. The correlations between the known dilution ratios and the panellists' responses are then used to calculate the number of dilutions of the original sample required to achieve the odour detection threshold. The units for odour measurement using dynamic olfactometry are "odour units" (OU) which are dimensionless and are effectively "dilutions to threshold".

### 3 RESULTS

The results of the odour monitoring are presented in **Table 3.1** for both solid (ALZN cake), liquid and compound waste streams. Odour Monitoring Certificates of Analysis are shown in **Appendix A**.

Specific Odour Emission Rates (SOERs) (expressed as  $\text{OU.m}^3/\text{m}^2/\text{s}$ ) are also presented<sup>b</sup>. As seen in **Table 3.1**, the odour character reported in the analysis suggests that the fresh waste does have a sulphide character, indicated by the rotten eggs descriptor (which is typically used to describe  $\text{H}_2\text{S}$ ).

**Table 3.1: Odour Monitoring Results**

Sample	Sample Description	Date / Time	Odour Concentration (OU)	Specific Odour Emission Rate (SOER) ( $\text{OU.m}^3/\text{m}^2/\text{s}$ )	Odour Character
ALZN Cake – “Fresh”	Prepared immediately prior to sampling	12/02/2013 10:30	1,450	0.86	Rotten Eggs
ALZN Cake	Prepared in advance and stored in a sealed drum	6/12/2012 14:30	223	0.13	Musty / Stale Water
ALZN Cake – “Aged”	Left exposed to atmosphere for 5 days	12/02/2013 09:24	91	0.05	Musty / Stale Water
Liquid Waste Stream	Prepared immediately prior to sampling	6/12/2012 15:10	256	0.15	Musty / Stale Water
Compound Waste Stream	Prepared immediately prior to sampling	12/02/2013 11:28	128	0.08	Musty / Stale Water

### 4 CONCLUSION

Odour monitoring was conducted on 6 December 2012 and 12 February 2013 for solid, liquid and compound waste streams produced at an AZL pilot plant operated by ANSTO at Lucas Heights, NSW.

Odour emission rates are derived for input into a dispersion model to assess of the potential for odour impacts at the proposed full scale processing plant at Dubbo, NSW.

### 5 REFERENCES

Australian Standard AS/NZS 4323.4:2009 Area source sampling – Flux chamber technique.

Australian Standard AS/NZS 4323.3:2001 Determination of Odour Concentration by Dynamic Olfactometry

NSW DEC (2005) “Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales”. August, 2005

US EPA method (EPA/600/8-86/008) Measurement of Gaseous Emissions Rates from Land Surfaces Using an Emissions Isolation Flux Chamber Users Guide.

<sup>b</sup> SOERs are calculated from the measured odour concentration (OC), based on the area of the IFH (A) and the chamber flow rate (Q), according to equation 1:

$$SOER = OC \times \frac{Q}{A} \quad \text{equation 1}$$



---

**APPENDIX A – MONITORING CERTIFICATES**

---



# THE ODOUR UNIT



**THE ODOUR UNIT**

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ABN: 53 091 165 061



Accreditation Number:  
14974

## Odour Concentration Measurement Results

The measurement was commissioned by:

Organisation	Pacific Environment	Telephone	(02) 9870 0900
Contact	Ronan Kellaghan	Facsimile	-
Sampling Site	Undisclosed	Email	<a href="mailto:Ronan.Kellaghan@pacific-environment.com">Ronan.Kellaghan@pacific-environment.com</a>
Sampling Method	Undisclosed	Sampling Team	Pacific-Environment

Order details:

Order requested by	R. Kellaghan	Order accepted by	J. Schulz
Date of order	5/12/2012	TOU Project #	N1840R
Order number	6622-NSW01	Project Manager	J. Schulz
Signed by	Refer to correspondence	Testing operator	A. Schulz

Investigated Item	Odour concentration in odour units 'ou', determined by sensory odour concentration measurements, of an odour sample supplied in a sampling bag.
Identification	The odour sample bags were labelled individually. Each label recorded the testing laboratory, sample number, sampling location (or Identification), sampling date and time, dilution ratio (if dilution was used) and whether further chemical analysis was required.
Method	The odour concentration measurements were performed using dynamic olfactometry according to the Australian Standard 'Determination of Odour Concentration by Dynamic Olfactometry AS/NZS4323.3:2001. The odour perception characteristics of the panel within the presentation series for the samples were analogous to that for butanol calibration. Any deviation from the Australian standard is recorded in the 'Comments' section of this report.
Measuring Range	The measuring range of the olfactometer is $2^2 \leq \chi \leq 2^{18}$ ou. If the measuring range was insufficient the odour samples will have been pre-diluted. The machine is not calibrated beyond dilution setting $2^{17}$ . This is specifically mentioned with the results.
Environment	The measurements were performed in an air- and odour-conditioned room. The room temperature is maintained between 22°C and 25°C.
Measuring Dates	The date of each measurement is specified with the results.
Instrument Used	The olfactometer used during this testing session was: ODORMAT SERIES V04
Instrumental Precision	The precision of this instrument (expressed as repeatability) for a sensory calibration must be $r \leq 0.477$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V04: $r = 0.3234$ (September 2012) Compliance – Yes
Instrumental Accuracy	The accuracy of this instrument for a sensory calibration must be $A \leq 0.217$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V04: $A = 0.1995$ (September 2012) Compliance – Yes
Lower Detection Limit (LDL)	The LDL for the olfactometer has been determined to be 16 ou (4 times the lowest dilution setting)
Traceability	The measurements have been performed using standards for which the traceability to the national standard has been demonstrated. The assessors are individually selected to comply with fixed criteria and are monitored in time to keep within the limits of the standard. The results from the assessors are traceable to primary standards of n-butanol in nitrogen.

Date: Tuesday, 18 December 2012

Panel Roster Number: SYD20121207\_099

**J. Schulz**  
NSW Laboratory Coordinator

**A. Schulz**  
Authorised Signatory



# THE ODOUR UNIT PTY LIMITED



Accreditation Number: 14974

## Odour Sample Measurement Results Panel Roster Number: SYD20121207\_099

Sample Location	TOU Sample ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITEs	Nominal Sample Dilution	Actual Sample Dilution (Adjusted for Temperature)	Sample Odour Concentration (as received, in the bag) (ou)	Sample Odour Concentration (Final, allowing for dilution) (ou)	Specific Odour Emission Rate (ou.m <sup>3</sup> /m <sup>2</sup> /s)
ALZN CAKE	SC12641	06/12/2012 1430hrs	07/12/2012 1019hrs	5	10	-	-	223	223	N/A
2 Liquid Waste	SC12642	06/12/2012 1510hrs	07/12/2012 1051hrs	5	10	-	-	256	256	N/A

Note: The following are not covered by the NATA Accreditation issued to The Odour Unit Pty Ltd:

1. The collection of Isolation Flux Hood (IFH) samples and the calculation of the Specific Odour Emission Rate (SOER).
2. Final results that have been modified by the dilution factors where parties other than The Odour Unit Pty Ltd. have performed the dilution of samples.



# THE ODOUR UNIT PTY LIMITED



Accreditation Number: 14974

## Odour Panel Calibration Results

Reference Odorant	Reference Odorant Panel Roster Number	Concentration of Reference gas (ppb)	Panel Target Range for n-butanol (ppb)	Measured Concentration (ou)	Measured Panel Threshold (ppb)	Does this panel calibration measurement comply with AS/NZS4323.3:2001 (Yes / No)
n-butanol	SYD20121207_099	50,000	$20 \leq \chi \leq 80$	955	52	Yes

Comments: None.

**Disclaimer**  
Parties, other than TOU, responsible for collecting odour samples hereby certify that they have voluntarily furnished these odour samples, appropriately collected and labelled, to The Odour Unit Pty Ltd for the purpose of odour testing. The collection of odour samples by parties other than The Odour Unit Pty Ltd relinquishes The Odour Unit Pty Ltd from all responsibility for the sample collection and any effects or actions that the results from the test(s) may have.

**Note**  
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ABN 53 061 165 061  
Form 06 – Odour Concentration Results Sheet

Issue Date: 13.11.2003  
Issued By: SB  
Last printed 12/19/2012 11:30:00 AM

Revision: 8  
Revision Date: 18.07.2008  
Approved By: TJS



# THE ODOUR UNIT



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 ABN: 53 091 165 061



Accreditation Number:  
 14974

## Odour Concentration Measurement Results

The measurement was commissioned by:

Organisation	Pacific Environment	Telephone	+61 2 9870 0900
Contact	R. Kellaghan	Facsimile	
Sampling Site	Undisclosed	Email	<a href="mailto:Ronan.Kellaghan@pacific-environment.com">Ronan.Kellaghan@pacific-environment.com</a>
Sampling Method	Drum & Pump AS4323.3:2001	Sampling Team	PEL

Order details:

Order requested by	R. Kellaghan	Order accepted by	J. Schulz
Date of order	07/02/2013	TOU Project #	N1867R.03
Order number	6622C-NSW01.	Project Manager	M. Assal
Signed by	R. Kellaghan	Testing operator	A. Schulz

Investigated Item	Odour concentration in odour units 'ou', determined by sensory odour concentration measurements, of an odour sample supplied in a sampling bag.
Identification	The odour sample bags were labelled individually. Each label recorded the testing laboratory, sample number, sampling location (or Identification), sampling date and time, dilution ratio (if dilution was used) and whether further chemical analysis was required.
Method	The odour concentration measurements were performed using dynamic olfactometry according to the Australian Standard 'Determination of Odour Concentration by Dynamic Olfactometry AS/NZS4323.3:2001. The odour perception characteristics of the panel within the presentation series for the samples were analogous to that for butanol calibration. Any deviation from the Australian standard is recorded in the 'Comments' section of this report.
Measuring Range	The measuring range of the olfactometer is $2^2 \leq \chi \leq 2^{18}$ ou. If the measuring range was insufficient the odour samples will have been pre-diluted. The machine is not calibrated beyond dilution setting $2^{17}$ . This is specifically mentioned with the results.
Environment	The measurements were performed in an air- and odour-conditioned room. The room temperature is maintained between 22°C and 25°C.
Measuring Dates	The date of each measurement is specified with the results.
Instrument Used	The olfactometer used during this testing session was: ODORMAT SERIES V04
Instrumental Precision	The precision of this instrument (expressed as repeatability) for a sensory calibration must be $r \leq 0.477$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V04: $r = 0.3234$ (September 2012) Compliance – Yes
Instrumental Accuracy	The accuracy of this instrument for a sensory calibration must be $A \leq 0.217$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V04: $A = 0.1995$ (September 2012) Compliance – Yes
Lower Detection Limit (LDL)	The LDL for the olfactometer has been determined to be 16 ou (4 times the lowest dilution setting)
Traceability	The measurements have been performed using standards for which the traceability to the national standard has been demonstrated. The assessors are individually selected to comply with fixed criteria and are monitored in time to keep within the limits of the standard. The results from the assessors are traceable to primary standards of n-butanol in nitrogen.

Date: Friday, 15 February 2013

Panel Roster Number: SYD20130213\_011

**J. Schulz**  
 NSW Laboratory Coordinator

**A. Schulz**  
 Authorised Signatory

The Odour Unit Pty Ltd  
 ABN 53 091 165 061  
 Form 06 – Odour Concentration Results Sheet

Issue Date: 13.11.2003  
 Issued By: SB  
 Last printed 2/20/2013 2:56:00 PM

Revision: 8  
 Revision Date: 18.07.2008  
 Approved By: TJS

1





# THE ODOUR UNIT PTY LIMITED



## Odour Sample Measurement Results Panel Roster Number: SYD20130213\_011

Sample Location	TOU Sample ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITEs	Nominal Sample Dilution	Actual Sample Dilution (Adjusted for Temperature)	Sample Odour Concentration (as received, in the bag) (ou)	Sample Odour Concentration (Final, allowing for dilution) (ou)	Specific Odour Emission Rate (ou.m <sup>3</sup> /m <sup>2</sup> /s)
AL2 Cake	SC13084	12/02/2013 09:24 hrs	13/02/2013 10:29 hrs	5	10	-	-	91	91	N/A
AL2 Cake Fresh	SC13085	12/02/2013 10:30 hrs	13/02/2013 11:07 hrs	5	10	-	-	1,450	1,450	N/A
Compound Waste	SC13086	12/02/2013 11:28 hrs	13/02/2013 11:39 hrs	5	10	-	-	128	128	N/A

Note: The following are not covered by the NATA Accreditation issued to The Odour Unit Pty Ltd:

1. The collection of Isolation Flux Hood (IFH) samples and the calculation of the Specific Odour Emission Rate (SOER).
2. Final results that have been modified by the dilution factors where parties other than The Odour Unit Pty Ltd. have performed the dilution of samples.



# THE ODOUR UNIT PTY LIMITED



Accreditation Number: 14974

## Odour Panel Calibration Results

Reference Odorant	Reference Odorant Panel Roster Number	Concentration of Reference gas (ppb)	Panel Target Range for n-butanol (ppb)	Measured Concentration (ou)	Measured Panel Threshold (ppb)	Does this panel calibration measurement comply with AS/NZS4323.3:2001 (Yes / No)
n-butanol	SYD20130213_011	50,000	$20 \leq \chi \leq 80$	832	60	Yes

Comments: None.

**Disclaimer**  
Parties, other than TOU, responsible for collecting odour samples hereby certify that they have voluntarily furnished these odour samples, appropriately collected and labelled, to The Odour Unit Pty Ltd for the purpose of odour testing. The collection of odour samples by parties other than The Odour Unit Pty Ltd relinquishes The Odour Unit Pty Ltd from all responsibility for the sample collection and any effects or actions that the results from the test(s) may have.

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# **Appendix 5**

## **Greenhouse gas emission calculations**

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## Diesel

GHG emissions from diesel consumption were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

$E_{CO_2-e}$	=	Emissions of GHG from diesel combustion	(t CO <sub>2</sub> -e)
Q	=	Estimated combustion of diesel	(GJ) <sup>1</sup>
EF	=	Emission factor (scope 1 or scope 3) for diesel combustion	(kg CO <sub>2</sub> -e/GJ) <sup>2</sup>

<sup>1</sup> GJ = Gigajoules

<sup>2</sup> kg CO<sub>2</sub>-e/GJ = kilograms of carbon dioxide equivalents per gigajoule

The quantity of diesel consumed in GJ is calculated using an energy content factor for diesel of 38.6 gigajoules per kilolitre (GJ/kL). Greenhouse gas emission factors and energy content for diesel were sourced from the NGA Factors (DCCEE, 2012). As discussed in Section 2.4 there are three transport options that would use a combination of road and rail to transport materials to and from the Proposal. The Scope 3 emissions for all three scenarios have been calculated. The estimated annual and project total GHG emissions from diesel usage are presented in **Table 1**.

**Table 1: Estimated CO<sub>2</sub>-e (tonnes) for Diesel Consumption**

Phase	Fuel Usage (kL)	Emission Factor (kg CO <sub>2</sub> -e/GJ)		Energy Content (GJ/kL)	Emissions (t CO <sub>2</sub> -e)		Total
		Scope 1	Scope 3		Scope 1	Scope 3	
Transport Option A	8,921	69.9	5.3	38.6	4,278	1,501	<b>5,778</b>
Transport Option B	7,090	69.9	5.3	38.6	4,278	1,126	<b>5,404</b>
Transport Option C	6,996	69.9	5.3	38.6	4,278	1,107	<b>5,385</b>
<b>Total Diesel Option A</b>	<b>178,423</b>	<b>69.9</b>	<b>5.3</b>	<b>38.6</b>	<b>85,552</b>	<b>30,015</b>	<b>115,567</b>
<b>Total Diesel Option B</b>	<b>141,799</b>	<b>69.9</b>	<b>5.3</b>	<b>38.6</b>	<b>85,552</b>	<b>22,523</b>	<b>108,075</b>
<b>Total Diesel Option C</b>	<b>139,928</b>	<b>69.9</b>	<b>5.3</b>	<b>38.6</b>	<b>85,552</b>	<b>22,140</b>	<b>107,692</b>

## Liquefied Petroleum Gas

Greenhouse gas emissions from Liquefied Petroleum Gas (LPG) consumption were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

$E_{CO_2-e}$	=	Emissions of GHG from LPG combustion	(t CO <sub>2</sub> -e)
Q	=	Estimated combustion of LPG	(GJ) <sup>1</sup>
EF	=	Emission factor (scope 1) for LPG combustion	(kg CO <sub>2</sub> -e/GJ) <sup>2</sup>

<sup>1</sup> GJ = giga joules

<sup>2</sup> kg CO<sub>2</sub>-e/GJ = kilograms of carbon dioxide equivalents per gigajoule

The quantity of LPG consumed in GJ is calculated using an energy content factor for LPG of 26.2 gigajoules per kilolitre (GJ/kL). Greenhouse gas emission factors and energy content for LPG were sourced from the NGA Factors (DCCEE, 2012). The estimated annual and Proposal total GHG emissions from LPG usage are presented in **Table 2**.

**Table 2: Estimated CO<sub>2</sub>-e (tonnes) for LPG Consumption**

Phase	Fuel Usage (kL)	Emission Factor (kg CO <sub>2</sub> -e/GJ)	Energy Content (GJ/kL)	Emissions (t CO <sub>2</sub> -e)	Total
		Scope 1		Scope 1	
Average operational year	26,000	60.8	26.2	41	41
20 year life of Proposal	520,000	60.8	26.2	828	828

### Compressed Natural Gas

Greenhouse gas emissions from Compressed Natural Gas (CNG) consumption were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

E <sub>CO<sub>2</sub>-e</sub>	=	Emissions of GHG from CNG combustion	(t CO <sub>2</sub> -e)
Q	=	Estimated combustion of CNG	(GJ) <sup>1</sup>
EF	=	Emission factor (scope 1) for CNG combustion	(kg CO <sub>2</sub> -e/GJ) <sup>2</sup>

<sup>1</sup> GJ = giga joules

<sup>2</sup> kg CO<sub>2</sub>-e/GJ = kilograms of carbon dioxide equivalents per gigajoule

The quantity of CNG consumed in GJ is calculated using an energy content factor for CNG of 0.039 gigajoules per kilolitre (GJ/m<sup>3</sup>). Greenhouse gas emission factors and energy content for CNG were sourced from the NGA Factors (DCCEE, 2012). The estimated annual and Proposal total CNG emissions from CNG usage are presented in **Table 3**.

**Table 3: Estimated CO<sub>2</sub>-e (tonnes) for CNG Consumption**

Phase	Fuel Usage (m <sup>3</sup> )	Emission Factor (kg CO <sub>2</sub> -e/GJ)	Energy Content (GJ/m <sup>3</sup> )	Emissions (t CO <sub>2</sub> -e)	Total
		Scope 1		Scope 1	
Average operational year	28,978,022	51.3	0.039	58,456	58,456
20 year life of Proposal	579,560,440	51.3	0.039	1,169,129	1,169,129

### Blasting

Greenhouse gas emissions from blasting ammonium nitrate-fuel oil (ANFO) usage were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

E <sub>CO<sub>2</sub>-e</sub>	=	Emissions of greenhouse gases from blasting using ANFO	(tCO <sub>2</sub> -e/annum)
Q	=	Estimated blasting using ANFO	(tonnes/annum) <sup>1</sup>
EF	=	Emission factor (scope 2 or scope 3) for blasting using ANFO	(kgCO <sub>2</sub> -e/kWh) <sup>2</sup>

<sup>1</sup> kWh/annum = kilowatt hours per annum

<sup>2</sup> kgCO<sub>2</sub>-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour

Greenhouse gas emission factors were sourced from the NGA Factors (DCCEE, 2012). The estimated annual and Proposal total GHG emissions from ANFO usage are presented in **Table 4**.



**Table 4: Estimated CO<sub>2</sub>-e (tonnes) for On-site ANFO Use**

Phase	ANFO Usage (t)	Emission Factor (kg CO <sub>2</sub> -e/t)	Emissions (t CO <sub>2</sub> -e)	Total
		Scope 1	Scope 1	
Average operational year	246	0.17	45	45
20 year life of Proposal	5,280	0.17	898	898

### Electricity

Greenhouse gas emissions from electricity usage were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

E <sub>CO<sub>2</sub>-e</sub>	=	Emissions of greenhouse gases from electricity usage	(tCO <sub>2</sub> -e/annum)
Q	=	Estimated electricity usage	(kWh/annum) <sup>1</sup>
EF	=	Emission factor (scope 2 or scope 3) for electricity usage	(kgCO <sub>2</sub> -e/kWh) <sup>2</sup>

<sup>1</sup> kWh/annum = kilowatt hours per annum

<sup>2</sup> kgCO<sub>2</sub>-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour

Greenhouse gas emission factors were sourced from the NGA Factors (DCCEE, 2012). The estimated annual and Proposal total GHG emissions from electricity usage are presented in **Table 5**.

**Table 5: Estimated CO<sub>2</sub>-e (tonnes) for Electricity Use**

Phase	Electricity Usage (GWh)	Emission Factor (kg CO <sub>2</sub> -e/kWh)	Emissions (t CO <sub>2</sub> -e)	Total
		Scope 2	Scope 2	
Average operational year	137	0.88	120,560	2,411,200
20 year life of Proposal	2,740	0.88	2,411,200	2,411,200

### Calcium carbonate

Greenhouse gas emissions from usage of calcium carbonate at the processing plant were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

E <sub>CO<sub>2</sub>-e</sub>	=	Emissions of greenhouse gases from electricity usage	(tCO <sub>2</sub> -e/annum)
Q	=	Estimated calcium carbonate usage	(tonnes/annum)
EF	=	Emission factor for calcium carbonate usage	(kgCO <sub>2</sub> -e/tonne)

Greenhouse gas emission factors were sourced from the NGA Factors (DCCEE, 2012). The estimated annual and Proposal total GHG emissions from use of calcium carbonate are presented in **Table 6**.

**Table 6: Estimated CO<sub>2</sub>-e (tonnes) for calcium carbonate usage**

Phase	Calcium carbonate usage (tonnes)	Emission Factor (kg CO <sub>2</sub> -e/kWh	Emissions (t CO <sub>2</sub> -e)	Total
		Scope 2	Scope 2	
<b>Average operational year</b>	195,000	0.396	77,220	<b>77,220</b>
<b>20 year life of Proposal</b>	<b>3,900,000</b>	<b>0.396</b>	<b>1,544,400</b>	<b>1,544,400</b>