Midwest Corporation
Koolanooka Iron Ore Mine

KOOLANOOKA DUST MODELLING AND IMPACT ASSESSMENT

- Final Ver1
- December 2006

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Sinclair Knight Merz
7th Floor, Durack Centre
263 Adelaide Terrace
PO Box H615
Perth WA 6001 Australia

Tel: +61 8 9268 4400
Fax: +61 8 9268 4488
Web: www.skmconsulting.com

Contents

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Executive Summary

Midwest Corporation Ltd (Midwest) is planning to operate several iron ore mines near the central coast of Western Australia, including the Koolanooka iron ore mine near Morawa. The operations at Koolanooka are located at an old mine site which has been re-opened, with mining proposed for commencement in the near future. Existing and proposed operations and infrastructure at the Koolanooka site consist of mining activities, a crushing and screening plant and various administration, workshop and infrastructure buildings. Ore will be transported via truck to the nearby Tilly Siding where it will be transferred to rail and transported to Geraldton for export.

It has been identified that the vegetation surrounding the South Fold Orebody comprises the ‘Koolanooka System’ Threatened Ecological Community (TEC). This TEC has been assessed by the WA Threatened Ecological Communities Scientific Committee as ‘Vulnerable’. To ensure the protection of this TEC, dust modelling has been undertaken to identify potential dust deposition loads.

Sinclair Knight Merz (SKM) has been commissioned to investigate the potential air quality impacts the mining processes will have on dust deposition within the surrounds of the mine site. Therefore this report has focused on total suspended particulate (TSP) emissions to estimate dust deposition.

To examine any potential change in ground level TSP concentrations that could occur with the development of the Koolanooka operations, Sinclair Knight Merz (SKM) have utilised the Victorian EPA’s Gaussian plume model AUSPLUME. Estimates of emissions were made based on predicted ore and waste tonnage mined at Koolanooka, with these estimations used as model input parameters. The model predictions for TSP show that the Koolanooka operations will result in increased dust deposition in the surrounding area. Deposition standards established in NSW (NSW DEC 2005) have been exceeded, while concentrations sourced from research indicating dust deposition impacts on vegetation health (Doley 2006) have not been exceeded.

1. Introduction

1.1 Project Background

Midwest Corporation Ltd (Midwest) is planning to operate several iron ore mines near the central coast of Western Australia, including the Koolanooka iron ore mine near Morawa. The operations at Koolanooka are located at an old mine site which has been re-opened, with mining proposed for commencement in the near future. Existing and proposed perations and infrastructure at the Koolanooka site consist of mining activities, a crushing and screening plant and various administration, workshop and infrastructure buildings. Ore will be transported via truck to the nearby Tilly Siding where it will be transferred to rail and transported to Geraldton for export.

A locality diagram, showing the location of the Koolanooka mine, is provided in **Figure 1**.

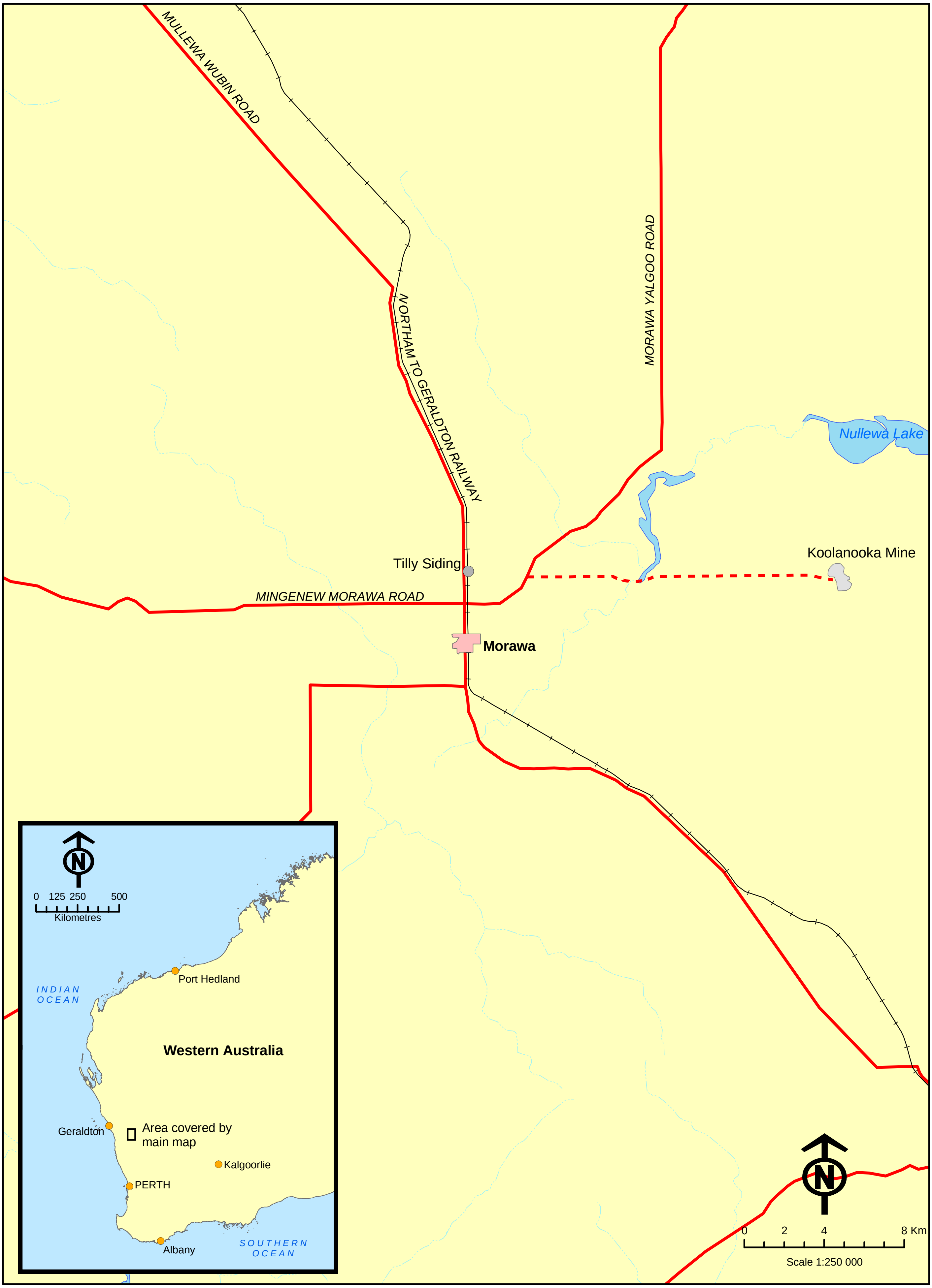
It has been identified that the vegetation surrounding the South Fold Orebody (**Figure 2**) comprises the 'Koolanooka System' Threatened Ecological Community (TEC). This TEC has been assessed by the WA Threatened Ecological Communities Scientific Committee as 'Vulnerable'. To ensure the protection of this TEC, dust modelling has been undertaken to identify potential dust deposition loads.

1.2 Overview of This Report

The iron ore handling and processing facilities which will re-commenced at Koolanooka have the potential to impact on the TEC. Sinclair Knight Merz (SKM) has been commissioned to investigate the potential air quality impacts the mining processes will have on dust deposition within the surrounds of the mine site. Therefore this report has focused on total suspended particulate (TSP) emissions to estimate dust deposition.

As part of this assessment of dust impacts from the Koolanooka mine the following investigations have been performed:

- Review of ambient air quality guidelines and discussion of project specific goals (**Section 2)**;
- Analysis of the existing environment (**Section 3**), including:
  - climate; and
  - prevailing meteorological conditions.
- Estimation of dust emissions from various site activities (**Section 4**);
- Prediction of dust levels from the Koolanooka operations using air dispersion modelling techniques and assessment of impacts to the TEC (**Section 5**);
- Conclusions (**Section 6**); and
- Recommendations (**Section 7)**.



263 Adelaide Terrace
PERTH WA 6000
Tel : +61 8 9268 4400
www.skmconsulting.com.au

Koolanooka

REGIONAL LOCATION

Figure 1

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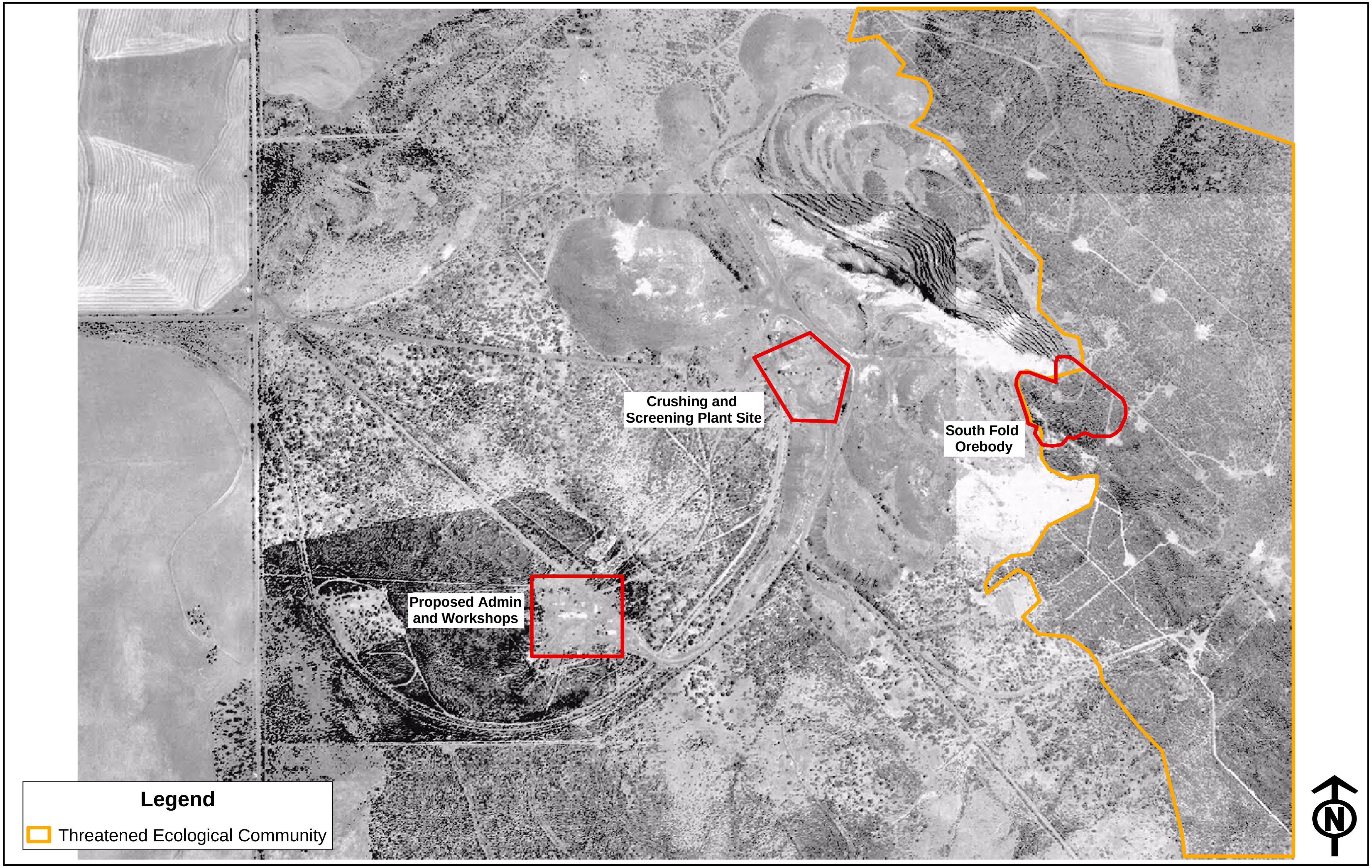

SKM
263 Adelaide Terrace
PERTH WA 6000
Tel : +61 8 9268 4400
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Koolanooka Mine

THREATENED ECOLOGICAL COMMUNITIES

Figure 2

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2. Air Quality Guidelines

There are currently no air quality legislative requirements which apply directly to operations at Koolanooka. A discussion of ambient and dust deposition air quality guidelines and those applicable to mining and material handling activities is provided below.

2.1 Overview of Ambient Standards

2.1.1 Western Australia Department of Environment and Conservation (WA DEC)

The only legislated dust criteria for Western Australia are those prescribed in the Kwinana Environmental Protection Policy (EPP) (EPA 1999). The EPP specifies air quality standards and limits for Total Suspended Particulate Matter (TSP), expressed as a 24 hour average, within the Kwinana industrial areas (Area A), an intermediate buffer zone area (Area B) and surrounding residential areas (Area C). The EPP defines a standard as a concentration that is desirable not to be exceeded, and a limit as the concentration that is not to be exceeded. The EPP standards and limits are listed in **Table 1**. While these criteria do not apply to Koolanooka, they can be used for comparison purposes.

In addition to 24-hour standards, the Kwinana EPP outlines a short-term (15-minute average) standard of 1000 $\mu g/m^3$ for very short term dust events. This limit was originally established to control nuisance-causing dust from stock holding paddocks.

Table 1 Total Suspended Particulate Standards and Limits for the Kwinana Policy Area

Species	Area [2]	Averaging Period	Standard[1] ($\mu g/m^3$)	Limit[1] ($\mu g/m^3$)
Particles	A,B,C	15-minute	-	1000
	A	24-hour	150	260
	B	24-hour	90	260
	C	24-hour	90	150

Notes:
1) All values expressed at 0^oC and 101.3 kPa.
2) Area A: the area of land on which heavy industry is located
Area B: the area surrounding industry designated as buffer zone, plus other outlying land zoned for industrial use
Area C: land beyond areas A and B used predominantly for rural and residential purposes.

Historically the Department of Environment and Conservation (DEC) has used the residential TSP standards and limits as objectives for new industrial developments, including mines and material handling facilities, within WA.

2.2 Overview of Deposition Standards

There are no Western Australian air quality guidelines which address potential impacts from dust deposition. However the NSW Department of Environment and Conservation (DEC) sets a criteria for dust deposition rates (NSW DEC 2005), which is outlined in **Table 2** below.

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- **Table 2 NSW deposited dust criteria**

	Averaging period	Maximum increase in deposited dust levels	Maximum total deposited dust levels
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

These criteria apply to insoluble solids, as defined in AS 3580.10.1:2003 *Methods for sampling and analysis of ambient air - Determination of particulate matter - Deposited matter - Gravimetric method* (Standards Australia 2003). If no baseline data is available on existing dust deposition levels, the maximum total deposited dust level of 4 g/m^2/month is applied.

Research on the effects of dust deposition on vegetation health has been undertaken in Australia. This research indicates that vegetation health is not impacted by the direct physical effects of mineral dust deposition until relatively high surface loads are experienced, at >7 g/m^2 (Doley 2006).

3. Existing Environment

3.1 Climate

3.1.1 Overview

Koolanooka is located in the mid-west region of Western Australia (WA), approximately 200 kilometres east of Geraldton. The mine is located at the northern edge of a belt of Mediterranean-type climate which occurs across south-western WA. Characterised by hot, dry summers and mild wet winters, the region is strongly influenced by the sub-tropical ridge, which is a band of high pressure, and by the 'West Coast Trough', an area of low pressure that extends south from the tropics.

The meteorological data used for the modelling conducted as part of this study was extracted from the Bureau of Meteorology (BoM) Morawa dataset for 2004. This dataset was used as it was the nearest location with a complete hourly dataset available for a year and is located in close proximity to the Koolanooka mine site and Tilly Siding.

3.1.2 Wind

The annual wind rose for Morawa is presented in **Figure 3**, and represents the period from January 2004 to December 2004. The seasonal wind roses for Morawa are displayed in **Figure 4** to **Figure 7**, while the annual statistics for wind speed and directions are presented in **Appendix A**.

The seasonal wind roses show that winds are quite evenly distributed throughout the year, with winds from the south the strongest. During summer southerly winds are predominant, with autumn winds ranging from the south, to east to north. The winds in winter are predominantly from the north and north-west. The wind direction during spring ranges from strong westerly winds through to southerly winds.

Due to local terrain and micro-meteorological effects, the actual wind conditions at any location within the study area may differ from those shown in the wind roses. However, the broad patterns of winds across the local area are expected to be similar to those observed at Morawa.

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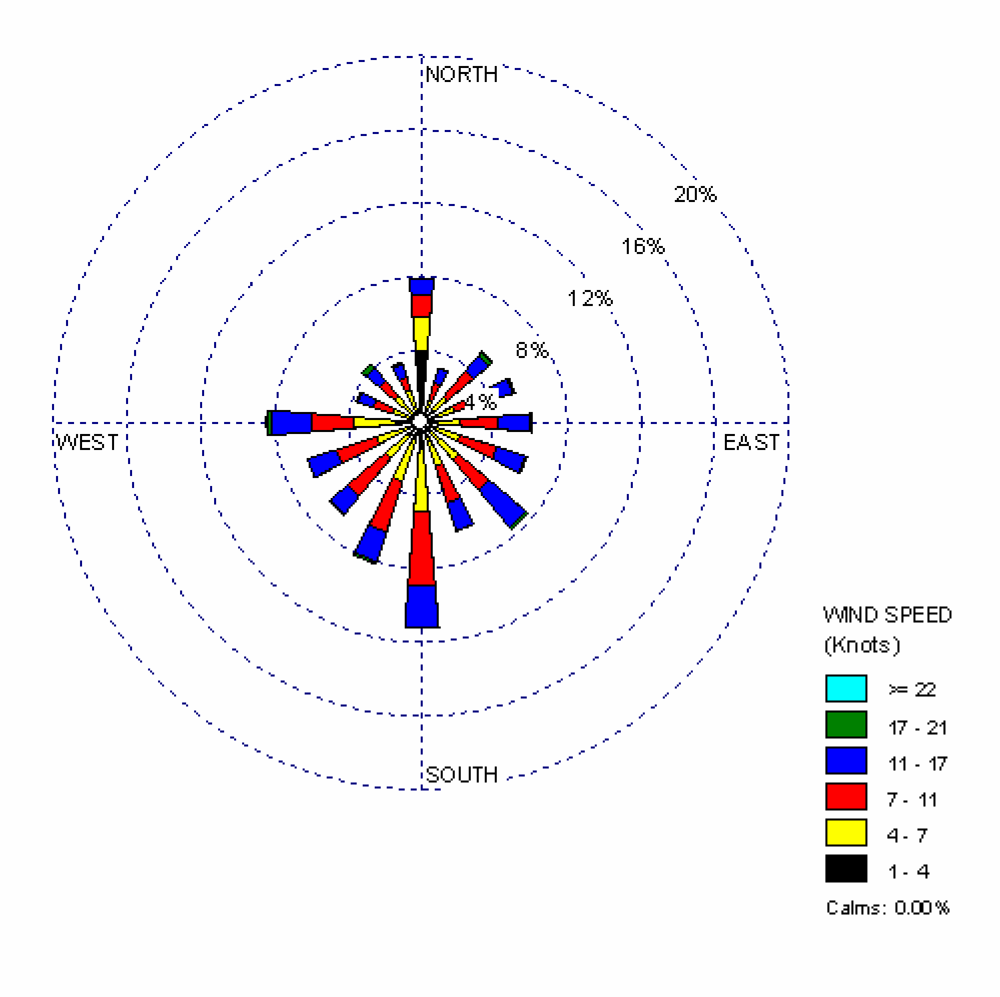
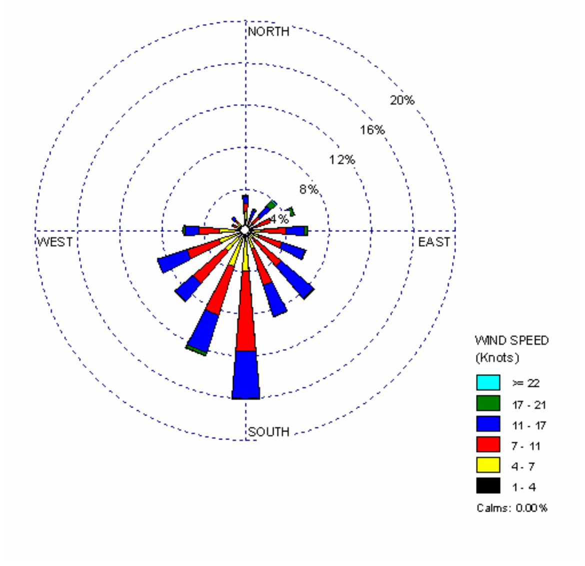
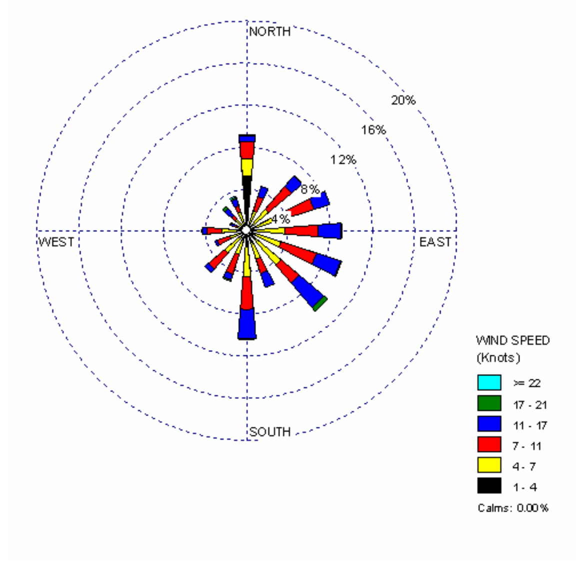


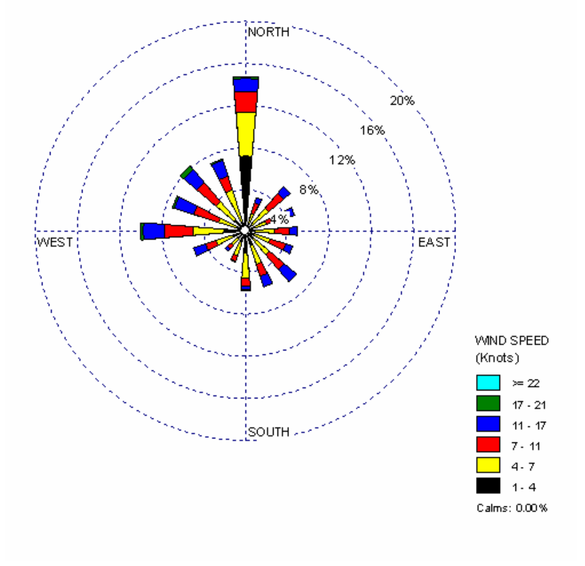
- **Figure 3 Annual Wind Rose (January 2004 – December 2004) for Morawa**



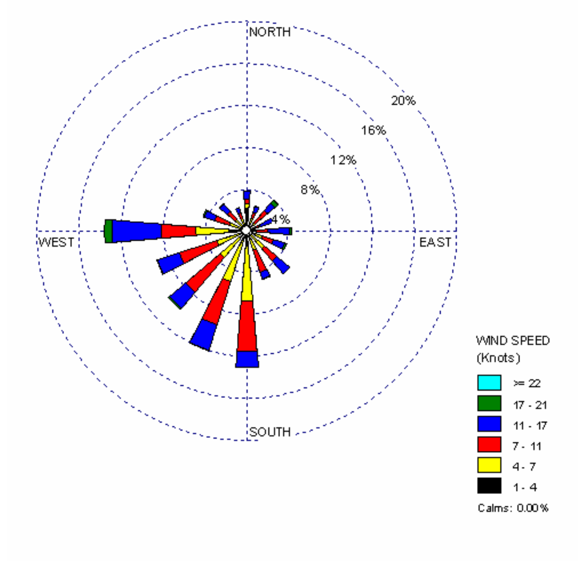
■ **Figure 4 Summer Wind Rose**



■ **Figure 5 Autumn Wind Rose**



■ **Figure 6 Winter Wind Rose**



■ **Figure 7 Spring Wind Rose**

4. Dispersion Modelling Emission Estimates

For the purposes of this report onsite monitoring of dust emissions was beyond the scope of works, therefore dust emissions have been estimated using the methodologies outlined in the National Pollutant Inventory (NPI) *Emission Estimation Technique Manual (EET) for Mining Version 2.3* (DEH 2001). Default values of 3% moisture content and 10% silt content have been applied where estimates of these parameters are required.

4.1 Dust Emission Sources

The mining and material handling operations at Koolanooka investigated as part of this study include:

- Drilling;
- Blasting of waste material and ore;
- Loading of material into haul trucks;
- Vehicle (wheel) generated dust;
- Truck dumping of waste material and ore;
- Bulldozer operations;
- Wind erosion from waste and product stockpiles and unsealed areas;
- Grader generated emissions;
- Fugitive emissions from crushing and screening; and
- Ore transfer to road trains for transport to Tilly Siding.

4.2 Tonnage

The hourly tonnage of material for various activities such as the dumping of waste was determined by estimating the monthly tonnage of ore and waste to be mined at Koolanooka and an estimate of the operating hours per year for each activity. This data was supplied by Midwest, with the operating hours and average hourly tonnage presented **Table 3**.

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▪ **Table 3 Average Tonnage of Ore and Waste at Koolanooka**

Product	Activity	Estimated Tonnage per Year	Average Tonnage per Operating Hour
Ore	Truck loading	1,780,000	200
	Dumping of ore		
	Crushing plant		
	Loading road trains		
Waste	Truck loading	1,620,000	180
	Dumping of waste		

4.3 Drilling and Blasting

Emission volumes from drilling of blast holes are potentially impacted by a number of factors such as depth of hole, moisture content and silt content. However, as it is a relatively minor source of total dust emissions the estimations calculation is a simple emission factor of 0.59 kg per hole for TSP (DEH 2001).

Dust emissions from blasting are difficult to model due to the short time interval and variability of the physical factors that define a blast event. Blasting activities are episodic in nature and the impacts are generally short-term, resulting from a distinct event at a specific location, in contrast with a number of diffuse sources spread across various locations within an open cut operation. The uncertainties associated with calculating dust impacts from blasting are therefore generally greater than those associated with other longer term activities of the mining operations as a whole.

Dust emissions from blasting have been estimated using the NPI blasting emissions equation (DEH 2001). This equation is presented as:

$$E = 344 \text{ x } A^{0.8} / (M^{1.9} \text{ x } D^{1.8}) \text{ kg/blast}$$

Where,

A = the blast area (square metres)
M = moisture content (%)
D = depth of blast holes (m).

Data supplied by Midwest indicate that approximately 32,000 holes will be drilled annually, with drilling occurring during daylight hours only. Blasting will occur on an approximately weekly basis, at either 12.00 pm or 5.30pm.

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4.4 Loading / Unloading Operations

Emissions from these two activities were estimated using the default emission factors from the NPI EET Manual (DEH, 2001), as presented in **Table 4**. These default emission factors were used instead of the US-EPA (1995) equation for batch loading/unloading, as recommended for metalliferous operations in the mining manual, because the US-EPA (1995) equations returned emissions estimates that were a factor of ten lower than the NPI default. The NPI emissions factors were used as the more conservative estimate.

Table 4 Default TSP Emission Factors for Loading/Unloading Trucks

Activity	Default Emission Factor
Loading trucks with overburden	0.025kg/t
Truck unloading overburden	0.012kg/t

Source: Emission Estimation Technique Manual for Mining Ver2.3 (DEH 2001)

4.5 Bulldozing and Grading

Bulldozing at Koolanooka was estimated using the EET (DEH, 2001) TSP direct emission factor for bulldozer on overburden. This factor, of 17 kg/hr, was applied to bulldozer operations of 10 hours per day throughout the year.

Grading is a relatively minor source of TSP, however emissions were estimated based on the EET (DEH, 2001) equation for grading, which is presented as:

$$E = 0.0034 \text{ x } S^{2.5} \text{ kg/VKT}$$

Where,

S = mean vehicle speed (km/h)

Information provided by Midwest indicates that the grader at Koolanooka will be in operation for 3 hours per day, and travels at an average of 5 km/h.

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4.6 Wind Erosion Estimates

To determine wind erosion emissions the formulae used for determining wind erosion from the BHP Iron Ore operations in Port Hedland (SKM, 2002) was utilised:

PM_{10} (g/s) = (4/5.7) x 1.1 x $(ws-6)^{1.5}$;   for WS > 6

PM_{10} (g/s) = 0,   for WS < 6

Where:

WS is the wind speed (m/s).

The wind speed data for Morawa was used to calculate wind erosion from stockpiles and open areas on an hourly basis for a whole year.

4.7 Vehicles and Wheel Generated Dust

The contribution to dust emissions from vehicles travelling along unpaved roads at Koolanooka has been estimated using the equation developed by the USEPA and provided in the NPI EET. This equation is presented as:

$$EF_i = k_i \text{ x } (s/12)^A \text{ x } (W/3)^B / (M/0.2)^C \text{ kg/VKT}$$

Where,

K_i = 2.82 constant for particles less than 30 micrometres
s = surface silt content (%)
W = vehicle gross mass (t)
M = surface moisture content (%)
A = empirical constant (0.8 for TSP)
B = empirical constant (0.5 for TSP)
C = empirical constant (0.4 for TSP)

Total VKT for haul trucks has been provided by Midwest, based on each of three operational haul trucks travelling 38.9km each day, over the 24 hours.

4.8 Crushing

The emission estimation technique for crushing of ore, as recommended by the EET (DEH 2001) is a simple default emission factor. For primary crushing of low moisture content ores, the TSP default emission factor is given as 0.2 kg/t. Crushing will occur for 24 hours each day.

4.9 Dust Estimates Summary

A summary of the dust emission rates for each source identified at the Kollanooka mine are summarised below in **Table 5**.

- **Table 5 Calculated emission rates for TSP at Koolanooka**

Source	Maximum (g/s)	99 Percentile (g/s)	95 Percentile (g/s)	90 percentile (g/s)	Average (g/s)
Drilling	18.62	18.62	18.62	18.62	7.76
Blasting	615.66	0.00	0.00	0.00	3.44
Haul truck loading	2.85	2.85	2.85	2.85	2.85
Dumping - ore	0.79	0.79	0.79	0.79	0.79
Dumping - waste	0.58	0.58	0.58	0.58	0.58
Bulldozing	4.72	4.72	4.72	4.72	1.97
Crushing	19.46	19.46	19.46	19.46	12.97
Transport truck loading	2.82	2.82	2.82	2.80	2.08
Unpaved road emissions	7.22	7.22	7.22	7.22	7.22
Grading	0.01	0.01	0.01	0.01	0.00
Wind erosion - open area	24.78	13.69	8.12	5.27	1.39
Wind erosion - stockpiles	24.78	13.69	8.12	5.27	1.39

The sources that are responsible for the largest emissions based on the annual average are the crushing plant, unpaved roads and drilling activities. During high wind periods erosion from the ore and waste stockpiles and open areas is also significant, whereas blasting is the single largest source, but emissions only occur at a single event on a weekly basis.

5. Model Results

Atmospheric dispersion models are widely used to study the complex relationship between emissions and air quality as a function of source and meteorological conditions. Models used for estimating dispersion range from simple empirical expressions to very elaborate numerical solutions of the conservation equations governing pollutant concentration. Due to the complexity of atmospheric transport processes, practical or operational dispersion models rely heavily on empirical methods.

5.1 Modelling Methodology

Air quality impacts from the existing and proposed future mining and processing operations have been assessed using the Victorian EPA's AUSPLUME (Version 5.4) computer dispersion model, which is one of the primary air dispersion models used for assessing air quality impacts from industrial sites within Australia. The model is designed to predict ground-level concentrations or dry deposition of pollutants emitted from one or more sources, which may be stacks, area sources, volume sources, or any combination of these. AUSPLUME is essentially a statistical Gaussian plume model that requires a time series of both meteorological and source emission data.

5.2 AUSPLUME Modelling

AUSPLUME can be run for a number of different model options and meteorological data formats. In this report the main model options and assumptions used are:

- Meteorological data from an annual file of hourly observations was used;
- Rural dispersion options;
- Assumption of no terrain;
- Dry depletion included; and
- Average roughness length of 0.4 m.

5.2.1 Grid System

AUSPLUME can calculate concentrations both on a set grid (typically Cartesian) or at specified locations. The model was configured to predict the ground-level concentrations on a rectangular grid of spacing established at 100m intervals. This grid approach was chosen to restrict the duration of model runs, while using the particle deposition algorithms.

5.2.2 Dry Depletion Method

Particles settling under gravity are subject to dry deposition. For this option, particle size distribution data and the particle density for each size fraction is required. AUSPLUME then calculates a settling velocity and a deposition velocity for each of these size categories. The settling velocity causes an elevated plume to "tilt" towards the surface as it travels downwind, while the deposition velocity is used to calculate the flux of matter deposited at the surface. Plume depletion allows material to be removed from the plume as it is deposited on the surface.

As the plume of airborne particles is transported downwind, such deposition near the surface reduces the concentration of particles in the plume, and thereby alters the vertical distribution of the remaining particles. Furthermore, the larger particles will also move steadily nearer the surface at a rate equal to their gravitational settling velocity. As a result, the plume centreline height is both reduced, and the vertical concentration distribution is no longer Gaussian.

Version 5 or later versions of AUSPLUME employ the deposition algorithm used in the US EPA model ISC3. This algorithm also tilts the plume downwards at an angle which depends on the particle settling velocities but now uses a better method for estimating deposition at the ground (dry deposition).

The particle size distribution for Koolanooka was taken as the same as that given in SKM (2002) for Port Hedland and is presented in **Table 6**.

- **Table 6 Particle size distribution (% by weight) used within model for dust depletion**

Mid Range Particle Size (µm)	Mass Fraction	
	PM10	TSP
1	0.31	0.11
4	0.26	0.09
7	0.23	0.08
9	0.20	0.07
12		0.13
19		0.13
26		0.13
35		0.13
45		0.13

5.2.3 Dispersion Curves

Horizontal dispersion of plumes can be determined within AUSPLUME according to Pasquill stability classes or through the standard deviation in wind direction known as sigma theta (σ_θ). The latter is preferred where observations are available, as sigma theta is a direct measure of horizontal dispersion and the resultant lateral dispersion coefficient will be a continuous function, not discrete curves. In the absence of sigma theta measurements for Koolanooka, horizontal dispersion was determined using the Pasquill Gifford curves which are applicable to surfaces releases.

5.2.4 Time Series Meteorological Data

A time series air quality meteorological data file, containing hourly averaged values of:

- Wind speed and direction;
- Ambient air temperature;
- Pasquill- Gifford stability class; and
- Atmospheric mixing height

was required for the AUSPLUME modelling. The wind speed and direction and temperature data was obtained from meteorological measurements recorded at Morawa by the Bureau of Meteorology for the year 2004. Stability and mixing height data was derived from observations at Geraldton, as the data was not available for Morawa.

Wind speed and direction were obtained from the 10 m above ground level (agl) wind records, collected at 30 minute intervals by BoM automatic weather station (AWS) and is discussed in **Section 3.1.2.** Ambient air temperature was obtained from surface (approximately 1.2 m agl) measurements.

Atmospheric stability categories were determined using the net radiation index method, or *Turner's method* as described in USEPA (1998). This method estimates stability from solar altitude, wind speed and cloud observations.

Mixing heights were estimated from surface observations using wind speed and stability class estimates to determine the Monin-Obukhov length and surface friction velocity. From these the mechanical mixing heights were computed using the methods reported by the NSW EPA (2001). These are noted are an approximate measure particularly during the day, but are considered sufficient, for the surface releases of dust and that only 24 hour and longer averages are recorded. For elevated sources such as tall stacks where hourly average concentrations are predicted, more accurate methods are recommended (NSW EPA, 2000).

A summary of the stability, wind speeds, and mixing heights of this data is given in **Appendix A**.

5.2.5 Model Inputs

A model of the existing operations was established to predict maximum 24-hour ground-level TSP concentrations at the nearest sensitive receiver to the site, being the Koolanooka System TEC. Inputs to the model include:

- Operational data and emissions release estimates, as discussed in **Section 4;** and
- One full year of hourly meteorological data for the Geraldton region for the period August 1994 – July 1995, as described in **Section 5.2.4**.

The source characteristics input into the AUSPLUME model are summarised in **Table 7**.

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- **Table 7 Input Parameters for AUSPLUME**

Source	AUSPLUME ID	Easting	Northing	Source Characteristics (m)		
				Horizontal Spread	Height	Vertical Spread
Drilling	K-DRL	422850	6771150	100	2	1
Blasting	K_BLS	422850	6771150	100	10	6
Haul truck loading	K_HTL	422810	6771180	100	5	1
Dumping - ore	K_DMO	422220	6770950	50	4	1
Dumping - waste	K_DMW	422560	6771070	80	4	1
Bulldozing	K_BUL	422750	6771180	50	3	1
Crushing	K_CR	422240	6771200	4	5	3
Transport truck loading	K_TTL	422270	6771120	20	3	1
Unpaved road emissions	K_UNH	422570	6771250	100	1	1
Grading	K_GRD	422750	6771110	100	1	1
Wind erosion - open area	K_OWE	422700	6770800	100	1	2
Wind erosion - stockpiles	K_SWE	422300	6770850	40	15	2

5.3 Predicted Existing and Future Ground-level Dust Concentrations

To examine any potential increase in ground-level TSP concentrations that could occur with the re-opening of the Koolanooka operations, ground-level concentrations were predicted using the AUSPLUME model results (**Figure 8**). The results represent the maximum ground-level concentrations that are predicted to occur in the areas surrounding the Koolanooka site.

The results of the model indicate that maximum concentrations of TSP likely to be deposited over the TEC will reach approximately 2-5g/m^2/month across the area surrounding the South Fold Orebody. The NSW DEC (2005) standard of 4 g/m^2/month is exceeded in some locations, however no areas are predicted to experience deposition concentrations greater than 7g/m^2, which has been indicated by Doley (2006) to be the concentration at which vegetation is impacted by dust deposition.

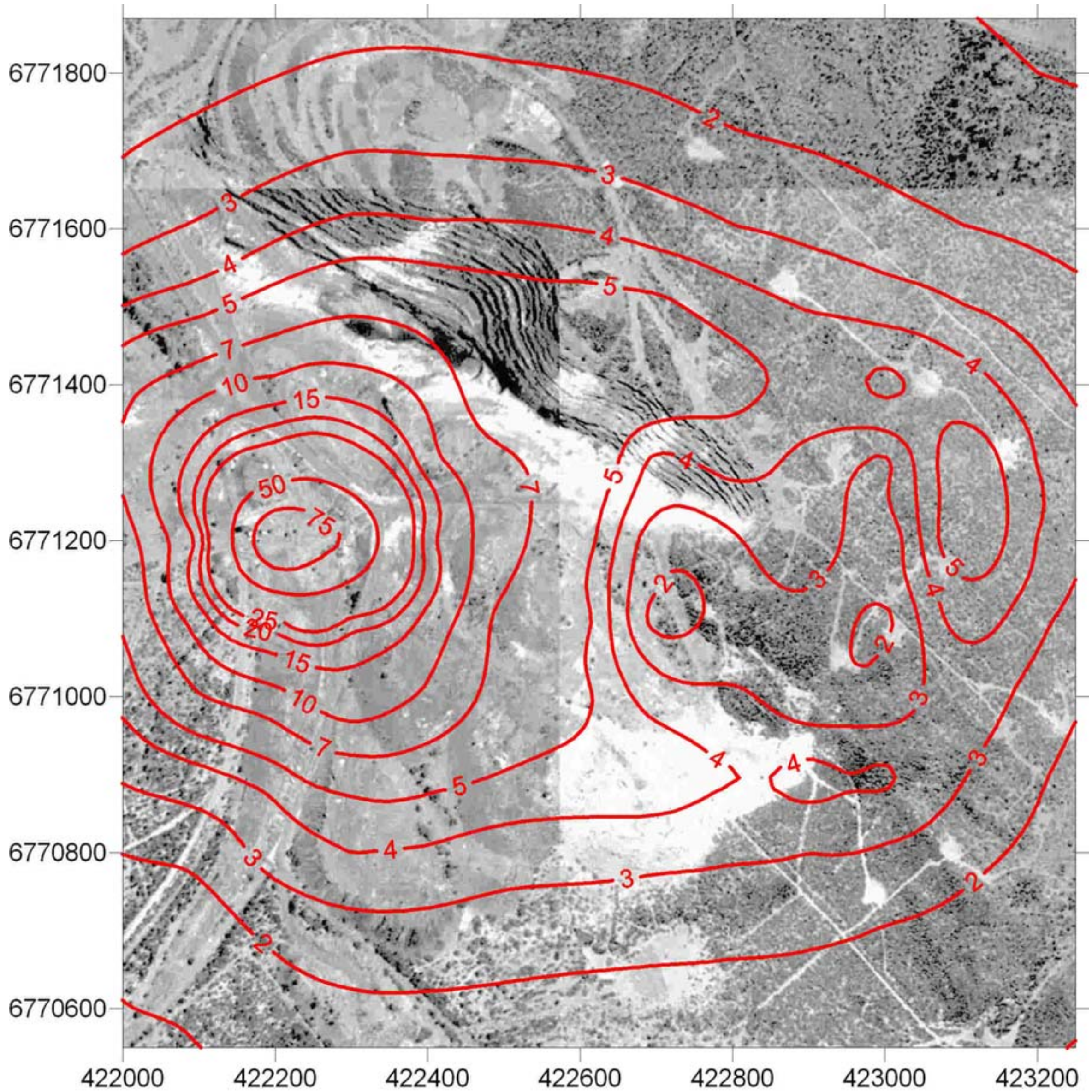

Figure 8 Modelled predicted TSP concentrations ($g/m^2/month$)

5.4 Discussion of Potential Errors

The predicted concentrations and depositions have a degree of uncertainty and may under or over-predict actual dust levels. A major source of uncertainty lies in the estimation of emissions from the dust sources on site, due to the many influencing variables. There are also inherent uncertainties in the use of any model to predict the dispersion of the dust.

6. Conclusions

The AUSPLUME computer dispersion model was used to predict the dispersion of dust from the mining operations at Koolanooka. A one year period was used in this assessment, based on projected ore and waste mining volumes.

The AUSPLUME modelling represents, as near as possible, the maximum forecasted ore and waste mining at Koolanooka and therefore the maximum dust emission conditions that could be expected to occur. The results represent the maximum potential TSP concentrations that would occur as a result of the mining operations at Koolanooka.

The model is based on dry weather conditions and assuming no dust control measures are undertaken at the mine site. Dispersion of TSP emissions will be reduced in many instances due to rain and dust control measures.

Based on the results of the modelling it is predicted that the mining operations at Koolanooka will result in an increase in TSP concentrations in the surrounding area. The predicted maximum concentrations are above NSW DEC (2005) standards for dust deposition, but below the more lenient concentrations which research (Doley 2006) indicates is the level at which vegetation is impacted by deposition.

7. Recommendations

Due to the proximity of the TEC to the mining operations at Koolanooka, and the predicted extent of the modelled TSP emissions, SKM makes the following recommendations.

- Dust deposition monitoring at the boundary between the mining operations and the TEC.
- Ongoing monitoring of vegetation health.
- Dust suppression and/or minimisation techniques to be applied at Koolanooka, including, but not limited to, water application to stockpiles and unpaved surfaces and limiting ore handling during high wind periods.

8. References

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Appendix A AUSPLUME Meteorological File

Stability Classes

	A	B	C	D	E	F	Total
Number	182	910	1887	2199	1505	1765	8448
Percent	2.15	10.77	22.34	26.03	17.81	20.89	

Stability Class by Wind direction

	A	B	C	D	E	F
N	5.2	17.0	24.9	8.8	9.5	34.5
NE	2.2	12.7	36.8	18.1	16.4	13.9
E	2.5	9.8	32.8	22.8	16.2	16.0
SE	1.9	9.5	20.2	34.9	16.4	17.1
S	1.5	10.7	15.9	27.7	23.2	21.0
SW	1.3	6.6	14.7	33.2	24.0	20.2
W	1.8	9.5	17.8	31.5	15.5	24.0
NW	1.5	12.9	25.4	23.3	16.8	20.1

Stabilty Class by Hour of Day

Hour	A	B	C	D	E	F
1	0	0	0	68	137	147
2	0	0	0	43	136	173
3	0	0	0	38	132	182
4	0	0	0	36	120	196
5	0	0	0	35	114	203
6	0	0	0	58	117	177
7	0	65	204	83	0	0
8	0	57	178	117	0	0
9	27	116	90	119	0	0
10	10	100	90	152	0	0
11	43	98	200	11	0	0
12	38	88	216	10	0	0
13	32	111	195	14	0	0
14	29	115	190	18	0	0
15	1	75	132	144	0	0
16	2	74	136	140	0	0
17	0	4	132	216	0	0
18	0	7	124	221	0	0
19	0	0	0	170	100	82
20	0	0	0	131	116	105
21	0	0	0	118	125	109
22	0	0	0	99	135	118
23	0	0	0	83	137	132
24	0	0	0	75	136	141

Mixing heights Time (hr)

Mixing heights	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
> 2000 m	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2	2	2	1	1	1
1800 to 2000 m	0	0	1	0	0	0	0	0	1	2	3	1	2	2	1	3	1	0	1	0	0	0	0	0
1600 to 1800 m	2	1	1	1	0	1	1	1	5	6	5	6	4	4	5	5	2	3	2	2	0	2	1	1
1400 to 1600 m	1	2	1	3	3	2	2	4	15	17	34	30	28	28	14	17	22	12	6	8	6	3	4	3
1200 to 1400 m	9	7	7	7	10	5	7	18	41	54	47	44	49	44	51	55	56	73	60	43	25	32	24	19
1000 to 1200 m	32	21	13	14	13	14	20	37	40	57	53	73	54	60	64	54	63	62	63	42	46	31	26	31
800 to 1000 m	20	10	15	11	9	15	27	40	53	45	77	78	91	95	69	74	70	66	28	27	29	30	26	19
600 to 800 m	3	1	0	0	0	18	109	102	73	79	61	64	66	63	95	90	95	85	8	7	10	2	2	2
400 to 600 m	0	0	0	0	0	1	85	66	54	46	46	36	39	38	33	37	30	36	1	0	0	0	0	0
200 to 400 m	0	0	0	0	0	2	54	50	39	30	22	16	13	17	16	14	12	13	3	1	0	0	0	0
0 to 200 m	284	309	314	316	317	294	47	34	31	16	4	4	5	1	3	3	1	2	178	220	234	251	268	276

Wind Occurence Matrix

Speed (m/s)	N	NE	E	SE	S	SW	W	NW	Total
<0.5 (calm)									3.12
0.5 - 1.9	1.33	0.84	0.98	1.33	2.39	1.56	2.15	1.17	11.75
2.0 - 3.9	3.05	2.92	3.14	3.79	5.58	3.79	3.93	2.32	28.52
4.0 - 5.9	1.95	3.31	3.98	4.30	6.57	5.26	3.88	2.18	31.43
6.0 - 7.9	1.20	1.91	2.63	3.73	3.37	2.69	2.38	1.29	19.19
8.0 - 9.9	0.37	0.71	0.78	0.78	0.50	0.51	1.05	0.60	5.30
10.0 - 11.9	0.08	0.14	0.05	0.05	0.01	0.01	0.07	0.15	0.57
12.0 - 13.9	0.01	0.01	0.01	0.02	0.00	0.01	0.00	0.01	0.08
14.0 - 15.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.0 - 17.9	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02
>18.0	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total	7.99	9.88	11.56	13.99	18.42	13.83	13.47	7.73	100.00

Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
<0.5 (calm)																	3.1
0.5 - 1.9	0.9	0.3	0.5	0.4	0.5	0.5	0.7	0.9	1.5	0.8	0.8	0.9	1.4	0.5	0.7	0.6	11.8
2.0 - 3.9	1.8	1.1	1.4	1.5	1.7	1.8	2.0	1.7	3.4	2.6	1.8	1.7	2.3	1.1	1.3	1.4	28.5
4.0 - 5.9	1.2	1.0	1.8	1.8	2.1	2.1	2.2	2.1	4.0	2.9	2.7	2.3	2.3	1.2	1.1	0.7	31.4
6.0 - 7.9	0.7	0.7	0.8	1.3	1.4	1.2	2.2	1.4	2.1	1.4	1.1	1.4	1.6	0.7	0.7	0.5	19.2
8.0 - 9.9	0.2	0.1	0.5	0.3	0.4	0.4	0.5	0.2	0.2	0.4	0.2	0.3	0.8	0.2	0.3	0.3	5.3
10.0 - 11.9	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.6
12.0 - 13.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
14.0 - 15.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0 - 17.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	4.8	3.2	5.1	5.4	6.1	6.1	7.7	6.2	11.2	8.1	6.6	6.5	8.4	3.8	4.2	3.5	100.0

Ave wind speed = 4.47

Wind Speed range (m/s)	Count	Percentage (%)
0.00 - 0.99	341	4.04
1.00 - 1.99	916	10.84
2.00 - 2.99	723	8.56
3.00 - 3.99	1686	19.96
4.00 - 4.99	1494	17.68
5.00 - 5.99	1161	13.74
6.00 - 6.99	983	11.64
7.00 - 7.99	638	7.55
8.00 - 8.99	336	3.98
9.00 - 9.99	112	1.33
10.00 - 10.99	42	0.50
11.00 - 11.99	6	0.07
12.00 - 12.99	6	0.07
13.00 - 13.99	1	0.01
14.00 - 14.99	0	0.00
15.00 - 15.99	0	0.00
16.00 - 16.99	0	0.00
17.00 - 17.99	2	0.02
18.00 - 18.99	0	0.00
19.00 - 19.99	1	0.01
20.00 - 20.99	0	0.00
21.00 - 21.99	0	0.00

22.00 - 22.99	0	0.00
23.00 - 23.99	0	0.00
24.00 - 24.99	0	0.00
25.00 - 25.99	0	0.00
26.00 - 26.99	0	0.00
27.00 - 27.99	0	0.00
28.00 - 28.99	0	0.00
29.00 - 29.99	0	0.00

SKM

Appendix B AUSPLUME Output File

```
1               _________________________________________________

                  Wv03244, Koolanooka Run4, VLazenby, 17/11/2006
                _________________________________________________
 Concentration or deposition                        Dry deposition only
 Emission load units                                grams/second
 Deposition units                                   microgram/m2
 Units conversion factor                            1.00E+06
 Plume depletion due to dry removal mechanisms included.
 Smooth stability class changes?                    No
 Other stability class adjustments ("urban modes")  None
 Ignore building wake effects?                      Yes
 Decay coefficient (unless overridden by met. file) 0.000
 Anemometer height                                  10 m
 Roughness height at the wind vane site             0.300 m
 Use the convective PDF algorithm?                  No

                    DISPERSION CURVES
 Horizontal dispersion curves for sources <100m high  Pasquill-Gifford
 Vertical  dispersion  curves for sources <100m high  Pasquill-Gifford
 Horizontal dispersion curves for sources >100m high  Briggs Rural
 Vertical  dispersion  curves for sources >100m high  Briggs Rural
 Enhance horizontal plume spreads for buoyancy?       Yes
 Enhance  vertical  plume spreads for buoyancy?       Yes
 Adjust horizontal P-G formulae for roughness height? Yes
 Adjust  vertical  P-G formulae for roughness height? Yes
 Roughness height                                     0.400m
 Adjustment for wind directional shear                None

                     PLUME RISE OPTIONS
 Gradual plume rise?                                  Yes
 Stack-tip downwash included?                         Yes
 Building downwash algorithm:                        PRIME method.
 Entrainment coeff. for neutral & stable lapse rates 0.60,0.60
 Partial penetration of elevated inversions?          No
 Disregard temp. gradients in the hourly met. file?   No

 and in the absence of boundary-layer potential temperature gradients
 given by the hourly met. file, a value from the following table
 (in K/m) is used:

    Wind Speed                 Stability Class
     Category       A      B      C      D      E      F
  _________________________________________________________
        1         0.000  0.000  0.000  0.000  0.020  0.035
        2         0.000  0.000  0.000  0.000  0.020  0.035
        3         0.000  0.000  0.000  0.000  0.020  0.035
        4         0.000  0.000  0.000  0.000  0.020  0.035
        5         0.000  0.000  0.000  0.000  0.020  0.035
        6         0.000  0.000  0.000  0.000  0.020  0.035

 WIND SPEED CATEGORIES
 Boundaries between categories (in m/s) are:  1.54,  3.09,  5.14,  8.23, 10.80

 WIND PROFILE EXPONENTS: "Irwin Rural" values (unless overridden by met. file)
```

AVERAGING TIMES
24 hours

1

Wv03244, Koolanooka Run4, VLazenby, 17/11/2006

SOURCE CHARACTERISTICS

VOLUME SOURCE: K-DRL

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
422850	6771150	0m	2m	100m	1m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.1100	1.0	1.00
0.0900	4.0	1.00
0.0800	7.0	1.00
0.0700	9.0	1.00
0.1300	12.0	1.00
0.1300	19.0	1.00
0.1300	26.0	1.00
0.1300	35.0	1.00
0.1300	45.0	1.00

VOLUME SOURCE: K-BLS

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
422850	6771150	0m	10m	100m	6m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.1100	1.0	1.00
0.0900	4.0	1.00
0.0800	7.0	1.00
0.0700	9.0	1.00
0.1300	12.0	1.00
0.1300	19.0	1.00
0.1300	26.0	1.00

SKM

0.1300	35.0	1.00
0.1300	45.0	1.00

VOLUME SOURCE: K-HTL

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
422810	6771180	0m	5m	100m	1m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.1100	1.0	1.00
0.0900	4.0	1.00
0.0800	7.0	1.00
0.0700	9.0	1.00
0.1300	12.0	1.00
0.1300	19.0	1.00
0.1300	26.0	1.00
0.1300	35.0	1.00
0.1300	45.0	1.00

VOLUME SOURCE: K-DMO

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
422220	6770950	0m	4m	50m	1m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.1100	1.0	1.00
0.0900	4.0	1.00
0.0800	7.0	1.00
0.0700	9.0	1.00
0.1300	12.0	1.00
0.1300	19.0	1.00
0.1300	26.0	1.00
0.1300	35.0	1.00
0.1300	45.0	1.00

VOLUME SOURCE: K-DMW

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
422560	6771070	0m	4m	80m	1m

(Constant) emission rate = 1.00E+00 grams/second

```
         Hourly multiplicative factors will be used with
         this emission factor.

                    Particle  Particle  Particle
                      Mass      Size    Density
                    fraction  (micron)  (g/cm3)
                   _____________________________
                      0.1100       1.0      1.00
                      0.0900       4.0      1.00
                      0.0800       7.0      1.00
                      0.0700       9.0      1.00
                      0.1300      12.0      1.00
                      0.1300      19.0      1.00
                      0.1300      26.0      1.00
                      0.1300      35.0      1.00
                      0.1300      45.0      1.00


                    VOLUME SOURCE: K-BUL

  X(m)     Y(m)      Ground Elevation    Height   Hor. spread   Vert. spread
422750  6771180            0m              3m         50m             1m

               (Constant) emission rate = 1.00E+00 grams/second

         Hourly multiplicative factors will be used with
         this emission factor.

                    Particle  Particle  Particle
                      Mass      Size    Density
                    fraction  (micron)  (g/cm3)
                   _____________________________
                      0.1100       1.0      1.00
                      0.0900       4.0      1.00
                      0.0800       7.0      1.00
                      0.0700       9.0      1.00
                      0.1300      12.0      1.00
                      0.1300      19.0      1.00
                      0.1300      26.0      1.00
                      0.1300      35.0      1.00
                      0.1300      45.0      1.00


                    VOLUME SOURCE: K-CR

  X(m)     Y(m)      Ground Elevation    Height   Hor. spread   Vert. spread
422240  6771200            0m              5m          4m             3m

               (Constant) emission rate = 1.00E+00 grams/second

         Hourly multiplicative factors will be used with
         this emission factor.

                    Particle  Particle  Particle
                      Mass      Size    Density
                    fraction  (micron)  (g/cm3)
                   _____________________________
                      0.1100       1.0      1.00
                      0.0900       4.0      1.00
```

0.0800	7.0	1.00
0.0700	9.0	1.00
0.1300	12.0	1.00
0.1300	19.0	1.00
0.1300	26.0	1.00
0.1300	35.0	1.00
0.1300	45.0	1.00

VOLUME SOURCE: K-TTL

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
422270	6771120	0m	3m	20m	1m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.1100	1.0	1.00
0.0900	4.0	1.00
0.0800	7.0	1.00
0.0700	9.0	1.00
0.1300	12.0	1.00
0.1300	19.0	1.00
0.1300	26.0	1.00
0.1300	35.0	1.00
0.1300	45.0	1.00

VOLUME SOURCE: K-UNH

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
422570	6771250	0m	1m	100m	1m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.1100	1.0	1.00
0.0900	4.0	1.00
0.0800	7.0	1.00
0.0700	9.0	1.00
0.1300	12.0	1.00
0.1300	19.0	1.00
0.1300	26.0	1.00
0.1300	35.0	1.00
0.1300	45.0	1.00

VOLUME SOURCE: K-GRD

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
422750	6771110	0m	1m	100m	1m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.1100	1.0	1.00
0.0900	4.0	1.00
0.0800	7.0	1.00
0.0700	9.0	1.00
0.1300	12.0	1.00
0.1300	19.0	1.00
0.1300	26.0	1.00
0.1300	35.0	1.00
0.1300	45.0	1.00

VOLUME SOURCE: K-OWE

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
422700	6770800	0m	1m	100m	2m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
0.1100	1.0	1.00
0.0900	4.0	1.00
0.0800	7.0	1.00
0.0700	9.0	1.00
0.1300	12.0	1.00
0.1300	19.0	1.00
0.1300	26.0	1.00
0.1300	35.0	1.00
0.1300	45.0	1.00

VOLUME SOURCE: K-SWE

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
422300	6770850	0m	15m	40m	2m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with this emission factor.

Particle Particle Particle

Mass fraction	Size (micron)	Density (g/cm3)
0.1100	1.0	1.00
0.0900	4.0	1.00
0.0800	7.0	1.00
0.0700	9.0	1.00
0.1300	12.0	1.00
0.1300	19.0	1.00
0.1300	26.0	1.00
0.1300	35.0	1.00
0.1300	45.0	1.00

1

Wv03244, Koolanooka Run4, VLazenby, 17/11/2006

RECEPTOR LOCATIONS

```
 The Cartesian receptor grid has the following x-values (or eastings):
 422000.m  422100.m  422200.m  422300.m  422400.m  422500.m  422600.m
 422700.m  422800.m  422900.m  423000.m  423100.m  423200.m  423300.m
 423400.m

 and these y-values (or northings):
6770500.m 6770600.m 6770700.m 6770800.m 6770900.m 6771000.m 6771100.m
6771200.m 6771300.m 6771400.m 6771500.m 6771600.m 6771700.m 6771800.m
6771900.m
```

```
 METEOROLOGICAL DATA : 2004 WS, WD, Temp from Morawa, Stabs mix ht from Ger
a

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             HOURLY VARIABLE EMISSION FACTOR INFORMATION
             -------------------------------------------

 The input emission rates specfied above will be multiplied by hourly varying
 factors entered via the input file:
 I:\WVES\Projects\WV03244\Technical\Koolanooka\Koolanooka emissions 2.src
 For each stack source, hourly values within this file will be added to each
 declared exit velocity (m/sec) and temperature (K).

 Title of input hourly emission factor file is:
 Koolanooka emis file, Ver3, V Lazenby, 2/11/2006, Morawa met

             HOURLY EMISSION FACTOR SOURCE TYPE ALLOCATION
             ---------------------------------------------

 Prefix K-DRL  allocated: K-DRL
 Prefix K-BLS  allocated: K-BLS
 Prefix K-HTL  allocated: K-HTL
 Prefix K-DMO  allocated: K-DMO
 Prefix K-DMW  allocated: K-DMW
```

```
Prefix K-BUL  allocated: K-BUL
Prefix K-CR   allocated: K-CR
Prefix K-TTL  allocated: K-TTL
Prefix K-UNH  allocated: K-UNH
Prefix K-GRD  allocated: K-GRD
Prefix K-OWE  allocated: K-OWE
Prefix K-SWE  allocated: K-SWE
```