Perilya Broken Hill Limited
ABN: 46 099 761 289

Broken Hill North Mine

Air Quality and Greenhouse Gas Assessment

Prepared by

Pacific Environment Limited

January 2017

Specialist Consultant Studies Compendium
Part 1

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Air Quality and Greenhouse Gas Assessment

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COMMONLY USED ACRONYMS AND UNITS

AHD	Australia Height Datum
BoM	Bureau of Meteorology
CO	carbon monoxide
DPE	Department of Planning and Environment
km	kilometres
NSW EPA	New South Wales Environment Protection Authority
GHG	Greenhouse Gas
HVAS	High Volume Air Sampler
$g/m^2/month$	grams per square metre per month
m/s	metres per second
m^2	metres squared
m^3	cubic metres
$\mu g/m^3$	micrograms per cubic metre
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measures
NO	nitrogen oxide
NO_2	nitrogen dioxide
NPI	National Pollutant Inventory
˚C	degrees Celsius
$PM_{2.5}$	particulate matter less than 2.5µm in diameter
PM_{10}	particulate matter less than 10µm in diameter
ROM	Run-Of-Mine
SEARs	Secretary's Environmental Assessment Requirements
SO_2	sulfur dioxide
t	tonnes
TAPM	The Air Pollution Model
TEOM	Tapered Element Oscillating Microbalance
tpa	tonnes per annum
TSP	total suspended particulates
US EPA	United States Environment Protection Agency

DEFINITION OF TERMS

Term	Definition
AERMET	AERMET is a meteorological data pre-processor for AERMOD.
AERMOD	AERMOD is the US-EPA's recommended steady-state plume dispersion model for regulatory purposes and it is an accepted model of the NSW EPA.
Air dispersion modelling	Mathematical simulation of how air pollutants disperse in the ambient atmosphere.
Ambient air quality	The state of quality and chemical characteristics of air as it exists in the environment.
Carbon monoxide (CO)	Carbon Monoxide (CO) is a toxic, colourless, odourless gas produced by burning any fuel.
Dust deposition	Dust deposition is the process of particles (mostly greater than 10 µm in diameter) settling and accumulating on surfaces.
Emissions	Release of pollutants to air.
Environmental Impact Statement (EIS)	The information document prepared by or on behalf of the Applicant when undertaking an environmental impact assessment. It is prepared in accordance with requirements provided by local and state Government agencies.
Erosion	The process by which material, such as rock or soil, is worn away or removed by wind or water.
Gaussian models	It assumes that the air pollutant dispersion has a Gaussian distribution, meaning that the pollutant distribution has a normal probability distribution.
Nitrogen Dioxide (NO_2)	Nitrogen dioxide (NO_2) is a reddish-brown gas. It is a lung irritant and is present in the highest concentrations among other oxides of nitrogen in ambient air. Nitric oxide (NO) and NO_2 are collectively known as NO_x.
Particulate matter (PM)	Dust particles that are introduced or resuspended into the air through certain activities such as soil cultivation, or vehicles operating on open fields or dirt roadways.
Percentile	A value on a scale that indicates the percent of a distribution that is equal to it or below it. For example, a score at the 95th percentile is equal to or better than 95 percent of the scores.
Pollution	An alteration in the character or quality of the environment, or any of its components, that renders it less suited for certain uses. The alteration of the physical, chemical, or biological properties of water by the introduction of any substance that renders the water harmful to use.
Receptor	Locations that may be sensitive to air quality that exceeds the assessment criteria objectives for air quality.
Silt	For the purposes of air quality assessment, silt content refers to the particles less than 75µm
Sulphur Dioxide (SO_2)	A toxic gas found in the emissions of volcanos and those of burning coal or petroleum. Dissolves in water to form sulphurous acid and, in the presence of oxygen, sulphuric acid.
Wind roses	Wind roses show the frequency of occurrence of winds by direction and strength.

EXECUTIVE SUMMARY

OVERVIEW

Perilya Broken Hill Limited ("the Applicant") proposes the recommencement of mining operations ("the Proposal") at the Broken Hill North Mine ("the Mine"). The Mine Site is located on the Line of Lode, Broken Hill, within Consolidated Mining Leases (CML) 4 and 5.

Between 2003 and 2008 the Applicant operated the Mine under DA 54/2003 granted by Broken Hill City Council on 6 March 2003. Mining under that development consent ceased in 2008. During the intervening period, on-site activities have included maintenance of ventilation and essential infrastructure. Following the recommencement of mining operations, the Applicant proposes to undertake the following.

- Resume mining operations using the existing Cosmopolitan Decline to extract ore to a depth of between 1,750m and 2,250m below surface over a period of approximately 20 years.
- Crush extracted ore within a surface ROM pad using a mobile crusher.
- Transportation of crushed ore via the public road network to the South Mine using B-Double trucks or double road trains.

An Air Quality and Greenhouse Gas Assessment has been prepared for the Proposal in accordance with the Secretary's Environmental Assessment Requirements (SEARs) dated 6 May 2016, and *supporting* requirements from other State and Local government agencies for the Proposal.

EXISTING ENVIRONMENT

A monitoring program comprising of dust and ambient air monitoring was established in July 2008 in the vicinity of the Proposal. A review of the air quality monitoring data indicates that ambient air quality in Broken Hill is below the relevant ambient air quality criteria.

Meteorology for the assessment was taken from the Bureau of Meteorology (BoM) Automatic Weather Station (AWS) located at Broken Hill Airport, 5km, south-south-west from the Proposal. Insufficient cloud data were available at the Broken Hill AWS, so TAPM (prognostic model) was used to generate the cloud data for the modelled 2014 year. Dominant winds are from the south and north-east quadrants on an annual basis. These patterns are reflected in varying degrees in all seasons throughout the years, with north-west winds also prevalent in winter.

EMISSIONS AND MODELLING ASSESSMENT

Detailed emission inventories were prepared for both annual and maximum daily operating scenarios.

The modelling indicates that there are predicted to be no exceedances at privately-owned receptors of the annual average $PM_{2.5}$, PM_{10}, TSP or dust deposition assessment criteria, either from the Proposal alone or cumulatively. The modelling also indicated that the Proposal would not cause any additional 24-hour exceedances of the $50\mu g/m^3$ PM_{10} criterion at the privately-owned receptors during maximum daily (worst case) operations. Further, no exceedances of the relevant NSW EPA impact assessment criteria for the assessed toxic air pollutants were predicted to occur.

GREENHOUSE GAS ASSESSMENT

A GHG assessment for the Proposal indicates that average annual Scope 1 emissions from the Proposal (0.04 Mt CO_2-e) would represent approximately 0.007% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global greenhouse emissions.

1. INTRODUCTION

1.1 BACKGROUND

This air quality assessment has been prepared on behalf of Perilya Broken Hill Limited ("the Applicant") to describe the proposed recommencement of mining operations ("the Proposal") at the Broken Hill North Mine ("the Mine"). The Mine Site is located on the Line of Lode, Broken Hill, within Consolidated Mining Leases (CML) 4 and 5 (as shown in **Figure 1-1**).

Between 2003 and 2008 the Applicant operated the Mine under DA 54/2003 granted by Broken Hill City Council on 6 March 2003. The consent permitted the following activities.

- Underground mining operations within the upper levels of the existing mine for a period of approximately two years.
- Crushing of the ore within the existing Cosmopolitan Open Cut.
- Transportation of crushed ore to the Applicants Broken Hill South Mine via the existing rail network.

Mining under that development consent ceased in 2008. During the intervening period, on-site activities have included maintenance of ventilation and essential infrastructure.

Following the recommencement of mining operations, the Applicant proposes to undertake the following.

- Resume mining operations using the existing Cosmopolitan Decline to extract ore to a depth of between 1,750m and 2,250m below surface over a period of approximately 20 years.
- Crush extracted ore within a surface ROM pad using a mobile crusher.
- Transportation of crushed ore via the public road network to the South Mine using B-Double trucks or double road trains.

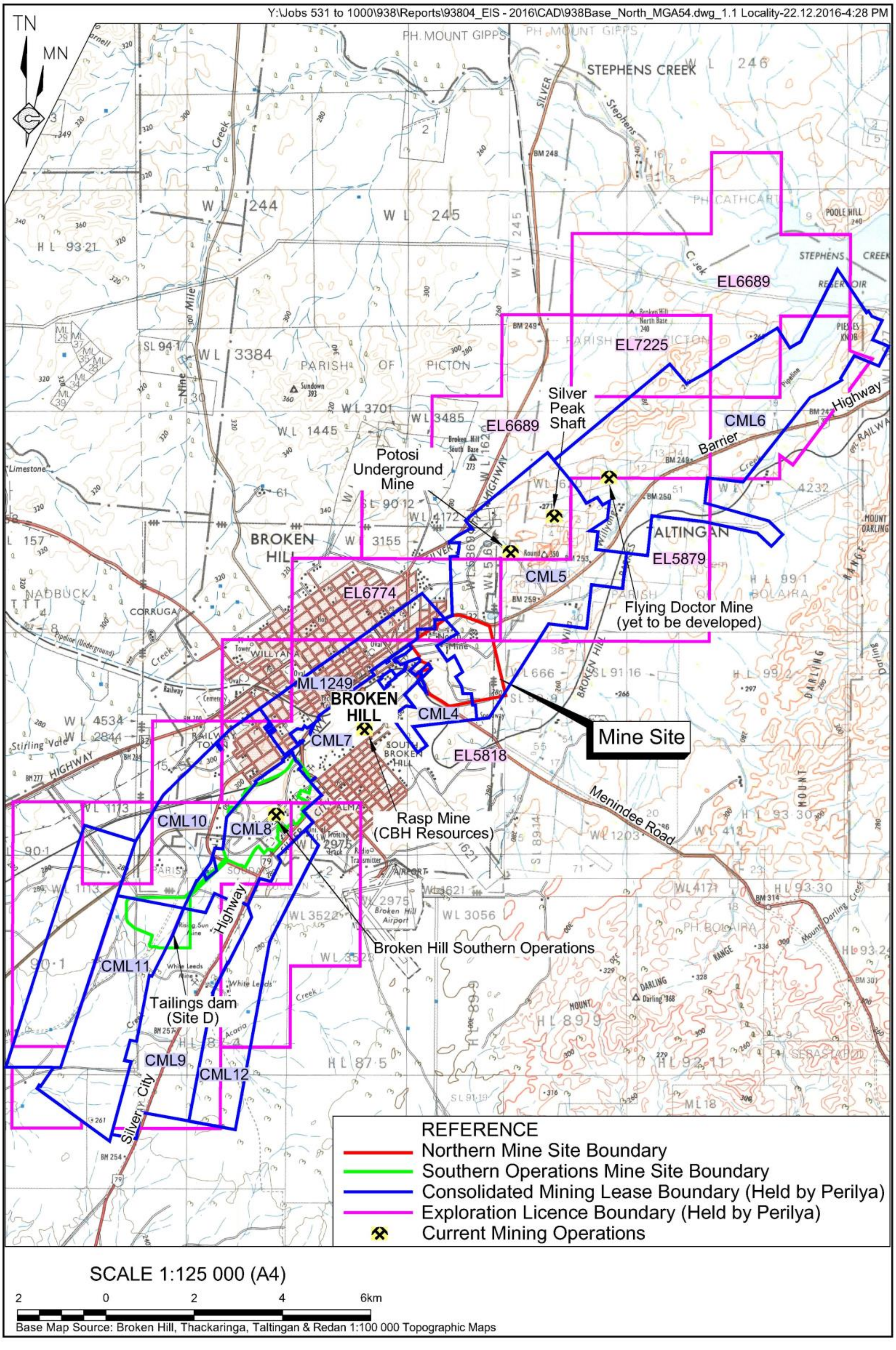

Figure 1-1 Locality Plan

1.2 SEARS AND AGENCY REQUIREMENTS FOR ASSESSMENT

The Secretary's Environmental Assessment Requirements (SEARs) requirements and where they are addressed in this document are outlined in **Table 1.1.**

Table 1.1
Coverage of Air Quality

Government Agency	Paraphrased Requirement	Relevant Section(s)
	Air Quality	
DPE (06/05/16)	• An assessment of the likely air quality impacts of the development in accordance with the Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW, having regard to EPA's requirements.	Section 9
	• An assessment of the likely greenhouse gas impacts of the development.	Section 11
EPA (20/04/16)	• The EA must document an emissions inventory that identifies all potential air pollutants at their source and discharge point. A map detailing the location of all plant and activities must be included that also identifies surrounding potentially affected receptors.	Section 8
	• Details need to be provided on the proposed measures to manage particulates and dust from all sources and in particular from road construction, blasting, crushing and vehicle movements. Measures to prevent or control the emission of particulates and dust from these activities on sensitive receptors must be detailed.	Section 7
	• For a proposal of this scope and in the existing location we would expect a cumulative assessment of particulates and dust to be undertaken in accordance with our guideline the 'Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales' (EPA, 2005). The assessment must identify all sensitive receptors in proximity to the proposed development and include air quality modelling, in conjunction with analyses of local meteorologic and terrain data in order to make informed decisions about design and management options for the proposed development.	Section 9
	• Emissions from any plant must meet the design criteria detailed in the Protection of the Environment Operations (Clean Air) Regulation 2010. Details need to be provided on the proposed air pollution control techniques from any air emission points, including proposed measures to manage and monitor efficiency and performance.	Section 7 Section 8

2. PROPOSAL DESCRIPTION

2.1 OVERVIEW

The Proposal would include the following (**Figure 2-1**, **Figure 2-2** and **Figure 2-3**).

- Remediate the existing Cosmopolitan access ramp, portal and decline to the 12 Level (limit of the existing decline) to facilitate safe and efficient access to the underground workings
- Restore and upgrade existing electrical, ventilation, air and water services, including on surface and within the decline, No. 2 and No. 3 Shafts, No. 3 Return Air Rise.
- Extend the existing decline from the 12 Level to link with the existing decline between the 32 Level and the 38 Level.
- Undertake exploration drilling from underground to further define remanent ore and identify additional ore lenses and lodes.
- Develop access drives to permit access by modern mining equipment.
- Extract remnant ore and ore below the base of previous mining operations, including within the Fitzpatrick Area.
- Transport extracted ore to the surface ROM Pad using underground haul trucks, including establishment of a haulage route utilising existing roads and a proposed haul road cutting.
- Transport extracted waste rock for placement either within completed stopes underground or within the in-pit waste rock emplacement in the Cosmopolitan Open Cut.
- Extract waste rock from the existing surface waste rock emplacement for transportation back underground as required.
- Extract tailings from a former Tailings Storage Facility for mixing with water and cement in a proposed pastefill plant for use backfilling completed stopes.
- Re-establish surface infrastructure required to support the mining operation, including a ROM pad, office and store, workshop and fuel store, change house and car park, services (power, water, air and communications), surface magazine and ancillary infrastructure.
- Stockpile and crush ore within the existing ROM Pad using a mobile crusher.
- Load and transport the crushed ore to the Southern Operations using double road trains utilising the transport route approved for the Applicant's Potosi Mine, namely Barrier Highway, Iodide Street, Crystal Street and Gypsum Street.
- Process the transported ore within the Southern Operations Concentrator under the continuing use rights held for that operation.
- Dewater the existing workings and transfer that water to on site evaporation ponds or the Southern Operations.

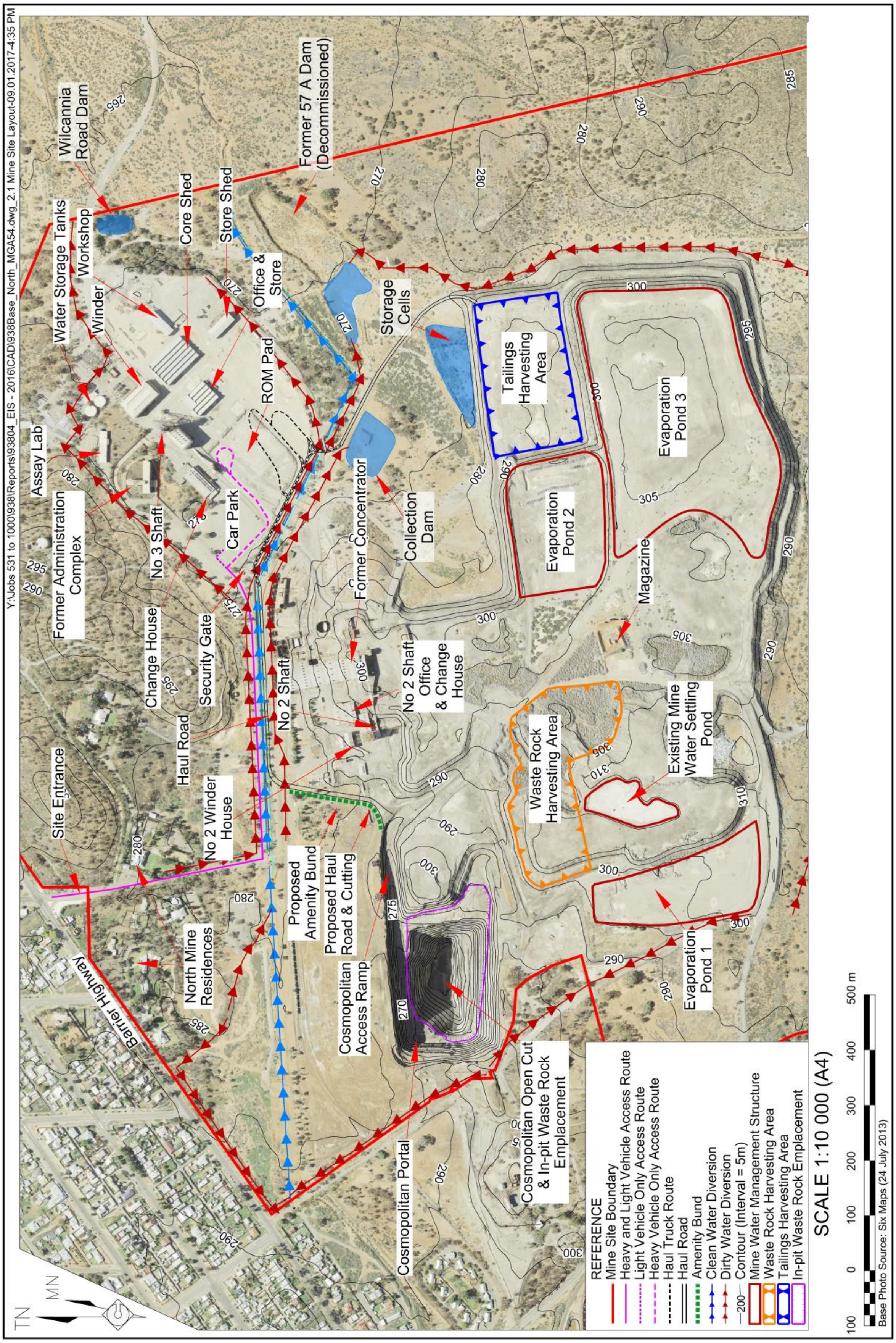

Figure 2-1 Mine Site Layout

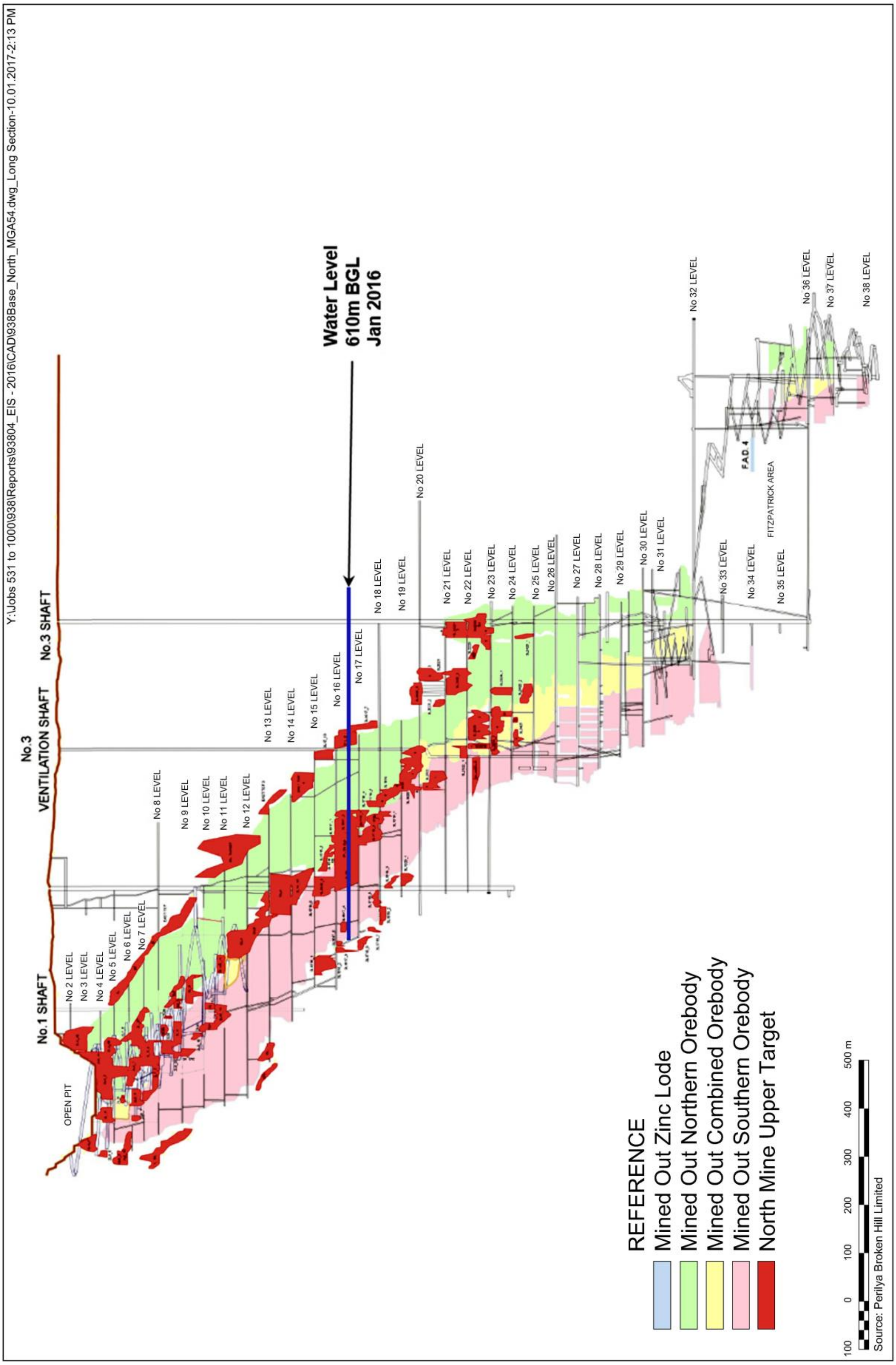

Figure 2-2 Long Section of the Mine Site

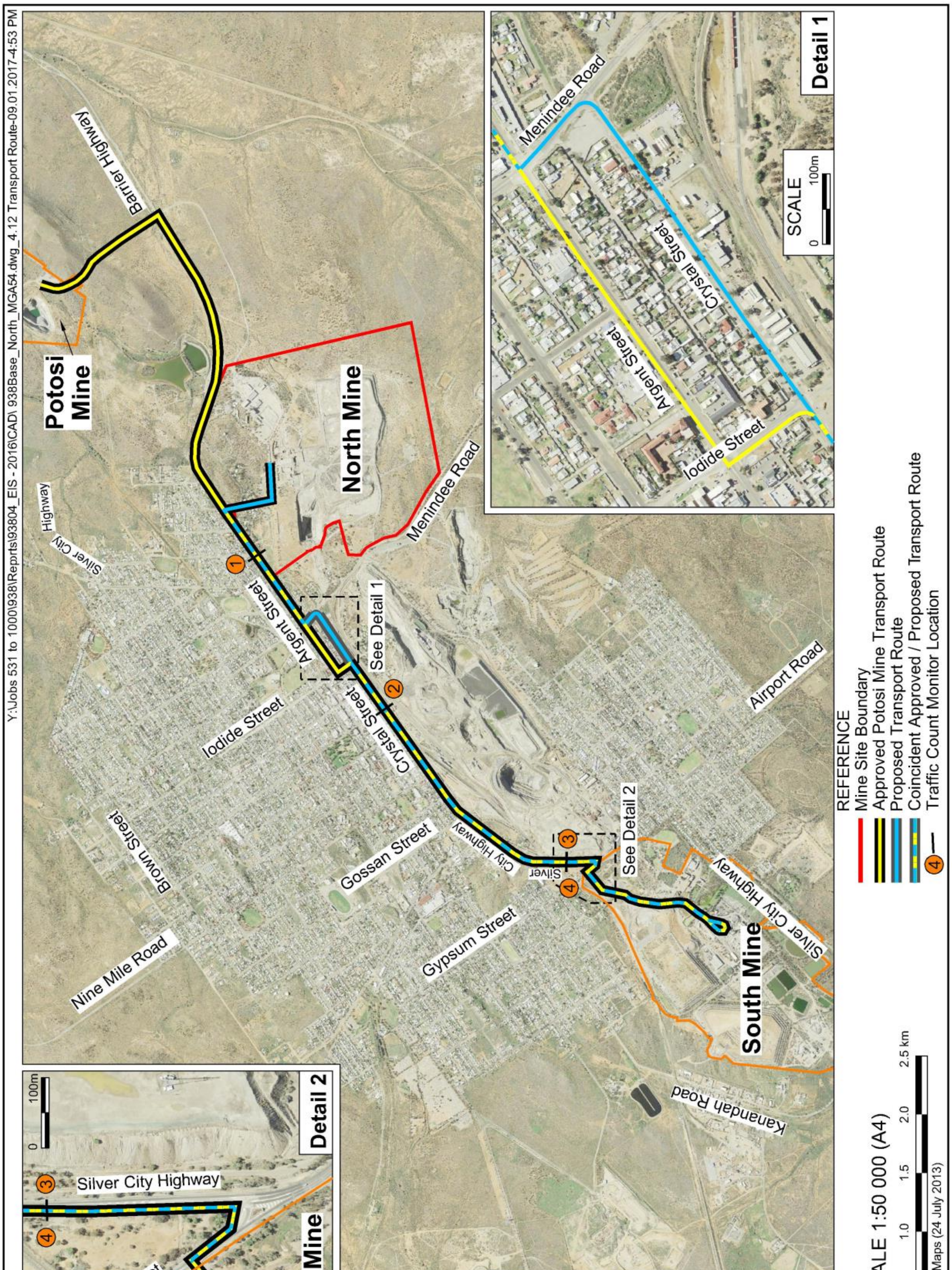

Figure 2-3 Transport Route

2.2 REMEDIATION AND RESTORATION OPERATIONS

The Applicant anticipates that the following remediation and restoration operations would be required to facilitate the recommencement of mining operations (**Figure 2-1**).

- Stabilise and making safe the northern wall of the Cosmopolitan Open Cut.
- Inspect and stabilise the existing Cosmopolitan portal and decline and associated access drives, ventilation shafts and escape ways.
- Re-establish surface and underground services to current standards, including update the:
    - existing site electrical infrastructure;
    - secondary ventilation;
    - water management infrastructure (pumps, pipes, fittings, etc.);
    - compressed air distribution system;
    - surface and underground communication infrastructure; and
    - surface magazine.
- Establish a suitable haul road from the Cosmopolitan Open Cut to the ROM Pad, including construction of a haul road and amenity bund to the northeast of the open cut to eliminate the requirement for underground mining equipment, including haul trucks, to travel in line of sight to surrounding residential areas.
- Re-establish the existing ROM Pad and associated traffic management systems to ensure that interaction between surface and underground vehicles is minimised to the greatest extent practicable.
- Refurbish and re-establish surface facilities, including the office/store, workshop, change house and car park.
- Construct a pastefill plant, including a dewatered tailings stockpile area, transportable cement silo(s), pug mill and associated infrastructure.
- Refurbish the No. 3 Shaft and associated surface infrastructure, including storage tanks and pipework, to permit dewatering of the existing workings.

2.3 MINING OPERATIONS AND DEVELOPMENT SCHEDULE

Mining operations at the Proposal would be undertaken in three phases as follows.

2.3.1 Phase 1 – Remediation and Restoration

This phase is described in **Section 2.2** and would principally prepare the Mine Site for the recommencement of routine mining operations. The Applicant anticipates that Phase 1 would require up to 18 months to complete, with Phase 2 mining operations commencing approximately 9 months after the commencement of Phase 1.

2.3.2 Stage 2 – Uppers Phase

The North Mine Uppers is defined as those sections of the North Mine above the 26 Level (see **Figure 2-2**). Mining operations during this phase would include the following.

- Extension of the existing decline from the 12 Level to the 26 Level.
- Extraction of remnant ore above the 26 Level. Extraction rates during this phase are expected to be up to 295,000tpa of ore and 110,000tpa of waste rock, the majority of which would be placed underground.
- Further exploration drilling to better define remnant ore boundaries, unmapped voids and explore for yet to be identified ore lodes or lenses.

The Applicant anticipates that Phase 2 would require up to seven years to complete, commencing towards the end of Year 1 of the Proposal. Phase 3 mining operations would commencing approximately 2 years prior to the completion of Phase 2.

2.3.3 Stage 3 – Deeps Phase

The North Mine Deeps is defined as those sections of the North Mine below the 26 Level (see **Figure 2-2**), including ore lodes and lenses that may be identified during underground drilling operations.

- Extension of the existing decline and access drives to permit access to the known and yet to be identified ore lodes and lenses. The maximum depth of mining operations would be approximately 2,250mbgl.
- Extraction of ore below the 26 Level. Extraction rates during this phase are expected to be approximately 300,000tpa of ore and 231,000tpa of waste rock, the majority of which would be placed underground as backfill and the remainder placed in-pit in the Cosmopolitan Open Cut to facilitate rehabilitation of that open cut.
- Further exploration drilling to identify further ore lodes or lenses.

The Applicant anticipates that Phase 3 would require up to nine years to complete, commencing during Year 6 of the Proposal.

2.4 MINING AND DEVELOPMENT METHODS

Ore mining methods would be determined based on the geometry or the ore lenses or lodes and geotechnical considerations. In summary, the Applicant anticipates that mining methods would include Long Hole Open Stoping or a modified Avoca method. These mining methods will be fully described in the Environmental Impact Statement, however, each involve drilling fans of drillholes from one level to the level above or below, filling those holes with explosives and fragmenting the ore.

Overhand or underhand cut and fill mining methods may also be utilised during the Deeps Phase. These mining methods require the filling of the extracted stope using cemented paste fill. The paste fill supports the completed stope, permitting full extraction of the identified resource.

Development, or mining that would be undertaken to permit access to the ore, would be undertaken using one or more jumbos (multi-armed underground drill rigs) to drill the face of the drive. These holes would also be loaded with explosives and the ore or waste fragmented.

Fragmented material would be loaded into haul trucks using an underground loaded and transported to:

- the ROM Pad:
- the in-pit waste rock emplacement; or
- an underground void.

2.5 STOCKPILING AND PROCESSING OPERATIONS

Ore would be transported to the ROM Pad using underground haul trucks. The Applicant would construct a cutting to permit underground mobile plant to travel from the end of the Cosmopolitan Access ramp to the existing road network (see **Figure 2-1**). The cutting would ensure that underground vehicles which are typically noisy items, are able to exit the Cosmopolitan Open Cut and access the existing road network without being in direct line of sight of residential areas to the north and northwest of the Mine Site. The Environmental Impact Statement will present a detailed design of the cutting and the Applicant will ensure that the proposed footprint of the cutting is inspected and any heritage impacts are appropriately identified in the Environmental Impact Statement and mitigated.

Ore would then be transported via the existing road network which would be upgraded to cater for the type of vehicles proposed to use the road. Haul trucks would cross the clean water diversion using existing crossings (see **Figure 2-1**). Those crossing would be inspected to ensure that they are suitable for the mass of the vehicles that would be used.

Ore would be stockpiled within the existing ROM Pad. A mobile crushing plant would be installed within the ROM Pad and stockpiled ore would be loaded into the crusher using a frontend loader. The crushed ore would then be stockpiled prior to loading into road-registered trucks for transportation to the Southern Operations.

Crushing operations would typically be undertaken on weekdays during daylight hours.

2.6 TRANSPORTATION OPERATIONS

Crushed ore would loaded into road-registered duel-axle B-Double trucks, tri-axle B-Double trucks or double road trains using a front-end loader. Material would be transported to the Southern Operations via the approved transportation route for the Potosi Mine (see **Figure 2-3**).

The development consent for the Potosi Mine (DA 448/2004) identifies that 48 heavy vehicle movements per day, up to duel-axle B-Double size, are permitted. The Applicant has identified that the combined ore transportation operations for the North Mine and the Potosi Mine would, together, result in less than 48 movements per day using tri-axle B-Double trucks.

2.7 ANCILLARY ACTIVITIES

The Applicant would undertake a range of ancillary activities to facilitate re-establishment and ongoing operations at the North Mine. These would include, but not be limited to the following. Each would be covered by the proposed Development Consent.

- Refurbish existing office and store, core shed, stores shed and storage facilities, including upgrading electrical infrastructure and communication equipment.
- Refurbish sections of the change house as required, including upgrading, electrical, plumbing, washing and laundry facilities and related infrastructure.
- Refurbish the existing workshop, including establishing a fuel and oil store and sealed refuelling area in accordance with the requirements of AS 1940 – The storage and handling of flammable and combustible liquids.
- Refurbish the No. 3 Shaft for dewatering of the mine workings and services supply, including use of the existing water storage tanks and installation of pipework for the transfer of mine water to the Southern Operations. Transfer of that water is an activity permitted under existing use rights that apply to the Southern Operations and the services corridor that links the two sites.
- Re-establishment of the existing surface explosives magazines.

2.8 HOURS OF OPERATIONS AND LIFE OF THE PROPOSAL

2.8.1 Hours of Operation

Table 2.1 presents the proposed hours of operation for the Proposal.

Table 2.1
Proposed Hours of Operation

Activity	**Proposed Days of Operation**	**Proposed Hours of Operation**
Surface site preparation activities	7 days per week during Year 1	Daylight hours
Underground site preparation activities	7 days per week	24 hours per day
Mining and stockpiling operations	7 days per week	24 hours per day
Crushing operations	7 days per week	7:00am to 7:00pm
Transportation operations	7 days per week	7:00am to 7:00pm
Maintenance operations	7 days per week	24 hours per day
Rehabilitation operations	7 days per week	Daylight hours

2.8.2 Life of the Proposal

The Applicant anticipates that Phase 1 to Phase 3 mining operations (see **Section 2.3**) would, based on known ore reserves, require approximately 16 years to complete. However, the Applicant anticipates that additional ore would be identified during mining operations. As a result, the Applicant proposes to undertake mining operations for a period of 25 years from the date of granting of development consent, with rehabilitation and mine closure activities expected to require a number of years following the completion of mining operations.

3. LOCAL SETTING

The Broken Hill North Mine Proposal is located in Broken Hill, NSW (see **Figure 1-1**). Nearby land uses include urban development within the city of Broken Hill, undeveloped arid landscapes beyond the city limits and extractive industries including mines and quarrying activities.

There are a number of privately-owned and resource company-owned residences in the vicinity of the Mine Site, as shown in **Figure 3-1**. Ownership details are provided in **Table 3.1**.

The Mine Site is located on the eastern side of the city of Broken Hill, within a plain of relatively flat terrain. Within the Mine Site, the topography ranges with slopes outwards from the highest elevations at the central area of the mine (elevations range from 270m AHD to 310m AHD) inside the boundary.

Topography plays an important role in steering winds, generating turbulence and large scale eddies, and in generating drainage flows at night and upslope flows in the day. The topography within the region and surrounding the Mine Site is consistent with a relatively flat, arid setting. Notably elevated terrain exists through the centre of Broken Hill which has been the focus for historical mining activity. **Figure 3-2** shows a pseudo three-dimensional (3D) representation of the local topography around the Mine Site.

Table 3.1
Receptor Locations in the Vicinity of the Proposal

Type	ID	East (m)	North (m)	Description
Residential	R1	546102	6466100	Brady Street
Residential	R2	545989	6465688	Mann Street
Residential	R3	545971	6465521	Argent Street (Barrier Hwy)
Residential	R4	545752	6465380	Argent Street (Barrier Hwy)
Residential	R5	545564	6465248	Argent Street (Barrier Hwy)
Residential	R6	545355	6465097	Argent Street (Barrier Hwy)
Residential	R7	545189	6464985	Argent Street (Barrier Hwy)
Residential	R8	545166	6464867	Chettle Street
Residential	R9	545068	6464733	Sturt Street
Residential	R10	545071	6464581	Junction Circle
Residential	R11	544793	6464518	Crystal Street
Residential	R12	544642	6464418	Crystal Street
Residential	R13	544684	6464163	Iodide Street
Residential	R14	544582	6463063	Eyre Street North
Residential	R15	544456	6462950	Eyre Street North
Residential	R16	544570	6462236	Lawton Street
Residential	R17	545137	6461970	Duff Street
Residential	R18	544964	6460752	Airport Road
Residential	R19	545745	6460814	Airport Road
Residential	R20	547538	6461001	Menindee Road
Residential	R21	548552	6463185	Menindee Road
Residential	R22	548751	6465766	Barrier Highway
Residential	R23	548977	6465760	Barrier Highway
School	R24	544654	6466445	Willyama High School
School	R25	544609	6465600	Broken Hill North Public School
School	R26	543430	6465852	Morgan Street Public School
School	R27	543296	6464626	Sacred Heart Parish Primary School
School	R28	543161	6464333	Broken Hill Public School
School	R29	543136	6463898	Broken Hill High School
School	R30	542804	6461173	Rainbow Pre-School
School	R31	541557	6462732	Railway Public School
School	R32	541709	6463886	Burke Ward Primary School
School	R33	543720	6461402	Alma Public School
School	R34	543177	6461665	Alma Bugdlie Pre School
Hospital	R35	542973	6465219	Broken Hill Hospital
Health Centre	R36	543945	6464383	Far West Mental Health Recovery Centre
Aged care	R37	543781	6464187	Aruma Lodge Aged Care Service
Aged care	R38	543701	6462294	Harold Williams Home Aged Care Service
Flying Doctors Medical Centre	R39	544454	6459590	Broken Hill Airport

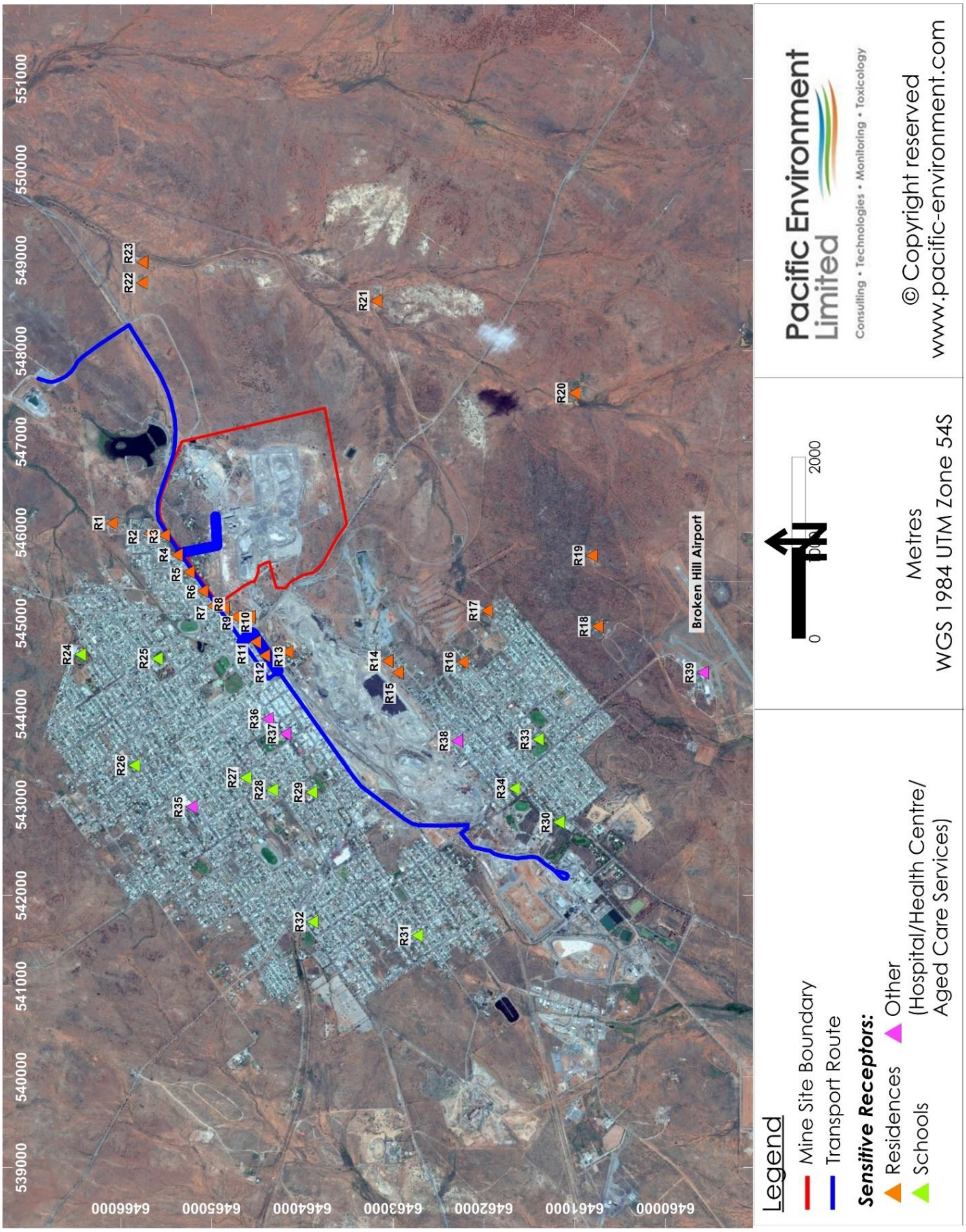

Figure 3-1 Location of the Mine Site and Sensitive Receptors

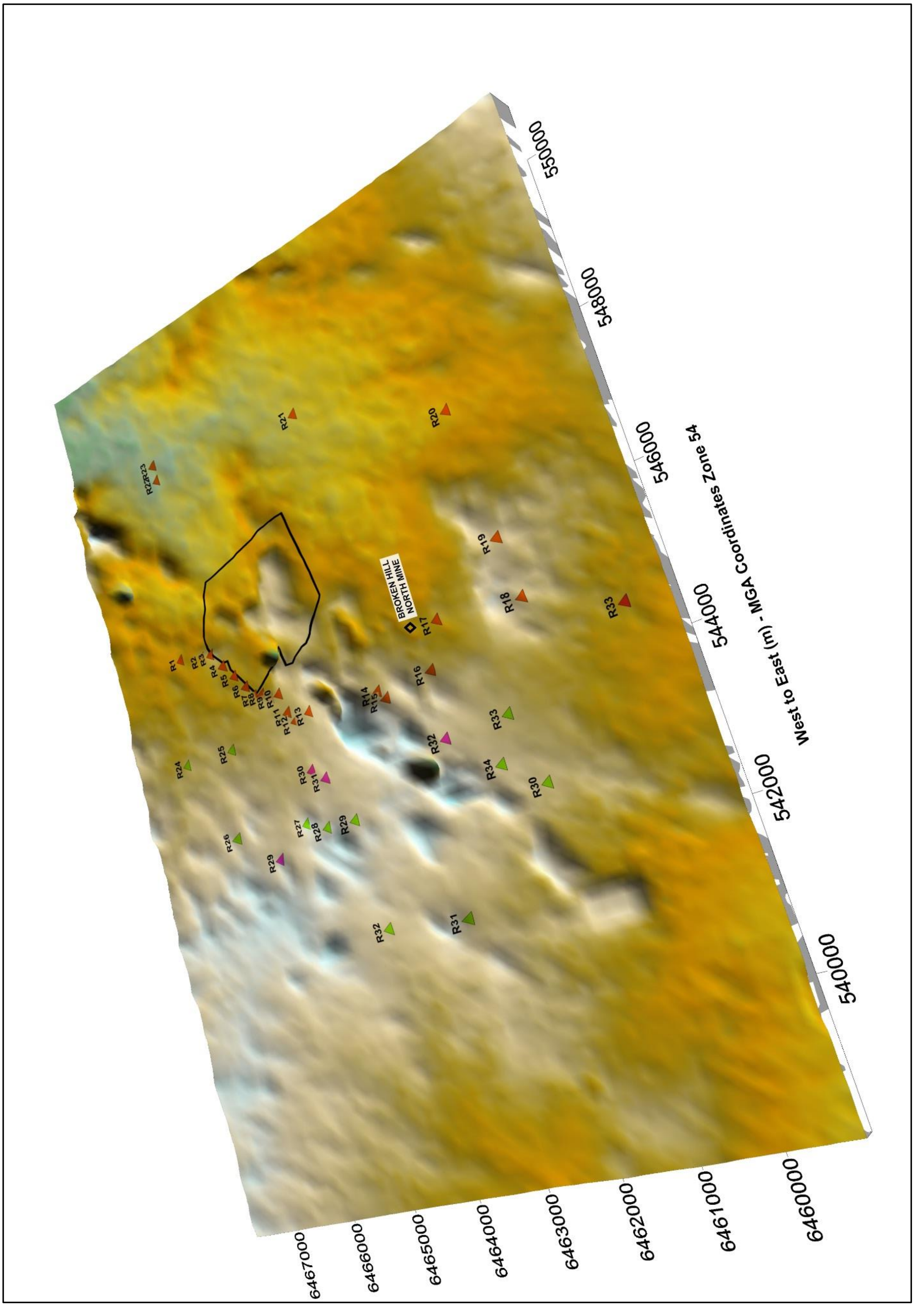

Figure 3-2 Pseudo 3-Dimensional Plot of the Local Topography

4. AIR QUALITY CRITERIA

4.1 INTRODUCTION

All activities described in **Section 8** have the potential to generate suspended metal/metalloid concentrations and 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 (μm) (PM_{10}) or less, particulate matter with an equivalent aerodynamic diameter of 2.5 micrometres (μm) ($PM_{2.5}$) or less and deposited dust emissions.

In addition, combustion engines release emissions through engine exhausts including carbon monoxide (CO), minor quantities of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). Diesel combustion also results in the emission of particulate matter (greater than 97% of which are $PM_{2.5,}$ (NSW EPA, 2012)).

The low sulphur content of Australian diesel, in combination with the fact that mining equipment is expected to be dispersed over the Mine Site, is such that the ambient air quality criterion for SO_2 would not be exceeded, even in mining operations that use large quantities of diesel. For this reason, no detailed study is required to demonstrate that emissions of SO_2 from the Mine Site would not significantly affect ambient SO_2 concentrations. Similarly, CO emissions from the mining and related activities are limited and too widely dispersed to require a detailed modelling assessment. For this reason, these emissions are not considered further in this report.

Other emissions to air from the Proposal include greenhouse gases (GHG) such as fugitive methane (CH_4), carbon dioxide (CO_2) from the combustion of fuel in combustion engines and indirect GHG emissions from the combustion of fuels on site. GHG emissions are assessed in **Section 10**.

4.2 PARTICULATE MATTER

4.2.1 Health Effects

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. In practice, the upper size range is typically 30μm to 50μm.
- PM_{10} – refers to all particles with equivalent aerodynamic diameters of less than 10μm, that is, all particles that behave aerodynamically in the same way as spherical particles with diameters less than 10 μm and with a unit density. PM_{10} are a sub-component of TSP.
- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5μm diameter (a subset of PM_{10}). These are often referred to as the fine particles and are a sub-component of $PM_{10.}$
- $PM_{2.5-10}$ – defined as the difference between PM_{10} and $PM_{2.5}$ 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 (WHO, 2011). The human respiratory system has in-built defensive systems that prevent larger particles from reaching the more sensitive parts of the respiratory system. Particles larger than approximately 10μm, while not able to affect health, can soil materials and generally degrade aesthetic elements of the environment. For this reason, air quality criteria 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 pollutants.

Both natural and anthropogenic processes contribute to the atmospheric load of particulate matter. Coarse particles ($PM_{2.5-10}$) and larger are derived primarily from mechanical processes resulting in the suspension of dust, soil, or other crustal[1] materials from roads, farming, mining, dust storms, and so forth. Coarse particles also include sea salts, pollen, mould, spores, and other plant parts. Mining dust is composed of predominantly coarse particulate matter (and larger).

Fine particles or $PM_{2.5}$ 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 aerosols from volatile organic compound emissions. $PM_{2.5}$ 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_{10}.

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 4-1**, which shows the relative deposition by particle size within various regions of the respiratory tract. Additionally, particle size is an important parameter in determining the residence time and spatial distribution of particles in ambient air, key considerations in assessing exposure.

The health-based assessment criteria used by NSW 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 (NSW 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.

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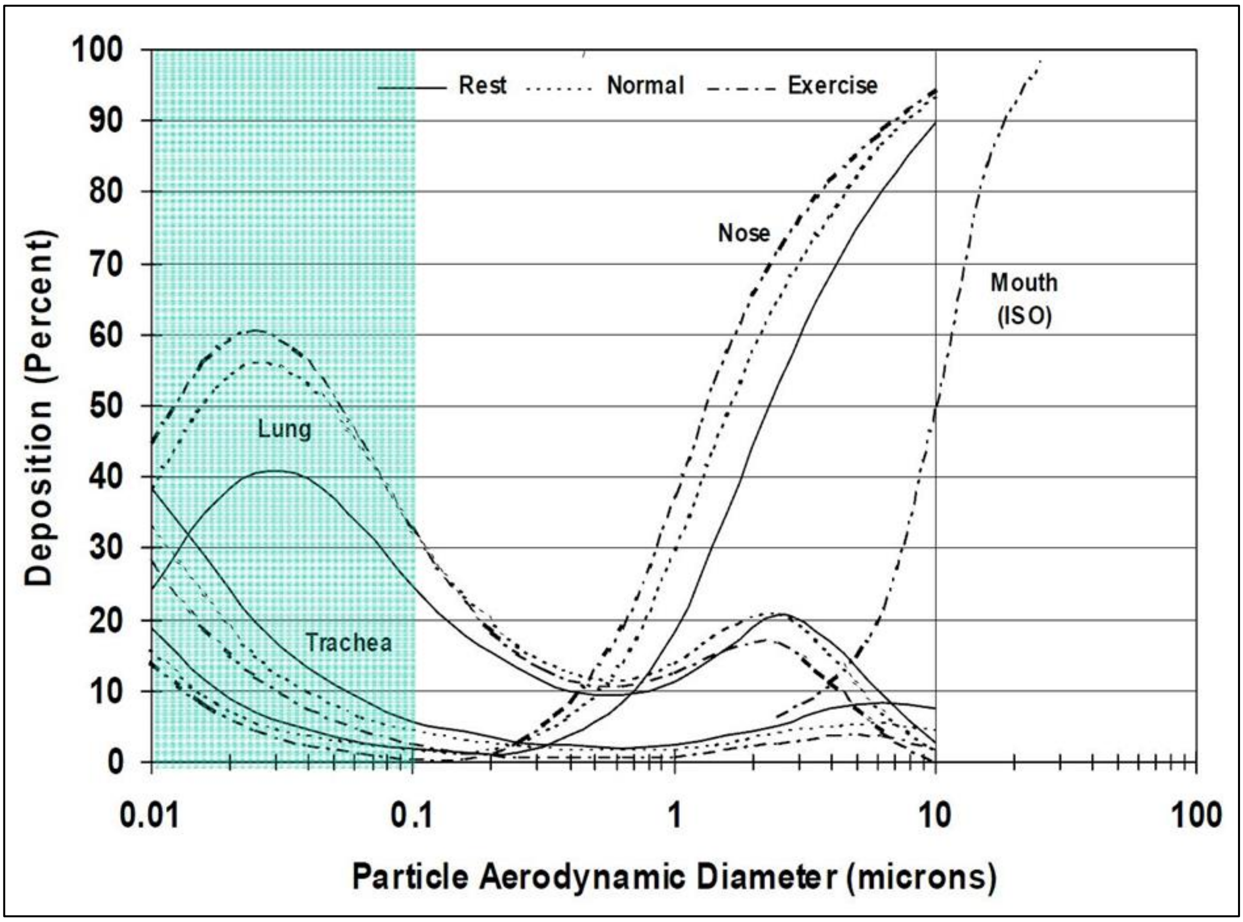
[1] Crustal dust refers to dust generated from materials derived from the earth's crust.



Source: Chow, 1995

Figure 4-1 Particle Deposition within the Respiratory Track

4.2.2 NSW EPA Impact Assessment Criteria

The NSW EPA *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (NSW DEC, 2005) (hereafter referred to as 'the Approved Methods') specifies air quality assessment criteria relevant for assessing impacts from air pollution. The air quality criteria relate to the total dust burden in the air and not just the dust from proposed activities. In other words, consideration of background dust levels needs to be made when using these criteria to assess potential impacts. These criteria are health-based (i.e. they are set at levels to protect against health effects).

Table 4.1 summarises the air quality criteria for concentrations of particulate matter that are relevant to this study.

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

In January 2016, the NEPC released an amended Ambient Air-NEPM (NEPC, 2016) to take into account the latest scientific evidence about the health impacts of particles. The amendment changed the 'advisory reporting standards' status for annual average and 24-hour average $PM_{2.5}$ to 'standards', but in absence of any other relevant standard/goal, the 2016 NEPM for $PM_{2.5}$ standards have been used in this report for comparison against dispersion modelling results.

Table 4.1
Air Quality Standards/Criteria for Suspended Particulate Matter Concentrations

Pollutant	Averaging period	Standard/Goal	Source
TSP	Annual mean	90 $\mu g/m^3$	NSW DEC (2005) (assessment criteria)
PM_{10}	Maximum 24-hour average	50 $\mu g/m^3$	NSW DEC (2005) (assessment criteria)
	Annual mean	30 $\mu g/m^3$	NSW DEC (2005) (assessment criteria)
$PM_{2.5}$	Annual Mean	8 $\mu g/m^3$	NEPC (2016)
	Maximum 24-hour average	25 $\mu g/m^3$	
Lead	Annual mean	0.5 $\mu g/m^3$	NSW DEC (2005) (assessment criteria)

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

In addition to health impacts, airborne dust also has the potential to cause nuisance effects by depositing on surfaces, including native vegetation and crops. Larger particles do not tend to remain suspended in the atmosphere for long periods of time and will fall out relatively close to source. Dust fallout can soil materials and generally degrade aesthetic elements of the environment, and are assessed for nuisance or amenity impacts. Section 4.3 discusses the lead content of the dust.

Table 4.2 shows the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust fallout levels are set to protect against nuisance impacts (NSW DEC, 2005).

Table 4.2
EPA Criteria for Dust (Insoluble Solids) Fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2g/m^2/month	4g/m^2/month
Notes: g/m^2/month – grams per square metre per month.			

4.2.3 NSW Department of Planning and Environment Voluntary Land Acquisition and Mitigation Policy

In December 2014, NSW Department of Planning and Environment (DPE) released a policy relating to voluntary mitigation and land acquisition criteria for air quality and noise (DPE, 2014). This is reflected in State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (the Mining SEPP) at Clause 12A.

The policy sets out voluntary mitigation and land acquisition rights where it is not possible to comply with the EPA impact assessment criteria even with the implementation of all reasonable and feasible avoidance and/or mitigation measures.

The DPE voluntary mitigation and acquisition criteria are summarised in **Table 4.3** and **Table 4.4**, respectively. The Proposal has been assessed against these criteria, in addition to the EPA impact assessment criteria discussed in **Section 4.2.2**.

Table 4.3
DPE Particulate Matter Mitigation Criteria

Pollutant	Criterion	Averaging Period	Application
TSP	90 μg/m^3	Annual mean	Total impact
PM_{10}	50 μg/m^3	24-hour average	Incremental impact[(a)]
	30 μg/m^3	Annual mean	Total impact
Deposited dust	2g/m^2/month	Annual mean	Incremental impact[(a)]
	4g/m^2/month	Annual mean	Total impact

Note:
(a) Zero allowable exceedances of the criterion over the life of the development.

Table 4.4
DPE Particulate Matter Acquisition Criteria

Pollutant	Criterion	Averaging Period	Application[(a)]
TSP	90 μg/m^3	Annual mean	Total impact
PM_{10}	50 μg/m^3	24-hour average	Incremental impact[(b)]
	30 μg/m^3	Annual mean	Total impact
Deposited dust	2g/m^2/month	Annual mean	Incremental impact[(b)]
	4g/m^2/month	Annual mean	Total impact

Notes:
(a) Voluntary acquisition rights apply where the Proposal contributes to exceedances of the acquisition criteria at any residence or workplace on privately-owned land, or, on more than 25% of any privately-owned land, and a dwelling could be built on that land under exiting planning controls.
(b) Up to five allowable exceedances of the criterion over the life of the development.

Total impact includes the impact of the Proposal and all other sources, whilst incremental impact refers to the impact of the Proposal considered in isolation.

At Clause 12AB(4), the Mining SEPP also sets a non-discretionary development standard of cumulative annual average PM_{10} concentration for private dwellings of 30μg/m^3.

4.3 LEAD & TOXIC AIR POLLUTANTS

4.3.1 Health Effects

Lead emissions from the Proposal are considered to be the most significant of the metals emitted given the current community interest and concern in relation to lead exposure associated with the mining activities in Broken Hill.

In humans, lead can result in a wide range of biological effects depending upon the level and duration of exposure. Effects may range from inhibition of enzymes to the production of marked morphological changes and death. Such changes occur over a broad range of doses. For neurological, metabolic and behavioural reasons, children are more vulnerable to the effects of lead than adults (UNEP 2006, ATSDR 2007).

Lead has been shown to have effects on haemoglobin synthesis and anaemia has been observed in children at lead blood levels above 40µg/dl. Lead is also known to cause kidney damage. Some of the effects are reversible, whereas chronic exposure to high lead levels may result in continued decreased kidney function and possible renal failure.

Renal effects have been seen among the general population when more sensitive indicators of function were measured (WHO 1995, US EPA 2006, ATSDR 2007). The reproductive effects of lead in men are limited to sperm morphology and count. In women, some adverse pregnancy outcomes have been attributed to lead.

Lead does not appear to have deleterious effects on skin, muscle or the immune system (WHO 1995, US EPA 2006, ATSDR 2007). The evidence for carcinogenicity of lead and several inorganic lead compounds in humans is inadequate. Classification of International Agency for Research on Cancer (IARC) is class 2A 'The agent (mixture) is probably carcinogenic to humans. The exposure circumstance entails exposures that are possibly carcinogenic to humans' (IARC 2006).

4.3.2 Impact Assessment Criteria for Toxic Air Pollutants

The NSW EPA specifies impact assessment criteria for a range of principal and individual toxic air pollutants (NSW DEC, 2005). A synopsis of the criteria relevant to metals of interest in the current study is given in **Table 4.5**.

The impact assessment criteria specified by the NSW EPA (2005) for toxic air pollutants must be applied at and beyond the boundary of the facility, with the incremental impact (predicted impacts due to the pollutant source alone) for each pollutant reported for an averaging period of 1 hour.

Table 4.5
Impact Assessment Criteria for Suspended Toxic Air Pollutants Published by NSW EPA

Substance	Averaging Period	Percentile	Impact Assessment Criteria ($\mu g/m^3$)
Arsenic	1-hour	99.9^{th}	0.09
Cadmium	1-hour	99.9^{th}	0.018
Chromium (as CR III)	1-hour	99.9^{th}	9
Chromium(as CR VI)	1-hour	99.9^{th}	0.09
Copper	1-hour	99.9^{th}	18
Iron	1-hour	99.9^{th}	50
Lead	1-hour	99.9^{th}	0.5
Manganese and compounds	1-hour	99.9^{th}	18
Mercury	1-hour	99.9^{th}	0.18
Nickel	1-hour	99.9^{th}	0.18
Silver	1-hour	99.9^{th}	0.18
Zinc	1-hour	99.9^{th}	90

4.4 OTHER LEGISLATIVE REQUIREMENTS

4.4.1 NSW Action for Air

The NSW State Plan identifies cleaner air and progress on GHG reductions as priorities. In 1998, the NSW Government implemented a 25 year air quality management plan, Action for Air, for Sydney, Wollongong and the Lower Hunter (DECCW, 2009). Action for Air is a key strategy for implementing the NSW State Plan's cleaner air goals. Action for Air seeks to provide long-term ongoing emission reductions. It does not take into consideration acute and extreme exceedances from transient and localised events such as bushfires. The aims of Action for Air include:

- Meeting the national air quality standards for six pollutants as identified in the Ambient Air-NEPM; and
- Reducing the population's exposure to air pollution, and the associated health costs.

The six pollutants in the Ambient Air-NEPM include CO, NO_2, SO_2, lead, ozone and PM_{10}. The main pollutants from the Proposal that are relevant to the Action for Air include PM_{10} and NO_2. Action for Air aims to reduce air emissions to enable compliance with the Ambient Air-NEPM targets to achieve the aims described above, with a focus on motor vehicle emissions. Whilst the Proposal is not located within the areas relevant to the Action for Air plan (i.e. Sydney, Wollongong and the Lower Hunter), the Proposal generally addresses the aims of the Action for Air Plan in the following ways:

- Potential mitigation measures have been reviewed, and a range of measures have been adopted for the Proposal (see **Section 7**);
- Air quality emissions potentially associated with the Proposal have been quantified (see **Section 8**); and

Dispersion modelling has been conducted to predict the impact of these emissions on nearby receptors, and assess the effect of the emissions on ambient concentrations which can then be compared with the Ambient Air-NEPM goals (see **Section 9**).

4.4.2 Protection of the Environment Operations (POEO) Act, 1997

If approved, the Environmental Protection Licence (EPL) held (EPL2683) would be modified Proposal. Relevant to air quality, the EPL would outline the Proposal's requirements to minimise dust emissions and specify air quality monitoring requirements. The Protection of the Environment Operations (Clean Air) Regulations 2010 (POEO (Clean Air) Regulation) sets out standards of concentration for emissions to air from scheduled activities. The maximum pollution levels allowed under the regulations for general activities are provided in **Table 4.6**.

Table 4.6
Maximum Allowable Emission Levels

Air Impurity	Activity or Plant	Standard of Concentration
Solid Particles	Any process emitting solid particles	50 mg/m^3

In addition, the POEO (Clean Air) Regulation prescribes requirements for domestic solid fuel heaters, control of burning, motor vehicle emissions and industrial emissions. Motor vehicle emissions would be addressed by regular maintenance of all vehicles associated with the Proposal. In addition, no burning on-site would be conducted to minimise potential for smoke impacts on neighbouring receptors.

4.4.3 The Best Practice Report

The NSW EPA commissioned *the NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Donnelly et al., 2011) (hereafter referred to as the Best Practice Report).

The Best Practice report provides guidance on controls for reducing emissions and is benchmarked on the international best practice for the following activities:

- Haul roads.
- Wind erosion of exposed materials and stockpiles.
- Bulldozing.
- Blasting.
- Drilling.
- Draglines.
- Loading and dumping overburden.
- Loading and dumping ROM coal.
- Monitoring, proactive and reactive management.

The full set of potential best practice control measures to be adopted by the Proposal, have been summarised in **Section 7**.

5. EXISTING ENVIRONMENT

5.1 INTRODUCTION

A monitoring program comprising of dust and ambient air monitoring was established in July 2008 in the vicinity of the Proposal, as outlined in the Environmental Protection License (EPL 2683) for Perilya Broken Hill Limited.

The monitoring network established for the Proposal (shown in **Figure 5-8**) consists of:

- Eleven dust deposition gauges, measuring dust deposition rates (TSP and lead) over period of one month.
- Two high volume air samplers (HVASs), measuring PM_{10} concentrations for 24-hours periods on a one day in six run cycle.

As outlined in the EPL, the air quality sampling is undertaken in accordance with the AM-19, Australian Standard 2800 – 1985 and AS/NZS 3580.9.6:2003.

5.2 METEOROLOGY

5.2.1 Wind Speed and Direction

The closest meteorological station to the Mine Site is the Bureau of Meteorology (BoM) Automatic Weather Station (AWS) located at Broken Hill Airport, 5km, south-south-west direction from the site. Meteorological data collected at the site include wind speed, wind direction, temperature, humidity and sigma-theta. Insufficient cloud data were available from Broken Hill AWS, so TAPM (prognostic model) was used to generate the cloud data for the modelled 2014 year.

It is important to note that as required by the Approved Methods, dispersion modelling requires the use of a full year of continuous meteorological data (at least 90% complete). For a full 12–month period this equates to 8,760 hours (in a non-leap year). Therefore any data from sites that are only collected at 9am and 3pm are not valid for use in an assessment of this nature.

Table 5.1 provides statistics for the annual periods 2011 to 2015. The data show that the percentage of calms, annual average wind speed and percentage data recovery is similar across all years. The percentage of calms ranges from 2.8% to 3.8%, the average wind speed between 4.6 m/s and 4.8 m/s and the data recovery is at or above 93% for all periods.

Annual and seasonal windroses for Broken Hill Airport for 2011, 2012, 2013 and 2015 are shown in **Figure 5-1** and **Figure 5-2**. Windroses for 2014 (the assessment period) are shown in **Figure 5-3**. An explanation of how to interpret wind roses is given in **Appendix A**.

The annual wind roses for 2011, 2012, 2013 and 2015 show very similar patterns to those for the modelling period (2014) with dominant winds from the south and north-east quadrants. These patterns are reflected in varying degrees in all seasons throughout the years, with north-west winds also prevalent in winter. The annual and seasonal percentage of calms during the assessment period are comparable to those in the subsequent years. Further, the selected 2014 period has a greater percentage of winds from the south quadrant. These characteristics are significant as they ensure that a conservative meteorological year was selected, with a higher percentage of prevailing winds towards the closest receptor locations.

It was also confirmed that the temperature, rainfall and solar exposure for the 2014 year was comparable with historical data recorded at the Broken Hill Airport AWS (see **Figure 5-4** and **Figure 5-5**). That is, the wind data for 2014 were found to be generally representative of the larger data set in terms of average wind speed, percentage of calms and directional patterns, temperature and rainfall and were therefore chosen to represent the meteorology in the analysis.

Table 5.1
Comparative Statistics for Meteorological Data

Period	Calms (% occurrence)	Average Wind Speed (m/s)	Data Recovery (% complete)
January - December 2011	3.5	4.6	99.9
January - December 2012	3.8	4.6	99.7
January - December 2013	3.6	4.8	99.9
January - December 2014	2.9	4.7	93.5
January - December 2015	2.8	4.7	93.3

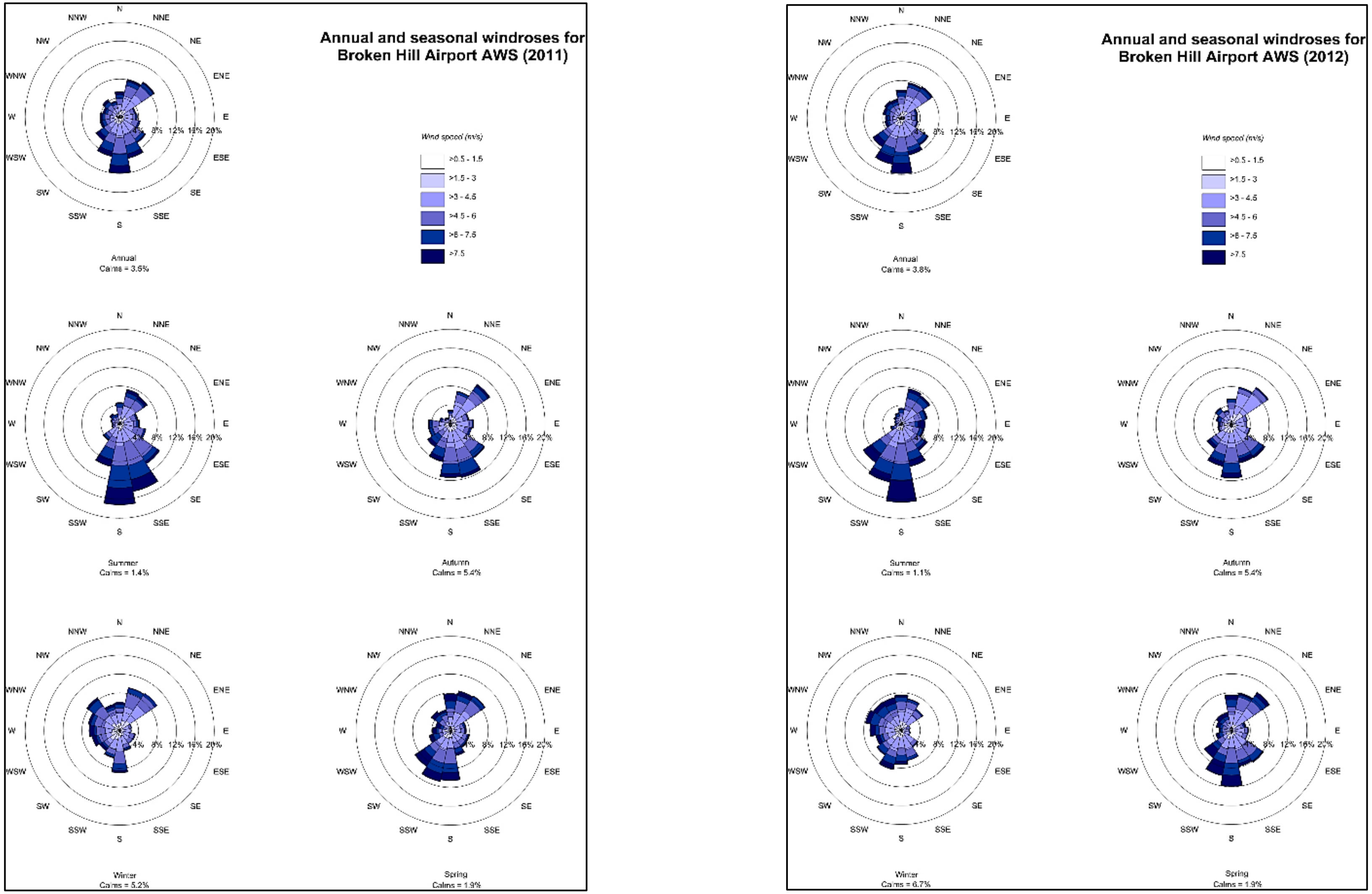


Figure 5-1 Annual and Seasonal Wind Roses for BoM Broken Hill Airport AWS – 2011 and 2012

Figure 5-2 Annual and Seasonal Wind Roses for BoM Broken Hill Airport AWS – 2013 and 2015

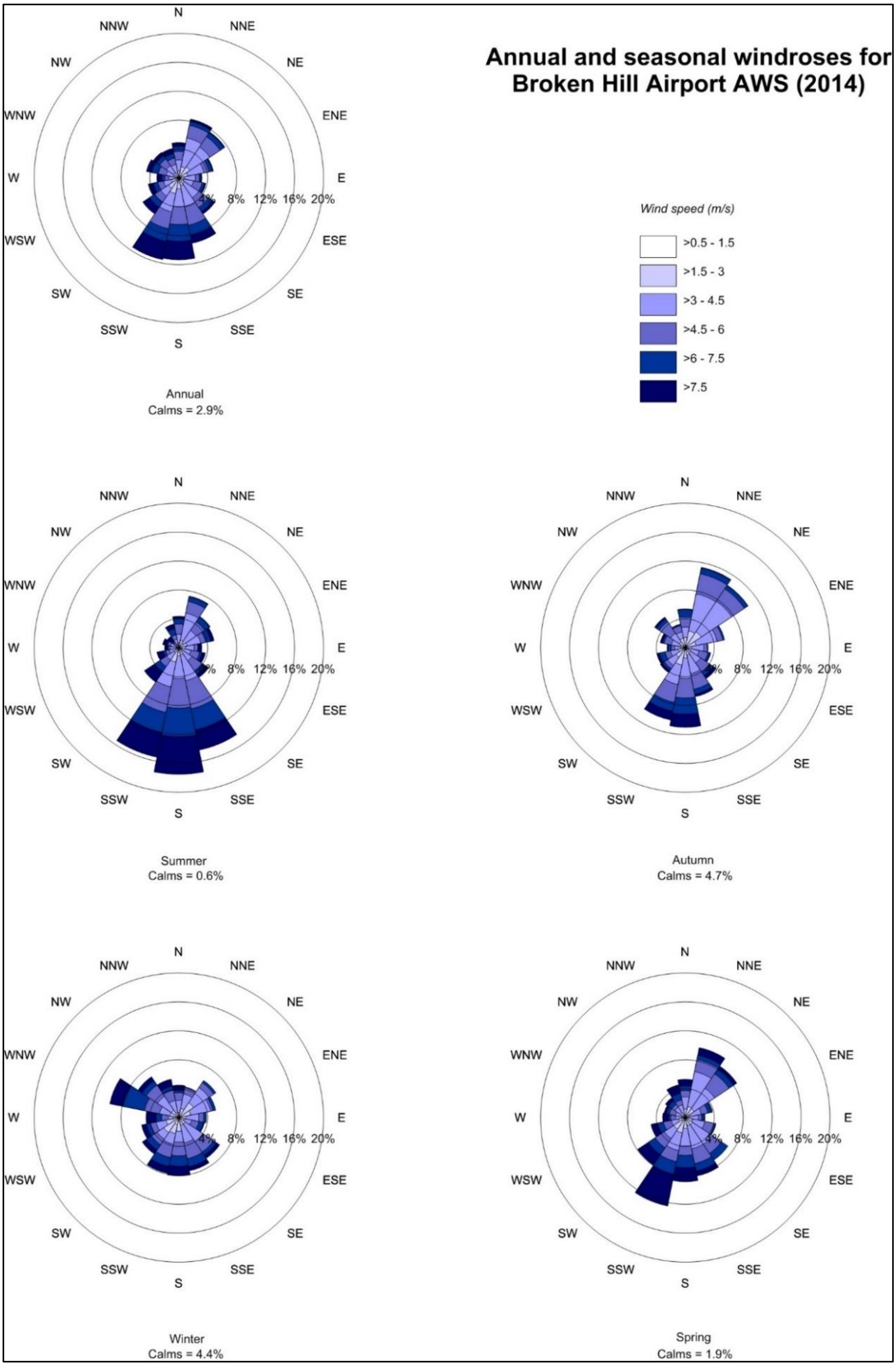
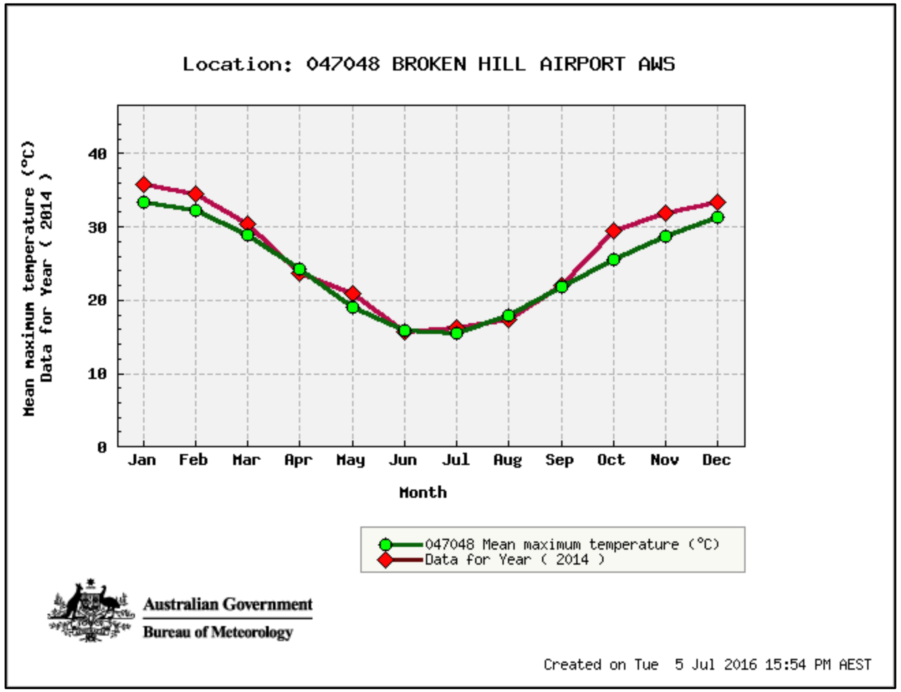


Figure 5-3 Annual and Seasonal Wind Roses for BoM Broken Hill Airport AWS – 2014



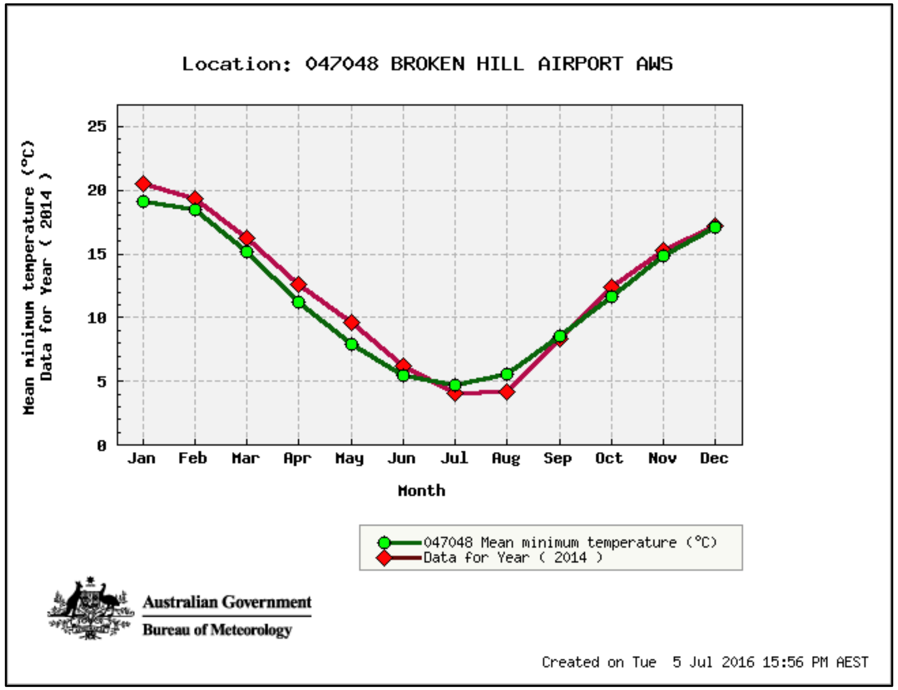
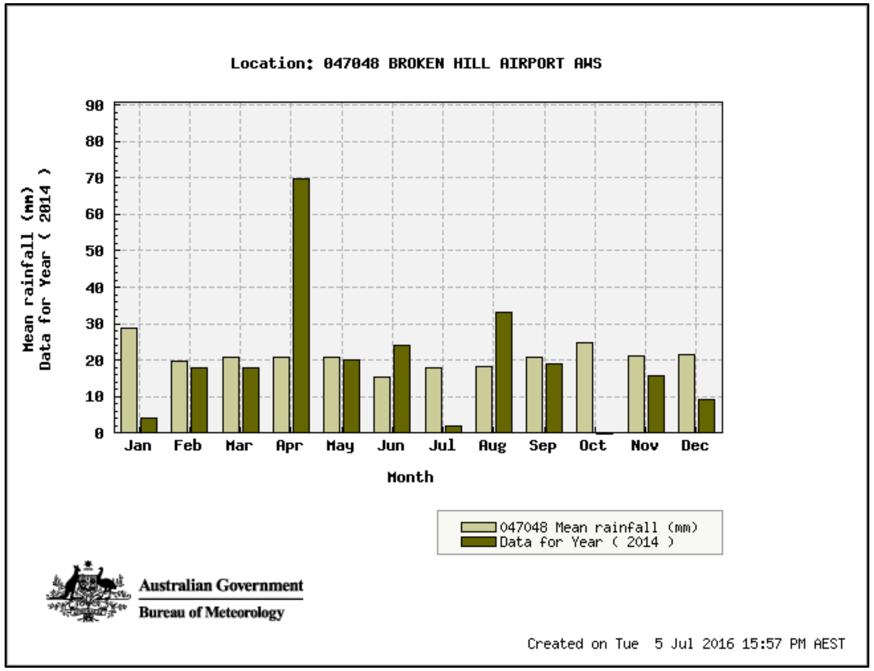


Figure 5-4 Comparison of 2014 and Mean Historical Data Collected for BoM Broken Hill Airport AWS (BoM, 2016)



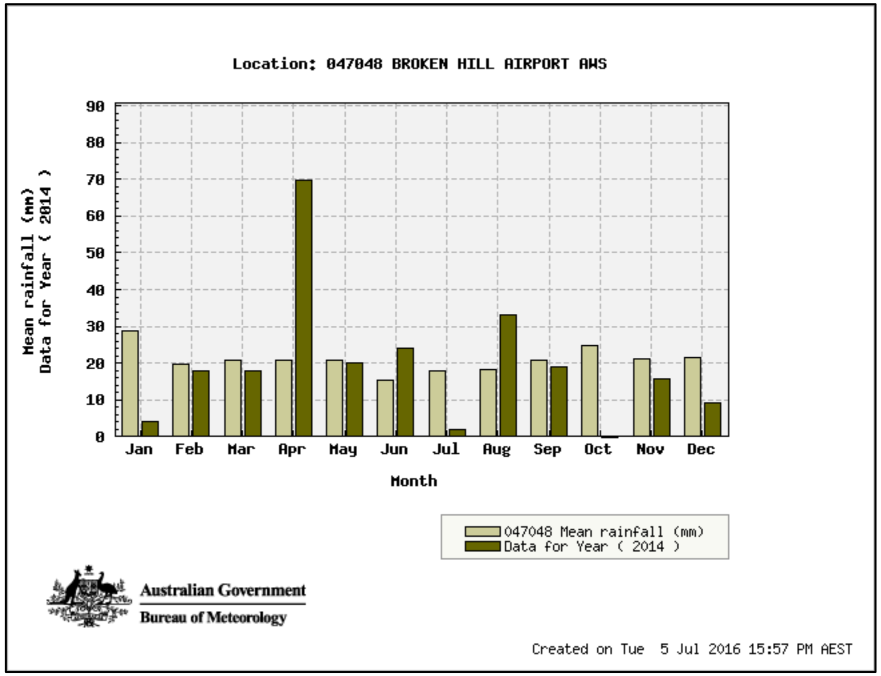


Figure 5-5 Comparison of 2014 and Mean Historical Data Collected for BoM Broken Hill Airport AWS (BoM, 2016)

5.2.2 Atmospheric Stability

An important aspect of pollutant dispersion is the level of turbulence in the lowest 1 km of the atmosphere, known as the planetary boundary layer (PBL). Turbulence controls how effectively a plume is diffused into the surrounding air and hence diluted. It acts by increasing the cross-sectional area of the plume due to random motions. With stronger turbulence, the rate of plume diffusion increases. Weak turbulence limits diffusion and contributes to high plume concentrations downwind of a source.

Turbulence is generated by both thermal and mechanical effects to varying degrees. Thermally driven turbulence occurs when the surface is being heated, in turn transferring heat to the air above by convection. Mechanical turbulence is caused by the frictional effects of wind moving over the earth's surface, and depends on the roughness of the surface as well as the flow characteristics.

Turbulence in the boundary layer is influenced by the vertical temperature gradient, which is one of several indicators of stability. Plume models use indicators of atmospheric stability in conjunction with other meteorological data to estimate the dispersion conditions in the atmosphere.

Stability can be described across a spectrum ranging from highly unstable through neutral to highly stable. A highly unstable boundary layer is characterised by strong surface heating and relatively light winds, leading to intense convective turbulence and enhanced plume diffusion. At the other extreme, very stable conditions are often associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Neutral conditions are linked to windy and/or cloudy weather, and short periods around sunset and sunrise, when surface rates of heating or cooling are very low.

The stability of the atmosphere plays a large role in determining the dispersion of a plume and it is important to have it correctly represented in dispersion models. Current air quality dispersion models (such as AERMOD and CALPUFF) use the Monin-Obukhov Similarity Theory (MOST) to characterise turbulence and other processes in the PBL. One of the measures of the PBL is the Monin-Obukhov length (L), which approximates the height at which turbulence is generated equally by thermal and mechanical effects (Seinfeld and Pandis, 2006). It is a measure of the relative importance of mechanical and thermal forcing on atmospheric turbulence.

Because values of L diverge to + and - infinity as stability approaches neutral from the stable and unstable sides, respectively, it is often more convenient to use the inverse of L (i.e., 1/L) when describing stability.

Figure 5-6 shows the hourly averaged 1/L for the site computed from all data in the AERMET extract file. Based on **Table 5.2** this plot indicates that, as to be expected, the PBL is stable overnight and becomes unstable as radiation from the sun heats the surface layer of the atmosphere and drives convection. The changes from positive to negative occur at the shifts between day and night. This indicates that the diurnal patterns of stability are realistic.

Table 5.2
Inverse of the Monin-Obukhov length L with respect to Atmospheric Stability

1/L	Atmospheric Stability
Negative	Unstable
Zero	Neutral
Positive	Stable

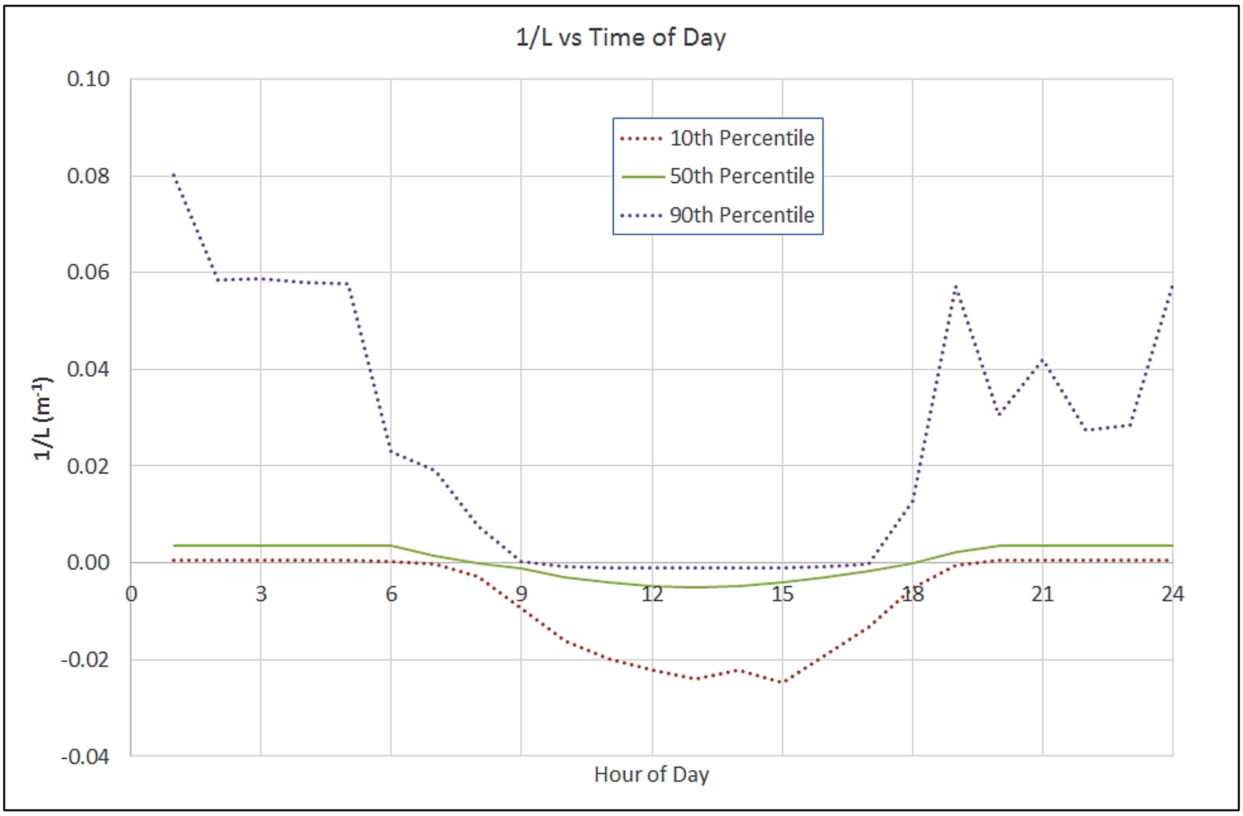


Figure 5-6 Annual Statistics of 1/L by Hour of the Day

Figure 5-7 shows the variations in stability over the year by hour of the day, with reference to the widely known Pasquill-Gifford classes of stability. The relationship between L and stability classes is based on values derived by Golder (1972) set out in NSW DEC (2005). Note that the reference to stability categories here is only for convenience in describing stability. The AERMET/AERMOD modelling system uses calculated values of L across a continuum.

Figure 5-7 shows that stable and very stable conditions occur for about 50% of the time, which is typical for inland locations that experience temperature inversions at night. Atmospheric instability increases during the morning and reaches a peak around 1 pm. A stable atmosphere is prevalent during the night. These profiles indicate that pollutant dispersion is most effective during the daytime and least effective at night.

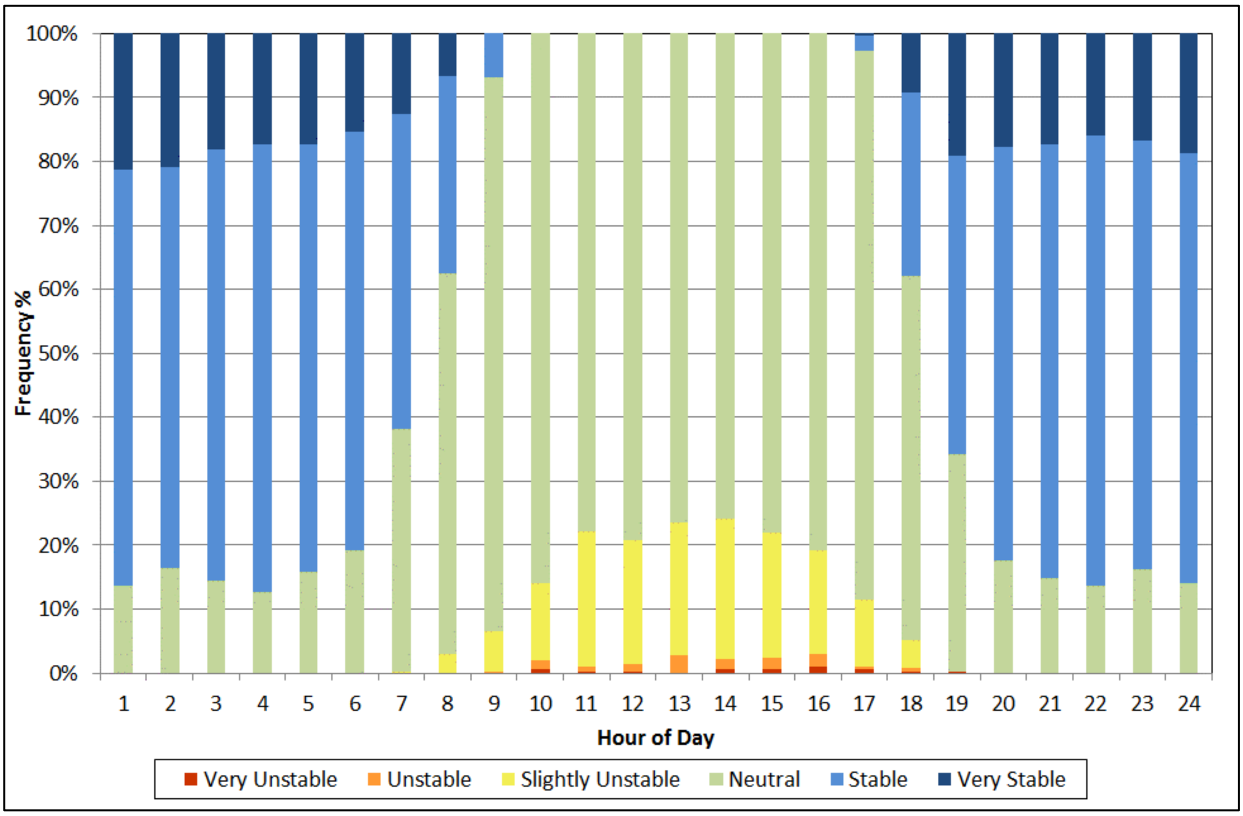


Figure 5-7 Annual Distribution of Stability type by Hour of the Day

5.3 LOCAL CLIMATIC CONDITIONS

The Bureau of Meteorology (BoM) collects climatic information in the vicinity of the study area at Broken Hill Airport AWS approximately 6km south-south-west of the site. This climatic information is presented in **Table 5.3**. (BoM, 2016).

The annual average maximum temperature recorded at the site is 24.6°C and the annual average minimum temperature is 11.6°C. The highest maximum temperature of 33.4°C is recorded in January, while the lowest minimum temperature of 4.7°C is recorded in July. The annual average humidity is 54% at 9am and 34% at 3pm. The annual average rainfall is 253.2mm, falling throughout the year over approximately 50 rain days.

Table 5.3
Monthly Meteorological Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
9am Mean Dry-bulb and Wet-bulb Temperatures (ºC) and Relative Humidity (%)													
Dry-bulb	24.0	22.9	20.2	17.5	13.3	10.1	9.5	11.6	14.8	17.9	20.7	22.7	17.1
Humidity	41.0	46.0	49.0	51.0	65.0	73.0	72.0	61.0	53.0	45.0	44.0	42.0	54.0
3pm Mean Dry-bulb and Wet-bulb Temperatures (ºC) and Relative Humidity (%)													
Dry-bulb	31.4	30.1	27.4	23.3	18.4	15.2	14.6	16.8	20.2	23.5	27.0	29.3	23.1
Humidity	25.0	28.0	28.0	32.0	43.0	49.0	48.0	38.0	34.0	28.0	26.0	25.0	34.0
Daily Maximum Temperature (ºC)													
Mean	33.4	32.3	28.9	24.3	19.1	15.9	15.5	17.9	21.8	25.5	28.8	31.4	24.6
Daily Minimum Temperature (ºC)													
Mean	19.1	18.5	15.2	11.2	7.8	5.5	4.7	5.6	8.5	11.6	14.8	17.1	11.6
Rainfall (mm)													
Mean	28.9	19.7	20.9	20.9	20.7	15.6	17.9	18.2	20.6	24.6	21.2	21.5	253.2
Rain days (Number)													
Mean	3.5	2.7	3.2	3.2	4.8	5.1	5.7	5.0	4.6	4.3	4.2	3.4	49.7
Source: (BoM, 2016) Climate averages for Station: 047048; Commenced: 2009 – present Latitude: 32.00°S; Longitude: 141.47 °E													

5.4 AIR QUALITY

The characterisation of baseline air quality is dependent upon the quantification of cumulative air pollution concentrations and the assessment of compliance with ambient air quality limits. Particulate matter and several heavy metals represent the primary emissions expected from the Proposal, therefore it is appropriate that existing sources and ambient air pollutant concentrations of these pollutants be considered as part of the assessment.

5.4.1 Local Sources of Emissions

Industrial and mining activities operating within 10km of the Proposal are stated in **Table 5.4.**

Table 5.4
Industrial Operations and Mines within 10km of the Proposal Area

Facility	Distance from Site	Description
RASP Mine	Operations located adjacent to the east of the site	Zinc, lead and silver mine
E B Mawsons & Sons	Operations located adjacent to the east of the site	Gravel quarry and concrete batching plant
Bemax Mineral Separation Plant (MSP Mine)	8km south-west of the site	Mineral sand processing plant

In addition to these stated facilities, naturally generated dust storms in Broken Hill are also a contributor to elevated ambient particulate matter concentrations events in the region. Windblown dust represents a key component of suspended particulate concentrations and dust deposition in the area. Other potential sources of emissions in the vicinity of the Mine Site include:

- Vehicle movements causing dust along unsealed/sealed town and rural roads with high silt loading levels;
- Vehicle exhaust and rail related emissions;
- Wood-burning fires in homes and
- Episodic emissions from bushfires.

5.4.2 Monitoring Data for Baseline Air Quality Characterisation

Monitoring data sets used in the characterisation of existing air quality in the study area are listed in **Table 5.5**. The locations of the monitoring stations are given in **Figure 5-8**.

Table 5.5
Monitoring Data Collected in Broken Hill

Mine Site	Parameter	Monitoring Method	Number of Locations	IDs	Date Commenced
Perilya	Dust Deposition	Dust Deposition Gauges (DDG)	11	LP15 to LP25	July 2011
Perilya	Concentration (TSP and Total Lead)	High Volume Air Sampler (HVAS)	2	LP26-LP27	July 2008
RASP Mine	Concentration (PM_{10})	Tapered element oscillating microbalance (TEOM)	2	EPL13-EPL14	February 2014

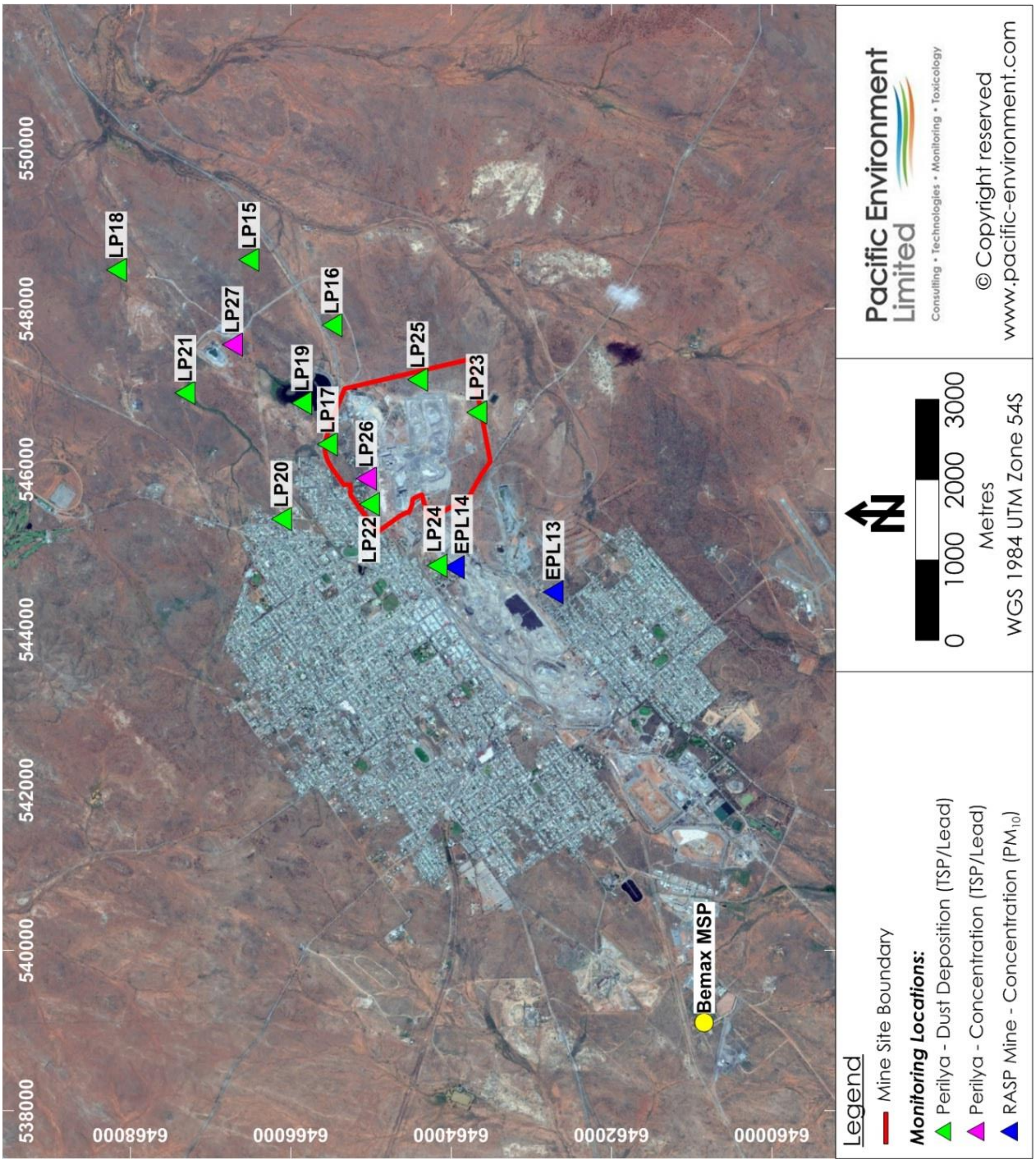


Figure 5-8 Location of Monitoring Stations

5.4.3 Particle Matter

The NSW EPA impact assessment criteria refer to pollutant levels that include the contribution from specific Proposals and existing sources. To fully assess impacts against the relevant air quality standards and criteria, it is necessary to have data on existing dust concentration and deposition levels in the area in which the Proposal under consideration is likely to contribute to these levels.

5.4.3.1 Ambient TSP Concentration

TSP concentrations have been recorded using HVAS at two locations (LP26 and LP27) as shown in **Figure 5-8** since 2008. The maximum recorded average TSP concentration for the recording period was 1180.4µg/m³. This peak concentration occurred during a recorded dust storm event in November 2009.

Table 5.6 provides a summary of the annual average TSP data collected to date. The average TSP concentration for all recorded years over both sites is 42.8µg/m³ including dust storm events. Ambient concentrations of TSP are therefore within the annual guideline value of 90µg/m³.

Table 5.6
Annual Average TSP for the Broken Hill North Mine Site (µg/m³)

Date	LP26	LP27
2008[(a)]	40.8	-
2009	80.8	-
2010	32.5	-
2011	21.7	-
2012	29.4	32.0
2013	44.5	55.9
2014	24.0	61.9
2015	22.4	48.3
2016[(b)]	23.8	51.8
Average	**35.5**	**50.0**
Average across all sites		**42.8**

Note: (a) Monitoring available from March 2008 for LP26 therefore average based on less than 6 months of data
(b) Monitoring available up till April 2016 for LP26-LP27 therefore average based on less than 6 months of data.

5.4.3.2 Ambient Dust Deposition Levels

Table 5.7 provides a summary of the annual average dust deposition data collected to date.

The average across all sites over the whole monitoring period to March 2016 is 2.0g/m^2/month, which indicates that dust deposition levels for the area are typical of arid rural areas The cumulative impact assessment criterion for dust deposition is 4g/m^2/month (annual average) with a maximum allowable increment of 2g/m^2/month (annual average).

Table 5.7
Dust Deposition Data (Insoluble Solids) for the Broken Hill North Mine Site (g/m^2/month)

Date	LP15	LP16	LP17	LP18	LP19	LP20	LP21	LP22	LP23	LP24	LP25
2011 (a)	9.0	3.4	2.1	2.2	3.8	2.2	3.7	0.3	1.5	1.5	2.2
2012	4.0	3.1	1.6	1.7	2.0	1.8	2.3	2.5	1.8	2.4	2.0
2013	1.9	0.9	1.2	1.5	1.1	1.5	1.2	2.1	1.6	2.0	1.4
2014	2.6	2.2	1.6	4.5	1.5	1.7	2.2	3.5	1.2	2.0	2.5
2015	1.3	1.1	1.2	1.7	1.0	1.2	3.8	1.2	0.8	1.2	2.0
2016 (b)	0.9	0.8	1.1	1.2	1.2	0.9	1.2	1.0	1.0	1.5	4.5
Average	**3.3**	**1.9**	**1.5**	**2.1**	**1.8**	**1.6**	**2.4**	**1.8**	**1.3**	**1.8**	**2.4**
Average across all sites											**2.0**

Note: (a) Monitoring available from July 2011 for LP15-LP25 therefore average based on less than 6 months of data.
(b) Monitoring available up till March 2016 for LP15-LP25 therefore average based on less than 6 months of data.

5.4.3.3 Ambient PM_{10} Concentrations

PM_{10} concentrations are not measured as part of the monitoring done by the Applicant for the Proposal. However the adjacent RASP Mine currently undertakes PM_{10} monitoring as part of their ongoing operations in Broken Hill.

The PM_{10} concentrations have been recorded using TEOMs at two locations (EPL13 and EPL14) as shown in **Figure 5-8**. **Figure 5-9** shows the PM_{10} concentrations measured by the TEOMs with the annual and 24-hour assessment criteria (see **Section 4.2**).

As shown in **Table 5.8**, the average PM_{10} concentration for all recorded data (February 2014 to April 2016) across both monitoring locations is 15.9µg/m³. Ambient concentrations of PM_{10} are therefore within the annual guideline value of 30µg/m³ (CBH, 2016).

Table 5.8
Annual Average PM_{10} at the RASP Mine (µg/m^3)

Date	EPL 13	EPL 14
2014 (a)	14.7	18.4
2015	14.0	14.7
2016 (b)	15.0	18.6
Average	**14.6**	**17.2**
Average across both sites		**15.9**

Note: (a) Monitoring data available from February 2014
(a) Monitoring available until April 2016 therefore average based on less than 6 months of data

Bemax Resources Limited (Bemax) also undertakes PM_{10} monitoring through one-in-six day sampling of PM_{10} concentrations with a HVAS at the Broken Hill Mineral Separation Plant (MSP) situated approximately 8km to the southwest of the Proposal (as shown on **Figure 5-8** labelled 'Bemax MSP'). Monitoring data for the period of April 2012 to May 2016 was used to characterise the ambient PM_{10} concentrations. The average PM_{10} concentration for this period 11.7 µg/m³ across the 251 data days (Cristal Mining, 2016).

However since this processing facility is further away from the Mine Site and the background levels are lower than the those recorded at the RASP Mine adjacent to the Mine Site, for conservatism, the 15.9µg/m³ measured at the RASP Mine over the monitoring campaign has been used to characterise the background PM_{10} for this assessment.

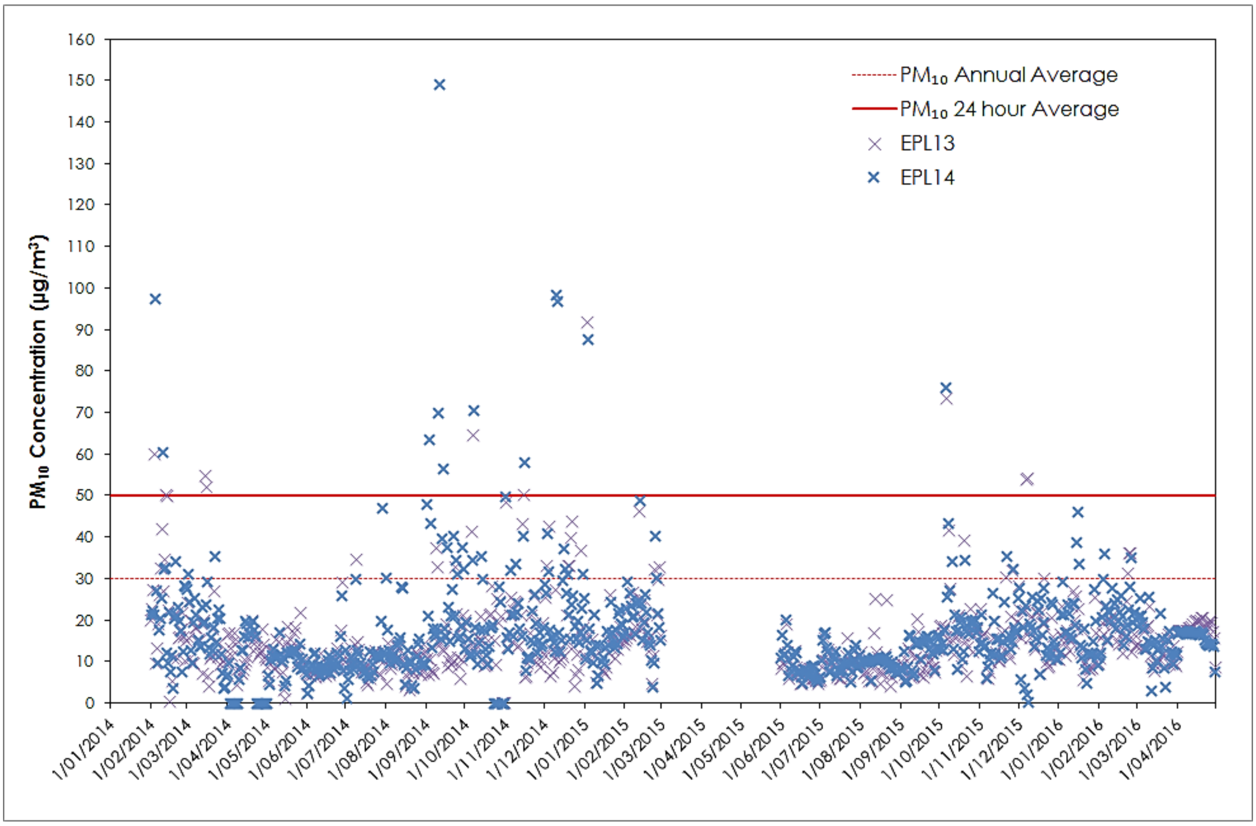


Figure 5-9 Measured PM_{10} for EPL13 and EPL14 at RASP Mine

5.4.3.4 Ambient $PM_{2.5}$ Concentrations

No site-specific $PM_{2.5}$ monitoring data is available for the Broken Hill region. Therefore, the assessment for this pollutant has been restricted to considering the incremental impact of the Proposal only.

5.4.4 Ambient Lead Concentrations and Deposition

Ambient concentrations of lead (Pb) are recorded at LP 26 and LP 27 (as shown on **Figure 5-8**) through the TSP HVAS monitoring and dust deposition sampling and subsequent laboratory analysis. Measurements available for the recording period are presented in **Table 5.9**.

Annual average suspended lead concentrations (in the TSP fraction) are of the order of 0.13μg/m³, comprising about 25% of the NSW EPA criterion of 0.5μg/m³. On average, Pb concentrations represent about 0.3% of total TSP concentrations.

Table 5.9
Lead Concentrations from TSP Monitoring

Period	Average 24-hour Concentration		% Lead of TSP	Lead % of NSW EPA Guideline Value
	TSP (μg/m³)	Lead (μg/m³)		
2008 (Mar – Dec)	40.8	0.07	0.2	13
2009	80.8	0.10	0.1	20
2010	32.5	0.09	0.3	19
2011	21.7	0.05	0.2	9
2012	30.7	0.17	0.6	35
2013	50.2	0.19	0.4	37
2014	43.0	0.18	0.4	36
2015	35.4	0.18	0.5	35
2016 (Jan – Apr)	37.8	0.13	0.3	25

Note: NSW EPA Guideline – 0.5 (μg/m³)
Data for LP26 (Mar 2008 – April 2016). Data for LP27 (May 2012 – April 2016)

Pb levels within the total insoluble dust deposition monitoring conducted, as reported by the Applicant, are provided in **Table 5.10**. The average lead deposition across all license points for the recorded years is 0.003g/m²/month, constituting on average 0.2% of the annual total insoluble dust deposition measured. These data demonstrate that there are very low levels of Pb in the deposited dust.

Table 5.10
Dust Deposition Data (Insoluble Solids) for the Broken Hill North Mine Site (g/m²/month)

Date	LP15	LP16	LP17	LP18	LP19	LP20	LP21	LP22	LP23	LP24	LP25
2014[(a)]	0.003	0.002	0.004	0.001	0.003	0.003	0.005	0.004	0.003	0.006	0.003
2015	0.002	0.002	0.004	0.002	0.002	0.003	0.003	0.004	0.003	0.009	0.003
2016[(b)]	0.001	0.002	0.002	0.002	0.003	0.004	0.003	0.001	0.002	0.013	0.003
Average	**0.002**	**0.002**	**0.003**	**0.002**	**0.002**	**0.003**	**0.004**	**0.003**	**0.003**	**0.009**	**0.003**
Average across all sites											**0.003**

Note: (a) Monitoring available from August 2014 for LP15-LP25 therefore average based on less than 6 months of data.
(b) Monitoring available up till March 2016 for LP15-LP25 therefore average based on less than 6 months of data.

5.5 EXISTING AIR QUALITY FOR ASSESSMENT PURPOSES

For the purposes of assessing cumulative impacts, the baseline monitoring data have been used to account for contributions from all other sources in the vicinity of the Proposal. The following background levels are assumed for sources other than the Proposal:

- Maximum 24-hour average PM_{10} – daily varying based on 2014 RASP data (see Section 9.5).
- Annual average PM_{10} concentration of 16 µg/m^3 (average of annual data collected at RASP Mine).
- Annual average TSP concentration of 43 µg/m^3 (average of annual data collected by Perilya Broken Hill Limited).
- Annual average dust deposition of 2g/m^2/month (average of annual data collected by Perilya Broken Hill Limited).

6. MODELLING APPROACH

The overall approach to the assessment generally follows the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW DEC, 2005) using the Level 2 assessment methodology. The Approved Methods specify how assessments based on the use of air 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 Proposals.

6.1 MODELLING SYSTEM

AERMOD was chosen as the most suitable model due to the source types, location of nearest receptors and nature of local topography. AERMOD is the US-EPA's recommended steady-state plume dispersion model for regulatory purposes and it is an accepted model of the NSW EPA. AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the US in December 2006 as it provides more realistic results. Ausplume, a steady state Gaussian plume dispersion model developed by the Victorian EPA and frequently used in Australia for simple near-field applications is based on ISC, which has now been replaced by AERMOD.

A significant feature of AERMOD is the Pasquill-Gifford stability based dispersion is replaced with a turbulence-based approach that uses the Monin-Obukhov length scale to account for the effects of atmospheric turbulence based dispersion.

The AERMOD system includes AERMET, used for the preparation of meteorological input files and AERMAP, used for the preparation of terrain data.

Terrain data was sourced from NASA's Shuttle Radar Topography Mission (SRTM) Data (3 arc second (~30m) resolution) and processed within AERMAP to create the necessary input files.

AERMET requires surface and upper air meteorological data as input. Surface data was sourced from the Broken Hill Airport BoM weather station and cloud data from TAPM. Appropriate values for three surface characteristics are required for AERMET as follows:

- Surface roughness, which is the height at which the mean horizontal wind speed approaches zero, based on a logarithmic profile.
- Bowen ratio, which is an indicator of surface moisture.
- Albedo, which is an indicator of reflectivity of the surface.

Values of surface roughness, Bowen ratio and albedo were determined based on a review of aerial photography for a radius of 3km centred on the Proposal. Default values for urban and desert shrubland were chosen for the area.

The configuration of the model and the inputs used are explained below. A summary of all the AERMOD inputs is provided in **Appendix B**.

6.2 MODEL SET UP

Observed hourly surface data from Broken Hill Airport BoM AWS was incorporated into the modelling. Cloud amount and cloud heights were incorporated through the use of prognostic 3D data extracted from The Air Pollution Model (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. The Technical Paper by Hurley (2008) describes details of the model equations, parameterisations, and numerical methods. A summary of some verification studies using TAPM is also given in Hurley et al. (2008).

TAPM solves the fundamental fluid dynamics and scalar transport equations to predict meteorology and (optionally) pollutant 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.

Cloud data were generated over the study region using TAPM. The TAPM-generated cloud data and observed surface meteorological data from Broken Hill were then entered into the AERMET meteorological model.

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

6.3 MODELLING SCENARIOS

Two operational scenarios were chosen for quantitative dispersion modelling, as outlined below:

- Annual operations
  - Based on maximum annual transport off-site of 300,000 tonnes per annum ; and
- Maximum daily operations
  - Based on maximum daily transport off-site of 1,800 tonnes per day (which would equate to almost 500,000 tonnes per annum).
  - The maximum daily emissions are applied for each day of the modelled year to ensure that the potential contribution from the maximum daily transport off-site is assessed under worst-case meteorological conditions.
  - It is expected that that actual transportation rates on most days would be less than 1,800 tonnes per day. As a result, this does not represent a realistic estimate of annual dust emissions, although they could potentially reach these emission levels on a daily basis.

Most activities and emissions (including offsite hauling) are assumed to occur between 7am and 7pm, seven days per week. Wind erosion is assumed to occur 24 hours per day. TSP, PM_{10} and $PM_{2.5}$ emission rates were calculated using emission factors derived from US EPA (1995) (see **Appendix D**).

Figure 8-1 and **Appendix C** displays the indicative activity areas and sources of dust for each of the above operational scenarios.

The results of dispersion modelling (see **Section 9**) are compared with the relevant NSW EPA air quality criteria discussed in **Section 4**, which are generally health-based (with the exception of dust deposition, which is an amenity-based criterion).

7. OVERVIEW OF BEST PRACTICE DUST CONTROL

7.1 SUMMARY

Table 7.1 provides an overview of the relevant applicable best practice management measures recommended by the NSW EPA and identifies those to be implemented for the Proposal. These controls are compared to recommendations of the *NSW Coal Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Donnelly et al, 2011), a study that was commissioned by the EPA, hereafter referred to as “the Best Practice Report”.

Measures to be employed at the Proposal include the following.

- Use of water carts/trucks to control emissions from active haul roads.
- Application of water at transfer points, including water sprays at the crusher.
- Minimising drop heights when unloading material.

Table 7.1
Overview of EPA Best Practice Emission Reduction Measures

Air Quality Emission Source	Emission Reduction Measure	Used for the Proposal?	Comments	Effectiveness of reduction in Emissions Inventory
Loading and dumping of Product/Tailings	Minimisation of drop heights (Reduce from 3m to 1.5m)	Yes	Drop heights from excavators/loaders into haul trucks to be minimised, where possible.	For conservatism, no control factor applied.
Haul Trucks travelling on Unsealed Roads	Use of water carts/trucks to control emissions	Yes	Water carts to be used.	The watering rate assumed for 75% control is consistent Level 2 watering (>2L/m2/hr) per the NPI EET Manual Table 4.
Crushing	Water sprays	Yes	All sizing activities will involve the use of water sprays.	50% effectiveness due to water sprays.
Wind Erosion from Product/Tailings Stockpiles	Water sprays	Yes	Application of water is considered feasible/practical at the Proposal.	50% effectiveness due to water sprays.
Hauling on sealed roads (from the Proposal to the Argent Street)	Sealed road	Yes	Haul road from the Proposals' boundary to the boundary is completely sealed.	Accounted for in emission factor (for sealed roads) applied in the inventory.

8. EMISSIONS TO AIR

8.1 INTRODUCTION

Emissions during operation of the Proposal have been estimated based on activities and equipment operating, as follows:

- Extraction of ore from underground.
- Transportation of extracted ore to the surface ROM Pad using underground trucks, including establishment of a haulage route utilising existing roads and a proposed haul road cutting.
- Transportation of extracted waste rock for placement either within completed stopes underground or within the Cosmopolitan Open Cut within the existing in-pit waste rock emplacement.
- Extraction and transport of tailings from an existing Tailings Storage Facility for use within a proposed paste fill plant and use the resulting paste to backfill completed stopes.
- Stockpiling and crushing of ore within the existing ROM Pad using a mobile crusher.
- Loading and transport of the crushed ore to the boundary of the North Mine.
- The continuous operation of the upcast vent shaft at the ROM Pad.

8.2 PARTICLE SIZE CATEGORIES

Emission rates of TSP, PM_{10} and $PM_{2.5}$ have been calculated using emission factors developed both within NSW and by the US EPA. Modelling of PM_{10} and $PM_{2.5}$ was undertaken using the particle size specific inventories and was assumed to emit and deposit from the plume in accordance with the deposition rate appropriate for particles with an aerodynamic diameter equal to the geometric mass of the particle size range.

8.3 EMISSION ESTIMATES

Estimates of 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 (and point source for the vent shaft) situated according to the location of activities for the modelled scenarios.

The locations of the volume sources, used to represent mining activity, are shown in **Figure 8-1**. **Table 8.1** presents the list of activities modelled and the respective source locations at the Mine Site.

The information used for developing the inventories has been based on the operational descriptions and mine plan drawings and 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.

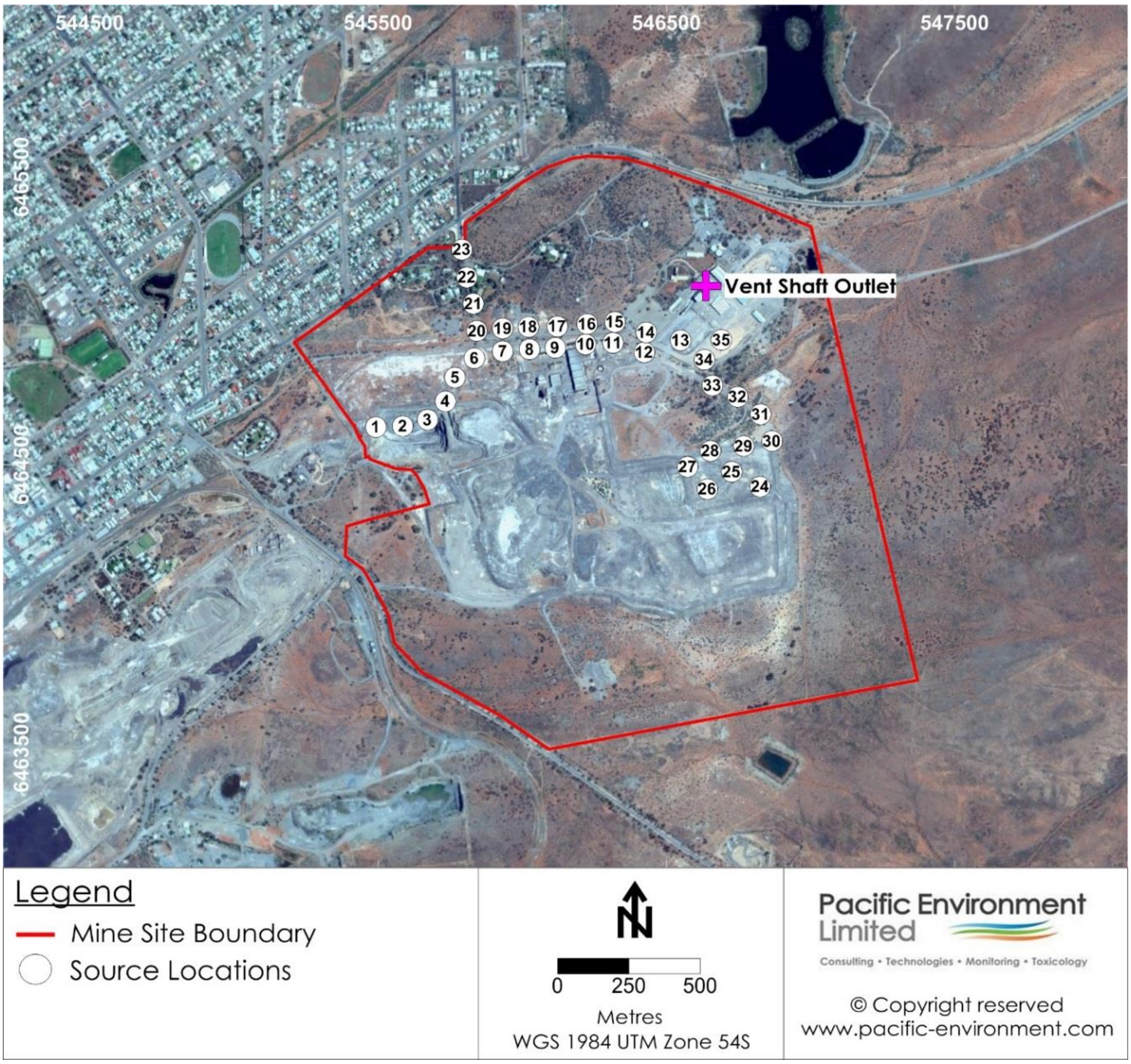


Figure 8-1 Source Locations

Table 8.1
Source Locations and Activities

Activity	Location
ORE - Hauling ore from Portal to ROM Pad (unsealed)	1,2,3,4,5,6,7,8,9,10,11,12,13
ORE - Unloading ore at ROM Pad	13
ORE - FEL Loading ore to crusher	13
ORE - Crusher (uncontrolled)	13
ORE - Unloading crushed ore to stockpile	13
ORE - FEL Loading crushed ore to road trucks	13
ORE - Hauling crushed ore out of site (unsealed)	13
ORE - Hauling crushed ore out of site (sealed)	14,15,16,17,18,19,20,21,22,23
TAILINGS - FEL Loading tailings to haul trucks	24,25,26,
TAILINGS - Hauling tailings from Tailings Storage Facility to Pastefill Storage Facility (unsealed)	24,25,26,27,28,29,30,31,32,33,34,35
TAILINGS - Emplacing tailings at Pastefill Plant Stockpile	35
TAILINGS - FEL Loading tailings to hopper at Pastefill Plant Stockpile	35
WE - ROM Pad uncrushed ore stockpile	13
WE - ROM Pad crushed ore stockpile	13
WE - Pastefill Plant tailings stockpile	35

8.3.1 Dust

The estimated dust emissions for annual average production and worst case maximum day are presented in **Table 8.2**. The full emissions inventories are presented in **Appendix C**.

Table 8.2
Estimated Emissions from the Proposal

Activity	TSP emissions (kg/yr)	PM_{10} emissions (kg/yr)		$PM_{2.5}$ emissions (kg/yr)	
	Annual	**Annual**	**Maximum Daily**	**Annual**	**Maximum Daily**
ORE - Hauling ore from Portal to ROM Pad (unsealed)	9,817	2,459	4,039	246	404
ORE - Unloading ore at ROM Pad	675	319	524	48	79
ORE - FEL Loading ore to crusher	675	319	524	48	79
ORE - Crusher (uncontrolled)	2,925	1,125	1,848	1,125	1,848
ORE - Unloading crushed ore to stockpile	675	319	524	48	79
ORE - FEL Loading crushed ore to road trucks	675	319	699	48	106
ORE - Hauling crushed ore out of site (unsealed)	2,518	631	1,381	63	138
ORE - Hauling crushed ore out of site (sealed)	1,320	253	555	61	134
TAILINGS - FEL Loading tailings to haul trucks	337	160	272	24	41
TAILINGS - Hauling tailings from Tailings Storage Facility to Pastefill Storage Facility (unsealed)	3,272	820	1,396	82	140
TAILINGS - Emplacing tailings at Pastefill Plant Stockpile	337	160	272	24	41
TAILINGS - FEL Loading tailings to hopper at Pastefill Plant Stockpile	337	160	272	24	41
WE - ROM Pad uncrushed ore stockpile	438	219	219	33	33
WE - ROM Pad crushed ore stockpile	219	110	110	16	16
WE - Pastefill Plant tailings stockpile	219	110	110	16	16
Total	**24,438**	**7,480**	**12,742**	**1,909**	**3,197**

Notes: WE = wind erosion; kg/yr = kilograms per year

8.3.2 Metals

The predicted metal emissions from the Proposal accounted for both the dust activities and the vent shaft. Sample data provided by the Applicant was used to characterise the metal speciation from different areas of the operations.

Presented in **Table 8.3** are the averages of the samples collected with detail of how they were applied to the predicted TSP emissions in **Table 8.2**. Note that the source locations refer to **Figure 8-1**.

Table 8.3
Metal Speciation in Dust Generating Activities

Metal	Unit	Source locations 1-12 (see Figure 8-1)	Source locations 13-35 (see Figure 8-1)
Lead	%	0.51	4.12
Silver	ppm	9.13	76.00
Zinc	%	0.98	2.88
Copper	ppm	127.13	759.00
Iron	%	2.09	2.70
Mercury	ppm	0.48	2.20
Nickel	ppm	13.00	10.00
Arsenic	ppm	168.75	480.00
Manganese	%	0.29	0.62
Cadmium	ppm	5.57	17.00
Chromium	ppm	25.38	26.00

Source: Perilya Broken Hill Limited, 2016

The vent shaft is the dominant source for metals from the Proposal. Presented in **Table 8.4** are the modelled parameters to represent the source.

Table 8.4
Vent Shaft Parameters

Parameter	Value
Height above ground (NB: modelled as a horizontal outlet)	6 m
Diameter	3.35 m
Flowrate	350 m^3/s
Stack Temperature	21 ºC

Source: Perilya Broken Hill Limited, 2016

Speciation data to identify the metals from the source were referenced from the source emissions monitoring completed in April 2016 at the adjacent RASP Mine in Broken Hill (AMG, 2016). Using the in-stack concentrations and volumetric flowrate, the individual emission rates for each of the metals was determined.

Note that given the time-intensity associated with running all the stated metals, Pacific Environment adopted a 'unit emission rate' approach to this component of the assessment.

Table 8.5
Modelled Vent Shaft In-stack Concentrations

Metal	In-stack Concentration (µg/Nm^3)
Arsenic	5.03
Cadmium	2.22
Chromium	2.10
Copper	3.80
Lead	15.00
Manganese	2.70
Nickel	0.56
Silver	3.77
Zinc	18.00
Mercury	0.70

9. IMPACT ASSESSMENT

Dispersion model predictions made for the Proposal (annual operations and maximum daily) are presented in the sections below. Contour plots of PM ground level concentrations (glcs), dust deposition rates and metal concentrations that could potentially be reached, under the conditions modelled are presented in the following sections. The actual predicted particulate concentrations/levels at the surrounding residences/receptors are also presented in tabular form (see **Table 9.1** to **Table 9.7**). At the assessed receptors there are no concentrations predicted to exceed the NSW EPA's impact assessment criteria.

Contour plots of particulate concentrations and deposition levels show the areas that are predicted to be affected by dust at different levels. 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. They are nevertheless useful to establish indicative particulate concentrations or deposition levels from the Proposal.

9.1 ANNUAL AVERAGE TSP

The Proposal-only and cumulative contributions to annual average TSP concentrations are presented in **Figure 9-1** and **Figure 9-2**, with a summary at each of the individual receptors provided in **Table 9.1**.

At privately-owned receptors there are no concentrations predicted to exceed the annual average impact assessment criterion of 90µg/m^3 either as a result of the Proposal-only or cumulatively.

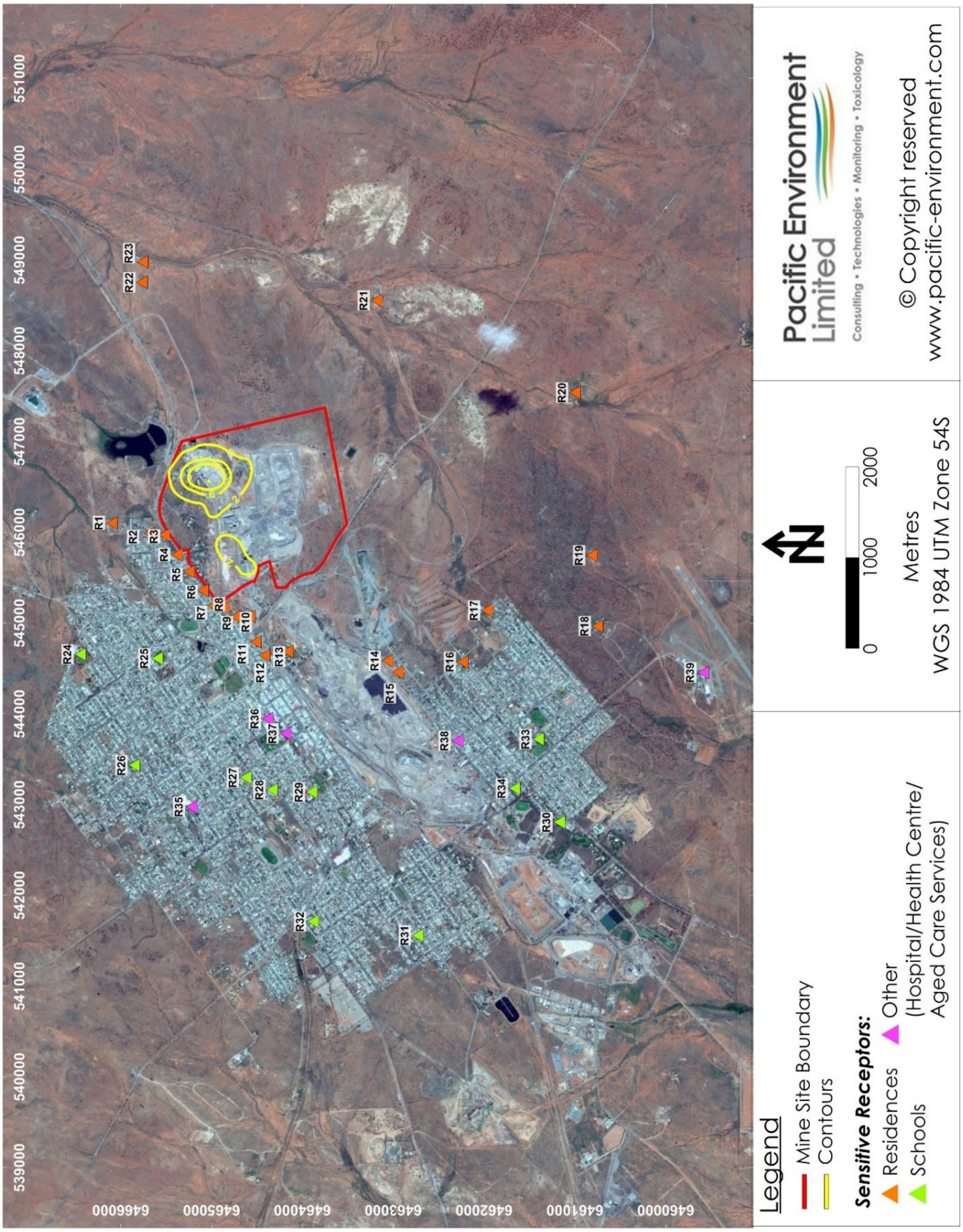


Figure 9-1 Predicted Annual TSP Concentration (µg/m^3) – Proposal Only

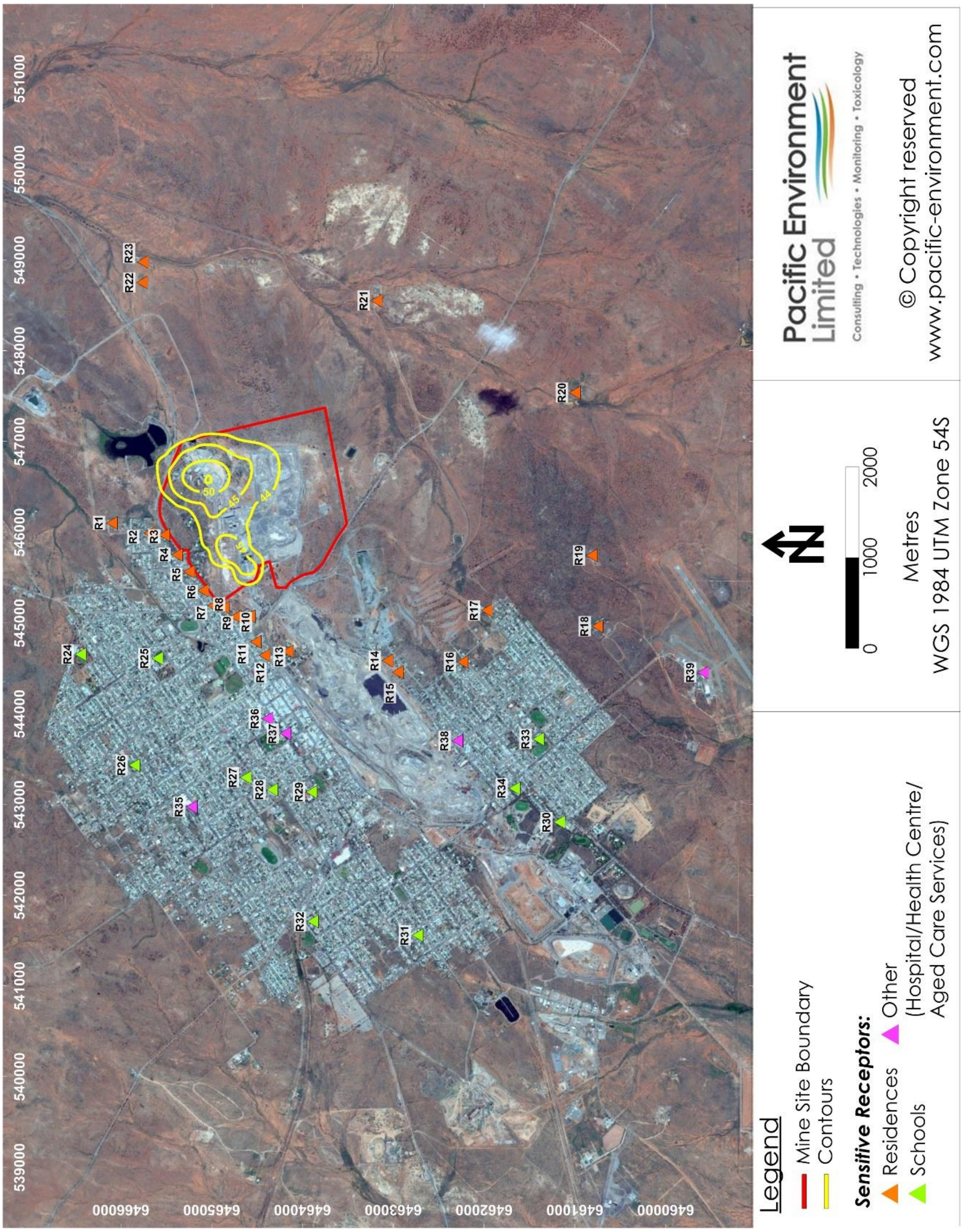


Figure 9-2 Predicted Annual TSP Concentration (μg/m^3) – Cumulative

Table 9.1
Annual Average TSP Concentrations (µg/m³)

Pollutant	**TSP (µg/m³)**	
Operational Scenario	***Normal operations***	
Averaging Period	**Annual average**	
	Proposal-only	**Cumulative**
	Assessment criteria	
Receptor ID	***N/A***	***90* µg/m³**
R1	0.3	43.3
R2	0.4	43.4
R3	0.5	43.5
R4	0.4	43.4
R5	0.3	43.3
R6	0.3	43.3
R7	0.2	43.2
R8	0.2	43.2
R9	0.2	43.2
R10	0.2	43.2
R11	0.2	43.2
R12	0.1	43.1
R13	0.1	43.1
R14	0.1	43.1
R15	0.1	43.1
R16	0.1	43.1
R17	0.1	43.1
R18	0.0	43.0
R19	0.0	43.0
R20	0.0	43.0
R21	0.1	43.1
R22	0.2	43.2
R23	0.1	43.1
R24	0.1	43.1
R25	0.1	43.1
R26	0.0	43.0
R27	0.0	43.0
R28	0.0	43.0
R29	0.0	43.0
R30	0.0	43.0
R31	0.0	43.0
R32	0.0	43.0
R33	0.0	43.0
R34	0.0	43.0
R35	0.0	43.0
R36	0.1	43.1
R37	0.1	43.1
R38	0.0	43.0
R39	0.0	43.0

9.2 ANNUAL AVERAGE PM_{10}

The Proposal-only and cumulative contributions to annual average PM_{10} concentrations are presented in **Figure 9-3** and **Figure 9-4**, with a summary at each of the individual receptors provided in **Table 9.2**.

At privately-owned receptors there are no concentrations predicted to exceed the annual average impact assessment criterion of 30µg/m^3 either as a result of the Proposal-only or cumulatively.

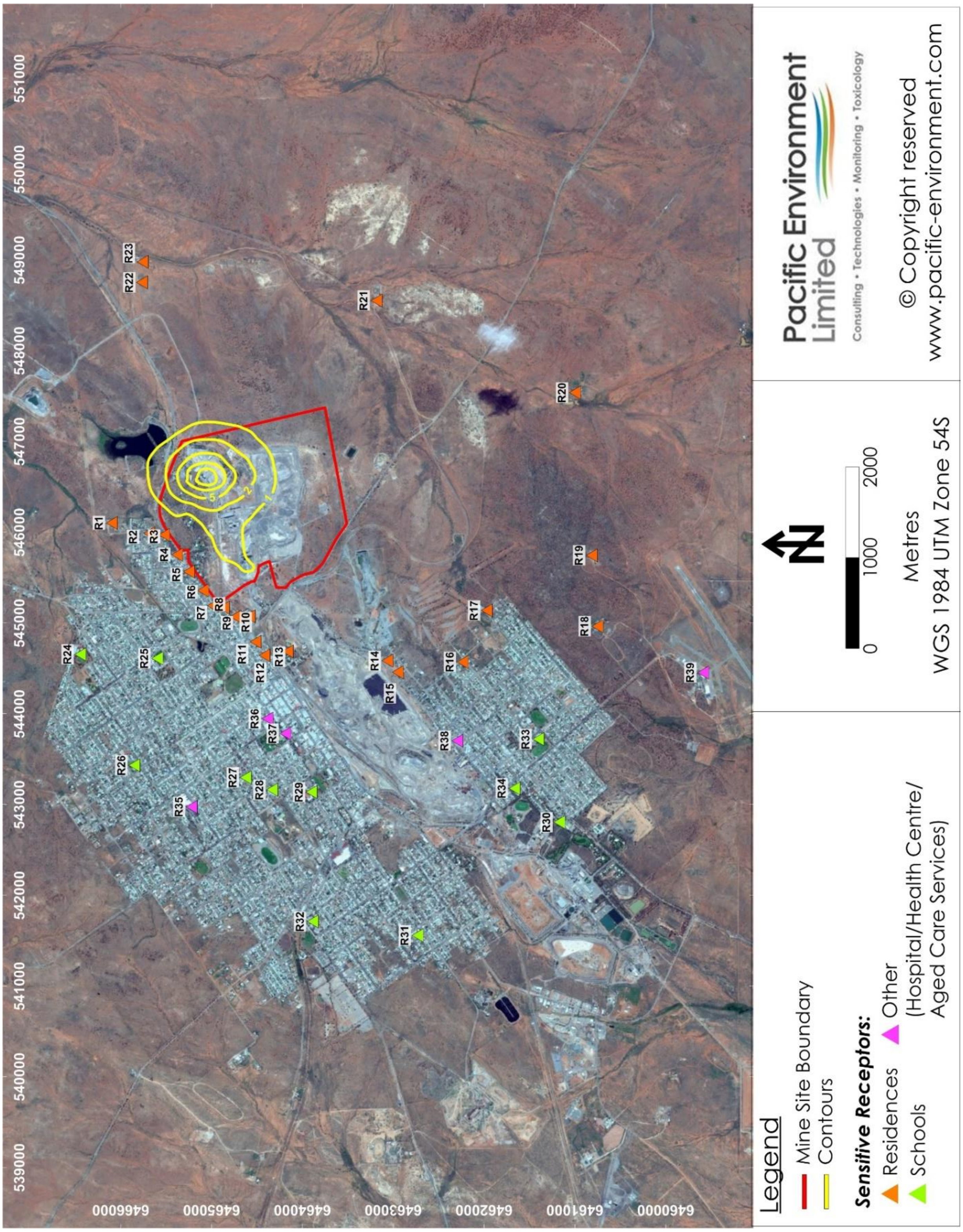


Figure 9-3 Predicted Annual PM_{10} Concentration (µg/m^3) – Proposal Only

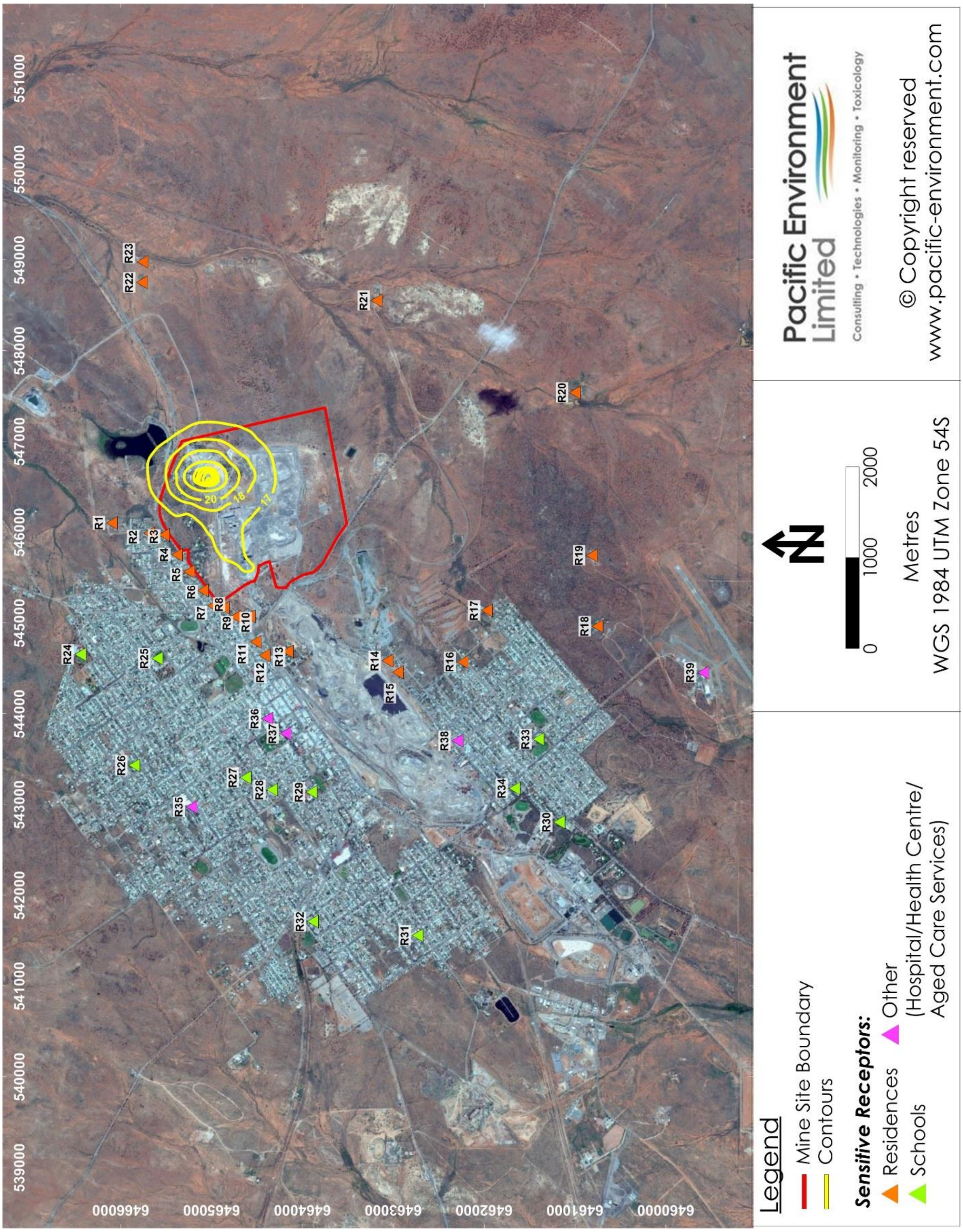


Figure 9-4 Predicted Annual PM_{10} Concentration ($\mu g/m^3$) – Cumulative

Table 9.2
Annual Average PM_{10} Concentrations (µg/m^3)

Pollutant	**PM_{10} (µg/m^3)**	
Operational Scenario	***Normal operations***	
Averaging Period	**Annual average**	
	Proposal-only	**Cumulative**
	Assessment criteria	
Receptor ID	***N/A***	***30* µg/m^3**
R1	0.3	16.3
R2	0.5	16.5
R3	0.4	16.4
R4	0.4	16.4
R5	0.3	16.3
R6	0.2	16.2
R7	0.2	16.2
R8	0.2	16.2
R9	0.2	16.2
R10	0.2	16.2
R11	0.1	16.1
R12	0.1	16.1
R13	0.1	16.1
R14	0.1	16.1
R15	0.1	16.1
R16	0.1	16.1
R17	0.1	16.1
R18	0.1	16.1
R19	0.1	16.1
R20	0.1	16.1
R21	0.1	16.1
R22	0.1	16.1
R23	0.1	16.1
R24	0.1	16.1
R25	0.1	16.1
R26	0.0	16.0
R27	0.0	16.0
R28	0.0	16.0
R29	0.0	16.0
R30	0.1	16.1
R31	0.0	16.0
R32	0.0	16.0
R33	0.1	16.1
R34	0.1	16.1
R35	0.0	16.0
R36	0.1	16.1
R37	0.1	16.1
R38	0.1	16.1
R39	0.0	16.0

9.3 ANNUAL AVERAGE $PM_{2.5}$

The Proposal-only contributions to annual average $PM_{2.5}$ concentrations are presented in **Figure 9-5**, with a summary at each of the individual receptors provided in **Table 9.3**.

As described previously in **Section 5.4**, background $PM_{2.5}$ is not measured in the vicinity of the Proposal. However as shown from the results, the contributions from the Proposal are negligible. Therefore it is anticipated that at the privately-owned receptors there will be no exceedances of the annual average impact assessment criterion of 8µg/m^3 on a cumulative basis.

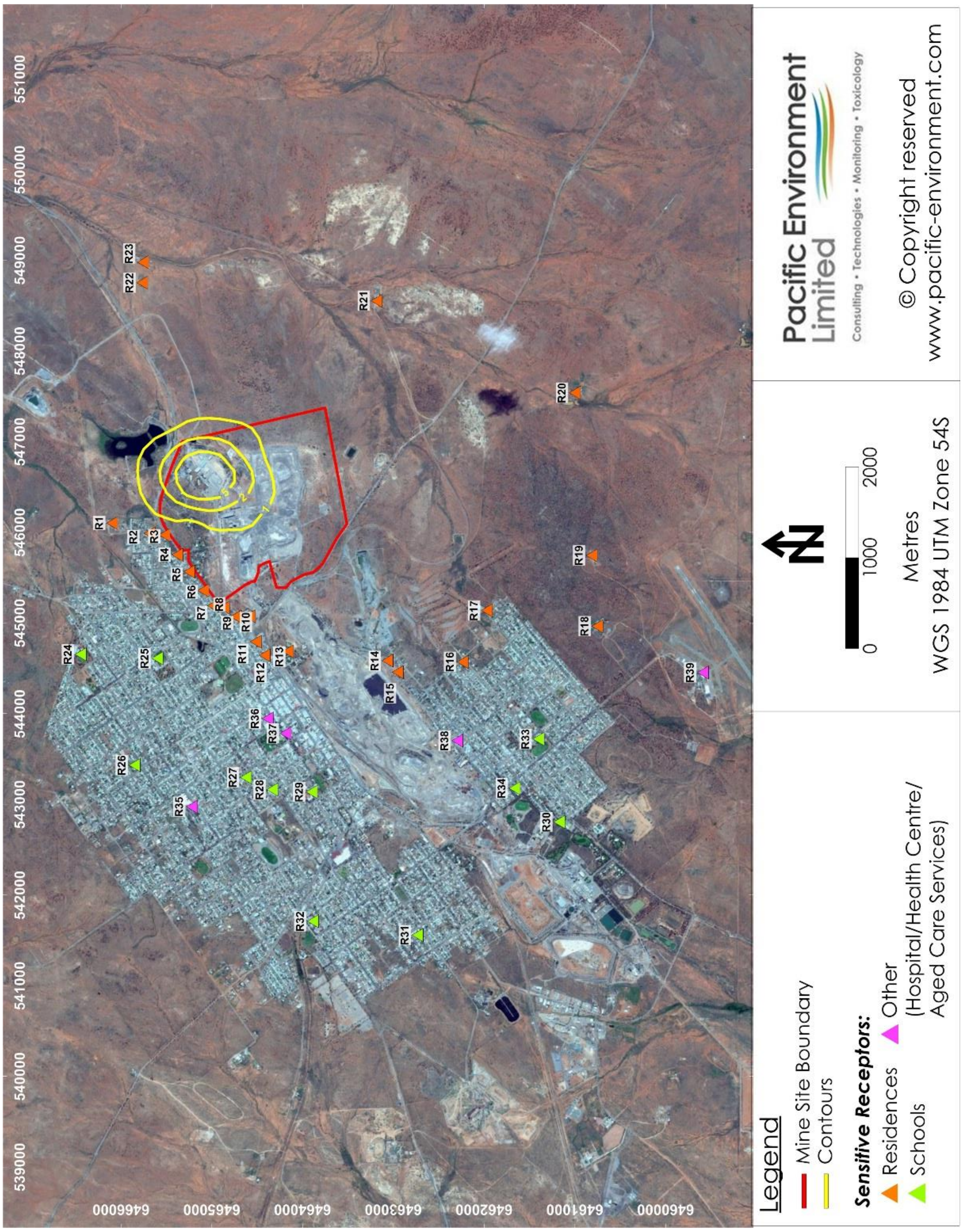


Figure 9-5 **Predicted Annual $PM_{2.5}$ Concentration (µg/m^3) – Proposal Only**

Table 9.3
Annual Average $PM_{2.5}$ Concentrations (µg/m³)

Pollutant	$PM_{2.5}$
Operational Scenario	***Normal operations***
Averaging Period	**Annual average**
	Proposal-only
	Assessment criteria
Receptor ID	***N/A***
R1	0.5
R2	0.6
R3	0.5
R4	0.4
R5	0.3
R6	0.3
R7	0.2
R8	0.2
R9	0.2
R10	0.2
R11	0.1
R12	0.1
R13	0.1
R14	0.2
R15	0.1
R16	0.1
R17	0.1
R18	0.1
R19	0.1
R20	0.1
R21	0.1
R22	0.1
R23	0.1
R24	0.1
R25	0.1
R26	0.0
R27	0.0
R28	0.0
R29	0.0
R30	0.1
R31	0.0
R32	0.0
R33	0.1
R34	0.1
R35	0.0
R36	0.1
R37	0.1
R38	0.1
R39	0.0

9.4 ANNUAL AVERAGE DUST DEPOSITION

The Proposal-only and cumulative contributions to annual average dust deposition are presented in **Figure 9-6** and **Figure 9-7**, with a summary at each of the individual receptors provided in **Table 9.4**.

At privately-owned receptors there are no privately-owned residences/receptors which are predicted to exceed the annual average dust deposition criterion of 2g/m^2/month as a result of the Proposal alone or the cumulative criterion of 4g/m^2/month.

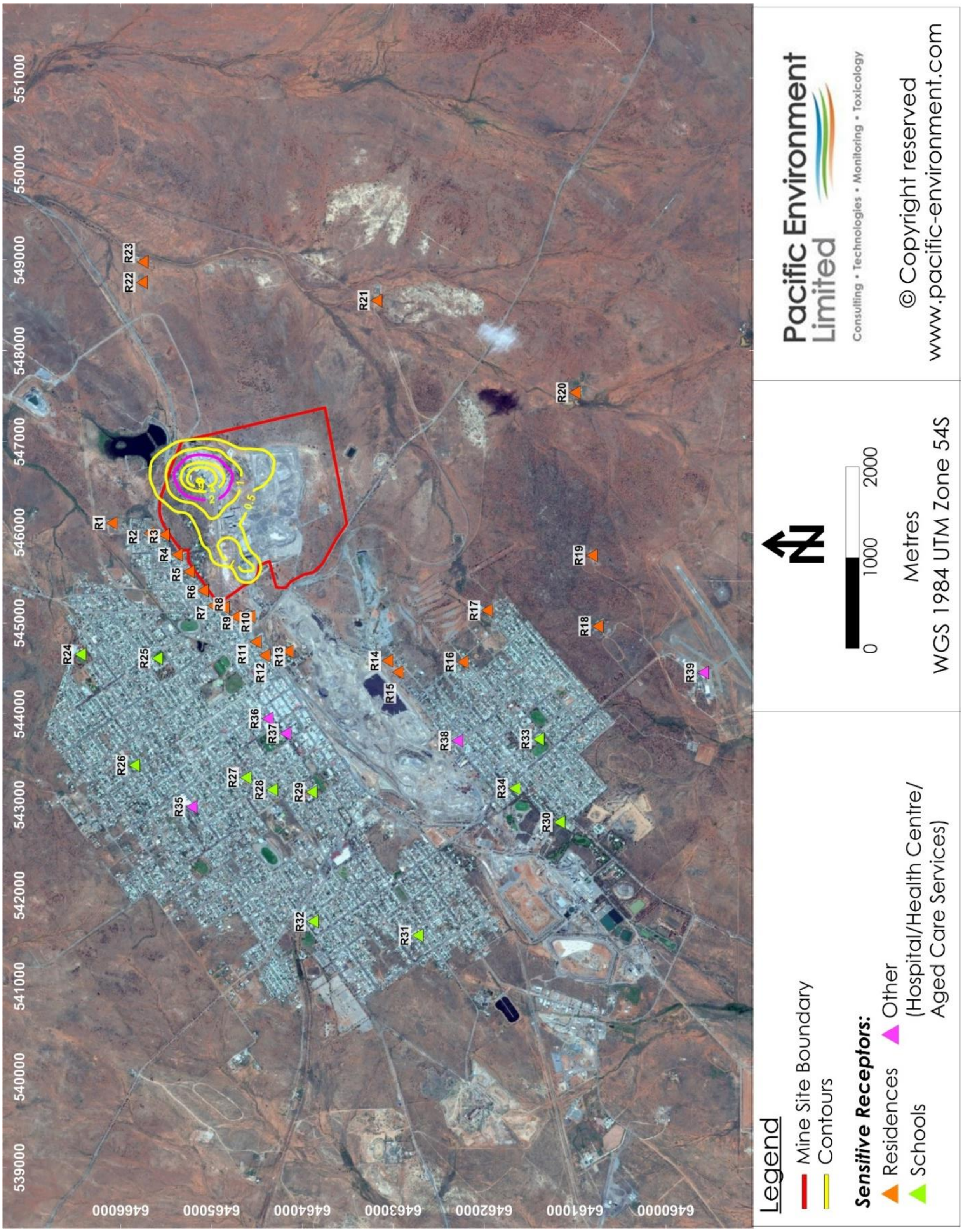


Figure 9-6 Predicted Annual Dust Deposition (g/m²/month) – Proposal Only

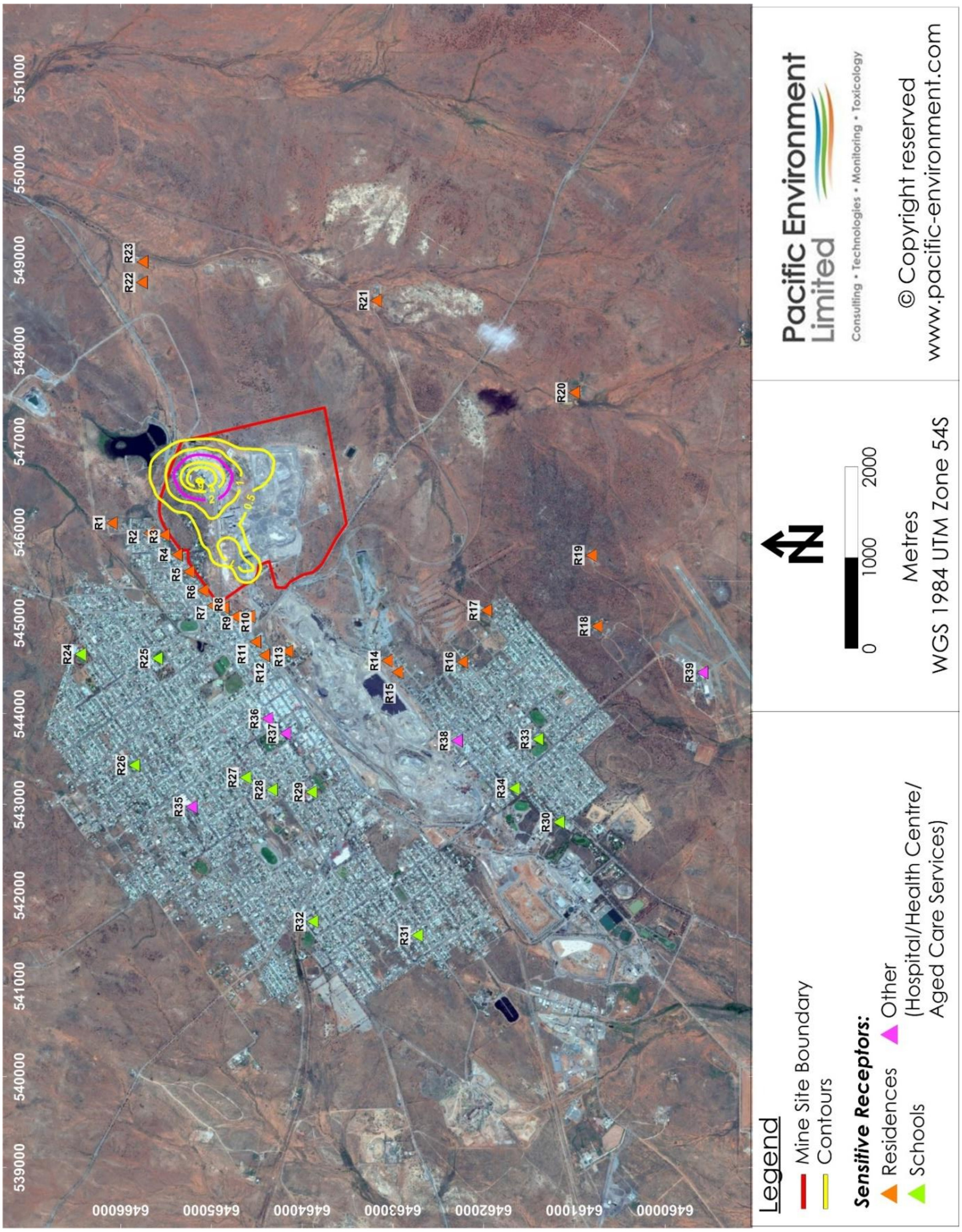


Figure 9-7 Predicted Annual Dust Deposition (g/m²/month) – Cumulative

Table 9.4
Annual Average Dust Deposition Levels (g/m^2/month)

Pollutant	**Dust Deposition (g/m^2/month)**	
Operational Scenario	***Normal operations***	
Averaging Period	**Annual average**	
	Proposal-only	**Cumulative**
	Assessment criteria	
Receptor ID	**2g/m^2/month**	**4g/m^2/month**
R1	0.1	2.1
R2	0.2	2.2
R3	0.2	2.2
R4	0.2	2.2
R5	0.1	2.1
R6	0.1	2.1
R7	0.1	2.1
R8	0.1	2.1
R9	0.1	2.1
R10	0.1	2.1
R11	0.0	2.0
R12	0.0	2.0
R13	0.0	2.0
R14	0.0	2.0
R15	0.0	2.0
R16	0.0	2.0
R17	0.0	2.0
R18	0.0	2.0
R19	0.0	2.0
R20	0.0	2.0
R21	0.0	2.0
R22	0.0	2.0
R23	0.0	2.0
R24	0.0	2.0
R25	0.0	2.0
R26	0.0	2.0
R27	0.0	2.0
R28	0.0	2.0
R29	0.0	2.0
R30	0.0	2.0
R31	0.0	2.0
R32	0.0	2.0
R33	0.0	2.0
R34	0.0	2.0
R35	0.0	2.0
R36	0.0	2.0
R37	0.0	2.0
R38	0.0	2.0
R39	0.0	2.0

9.5 24-HOUR AVERAGE CONCENTRATIONS

9.5.1 Introduction

It is important to note the difficulty in accurately predicting both the Proposal-only contribution, and the cumulative, maximum 24-hour average concentrations. This is due to a combination of the day-to-day variability in existing ambient dust levels, and the spatial and temporal variation in any other anthropogenic activity in the vicinity e.g. agricultural activity, bushfires, and other dust-generating activity in the future.

The following sections present maximum 24-hour average predictions for of PM_{10} and $PM_{2.5}$ due to the Proposal-only and for PM_{10} cumulatively.

9.5.2 24-hour Average PM_{10} Impacts

Maximum predicted 24-hour average PM_{10} concentrations at the receptors due to the Proposal-only are presented in **Table 9.5** for both the annual operations and maximum daily operations. Contour plots for the predicted concentrations of PM_{10} are presented in **Figure 9-8** and **Figure 9-9**.

The highest predicted glcs occur at the closest receptor (No. 2). At this location, the predicted incremental 24-hour PM_{10} concentration during maximum daily production is 15µg/m^3.

As the impact assessment criterion of 50µg/m^3 is applicable to cumulative concentrations, further analysis of the predicted cumulative concentration at the most impacted receptor is provided in **Figure 9-10**.

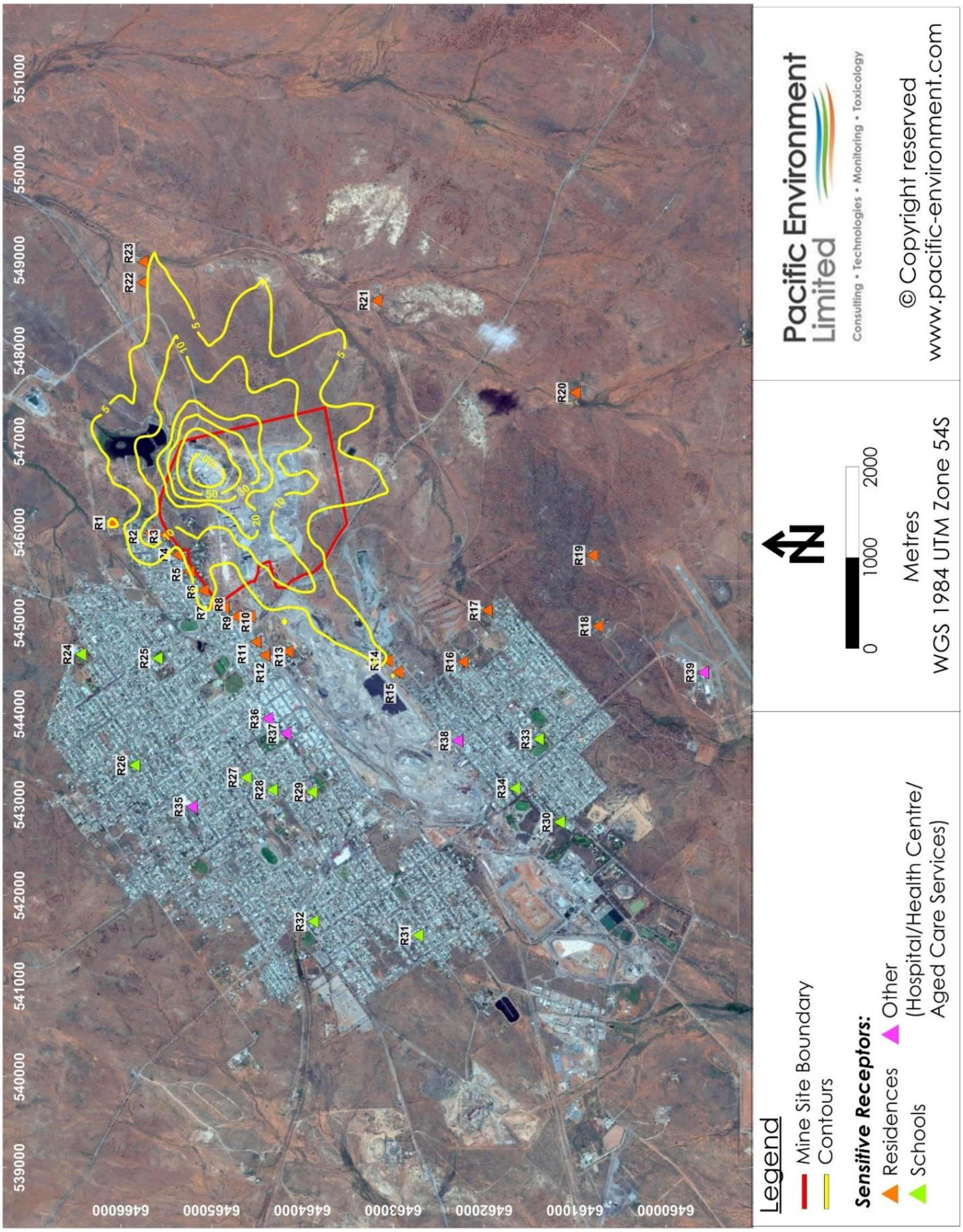


Figure 9-8 Maximum 24-hour average PM_{10} ($\mu g/m^3$) – Proposal Only (Annual Operations)

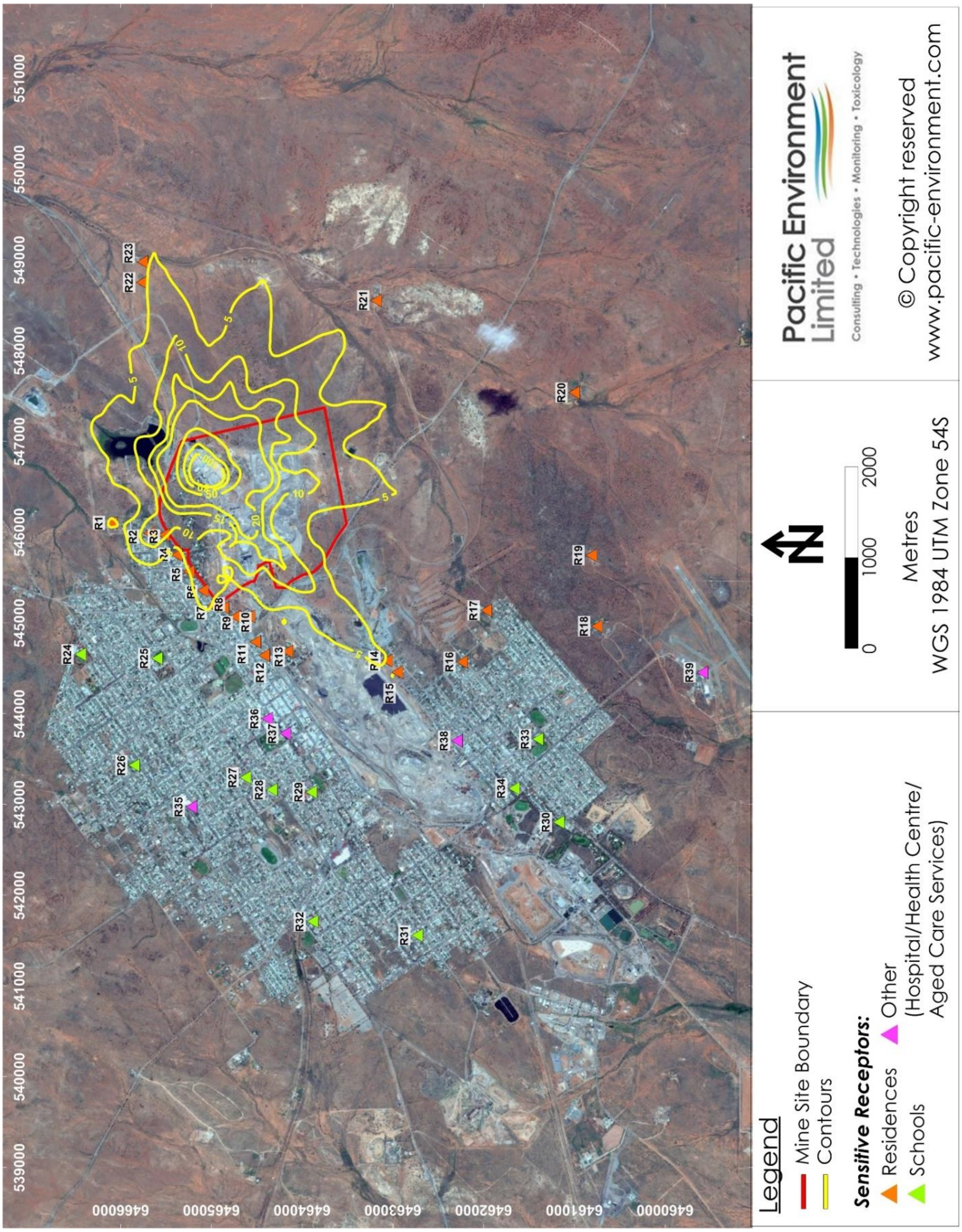


Figure 9-9 Maximum 24-hour average PM_{10} (µg/m[3]) – Proposal Only (Maximum daily operations)

Table 9.5
Maximum 24-hour average PM_{10} Concentrations due to the Proposal-only (µg/m^3)

Pollutant	PM_{10} (µg/m^3)	
Operational Scenario	*Annual operations*	*Maximum daily operations*
Averaging Period	Maximum 24-hour average	
	Proposal-only	
	Assessment criteria	
ID	*N/A (Cumulative = 50 µg/m^3)*	
R1	6.4	6.4
R2	14.6	14.6
R3	11.1	11.1
R4	3.3	3.3
R5	4.9	4.9
R6	5.5	5.5
R7	5.0	5.0
R8	3.0	3.5
R9	2.1	3.0
R10	2.5	2.5
R11	1.6	1.6
R12	1.5	1.5
R13	2.9	2.9
R14	5.1	5.1
R15	4.5	4.5
R16	0.9	0.9
R17	1.0	1.0
R18	1.0	1.0
R19	1.3	1.3
R20	1.3	1.4
R21	3.8	3.8
R22	4.3	4.3
R23	4.6	4.6
R24	2.7	2.7
R25	0.9	1.4
R26	1.3	1.4
R27	0.9	1.1
R28	1.1	1.1
R29	0.9	0.9
R30	1.4	1.4
R31	0.5	0.6
R32	0.6	0.6
R33	0.8	0.8
R34	2.0	2.0
R35	1.6	1.6
R36	0.9	1.0
R37	0.9	1.1
R38	3.2	3.2
R39	0.5	0.5

The cumulative assessment of PM_{10} concentrations at the most impacted receptor for the maximum daily operations is shown in **Figure 9-10**. The plot presents the cumulative concentration as a stacked bar-chart with the measured background concentration at the RASP Mine over the 2014 period shown in grey, and the Proposal contribution, for the maximum daily operations, shown in blue.

As detailed in **Figure 9-10**, the background data from RASP Mine in 2014 contains 10 days that exceed the assessment criterion of 50µg/m^3. Given that a full set of data were not available for 2014, where gaps were present, the annual average of 15.9µg/m^3 was used.

The results indicate that at the closest receptor (R2), there is no potential for any additional exceedances of the cumulative 24-hour PM_{10} impact assessment criteria of 50µg/m^3. Supplementary receptors were not deemed necessary to assess given the positive outcome of the worst case receptor presented.

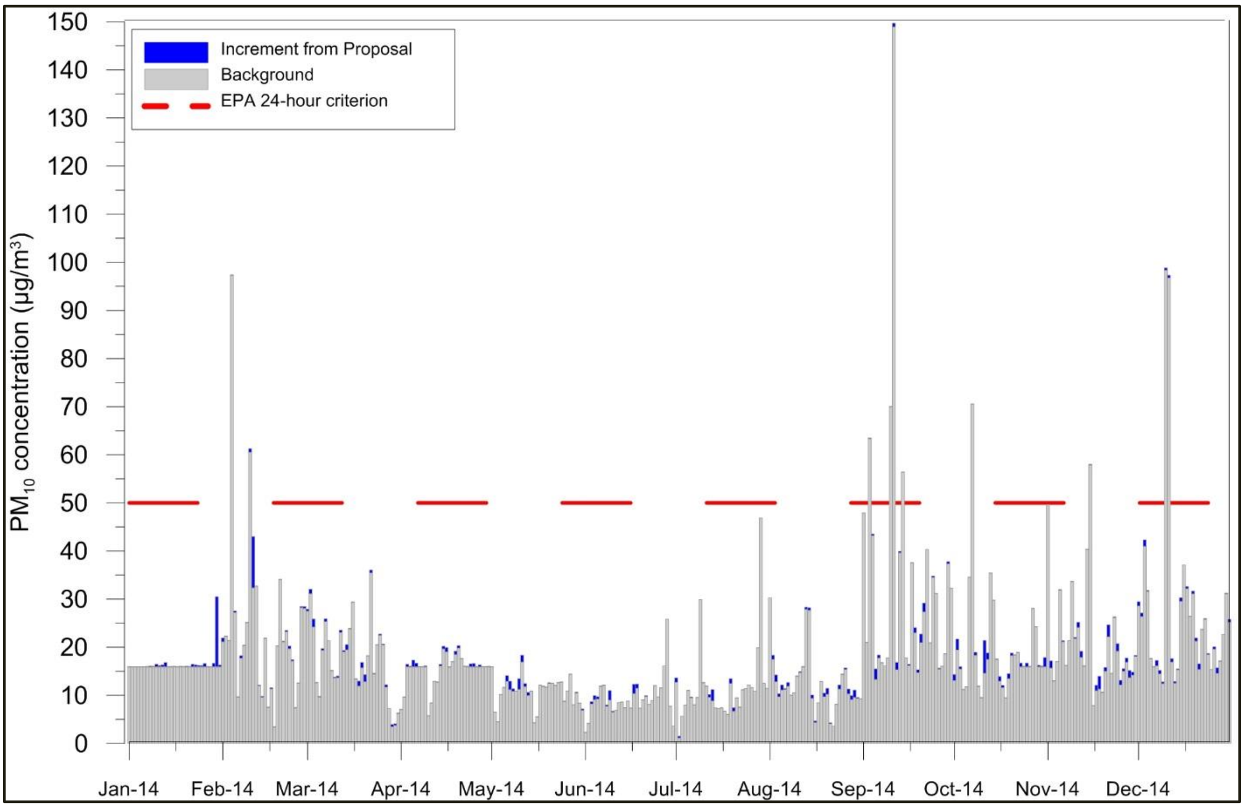


Figure 9-10 Maximum 24-hour average PM_{10} – worst-case cumulative at R2 (µg/m^3)

9.5.3 24-hour Average $PM_{2.5}$ Impacts

Maximum predicted 24-hour average $PM_{2.5}$ concentrations at the receptors due to the Proposal-only are presented in **Table 9.6** for both the annual operations and maximum daily operations. Contour plots for the predicted concentrations of $PM_{2.5}$ are presented in **Figure 9-11** and **Figure 9-12**.

The highest predicted glcs occur at the closest receptor (R2). At this location, the predicted incremental 24-hour $PM_{2.5}$ concentration during maximum daily operations is 16µg/m^3.

As discussed in **Section 9.3**, the cumulative impact of $PM_{2.5}$ has not been assessed. However based upon the results of the Proposal-only study, the concentrations at the receptors are below the NEPM cumulative standard of 25µg/m^3. Further, given the small incremental increase of PM_{10} predicted (**Section 9.2**), it is anticipated that the Proposal will have a negligible impact upon the 24-hour average $PM_{2.5}$ concentrations in Broken Hill.

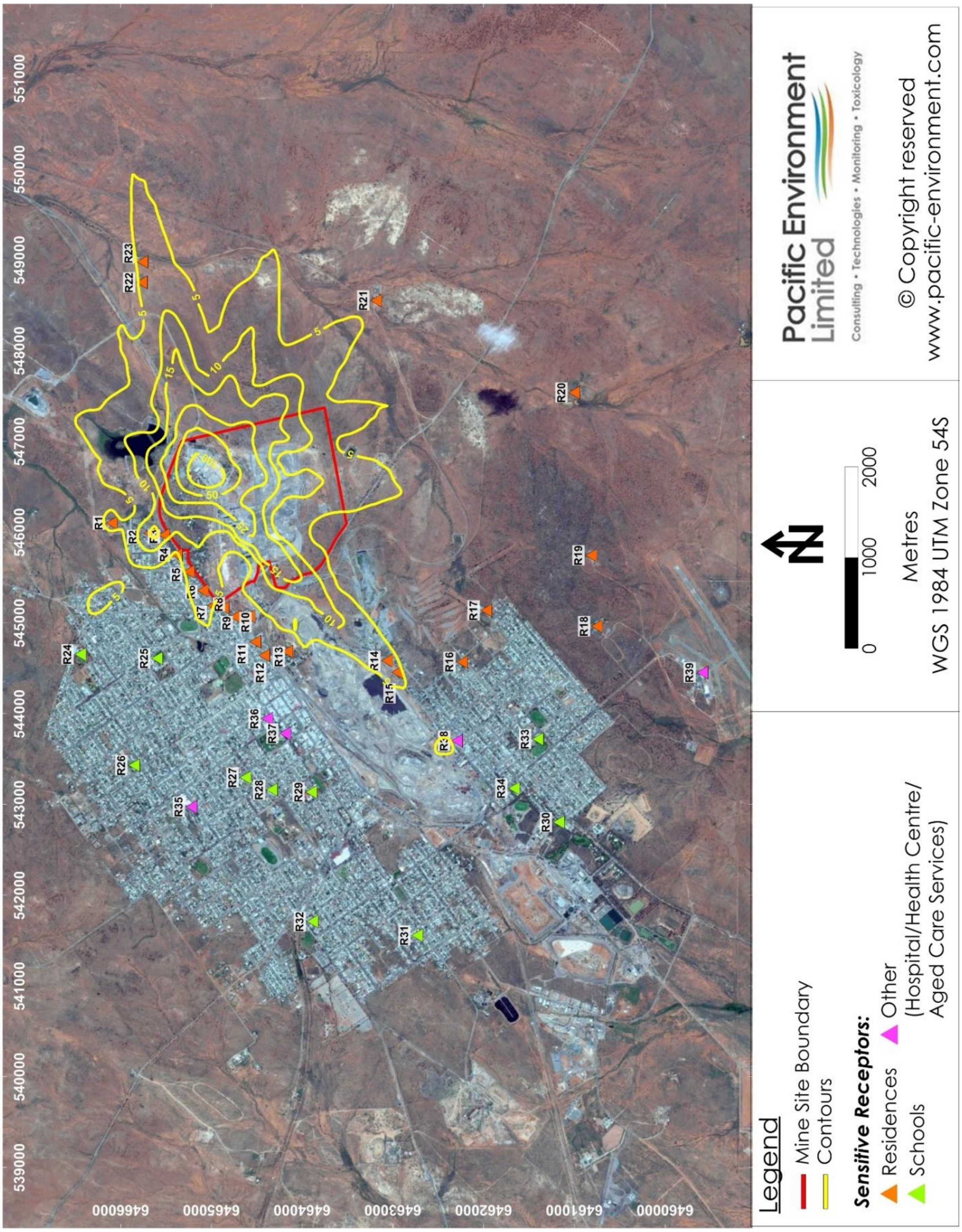


Figure 9-11 Maximum 24-hour average $PM_{2.5}$ ($\mu g/m^3$) – Proposal Only (Annual Operations)

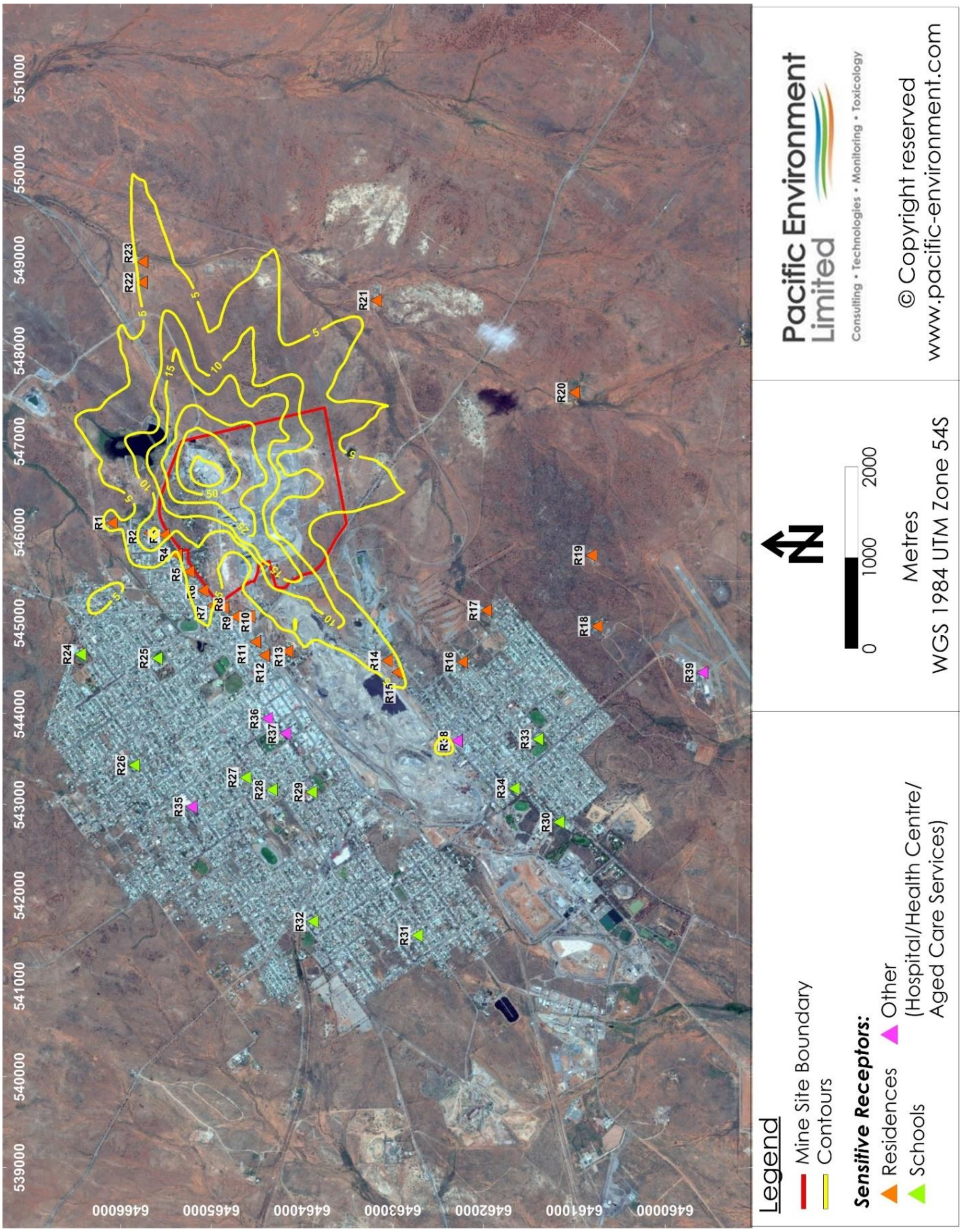


Figure 9-12 Maximum 24-hour average $PM_{2.5}$ ($\mu g/m^3$) – Proposal Only (Maximum daily operations)

Table 9.6
Maximum 24-hour average $PM_{2.5}$ Concentrations due to the Proposal-only (µg/m³)

Pollutant	**$PM_{2.5}$ (µg/m³)**	
Operational Scenario	***Annual operations***	***Maximum daily operations***
Averaging Period	**Maximum 24-hour average**	
	Proposal-only	
	Assessment criteria	
ID	***N/A (= 25 µg/m³ cumulative)***	
R1	7.7	7.7
R2	16.0	16.0
R3	12.1	12.1
R4	4.1	4.1
R5	5.8	5.8
R6	6.5	6.5
R7	5.5	5.4
R8	3.4	3.4
R9	2.5	2.5
R10	3.4	3.4
R11	2.3	2.3
R12	2.1	2.1
R13	3.4	3.4
R14	6.9	6.9
R15	6.1	6.1
R16	1.2	1.2
R17	1.0	1.0
R18	1.1	1.1
R19	1.6	1.6
R20	0.8	0.8
R21	4.5	4.5
R22	5.9	5.9
R23	6.4	6.4
R24	3.3	3.3
R25	1.1	1.1
R26	0.8	0.9
R27	0.6	0.7
R28	0.9	0.9
R29	0.7	0.7
R30	2.1	2.1
R31	0.8	0.8
R32	0.5	0.5
R33	1.1	1.1
R34	2.9	2.9
R35	1.7	1.7
R36	0.9	0.9
R37	0.7	0.8
R38	4.7	4.7
R39	0.5	0.5

9.6 HEAVY METAL CONCENTRATIONS

A summary of maximum Proposal-only incremental 99.9th percentile hourly and annual average heavy metal concentrations predicted for maximum production activities across all discrete receptor locations is given in **Table 9.7**, with reference made to relevant NSW EPA impact assessment criteria. Such criteria are reported at the predicted 99.9th percentile (or 9th highest 1-hourly average over the modelled year) concentration, consistent with Section 7.2.2 of the NSW EPA Approved Methods.

Table 9.7
Predicted Incremental 99.9th Percentile Hourly Heavy Metal Concentrations Predicted due to Maximum Production Activities

Substance	Maximum Predicted 99.9th Percentile Concentrations (µg/m³) across Sensitive Receptors	Most Impacted Receptor	Assessment Period	NSW EPA Impact Assessment[(a)] Criteria (µg/m³)	Incremental Concentration of % NSW EPA Criterion
Ag	0.02	R4	1-hr	0.18	13.5%
Zn	0.3	R3	1-hr	90	0.3%
Cu	0.02	R4	1-hr	18	0.1%
Fe	0.3	R4	1-hr	50	0.6%
Hg	0.005	R4	1-hr	0.18	2.5%
Ni	0.004	R4	1-hr	0.18	2.0%
Mn	0.07	R3	1-hr	18	0.4%
Cr (as CR III)	0.01	R4	1-hr	9	0.2%
Cr (as CR VI)	0.01	R4	1-hr	0.09	15.0%
As	0.03	R4	1-hr	0.09	36.0%
Cd	0.014	R4	1-hr	0.018	79.4%
Pb	0.006	R4	Annual	0.5	1.2%

(a) Specified for evaluation of incremental concentrations due to proposed projects

No exceedances of the relevant NSW EPA impact assessment criteria for the above toxic air pollutants are predicted to occur.

No data are available concerning the partitioning of chromium (Cr) between Cr III and Cr VI oxidation states. However, inspection of **Table 9.7** indicates that even using the highly conservative assumption that all Cr is found as Cr VI (Cr III is the most stable oxidation state), Cr is anticipated to comprise 15% of the NSW EPA 1-hour criterion.

10. GREENHOUSE GAS ASSESSMENT

10.1 INTRODUCTION

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*; and
- The Department of Environment (DoE) *National Greenhouse Accounts* (NGA) *Factors August 2015* (DoE, 2015).

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 Proposal) 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. The 'scope' of an emission is relative to the reporting entity. Indirect scope 2 and scope 3 emissions are reportable as direct scope 1 emissions from another facility.

1) 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 on-site 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_4 emissions from mines and venting); hydrofluorocarbon emissions during the use of refrigeration and air conditioning equipment; and CH_4 leakages from gas transport.

2) 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 mines, typically covers purchased electricity, defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity.

3) 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 the transportation of diesel. The GHG Protocol provides 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.

The *National Greenhouse and Energy Reporting Act 2007 (*NGER Act) was passed in September 2007. The NGER Act establishes a mandatory corporate reporting system for greenhouse gas emissions, energy consumption and production. Scope 1 and Scope 2 greenhouse gas emissions are required to be reported under the NGER Act.

10.2 GREENHOUSE GAS EMISSION ESTIMATES

Emissions of CO_2 would be the most significant GHGs for the Proposal. These gases are formed and released during the combustion of fuels used on-site and from fugitive emissions occurring during the mining process.

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. The estimated emissions are referred to in terms of CO_2 equivalent (CO_2-e) emissions by applying the relevant global warming potential. The GHG assessment has been conducted using the NGA Factors (DoE, 2015).

Proposal GHG sources included in the assessment are as follows:

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

A summary of the annual GHG emissions is provided in **Table 10.1**. More detail on the emission calculations are provided in **Appendix D**. Note that there will be 16 years of mining completed at the Proposal, however no data for year 1 has been provided.

Table 10.1
Summary of Estimated CO_2-e (tonnes) – All Scopes

Year	Scope 1 Emissions (t CO_2-e)	Scope 2 Emissions (t CO_2-e)	Scope 3 Emissions (t CO_2-e)		***Total*** (t CO_2-e)
	Diesel	Electricity	Diesel	Electricity	
2	1,971	13,905	101	1,986	*17,964*
3	2,169	13,905	111	1,986	*18,172*
4	2,060	13,905	106	1,986	*18,058*
5	2,147	13,905	110	1,986	*18,149*
6	2,469	13,905	127	1,986	*18,487*
7	2,500	13,905	128	1,986	*18,520*
8	3,749	33,373	192	4,768	*42,082*
9	2,959	33,373	152	4,768	*41,252*
10	2,959	33,373	152	4,768	*41,252*
11	2,959	33,373	152	4,768	*41,252*
12	2,957	33,373	152	4,768	*41,250*
13	2,950	33,373	151	4,768	*41,242*
14	2,943	27,811	151	3,973	*34,878*
15	1,928	13,905	99	1,986	*17,919*
16	1,756	13,905	90	1,986	*17,738*
Total	**38,476**	**339,293**	**1,973**	**48,470**	***428,213***

* Totals may differ to the sum of the columns due to rounding and significant figures.

10.3 IMPACT ON THE ENVIRONMENT

According to the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report, global surface temperature has increased by 0.89ºC ± 0.2ºC during the 100 years ending 2012 (IPCC, 2013). 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, 2013).

Climate change projections specific to Australia have been determined by the CSIRO and the Australian Bureau of Meteorology (BoM), based on global emissions scenarios predicted by the latest IPCC assessment (CSIRO, 2015a). These projections supersede those released by CSIRO and the BoM in 2007. Although the findings are similar to those of the 2007 projections, the range of emissions scenarios is broader than those used for the 2007 projections. The latest projections begin with concentration levels, rather than socio-economic assumptions followed by inferred emissions.

The projection changes have been prepared for four Representative Concentration Pathways (RCPs), which represent the following scenarios of emissions of greenhouse gases, aerosols and land-use change:

- RCP8.5 (high emissions) - represents a future with little curbing of emissions, with CO_2 concentrations continuing to rapidly rise, reaching 940 parts per million (ppm) by 2100.
- RCP6.0 (intermediate emissions) - represents lower emissions, achieved by application of some mitigation strategies and technologies. This scenario results in the CO_2 concentration rising less rapidly than RCP8.5, but still reaching 660ppm by 2100.
- RCP4.5 (intermediate emissions) - represents a similar scenario to RCP6.0, but emissions peak earlier (around 2040), and the CO_2 concentration reaches 540ppm in 2100.
- RCP2.6 (low emissions) - assumes a very strong emissions reductions from a peak at around 2020 to reach a CO_2 concentration at about 420ppm by 2100. This pathway would require early participation from all emitters, including developing countries, as well as the application of technologies for actively removing carbon dioxide from the atmosphere.

For climate change projections, a regionalisation scheme using natural resource management regional boundaries has been used to divide Australia up into 8 clusters and 15 sub-clusters. For the projections described above, **Table 10.2** presents the changes in annual temperature relative to the 1986-2005 period for the Rangelands cluster where the Proposal is located.

Table 10.2
Rangelands Projected Changes in Annual Temperature (relative to the 1986-2005 period)

2030 – RCP2.6 (low emissions scenario)	2030 – RCP4.5 (intermediate emissions scenario)	2030 – RCP8.5 (high emissions scenario)	2090 – RCP2.6 (low emissions scenario)	290 – RCP4.5 (intermediate emissions scenario)	2090 – RCP8.5 (high emissions scenario)
Temperature (°C)					
0.9 (0.6 to 1.3)	1 (0.6 to 1.4)	1 (0.8 to 1.4)	1.1 (0.6 to 1.8)	2.1 (1.5 to 2.9)	4.3 (2.9 to 5.3)

Notes: The table gives the median (50th percentile) change with the 10th and 90th percentile range given within brackets.
RCP6.0 is not included due to a smaller sample of model simulations available compared to the other RCPs. (CSIRO, 2015a).
Source: CSIRO (2015b) Climate Change in Australia – Projections for Australia's NRM Regions – Rangelands Cluster Report, 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.
- Geopolitical stability and the Asia Pacific region.

The Proposals contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global GHG emissions. Average annual scope 1 emissions from the Proposal (0.04 Mt CO_2-e) would represent approximately 0.007% of Australia's commitment under the original Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global GHG emissions, given that Australia contributed approximately 1.12% of global GHG emissions in 2012 (PBL Netherlands Environmental Assessment Agency, 2015).

A comparison of predicted annual GHG emissions from the Proposal with global, Australian and NSW emissions inventories are presented in **Table 10.3**.

Table 10.3
Comparison of Greenhouse Gas Emissions

Geographic coverage	Source coverage	Timescale	Annual Emissions Mt CO_2-e	Reference
Proposal	Scope 1 only	Average annual	0.04	This report.
Global	Consumption of fossil fuels	Total since industrialisation 1750 - 1994	865,000	IPCC (2007). Figure 7.3 converted from Carbon unit basis to CO_2 basis. Error is stated greater than ±20%.
Global	CO_2-e emissions	2014	35,700	PBL Netherlands Environmental Assessment Agency, 2015
Australia	1990 Base	1990	547.7	United Nations Framework on Climate Change – Kyoto Protocol base year data http://unfccc.int/ghg_data/kp_data_unfccc/base_year_data/items/4354.php
Australia	Kyoto target	Average annual 2008 - 2012	591.5	Based on 1990 net emissions multiplied by 108% Australia's Kyoto emissions target.
Australia	Total	2013	538.0	Taken from the National Greenhouse Gas Inventory 2013 http://www.environment.gov.au/system/files/resources/7d7f7ef6-e028-462e-b15c-ede14e222e65/files/national-inventory-report-2013-vol1.pdf
NSW	Total	2013	151.5	Taken from the State and Territory National Greenhouse Gas Inventory (2013) http://www.environment.gov.au/system/files/resources/9e33b185-1fb6-44b7-9d72-6979f3427b94/files/state-territory-inventories-2013.pdf

The commitment from the Australian Government to reduce GHG emissions is proposed to be achieved through the introduction of the Australian Government's *Direct Action Plan*. The centrepiece of the plan is Emissions Reduction Fund which will provide incentives for emissions reduction activities across the Australian economy. The legislation to establish the Emissions Reduction Fund came into effect in December 2014.

11. CONCLUSION

Pacific Environment has completed an Air Quality and Greenhouse Gas Assessment for the Broken Hill North Mine Proposal to address all relevant issues identified in the SEARs.

An ambient air monitoring network was established in July 2008 and used to characterise and describe the baseline air quality environment for the Proposal.

Mine Site plans for the Proposal have been analysed and detailed emission inventories prepared for the annual operations and maximum daily operating scenarios.

Dispersion modelling was conducted to predict the ground level concentrations for all relevant particulate matter, deposited dust and toxic metals. Cumulative impacts were also considered, taking into account existing mining activity in Broken Hill and contributions from other non-mining sources.

There are no predicted exceedances at privately-owned receptors of the annual average $PM_{2.5}$, PM_{10}, TSP or dust deposition assessment criteria, either from the Proposal alone or cumulatively. The modelling also indicated that the Proposal would not cause any additional 24-hour exceedances of the 50µg/m^3 PM_{10} criterion at the privately-owned receptors during maximum daily (worst case) operations. Further, no exceedances of the relevant NSW EPA impact assessment criteria for the assessed toxic air pollutants were predicted to occur.

A GHG assessment for the Proposal indicates that average annual Scope 1 emissions from the Proposal (0.04 Mt CO_2-e) would represent approximately 0.007% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global greenhouse emissions.

Generally, the predictions presented in this report incorporate a level of conservatism due to worst case assumptions and the nature of dispersion modelling. As a result, it is expected that actual ground level concentrations would be lower during the normal operation of the Proposal.

12. REFERENCES

AMG (2016). Source Emissions Monitoring – RASP Mine, Broken Hill, April 2016.

ATSDR (2007). “Toxicological profile for lead”. US Department of Health and Human services, Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

Bureau of Meteorology (2016). Climate averages for Station: 047048 http://www.bom.gov.au/climate/averages/tables/cw_047048.html

CBH Resource Limited (2016). Environmental Monitoring. Available from: http://www.cbhresources.com.au/index.php/operations/rasp-mine/sustainablity/environment/environmental-monitoring (accessed 2 August 2016)

Cristal Mining (2016). Environmental Documents Cristal Mining East. Available from: http://www.cristalmining.com/Social%20Responsibility/Environmental-Management/Pages/East-Operations.aspx (accessed 10 August 2016)

Chow, J.C. (1995). Measurement methods to determine compliance with ambient air quality standards for suspended particles, J. Air & Waste Manage. Assoc. 45, 320-382, May 1995.

CSIRO (2015a). Climate Change in Australia – Climate Change Projections, Technical Report.

CSIRO (2015b). Technical Report, Climate Change in Australia, Projections for Australia’s Natural Resource Management Regions.

DECCW (2009). Action for Air: 2009 Update. Available from http://www.environment.nsw.gov.au/resources/air/actionforair/09712ActionforAir.pdf (accessed 15 August 2016).

DoE (2015). National Greenhouse Account (NGA) Factors. Published by the Australian Government Department of Environment. Available from http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-aug-2015

Donnelly, S.J., Balch, A., Wiebe, A., Shaw, N., Welchman, S., Schloss, A., Castillo, E., Henville, K., Vernon, A., Planner, J. (2011). NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining. Prepared by Katestone Environmental Pty Ltd for Office of Environment and Heritage June 2011.

DPE (2014). Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Development. NSW Government 15 December 2014. NSW Department of Planning and Environment.

Garnaut, R (2008). The Garnaut Climate Change Review. Cambridge University Press.

Golder, D., (1972). Relations among Stability Parameters in the Surface Layer, Boundary-Layer Meteorology, 3: 47-58

Hurley, P. (2008). TAPM V4. Part 1: Technical Description, CSIRO Marine and Atmospheric Research Paper.

IARC (2006). Volume 87: Inorganic and Organic Lead Compounds. IARC monographs on the evaluation of carcinogenic risks to humans.

IPCC (2007) Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (2013) Working Group I Contribution to the IPCC Fifth Assessment Report Climate Change 2013: The Physical Science Basis: Final Draft Underlying Scientific-Technical Assessment. Prepared by the IPCC, 30 September 2013.

NEPC (1998a). National Environment Protection Measure for Ambient Air Quality. National Environment Protection Council.

NEPC (1998b). Final Impact Statement for Ambient Air Quality National Environment Protection Measure. National Environment Protection Council.

NEPC (2016). Ambient Air – National Environment Protection Measures (Ambient Air Quality) Measure as amended. 25 February 2016. National Environment Protection Council.

NSW DEC (2005). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales.

NSW EPA (1998). Action for Air – The NSW Government's 25-Year Air Quality Management Plan NSW Environment Protection Authority, Sydney

NSW EPA (2012). Air Emissions Inventory for the Greater Metropolitan Region in New South Wales: 2008 Calendar Year. Technical Report No. 6: Off-Road Mobile Emissions. NSW Environment Protection Authority, South Sydney.

PBL Netherlands Environmental Assessment Agency (2015). Trends in Global CO2 Emissions. 2015 Report. Available from http://edgar.jrc.ec.europa.eu/news_docs/jrc-2015-trends-in-global-co2-emissions-2015-report-98184.pdf.

Perilya Broken Hill Limited (2016). Email correspondence between PBHL and Judith Cox

UNEP (2006). Interim review of scientific information on lead. United Nations Environment Programme.

US EPA (1995) Compilation of Air Pollutant Emission Factors, AP-42, Fourth Edition United States Environmental Protection Agency, Office of Air and Radiation Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711.

US EPA (2006). Air Quality Criteria for Lead. Volume I. National Centre for Environmental Assessment-RTP Division Office of Research and Development U.S. Environmental Protection Agency Research Triangle Park, NC EPA/600/R-05/144aF p 8-61/2.

US EPA (2006). AP-42 Emission Factors Section 13.2.2 Unpaved Roads. United States Environment Protection Agency (2006).

WHO (1995). Environmental Health Criteria 165: Lead. International Programme on Chemical Safety, World Health Organisation, Geneva."

WHO (2011), World Health Organisation Air Quality and Health Fact Sheet Number 313 http://www.who.int/mediacentre/factsheets/fs313/en/index.html (accessed 19 May 2016)

World Resources Institute/World Business Council for Sustainable Development (2004). The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition March 2004.

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Appendices

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Appendix A

How to Read a Wind Rose

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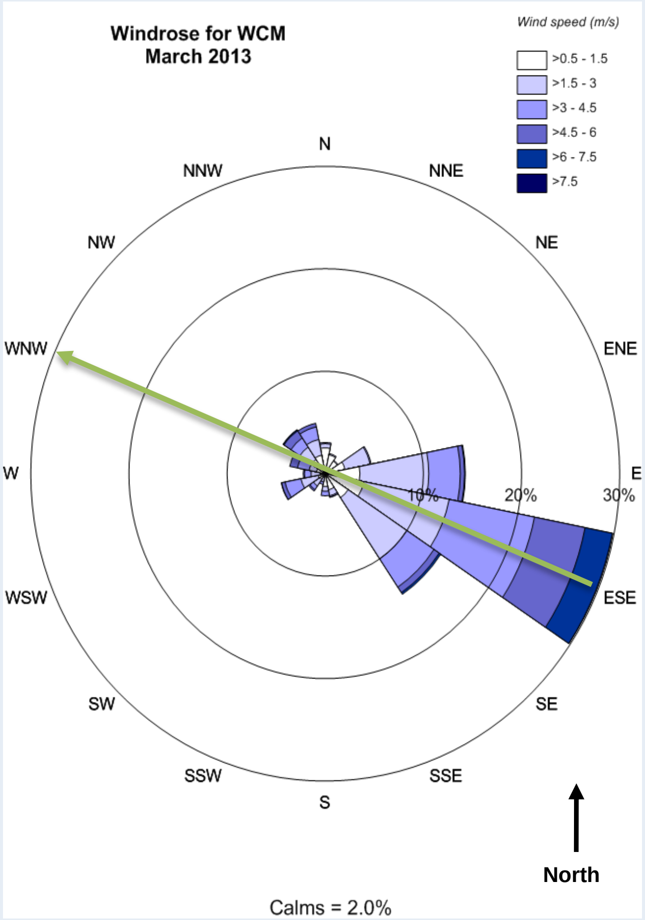
How to read a wind rose

A wind rose shows the frequency of occurrence of winds by direction and strength, presented as 16 bars that correspond to the compass points (N, NNE, NE, etc). The length of each bar represents the frequency of occurrence of winds from that direction, and the colours of the bar sections correspond to wind speed categories, the darker colours representing stronger winds.

In this example, 30% of winds are from the ESE direction, and the winds from this direction have the following speed distribution:

- 10% between 1.5 m/s and 3 m/s
- 10% between 3 m/s and 4.5 m/s
- 7% between 4.5 m/s and 6 m/s
- 3% between 6 m/s and 7.5 m/s

Predominant wind direction



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Appendix B

Model Set-Up

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TAPM (v4.0.4)				
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)			
Number of grid points	25 x 25 x 25			
Year of analysis	January 2014 – December 2014			
Centre of analysis (local co-ordinates)	(545935, 6464498)			
Meteorology				
Meteorological data for Surface Files –(Samson file)	Broken Hill Airport - Meteorological Station • Air temperature • Relative Humidity • Wind speed • Wind direction • Station Pressure • Precipitation TAPM centred over the Proposal • Cloud cover • Cloud height			
Land Use	Urban (Albedo – 0.2075, Bowen ratio – 1.625 and Surface roughness – 1) Desert Shrubland (Albedo – 0.3275, Bowen ratio – 4.75 and Surface roughness – 0.2625)			
AERMET PFL	Upper Air estimator			
Year of analysis	January 2014 - December 2014			
Model Set up				
Centre of domain (lat, long)	-33°57’33” S, 141°27’37” E			
Centre of domain (easting, northing)	543500, 6464000			
MGA coordinate zone	54 S			
Grid domain size	12km x 12km			
Grid spacing	200m			
South west corner of gridded receptor domain (m)	540000, 6458000			
Number of grid points	60 x 60			
Terrain data	SRTM3 at 30m resolution			
Rural Mode	Selected			
Particle parameters				
Particle type	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**Dust deposition**
Particle Method	Method 1	Method 1	Method 1	Selected
Particle diameter (microns)	17	5	1	17
Mass Fraction	1	1	1	1
Particle Density	2.5	2.5	2.5	2.5
Dry depletion	Selected	Selected	Selected	Selected
Output Options				
Highest values				

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Appendix C

Estimation of Emissions

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Silt and Moisture Content

Silt and moisture content values for in quarry activities are based on measured values provided by the Applicant.

	Silt content (%)	Moisture content (%)
Ore/Tailings	4.4	3
Hauling - unsealed	4.4	N/A

Loading / transfer Material Dumping

Each tonne of material loaded will generate a quantity of particulate matter that will depend on the wind speed and the moisture content according to the US EPA emission factor equation

(US EPA, 1985 and updates) shown below:

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

Where:
K = 0.74 for TSP, 0.35 for PM_{10} and 0.053 for $PM_{2.5}$
U – wind speed (m/s)
M – moisture content (%)

The moisture content of the ore/tailings material is assumed to be 3% and the wind speed is taken from the wind speed data from Broken Hill Airport AWS.

Hauling Material on Unsealed Surfaces

The emission estimate of wheel generated dust associated with hauling at the quarry (i.e. for hauling of material during construction is based the US EPA AP42 emission equation for unpaved surfaces at industrial sites (US EPA, 1985 and updates) shown below:

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

$$E_{PM_{10}}\ \ (kg/VKT) = 0.2819 \times 1.5 \times [\ (s/12)\text{^}0.9 \times ((W \times 1.1023)/3)\text{^}0.45]$$

$$E_{PM_{2.5}}\ \ (kg/VKT) = 0.2819 \times 0.15 \times [\ (s/12)\text{^}0.9 \times ((W \times 1.1023)/3)\text{^}0.45]$$

Where:
s = silt content of road surface
W = mean vehicle weight
The silt content (s) for the haulage routes is assumed to be 4.4%.

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.

Client supplied	Vehicle type	Unloaded (tare) weight	Loaded (GVM) including load	Capacity (tonnes)
Onsite	Haul Truck (ore)	24	69	45
Onsite	Haul Truck (crushed ore)	30.5	68	37.5
Onsite	Haul Truck (tailings)	24	69	45

Hauling Material on Sealed Surfaces

The emission estimate of wheel generated dust associated with hauling from the Proposal to the sealed road off site is based the US EPA AP42 emission equation for paved roads at (US EPA, 1985 and updates) shown below:

$$E_{TSP}\ (kg/VKT) = k \times [\ (sL)\text{^}0.91 \times (W)\text{^}1.02]$$

Where:
k = 3.23 for TSP, 0.62 for PM_{10} and 0.15 for $PM_{2.5}$ in g/VKT
sL = road surface silt loading
W = mean vehicle weight

The silt content (s) for the haulage routes is assumed to be 4.4%.

Wind Erosion

The emission factor used for wind erosion has been taken as 0.1 kg/ha for TSP and 0.05 kg/ha for PM_{10} and 0.075 kg/ha for $PM_{2.5}$ US EPA (1985 and updates).

TSP Emission Inventory (Annual)

ACTIVITY	TSP (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Control Assumption
Waste & Ore																		
ORE - Hauling ore from Portal to ROM Pad (unsealed)	9,817	300,000	t/y	0.131	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	2.4	km/return trip	2.45	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Unloading ore at ROM Pad	675	300,000	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading ore to crusher	675	300,000	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Crusher (uncontrolled)	2,925	300,000	t/y	0.0195	kg/t											50	% control	Water sprays
ORE - Unloading crushed ore to stockpile	675	300,000	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading crushed ore to road trucks	675	300,000	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Hauling crushed ore out of site (unsealed)	2,518	300,000	t/y	0.034	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	0.5	km/return trip	2.52	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Hauling crushed ore out of site (sealed)	1,320	300,000	t/y	0.004	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	2	km/return trip	0.08	kg/VKT	0.4	g/m2 silt loading	0	% control	
Storage & Tailings																		
TAILINGS - FEL Loading tailings to haul trucks	337	150,000	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - Hauling tailings from Tailings Storage Facility to Plastefill Storage Facility (unsealed)	3,272	150,000	t/y	0.087	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	1.6	km/return trip	2.45	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
TAILINGS - Emplacing tailings at Pastefill Plant Stockpile	337	150,000	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - FEL Loading tailings to hopper at Pastefill Plant Stockpile	337	150,000	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
Wind Erosion																		
WE - ROM Pad uncrushed ore stockpile	438	1.0	ha	0.1	kg/ha/h	8,760	h									50	% control	Water sprays
WE - ROM Pad crushed ore stockpile	219	0.5	ha	0.1	kg/ha/h	8,760	h									50	% control	Water sprays
WE - Plastefill Plant tailings stockpile	219	0.5	ha	0.1	kg/ha/h	8,760	h									50	% control	Water sprays
TOTAL EMISSIONS	**24,438**																	

PM10 Emission Inventory (Annual)

ACTIVITY	PM10	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Control Assumption
Waste & Ore																		
ORE - Hauling ore from Portal to ROM Pad (unsealed)	2,459	300,000	t/y	0.033	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	2.4	km/return trip	0.61	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Unloading ore at ROM Pad	319	300,000	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading ore to crusher	319	300,000	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Crusher (uncontrolled)	1,125	300,000	t/y	0.0075	kg/t											50	% control	Water sprays
ORE - Unloading crushed ore to stockpile	319	300,000	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading crushed ore to road trucks	319	300,000	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Hauling crushed ore out of site (unsealed)	631	300,000	t/y	0.008	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	0.5	km/return trip	0.63	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Hauling crushed ore out of site (sealed)	253	300,000	t/y	0.001	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	2	km/return trip	0.02	kg/VKT	0.4	g/m2 silt loading	0	% control	
Storage & Tailings																		
TAILINGS - FEL Loading tailings to haul trucks	160	150,000	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - Hauling tailings from Tailings Storage Facility to Plastefill Storage Facility (unsealed)	820	150,000	t/y	0.022	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	1.6	km/return trip	0.61	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
TAILINGS - Emplacing tailings at Pastefill Plant Stockpile	160	150,000	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - FEL Loading tailings to hopper at Pastefill Plant Stockpile	160	150,000	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
Wind Erosion																		
WE - ROM Pad uncrushed ore stockpile	110	1.0	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
WE - ROM Pad crushed ore stockpile	55	0.5	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
WE - Plastefill Plant tailings stockpile	55	0.5	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
TOTAL EMISSIONS	**7,261**																	

PM2.5 Emission Inventory (Annual)

ACTIVITY	PM2.5	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Control Assumption
Waste & Ore																		
ORE - Hauling ore from Portal to ROM Pad (unsealed)	246	300,000	t/y	0.003	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	2.4	km/return trip	0.06	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Unloading ore at ROM Pad	48	300,000	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading ore to crusher	48	300,000	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Crusher (uncontrolled)	1,125	300,000	t/y	0.0075	kg/t											50	% control	Water sprays
ORE - Unloading crushed ore to stockpile	48	300,000	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading crushed ore to road trucks	48	300,000	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Hauling crushed ore out of site (unsealed)	63	300,000	t/y	0.001	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	0.5	km/return trip	0.06	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Hauling crushed ore out of site (sealed)	61	300,000	t/y	0.000	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	2	km/return trip	0.00	kg/VKT	0.4	g/m2 silt loading	0	% control	
Storage & Tailings																		
TAILINGS - FEL Loading tailings to haul trucks	24	150,000	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - Hauling tailings from Tailings Storage Facility to Plastefill Storage Facility (unsealed)	82	150,000	t/y	0.002	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	1.6	km/return trip	0.06	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
TAILINGS - Emplacing tailings at Pastefill Plant Stockpile	24	150,000	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - FEL Loading tailings to hopper at Pastefill Plant Stockpile	24	150,000	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
Wind Erosion																		
WE - ROM Pad uncrushed ore stockpile	8	1.0	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
WE - ROM Pad crushed ore stockpile	4	0.5	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
WE - Plastefill Plant tailings stockpile	4	0.5	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
TOTAL EMISSIONS	**1,859**																	

TSP Emission Inventory (Daily Maximum)

ACTIVITY	TSP (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Control Assumption
Waste & Ore																		
ORE - Hauling ore from Portal to ROM Pad (unsealed)	16,124	492,750	t/y	0.131	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	2.4	km/return trip	2.45	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Unloading ore at ROM Pad	1,108	492,750	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading ore to crusher	1,108	492,750	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Crusher (uncontrolled)	4,804	492,750	t/y	0.0195	kg/t											50	% control	Water sprays
ORE - Unloading crushed ore to stockpile	1,108	492,750	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading crushed ore to road trucks	1,477	657,000	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Hauling crushed ore out of site (unsealed)	5,515	657,000	t/y	0.034	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	0.5	km/return trip	2.52	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Hauling crushed ore out of site (sealed)	2,891	657,000	t/y	0.004	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	2	km/return trip	0.08	kg/VKT	0.4	g/m2 silt loading	0	% control	
Storage & Tailings																		
TAILINGS - FEL Loading tailings to haul trucks	574	255,500	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - Hauling tailings from Tailings Storage Facility to Plastefill Storage Facility (unsealed)	5,574	255,500	t/y	0.087	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	1.6	km/return trip	2.45	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
TAILINGS - Emplacing tailings at Pastefill Plant Stockpile	574	255,500	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - FEL Loading tailings to hopper at Pastefill Plant Stockpile	574	255,500	t/y	0.00225	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
Wind Erosion																		
WE - ROM Pad uncrushed ore stockpile	438	1.0	ha	0.1	kg/ha/h	8,760	h									50	% control	Water sprays
WE - ROM Pad crushed ore stockpile	219	0.5	ha	0.1	kg/ha/h	8,760	h									50	% control	Water sprays
WE - Plastefill Plant tailings stockpile	219	0.5	ha	0.1	kg/ha/h	8,760	h									50	% control	Water sprays
TOTAL EMISSIONS	**42,309**																	

PM_{10} Emission Inventory (Daily Maximum)

ACTIVITY	PM10	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Control Assumption
Waste & Ore																		
ORE - Hauling ore from Portal to ROM Pad (unsealed)	4,039	492,750	t/y	0.033	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	2.4	km/return trip	0.61	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Unloading ore at ROM Pad	524	492,750	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading ore to crusher	524	492,750	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Crusher (uncontrolled)	1,848	492,750	t/y	0.0075	kg/t											50	% control	Water sprays
ORE - Unloading crushed ore to stockpile	524	492,750	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading crushed ore to road trucks	699	657,000	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Hauling crushed ore out of site (unsealed)	1,381	657,000	t/y	0.008	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	0.5	km/return trip	0.63	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Hauling crushed ore out of site (sealed)	555	657,000	t/y	0.001	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	2	km/return trip	0.02	kg/VKT	0.4	g/m2 silt loading	0	% control	
Storage & Tailings																		
TAILINGS - FEL Loading tailings to haul trucks	272	255,500	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - Hauling tailings from Tailings Storage Facility to Plastefill Storage Facility (unsealed)	1,396	255,500	t/y	0.022	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	1.6	km/return trip	0.61	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
TAILINGS - Emplacing tailings at Pastefill Plant Stockpile	272	255,500	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - FEL Loading tailings to hopper at Pastefill Plant Stockpile	272	255,500	t/y	0.00106	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
Wind Erosion																		
WE - ROM Pad uncrushed ore stockpile	110	1.0	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
WE - ROM Pad crushed ore stockpile	55	0.5	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
WE - Plastefill Plant tailings stockpile	55	0.5	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
TOTAL EMISSIONS	**12,523**																	

$PM_{2.5}$ Emission Inventory (Daily Maximum)

ACTIVITY	PM2.5	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Control Assumption
Waste & Ore																		
ORE - Hauling ore from Portal to ROM Pad (unsealed)	404	492,750	t/y	0.003	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	2.4	km/return trip	0.06	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Unloading ore at ROM Pad	79	492,750	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading ore to crusher	79	492,750	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Crusher (uncontrolled)	1,848	492,750	t/y	0.0075	kg/t											50	% control	Water sprays
ORE - Unloading crushed ore to stockpile	79	492,750	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - FEL Loading crushed ore to road trucks	106	657,000	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
ORE - Hauling crushed ore out of site (unsealed)	138	657,000	t/y	0.001	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	0.5	km/return trip	0.06	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
ORE - Hauling crushed ore out of site (sealed)	134	657,000	t/y	0.000	kg/t	37.5	t/load	49.25	Mean Vehicle Mass (t)	2	km/return trip	0.00	kg/VKT	0.4	g/m2 silt loading	0	% control	
Storage & Tailings																		
TAILINGS - FEL Loading tailings to haul trucks	41	255,500	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - Hauling tailings from Tailings Storage Facility to Plastefill Storage Facility (unsealed)	140	255,500	t/y	0.002	kg/t	45	t/load	46.5	Mean Vehicle Mass (t)	1.6	km/return trip	0.06	kg/VKT	4.4	% silt content	75	% control	Level 2 watering
TAILINGS - Emplacing tailings at Pastefill Plant Stockpile	41	255,500	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
TAILINGS - FEL Loading tailings to hopper at Pastefill Plant Stockpile	41	255,500	t/y	0.00016	kg/t	3.35	average of (wind speed/2.2)^1.3 in m/s	3	moisture content (%)							0	% control	
Wind Erosion																		
WE - ROM Pad uncrushed ore stockpile	8	1.0	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
WE - ROM Pad crushed ore stockpile	4	0.5	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
WE - Plastefill Plant tailings stockpile	4	0.5	ha	0.0	kg/ha/h	8,760	h									50	% control	Water sprays
TOTAL EMISSIONS	**3,147**																	

Appendix D

GHG Emissions Estimate

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Fuel Consumption - Diesel

An estimate of diesel consumption was provided by Perilya Broken Hill Limited. The total diesel accounted for within the data is equal to diesel used for transport, stationary and non-combustion purposes. Diesel consumed at the Mine Site will be used in the following activities:

- Exploration;
- Extraction of ore;
- Ore handling; and
- Internal transport.

Greenhouse gas emissions from diesel consumption were estimated using the following equation:

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

Where:

E_{ij}	=	Emissions of GHG from diesel combustion	(t CO_2-e)[1]
Q_i	=	Quantity of fuel	(GJ)[2]
EC_i	=	Energy content of fuel	(GJ/kL)[3]
EF_{ijoxec}	=	Emission factor (Scope 1) for diesel combustion	(kg CO_2-e/GJ)[4]

[1] t CO_2-e = tonnes of carbon dioxide equivalent
[2] GJ = giga joules
[3] GJ/kL = gigajoules per kilolitre
[4] kg CO2-e/GJ = kilograms of carbon dioxide equivalents per gigajoule

The quantity of diesel consumed (Q) in each year has been estimated for the Proposal. The quantity of diesel consumed in gigajoules (GJ) (Q) is then 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 (DoE, 2015). The estimated annual and Proposal total GHG emissions from diesel usage are presented in **Table D-1**.

Table D-1
Estimated CO_2-e (tonnes) for Diesel Consumption

Year	Diesel Consumption (KL)	Emissions (t CO_2-e)		
		Scope 1	Scope 3	Total
2	727	1,971	101	2,072
3	800	2,169	111	2,280
4	760	2,060	106	2,166
5	792	2,147	110	2,257
6	911	2,469	127	2,595
7	923	2,500	128	2,628
8	1,383	3,749	192	3,941
9	1,092	2,959	152	3,111
10	1,092	2,959	152	3,111
11	1,092	2,959	152	3,111
12	1,091	2,957	152	3,109
13	1,089	2,950	151	3,101
14	1,086	2,943	151	3,094
15	712	1,928	99	2,027
16	648	1,756	90	1,846
Total		**38,476**	**1,973**	**40,449**

Fuel Consumption - Electricity

GHG emissions from electricity usage were estimated using the following equation:

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

where:

E_{CO2-e}	=	Emissions of GHG from electricity usage	(t CO_2-e/annum)
Q	=	Estimated electricity usage	(kWh/annum)[1]
EF	=	Emission factor (Scope 2 or Scope 3) for electricity usage	(kgCO_2-e/kWh)[2]

[1] kWh/annum = kilowatt hours per annum
[2] kgCO_2-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour

The quantity of electricity used each year was provided by Perilya Broken Hill Limited, as presented in **Table 12.2**.

The quantity of electricity used each year has been estimated for the Proposal. Greenhouse gas emission factors were sourced from the NGA Factors (DoE, 2015). The estimated annual Proposal GHG emissions from electricity usage are presented in **Table 12.2**.

Table 12.2
Estimated CO_2-e (tonnes) for Electricity Usage

Year	Residual Electricity Requirement (kWh)	Emissions (t CO_2-e)		
		Scope 2	Scope 3	Total
2	16,554,000	13,905	1,986	15,892
3	16,554,000	13,905	1,986	15,892
4	16,554,000	13,905	1,986	15,892
5	16,554,000	13,905	1,986	15,892
6	16,554,000	13,905	1,986	15,892
7	16,554,000	13,905	1,986	15,892
8	39,730,000	33,373	4,768	38,141
9	39,730,000	33,373	4,768	38,141
10	39,730,000	33,373	4,768	38,141
11	39,730,000	33,373	4,768	38,141
12	39,730,000	33,373	4,768	38,141
13	39,730,000	33,373	4,768	38,141
14	33,108,000	27,811	3,973	31,784
15	16,554,000	13,905	1,986	15,892
16	16,554,000	13,905	1,986	15,892
Total		**339,293**	**48,470**	**387,763**

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