CHAPTER 8 AIR QUALITY AND GREENHOUSE GASES

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8 AIR QUALITY AND GREENHOUSE GASES

This chapter provides an overview of the air quality and greenhouse gas assessments conducted for the construction and operation of the Project.

The air quality assessment and this chapter was completed by ENVIRON.

8.1 AIR QUALITY ASSESSMENT

8.1.1 Introduction

The air quality assessment conducted for the Rasp Project primarily focussed on emissions of total suspended particulates (TSP), particulate matter less than 10 microns and 2.5 microns in aerodynamic diameter (PM_{10} and $PM_{2.5}$ respectively), dust deposition and a range of individual metals/metalloids.

The air quality assessment was conducted in accordance with the NSW Department of Environment, Climate Change and Water (DECCW) *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DECCW Approved Methods).

8.1.2 Proposed dust management

In view of the proposed Project's proximity to sensitive receptors, combined with the potential impacts associated with the production of the lead and zinc concentrates, BHOP have committed to best practice dust controls for the duration of the Project. Such practices include:

- Extensive sealing of haul routes and primary roadways;
- Application of chemical dust suppression for all unsealed road sections, ROM stockpile area and exposed designated areas on site;
- Full enclosure of the crushing circuit (primary, secondary and tertiary crushing and associated screens). Enclosure to be kept under negative pressure and vented to a bag house.
- Enclosure of potentially dust generating conveyors and transfer points;
- Installation of real-time air quality monitoring to assist in the active management of emissions;
- Static wind breaks (orientated perpendicular to the dominant wind direction) along with top-mounted water sprays at the ROM stockpile;
- Use of water spray / chemical dust suppressant system at the tailings storage facilities; and
- Installation of wagon and vehicle wash facilities.

8.1.3 Sensitive Receptors

A number of occupied buildings used for a variety of purposes located near to the Project Area have been selected to represent sensitive receptors. These receptors are non-project related and are illustrated in *Figure 8-1*.

These comprise a selection of nearby residences and other sensitive receptors, consistent with the DECCW definition of sensitive receptors (DECCW, 2005) as:

A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area.

Receptor numbers R1 to R10 and R21 to R42 comprise individual residences or commercial offices located in the vicinity of the Project Area. Receptor numbers R11 to R20 represent schools, pre-schools and hospitals in the broader area. These localities represent places of greater community exposure potentials and are therefore of specific relevance to the Health Risk Assessment.

Figure 8-1: Representative Sensitive Receptors in the Vicinity of the Project

8.1.4 Ambient air quality criteria

To satisfy the requirements of the NSW DECCW, proposed operations must demonstrate that cumulative air pollutant concentrations, taking into account incremental concentrations due to the operation's emissions and existing background concentrations, are within ambient air quality limits. Ambient air quality criteria applicable to the Project, sourced from the NSW DECCW Approved Methods and relevant Federal guidelines, are provided in *Table 8-1* through to *Table 8.3*.

Table 8-1 NSW DECCW impact assessment criteria for the particulate matter

Pollutant	Averaging Period	Concentration (µg/m³)	Reference
TSP	Annual	90	NSW DECCW(a)(b)
PM_{10}	24 hours	50	NSW DECCW(a)
	24 hours	50(d)	NEPM(c)
	Annual	30	NSW DECCW(a)
$PM_{2.5}$	24 hours	25	NEPM(e)
	Annual	8	NEPM(e)
Lead	Annual	0.5	NSW DECCW(a)

(a) DECCW, 2005 *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*
(b) DECCW impact assessment criterion based on the subsequently rescinded National Health and Medical Research Council (NHMRC) recommended goal.
(c) NEPC, 2003, *National Environment Protection (Ambient Air Quality) Measure, as amended.*
(d) Provision made for up to five exceedances of the limit per year.
(e) Advisory reporting goal issued by the NEPC (NEPC, 2003).

Table 8-2 NSW DECCW impact assessment criteria for dust deposition

Pollutant	Maximum Increase in Dust Deposition	Maximum Total Dust Deposited Level
Deposited dust (assessed as insoluble solids)	2 g/m^2/month	4 g/m^2/month

Table 8-3 NSW DECCW impact assessment criteria for assorted metals

Pollutant	Averaging Period	Concentration (µg/m³)
Antimony and compounds	1 hour	9.0
Arsenic and compounds	1 hour	0.09
Barium (soluble compound)	1 hour	9.0
Beryllium	1 hour	0.004
Cadmium and compounds	1 hour	0.018
Chromium III and compounds	1 hour	9.0
Chromium VI and compounds	1 hour	0.09
Copper dusts and mists	1 hour	18
Manganese and compounds	1 hour	18
Mercury organic	1 hour	0.18
Mercury inorganic	1 hour	1.8
Nickel and compounds	1 hour	0.18
Zinc oxide fumes	1 hour	90

Note: The criteria shown in Table 8-3 are expressed as incremental, and at the 99.9th percentile for site-specific impact assessment purposes.

8.1.5 Background air quality environment

The local region surrounding the Rasp Project site was reviewed to identify surrounding sources that may contribute to the local air shed. Additionally, historical observations of notable dust storm activity was sourced from the Bureau of Meteorology.

On the basis of the scale and nature of the surrounding particulate-generating activities, it is considered that the regional wind-generated suspension of particulate matter, such as dust storm events, is the likely dominant influence on baseline air quality for the Broken Hill area.

Air quality monitoring data for the area was derived from a number of sources including:

- 24-hour average TSP concentrations recorded by BHOP at the Rasp Project site using a high volume air sampler between May 2007 and January 2010;
- Monthly dust deposition levels from a network of dust deposition gauges maintained by BHOP surrounding the Rasp Project site;
- Measured lead content in CBH-recorded TSP and dust deposition samples; and
- 24-hour average PM_{10} concentrations recorded using a high volume air sampler by Bemax Resources Limited between January 2010 at the Broken Hill Mineral Separation Plant, 4 km to the west-southwest of the Rasp Project site.

Statistics for the TSP, PM_{10}, dust deposition and lead monitoring results are presented within *Table 8-4* through to *Table 8-6* respectively.

Table 8-4 TSP and PM_{10} dataset statistics – January 2008 to December 2009

Statistic	BHOP recorded TSP Concentration (µg/m³)	Bemax recorded PM_{10} Concentration (µg/m³)
Mean	56.4	29.1
Standard Deviation	59.4	43.2
Median	37.1	17.3
Lower Quartile (25th Percentile)	23.6	7.9
Upper Quartile (75th Percentile)	68.3	33.2
Minimum	3.2	0.9
Maximum	415.3	281.2

Table 8-5 Dust deposition monitoring statistics – March 2007 to December 2009 (BHOP)

Statistics	Dust Deposition (g/m²/month)				
	D1	D2	D3	D4	Casuarina Ave
Mean	4.0	3.1	4.3	5.7	5.8
Standard Deviation	5.4	4.3	6.5	8.2	6.2
Median	1.8	1.4	1.3	2.5	3.3
Lower Quartile (25th Percentile)	0.8	0.5	0.8	1.2	1.5
Upper Quartile	5.3	3.0	3.3	4.9	9.0

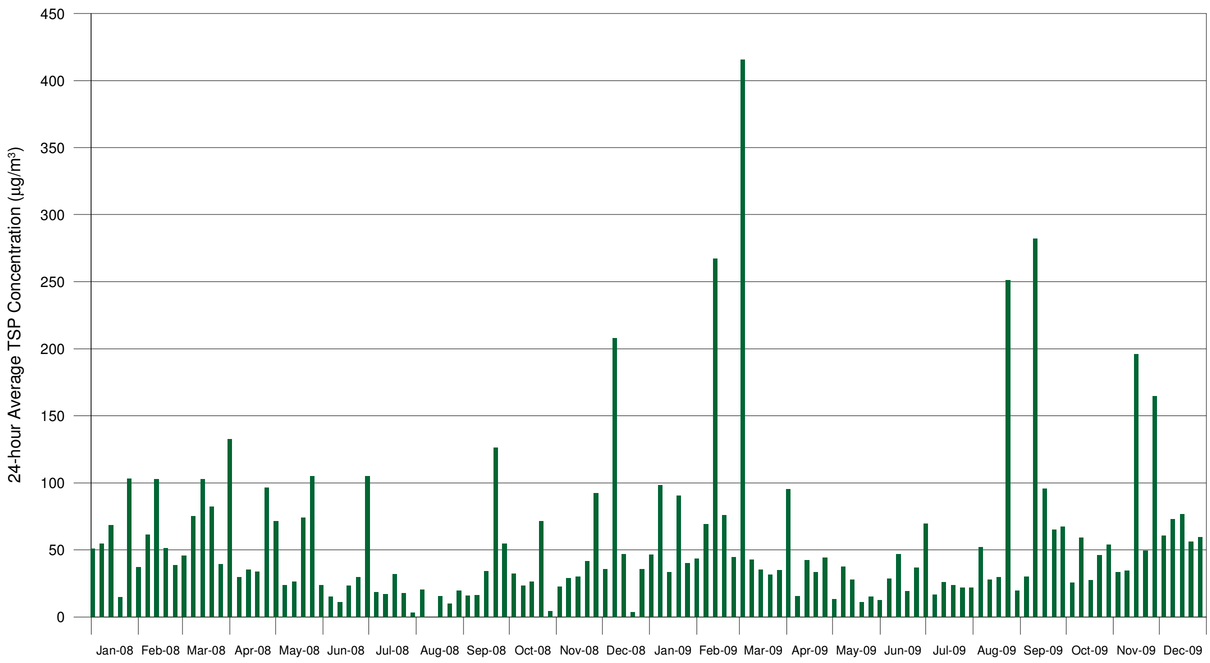
Statistics	Dust Deposition (g/m²/month)				
	D1	D2	D3	D4	Casuarina Ave
(75th Percentile)					
Minimum	0.1	0.1	0.2	0.1	0.1
Maximum	21.4	19.1	22.5	31.1	21.5

Table 8-6 Dust deposition and lead comparison – March 2007 to December 2009 (BHOP)

Location	Average Dust Deposition (g/m²/month)	Average Lead Deposition (g/m²/month)	Lead within Dust Deposition (%)
D1	4.0	0.0034	0.09
D2	3.1	0.0045	0.15
D3	4.3	0.0046	0.11
D4	5.7	0.0060	0.11
Casuarina Ave	5.8	0.0036	0.06
Average	**4.6**	**0.0044**	**0.10**

To illustrate the both the magnitude and variability of the background air quality in the region, the 24-hour average TSP concentrations recorded by the BHOP HVAS between January 2008 and December 2009 are presented in *Figure 8-2*.

Figure 8-2 24-hour average TSP concentrations recorded at BHOP HVAS during January 2008 to December 2009



Further, the 24-hour average PM_{10} concentrations recorded by the Bemax HVAS between January 2008 and December 2009 are presented within *Figure 8-3*. Statistics for the five long term BHOP dust deposition monitoring locations are shown as a box-and-whisker plot presented *Figure 8-4*.

Figure 8-3 24-hour Average PM10 concentrations recorded by Bemax during January 2008 to December 2009

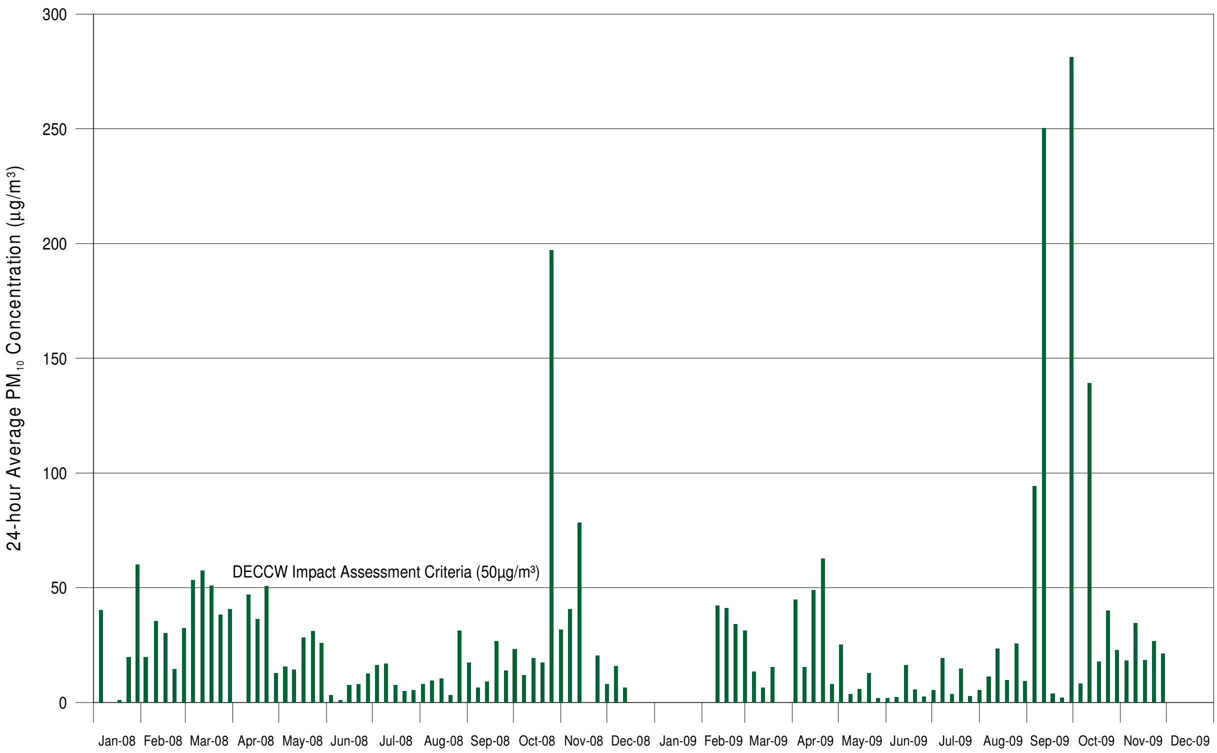
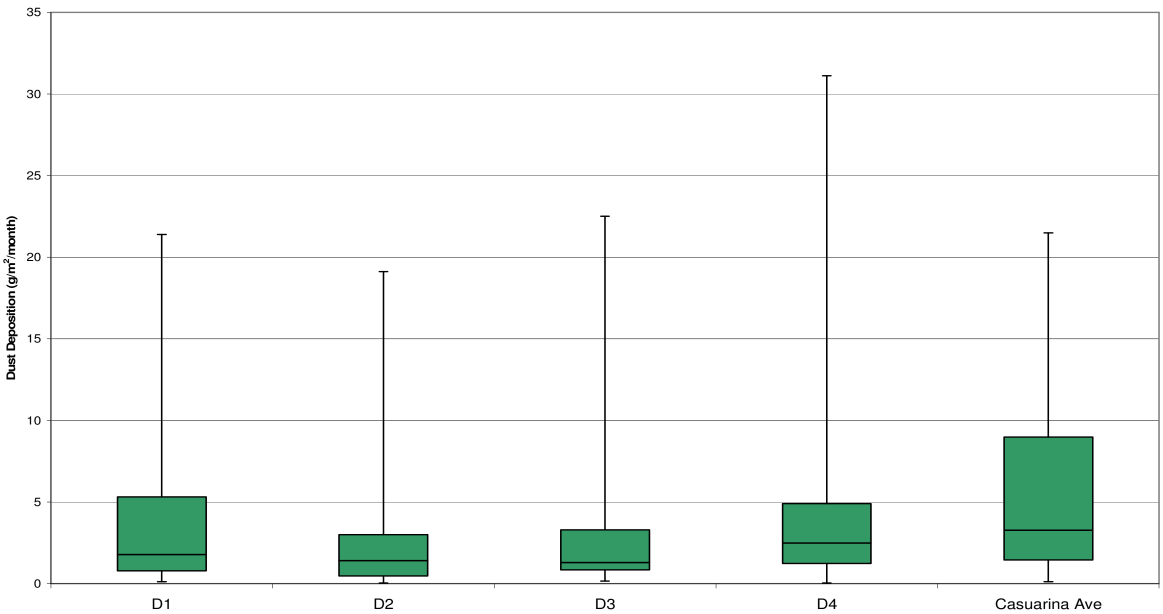


Figure 8-4 Distribution of BHOP dust deposition levels – March 2007 to December 2009



Note: Horizontal lines of boxes indicate 25th percentile, 50th percentile (Median) and 75th percentile concentrations for the dataset. Whiskers indicate the maxima and minima of the dataset.

Figure 8-2, *Figure 8-3* and *Figure 8-4* illustrate that the background air quality within the region may be regarded as elevated when compared with other locations in NSW, and exceeds the NSW

DECCW guidelines for both 24-hour PM10 and annual dust deposition without the presence of additional sources. Such exceedances are anticipated to the product of largely natural processes, associated with the arid desert climate that is frequently impacted by dust storms.

No monitoring data for ambient $PM_{2.5}$ or metals (excluding lead) were available for the Broken Hill region.

8.1.6 Emissions inventory

To conduct dispersion modelling for the key aspects of the Project, the following scenarios were developed:

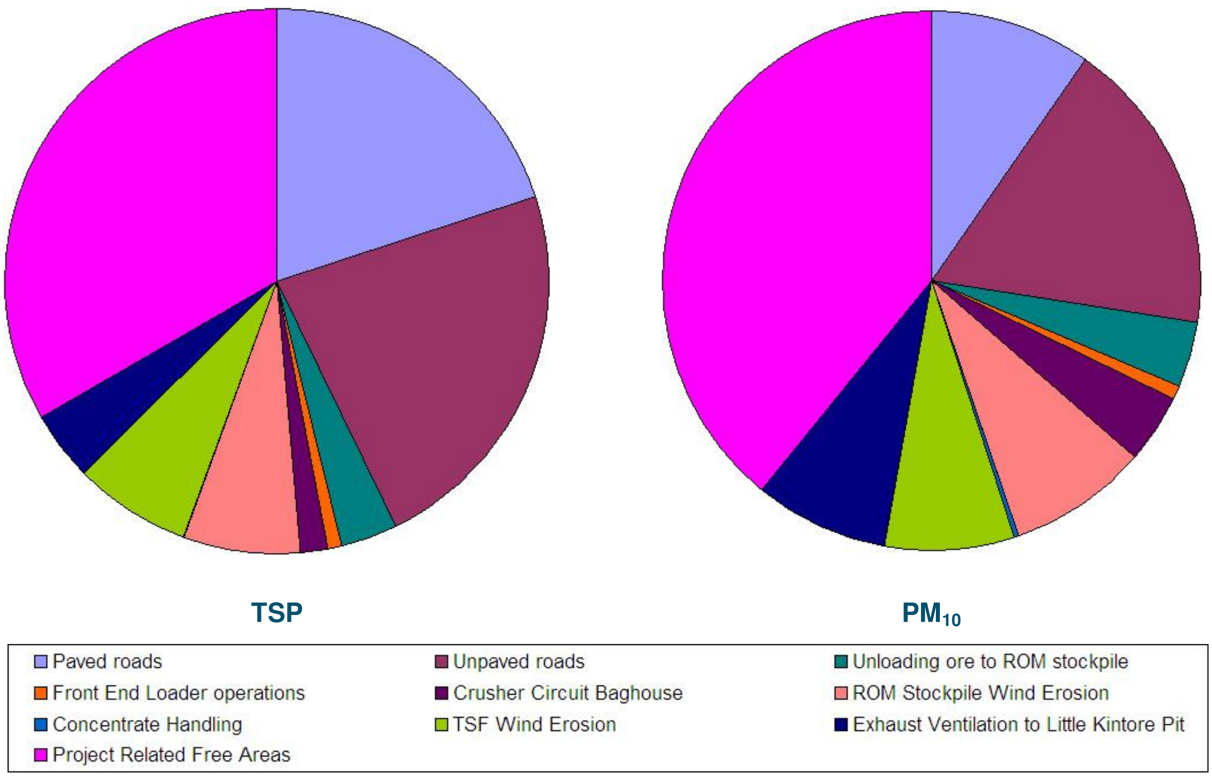
- Project Construction phase; and
- Project Operational phase under maximum production.

Additionally, to provide an estimate of baseline metal concentration/deposition, simulations were undertaken for the existing free areas (exposed areas on the site with potential for wind erosion) assuming the implementation of future controls with a control efficiency of 80%. The distribution of land use categories, including free areas, across the CML7 site is presented within *Figure 2* of the full air quality impact assessment.

Emissions from all key construction and operational sources of particulate matter were estimated based on published (principally United States Environment Protection Agency) literature. Where applicable, emission reduction factors were applied to account for the dust management techniques proposed for the site.

Emission estimates for the different potential particulate sources associated with the maximum production operation phase of the Project are graphically presented in *Figure 8-5* to illustrate source contributions to total emissions.

Figure 8-5 Summary of operation phase TSP and PM_{10} emissions by source



Wind erosion of Project-related disturbed/exposed (free) areas is estimated to contribute significantly to total TSP and PM_{10} emissions. Vehicle entrainment from paved and unpaved roads represents the next largest sources of dust emissions. The contribution of vehicle entrainment to PM_{10} emissions is lower, due to PM_{10} emissions only comprising about 20% of paved road TSP emissions and about 30% of unpaved road TSP emissions (US-EPA, 2006). The contribution of sources such as the ventilation shaft (which includes blasting emissions) and the baghouse stack is enhanced for PM_{10} due to these sources being characterised by particle size distributions with a higher proportion of finer particles.

The relatively minor contribution to predicted site emissions from the Tailings Storage Facility (TSF) is highlighted. This is a function of the proposed dust controls on this source. The operational dust prevention strategy for the TSF comprises the installation of a spray system around the perimeter of each TSF cell and the application of chemical dust suppressant after a cycle of tailings deposition ceases. The dust suppressant currently proposed is a polymer and water mixture which forms a crust over the tailings surface.

It is intended that the active tailings storage cell will be continually kept wet (tailings are to be pumped to a storage cell at 55-60% solids), and thus will result in zero emissions.

The inactive storage cell will have chemical dust suppressant applied while the surface is initially still wet due to recent tailings deposition, with gradual drying until the next deposition cycle. A highly conservative estimate of the maximum surface area of the inactive cell likely to dry out sufficiently to be prone to wind exposure (assuming no controls) is given as 25% of the surface area of the inactive storage cell (personal communication F. Gassner, Golder & Associates). Chemical dust suppression will be applied over the entire inactive storage cell surface including the wet beach and potentially drier areas.

The control efficiency of the types of dust supressant products being proposed for use is documented to be >95%. This dust control efficiency is based on third party wind tunnel testing of various tailings materials, including lead tailings, under wind speeds of 10 m/s. The dust control efficiency of a range of products that may be applied at the Project Site is discussed in detail within Annexure I(B). BHOP propose to have the site-specific control efficiency confirmed through field testing.

Finally, it is noted that *Figure 8-5* only shows additional particulate sources associated with the Project, and does not consider existing, potentially wind-erodible free areas on the mining lease. The contribution of these existing, uncontrolled free areas is anticipated to represent three times the emission associated with the Project.

This is illustrated in *Figure 8-6* which shows contours of predicted 24-hour PM_{10} concentrations from the existing free areas alone, excluding any control (i.e., the status quo).

By way of comparison, *Figure 8-7* shows contours of predicted 24-hour PM_{10} concentrations from the existing free areas, including BHOP's commitment to control these existing areas through the application of chemical dust suppressants.

Figure 8-7 indicates that that there are tangible air quality benefits associated with the application of dust suppressants on, and ongoing management of existing free areas at the site.

It is anticipated that such an activity will go some way towards offsetting additional air quality impacts associated with the Project.

Regarding the justification for the use of an 80% control efficiency for the use of chemical dust suppressants on roads and free areas, according to the US-EPA (2006), the control effectiveness of chemical dust suppressants depends on: (a) the dilution rate used in the mixture; (b) the application rate (volume of solution per unit road surface area); (c) the time between applications; (d) the size, speed and amount of traffic during the period between applications; and (e) meteorological conditions (rainfall) during the period. Other factors that affect the performance of dust suppressants include other traffic characteristics (e.g. track-on from unpaved areas) and road characteristics.

Due to the above factors, and given the difference between individual dust control products, the actual control efficiencies of chemical dust suppressants is difficult to estimate. According to the US-EPA (2006) past field testing of emissions from controlled unpaved roads has shown that chemical dust suppressants provide a PM_{10} control efficiency of about 80% when applied at regular intervals of 2 weeks to 1 month.

A full description of the emission inventory is provided within the air quality assessment report.

Figure 8-6   Existing uncontrolled free areas – predicted maximum 24 hour average PM_{10} concentrations (µg/m^3)

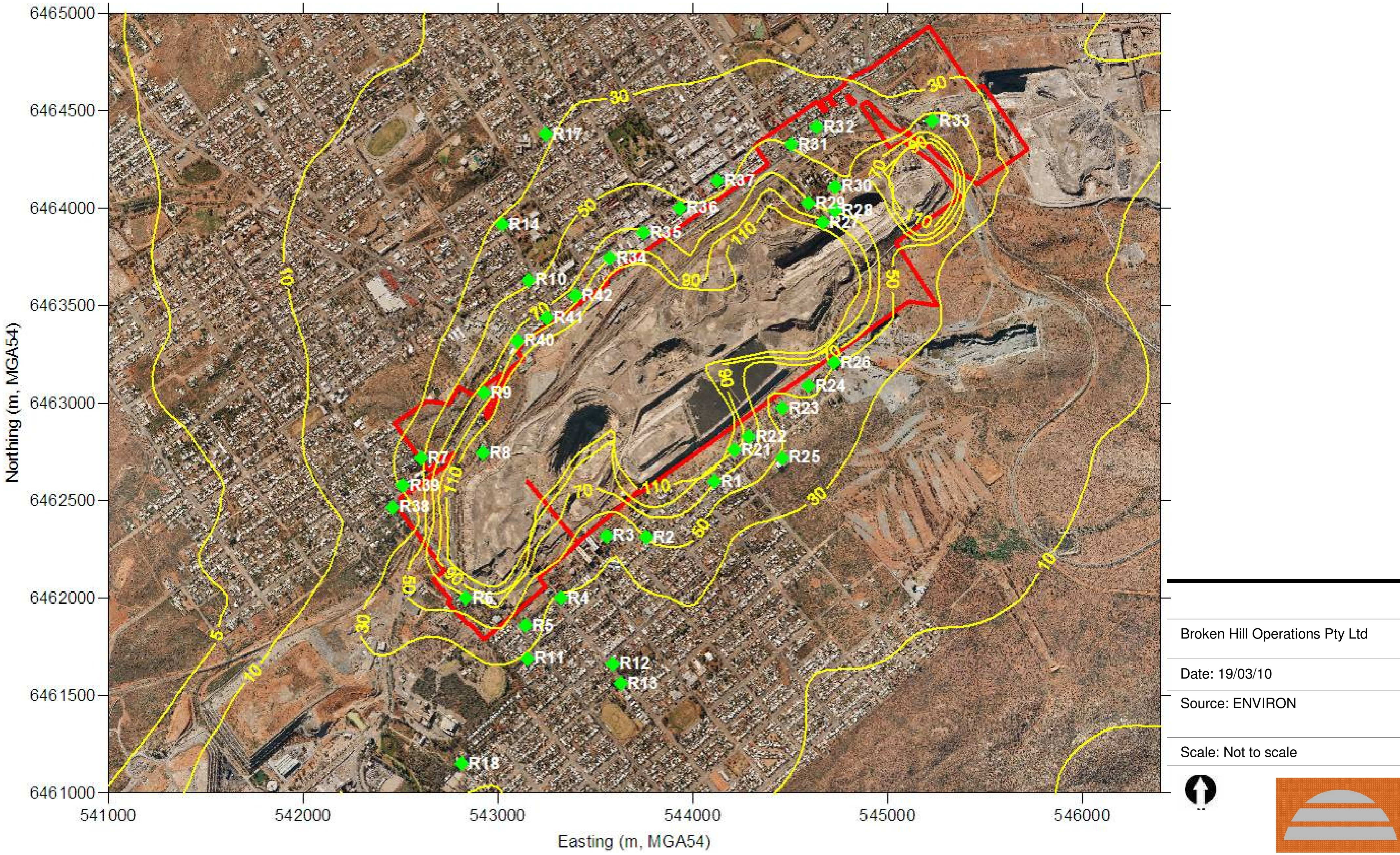
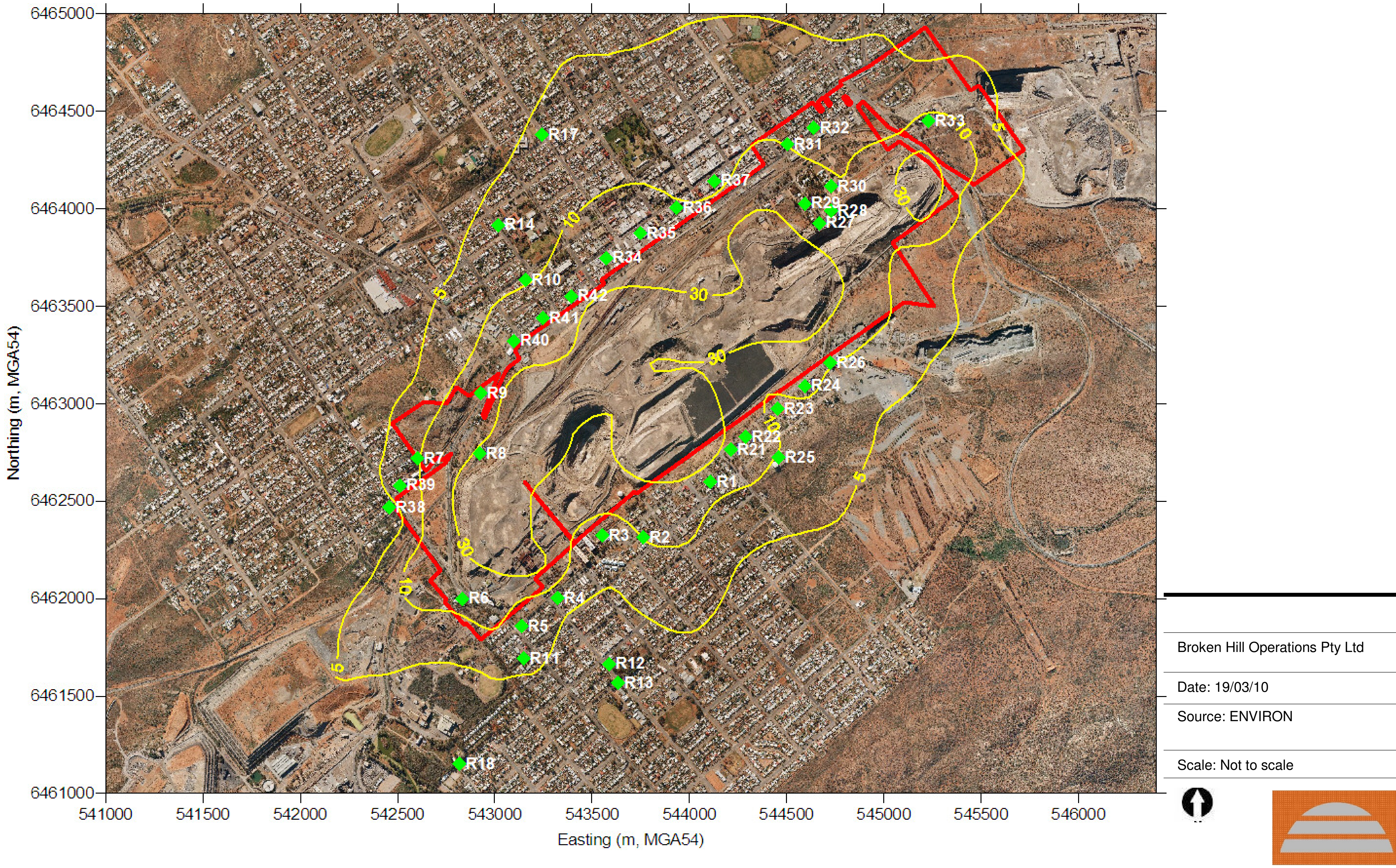


Figure 8-7 Existing free areas 80% controlled – maximum predicted 24 hour average PM_{10} concentrations ($\mu g/m^3$)



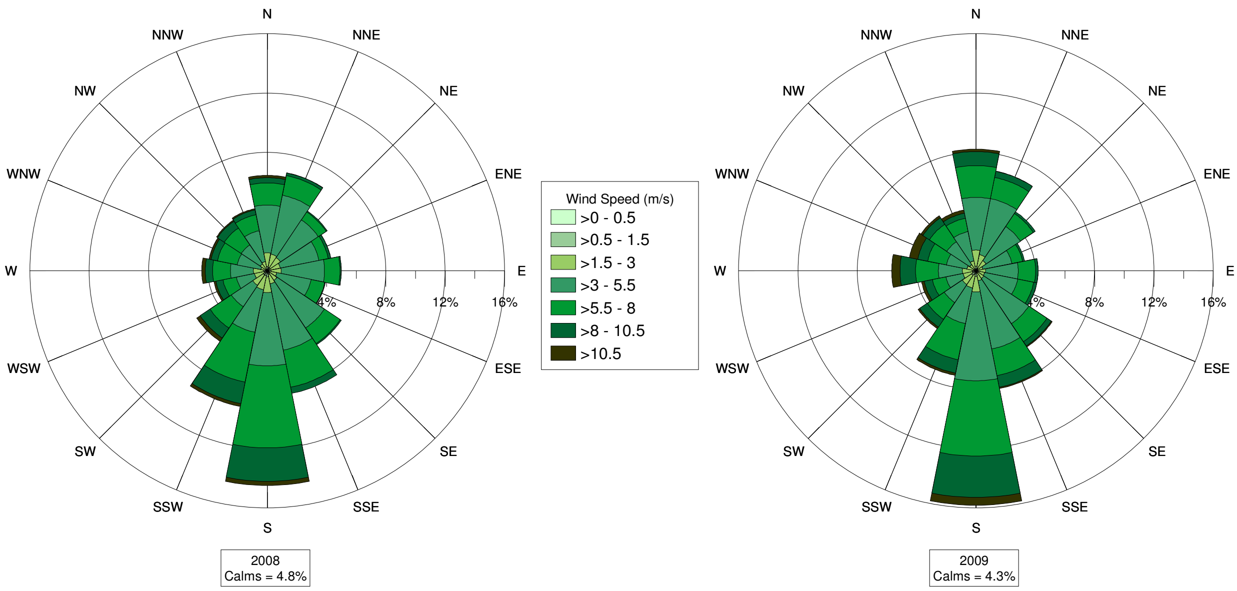
8.1.7 Dispersion modelling

Dispersion simulations were undertaken and results analysed for TSP, PM_{10}, $PM_{2.5}$ and a range of heavy metal concentrations and dust deposition.

Simulations were also undertaken for gaseous emissions associated with the planned ventilation shaft to be situated within the Little Kintore Pit during the operation phase.

Dispersion modelling of particulate emissions from the Rasp Project was conducted utilising the United States Environment Protection Agency regulatory model AERMOD for two complete calendar years, 2008 and 2009. Local meteorological conditions recorded at the nearby Bureau of Meteorology Broken Hill Airport automatic weather station were integrated into the dispersion modelling process. Annual wind roses for the Broken Hill automatic weather station are presented in *Figure 8-8*. To assess the performance of the Rasp Project, dispersion modelling predictions for a range of local sensitive receptor locations were compared with relevant NSW DECCW assessment criteria.

Figure 8-8 Comparison of annual wind roses for Broken Hill airport AWS – 2008 and 2009



8.1.8 Predicted results for 24-hour average PM_{10} concentrations

Predicted incremental concentrations of 24-hour PM_{10} are below the applicable NSW DECCW assessment criteria for both construction and operational phases of the Rasp Project for 24-hour and annual average concentrations.

Incremental highest 24-hour average PM_{10} concentrations predicted to occur at the top ten most impacted nearby receptor locations due to operations at maximum production levels for the modelled years 2008 and 2009 are summarised in *Table 8-7*.

Table 8-7 Predicted top ten highest incremental 24-Hour average PM_{10} concentrations (µg/m³) at representative sensitive receptors due to maximum production activities

ID	Receptors	Maximum for Model Years 2008 and 2009	
		Project-Related Increment	Conc. as % of DECCW Criterion
R8	Old South Road	10.5	21%
R6	South Road	6.5	13%

ID	Receptors	Maximum for Model Years 2008 and 2009	
		Project-Related Increment	Conc. as % of DECCW Criterion
R3	Eyre Street North	5.9	12%
R5	Eyre Street South	4.3	9%
R4	Eyre Street Central	4.2	8%
R2	Piper Street Central	3.6	7%
R22	Eyre Street North	3.6	7%
R9	South Rd	3.4	7%
R7	Carbon Lane	3.1	6%
R10	Cnr Garnet & Blende Streets	1.8	4%

Figure 8-9 presents the maximum predicted incremental 24-hour average concentration contours for the operation of the Project under maximum production.

Application of the recorded PM_{10} concentrations for the Broken Hill area indicated that the cumulative impact of the Rasp Project (combining existing ambient concentrations with projected incremental impacts) could result in the exceedance of the DECCW criterion of 50 $\mu g/m^3$ for 24-hour average PM_{10}. However, review of the ambient PM_{10} monitoring data (as shown in *Figure 8-3*) suggests that existing ambient concentrations of PM_{10} are expected to already be in exceedance of the DECCW criterion approximately 10% (35 days) per year, without the inclusion of the Rasp Project.

Analysis of the concurrent AERMOD-predicted and measured 24-hour average PM_{10} concentrations throughout 2008 and 2009 indicated that, in addition to the existing exceedances within the PM_{10} dataset, the DECCW criterion would be exceeded an additional one and two occasions at the two closest sensitive receptors over each of the 2008 and 2009 modelled years.

To provide additional clarity as to the likelihood of exceedances of the 24-hour PM_{10} criterion following the addition of Project-related air quality impacts, the frequency of occurrence of predicted concentrations may be examined.

Figure 8-9 Maximum predicted incremental 24-hour average PM_{10} concentrations – Project only

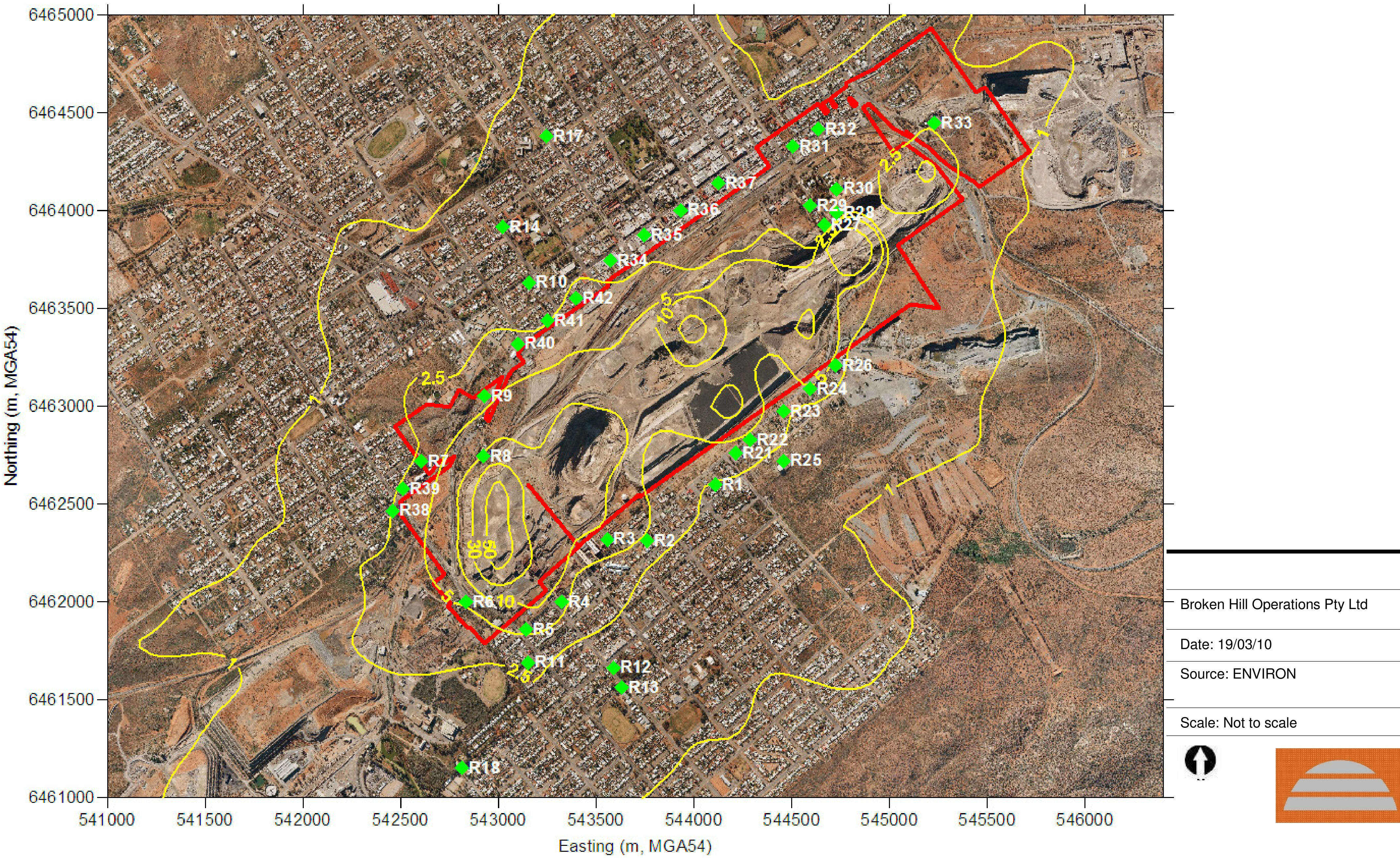


Figure 8-10 shows the frequency of occurrence of predicted 24-hour concentrations at two of the most impacted receptors (referred to as receptor R3 and R8) over the two model years 2008 and 2009.

Figure 8-10 Frequency distribution of predicted Project-related 24-hour PM_{10} concentrations over two years modelled

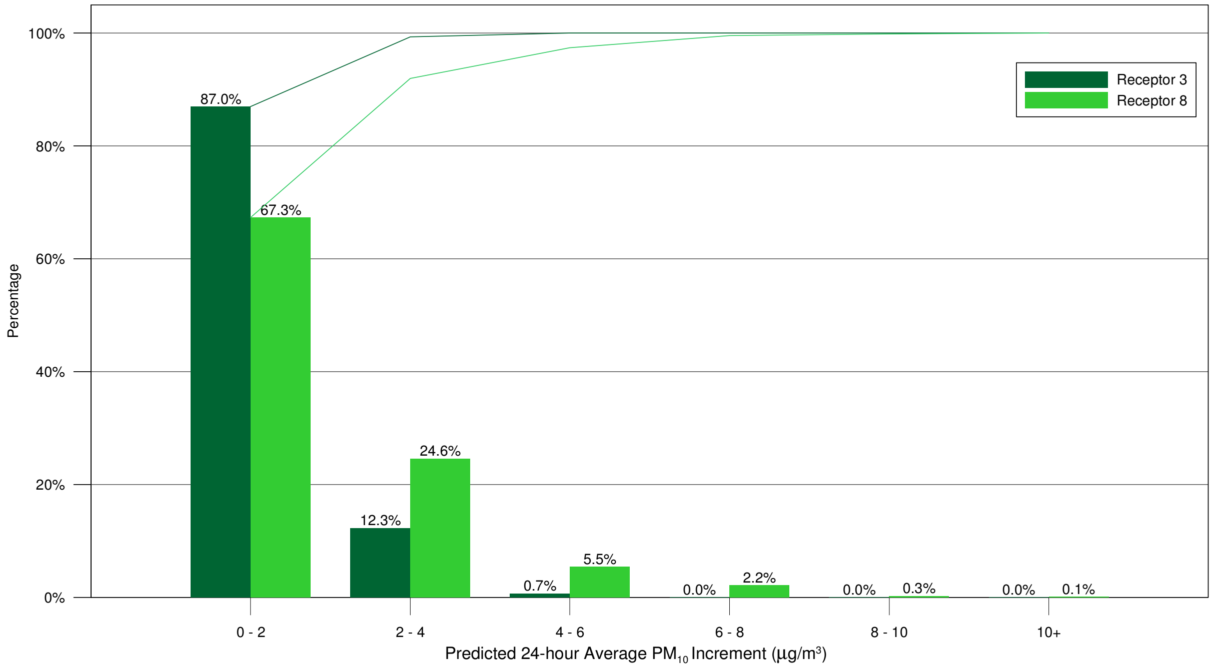


Figure 8-10 indicates that greater than 99% of predictions at Receptor R3 are anticipated to be less than 4µg/m^3 (expressed as a 24-hour average). Greater than 99% of predictions at Receptor R8 are anticipated to be less than 8µg/m^3 (expressed as a 24-hour average).

Given the low frequency of occurrence of predicted 24-hour average concentrations in excess of 8µg/m^3 at either Receptor R3 or R8 (3 occasions), the likelihood that increments attributable to the Project will cause any additional exceedance of the Project air quality criterion of 50µg/m^3 is low. This is even when considering that approximately 10% of occasions of background concentrations are anticipated to exceed 40 µg/m^3.

8.1.9 Predicted results for annual average PM_{10}

Annual average PM_{10} concentrations simulated to occur at nearby receptor locations due to operations at maximum production levels are summarised in *Table 8-8*, expressed as maximum predictions over the model years 2008 and 2009, for the top ten impacted receptors.

Table 8-8 Predicted top ten highest annual average PM_{10} concentrations due to maximum production activities at representative sensitive receptors – maximum for modelled years 2008 and 2009

ID	Receptors	PM_{10} Concentrations (µg/m³)			
		Measured Background Conc. [1]	Project-Related Increment	Cumulative. (Background + Increment)	Cumulative as % of DECCW Criterion
R8	Old South Road	27.7	1.7	29.4	98%
R3	Eyre Street North	27.7	0.9	28.6	95%
R4	Eyre Street Central	27.7	0.8	28.5	95%
R6	South Road	27.7	0.8	28.5	95%

ID	Receptors	PM$_{10}$ Concentrations (µg/m³)			
		Measured Background Conc. [1]	Project-Related Increment	Cumulative. (Background + Increment)	Cumulative as % of DECCW Criterion
R9	South Rd	27.7	0.7	28.4	95%
R5	Eyre Street South	27.7	0.6	28.3	94%
R40	Silver City Hwy	27.7	0.6	28.3	94%
R2	Piper Street Central	27.7	0.5	28.2	94%
R22	Eyre Street North	27.7	0.5	28.2	94%
R41	Silver City Hwy	27.7	0.5	28.2	94%

Annual average PM$_{10}$ concentrations are predicted to be below the DECCW air quality criterion of 30µg/m³. Taking background particulate concentrations into account, the maximum (cumulative) concentration predicted over the two years of modelling is anticipated to be between 93% and 98% of the DECCW criterion across all sensitive receptors.

It is noted that the maximum predicted Project-related increment in annual PM$_{10}$ concentrations across all receptors and modelled years is 1.7 µg/m³, or 6% the DECCW criterion. The background annual average PM$_{10}$ concentration within the region represents 92% of the DECCW criterion in isolation.

8.1.10 Predicted results for total suspended particulate

Annual average TSP concentrations predicted to occur at representative receptor locations due to operations at maximum production levels are summarised in *Table 8-9*, expressed as maximum concentrations over the model years 2008 and 2009, for the top ten impacted receptors.

Table 8-9 Predicted top ten highest annual average TSP concentrations due to maximum production activities – maximum for modelled years 2008 and 2009

ID	Receptors	TSP Concentrations (µg/m³)			
		Measured Background Conc. [1]	Project-Related Increment	Cumulative. (Background + Increment)	Cumulative as % of DECCW Criterion
R8	Old South Road	64.9	3	68	76%
R3	Eyre Street North	64.9	1.8	66.8	74%
R6	South Road	64.9	1.5	66.4	74%
R4	Eyre Street Central	64.9	1.4	66.3	74%
R9	South Rd	64.9	1.3	66.3	74%
R40	Silver City Hwy	64.9	1.1	66.1	73%
R41	Silver City Hwy	64.9	1.2	66.1	73%
R5	Eyre Street South	64.9	1.1	66	73%
R42	Silver City Hwy	64.9	1	66	73%
R2	Piper Street Central	64.9	1	65.9	73%

Annual average concentrations of TSP are predicted to be below the DECCW air quality criterion of 90 µg/m³. Taking background particulate concentrations into account, the maximum (cumulative) concentration predicted over the two years of modelling is anticipated to be 76% of the DECCW criterion across all sensitive receptors.

Table 8-9 indicates that the maximum predicted percentage of the DECCW criterion varies from 55% to 76% across receptors between the 2008 and 2009 modelled year. This reflects both the elevated background air quality within the region, and the variability in background concentration associated with the frequency of dust storms impacting the region.

8.1.11 Predicted results for 24-hour and annual average $PM_{2.5}$

Incremental highest daily and annual average $PM_{2.5}$ concentrations simulated to occur at nearby receptor locations due to maximum production activities are summarised in ***Table 8-10***, for the top ten impacted receptors.

Table 8-10 Predicted top ten highest incremental $PM_{2.5}$ concentrations due to maximum production activities at representative sensitive receptors – maximum for modelled years 2008 and 2009

ID	Receptors	$PM_{2.5}$ Concentrations (µg/m³)			
		Highest Daily Average (µg/m³)	**Annual Average (µg/m³)**	**Highest daily Increment as % of NEPM**	**Annual Ave. Increment as % of NEPM**
R8	Old South Road	3.48	0.46	14%	6%
R6	South Road	1.75	0.21	7%	3%
R3	Eyre Street North	1.64	0.25	7%	3%
R4	Eyre Street Central	1.35	0.22	5%	3%
R2	Piper Street Central	1.32	0.14	5%	2%
R15	Broken Hill Hospital	1.22	0.03	5%	0%
R21	Eyre Street North	1.18	0.13	5%	2%
R22	Eyre Street North	1.15	0.13	5%	2%
R9	South Rd	1.09	0.19	4%	2%
R5	Eyre Street South	1.09	0.17	4%	2%

The incremental maximum daily average $PM_{2.5}$ concentrations at the representative sensitive receptor sites due to maximum production emissions are predicted to peak at 14% of the 24-hour air quality criterion of 25 µg/m³. Taking into account the $PM_{2.5}/PM_{10}$ ratios characteristic of rural environments, and the proportion of fines in Project-related emissions it is anticipated that the PM_{10} air quality criterion will be sufficiently protective of incremental $PM_{2.5}$ exposure potentials.

Similarly, annual average concentrations of $PM_{2.5}$ are predicted to peak at 6% of the air quality criterion of 8 µg/m³ and as such are not anticipated to cause an exceedance of the DECCW criterion in the event that the PM_{10} criterion is complied with.

8.1.12 Predicted results for dust deposition levels

Annual average dust deposition rates simulated to occur at representative receptor locations due to the Project are summarised in *Table 8-11*, expressed as the average monthly dust deposition rate (maximum across two model years) deposition rate over the model years 2008 and 2009, at the top ten most impacted nearby receptor locations.

Table 8-11 Predicted top ten highest incremental annual average monthly dust deposition due to maximum production activities – maximum for modelled years 2008 and 2009

ID	Receptors	Dust Deposition ($g/m^2/month$)	
		% of DECCW Incremental Criterion	% of DECCW Incremental Criterion
R8	Old South Road	0.94	47%
R3	Eyre Street North	0.55	28%
R9	South Rd	0.37	19%
R4	Eyre Street Central	0.3	15%
R22	Eyre Street North	0.3	15%
R40	Silver City Hwy	0.3	15%
R2	Piper Street Central	0.29	15%
R21	Eyre Street North	0.28	14%
R41	Silver City Hwy	0.28	14%
R6	South Road	0.25	13%

A maximum incremental annual average dust deposition rate of 0.9 $g/m^2/month$ was predicted to occur across the receptor locations due to maximum production activities. This rate is within the NSW DECCW incremental dust deposition limit of 2 $g/m^2/month$.

As noted in Section 8.1.4, background period-average (2008-2009) dust deposition is estimated to be in the order of 3.3 to 7.2 $g/m^2/month$. Thus cumulative annual average dust deposition rates are expected to exceed the NSW DECCW cumulative dust deposition limit of 4 $g/m^2/month$.

It is queried however whether the cumulative dust deposition criterion should be applied in the region of Broken Hill. Broken Hill is in an arid desert climate, impacted by frequent dust storm events. As such, dust deposition levels due to natural processes are elevated compared to other regions, and are likely to approach or exceed the DECCW cumulative dust deposition limit without the impact of anthropogenic sources.

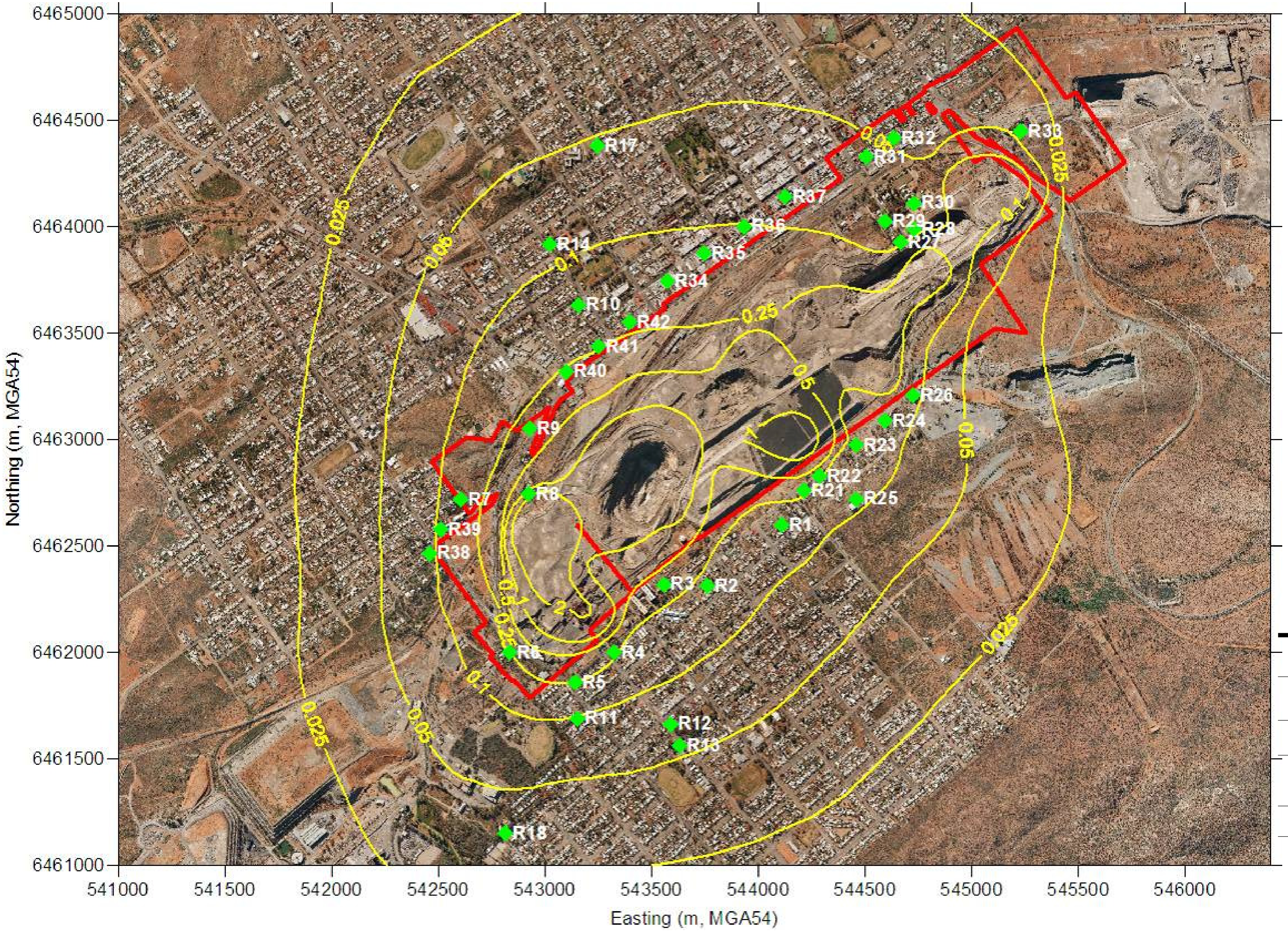
Figure 8-11 presents spatial variations in the predicted incremental dust deposition rates for the operation of the Project under maximum production.

8.1.13 Predicted results for heavy metal concentrations

Predicted concentrations of assorted metals were predicted to satisfy the relevant NSW DECCW assessment criteria at all surrounding sensitive receptors for both construction and operational phases of the Rasp Project.

A synopsis of maximum Project-related incremental 99.9th percentile hourly and annual average heavy metal concentrations predicted to maximum production activities across all discrete receptor locations is given in *Table 8-12*, with reference made to relevant DECCW impact assessment criteria. Such criteria are reported at the predicted 99.9th percentile (or 9th highest 1-hourly average) concentration, consistent with Section 7.2.2 of the DECCW Approved Methods.

Figure 8-11 Operation (Project increment) –predicted dust deposition (g/m2/month) criterion = 2g/m2/month (incremental)



Broken Hill Operations Pty Ltd

Date: 19/03/10

Source: ENVIRON

Scale: Not to scale

Table 8-12 Predicted incremental 99.9th percentile hourly heavy metal concentrations predicted due to maximum production activities

Substance	Predicted 99.9th Percentile Concentrations (µg/m³) across Sensitive Receptors	DECCW Hourly Impact Assessment[1] Criteria (µg/m³)	Incremental concentration of NEPM Criterion
Antimony	3.6×10^{-3}	9	0.04%
Arsenic	2.1×10^{-2}	0.09	23.33%
Barium	1.1×10^{-4}	9	0.00%
Beryllium	2.8×10^{-6}	0.004	0.07%
Cadmium	8.6×10^{-3}	0.018	47.79%
Chromium	8.6×10^{-4}	9	0.01%
Copper	3.8×10^{-2}	18	0.21%
Iron	2.5	90	2.74%
Manganese	6.2×10^{-2}	18	0.35%
Mercury	9.9×10^{-5}	0.18	0.05%
Nickel	6.1×10^{-4}	0.18	0.34%
Silver	2.0×10^{-3}	0.18	1.09%
Zinc	2.4	90	2.72%

Note 1: Specified for evaluation of incremental concentrations due to proposed projects

No exceedances of the relevant DECCW impact assessment criteria for the above toxic air pollutants were predicted to occur.

DECCW specify an annual air quality criterion for lead that is specific for cumulative concentrations. Performance against this criterion is evaluated in *Table 8-13,* for the top ten most impacted receptors.

Table 8-13 Predicted annual average lead (Pb) concentrations due to maximum production activities at representative sensitive receptors – maximum for modelled years 2008 and 2009

Receptors		Pb Concentrations (µg/m³)			
		"Future Baseline" (Existing Free Areas, 80% Control Efficiency)	Project-Related Increment	Cumulative Pb (Baseline + Project Increment)	Cumulative Pb. as % of DECCW Criterion
R8	Old South Road	0.119	0.109	0.228	46%
R9	South Rd	0.046	0.04	0.086	17%
R3	Eyre Street North	0.028	0.049	0.076	15%
R40	Silver City Hwy	0.044	0.029	0.074	15%
R41	Silver City Hwy	0.045	0.028	0.073	15%
R27	Proprietary Square	0.056	0.015	0.071	14%
R42	Silver City Hwy	0.048	0.024	0.071	14%
R21	Eyre Street North	0.05	0.015	0.064	13%
R6	South Road	0.023	0.041	0.063	13%
R34	Crystal Street	0.044	0.018	0.063	13%

Baseline lead concentrations have been estimated based on modelled contributions from lead-bearing existing free areas across the mine lease. Given BHOP's commitment to stabilise existing free areas using chemical dust suppressants the "future baseline" lead concentration (assuming 80% control efficiency for existing free areas) is shown as a reflection of background lead concentrations during the operation phase.

In all cases, the DECCW cumulative (baseline plus project increment) lead criterion of 0.5 µg/m³ is predicted to be satisfied at all receptors.

8.1.14 Mitigation and air quality monitoring

Mitigation of emissions from the Project has already largely been addressed by the commitments made by BHOP to implement best practice dust management techniques. It is noted that the control of wind erosion from existing free areas at the Rasp Project site through the addition of chemical dust suppressants should be viewed as a significant improvement to the surrounding air shed compared to the status quo.

A number of key recommendations in respect to air quality monitoring have been made within the air quality assessment, including the following:

- Establishment of real-time air quality monitoring for PM_{10} at key surrounding receptors;
- Additional dust deposition monitoring locations established away from the Rasp Project to provide a more robust indication of typical background levels for Broken Hill.
- Continuation of the sampling of lead in TSP and dust deposition monitoring samples, along with the analysis of additional metals covered in this study; and
- The review and amendment of the current Air Quality Management Plan.

Furthermore, significant contingency and redundancy has been built into the design of the TSF to ensure that adequate dust mitigation is available both during normal operations and under 'upset' conditions.

The proposed operation of the TSF will include:

- Tailings will be delivered to the active TSF cell as a slurry of 55-60% solids by volume at a rate of ~137 000 litres per day;
- After tailings has stopped being applied to the active cell, it will take ~1 to 2 weeks for the surface to go from 'wet' to 'spade-able';
- The binding dust supressant will be applied to the TSF sometime between when the surface is wet until it dries out enough to become spadeable;
- The dust supressant will be applied via sprinkler systems that have overlapping arcs.
- The dust supressant will not be applied during high wind due to the potential for uneven distribution;
- Sufficient moisture will be retained in the tailings prior to the dust supressant being applied, such that during high wind conditions, emissions can be adequately controlled prior to the dust supressant being applied;
- It is conservatively estimated that there will be a period of 1 week between when the material becomes spadeable and when further drying presents a high risk of wind blown dust emissions.

On this basis there will be time allowance to ensure that the dust supressant is applied under favourable meteorological conditions;

- Extra water can be supplied from the decant dam by the sprinklers surrounding the TSF cells at a maximum expected rate of 4,500 litres/minute (subject to the detailed design process);
- The tailings slurry can be directed to the inactive cell as a backup emission control, and it is estimated it would take approximately a 6 hour to flood the inactive cell. The time taken to cover the tailings surface with fresh tailings is an estimate based on the design tailings deposition rate. The areas most likely to dry first are the same areas that would be covered the quickest as these areas are near the spigot outlets;
- Tailings will only be directed to one cell at a time;
- The spigots that deliver the tailing slurry to the TSF cells have not currently been designed to enable the delivery of water from the decant dam to the inactive cell when tailings are being directed to the active cell. The technical feasibility of this additional control option is being investigated.
- Sprinklers can apply water to the surface of the inactive cell by switching on the pump without adding the dust supressant. This will not interfere with the tailings deposition on the active cell.

A summary of potential upset conditions, a qualitative assessment of their likelihood, and details of the contingency measures in place with regard to dust control are provided in *Table 8-14*.

Table 8-14 Dust Mitigation Contingencies Under Potential 'Upset' Conditions at the TSF

Scenario	Effect	Likelihood	Level 1 Control	Level 2 Control	Alternative Control
Sprinkler pump blows at active cell	Anticipated to take between 7 days and two weeks for the material within active cell to dry out to a condition where it is spadeable. .	Possible	Replacement pumps kept on site as essential spares – estimated 2 hour period to replace.	Wet tailings may be applied through spigot closest to the inactive sprinkler. Spigots may be selected individually to target the area with potential to dry out.	Spigots designed to enable the delivery of water from the decant dam to inactive cell (subject to technical feasibility investigation).
Weather conditions (high winds) cause delay in application of chemical dust suppressant to inactive cell	Minimum one week window within which chemical dust suppressant may be applied once cell becomes inactive.	Possible	Application of water with sprinklers.	Whole cell may be covered with tailings layer using spigots within 6 hours	Spigots designed to enable the delivery of water from the decant dam to inactive cell (subject to technical feasibility investigation).
All sprinklers are rendered inactive as sprinkler water supply is cut by a site upset.	Minimum one week window before material dries out to a condition where it is spadeable.	Unlikely	Whole cell may be covered with a layer of tailings using spigots within 6 hours.	Spigots designed to enable the delivery of water from the decant dam to the inactive cell when tailings are being directed to the active cell. (subject to technical feasibility investigation).	

Inactive cell seen to be raising visible dust	Dust raising detected by visual inspection or via feedback from real-time PM_{10} monitoring equipment fitted with telemetry.	Possible	Sprinkler spray arcs overlap. Whole cell may be covered with additional chemical dust suppressant within 10 minutes	Water may be applied through sprinklers. Sprinklers to be used for water application may be selected individually to target the area raising dust.	Whole cell may be covered with tailings layer using spigots within 6 hours
Production upset leads to cessation of tailings deposition. Active cell seen to be raising visible dust	Dust raising detected by visual inspection or via feedback from real-time PM_{10} monitoring fitted with telemetry.	Unlikely	Sprinkler spray arcs overlap. Whole cell may be covered with additional water within 10 minutes	Whole cell may be covered with chemical dust suppressant using sprinklers	Spigots designed to enable the delivery of water from the decant dam to inactive cell (subject to technical feasibility investigation).

Note: As an alternative control measure, manual water spraying using vehicle or mobile equipment may be applied in any of the above scenarios.

8.2 GREENHOUSE GAS ASSESSMENT

8.2.1 Introduction

Emissions of greenhouse gases (GHG), that may affect climate change, will result from activities associated with the Project that consume energy. The two international frameworks addressing the issue of climate change and the generation of GHG are the United Nations Framework Convention for Climate Change (UNFCCC) and the Kyoto Protocol. These frameworks guide the reporting of greenhouse gas emissions internationally, and form the basis of the approach to estimating GHG emissions. The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) is the legislative instrument guiding GHG reporting in Australia.

8.2.2 National greenhouse and energy reporting

The NGER Act commenced operation in July 2008 and is supported by the *National Greenhouse and Energy Reporting Regulations 2008,* and the *National Greenhouse and Energy Reporting (Measurement) Determination 2009* which provides methods and criteria for calculating greenhouse gas emissions and energy data under the Act.

Together NGER Act, regulations and Measurement Determination establish a framework which provides for the ‘reporting and dissemination of information related to greenhouse gas (GHG) emissions, GHG projects, energy production and energy consumption’.

The objectives of the NGER Act are to:

- underpin the introduction of an emissions trading scheme;
- inform government policy formulation and the Australian public;
- help meet Australia’s international reporting obligations;
- assist Commonwealth, state and territory government programs and activities; and
- avoid the duplication of similar reporting requirements in the states and territories

8.2.3 Carbon pollution reduction scheme

The Carbon Pollution Reduction Scheme (CPRS) provides a framework for carbon emission trading in Australia Facilities with Scope 1 emissions above 25ktCO_2-e are required to participate in the Scheme.

The CPRS legislation was introduced into the Australian parliament in February 2010, and as of mid-March 2010 the legislation has yet to be passed.

8.2.4 Reporting thresholds and greenhouse gases

The NGER Act and regulations provide reporting thresholds and define the greenhouse gases for reporting. For a facility, such as the Rasp Mine, the threshold for reporting is 25 kilotonnes carbon dioxide equivalent, or using/producing more than 100 TJ of energy. Reporting is mandatory and the Rasp Mine will exceed these thresholds when in operation and will be required to report under this legislation, refer *Table 8.8 below*

The Rasp Mine is not anticipated to trigger participation in the CPRS as the Scope 1 emissions do not exceed the threshold of 25ktCO_2-e.

The GHGs which form the basis for reporting are listed as:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)

8.2.5 Direct and indirect emissions

Emissions of GHG can be categorised as direct and indirect emissions.

The *AGO Factors and Methods Workbook* adopts the emissions categories of the international reporting framework of *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* (WRI/WBCSD). These emission categories are as follows:

- *Scope 1* covers direct emissions from sources within the boundary of an organisation such as fuel combustion and manufacturing processes.

  Project related Scope 1 sources include direct emissions resulting from the combustion of diesel in equipment used on-site, such as front end loaders and haul trucks

- *Scope 2* covers indirect emissions from the consumption of purchased electricity, steam or heat produced by another organisation. Scope 2 emissions result from the combustion of fuel to generate the electricity, steam or heat and do not include emissions associated with the production of fuel.

  Project related Scope 2 sources will result from electricity consumption from the mining operations, processing facility and associated infrastructure and buildings (e.g. administration offices);

- *Scope 3* includes all other indirect emissions that are a consequence of an organisation's activities but are not from sources owned, or controlled, by the organisation.

  Project related Scope 3 sources will result from transportation of the ore and indirect emissions associated with the extraction of fuels to supply diesel and electricity. This assessment will not consider other Scope 3 indirect emissions associated with the development.

Consistent with the methodologies described, Scope 3 emissions not included within the GHG calculations for this assessment are:

- disposal of waste generated at the mine;
- further processing and disposal (end life) of products sold;
- employee business travel;
- employees commuting to and from work;
- extraction, production and transport of other purchased materials and goods;
- out-sourced activities; and
- sea transport of product.

8.2.6 Estimating emissions

Emission factors for calculating emissions of greenhouse gases are generally expressed in the form of a quantity of a given greenhouse gas emitted per unit of energy, kt CO_2-e /GJ. Emission factors are used to calculate greenhouse gas emissions by multiplying the factor (e.g. kg CO_2-e energy in petrol) with activity data (e.g. kilolitres x energy density of petrol used).

Table 8-15 details the greenhouse gas emission sources included in this assessment. *Table 8-16* summarises Scope 1, 2 and 3 predicted GHG emissions. As shown, electricity consumption represents, by far, the most significant source of greenhouse gas emissions.

Table 8-15 Greenhouse gas emission sources included in this assessment

Scope 1 –direct emissions	Scope 2 –indirect emissions from purchased energy	Scope 3 – other indirect emissions
Diesel combustion	Electricity usage	Diesel transport of product (by rail)
Explosives		Indirect emissions for fuel extraction and transmission line loss associated with electricity supply
		Indirect emissions for fuel extraction associated with diesel supply

Table 8-16 Summary of predicted greenhouse gas emissions

Source	Quantity	Unit	Estimated emissions (kt CO_2-e)	Estimated emissions (kt CO_2-e)	Annual energy consumption (TJ)
Scope 1 –diesel consumption	1604400	L	4.33		61.93
Scope 1 – N2O (explosives)	1739	kg	0.54		0.00

Source	Quantity	Unit	Estimated emissions (kt CO_2-e)	Estimated emissions (kt CO_2-e)	Annual energy consumption (TJ)
Total Scope 1				**4.87**	
Scope 2 – electricity consumption	39,420,000	kWh	35.34		141.91
Total Scope 2				**35.34**	
Total NGER Reporting (Scope 1 + Scope 2)				**40.21**	**203.84**
Scope 3 Rail haulage of concentrate			0.67		
Scope 3 Emissions from fuel extraction and supply			0.48		
Scope 3 Emissions transmission losses and fuel extraction for electricity supply			6.78		
Total Scope 3				**7.93**	

8.2.7 Impact assessment

The Project is anticipated to process 750,000 tpa of ore material to produce approximately 131,000 tpa of concentrate. Annual emissions of GHG (Scope 1 and 2) are estimated at 40.21 $ktCO_{2-e}$ per annum or 203.84 TJ, both exceed the facility threshold for reporting.

The greenhouse intensity of the Project equates to approximately ~0.05 tCO_{2-e}/t of ore material and 0.37 tCO_{2-e}/t concentrate.

This represents a contribution of 0.025% to the State's reported greenhouse gas emissions in 2005 and less than 0.007% of Australia's reported greenhouse emissions in 2005.

Based on the magnitude of emissions estimated from the development, there will be no direct measurable environmental effect due to the emissions of greenhouse gases from the Project.

The Project has identified the most energy efficient methods and equipment that can be applied at this facility and efficiency of equipment will be a key consideration in procurement of additional equipment. In addition, BHOP has committed to continue to monitor greenhouse gas emissions, and intensity of production on an annual basis.

8.2.8 Management of emissions

To minimise energy consumption and greenhouse gas emissions, the following management measures will be undertaken:

- efficiency of all new mobile and fixed equipment will be considered during procurement for both diesel and electric powered equipment;
- within 12 months of commencement of underground mining, an energy audit will be conducted to compare predicted and actual energy consumption;
- equipment will be maintained to retain high levels of energy efficiency;
- the inventory of emissions developed for this assessment will be regularly updated and maintained; and

- emissions and abatement strategies will be reported annually.

These greenhouse mitigation and monitoring programmes will be used throughout the life of the Project.

8.3 *MANAGEMENT AND MONITORING MEASURES*

BHOP recognises that dust and in particular dust particulate containing lead minerals are critical issues in addressing the feedback and comments form the community and regulators. Therefore, a number of mitigation strategies, incorporating best practice measures, have been proposed to govern the management of lead bearing dust and dust across the site. BHOP also recognises its responsibilities in relation to its potential effect on greenhouse gas generation. Specific mitigation measures include:

- use of water spray / chemical dust suppressant system at the tailings storage facilities; and
- installation of wagon and vehicle wash facilities
- extensive sealing of haul roads and other primary roadways;
- application of chemical dust suppression for all unsealed road sections, ROM stockpile area and exposed designated areas on site;
- installation of coarse road base material on other site roads with regular compaction and watering;
- installation of sprinklers on site roads where required;
- full enclosure of the crushing circuit (primary, secondary and tertiary crushing and associated screens), enclosure to be kept under negative pressure and vented to a baghouse;
- enclosure of potentially dust generating conveyors and transfer points;
- static wind breaks (orientated perpendicular to the dominant wind direction) along with top-mounted water sprays at the ROM stockpile;
- water sprays on all permanent stockpiles;
- maintaining a concentrate moisture level of around 9 percent;
- installation of rubber curtains to enclose rail wagons when being loaded with concentrate;
- installation of a train wagon wash facility to remove and collect any potential spillage from the wagon’s prior to leaving the lease;
- restricted height of ore pad stockpile and installation of wind breaks around the stockpile;
- service roads and tip points around the stockpile will be laid with compacted road base (high moisture and low silt content);
- installation of real-time air quality monitoring to assist in the active management of emissions;
- limitation of vehicle or work access in exposed areas;
- maintaining of surface crust to minimise potential wind erosion;

- identification and remediation of areas where fines or silt has built up (typically after heavy rain storms);
- remediation of any area disturbed due to works carried out on site (include surface exploration drilling sites); and
- remediation will include but not limited to removal and burial of fine material, capping with inert waste rock, or use of dust suppressants.

In addition to mitigation measures, best practice will be employed during the operations. This includes:

- adoption of a lead management plan to address specific issues dealing with personal hygiene of employees, blood lead action guidelines, sampling and environmental monitoring;
- continuation and expansion of the existing air quality management programme to include, in addition to two high vol samplers and five dust deposition jars, a real time monitor to identify real time impacts and delineate short term concentrations; and
- regular maintenance of pollution control equipment to ensure that it is functioning at optimal performance levels. A maintenance schedule will be documented and implemented for all pollution control equipment as part of an environmental management plan.

A CEMP will also be developed prior to construction. The plan will include management and monitoring measures relating to air quality that will be implemented during all construction works.

As detailed in *Chapter 2*, a Tailings Construction and Operations Manual will be developed for the Project. This will incorporate measures outlined in *Section 2.6.*

In addition the following measures will be undertaken to minimise and monitor greenhouse gases:

- efficiency of all new mobile and fixed equipment will be considered during procurement for both diesel and electric powered equipment;
- within 12 months of commencement of underground mining, an energy audit will be conducted to compare predicted and actual energy consumption;
- equipment will be maintained to retain high levels of energy efficiency;
- the inventory of emissions developed for this assessment will be regularly updated and maintained; and
- emissions and abatement strategies will be reported annually.

8.4 CONCLUSIONS

The air quality assessment highlights that the underground operations will be in compliance with DECCW air quality impact assessment guidelines. Exceptions to this are in the case of 24-hour PM10 and cumulative (background air quality plus project increment) dust deposition. Any exceedance of these two guidelines is driven by the elevated background air quality within Broken Hill. This is a function of the arid desert climate impacted by frequent dust storm events. It is expected that 24-hour PM10 concentrations and background dust deposition rates would exceed the relevant DECCW criteria without the inclusion of any additional sources due to natural processes alone.

BHOP has proposed a number of management measures to ensure that emissions to atmosphere from its operations and the existing free areas on the Project site are minimised. BHOP will implement an air quality monitoring program to confirm that the results presented in this report are an accurate representation of emissions to atmosphere from the Project during operation as well as using this data to inform and develop operational controls to minimise impacts on local air quality. In addition, on-going management of the facility will adopt environment management measures to ensure that predicted levels are not exceeded.

Greenhouse gas emissions will result from activities associated with the Project that consume energy. Annual emissions will be in the order of 40 $ktCO_{2-e}$ triggering mandatory reporting requirements under the NGER Act. When compared to the 2005 reported greenhouse gas emissions for 2005, the Project is predicted to contribute less than 0.025% of the state's annual emissions.