Appendix 23

Air Quality Assessment

Noise Mapping Australia

Scalable Consulting Solutions

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Executive Summary

This report provides an assessment of the air quality and greenhouse gas impacts from the proposed Byerwen Coal Project (project). The Byerwen Coal Project comprises eight pits, two infrastructure areas and a projected 46 year operational life. The assessment addresses construction and operations of the mine.

The study included measurement of existing dust exposure at three locations and included one location within the lease and two locations close to the lease boundary. The lowest exposure levels recorded were near the on the subject site near the southern infrastructure area. The area was covered in pasture at least 0.5m high. This site represents the lowest likely dust exposures and is considered to be representative of the lowest dust levels likely in the region.

Finally, the area surrounding Cerito Station Homestead comprised of mix of bare earth and closely cropped grass (a fire break and working area) surrounding the stock yards and the measurement obtained at this location are adopted in this report as representative of the short-term ambient levels at all homesteads.

The Environmental Protection Policy (Air Quality) was reviewed. The review determined that the key issue to be addressed in the assessment is dust and that other air pollution measures have minor and impacts localised to the lease area. From the EPP(Air) this report assessed impacts to four environmental objectives associated with health and wellbeing and one developed for flora. A single nuisance objective was adopted in this report.

The mining staging is quite complex and three modelling cases were developed. In this instance three modelling cases were addressed representing Year 5, Year 17 and Year 36 since these represent the early phases of most of the pits when the activity in the pit is close to the ground surface and the out-of-pit landforms are being developed. However, this also represented the maximum rate of handling of waste rock for the respective mining phases.

The site specific meteorology was developed using TAPM. The TAPM meteorological file developed for the site covered the two year period 2004 and 2005. This period was used for modelling since Queensland was generally free from extreme weather events such as cyclones. The years 2004 and 2005 were also towards the end of an extended drought, so the climate is representative of a period likely to high dust exposures.

The modelling was also conducted using TAPM and included both a standard and enhanced water application measures. It was found that there may be some differences between the industry standard water application rate and the application rate in the reference (NPI 2012) documents. It is it likely that enhanced dust control may comprise careful loading of haul trucks (designed to avoid spillage), timely spillage control or spot watering of spills rather than a generalised increase in the watering rate for all hours and all roads. Since water is a valuable resource it is appropriate that the mine investigate and optimise water application rate that provides the desired level of dust control.

The modelling assumed standard and enhanced dust controls with results showing exceedences of the PM_{10}(24hour) air quality objective at sensitive receptor R5 i.e. at R5 there were more than 5 days per year where the dust concentration of PM_{10}(24 hour) was greater than the comparative level of 50 µg/m^3. These were noted to occur during adverse meteorological conditions.

A range of operational and direct dust control mitigation measures were then modelled which showed that air quality objectives could be met at all sensitive receptors; these mitigations would only be required during specific meteorological and operational conditions. As such, to enable the proponent to react to the adverse air quality conditions and implement enhanced dust controls and or modify operations to avoid exceedance of the objectives, it is proposed that the proponent undertake dust monitoring at the adversely affected locations along with development of a Dust Management Plan.

The Dust Management Plan should be developed to include an action response plan to sequentially implement mitigations and monitor the results. Mitigation measures would be implemented sequentially as required by meteorological conditions and dust monitoring results, until such time as the meteorological conditions return to a suitable state where these mitigations are no longer required. A greenhouse gas assessment was carried out utilising the 2012 NGA workbook and the best available projections for the project. The project will result in greenhouse gas emissions as the result of the use of diesel fuel, explosives, clearing and indirectly in the use of electrical power. Methane will be released from the coal seam. The estimated greenhouse gas emissions intensity (Scope 1 and Scope 2) is approximately 0.056 tonnes CO_2 -e /tonne product coal. This is less than the Australian coal mining industry average of 0.079 Tonnes CO_2-e/tonne of product coal.

1. Introduction

Byerwen Coal (the Proponent) engaged Noise Mapping Australia ('NMA') to prepare an air quality assessment for the proposed Byerwen Coal Project ('project'), west of Glenden.

The objective of this assessment is to provide Byerwen Coal with information to assist with obtaining the necessary approvals for the proposed project.

This report addresses the following issues:

- description of existing air quality environment;
- description of air emissions from proposed mining operations;
- description of air emissions from proposed railway operations;
- assessment of air quality to appropriate standards; and
- recommendations for relevant impact mitigation and management measures.

1.1 Project Description

The project is a proposed open-cut coal mine located in the Bowen Basin approximately 20 kilometres (km) west of Glenden Central Queensland.

The project consists of six mining leases, MLA 10355, MLA 10356, MLA 10357, MLA 70434, MLA 70435 and MLA 70436. Byerwen Coal holds the two underlying exploration tenements in the project area, EPC 614 and EPC 739. The project area covers a portion of the two underlying EPCs.

Byerwen Coal is seeking 50 year mining leases (two years for construction, 46 years of operation and two years for decommissioning and final rehabilitation) for the extraction of the coal resource at a rate of approximately 15 Mtpa ROM coal. From commencement, the project will ramp up production over 5 years to achieve a project average of 15 Mtpa ROM coal. The mine is anticipated to have a life of 46 years. The open cut operation will involve clearing of vegetation, salvage of topsoil, stripping of overburden, extraction of coal, emplacement of waste rock and coal rejects, placement of topsoil or growth media and progressive rehabilitation. Open cut coal mining would be performed using both truck and shovel and dragline.

1.2 Locality Description

The project is situated in a well established grazing and mining region. The region is relatively flat, generally comprising open broad acre grazing and native scrublands.

There are several existing coal mines near the project, with the closest being the Newlands Coal Mine and Newlands Coal Mine extension, within 15 km of the site, refer to Figure 1.

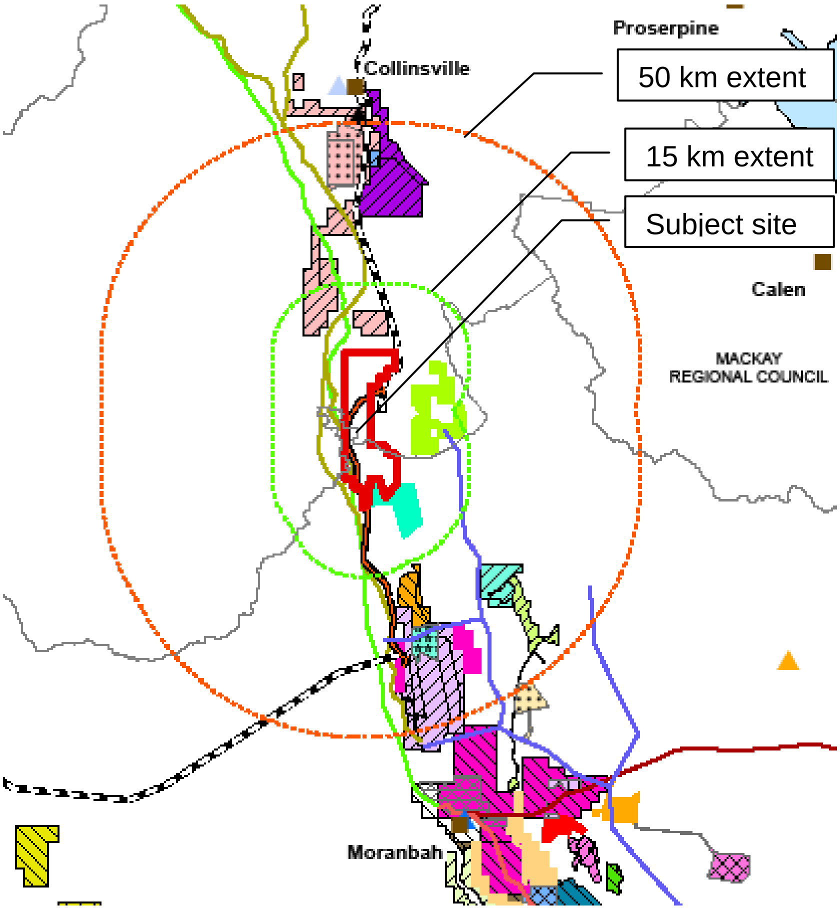

Figure 1: Regional View Showing Subject Site and Nearby Coal Mines (North Up)

The potentially sensitive locations in the vicinity of the project comprise the homesteads of grazing properties and Glenden township. The closest potentially sensitive locations are shown on Figure 1 along with the mine site. The locations and separation distances are contained in Table 1. Several sensitive receptors are either not occupied for the duration of the project or are occupied on a part-time basis. These sites have been identified for completeness but will not be considered in the assessment stages of this report.

Table 1: Sensitive Receptors Adjacent to MLA Tenement and Railway Corridor

Sensitive Receptor	***Permanently Occupied For Duration of Project***	***Separation Distance [km] and Direction To Sensitive Receptor to***		
		Project area	Project footprint	TLFs
Glenden Township	Yes	19.4km E	20.0km E	25.7km NE
R1 Suttor North Station Homestead (not occupied for duration of project)	No	(on lease)	-	-
R2 Suttor Creek Station Homestead	Yes	6.8km E	7.3km NW	14.2km NW
R3 Lancewood Station Homestead	Yes	9.7km SE	13.3km NW	19.5km NW
R4 Wollombi Station Homestead (not occupied for duration of project)	No	0.5 km E	0.6 km E	1.4 km E
R5 Cerito Station Homestead (occasional occupancy)	No	5.8km W	7.0km SE	12.7km SE
R6 Byerwen Station Homestead	Yes	1.5km E	7.9km SW	5.5km SW
R7 Weetlaba Station Homestead	Yes	4.9km NE	12.4km SW	10.7km SW
R8 Glenden Station Homestead	Yes	18.2km E	18.5km E	24.0km NE
R9 Two Sheds	No	3.7km N	8.3km N	14.6km N
R10 Fig Tree Station Homestead	Yes	13.2km SE	17.2km SE	20.8km SE

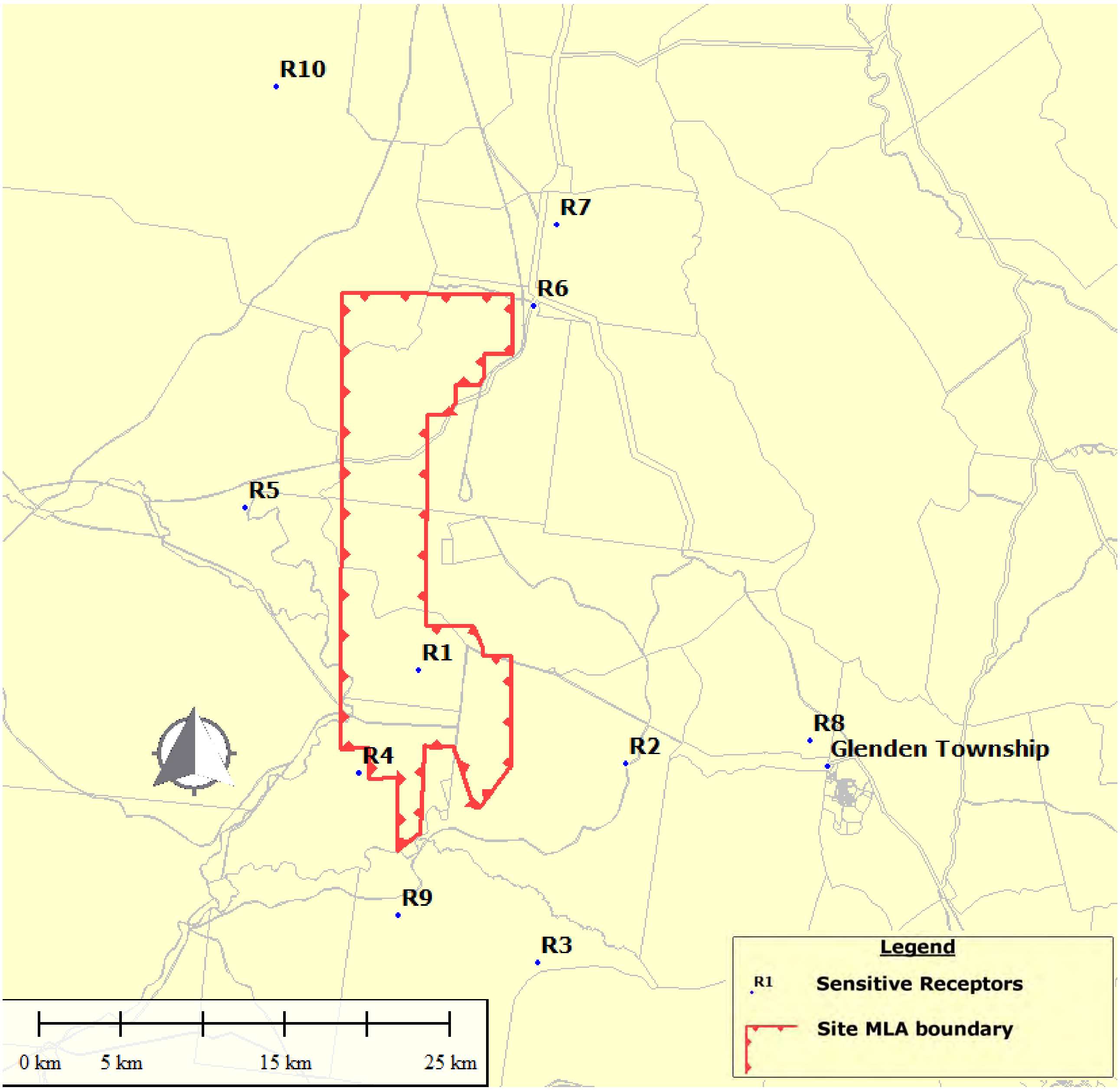

Figure 2: Regional View Showing Subject Site and Nearby Sensitive Receptors

1.3 Identification of Issues to be Addressed

The activities proposed to be undertaken at the project comprise extraction, handling, processing and placement of soil, overburden, interburden and coal. These processes will result in the release of particulate matter into the atmosphere. There is a potential for the ground level concentration of particulates and deposition of particulate matter to exceed environmental air quality objectives which is, as a result, the primary focus of this report.

The assessment of particulates needs to identify four main issues:

1. the existing exposure level in the environment without the mine;
2. the likely emissions from the proposed operation incorporating controls provided by rainfall and water application;
3. the meteorology for the site to determine the off-site transport and dilution effects of the atmosphere; and
4. calculated cumulative atmospheric dust concentration at nearest sensitive receptors, including the effects from other nearby proposed mines.

It is necessary to identify key stages in the project and model using a suitable atmospheric dispersion model, in this case Commonwealth Scientific and Industrial Research Organisation (CSIRO) The Air Pollution Model (TAPM). Impacts are assessed by taking into account the combined effect of existing and predicted exposures. The modelling adopted for this project involves a sophisticated approach to identify the emissions for each hour over a two year period using meteorological data to refine the emission rates. The meteorological data was also obtained from TAPM. By following this approach, a realistic estimate of dust emissions has been made incorporating the usual industry standard control methods adopted by mining operations.

The combustion of diesel in mining machines will result in gaseous emissions of CO, NOx and SO_2. Blasting also results in gaseous emissions. In practice, the sources of gaseous emissions are widely dispersed and have low levels of emission and a very localised impact. Thus the likelihood of exceeding emission related environmental air quality objectives beyond the lease boundary is minimal. As a consequence it is not proposed to address the gaseous emissions.

However, the use of diesel fuels, along with release of methane from coal and other matters makes the project a source of greenhouse gases. This report addresses the emissions of greenhouse gases using the Australian Department of Climate Change and Energy Efficiency, National Greenhouse Accounts (NGA) Factors' (June 2012).

2. Description of Existing Environment

2.1 Climate

The project is situated between Moranbah and Collinsville. Both of these locations maintain a Bureau of Meteorology (BOM) weather monitoring station. Refer to Appendix 1 for a summary of the main statistics collected at these sites. Moranbah (Latitude 21.99, Longitude 148.03) and Collinsville (Latitude 20.55, Longitude 147.85) are manual stations with the weather records recorded twice daily.

The region has a warm climate with two distinct seasons, a dry winter season and a wet summer season. Dry season temperatures average are approximately 9ºC to 30ºC, while wet season temperatures range from 20ºC to 33ºC. The rainfall is seasonal and highly variable and ranges from around 200 mm to above 1,200 mm each year, falling mostly between November and April.

During the wet summer season the soil moisture content increases and there is increased grass ground cover. This results in lower dust emissions from most activities, including from local roads and grazing lands. During the dry winter season the soil moisture content reduces (particularly at and close to the surface) and grass cover reduces. Dust emissions from all (non-mining) activities are more prevalent from most activities during this period. This is also the period when grass fires (including permitted fires) are likely to occur. These types of fire release significant quantities of smoke into the lower atmosphere.

2.2 Dust

Potential sources of particulate emissions from the surrounding environment primarily comprise:

- farming and grazing activities;
- existing commercial operations;
- unsealed roads; and
- smoke from grass/bush fires (permitted or otherwise).

A survey of the existing dust levels was undertaken at three locations, Wollombi Station Homestead), Cerito Station Homestead and on the subject site close to the proposed southern infrastructure area. The equipment at each monitoring location comprised two TSI Dusttrak Aerosol monitors, one configured to record PM_{10} concentrations and the other $PM_{2.5}$ and both set to fifteen minute intervals. To convert between fifteen minute averaging time and 24 hours averaging it was necessary to arithmetically average the 96 fifteen minute measurements making up the twenty four hours. The equipment was located near homesteads in the house compounds at least 4 m from buildings.

Existing atmospheric dust concentrations were measured at Wollombi Station Homestead over a period of two week from 29 July 2011 to 11 August 2011. The dust sampler recorded PM_{10} and $PM_{2.5}$ in fifteen minute intervals and the 24 hour averages were calculated from the samples. The charts of the PM_{10} and $PM_{2.5}$ are shown in Figure 3. The PM_{10} (24 hour) dust concentration levels varied over the monitoring period between 20 µg/m^3 and 40 µg/m^3. The $PM_{2.5}$ (24 hour) dust concentration levels vary between 5 µg/m^3 and 14 µg/m^3.

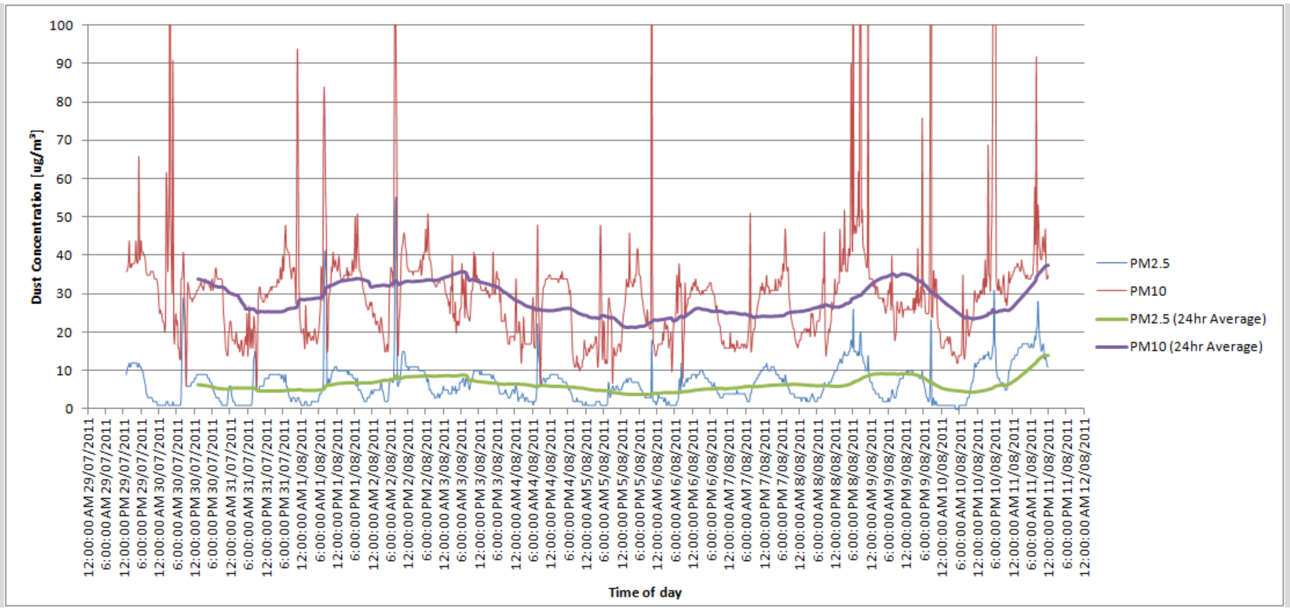

Figure 3: Measured PM_{10} and $PM_{2.5}$ Dust Concentration For Wollombi Station Homestead (R4)

Existing atmospheric dust concentrations were measured at Cerito Station Homestead over a period of 11 days from 29 July 2011 to 8 August 2011. The dust sampler recorded the PM_{10} and $PM_{2.5}$ in fifteen minute intervals and the 24 hour averages were calculated from the samples. The charts of the diurnal distribution of PM_{10} and $PM_{2.5}$ are shown in Figure 4. The PM_{10} (24 hour) dust concentration levels varied over the monitoring period between 14 µg/m^3 and 19 µg/m^3. The $PM_{2.5}$ (24 hour) dust concentration levels vary between 8 µg/m^3 and 14 µg/m^3.

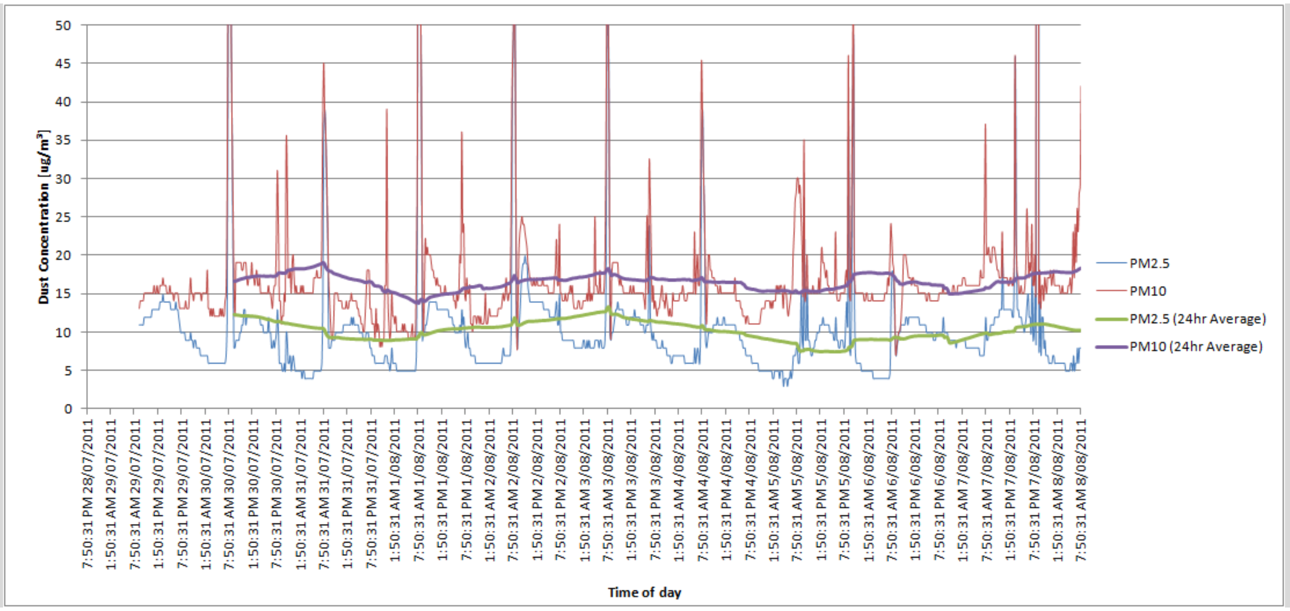

Figure 4: Measured PM_{10} and $PM_{2.5}$ Dust Concentration For Cerito Station Homestead (R5)

Existing atmospheric dust concentrations were measured near the proposed southern mine infrastructure area (MIA-south) over a period of nine days from 29 July 2011 to 6 August 2011. The dust sampler recorded the PM_{10} and $PM_{2.5}$ in fifteen minute intervals and the 24 hour averages were calculated from the samples. The chart of the PM_{10} and $PM_{2.5}$ measured and calculated dust concentrations are shown in Figure 5. The PM_{10} (24 hour) dust concentration levels varied over the monitoring period between 7 µg/m^3 and 17 µg/m^3. The $PM_{2.5}$ (24 hour) dust concentration levels vary between 2 µg/m^3 and 10 µg/m^3.

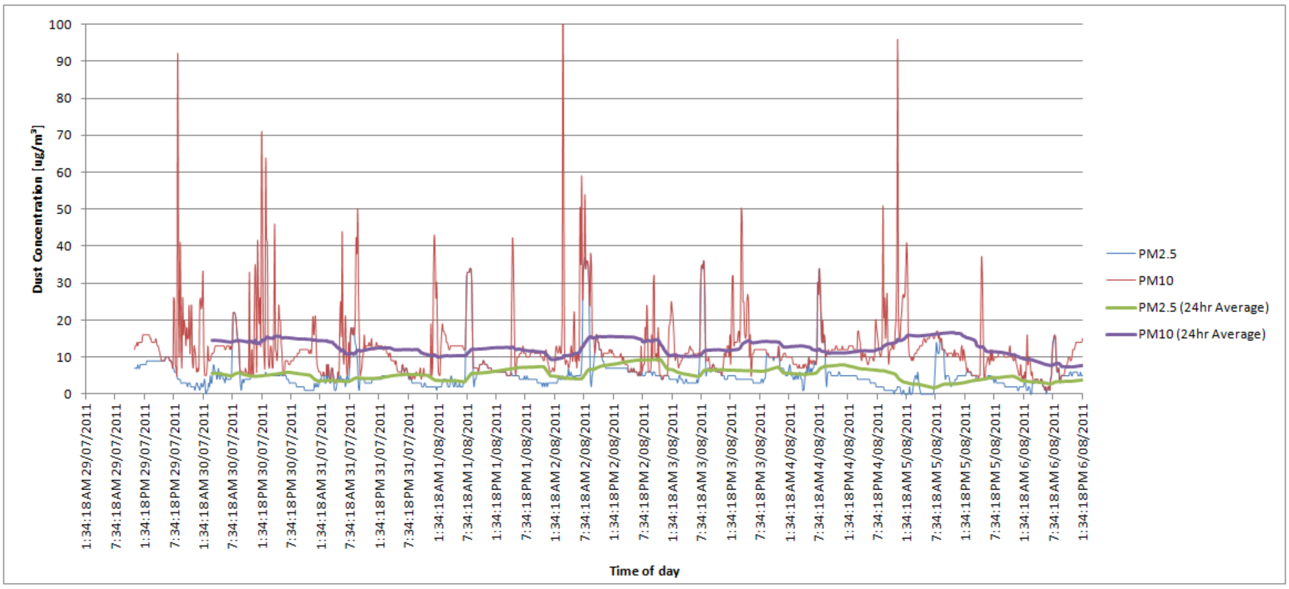

Figure 5: Measured PM_{10} and $PM_{2.5}$ Dust Concentration For MIA - south

Table 2: Summary of the Ambient Atmospheric Dust Concentrations (PM_{10} and $PM_{2.5}$) for Wollombi Station Homestead, Cerito Station Homestead and MIA

Date	**Ambient Dust Concentrations - 24 Hour Average**					
	Wollombi Homestead		**Ceritcerita Station Homestead**		**MIA**	
	$PM_{2.5}$ (µg/m^3)	**PM_{10} (µg/m^3)**	**$PM_{2.5}$ (µg/m^3)**	**PM_{10} (µg/m^3)**	**$PM_{2.5}$ (µg/m^3)**	**PM_{10} (µg/m^3)**
29 July 2011	8[Note 1]	38[Note 1]	12[Note 1]	15[Note 1]	7[Note 1]	15[Note 1]
30 July 2011	5	32	11	18	5	14
31 July 2011	5	28	9	15	5	10
1 Aug 2011	7	32	12	17	6	12
2 Aug 2011	9	35	12	17	8	14
3 Aug 2011	7	28	11	17	6	13
4 Aug 2011	5	24	9	15	5	13
5 Aug 2011	4	25	9	18	4	12
6 Aug 2011	5	25	9	15	4[Note 1]	7[Note 1]
7 Aug 2011	6	26	11	18	-	-
8 Aug 2011	9	38	6	19	-	-
9 Aug 2011	5	30	-	-	-	-
10 Aug 2011	9	35	-	-	-	-
11 Aug 2011	16[Note 1]	39[Note 1]	-	-	-	-
Median	6	31	11	17	5	13
Maximum	16	39	12	19	8	15

Note 1: Averaging period less than 24 hours

It was noted that there was construction/repair works taking place on the railway in the vicinity of Wollombi station. The construction works involved significant earthworks. It is likely that construction works contributed to the higher PM_{10} exposure levels at this location.

The lowest exposure levels recorded were near the MIA. The area surrounding the MIA was covered in lush green pasture at least 0.5m high. This site represents the lowest likely dust exposures. The measurements at the MIA are considered to be representative of the lowest dust levels likely in the region.

Finally, the area surrounding Cerito Station Homestead comprised of mix of bare earth and closely cropped grass (a fire break and working area) surrounding the stock yards. There was some human activity on the site. The measurements at R5 Cerito Station Homestead are adopted in this report as representative of the short-term ambient levels at all homesteads. The $PM_{2.5}$ at the MIA is taken to be representative on the annual average $PM_{2.5}$ for all sites.

The NMA 2007 report provided details of a long-term dust monitoring program near Isaac Plains

Coal Mine. Though the results included some sites near the mine it was found that the average dust deposition was 25 mg/m^2/day and the 20th percentile was 43 mg/m^2/day. For conservatism, and to be representative of the dustiest month a background level of 43 mg/m^2/day has been adopted.

3. Air Quality Criteria

3.1 Environmental Protection (Air) Policy

The Queensland Environmental Protection (Air) Policy 2008 (EPP(Air) 2008) commenced on 1 January 2009. The EPP (Air) 2008 (Part 2 Section 5) aims to achieve the object of the *Environmental Protection Act 1994* (the Act) in relation to Queensland's air environment. The object of the Act is ".. to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development)."

Specifically the EPP (Air) 2008 addresses the environmental values to be enhanced or protected namely—

(a) the qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems; and

(b) the qualities of the air environment that are conducive to human health and wellbeing; and

(c) the qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property; and

(d) the qualities of the air environment that are conducive to protecting agricultural use of the environment.

In order to meet the environmental values, Schedule 1 of the EPP (Air) nominates relevant air quality indicators and goals. Relevant air quality indicators from Schedule 1 are those dealing with particulates, as follows:

a) Total suspended particulate 90 µg/m^3 averaged over a year.

b) $PM_{2.5}$ 8 µg/m^3 averaged over one year.

c) $PM_{2.5}$ 25 µg/m^3 averaged over 24 hours.

d) no greater than 5 days per year where the dust concentration of PM_{10} averaged over 24 hours, or PM_{10}(24 hour), is greater than 50 µg/m^3 (i.e. the 5th highest)

All these indicators are qualities of the air environment that are conducive to human health and wellbeing. The indicators apply at any sensitive or commercial place, such as residences, parks, gardens, schools, shopping precincts, etc.

3.2 EHP – Guidelines

Although the EPP(Air) 2008 is the primary reference for air quality criteria in Queensland, it does not address dust deposition. Dust deposition monitoring is the most common method to measure the level of dustiness in areas surrounding developments. The sampling is conducted in accordance with Australian Standard AS3580.10.1: *Methods for Sampling and Analysis of Ambient Air – Method 10.1: Determination of Particulate Matter – Deposited Matter - Gravimetric Method*. Mine licenses issued by DEHP generally will include consideration of dust deposition air quality..

The relevant guideline for the assessment of air quality in relation to the project is the DEHP's (formerly EPA), "Preparing an Environmental Management Overview Strategy (EMOS) for Non-standard Mining Projects". This guideline requires that the release of dust or particulate matter or both resulting from the mining activity must not cause an environmental nuisance at any sensitive or commercial place. According to the guideline, the maximum permissible measured dust levels relevant to the proposed project comprise:

(a) Dust deposition of 120 mg/m^2/day, averaged over one month; and

(b) PM_{10} 150 µg/m^3 averaged over 24 hours, at a sensitive or commercial place downwind of the operational land.

The PM_{10} criterion has been superseded by the more recent and more stringent EPP(Air) 2008 levels for PM_{10} (Section 3.1).

3.3 National Environmental Protection Measure Air

The National Environmental Protection Measure (Air) 1998 was developed by the National Environment Protection Council. The desired environmental outcome of the measure is to provide ambient air quality that allows for the adequate protection of human health and well-being, refer to Table 3. This goal is the same as that contained in the EPP(Air).

Table 3: NEPM Standards and Goal for PM_{10}

Pollutant	Averaging Period	Concentration	Maximum Allowable Exceedences of Concentration
Particles as PM_{10}	1 day	50 µg/m^3	5 days a year

3.4 Vegetation

The direct physical and chemical effects of dusts on vegetation became apparent only at relatively high surface loads. There are a number of influential factors including inter-alia aerosol properties, vegetation condition as well as the deposition rate. It is not possible to determine the precise nature of a plants response to dust load, however Doley (2006) examined the physical effects of dust on vegetation and suggested that the most sensitive plant functions may be altered with monthly dust loads (deposition) of about 8 g/m^2 (266 mg/m^2/day) for dust with medium diameters of 50 µm.

An assessment of vegetation including the development of vegetation mapping and potential impacts was undertaken as part of the terrestrial ecology component of the EIS.

3.5 Site Specific Air Quality Objectives

Dusts are often described as respirable and inhalable. Respirable dusts are those small enough to penetrate the nose and enter into the lung. Respirable dusts that penetrate past the nose and upper respiratory system are likely to be retained in the body. This involves dusts having an aerodynamic diameter of up to 10 µm. Inhalable dusts are dusts which enter the body but are collected in the nose and upper respiratory system and rejected. Inhalable dusts are those having an aerodynamic diameter of nominally 10 μm and larger.

As a general guide, dusts having diameters of 7 to 10 μm are mostly large enough to be caught by nose and throat. Particles in the range 0.5 to 7 are small enough to reach the lung yet large enough to be retained. Since these dusts remain in the lung they may be hazardous to health and wellbeing.

In summary the adopted air quality objectives for the project (from NEPM, EPP Air and EHP Guidelines) are:

- dust concentration of $PM_{2.5}$ 25 μg/m^3 averaged over 24 hours;
- dust concentration of $PM_{2.5}$ 8 μg/m^3 averaged over a year;
- no greater than 5 days per year where the dust concentration of PM_{10}(24 hours) is greater than 50 μg/m^3;
- total suspended particulate 90 μg/m^3 averaged over a year; and
- dust deposition of 120 mg/m^2/day.

All these objectives (except deposition) are qualities of the air environment that are important to protect human health and wellbeing. The deposition goal (or dust fallout) is for assessing dust nuisance. The indicators apply at any sensitive or commercial place, such as residences, parks, gardens, schools, shopping precincts, etc.

For vegetation a maximum month dust deposition 266 mg/m^2/day is proposed.

4. Air Quality Modelling

4.1 Modelling Methodology

Typically, particulate matter is characterised by its size. The particulate size ranges specified in ambient air criteria are total suspended particulate (TSP), particulate matter below 10 µm (PM_{10}) and particulate matter below 2.5 µm ($PM_{2.5}$). By definition, TSP includes both the PM_{10} and $PM_{2.5}$ fractions, and PM_{10} includes the $PM_{2.5}$ fraction.

Under normal conditions, dust particles with aerodynamic diameters of more than PM_{10} will typically fall out and be deposited onto the ground within several minutes of release.

The PM_{10} and $PM_{2.5}$ dusts do not have a significant settling velocity and will behave in a gaseous fashion, that is, the fall out time is significantly longer than a few minutes. The settling velocity for PM_{10} dust is nominally 5 mm/s while for $PM_{2.5}$ it is 0.5 mm/s. This may be compared with PM_{20} where the settling velocity is approximately 20 mm/s (Baumeister, 1982).

The air quality modelling methodology comprised three phases namely:

(a) preparation of meteorological data;

(b) development of an emissions database using US-EPA AP-42 (2003) 5th Update 2003 and the Australian National Pollution Inventory (NPI) “Emission Estimation Technique Manual for Mining Version 3.1”; and

(c) modelling of the likely downwind ground level concentrations using The Air Pollution Model (TAPM).

The averaging period for ground level concentrations of pollutants are consistent with the relevant averaging periods for air quality indicators and goals in the EPP (Air) 2008 and the National Environmental Protection Measure (NEPM) Air. The ToR indicates that the modelling of PM_{10} is to be conducted for 1-hour, 24-hours and annual averaging periods. All modelling of the dusts is based on a one hour modelling period and the 24-hour an annual average periods are calculated from the one hour modelling results.

4.1.1 Preparation of Meteorological Data

TAPM predicts meteorology and pollutant concentration for a range of pollutants important for air pollution applications. The model consists of coupled prognostic meteorological and air pollution concentration components, eliminating the need to have site-specific meteorological observations. Instead, the model predicts the flows important to local-scale air pollution, such as sea breezes and terrain induced flows, against a background of larger-scale meteorology provided by synoptic analyses.

Some limitations of TAPM include:

- it is not suitable for horizontal domain sizes above approximately 1,000 km by 1,000 km;
- it cannot be used to accurately represent deep atmospheric circulations or extreme weather events (cyclones);
- it cannot be used for very steep terrain because of the use of a terrain following coordinate system in the model. Thus the model cannot represent discontinuities in terrain height (for

example, cliffs or bluffs); and

- it assumes that cloud processes are resolved by the typical inner grid spacing used in the model (i.e. 3km or less). Therefore no large-scale cloud convection parameterisation is included.

These limitations are of minor significance to the modelling of pollution for this study. The area of interest is much smaller than the maximum horizontal domain size. Extreme weather events (such as cyclones) are not of interest from an air pollution perspective. The terrain within the region does not have significant cliffs or bluff bodies and it is expected that the inclusion of large-scale cloud convection would only slightly change the radiation and moisture balances.

TAPM is highly regarded in the scientific community as a suitable tool to develop meteorological data sets for sites without site-specific meteorological observations.

The TAPM meteorological file developed for the site covered the two year period 2004 and 2005. This period was used for modelling since Queensland was generally free from extreme weather events such as cyclones. The years 2004 and 2005 were also towards the end of an extended drought, so the climate is representative of a period likely to high dust exposures.

The general features of winds affecting plume dispersion are illustrated in the wind rose table for the year 2004 and 2005, refer to Table 4 and Appendix 3. Table 4 summarises the wind statistics at a 10 m height on site, as calculated by the TAPM meteorological model. Table 4 shows the frequency of occurrence of winds by direction (corresponding to the eight compass points N, NE, E etc.) and strength in km/h. The value in the table represents the calculated percentage of time wind occurs during the month having the specified direction and wind speed range. It is noted that the predominant wind direction during the year is from the north-east through to the south-east. The representative frequency of Pasquil stability classes for the region is based on data from TAPM. Pasquil stability classes represent the stability of the atmosphere. Table 5 shows the frequency of stability classes for the site. Figure 6 shows the annual windrose for the site. The Figure shows that the most common winds are either from the N to NNE, approximately 23% of the time or from the E to SE, approximately 47% of the time.

Table 4: Windrose for Site (TAPM)

Hourly Average Wind Speed in km/h and Direction [% of Time per month]											
Direction	**1 to 5**	**6 to 10**	**11 to 20**	**21 to 30**	**31 and above**	**Dirn**	**1 to 5**	**6 to 10**	**11 to 20**	**21 to 30**	**31 and above**
January						February					
N	2	15	14	1	0	N	3	13	6	0	0
NE	3	11	5	0	0	NE	2	5	3	0	0
E	3	9	7	0	0	E	3	17	11	0	0
SE	2	4	11	4	0	SE	2	8	11	3	0
S	1	1	2	0	0	S	1	1	2	0	0
SW	1	0	0	0	0	SW	1	2	1	0	0
W	0	0	0	0	0	W	0	1	0	0	0
NW	2	2	2	0	0	NW	1	2	0	0	0
March						April					
N	2	4	3	0	0	N	0	0	0	0	0
NE	1	5	1	0	0	NE	0	0	0	0	0
E	2	15	17	1	0	E	1	5	9	0	0
SE	1	14	18	6	0	SE	0	16	55	10	0
S	0	1	4	0	0	S	0	0	1	0	0
SW	1	1	0	0	0	SW	0	0	1	0	0
W	1	0	1	0	0	W	0	0	0	0	0
NW	0	0	1	0	0	NW	0	0	0	0	0
May						June					
N	1	1	0	0	0	N	0	2	2	0	0
NE	2	2	0	0	0	NE	1	3	1	0	0
E	3	6	6	0	0	E	1	4	5	0	0
SE	2	17	39	0	0	SE	1	16	38	1	0
S	1	6	7	0	0	S	0	4	13	0	0
SW	1	1	3	0	0	SW	1	2	3	0	0
W	0	0	0	0	0	W	0	0	0	0	0
NW	0	0	0	0	0	NW	0	0	0	0	0
July						August					
N	1	1	1	0	0	N	2	6	3	0	0
NE	1	2	0	0	0	NE	2	5	1	0	0
E	2	10	5	0	0	E	3	11	8	1	0
SE	1	15	35	4	0	SE	1	10	23	2	0
S	0	2	12	0	0	S	0	3	10	0	0

Hourly Average Wind Speed in km/h and Direction [% of Time per month]										
Direction	**1 to 5**	**6 to 10**	**11 to 20**	**21 to 30**	**31 and above**	**Dirn**	**1 to 5**	**6 to 10**	**11 to 20**	**21 to 30**	**31 and above**
SW	0	1	2	0	0	SW	1	2	4	0	0
W	0	0	0	0	0	W	1	1	0	0	0
NW	0	1	1	0	0	NW	1	1	0	0	0
September						October					
N	2	7	13	1	0	N	3	18	37	0	0
NE	3	10	5	0	0	NE	3	8	4	0	0
E	5	16	9	0	0	E	2	6	7	0	0
SE	1	6	8	0	0	SE	1	3	1	0	0
S	1	2	4	0	0	S	0	1	0	0	0
SW	0	1	3	0	0	SW	0	1	1	0	0
W	0	1	0	0	0	W	0	1	0	0	0
NW	1	1	0	0	0	NW	0	1	1	0	0
November						December					
N	2	13	23	0	0	N	2	15	28	1	0
NE	3	14	10	0	0	NE	3	11	9	0	0
E	3	13	8	0	0	E	2	7	7	0	0
SE	1	5	2	1	0	SE	1	2	2	0	0
S	0	0	0	0	0	S	0	1	0	0	0
SW	0	0	0	0	0	SW	1	0	0	0	0
W	0	0	0	0	0	W	0	1	1	0	0
NW	1	1	0	0	0	NW	1	2	2	0	0

Table 5: Frequency of Stability Classes at Site

Stability Class	***Description***	***Frequency of Occurrence (%)***
A	Very unstable	3
B	Moderately unstable	11
C	Slightly unstable	23
D	Neutral	12
E	Slightly stable	25
F	Stable	26

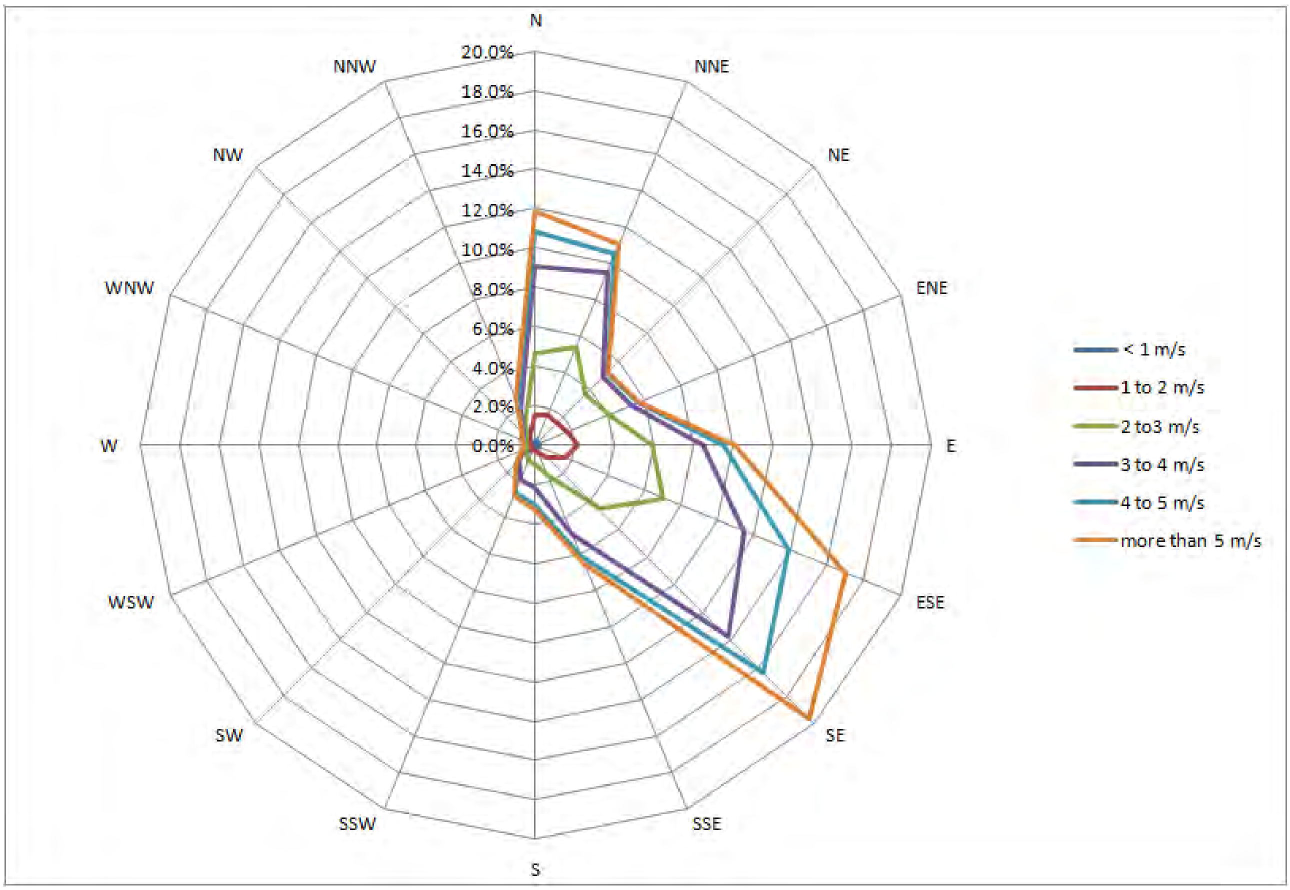

Figure 6: Annual Windrose for Site (TAPM Years 2004 and 2005)

4.1.2 Development of the Emissions Database

Construction Phase

The main components of the project construction phase include construction of the following:

- an internal road network for access to infrastructure and mining areas as well as development of heavy vehicle haul roads;
- a railway lines, rail loops and rail loaders;
- CHPPs;
- various supporting infrastructure including administration and workshops;
- materials handling infrastructure;
- power supply and reticulation infrastructure; and,
- water supply and management infrastructure.

The construction of these features will involve vegetation clearance and some earthworks and at a level of activity several orders of magnitude less than the operational coal mine. Dust emissions will be the main emissions during construction. The construction works are relatively minor in comparison to emissions from the operational mine and take place in similar locations to the operating mine. The construction phase has not been modelled since the construction phase dust emissions are predicted to be substantially lower than the emissions modelled for an operational mine. Conservatively, the assessment of the operational mine applies for the construction phase.

Operational Phase

The development of an accurate and representative emissions database has been primarily based on the National Pollution Inventory Emission Estimation Technique Manual for Mining Version 3.1 (NPI 2012) as well as US-EPA AP-42 (2003) 5th Update. The main mining activities and processes that produce, or could produce, dust emissions were identified for the project operations and throughput. Flowcharts for handling of overburden, interburden, coal and waste rock were developed and an emission factor (from NPI) was attributed to every handling point, handling activity and transport section. In addition, emissions for exposed surfaces were identified and included in the database.

All emission factor equations and default emission factors in the NPI document are for uncontrolled emissions. However this database has included the control effects from rainfall and from water trucks on haul roads. The effectiveness of dust controls has also been extracted from the NPI document. Several dust control activities have been provided at key emission points, as per Table 6. The NPI 2012 describes standard (level 1) and enhanced (level 2) watering rates for dust control.

Whilst there may be some onsite testing required to assess the actual water application rate, for the purposes of this assessment modelling assumes that enhanced (level 2) watering provides 75% dust control efficiency and standard (level 1) watering provides 50% dust control efficiency compared to no watering. Level 2 control may comprise careful loading of haul trucks (designed to avoid spillage), timely spillage control or spot watering of spills rather than a generalised increase in the watering rate for all hours and all roads.

Table 6: Dust Control for Mine (Source NPI 2012)

Dust Source	Control	Effectiveness of Control
Pit retention factor	Natural ability of pits to retain dust	50% retention for TSP, 5% retention for PM_{10} and $PM_{2.5}$
Haul roads	Enhanced watering (level 2)	Up to 75%, see discussion
Haul roads	Standard watering (level 1)	Up to 50%, see discussion
Haul roads	Chemical	Up to 95% control
Spray cannons	During overburden dumping by truck	Up to 50% control

The dust emissions were calculated for every hour of the day for the two years of the modelling simulation. Calculating emissions is a four-step process:

1. Identify sources of emissions.
2. Obtain information on the scale of the activity.

3. Apply the relevant emission factor equation or default emission factor from NPI 2012 to the activity data (see Appendix 2).
4. Where applicable, apply control efficiency reduction factors based on rainfall or water truck use or control options mentioned in Table 6.

The steps to establish the moisture content of overburden and undisturbed coal due to rain comprises:

1. the TAPM model was initially run in meteorology mode only and an hourly meteorological file for the entire year extracted. This TAPM calculated and generated file containing, inter alia, wind speed and rainfall for each hour;
2. if more than 0.5 mm of rainfall occurred during that hour then the moisture content of the ground is assumed to be 15%;
3. following rainfall, moisture content of the overburden reduced by 1% per hour until returning to the relevant dry season or wet season moisture content; and
4. otherwise the assumed moisture content for the ground or overburden is 10% during the wet season and 2% during the dry season.

The steps to establish the moisture content of roads and haulage routes due to rain and water truck operations comprises:

1. the TAPM model was initially run in meteorology mode only and an hourly meteorological file for the entire year extracted. This TAPM calculated and generated file containing, inter alia, wind speed and rainfall for each hour;
2. if there was at least 0.5mm of rain during that hour then the level of dust control is 75% (rain implies cloud cover and lower evaporation and as such is not the same case as for watering); and
3. for all other hours the level of dust control varies randomly between either 25% and 75% enhanced (level 2) dust control or 0% and 50% for standard dust control. The randomised level of dust control was adopted to account for various issues such as spot watering adopted on the inclines and declines in the pit and high evaporation rates during periods of the day.

Rather than adopt a constant emission rate for the entire modelling period, the model uses a methodology that provides an emission rate from every operation, for each hour of the simulation period and includes the effects of dust emission controls due to rainfall and the operation of water trucks. In addition, the emissions from wind-generated dusts have also been included, with control only provided by rainfall.

The reported emission database excludes the pit retention factor. Heavier fractions of dust tend to be trapped by the pit and the emission reduction factor specified in the NPI 2012 is 50% for TSP, 5% for PM_{10} and 5% for $PM_{2.5}$.

The main dust sources comprise the dragline(s), trucks and shovels, unpaved roads, dumping ROM coal, dumping and spreading overburden and loading trucks and trains. Since the pit is progressively backfilled as mining progresses eastwards, waste emplacement will take place in the pit. However, the emplacement and re-profiling of waste rock also takes place on waste rock emplacements elevated above the pit. Once final heights of the waste rock emplacements are reached they will be progressively rehabilitated.

Three main cases are addressed representing Year 5, Year 17 and Year 36 from opening.

The first year modelled is during the initial phase of the mine, Year 5 when the projected waste rock is 142.2 million bank cubic meters (Mbcm). The ROM coal for this year is approximately 15 Mtpa. The mining is taking place in West Pit 1 and South Pit 2 is in an early development phase with out of pit dumping of overburden.

The second modelling year (Year 17) includes the initial stage of the northern pits and the southern pits are well developed with in-pit placement of overburden. The northern MIA is operational. The waste rock is approximately 125.8 Mbcm. The ROM coal for this year is approximately 15 Mtpa.

The third modelling year (Year 36) includes the two eastern pits. The northern pit and northern ROM has ceased operation. The projected waste rock volume is 166.1 Mtpa and ROM coal is approximately 15 Mtpa.

All cases relate to the maximum rate of handling of waste rock for the respective mining phases. During the first 16 years of the mine's life there is only one case where the total waste rock exceeds 142.2 Mbcm, with the typical mining rate being less than 120 Mbcm.

A description of modelling years is contained in Table 7. The annual emission rates are contained in Table 8 for the individual dust sources.

Finally, the emissions database incorporates a contingency factor. For the purposes of calculating the emission rates, the annual mining and handling of overburden and coal is assumed to take place over 48 weeks rather than 52 weeks, effectively increasing the emissions rates by 9%. This is to account for minor fluctuations in production, production stoppages and minor emission sources (e.g. drill and blast) not accounted for in the emissions database.

By adopting this methodology the modelling inherently addresses the worst case emissions. Specifically the modelling contains the following:

1. The models have been based on the maximum production rate likely during the life of the mine.
2. The model comprises 52 weeks of operation with a 9% contingency factor.
3. The level of dust control is randomly varied for each hour throughout the year, from effective to not very effective control. This is particularly relevant to the watering of roads since it is possible watering is not applied as often as required for the heat load or truck usage rates. Hence the modelling incorporates a less than optimum dust control throughout the modelling period and in doing so it implies that worst-case emissions (low levels of dust control) are also incorporated in the modelling.
4. The modelling is based on a two year modelling simulation, specifically years 2004 and 2005. These were years that were in the middle of a six year period of below average rainfall for Queensland, with better than average rainfall returning and remaining since 2007. The period was also hotter than the long-term average for Queensland and with lower than average high wind events. All of these considerations imply that adopting the years 2004 and 2005 for the purpose of the simulation will lead to 'worst case' meteorology.

Hence, all aspects of the modelling has been designed to achieve a realistic worst-case down-wind atmospheric dust concentrations for modelling dust emissions from the mine.

Table 7: Modelling Cases

Item	Year 5	Year 17	Year 36
Annual ROM Coal (MTPA)	15	15	15
Waste rock (MBCM)	142.2	125.8	166.1
In pit operations	West pit 1 and South Pit 1 operational Dragline in south pit 1 Excavator on overburden Excavator on coal Dump trucks to overburden dump Haul trucks to ROM (coal) Wind erosion	West pit 2, South pit 1, South Pit 2, North pit 1operational Dragline in South pit 2 Excavator on overburden Excavator on coal Dump trucks to overburden dump Haul trucks to ROM (coal) Wind erosion	West pit 3, South pit 2, East pit 1, East pit 2 operational Dragline in South pit 2 Excavator on overburden Excavator on coal Dump trucks to overburden dump Haul trucks to ROM (coal) Wind erosion
Out of pit operations	Southern infrastructure area Dragline to waste rock emplacements Dump trucks to waste rock emplacements Haul trucks to ROM (coal) CHPP Rail loader Wind erosion Stockpiles	Both northern and southern infrastructure areas Dragline to waste rock emplacements Dump trucks to waste rock emplacements Haul trucks to ROM (coal) CHPP (2) Rail loader (2) Wind erosion Stockpiles	Southern infrastructure area Dragline to waste rock emplacements Dump trucks to waste rock emplacements Haul trucks to ROM (coal) CHPP Rail loader Wind erosion Stockpiles

Table 8: Dust Emissions for Main Dust Activities in Tonnes/Annum (Excluding Pit retention factor and including Dust Controls)

Operation	Location	Dust Emissions Per Activity Per Location in Tonnes/Annum											
		Yr 5 standard dust controls			Yr 5 enhanced dust controls			Yr17 enhanced dust controls			Yr36 enhanced dust controls		
		$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Dragline	SP1	526.0	4,208.2	9,711.3	526.0	4,208.2	9,711.3	526.0	4,208.2	9,711.3	635.9	5,087.5	11,740.4
Excavator on overburden	SP1	46.9	374.9	781.1	46.9	374.9	781.1	72.5	580.4	1,209.2	37.6	300.6	626.3
	SP2	-	-	-	-	-	-	159.5	1,276.2	2,658.7	-	-	-
	WP1	270.1	2,160.4	4,500.9	270.1	2,160.4	4,500.9	-	-	-	-	-	-
	WP2	-	-	-	-	-	-	159.0	1,271.8	2,649.6	99.9	799.1	1,664.7
	WP3	-	-	-	-	-	-	-	-	-	61.5	491.8	1,024.7
	EP1	-	-	-	-	-	-	-	-	-	282.9	2,262.8	4,714.2
	EP2	-	-	-	-	-	-	-	-	-	105.4	843.2	1,756.7
	NP1	-	-	-	-	-	-	71.6	572.6	1,192.9	-	-	-
Excavator on coal	SP1	17.5	279.5	578.9	17.5	279.5	578.9	34.9	279.5	578.9	27.9	223.6	463.1
	SP2	-	-	-	-	-	-	8.7	69.9	144.7	-	-	-
	WP1	34.9	139.7	289.5	34.9	139.7	289.5	-	-	-	-	-	-
	WP2	-	-	-	-	-	-	8.7	69.9	144.7	8.7	69.9	144.8
	WP3	-	-	-	-	-	-	-	-	-	8.7	69.9	144.8
	EP1	-	-	-	-	-	-	-	-	-	6.5	51.8	107.3
	EP2	-	-	-	-	-	-	-	-	-	8.7	69.9	144.8

Operation	Location	Dust Emissions Per Activity Per Location in Tonnes/Annum											
		Yr 5 standard dust controls			Yr 5 enhanced dust controls			Yr17 enhanced dust controls			Yr36 enhanced dust controls		
		$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
	NP1	-	-	-	-	-	-	8.7	69.9	144.7	-	-	-
Dump truck overburden	SP1	81.5	652.3	2,636.3	65.1	520.5	2,103.6	24.8	197.8	551.9	24.4	194.8	787.5
	SP2	-	-	-	-	-	-	81.9	652.3	1,820.3	-	-	-
	WP1	235.1	1,880.8	7,601.6	187.6	1,500.8	6,065.6	-	-	-	-	-	-
	WP2	-	-	-	-	-	-	108.8	866.7	2,418.7	129.7	1,037.4	4,192.9
	WP3	-	-	-	-	-	-	-	-	-	-	-	-
	EP1	-	-	-	-	-	-	-	-	-	367.3	2,938.6	11,877.0
	EP2	-	-	-	-	-	-	-	-	-	136.8	1,094.7	4,424.4
	NP1	-	-	-	-	-	-	36.8	292.7	816.7	-	-	-
Haul truck coal travelling	SP1 to CHPP	40.5	324.0	1,309.4	32.3	258.5	1,044.8	81.0	648.1	2,619.4	64.0	512.2	2,070.0
	SP2 to CHPP	-	-	-	-	-	-	32.4	259.2	1,047.8	-	-	-
	WP1 to CHPP	81.0	647.9	2,618.8	64.6	517.0	2,089.6	-	-	-	-	-	-
	WP2 to CHPP	-	-	-	-	-	-	20.3	162.0	654.8	16.7	133.4	539.0
	WP3 to CHPP	-	-	-	-	-	-	-	-	-	13.4	106.9	432.1
	EP1	-	-	-	-	-	-	-	-	-	9.9	79.1	319.6
	EP2	-	-	-	-	-	-	-	-	-	20.0	160.0	646.7
	NP1 to CHPP2	-	-	-	-	-	-	16.2	129.6	523.9	-	-	-
Bulldozer on coal	SP1	22.1	177.1	555.9	22.1	177.1	555.9	106.3	850.2	2,668.3	106.3	850.2	2,668.3
	SP2	-	-	-	-	-	-	53.1	425.1	1,334.2	-	-	-

Operation	Location	Dust Emissions Per Activity Per Location in Tonnes/Annum											
		Yr 5 standard dust controls			Yr 5 enhanced dust controls			Yr17 enhanced dust controls			Yr36 enhanced dust controls		
		$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
	WP1	22.1	177.1	555.9	22.1	177.1	555.9	-	-	-	-	-	-
	WP2	-	-	-	-	-	-	53.1	425.1	1,334.2	53.1	425.1	1,334.2
	WP3	-	-	-	-	-	-	-	-	-	53.1	425.1	1,334.2
	EP1	-	-	-	-	-	-	-	-	-	53.1	425.1	1,334.2
	EP2	-	-	-	-	-	-	-	-	-	53.1	425.1	1,334.2
	NP1	-	-	-	-	-	-	53.1	425.1	1,334.2	-	-	-
Truck dumping coal	CHPP	15.0	125.8	299.5	15.0	125.8	299.5	17.5	146.7	349.4	17.3	145.5	346.4
Truck dumping overburden	SP1	42.2	335.7	5,401.1	42.2	335.7	5,401.1	39.6	315.1	879.4	6.7	53.5	149.2
	SP2	-	-	-	-	-	-	87.0	692.9	1,933.6	-	-	-
	WP1	243.1	1,935.4	5,401.1	243.1	1,935.4	5,401.1	-	-	-	-	-	-
	WP2	-	-	-	-	-	-	86.7	690.5	1,927.0	17.8	142.1	396.6
	WP3	-	-	-	-	-	-	-	-	-	11.0	87.5	244.1
	EP1	-	-	-	-	-	-	-	-	-	50.5	402.5	1,123.2
	EP2	-	-	-	-	-	-	-	-	-	18.8	150.0	418.6
	NP1	-	-	-	-	-	-	39.0	310.9	867.6	-	-	-
Drilling	SP1	0.4	2.8	5.4	0.4	2.8	5.4	0.2	1.4	2.7	0.1	1.1	2.1
	SP2	-	-	-	-	-	-	0.2	1.4	2.7	-	-	-
	WP1	0.4	2.8	5.4	0.4	2.8	5.4	-	-	-	-	-	-
	WP2	-	-	-	-	-	-	0.2	1.4	2.7	0.1	1.1	2.1

Operation	Location	Dust Emissions Per Activity Per Location in Tonnes/Annum											
		Yr 5 standard dust controls			Yr 5 enhanced dust controls			Yr17 enhanced dust controls			Yr36 enhanced dust controls		
		$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
	WP3	-	-	-	-	-	-	-	-	-	0.1	1.1	2.1
	EP1	-	-	-	-	-	-	-	-	-	0.1	1.1	2.1
	EP2	-	-	-	-	-	-	-	-	-	0.1	1.1	2.1
	NP1	-	-	-	-	-	-	0.2	1.4	2.7	-	-	-
Blasting	SP1	27.1	216.5	416.3	27.1	216.5	416.3	12.3	98.1	188.7	12.3	98.0	188.5
	SP2	-	-	-	-	-	-	12.3	98.1	188.7	-	-	-
	WP1	27.1	216.5	416.3	27.1	216.5	416.3	-	-	-	-	-	-
	WP2	-	-	-	-	-	-	12.3	98.1	188.7	12.3	98.0	188.5
	WP3	-	-	-	-	-	-	-	-	-	12.3	98.0	188.5
	EP1	-	-	-	-	-	-	-	-	-	12.3	98.0	188.5
	EP2	-	-	-	-	-	-	-	-	-	12.3	98.0	188.5
	NP1	-	-	-	-	-	-	12.3	98.1	188.7	-	-	-
Graders	SP1	5.2	41.3	127.7	5.2	41.3	127.7	10.6	84.6	261.9	8.8	70.5	218.3
	SP2	-	-	-	-	-	-	5.3	42.3	131.0	-	-	-
	WP1	2.6	20.6	63.8	2.6	20.6	63.8	-	-	-	-	-	-
	WP2	-	-	-	-	-	-	5.3	42.3	131.0	4.4	35.3	109.1
	WP3	-	-	-	-	-	-	-	-	-	4.4	35.3	109.1
	EP1	-	-	-	-	-	-	-	-	-	4.4	35.3	109.1
	EP2	-	-	-	-	-	-	-	-	-	4.4	35.3	109.1

Operation	Location	Dust Emissions Per Activity Per Location in Tonnes/Annum											
		Yr 5 standard dust controls			Yr 5 enhanced dust controls			Yr17 enhanced dust controls			Yr36 enhanced dust controls		
		$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
	NP1	-	-	-	-	-	-	5.3	42.3	131.0	-	-	-
Loading stockpiles	CHPP	4.9	50.9	119.8	4.9	50.9	119.8	5.7	59.4	139.7	5.6	58.9	138.6
Unloading stockpiles	CHPP	4.9	50.9	119.8	4.9	50.9	119.8	5.7	59.4	139.7	5.6	58.9	138.6
Loading trains	CHPP	0.4	3.4	8.0	0.4	3.4	8.0	0.7	5.9	14.0	0.7	5.9	13.9
Bulldozer on overburden	SP1	26.2	209.3	889.4	26.2	209.3	889.4	19.6	157.0	667.1	21.8	174.4	741.2
	SP2	-	-	-	-	-	-	8.7	69.8	296.5	-	-	-
	WP1	26.2	209.3	889.4	26.2	209.3	889.4	-	-	-	-	-	-
	WP2	-	-	-	-	-	-	10.9	87.2	370.6	8.7	69.7	296.4
	WP3	-	-	-	-	-	-	-	-	-	8.7	69.7	296.4
	EP1	-	-	-	-	-	-	-	-	-	8.7	69.7	296.4
	EP2	-	-	-	-	-	-	-	-	-	8.7	69.7	296.4
	NP1	-	-	-	-	-	-	8.7	69.8	296.5	-	-	-
Wind erosion	SP1	4.4	34.9	69.8	4.4	34.9	69.8	4.4	34.9	69.8	4.4	34.9	69.8
	SP2	-	-	-	-	-	-	4.4	34.9	69.8	-	-	-
	WP1	4.4	34.9	69.8	4.4	34.9	69.8	-	-	-	-	-	-
	WP2	-	-	-	-	-	-	4.4	34.9	69.8	4.4	34.9	69.8
	WP3	-	-	-	-	-	-	-	-	-	4.4	34.9	69.8
	EP1	-	-	-	-	-	-	-	-	-	4.4	34.9	69.8
	EP2	-	-	-	-	-	-	-	-	-	4.4	34.9	69.8

Operation	Location	Dust Emissions Per Activity Per Location in Tonnes/Annum											
		Yr 5 standard dust controls			Yr 5 enhanced dust controls			Yr17 enhanced dust controls			Yr36 enhanced dust controls		
		$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
	NP1	-	-	-	-	-	-	4.4	34.9	69.8	-	-	-
	CHPP	0.9	7.0	14.0	0.9	7.0	14.0	0.4	3.5	7.0	0.9	7.0	14.0

4.1.3 Dispersion Model

TAPM was adopted as the dispersion model for the project. According to Hurley *et al*. (2005), air pollution predictions for environmental impact assessments usually use Gaussian plume/puff models driven by observationally-based meteorological inputs. An alternative approach is to use prognostic meteorological and air pollution models, which have many advantages over the Gaussian approach and are a viable tool for performing year-long simulations. TAPM performs well for general dispersion in complex rural conditions. In particular, TAPM performs very well for the prediction of extreme pollution statistics, important for environmental impact assessments and for particulates.

TAPM V3 was used to determine the downwind ground level pollutant concentrations. It is designed to predict ground-level concentrations or dry deposition of pollutants emitted from one or more sources, which may comprise either stacks, area sources, volume sources, line sources or any combination of these.

The sources in the TAPM model comprised the in-pit sources, the out-of pit sources, haul road1, and the CHPP (up to 2) and plant. All these sources were modelled as volume sources having dimensions similar to the extent of the source. The roads were modelled as line sources.

The in-pit sources were modelled as a number of small volume source having a footprint encompassing the open cut mining area and a height of 80 m (above the natural surface). Similarly the waste rock emplacements were also modelled as a number of volume sources having a height of 60 m (above the natural terrain). The CHPP (including coal stockpiles and rail loader) and have plan dimensions consistent with the dimensions of the sources and a height of 10 m (above natural ground levels).

The roads were modelled as line sources with a vertical height of 10 m for roads.

The innermost meteorological grid was based on a 1 km by 1 km grid and the domain is 50 km by 50 km. The pollution grid was reduced to 500m by 500m grid covering the entire innermost domain. Test runs were conducted using a 250 m grid, however computer run times were excessively long and the predicted downwind concentrations varied marginally. All modelling, for dust was carried out using volume sources and line sources. The lagrangian particle mode (LPM) in TAPM is only relevant to point sources. Since the model doesn't have point sources the model only uses the Eulerian grid mode.

4.2 Air Quality Results

The calculated dust emissions described in Section 4.1.2 were included in the TAPM model at the appropriate locations. The likely dust levels due to the operation of the mine at each nearby sensitive receptor have been determined and these are shown in Table 9 for Year 5, Table 10 for Year 17 and Table 11 for Year 36.

The calculated dust deposition and concentration contours are contained in:

- Figure 7: Year 5 - Maximum $PM_{2.5}$(24 hour) with Standard Dust Controls
- Figure 8: Year 5 - $PM_{2.5}$ (annual average) with Standard Dust Controls
- Figure 9: Year 5 - 5th highest PM_{10}(24 hour) with Standard Dust Controls
- Figure 10: Year 5 - TSP (annual average) with Standard Dust Controls
- Figure 11: Year 5 - Dust deposition (maximum month) with Standard Dust Controls
- Figure 12: Year 5 - Maximum PM2.5 (24 hour) With Enhanced Dust Controls
- Figure 13: Year 5 - $PM_{2.5}$(annual average) With Enhanced Dust Controls
- Figure 14: Year 5 - 5th highest PM_{10}(24 hour) with Enhanced Dust Controls
- Figure 15: Year 5 - TSP (annual average) with Enhanced Dust Controls
- Figure 16: Year 5 - Dust deposition (maximum month) with Enhanced Dust Controls
- Figure 17: Year 17 - Maximum $PM_{2.5}$ (24 hour) With Enhanced Dust Controls
- Figure 18: Year 17 - $PM_{2.5}$(Annual Average) with Enhanced Dust Controls
- Figure 19: Year 17 - 5th Highest PM_{10}(24 hour) with Enhanced Dust Controls
- Figure 20: Year 17 - TSP (Annual Average) with Enhanced Dust Controls
- Figure 21: Year 17 - Dust Deposition (maximum month) with Enhanced Dust Controls
- Figure 22: Year 36 - Maximum $PM_{2.5}$(24 hour) - With Enhanced Dust Controls
- Figure 23: Year 36 - $PM_{2.5}$(Annual average) - With Enhanced Dust Controls
- Figure 24: Year 36 - PM_{10}(24 hour) 5th Highest - With Enhanced Dust Controls
- Figure 25: Year 36 - TSP (Annual Average) With Enhanced Dust Controls
- Figure 26: Year 36 - Dust Deposition (Maximum Month) With Enhanced Dust Controls

The predicted dust concentration/deposition in Table 9 to Table 11 and Figure 7 to Figure 26 include the assumed background levels.

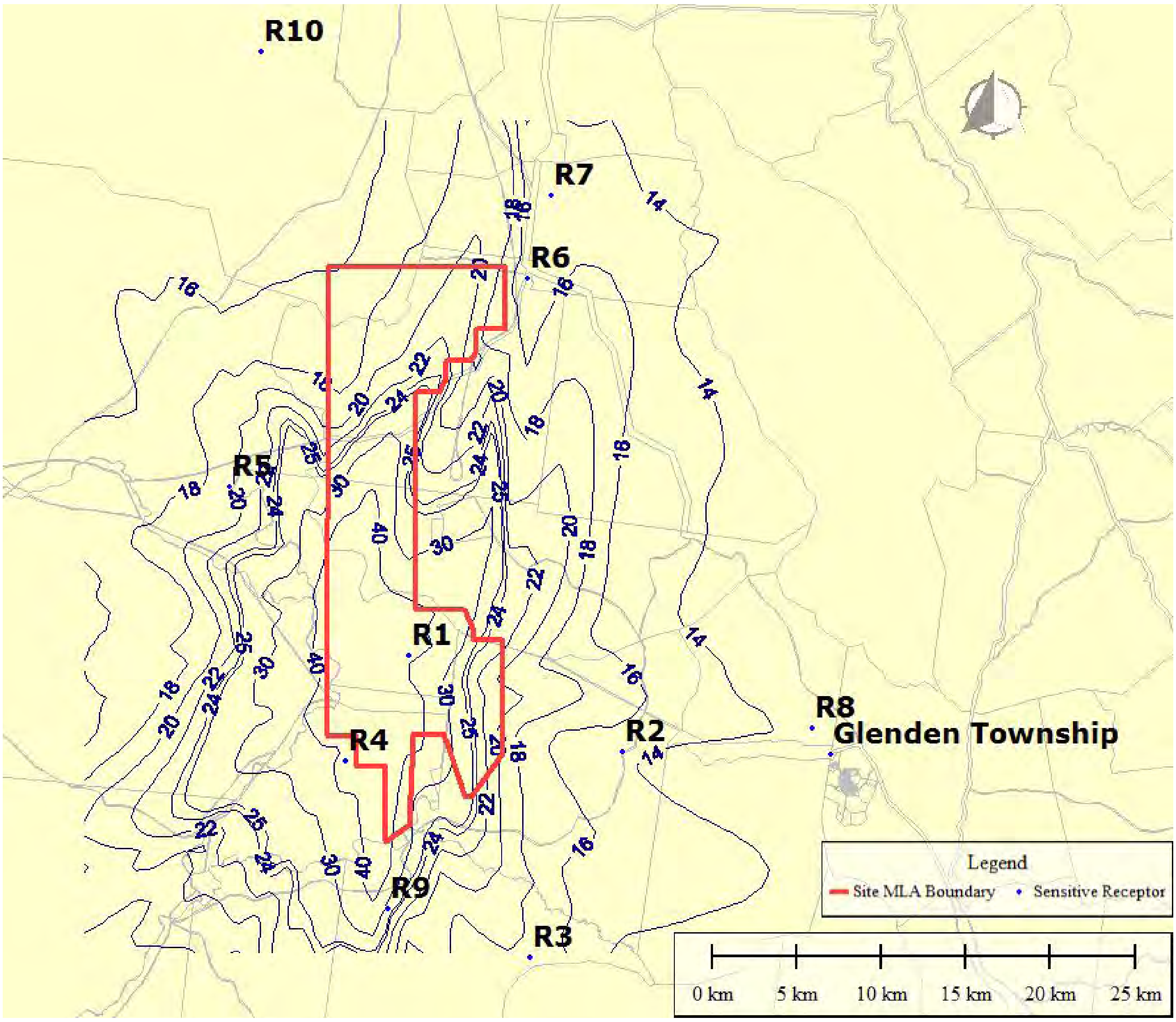

Figure 7: Year 5 - Maximum $PM_{2.5}$(24 hour) with Standard Dust Controls [$\mu g/m^3$]

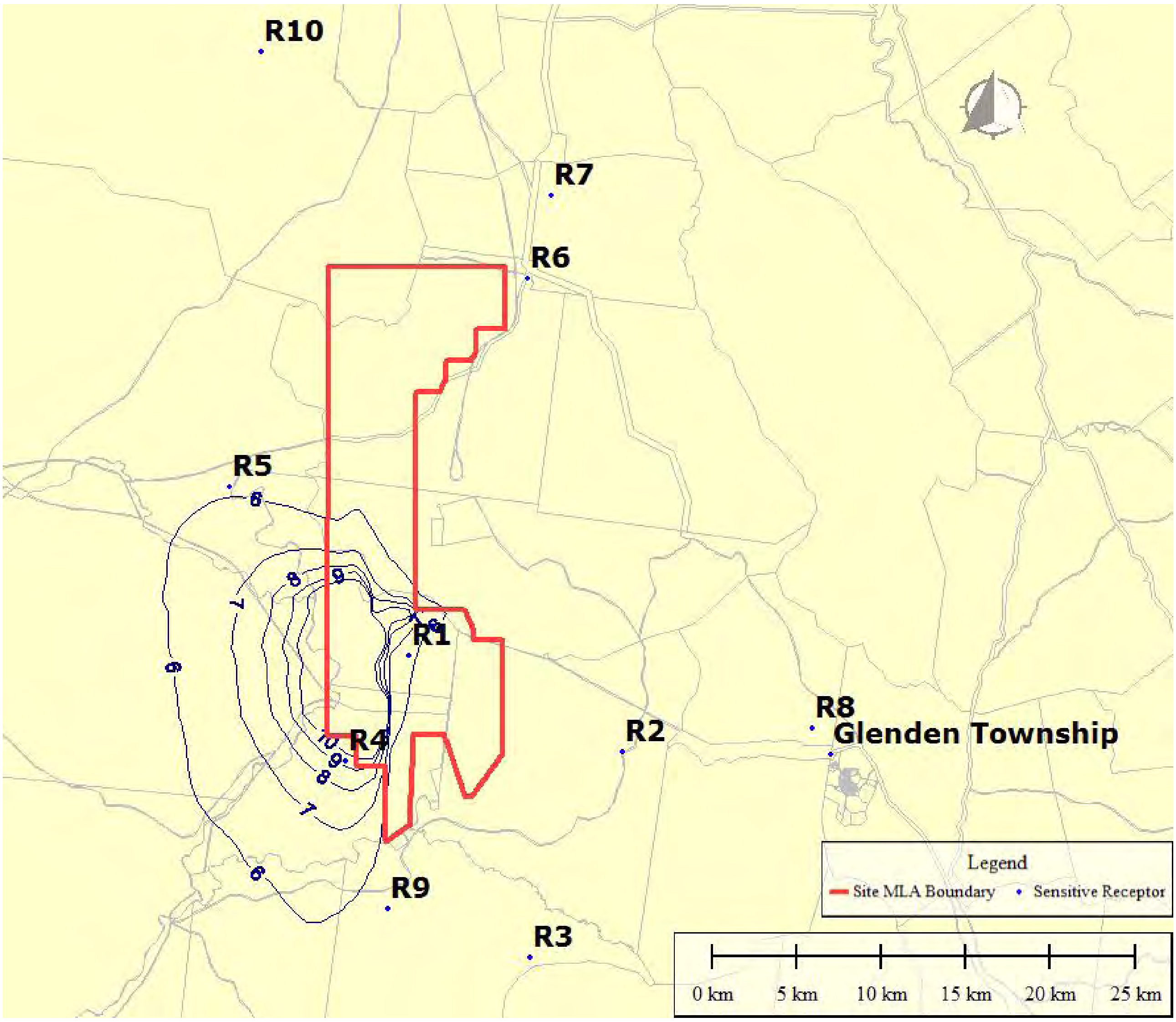

Figure 8: Year 5 - $PM_{2.5}$ (annual average) with Standard Dust Controls [µg/m³]

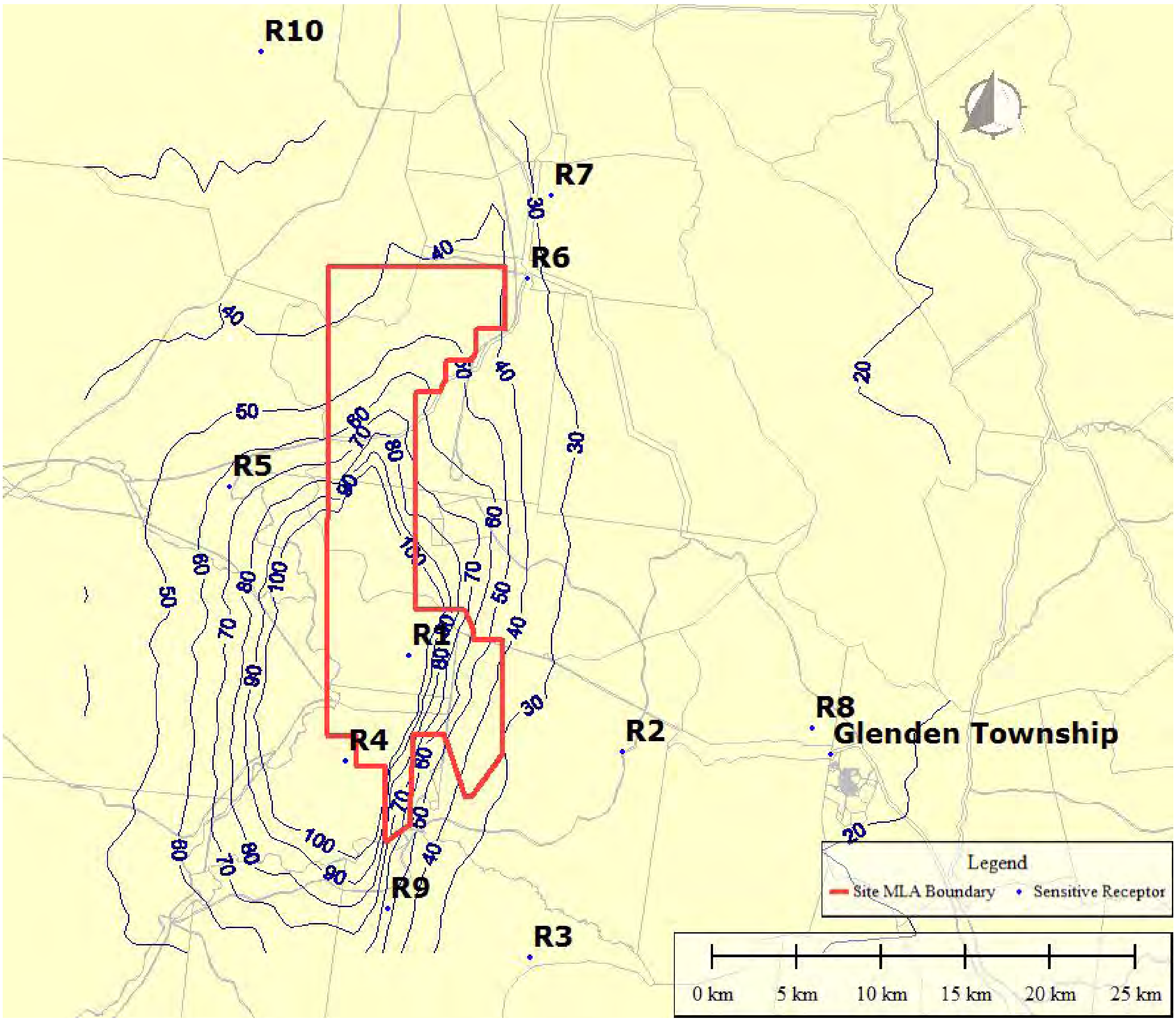

Figure 9: Year 5 - 5th highest PM_{10}(24 hour) with Standard Dust Controls [µg/m³]

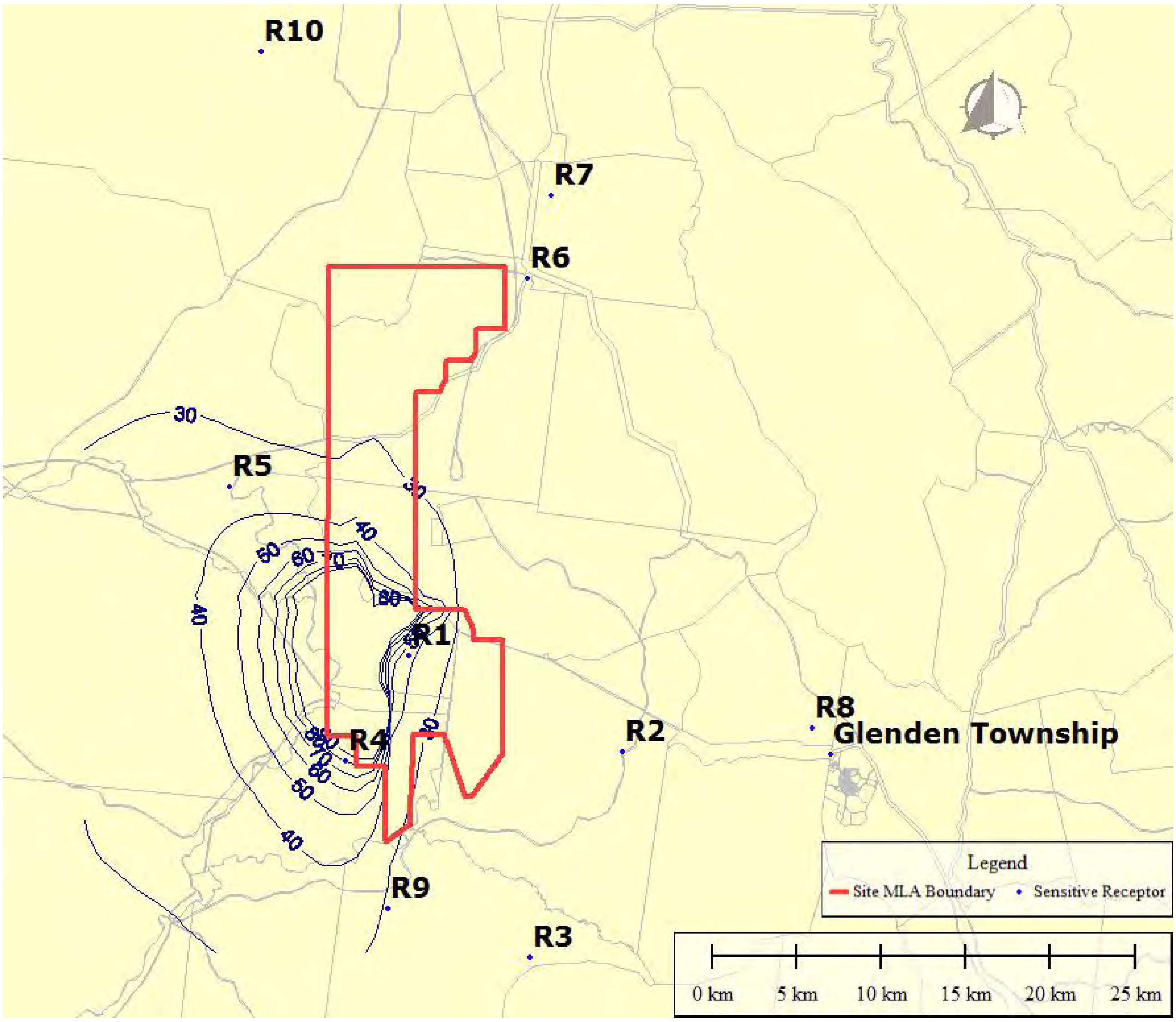

Figure 10: Year 5 - TSP (annual average) with Standard Dust Controls [µg/m³]

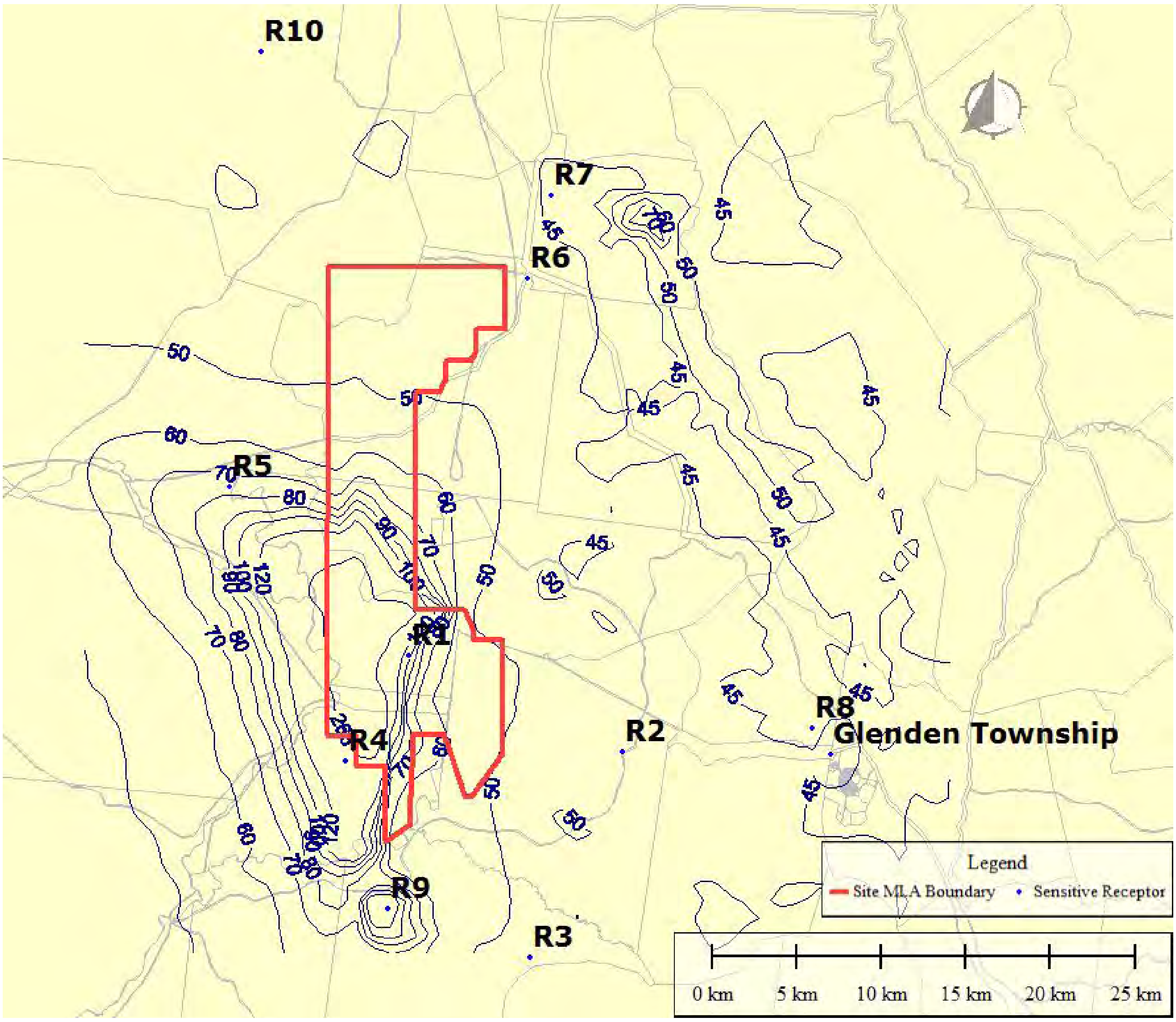

Figure 11: Year 5 - Dust deposition (maximum month) with Standard Dust Controls [mg/m²/day]

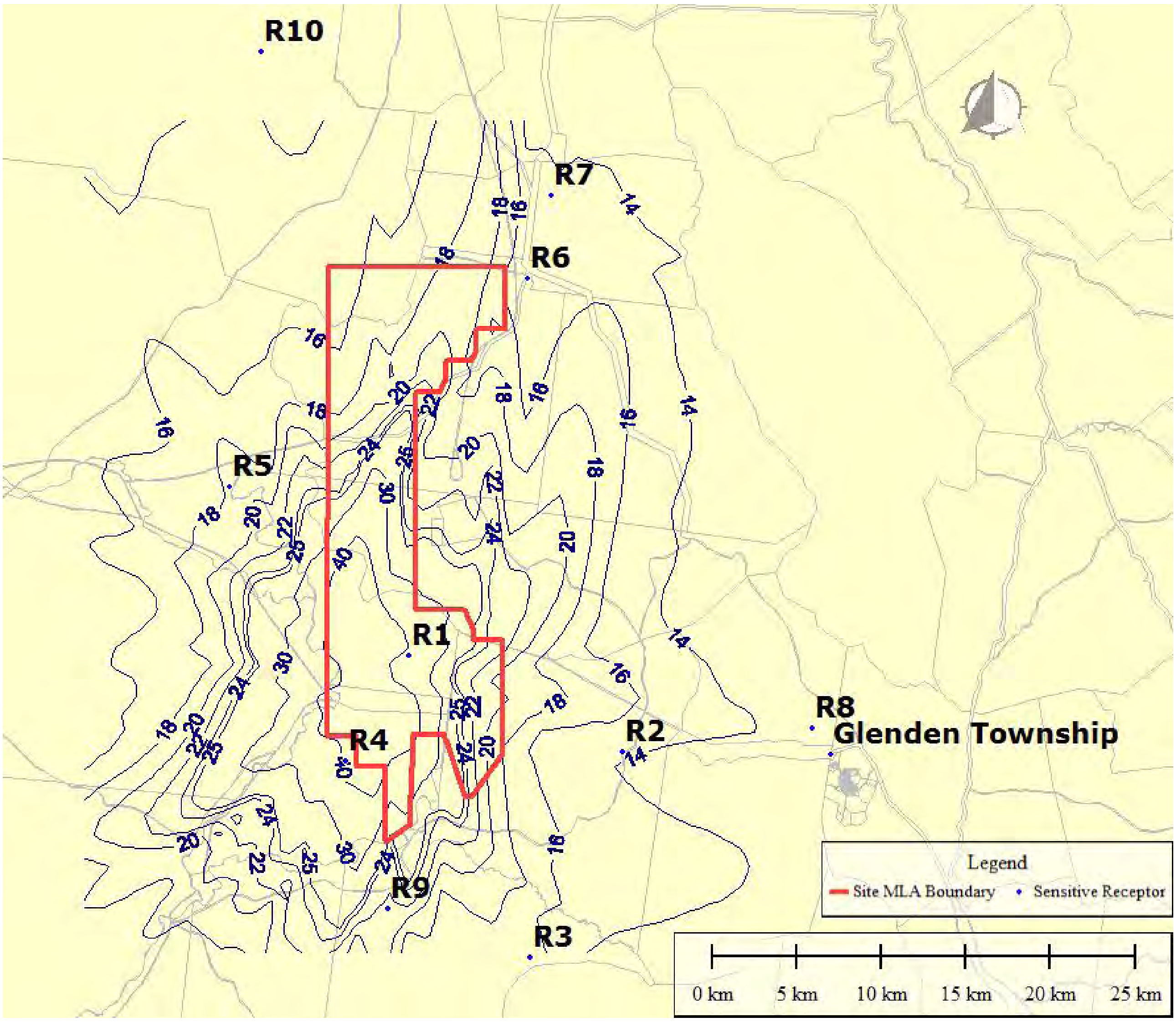

Figure 12: Year 5 - Maximum PM2.5 (24 hour) With Enhanced Dust Controls [µg/m^3]

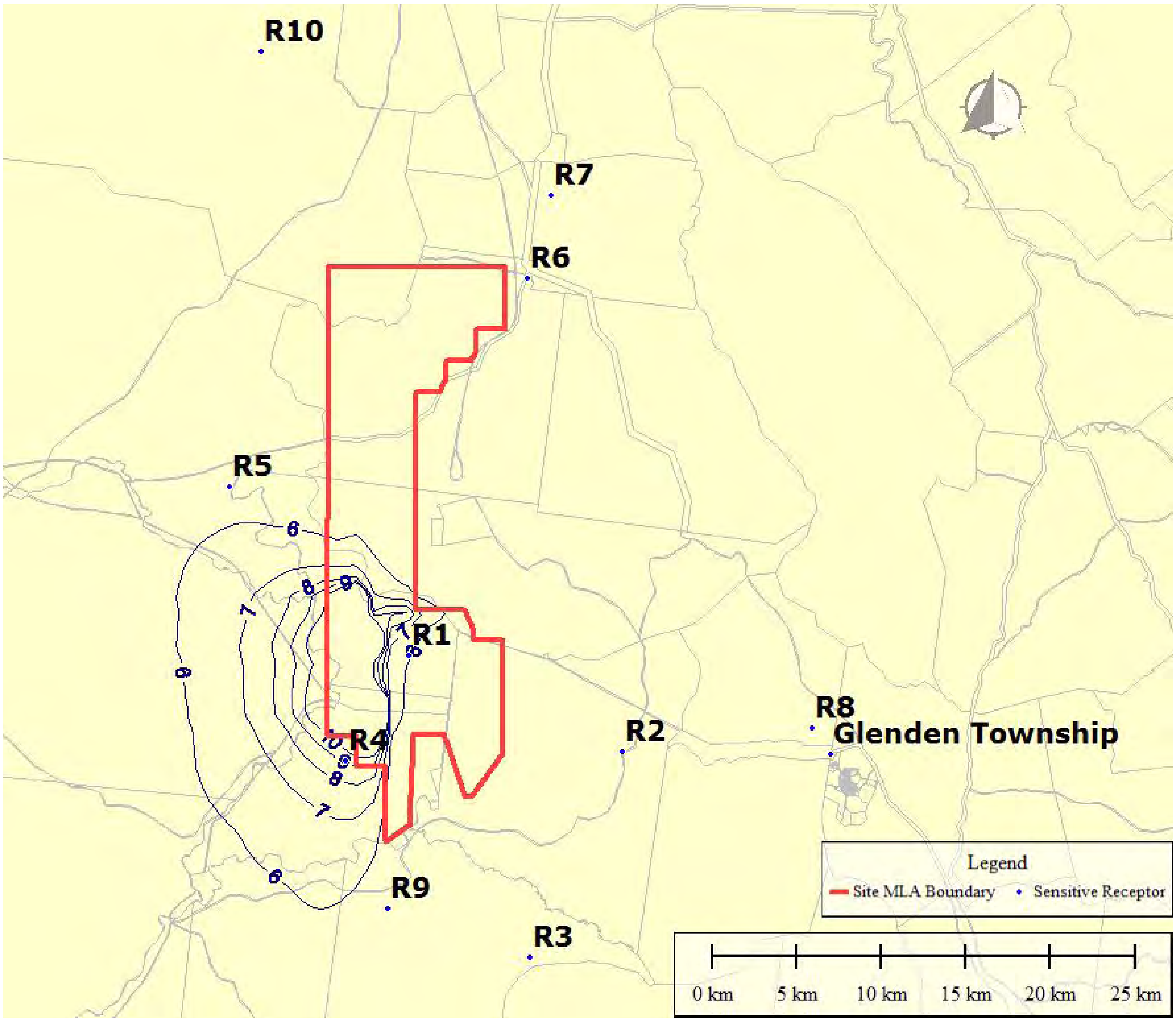

Figure 13: Year 5 - $PM_{2.5}$(annual average) With Enhanced Dust Controls [µg/m^3]

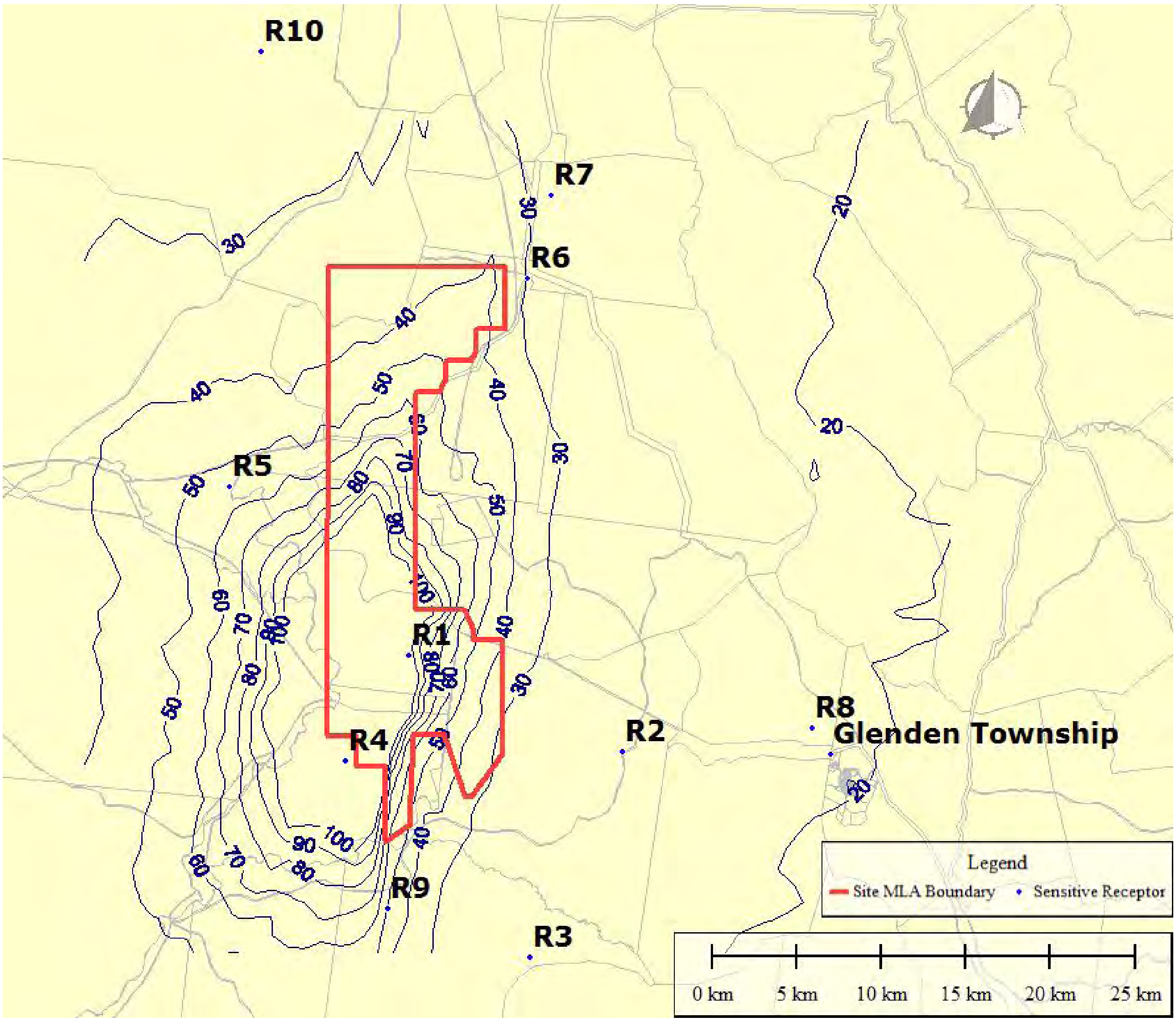

Figure 14: Year 5 - 5th highest PM_{10}(24 hour) with Enhanced Dust Controls [µg/m^3]

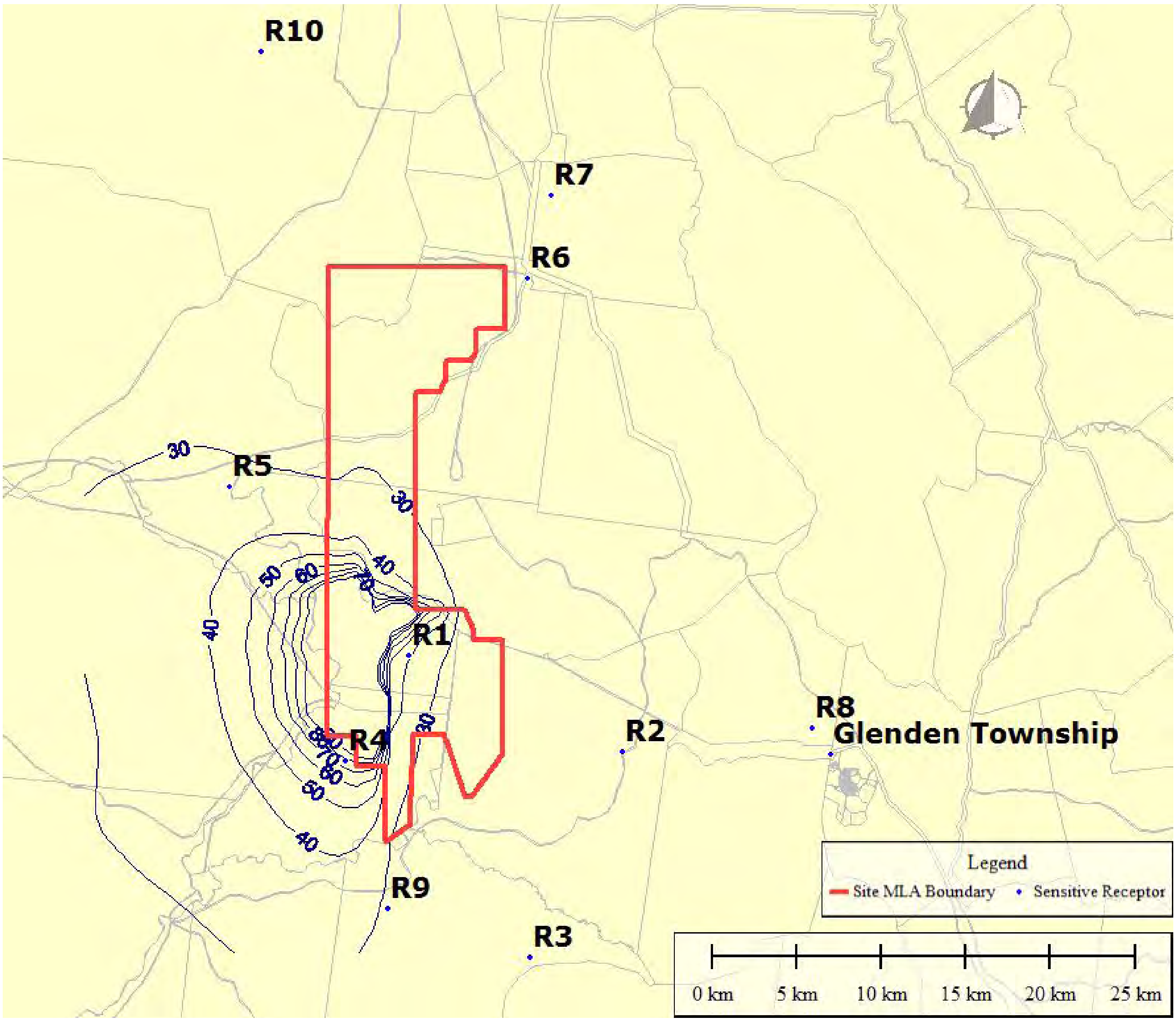

Figure 15: Year 5 - TSP (annual average) with Enhanced Dust Controls [µg/m^3]

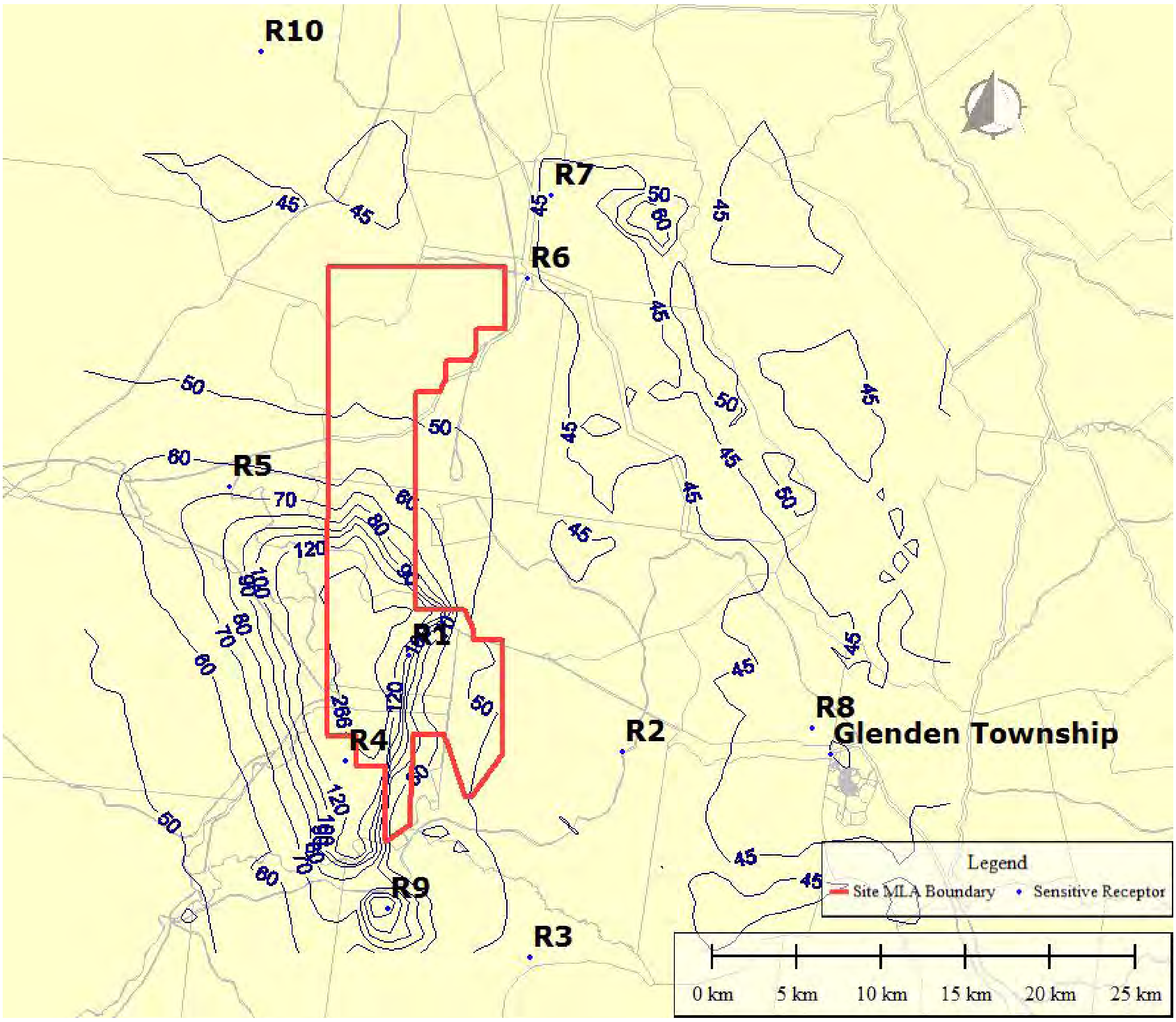

Figure 16: Year 5 - Dust deposition (maximum month) with Enhanced Dust Controls [mg/m^2/day]

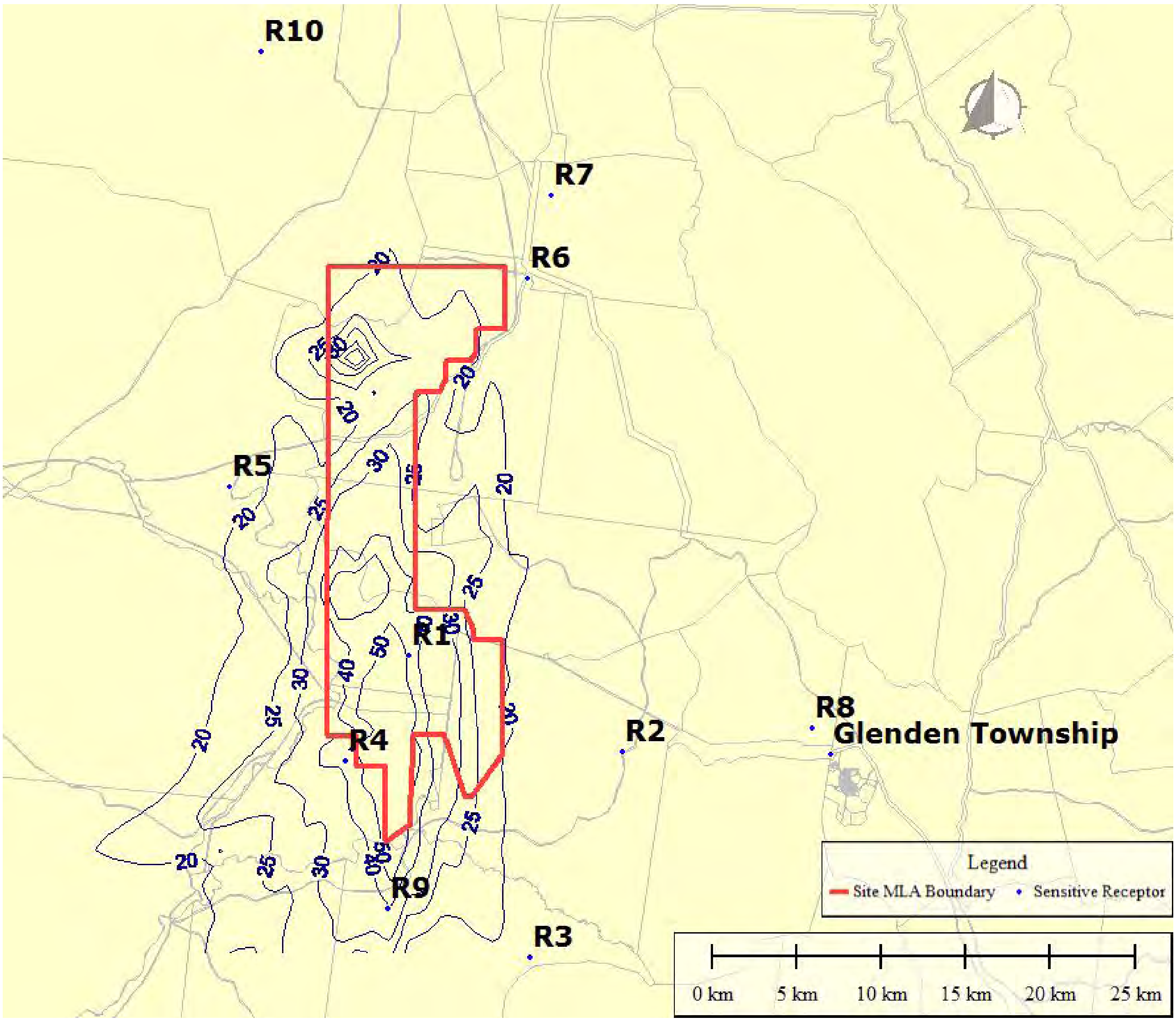

Figure 17: Year 17 - Maximum $PM_{2.5}$ (24 hour) With Enhanced Dust Controls [µg/m^3]

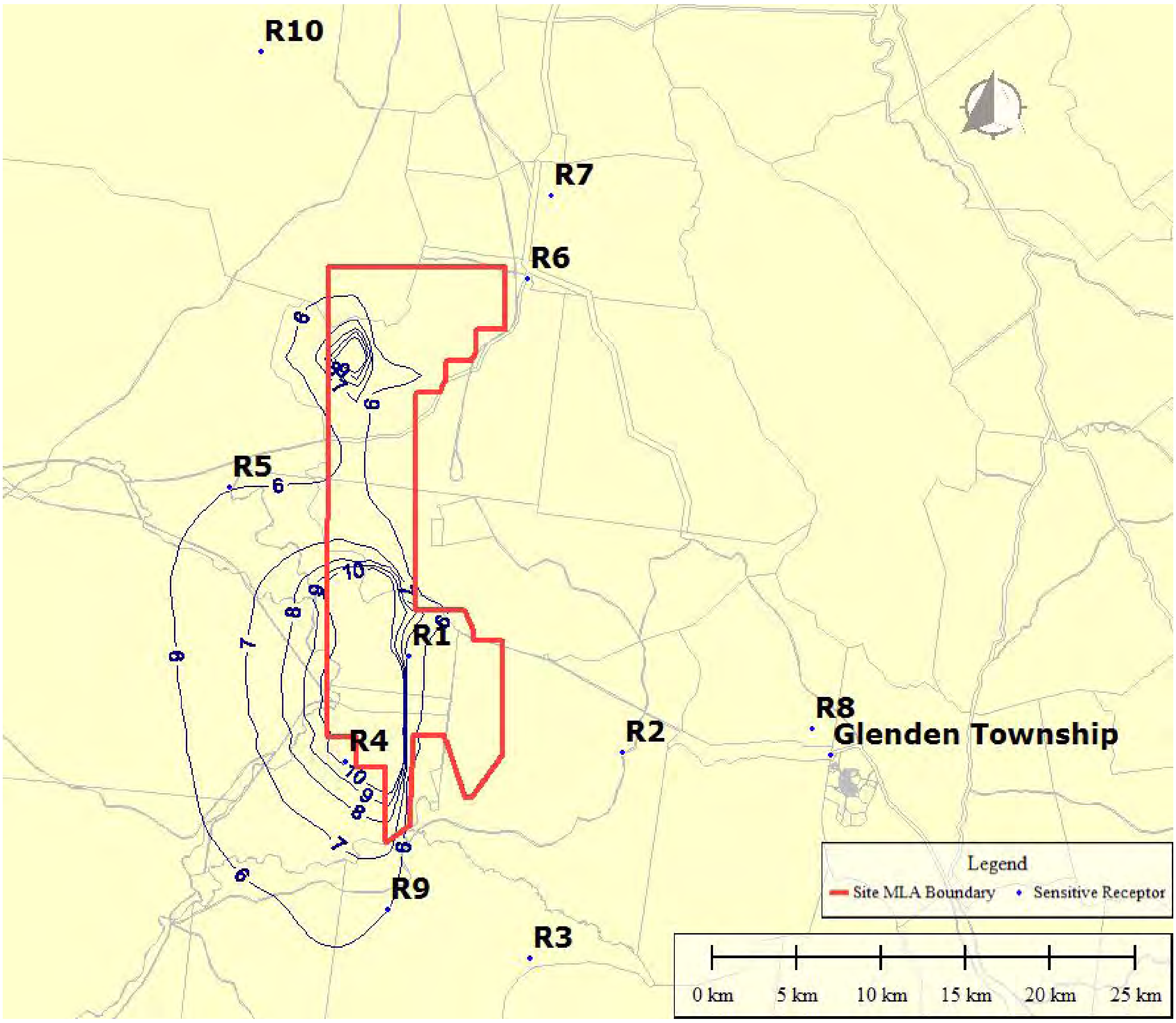

Figure 18: Year 17 - $PM_{2.5}$(Annual Average) with Enhanced Dust Controls [µg/m^3]

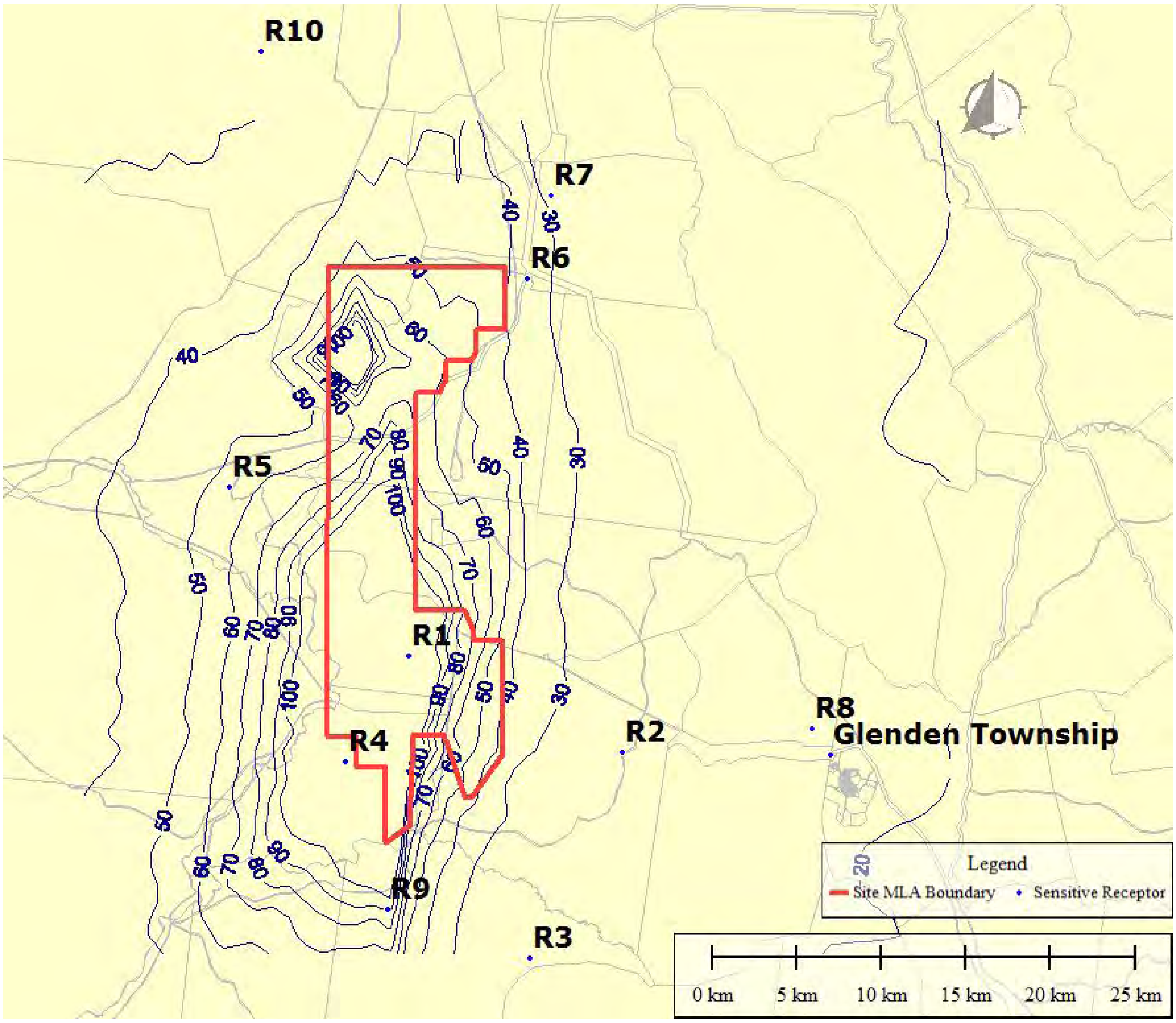

Figure 19: Year 17 - 5th Highest PM_{10}(24 hour) with Enhanced Dust Controls [µg/m^3]

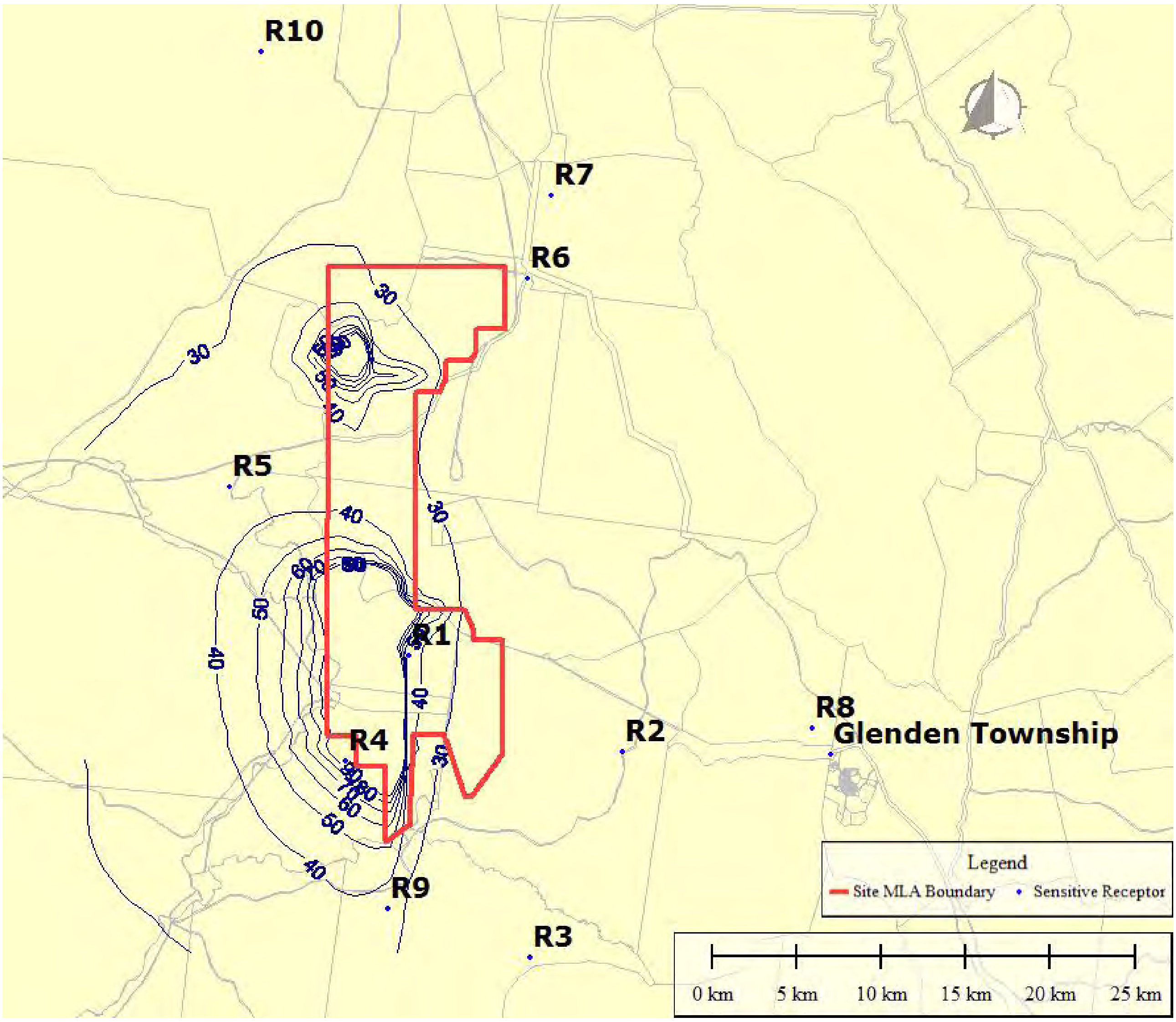

Figure 20: Year 17 - TSP (Annual Average) with Enhanced Dust Controls [µg/m^3]

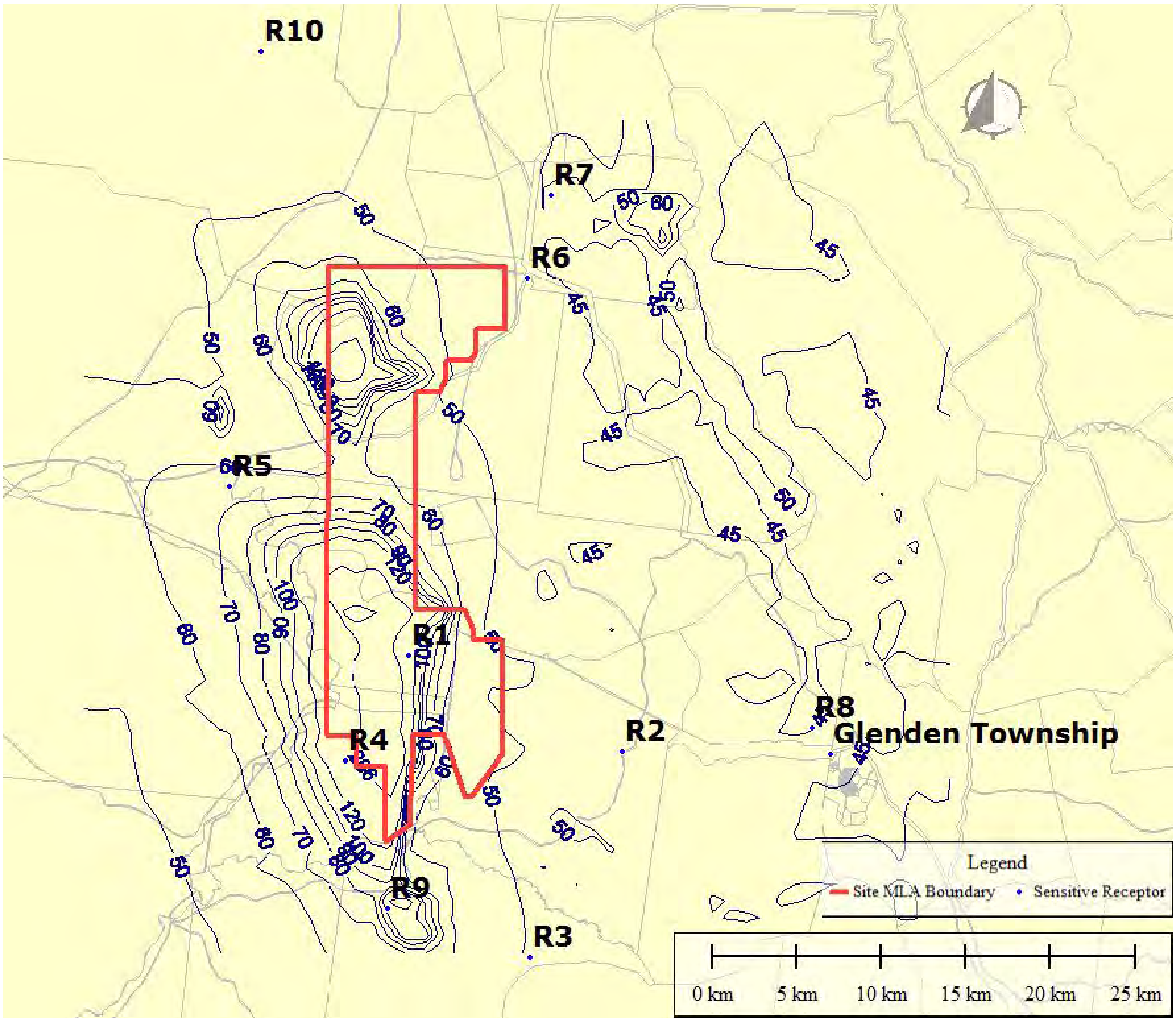

Figure 21: Year 17 - Dust Deposition (maximum month) with Enhanced Dust Controls [mg/m^2/day]

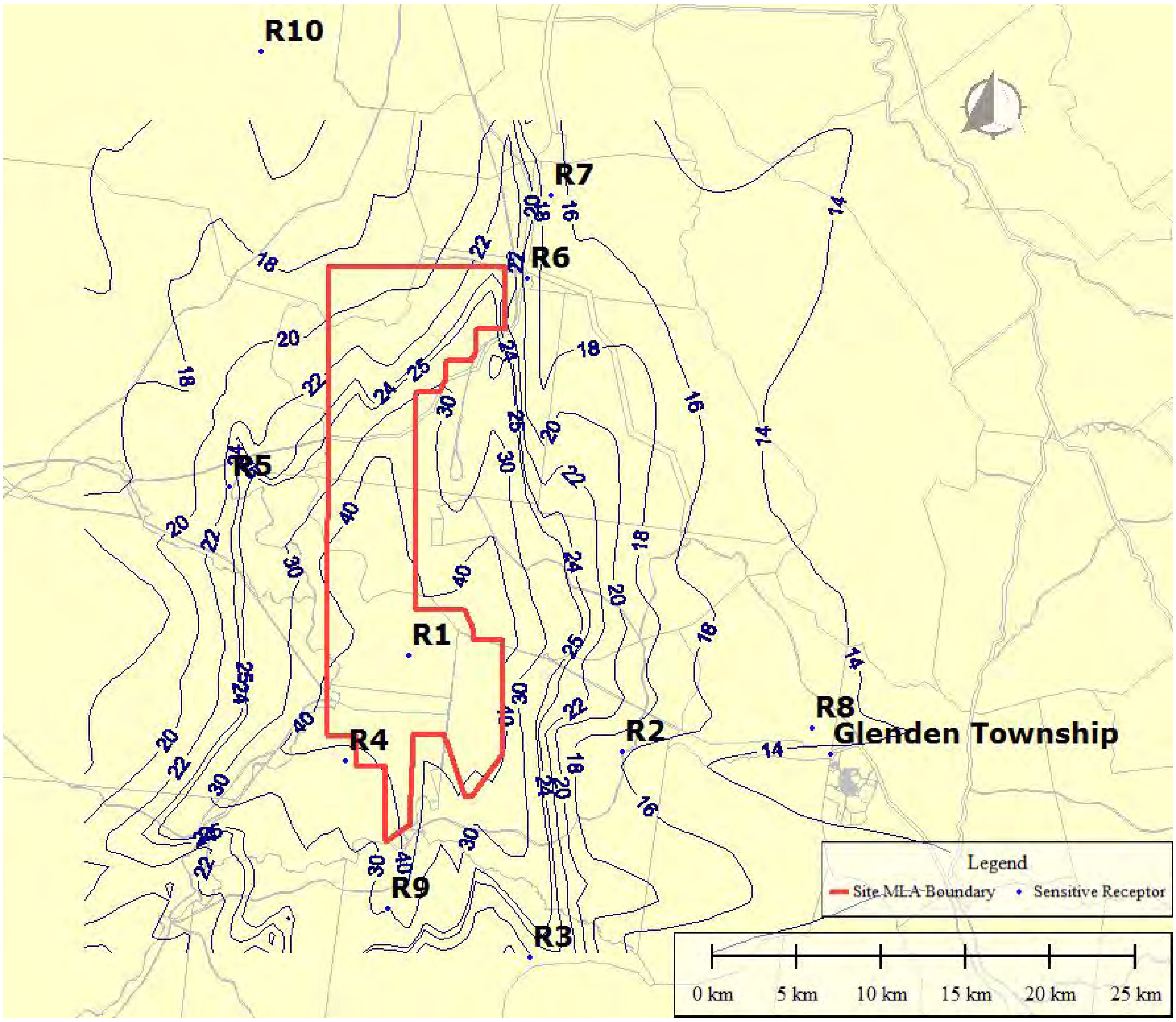

Figure 22: Year 36 - Maximum $PM_{2.5}$(24 hour) - With Enhanced Dust Controls [µg/m^3]

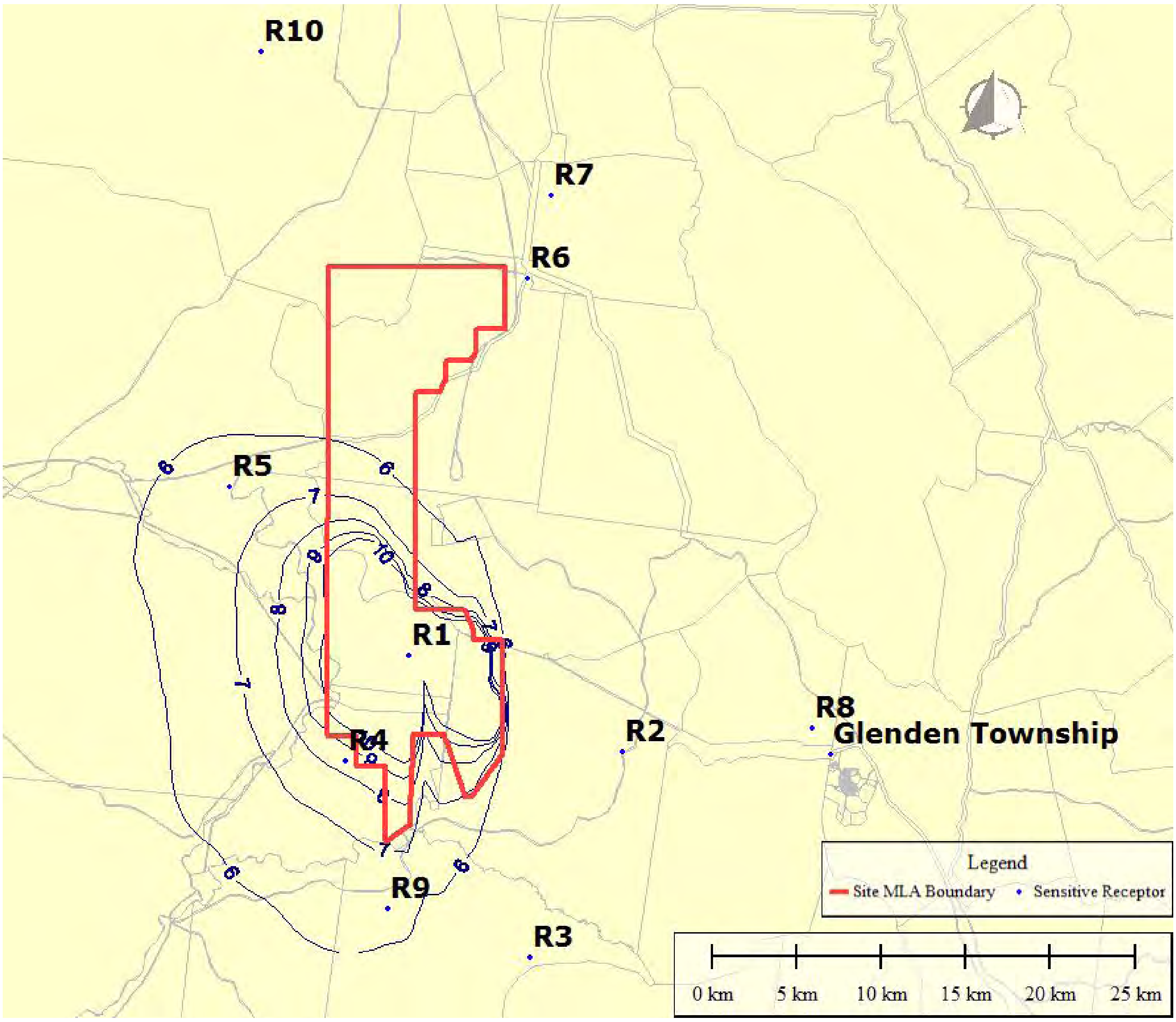

Figure 23: Year 36 - $PM_{2.5}$(Annual average) - With Enhanced Dust Controls [µg/m^3]

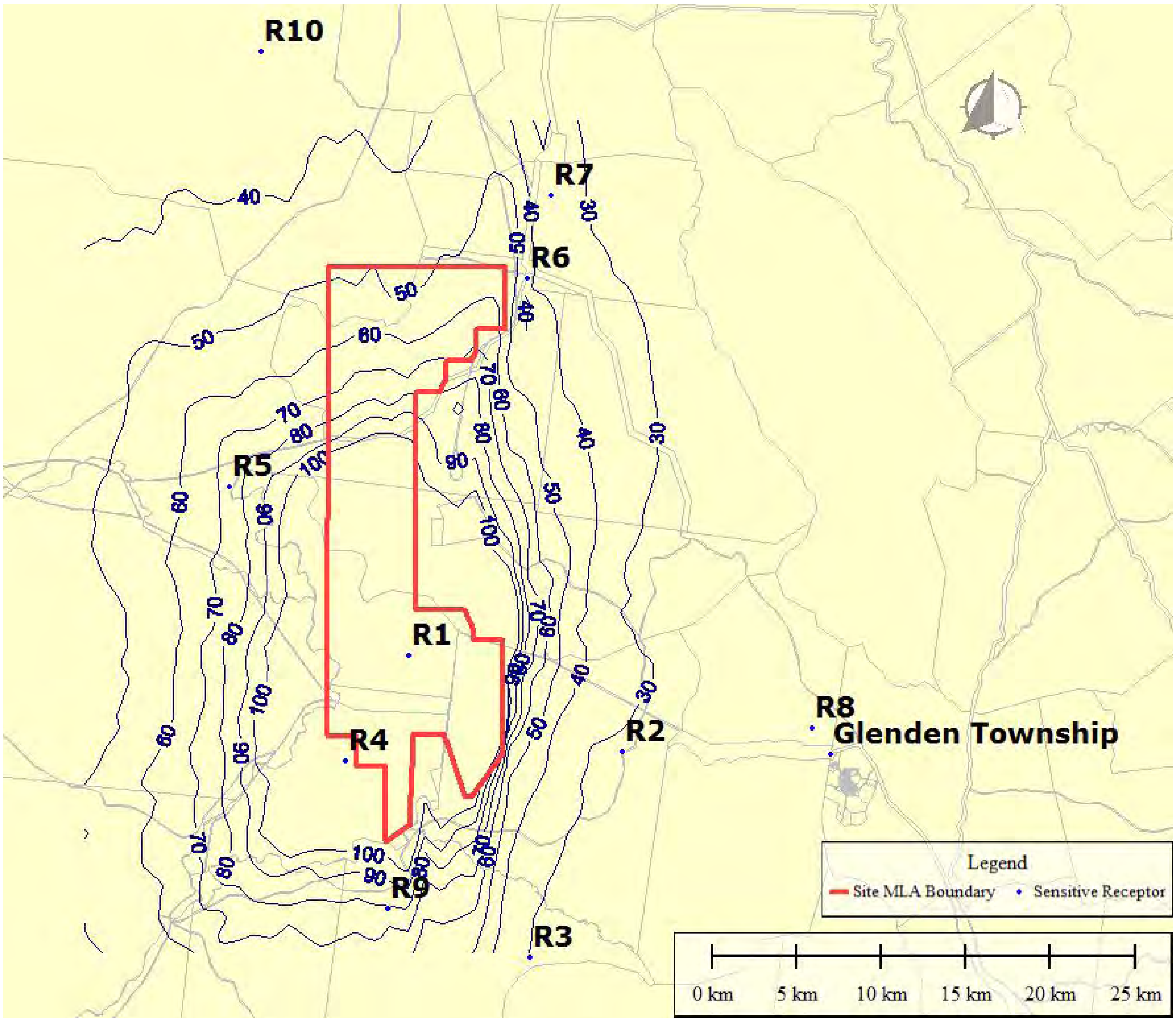

Figure 24: Year 36 - PM_{10}(24 hour) 5th Highest - With Enhanced Dust Controls [μg/m^3]

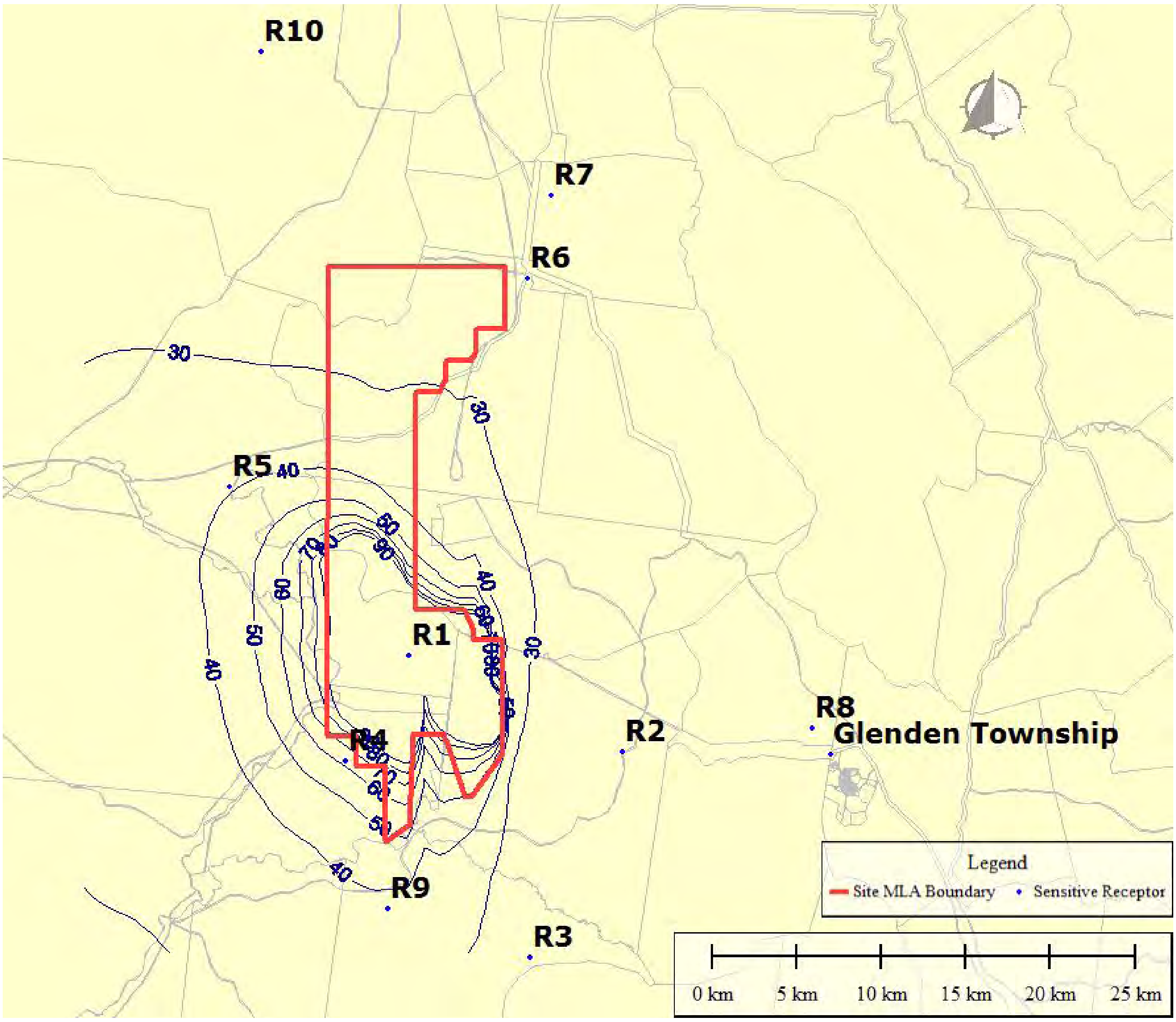

Figure 25: Year 36 - TSP (Annual Average) With Enhanced Dust Controls [µg/m^3]

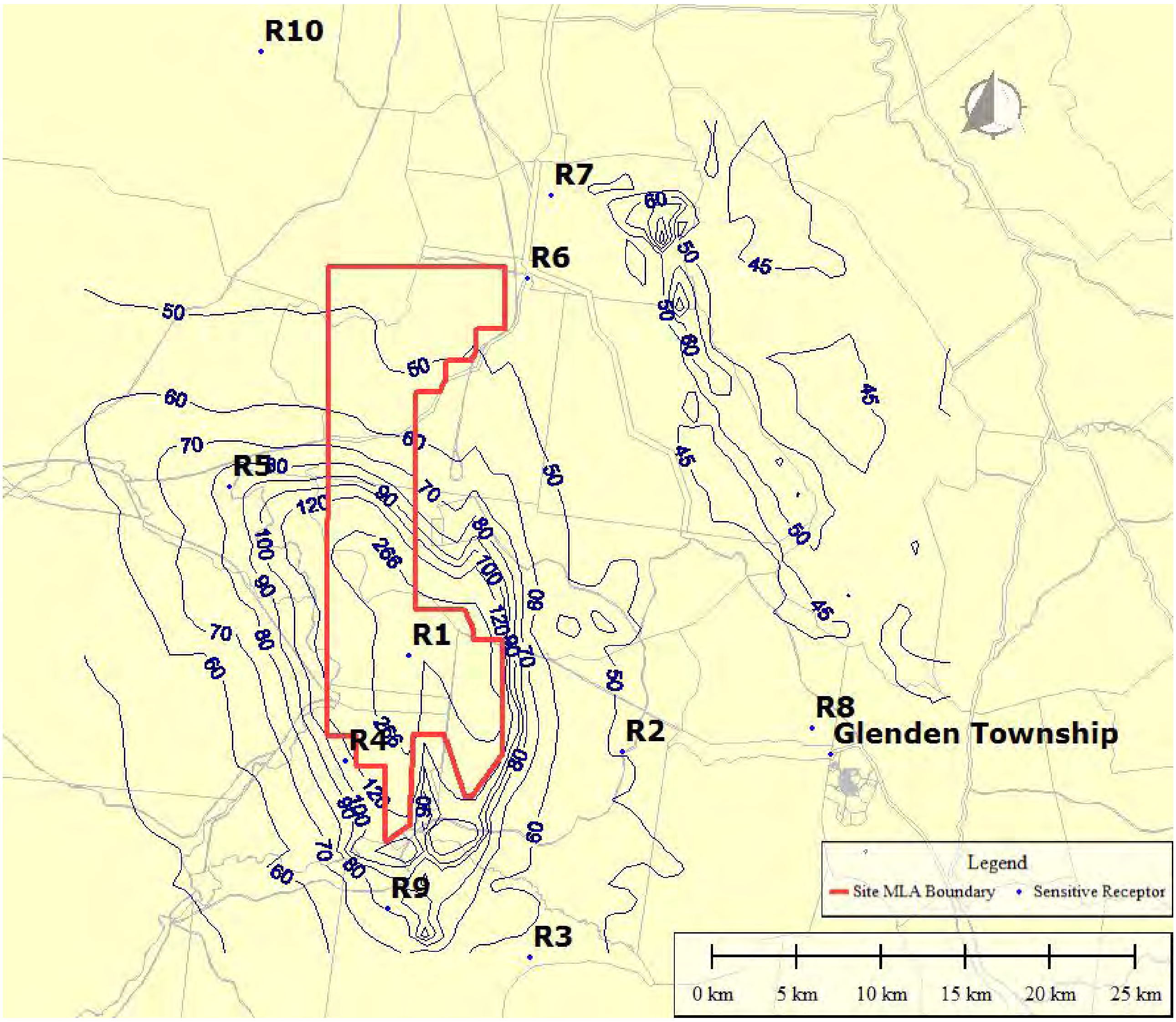

Figure 26: Year 36 - Dust Deposition (Maximum Month) With Enhanced Dust Controls [mg/m^2/day]

Table 9: Predicted Dust Concentration and Dust Deposition For Sensitive Receptors (including assumed ambient levels) – Year 5 - With Standard Dust Controls

Receptor	***Calculated Dust Levels At Nearby Residences***					
	$PM_{2.5}$(24 hour) (maximum) (µg/m³)	***$PM_{2.5}$ (annual average) (µg/m³)***	***PM_{10}(24 hour) (5th highest) (µg/m³)***	***PM_{10}(24 hour)* (µg/m³)***	***TSP (annual average) (µg/m³)***	***Dust Deposition (maximum month) (mg/m²/day)***
Air Quality Objectives	**25**	**8**	**50**	**NA**	**90**	**120**
Existing Ambient	***12***	***5***	***19***	***19***	***25***	***43***
R2 Suttor Creek Station Homestead	15	5	26	38	26	50
R3 Lancewood Station Homestead	17	5	26	59	26	50
R5 Cerito Station Homestead	19	6	64	75	35	75
R6 Byerwen Station Homestead	15	5	34	45	26	45
R7 Weetalaba Station Homestead	15	5	29	39	26	45
R8 Glenden Station Homestead	13	5	21	31	25	45
R10 Fig Tree Station Homestead	14	5	27	34	26	45
Glenden Township	13	5	21	29	25	47

**The PM10 (24 hour) maximum is shown for comparative purposes only. The PM10 (24 hour) air quality objective is established in the EPP (Air) as being for the 5th highest exceedance.*

Table 10: Predicted Dust Concentration and Dust Deposition For Sensitive Receptors (including assumed ambient levels) – Year 5 - With Enhanced Dust Controls

Receptor	***Calculated Dust Levels At Nearby Residences***					
	$PM_{2.5}$(24 hour) (maximum) ***(µg/m³)***	***$PM_{2.5}$ (annual average)*** ***(µg/m³)***	***PM_{10}(24 hour) (5th highest)*** ***(µg/m³)***	***PM_{10}(24 hour)**** ***(µg/m3)***	***TSP (annual average)*** ***(µg/m³)***	***Dust Deposition (maximum month)*** ***(mg/m²/day)***
Air Quality Objectives	**25**	**8**	**50**	**NA**	**90**	**120**
Existing Ambient	***12***	***5***	***19***	***19***	***25***	***43***
R2 Suttor Creek Station Homestead	14	5.0	25	37	26	48
R3 Lancewood Station Homestead	16	5.0	25	50	26	48
R5 Cerito Station Homestead	18	5.3	55	68	32	68
R6 Byerwen Station Homestead	15	5.0	30	40	26	45
R7 Weetlaba Station Homestead	14	5.0	28	40	26	45
R8 Glenden Station Homestead	13	5.0	21	38	25	45
R10 Fig Tree Station Homestead	13	5.0	27	30	26	45
Glenden Township	13	5.0	21	28	25	45

**The PM10 (24 hour) maximum is shown for comparative purposes only. The PM10 (24 hour) air quality objective is established in the EPP (Air) as being for the 5th highest exceedance.*

Table 11: Predicted Dust Concentration and Dust Deposition For Sensitive Receptors (including assumed ambient levels) – Year 17 - With Enhanced Dust Controls

Receptor	***Calculated Dust Levels At Nearby Residences***					
	$PM_{2.5}$(24 hour) (maximum) (µg/m³)	***$PM_{2.5}$ (annual average) (µg/m³)***	***PM_{10}(24 hour) (5th highest) (µg/m³)***	***PM_{10}(24 hour) * (µg/m³)***	***TSP (annual average) (µg/m³)***	***Dust Deposition (maximum month) (mg/m²/day)***
Air Quality Objectives	**25**	**8**	**50**	**NA**	**90**	**120**
Existing Ambient	***12***	***5***	***19***	***19***	***25***	***43***
R2 Suttor Creek Station Homestead	16	5	28	44	26	48
R3 Lancewood Station Homestead	17	5	28	61	26	50
R5 Cerito Station Homestead	18	6	54	64	35	66
R6 Byerwen Station Homestead	16	5	37	47	26	48
R7 Weetalaba Station Homestead	17	5	29	39	26	48
R8 Glenden Station Homestead	13	5	21	31	25	48
R10 Fig Tree Station Homestead	14	5	29	34	26	48
Glenden Township	13	5	21	29	25	48

**The PM10 (24 hour) maximum is shown for comparative purposes only. The PM10 (24 hour) air quality objective is established in the EPP (Air) as being for the 5th highest exceedance.*

Table 12: Predicted Dust Concentration and Dust Deposition For Sensitive Receptors (including assumed ambient levels) – Year 36 - With Enhanced Dust Controls

Receptor		***Calculated Dust Levels At Nearby Residences***				
	$PM_{2.5}$(24 hour) (maximum) (µg/m³)	***$PM_{2.5}$ (annual average) (µg/m³)***	***PM_{10}(24 hour) (5th highest) (µg/m³)***	***PM_{10}(24 hour) * (µg/m³)***	***TSP (annual average) (µg/m³)***	***Dust Deposition (maximum month) (mg/m²/day)***
Air Quality Objectives	**25**	**8**	**50**	**NA**	**90**	**120**
Existing Ambient	***12***	***5***	***19***	***19***	***25***	***43***
R2 Suttor Creek Station Homestead	17	5	29	49	26	49
R3 Lancewood Station Homestead	22	5	29	89	27	55
R5 Cerito Station Homestead	22	6	74	98	40	85
R6 Byerwen Station Homestead	20	5	44	70	27	48
R7 Weetalaba Station Homestead	17	5	35	54	26	50
R8 Glenden Station Homestead	14	5	23	34	25	48
R10 Fig Tree Station Homestead	16	5	34	44	26	46
Glenden Township	14	5	23	29	25	48

**The PM10 (24 hour) maximum is shown for comparative purposes only. The PM10 (24 hour) air quality objective is established in the EPP (Air) as being for the 5th highest exceedance.*

4.3 Air Quality Assessment

The predicted average ground level concentrations at nearby sensitive areas have been modelled and Section 4.1 contains a full description of the modelling methods. The methodology includes both normal and expected maximum emission conditions and the worst case meteorological conditions. The ground level predictions were made at all sensitive locations and the contours cover adjacent industrial and agricultural areas. All the techniques used to obtain the predictions are referenced and key assumptions and data sets explained.

Year 5 - Standard Dust Controls

$PM_{2.5}$

The modelled maximum $PM_{2.5}$(24 hour) and $PM_{2.5}$(annual average) dust concentration levels comply with the air quality objective at all sensitive receptors.

PM_{10}

The dust contours, particularly the maximum 24 hour contours, show that there are periods over the two year modelling simulation when adverse meteorological conditions persist for at least 24 hours leading to elevated dust levels some distance from the project.

The PM_{10}(24 hour) air quality objective of no more than 5 days per year where the dust concentration of PM_{10}(24 hour) is greater than 50 $\mu g/m^3$ (5^{th} Highest) is exceeded at R5, but is met at all other locations.

The maximum PM_{10}(24 hour) concentration exceeds 50 $\mu g/m^3$ at R3 and R5, although the 5th highest is recognised as an air quality objective under the EPP (Air).

TSP

TSP comprises the all fractions of dust. The heavier fractions rarely travel significant distances, especially under meteorological conditions likely to lead to high downwind concentrations (low wind speed, wind direction remaining steady for a long period of time, neutral to stable atmosphere). Thus the increase in the annual average TSP is predicted to be low and will be mostly associated with the lighter dust fractions (i.e. PM_{10}). The TSP(annual average) air quality objective is met at all sensitive receptors.

Dust Deposition

The dust deposition (maximum month) contours show that most dust fall will occur west of the site. The dust fallout at all permanently occupied sensitive receptors readily complies with the deposition goal. The high dust deposition levels to the north-east of the lease is due to wet deposition, i.e. in dusts/particulates in rainfall.

An assessment of vegetation including the development of vegetation mapping and potential impacts was undertaken as part of the terrestrial ecology component of the EIS.

Year 5 - Enhanced Dust Controls

$PM_{2.5}$

The modelled maximum $PM_{2.5}$(24 hour) and $PM_{2.5}$(annual average) atmospheric dust concentration levels comply with the air quality objective at all permanently occupied sensitive receptors.

PM_{10}

The PM_{10}(24 hour) air quality objective of no more than 5 days per year where the dust concentration of PM_{10}(24 hour) is greater than 50 µg/m^3 (5^{th} highest) is exceeded at R5, but is met at all other locations. The maximum PM_{10}(24 hour) concentration exceeds 50 µg/m^3 at R5, although the 5th highest is recognised as the air quality objective under the EPP (Air).

TSP

TSP comprises the all fractions of dust. The heavier fractions rarely travel significant distances, especially under meteorological conditions likely to lead to high downwind concentrations (low wind speed, wind direction remaining steady for a long period of time, neutral to stable atmosphere). Thus the increase in the annual average TSP is predicted to be low and will be mostly associated with the lighter dust fractions (i.e. PM_{10}). The TSP (annual average) air quality objective is met at all sensitive receptors.

Dust Deposition

The dust deposition (maximum month) contours show that most dust fall will occur west of the site. The dust fallout at all permanently occupied sensitive receptors readily complies with the deposition goal. The high dust deposition levels to the north-east of the lease is due to wet deposition, i.e. in dusts/particulates in rainfall.

An assessment of vegetation including the development of vegetation mapping and potential impacts was undertaken as part of the terrestrial ecology component of the EIS.

Year 17 - Enhanced Dust Controls

$PM_{2.5}$

The modelled maximum $PM_{2.5}$(24 hour) and $PM_{2.5}$(annual average) atmospheric dust concentration levels comply with the air quality objective at all permanently occupied sensitive receptors. The exposure to the south of the subject site has increased over the Year 5 assessment as a result of increases in activities in the southern part of the site.

PM_{10}

The dust contours, particularly the maximum 24 hour contours, show that there are periods over the two year modelling simulation when adverse meteorological conditions persist for at least 24 hours leading to elevated dust levels some distance from the project.

The PM_{10}(24 hour) air quality objective of no more than 5 days per year where the dust concentration of PM_{10}(24 hour) is greater than 50 µg/m^3 (5^{th} highest) is exceeded at R5, but is met at all other locations.

The maximum PM_{10}(24 hour) concentration exceeds 50 $\mu g/m^3$ at R3 and R5, although the 5th highest is recognised as an air quality objective under the EPP (Air).

TSP

TSP comprises the all fractions of dust. The heavier fractions rarely travel significant distances, especially under meteorological conditions likely to lead to high downwind concentrations (low wind speed, wind direction remaining steady for a long period of time, neutral to stable atmosphere). Thus the increase in the annual average TSP is predicted to be low and will be mostly associated with the lighter dust fractions (i.e. PM_{10}). The TSP (annual average) air quality objective is met at all sensitive receptors

Dust Deposition

The dust deposition (maximum month) contours show that most dust fall will occur west of the site. The dust fallout at all permanently occupied sensitive receptors readily complies with the deposition goal. The high dust deposition levels to the north-east of the lease is due to wet deposition, i.e. in dusts/particulates in rainfall.

An assessment of vegetation including the development of vegetation mapping and potential impacts was undertaken as part of the terrestrial ecology component of the EIS.

Year 36 - Enhanced Dust Controls

$PM_{2.5}$

The modelled maximum $PM_{2.5}$(24 hour) and $PM_{2.5}$(annual average) dust concentration levels comply with the air quality objective at all permanently occupied sensitive receptors. The exposure to the south of the subject site has reduced below the Year 17 level as a result of changes in the location of operations in the southern part of the site

PM_{10}

The dust contours, particularly the maximum 24 hour contours, show that there are periods over the two year modelling simulation when adverse meteorological conditions persist for at least 24 hours leading to elevated dust levels some distance from the project.

The PM_{10}(24 hour) air quality objective of no more than 5 days per year where the dust concentration of PM_{10}(24 hour) is greater than 50 $\mu g/m^3$ (5^{th} highest) is exceeded at R5, but is met at all other locations.

The maximum PM_{10}(24 hour) concentration exceeds 50 $\mu g/m^3$ at R3, R5, R6 and R7 although the 5th highest is recognised as an air quality objective under the EPP (Air).

TSP

TSP comprises the all fractions of dust. The heavier fractions rarely travel significant distances, especially under meteorological conditions likely to lead to high downwind concentrations (low wind speed, wind direction remaining steady for a long period of time, neutral to stable atmosphere). Thus the increase in the annual average TSP is predicted to be low and will be mostly associated with the lighter dust fractions (i.e. PM_{10}). The TSP (annual average) air quality objective is met at all sensitive receptors occupied for the duration of the project.

Dust Deposition

The dust deposition (maximum month) contours show that most dust fall will occur west of the site. The dust fallout at all permanently occupied sensitive receptors readily complies with the deposition goal. The high dust deposition levels to the north-east of the lease is due to wet deposition, i.e. in dusts/particulates in rainfall.

An assessment of vegetation including the development of vegetation mapping and potential impacts was undertaken as part of the terrestrial ecology component of the EIS.

Comment on Cumulative Impacts

The following section relates to a qualitative assessment of the cumulative impacts of the project within the region.

The modelling of the long-term air quality exposure, expressed in terms of the TSP (annual average) and the $PM_{2.5}$(annual average) may be used to address cumulative impacts since it incorporates all the prevailing wind directions. The contours from the operations show that the west of the site is more likely to experience a greater increase in dust levels than to the east of the site. A similar outcome would be expected for any future mines, i.e. greatest impacts to the west of any proposed mining operation.

There is one receptor (R5) to the west of the project. Although both the TSP (annual average) and the $PM_{2.5}$(annual average) are readily met; this receptor is likely to experience at most a 20% increase in $PM_{2.5}$(annual average) and a 60% increase TSP (annual average). There is one proposed mine to the east of R5 (i.e. predominantly upwind) beyond the project. Since the proposed mine is much further than project the likelihood of dusts from this proposed mine causing a further increase in the annual average dust levels at R5 is unlikely.

There are four receptors to the east of the project. Since these sensitive receptors (R2, R3, R6 and R7) are mostly upwind the impact from the project is much lower than for the sensitive receptor to the west of the project. Both the TSP (annual average) and the $PM_{2.5}$(annual average) are readily met at the eastern receptors and they are likely to experience <1% increase in $PM_{2.5}$(annual average) and at most a 4% increase TSP (annual average). These sensitive receptors are closer and generally to the east of the proposed development. Thus receptors R2, R3, R6 and R7 are more likely to be adversely affected by future proposed developments than from project. The modelling demonstrates that project has not constrained future mining development at these sensitive receptors.

The short-term impacts are typically assessed by the 24 hour averaging period, i.e. the PM_{10}(24 hour). The high dust levels at a large distance from the project are the result of a constant and consistent wind direction continuing for an extended long period, 24 hours or longer. Apart from a consistent wind direction, the meteorology conditions do not assist dispersion of particulates (low wind speed and a stable atmosphere). Typically a narrow dust plume is formed and in some instance, depending on the wind direction, it may pass and accumulate with dusts from several project sources. However it is unlikely that these short-term, narrow meandering dust plumes will accumulate with dusts from other mines since the plumes do not pass though any of the proposed mining areas. The dusts from other mines will travel on an entirely different path and are unlikely to combine.

4.4 Railway Corridor Assessment

It is understood the railway proposed for the project comprises a narrow gauge railway to join the GAP, to support up to 6,800 tonne trains. It is beyond the scope of this assessment to address the dust emissions for the entire rail line route, which was carried out as part of the railway GAP expansion.

Hence this assessment addresses the rail spurs from the project to the connection to rail line.

Prior to development of the northern tenement area, all trains will be loaded at the southern TLF. Once operations have commenced in the northern tenement area, approximately two thirds of coal will be loaded at the southern TLF and one third at the northern TLF.

The proponent is committed to complying with QR's (now Aurizon) Coal Dust Management Plan where appropriate, which stipulates various control measures (e.g. spray-on coal dust suppressant). This assessment is conservatively based on current dust emissions, rather than future controlled (lower) emissions.

4.4.1 Railway Modelling

Emission Rate

Dust is emitted from wagons whilst in transit. According to Connell Hatch (2008), coal dust can be emitted from the following sources in the coal rail system:

- coal surface of loaded wagons;
- coal leakage from doors of loaded wagons;
- wind erosion of spilled coal in corridor;
- residual coal in unloaded wagons and leakage of residual coal from doors; and
- parasitic load on sills, shear plates and bogies of wagons.

That study also concluded that at least six ambient air quality monitoring studies have been undertaken since 1993 to specifically investigate and quantify concentrations of TSP, PM_{10} and dust deposition rates adjacent to rail lines carrying coal. These studies did not find the potential for health impacts inside or outside of the rail corridor as assessed against current air quality goals due to coal dust emissions from trains. These studies did not find the potential for amenity impacts outside the rail corridor due to coal dust emissions from trains when assessed against current air quality guidelines for nuisance. It also concluded that ground level concentrations of TSP (and PM_{10}) comply with EPP(Air) goal and NEPM(Air) standard for human health at distance up to 10-15 m from the railway line.

The Connell Hatch (2008) study determined that the emission rate for coal dust from the coal surface of loaded wagons to be in the form:

$$m = k_1.v^2 + k_2.v + k_3$$

where:

- m is the mass emission rate of coal dust (as TSP) from the wagon surface in g/km/tonne of coal transported;
- k_1 is a constant with a value of 0.0000378;

- k_2 is a constant with a value of -0.000126;
- k_3 is a constant with a value of 0.000063; and
- v is the air velocity travelling over the surface of the train in km/h.

Since the Connell Hatch study concluded that the dust goals are met very close to railways it is considered to be a low-impact dust source. Hence a simplified model has been developed assuming a coal train travelling at high speed and various setback distances incorporating the site meteorology.

Assuming that the coal train is travelling at 80 km/h and the wind speed is 20 km/h (i.e. effectively 100 km/h over the surface of the coal) and an annual tonnage of product coal of either 5 or 10 Mtpa, then the total annual emissions per km of track is 3 or 4 tonnes per km of track per year respectively. It is understood that each loaded train carries an average of 6,800 tonnes of coal.

There will be approximately 4 to 5 trains per day, capable of transporting approximately 6,800 tonnes per train. Trains will be loaded at a rate of 3,300tph with a loading time of around 2 hours per train. Each train is expected to have three 4000 class diesel locomotives hauling approximately 85 coal wagons. For the purposes of modelling the maximum daily emission rate is taken to be 50% higher the long term average (i.e. 6 to 7 trains per day).

Thus the daily emission rate per km of railway line is conservatively assessed to be 0.009 and 0.018 tonnes of TSP where the rail spur carries an annual tonnage of 5 and 10 MTPA respectively. The PM_{10} fraction is taken to be 0.5 of TSP (Connell Hatch 2008) and PM2.5 fraction to be 12% of the PM_{10}.

The emission rate is worst-case since the train travelling at the maximum speed with a head wind of 20 km/h and the number of trains per day has been increased by 50% above the long term average to account for production fluctuations.

Modelling

Both the 4km (north) and the 7km (south) rail spurs have been modelled and the dust concentration at setbacks between 100 m and 2 km from the railway. The Ausplume modelling has been run with the TAPM meteorological file developed for the site. The railway line was modelled as a series of volume sources with a spacing of 50 m between each source as recommended by the Ausplume manual.

There are two coal loaders and rail spurs, one in the northern part of the site, the other in the south. For the purposes of this analysis it is assumed that either rail loader individually could achieve the rail loading rate noted above.

The calculated ground level atmospheric dust concentration are contained in Table 13 for the southern railway spur having an annual tonnage of 10 MTPA and Table 14 for the northern railway spur having an annual tonnage of 5 MTPA.

Table 13: Calculated Dust Concentration Levels at Various Setback Distance from the Southern Spur Line with Annual Tonnage of 10 MTPA

Dust Index	**Atmospheric Dust Concentrations in (µg/m^3) at various setback distances from Spur**					
	100 m	**200 m**	**300 m**	**500 m**	**1 km**	**2 km**
Maximum $PM_{2.5}$(24 hour)	0.3	0.2	0.2	0.1	0.1	0.1
$PM_{2.5}$ (Annual Average)	0.2	0.1	0.1	0.1	0	0
PM_{10}(24 hour) (5th highest)	1.7	1.3	1.1	0.8	0.5	0.3
TSP (Annual Average)	1.3	0.9	0.7	0.4	0.2	0.1

Table 14: Calculated Dust Concentration Levels at Various Setback Distance from the Northern Spur Line with Annual Tonnage of 5 MTPA

Dust Index	**Atmospheric Dust Concentrations in (µg/m^3) at various setback distances from Spur**					
	100 m	**200 m**	**300 m**	**500 m**	**1 km**	**2 km**
Maximum $PM_{2.5}$(24 hour)	0.1	0.1	0.1	0.1	0	0
$PM_{2.5}$ (Annual Average)	0.1	0.1	0	0	0	0
PM_{10}(24 hour) (5th highest)	0.8	0.7	0.5	0.4	0.3	0.2
TSP (Annual Average)	0.6	0.5	0.3	0.2	0.1	0.1

The closest sensitive receptor to either of the spur lines is at least 5 km. The modelled dust levels at 2 km from the railway are extremely low and at 5 km the dusts would be imperceptible. The dust from the railway are to be added to the dusts from mining. However, since the modelled dusts from the railway are very low, then the predicted dust levels from mining at all sensitive receptors (Table 9 to Table 12) would be the same when including the dusts from the railway.

4.5 Recommendations and Mitigation Measures

The modelling has demonstrated that sensitive receptor R5 to the west of the operations has the highest ground level concentrations of dust, specifically the PM_{10}(24 hour). The highest dust exposure occurs for modelling year 36, i.e. during the mining phase when all operations are in the southern parts of the site. Thus the recommendations and mitigations are primarily designed for R5. However, the dust exposure levels at other sensitive receptors are also implicitly addressed by the proposed mitigation measures.

Long-term Dust Monitoring

It is recommended that a meteorological and dust monitoring plan be implemented. In addition to monitoring dust it is recommended that local meteorological data will be collected from a monitoring station installed on the lease and situated close to the project administration area. It is recommended that this station collect temperature, relative humidity, rainfall and wind data over the life of the project.

Dust Deposition Monitoring

It is recommended that a network of seven dust deposition gauges be installed at all sensitive receptors surrounding the project. It is recommended that dust deposition (fallout) monitoring commences approximately 12 months prior to development of the mine and remain in operation for the life of the project.

Receptor 5 Dust Monitoring

It is recommended that more frequent monitoring of dust be undertaken at R5 and that the dust monitoring station be permanently installed close to the homestead. To assist with identifying weather conditions that lead to high dust events it is recommended that data correlations be drawn between meteorological conditions and dust monitoring results at R5 to enable prediction of high dust scenarios based on weather conditions and pre-emptively implement dust controls where required.

4.5.1 Dust Mitigation Measures

The dust emission database has been based on standard emission factors from the NPI 2012. There are a host of dust control measures that are available for operational management to significantly mitigate dust emissions. Table 15 provides a summary of some of the control procedures to mitigate dust emissions.

Table 15: Dust Mitigation Measures

Source	**Mitigation Measure**
Mining Areas	Disturb the minimum area necessary for mining and rehabilitate promptly.
Coal Handling Area	Use water sprays and water trucks to suppress dust in coal handling areas.
Stockpiles	Maintain water sprays on raw and product coal stockpile and transfer points. Topsoil stockpiles should be sown with an appropriate plant mix and managed to ensure adequate ground cover is maintained up to 40% control efficiency for early established vegetation
Loading Haul trucks	Overloading to avoid spillage in transit
Draglines	Reduce the drop height
Haul Roads	Maintain haul roads in good condition and use water trucks regularly to suppress dust. Investigate use of chemical suppressants if haul roads become too slippery or seeking higher levels of dust control.
Other Roads	Keep usage to a minimum and maintain in good condition. Use water trucks regularly to suppress dust.
Waste Rock Emplacements	Keep these areas moist, particularly if used by dump trucks. Keep the recently spread material moist to encourage crusting of surface. Use sprays or water cannon during dumping to control dust from dumping, up to 70% control is possible for water sprays.

Haul Roads

The modelling of dusts from haul roads is based on either standard or enhanced water application. For this model, the adoption of enhanced water control effectively provided a maximum of 75% control. However, since the model includes a randomising routine to vary dust control effectiveness, the average effectiveness is 50%. The use of chemical dust suppressants would increase effectiveness to 95%.

Draglines

NPI 2012 recommends that the equations be used where there is no site specific data for drop distance and/or moisture content. Since this data is seldom available prior to commencement of dragline operation for any project, the default values have been used for this assessment. The default emission rate adopted in NPI 2012 includes results of testing carried out in the Hunter Valley, which showed that approximately 43% of TSP particles will be in the PM_{10} range compared with 18% for the strict application of the equations.

However, the default emission rate is based on a drop height of 12 m and 2% moisture content. Thus reducing the drop height from 12 m to 6 m would result in a reduction in PM_{10} emissions (compared with the modelled emission rate) from the dragline of approximately 53% (including maintaining the Hunter Valley correction) or a reduction of 88% based on strict application of the equation.

Loading Haul trucks

There is the potential for spillage to occur from haul trucks in transit. This spillage would fall on haul roads and would potentially become dust by the action of subsequent vehicles. Maintaining a suitable profile on the upper surface of the load of haul trucks would avoid spillage in transit.

4.5.2 Mitigation Measures For Adverse Meteorology

At R5 it was determined that for Year 36 the PM_{10}(24 hour) dust concentration with enhanced water control, was likely to exceed the comparative maximum level of $50\mu g/m^3$ on approximately 40 days per annum. This exceeds the air quality objective of no more than 5 days per year where the PM_{10} (24 hour) dust concentration is greater than 50 $\mu g/m^3$. Accordingly a series of dust mitigation measures were investigated to ensure that the mine can achieve compliance with this air quality objective.

As assessment of various dust control measures for Year 36 was carried out to assist with the quantifying the likely impact on production. The emission rates used in this mitigation assessment retains the 9% contingency factor to account for peak production. The following is a summary of the results of modelling of the mitigation investigations:

1. Replacing enhanced watering with chemical dust suppressants of haul road resulted in a significant reduction in the ground level atmospheric concentration at all sensitive receptors. At R5 the dust concentration of PM_{10}(24 hour) is likely to be greater that the comparative maximum level of $50\mu g/m^3$ on approximately 23 days per year, which exceeds the objective of no more than 5 days per year.
2. Reducing the drop height for the dragline from the modelled 12m to 6m, as well as use of chemical dust suppression on the haul roads resulted in a further significant reduction at all sensitive receptors. At R5 the PM_{10}(24 hour) dust concentration will be greater than the comparative maximum level of PM_{10}(24 hour) on approximately 14 days per year (with a modelled maximum of $71\mu g/m^3$), which exceeds the air quality objective of no more than 5 days per year.
3. Reducing the activity rate in the west pit to 50% as well as reducing dragline drop height and chemical dust suppressants on the haul roads further reduces the PM_{10}(24 hour) dust concentrations. At R5 the PM_{10}(24 hour) dust concentration will be greater than the comparative maximum level of PM_{10}(24 hour) on approximately 8 days per year (with a modelled maximum of $64\mu g/m^3$), which exceeds the air quality objective of no more than 5 days per year.
4. Reducing the activity rate in both the west and east pits to 50% as well as reducing dragline drop height and chemical dust suppressants on the haul roads reduces the PM_{10}(24 hour) dust concentrations again. At R5 the PM_{10}(24 hour) dust concentration will be greater than the comparative maximum level of PM_{10}(24 hour) on approximately 2 days per year (with a modelled maximum of $58\mu g/m^3$); this meets the air quality objective of no more than 5 days

per year.

The modelling has demonstrated that the air quality objectives can be met for all sensitive receptors with the application of suitable mitigation measures as required based on meteorological conditions at the time. The only mitigation measures likely to affect production is the reduction in the activity rate in either the west pit or the east pit and modelling shows that this is likely for up to 14 days per year during the years when quantity of movement of overburden is at it's peak. For other years, when the quantity of overburden is less, then the number days of disrupted production would be significantly fewer in number. Furthermore the modelling has included a 9% contingency factor (i.e. production and movement of overburden increased by 9%). Operating at normal activity levels implies a reduction in the maximum exposure and fewer days when disrupted production is likely to occur.

4.5.3 Dust Management Plan

A Dust Management Plan should be developed and include an action response plan to mitigate adverse air quality impacts. The application of water is one of the primary dust control measures. However, water is also a valuable resource. Hence the dust management plan should investigate optimal application of water. The modelling has indicated that enhanced dust control is required for haul roads. Enhanced dust control may not necessarily comprise a generalised increase in the watering rate for all hours and all roads but may involve careful loading of haul trucks (designed to avoid spillage), timely spillage control on haul roads and/or spot watering of spills.

The assessment of dust emissions has revealed elevated dust exposure at several sensitive receptors with the greatest exceedance occurring in Year 36 at receptor R5 to the west of the site. It is not unexpected that the greatest exposure is to the west of the site since easterly winds dominate. Furthermore the closest approach of mining operations to R5 occurs in mining case Year 36.

The Dust Management Plan will address the sequential and incremental adoption of the adverse meteorology dust mitigation measures in response to meteorological conditions, seasonal effects and measured dust levels. For instance, during the wet season the dust emissions are likely to be low and additional dust control measured may be minimal. However, during the dry season, monitoring results may be such that the sequential implementation of mitigation measures (excluding reduction in mining operations) may be required until monitoring results demonstrate that compliance has again been achieved and should also be a water saving measure. These mitigation measures have been modelled to show compliance with the air quality objectives at all sensitive receptors except R5.

The dust monitoring at R5 correlated with the with the real time prevailing wind direction measurements will be used by management to make decisions regarding specific mining operational changes, to reduce dust exposure at R5. The modelling in this assessment has investigated operation changes such as reducing mining activities in specific pits and has shown that compliance with the air quality objectives at R5 is readily achievable. .

Although this assessment of dust control measures has been based on Year 36 operations, a similar approach would apply throughout the life of the mine. For example, initially dust mitigation measures for roads and the dragline during the dry season may be the most appropriate measures (since this does not interfere with production) followed by a reduction in activities at appropriate pits/locations on the basis of ongoing monitoring of dust levels at the R5 sensitive receptor.

5. Greenhouse Gas Emissions

The Australian Department of Climate Change and Energy Efficiency (DCCEE) delivers the majority of programs under the Australian Government's climate change strategy. The DCCEE provides a workbook, the 'National Greenhouse Accounts (NGA) Factors' (June 2012) to enable industry to calculate greenhouse gas emissions (GHG) using appropriate methods and emission factors.

The *National Greenhouse and Energy Reporting Act 2007* (the NGER Act) introduced a national framework for the reporting and dissemination of information about the greenhouse gas emissions, greenhouse gas projects, and energy use and production of corporations. The NGER doesn't cover Scope 3 reporting. Hence NGER is used for Scope 1 and Scope 2 future emissions from the project.

The scope that emissions are reported under is determined by whether the activity is within the organisation's boundary (direct emissions are scope 1) or outside it (indirect emissions scope 2).

5.1 Estimated Greenhouse Gas Emissions

The principal sources of Scope 1 greenhouse gas emissions would be:

- the consumption of diesel by the mining fleet;
- methane emissions (fugitive) from coal;
- blasting (ANFO);
- clearing vegetation.

Total biomass of the type of vegetation to be cleared is sourced from Raison (2003) and accounts for Eucalypts biomass, other species biomass, dead biomass and root biomass. The likely biomass is in the range 36 tonnes/ha to 123 tonnes/ha. Based on the generally disturbed nature of the site, it is proposed to adopt a biomass of 36 tonnes/hectare. It is understood that approximately 2,500 hectares will be cleared during the life of the project and that the majority of this will become grazing land.

The key assumptions underlying the greenhouse gas inventory are accessed from the 2011 NGA workbook and listed below.

- The Scope 1 CO_2 emissions or direct emissions for diesel transport are calculated using the 69.2 kg CO_2-e/GJ or 2.7 kg CO_2-e/L factor for energy factor of 38.6 GJ/kL. For CH_4 the emission factors are 0.2 kg CO_2-e/GJ and for N_2O the emissions are 0.5 kg CO_2-e/GJ.
- The Scope 1 emissions or direct emission associated with coal seam methane release prior to the production of coal (fugitive) for open cut mining in Queensland is 0.017 CO2-e/tonne raw coal as CH_4.
- The Scope 1 emissions or direct emissions for ANFO is 0.18 t CO2 / t product as N_2O.
- The Scope 1 emissions or direct emissions associated with clearing vegetation is estimated to be 36 tonnes/ha. To calculate the carbon dioxide emitted when this vegetation is cleared the quantity of carbon is multiplied by 3.67 (source NGA 2012).

- The Scope 2 emissions or indirect emissions from the Queensland electricity grid are calculated to be 0.89 kg CO_2-e/kWh.

During peak operations, it is estimated that approximately 20ML of diesel fuel will be required per annum whilst annual electricity consumption is estimated at 31 MW. It is estimated that annual ANFO consumption will be 55,000 tonnes.

The annual fuel usage during construction and decommissioning will be significantly less than during operations (1 MLpa compared to 20 MLpa) and hence an extra one year has been added to the 46 year period of operations as a conservative estimate of the fuel used during the 4 years of construction and decommissioning. The first year of construction is assumed to be powered by diesel generators hence electricity consumption is over 49 years.

Based on these assumptions, the projected emissions over the life of the project are contained in Table 16 for Scope 1 and Scope 2 emissions. The total and annual emissions in tonnes for Scope 1 and 2 greenhouse gases (CH_4, CO_2 and N_20) are also given in Table 16.

Table 16: Greenhouse Gas Emissions Summary (Scope 1, Scope 2) and Typical Annual and Total for Life of Mine

Source	Quantity	Units	Green-house Gas	Emission Factor	Emission Factor Units	Emissions	Emission Units
Scope 1 Blasting (annual)	55,000	ANFO tpa	CO_2	-		-	
			CH_4	-		-	
			N_2O	180	kg CO_2 -e/ t ANFO	9.9	tonnes*10^3 CO_2 -e/a
Scope 1 Fuel Consumption (Mining) (annual)	20	Ml/a	CO_2	2.67112	kg CO_2-e/L	53.4	tonnes*10^3 CO_2 -e/a
			CH_4	0.00772	kg CO_2-e/L	0.2	tonnes*10^3 CO_2 -e/a
			N_2O	0.0193	kg CO_2-e/L	0.4	tonnes*10^3 CO_2 -e/a
Scope 1 Coal Seam Gas (Annual)	15	MTPA	CO_2	-		-	
			CH_4	17	kg CO_2-e/tonne raw coal.	255.0	tonnes*10^3 CO_2 -e/a
			N_2O	-		-	
Scope 1 Clearing native vegetation and burning biomass. (entire project duration)	2500	Ha	CO_2	132,120	kg CO_2-e/Ha	330.3	tonnes*10^3 CO_2 -e/a
			CH_4	-		-	
			N_2O	-		-	
Scope 2 Electricity Consumptions (annual)	271560	MWh/a	CO_2	0.89	kg CO_2-e/kWh	241.7	tonnes*10^3 CO_2 -e/a
			CH_4			-	
			N_2O			-	
Total Scope 1 Emissions (Annual)						**318.9**	**tonnes*10^3 CO_2 -e/a**
Total Scope 1 Emissions (Annual) CO_2						53.4	tonnes*10^3 CO_2 -e/a

Total Scope 1 Emissions (Annual) CH_4	255.2	tonnes*10^3 CO_2 -e/a
Total Scope 1 Emissions (Annual) N_2O	10.3	tonnes*10^3 CO_2 -e/a
Total Scope 1 Emissions (Once)	**330.3**	**tonnes*10^3 CO_2 -e**
Total Scope 1 Emissions (Once) CO_2	330.3	tonnes*10^3 CO_2 -e
Total Scope 1 Emissions (Once) CH_4	0.0	tonnes*10^3 CO_2 -e
Total Scope 1 Emissions (Once) N_2O	0.0	tonnes*10^3 CO_2 -e
Total Scope 2 Emissions (Annual)	**241.7**	**tonnes*10^3 CO_2 -e/a**
Total Scope 2 Emissions (Annual) CO_2	241.7	tonnes*10^3 CO_2 -e/a
Total Scope 2 Emissions (Annual) CH_4	0.0	tonnes*10^3 CO_2 -e/a
Total Scope 2 Emissions (Annual) N_2O	0.0	tonnes*10^3 CO_2 -e/a
Total Annual Emissions (Scope 1 and Scope 2)	**560.6**	**tonnes*10^3 CO_2 -e/a**
Total Annual Emissions (Scope 1 and Scope 2) CO_2	295.1	tonnes*10^3 CO_2 -e/a
Total Annual Emissions (Scope 1 and Scope 2) CH_4	255.2	tonnes*10^3 CO_2 -e/a
Total Annual Emissions (Scope 1 and Scope 2) N_2O	10.3	tonnes*10^3 CO_2 -e/a
Total Emissions over Life of Mine (Scope 1 and Scope 2)	**26897**	**tonnes*10^3 CO_2 -e**
Total Emissions over Life of Mine (Scope 1 and Scope 2) CO_2	14684	tonnes*10^3 CO_2 -e
Total Emissions over Life of Mine (Scope 1 and Scope 2) CH_4	11739	tonnes*10^3 CO_2 -e
Total Emissions over Life of Mine (Scope 1 and Scope 2) N_2O	474	tonnes*10^3 CO_2 -e

5.2 Discussion and Mitigation Measures

The estimated greenhouse gas emissions intensity (Scope 1 and Scope 2) is approximately 0.056 tonnes CO_2 -e per tonne of product coal. This is less than the Australian coal mining industry average of 0.079 Tonnes CO_2-e/tonne of product coal (AGSO, 2000).

The proponent seeks to extract coal with the lowest energy usage while at same time comply with the requirements and intent of the Clean Energy Act 2011. The proponent will also assess and consider implementation, where feasible, of greenhouse gas and energy management and mitigation initiatives during the design, operation and decommissioning of the Project. Some of the opportunities for improving energy efficiency and reducing greenhouse gas emissions from the Project are discussed below. The Project mitigation measures are largely focused on energy management, energy efficiency and the potential reduction in diesel oil consumption for mine plant and equipment

The sizing and selection of mobile diesel powered equipment has an important bearing on greenhouse gas emissions. Diesel fuel consumption rates are an integral part of the decision matrix for their selection and fuel costs and efficiencies one of the most important parameters. Therefore higher fuel prices have made coal producers increasingly aware of fuel costs with flow on effects on consumption and greenhouse gas emissions subsequently.

The proponent is committed to the concept of sustainable development. The proponent is fully committed and complies with its obligations under the National Greenhouse Energy reporting (NGER) and specifically annual reporting of greenhouse gas emissions. The proponent is committed to reducing the greenhouse gas emissions of its operations, accelerating the uptake of energy efficiency, integrating greenhouse issues into business decision making and providing more consistent reporting of greenhouse gas emission levels.

Direct means of reducing greenhouse gas emissions could include such measures as:

- minimising clearing at the site;
- utilising the existing railway where practicable to transport construction material/equipment;
- maximising the use of renewable energy sources; and
- improved accuracy in greenhouse gas measurement by advancing from default factors to direct measurement methodologies.

Indirect means of reducing greenhouse gas emissions could include such measures as:

- carbon sequestration at nearby or remote locations by:
  - progressive rehabilitation of disturbed areas; and
  - planting trees or other vegetation to achieve greater biomass than that cleared for the project; and
- carbon trading through recognised markets (Carbon permits under the Clean Energy Act).

The Environmental Management Plan will include a specific module to address greenhouse abatement. This module will include:

- commitments to energy management, including undertaking periodic energy audits with a view to progressively improving energy efficiency as required under the Clean Energy Act 2011;
- a process for regular review of new technologies to identify opportunities to reduce emissions and use energy efficiently, consistent with best practice environmental management;
- commitments to monitor, audit and report on greenhouse emissions from all relevant activities and the success of offset measures.

5.3 Climate Change Adaptation

The Garnaut Review (2008) states "Effects of future warming on rainfall patterns are difficult to predict because of interactions with complex regional climate systems. Best-estimate projections show considerable drying in southern Australia, with risk of much greater drying. The mainstream Australian science estimates that there may be a 10 per cent chance of a small increase in average rainfall, accompanied by much higher temperatures and greater variability in weather patterns."

The life of the mine is approximately 46 years and the likely changes over this time will be gradual and relatively minor. A reduction in rainfall and an increase in temperatures will result in higher dust emissions. However, the changes are only likely to be small and within the capacity of management to respond within the bounds of current dust control technology. It is expected the risk of a significant increase in emissions is very small.

Management commits to undertake, where practicable, a cooperative approach with government, other industry and sectors to address adaptation to climate change. The proponent is committed to reducing its greenhouse gas emissions.

6. Conclusion

Monitoring of the existing environment has revealed that the existing PM_{10} levels are relatively low. There appears to be a diurnal cycle with the lowest dust levels at night and the highest during the day.

It was determined that the key issue to be addressed in the assessment is dust and that other air pollution measures have minor impacts localised to the lease area. From the EPP(Air) there are four environmental objectives associated with health and wellbeing and one developed for flora. From the DEHP Licensing and Permits, a single nuisance objective was obtained.

The modelling was carried out using the TAPM air quality model. This model was also used to develop the meteorology data set used in the modelling. The modelling simulation was carried out over two years, 2004 and 2005.

The development of the representative emissions database has been primarily based on the National Pollution Inventory Emission Estimation Technique Manual for Mining Version 2.3. The main mining activities and processes that produce, or could produce, dust emissions were identified for the project operations. Flowcharts for handling of overburden, interburden, coal and waste rock were developed and an emission factor (from NPI) was attributed to every handling point, handling activity and transport section. In addition emissions from exposed surfaces were identified and included in the database.

The predicted average ground level concentrations at nearby sensitive areas were modelled and Section 4.1 contains a full description of the modelling methods. The methodology includes both normal and expected maximum emission conditions and the worst meteorological conditions. The ground level predictions were made at all residential locations and the contours cover adjacent industrial and agricultural developments. All the techniques used to obtain the predictions have are referenced and key assumptions and data sets explained.

The likely dust levels from the railway line has also been modelled. A conservative modelling methodology has been adopted and based on the latest emission rates for Queensland coal trains. It was determined that the dust exposure at all sensitive receptors is negligible and the cumulative impact (railway and mining) readily complies with all dust goals.

The modelling assumed standard and enhanced dust controls with results showing exceedences of the PM_{10}(24hour) air quality objective at sensitive receptor R5 i.e. at R5 there were more than 5 days per year where the dust concentration of PM_{10}(24 hour) was greater than the comparative level of 50 $\mu g/m^3$. These were noted to occur during adverse meteorological conditions.

A range of operational and direct dust control mitigation measures were then modelled which showed that air quality objectives could be met at all sensitive receptors; these mitigations would only be required during specific meteorological and operational conditions.

As such, to enable the proponent to react to the adverse air quality conditions and implement enhanced dust controls and or modify operations to avoid exceedance of the objectives, it is proposed that the proponent undertake dust monitoring at the adversely affected locations along with development of a Dust Management Plan.

The Dust Management Plan should be developed to include an action response plan to sequentially implement mitigations and monitor the results. Mitigation measures would be implemented sequentially as required by meteorological conditions and dust monitoring results, until such time as the meteorological conditions return to a suitable state where these mitigations are no longer required.

A greenhouse gas assessment was carried out utilising the 2012 NGA workbook and the best available projections for the project. The project will result in greenhouse gas emissions as the result of the use of diesel fuel, explosives, clearing and indirectly in the use of electrical power. Methane will be released from the coal seam. The estimated greenhouse gas emissions intensity (Scope 1 and Scope 2) is approximately 0.056 tonnes CO_2 -e /tonne product coal. This is less than the Australian coal mining industry average of 0.079 Tonnes CO_2-e/tonne of product coal. The quantities of greenhouse emissions are comparatively small and unlikely to have a measureable effect on climate. Nevertheless the proponent intends to seek new and improved ways to reduce greenhouse gas emissions, whilst maintaining active involvement in appropriate greenhouse gas programs.

Glossary of Terms

Term	**Meaning**
Background levels	Existing concentrations of pollutants in the ambient air
Dispersion modelling	Modelling by computer to mathematically simulate the effect on plume dispersion under varying atmospheric conditions; used to calculate spatial and temporal fields of concentrations and particle deposition due to emissions from various source types
PM_{10}	particles in the air environment with an equivalent aerodynamic diameter of not more than 10microns.
$PM_{2.5}$	particles in the air environment with an equivalent aerodynamic diameter of not more than 2.5 microns
PM_{01}	particles in the air environment with an equivalent aerodynamic diameter of not more than 1microns.
TSP	total suspended particles are particles in the air environment with an equivalent aerodynamic diameter of not more than 50 microns.
air emission	a substance released into the air.
Carbon dioxide equivalent (CO_2-e)	The key greenhouse gases are carbon dioxide, methane and nitrous oxide. To simplify the accounting of GHGs, the unit of a carbon dioxide equivalent or CO_2-e is used. This ensures that the global warming potential of each gas is accounted for. Carbon dioxide has a global warming potential of 1, methane has a global warming potential of 21, and nitrous oxide has a global warming potential of 310
Climate change	Any long-term significant change in the „average weather" that a given region experiences.
Greenhouse Gas	The gases present in the earth's atmosphere which reduce the loss of heat into space and therefore contribute to global temperatures through the greenhouse effect.
Separation distance	The distance between a source and sensitive receptors

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Appendix 1 Climate Data for Moranbah and Collinsville

Climate Data for Moranbah

Statistic Element	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Mean maximum temperature (Degrees C) for years 1986 to 2012	33.8	33.1	32.1	29.5	26.5	23.7	23.7	25.5	29.2	32.3	33.1	34	29.7
Highest temperature (Degrees C) for years 1986 to 2012	45	41.1	40.4	36	33.9	31.9	31	36.4	38	40.5	42.7	42.5	45
Lowest maximum temperature (Degrees C) for years 1986 to 2012	23.3	22	21.8	17.8	14.2	10.6	13.9	11	18.9	17.5	20.8	20	10.6
Decile 1 maximum temperature (Degrees C) for years 1986 to 2012	30.2	28.8	28.8	26.4	23.3	19.9	20.2	21.8	25.4	28.5	28.8	29.5	
Decile 9 maximum temperature (Degrees C) for years 1986 to 2012	37.4	36.9	35.2	32.8	29.5	27.4	27.1	29.4	33.3	36.2	37.2	37.8	
Mean number of days >= 30 Degrees C for years 1986 to 2012	26.8	23.6	24.4	12.5	2	0.2	0.2	2.4	11.4	24	24.5	25.8	177.8
Mean number of days >= 35 Degrees C for years 1986 to 2012	10.3	7.7	3.9	0.6	0	0	0	0.1	0.7	5.4	8.1	12.1	48.9
Mean number of days >= 40 Degrees C for years 1986 to 2012	0.6	0.1	0	0	0	0	0	0	0	0.1	0.4	0.6	1.8
Mean minimum temperature (Degrees C) for years 1986 to 2012	21.9	21.8	20.2	17.6	14.2	11.2	9.9	11.1	14.1	17.6	19.4	21.1	16.7
Lowest temperature (Degrees C) for years 1986 to 2012	14.9	15.5	14.3	6	5	1.1	0.2	3	5.4	10.8	11.9	15	0.2
Highest minimum temperature (Degrees C) for years 1986 to 2012	28.5	26.5	27	25.2	21.6	21.9	18	20.2	23.6	23.6	25.6	27.9	28.5
Decile 1 minimum temperature (Degrees C) for years 1986 to 2012	19.8	19.5	18	15	9.5	6.1	4.7	6.5	10.4	14.6	16.7	18.4	
Decile 9 minimum temperature (Degrees C) for years 1986 to 2012	24.1	23.9	22.7	20.5	18	15.4	14.6	15.4	17.9	21	22.1	23.6	

Mean number of days <= 2 Degrees C for years 1986 to 2012	0	0	0	0	0	0.1	0.2	0	0	0	0	0	0.3
Mean number of days <= 0 Degrees C for years 1986 to 2012	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean rainfall (mm) for years 1972 to 2012	105.3	100.7	55.4	36.4	34.5	22.1	18	25	9.1	35.7	69.3	103.9	614.5
Highest rainfall (mm) for years 1972 to 2012	315	347.4	268	271	196.6	170.3	103.6	247.3	60.7	146.6	220.3	350	1109.2
Date of Highest rainfall for years 1972 to 2012	1975	2008	1988	1989	1983	2007	1978	1998	2010	1995	1998	2010	2010
Lowest rainfall (mm) for years 1972 to 2012	9.4	0.3	0.2	0	0	0	0	0	0	0	0	0.2	280.7
Date of Lowest rainfall for years 1972 to 2012	1988	1996	2005	1993	2010	2006	2009	2008	2009	2006	1980	2009	1982
Decile 1 monthly rainfall (mm) for years 1972 to 2012	21	9	1.4	0.6	0	0	0	0	0	0	4.5	20.8	375
Decile 5 (median) monthly rainfall (mm) for years 1972 to 2012	89.2	91.6	37.2	24.9	22.7	10.4	6	11.3	4.2	15.8	55	82.6	606.8
Decile 9 monthly rainfall (mm) for years 1972 to 2012	220.7	219	185.8	85.4	76.3	48	63.1	72.2	22.2	104.5	159.7	201.3	882.7
Highest daily rainfall (mm) for years 1972 to 2012	120.4	150.8	164.8	143.8	58	43.4	60	150.8	27.6	73.8	86	116	164.8
Mean number of days of rain for years 1800 to 3000	8.5	8.2	5.5	4.3	3.8	3.2	2.6	2.2	2.2	4	6.2	7.3	58
Mean number of days of rain >= 1 mm for years 1972 to 2012	6.4	6.4	3.9	3.1	2.6	2.1	1.8	1.7	1.4	3.1	4.9	5.9	43.3
Mean number of days of rain >= 10 mm for years 1972 to 2012	3	2.7	1.4	1.1	0.9	0.6	0.6	0.7	0.3	1.2	2.1	2.6	17.2
Mean number of days of rain >= 25 mm for years 1972 to 2012	1.4	1.1	0.6	0.4	0.4	0.3	0.2	0.3	0	0.4	1	1.4	7.5
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2012	24.1	22.1	21.9	18.9	16.1	14.5	15.9	18.7	22.3	24.6	25.4	25.3	20.8
Mean number of clear days for years 1986 to 2010	5.1	3.8	7.4	9.9	10.9	13.4	16.4	16.8	16.7	14.2	10.2	7.3	132.1
Mean number of cloudy days for years 1986 to 2010	10.4	11	8.6	7.2	7.7	6.6	4.8	4.1	2.8	4.7	6.6	8.3	82.8

Mean daily evaporation (mm) for years 1986 to 2012	8	7.4	6.8	5.7	4.3	3.5	3.7	4.9	6.6	8	8.5	8.5	6.3
Mean 9am temperature (Degrees C) for years 1986 to 2010	26.4	25.8	24.7	22.1	18.9	15.4	14.7	16.6	20.6	24	25.3	26.4	21.7
Mean 9am wet bulb temperature (Degrees C) for years 1986 to 2010	22.3	22.3	20.9	18.9	16	12.8	11.8	13.1	15.8	18.6	20	21.4	17.8
Mean 9am dew point temperature (Degrees C) for years 1986 to 2010	20.1	20.5	18.7	16.7	13.5	10.2	8.6	9.6	11.6	14.8	16.5	18.5	14.9
Mean 9am relative humidity (%) for years 1986 to 2010	69	74	70	72	73	73	69	66	60	58	60	64	67
Mean 9am cloud cover (okas) for years 1986 to 2010	4.4	4.6	3.8	3.3	3.3	2.8	2.4	2.1	1.8	2.3	3.1	3.7	3.1
Mean 9am wind speed (km/h) for years 1986 to 2010	7.5	7.7	8.1	7.6	6.2	5.5	5.3	6.6	7.7	8.4	8.4	8.4	7.3
Mean 3pm temperature (Degrees C) for years 1986 to 2010	32.7	31.9	31.2	28.6	25.8	22.9	22.9	24.6	28.3	31.4	32.2	33	28.8
Mean 3pm wet bulb temperature (Degrees C) for years 1986 to 2010	22.9	23.1	21.6	19.9	17.7	15.6	14.9	15.5	17.4	19.6	20.8	22.1	19.3
Mean 3pm dew point temperature (Degrees C) for years 1986 to 2010	17.3	18.2	15.7	13.8	11.2	8.8	7	6.7	7.6	10.5	12.7	15.4	12.1
Mean 3pm relative humidity (%) for years 1986 to 2010	43	48	41	43	43	44	39	35	30	31	34	38	39
Mean 3pm cloud cover (oktas) for years 1986 to 2010	5	5.2	4.5	4.3	4	3.2	2.7	2.6	2.4	3.3	3.8	4.4	3.8
Mean 3pm wind speed (km/h) for years 1986 to 2010	8.8	9.6	9.4	8.7	6.9	6.6	7	7.7	8.3	8.4	8.9	8.8	8.3

Climate Data for Collinsville

Statistic Element	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Mean maximum temperature (Degrees C) for years 1955 to 2012	33.4	32.7	31.9	30.3	27.5	25.1	25	26.9	29.6	32.2	33.4	34	30.2
Highest temperature (Degrees C) for years 1957 to 2012	44	43.3	40.7	36.8	33.2	32.8	31.7	34.2	36.6	39.9	41.6	42.2	44

Lowest maximum temperature (Degrees C) for years 1957 to 2012	24	23.2	22	20	16.4	11	13.4	15.2	20.8	21.7	22.7	23	11
Decile 1 maximum temperature (Degrees C) for years 1957 to 2012	29.8	29.4	29.3	27.8	24.8	21.8	22	23.8	26.8	29	30.1	30.5	
Decile 9 maximum temperature (Degrees C) for years 1957 to 2012	36.7	35.7	34.6	33	30.1	28	27.9	30	32.8	35.4	36.5	37.2	
Mean number of days >= 30 Degrees C for years 1957 to 2012	24.2	21.9	23	15.5	3.5	0.5	0.4	2.9	12.8	22.8	24.4	24.6	176.5
Mean number of days >= 35 Degrees C for years 1957 to 2012	7.6	5	2	0.3	0	0	0	0	0.2	3.6	7.3	10.5	36.5
Mean number of days >= 40 Degrees C for years 1957 to 2012	0.4	0.1	0	0	0	0	0	0	0	0	0.2	0.2	0.9
Mean minimum temperature (Degrees C) for years 1955 to 2012	21.9	21.9	20	17	13.7	10.4	9	10.6	13.6	17.3	20	21.3	16.4
Lowest temperature (Degrees C) for years 1957 to 2012	15	15.6	10.2	6.7	1.7	-1.1	-1	-1.1	2.2	8.3	12.8	14.3	-1.1
Highest minimum temperature (Degrees C) for years 1957 to 2012	28.3	27.2	26.9	25.4	22.5	21.8	20	21.5	24.5	26.1	25.5	27.4	28.3
Decile 1 minimum temperature (Degrees C) for years 1957 to 2012	19	19.3	17	13.5	8.7	5	3.3	5.2	9.4	13.3	16.7	18.3	
Decile 9 minimum temperature (Degrees C) for years 1957 to 2012	24.4	24.1	23	20.6	18.5	16	14.8	16	18.5	21.4	23	24.1	
Mean number of days <= 2 Degrees C for years 1957 to 2012	0	0	0	0	0.1	0.5	1.2	0.3	0	0	0	0	2.1
Mean number of days <= 0 Degrees C for years 1957 to 2012	0	0	0	0	0	0.1	0.1	0	0	0	0	0	0.2
Mean rainfall (mm) for years 1939 to 2012	134.8	162.3	97.8	42.3	32.4	27.2	20.3	17.8	11.4	21.6	51.8	96.8	716.6
Highest rainfall (mm) for years 1939 to 2012	505.8	524.6	341.8	448.6	246.6	207.6	207.4	200	56.2	158.3	216.2	410.4	1583.6
Date of Highest rainfall for years 1939 to 2012	1974	1991	1946	1940	1955	2007	1950	1998	2010	1985	1950	1956	1956
Lowest rainfall (mm) for years 1939 to 2012	15.4	4	2.6	0	0	0	0	0	0	0	0	4.2	282.8
Date of Lowest rainfall for years 1939 to 2012	1988	1983	2005	1967	1949	2004	2009	2009	2011	2006	2003	2009	1969
Decile 1 monthly rainfall (mm) for years 1939 to 2012	39.3	32.4	11.8	1.2	2	1.8	0	0	0	0	3.5	32.9	425.3
Decile 5 (median) monthly rainfall (mm) for years 1939 to 2012	105.4	132	72.6	21.9	14.2	14.8	6.4	4	4.3	12.8	33.5	77.8	687.8
Decile 9 monthly rainfall (mm) for years 1939 to 2012	271	349.5	218.6	81.9	67.5	55.4	60.9	45.6	32	47	125.2	215.3	1133.7
Highest daily rainfall (mm) for years 1939 to 2012	146.2	266.2	235.7	348.7	102.9	84.8	92.2	114	44	57	143	182.4	348.7

Mean number of days of rain for years 1800 to 3000	10.6	11.5	8.5	4.9	4.2	3.6	2.5	2.1	1.8	3	5	7.5	65.2
Mean number of days of rain >= 1 mm for years 1939 to 2012	8.9	10	7	3.8	3	2.7	1.7	1.6	1.4	2.3	4.1	6.6	53.1
Mean number of days of rain >= 10 mm for years 1939 to 2012	3.9	4.4	2.8	1	0.8	0.7	0.7	0.5	0.4	0.7	1.5	2.9	20.3
Mean number of days of rain >= 25 mm for years 1939 to 2012	1.6	2	1.2	0.4	0.3	0.3	0.2	0.2	0.1	0.2	0.7	1.3	8.5
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2012	22.5	21.1	21.2	18.6	16.1	14.8	16.1	18.6	22.3	24.5	25	24.1	20.4
Mean number of clear days for years 1957 to 2010	4.2	2.9	5.6	7.4	9.6	12.7	15.5	15.6	14.3	11.9	8.9	6	114.6
Mean number of cloudy days for years 1957 to 2010	10.6	10.7	8	5.8	6.6	4.9	4.1	3.2	3.1	3.7	5.6	7.3	73.6
Mean daily evaporation (mm) for years 1967 to 2012	6.1	5.6	5.2	4.4	3.4	2.9	3.1	4.1	5.3	6.4	6.9	6.8	5
Mean 9am temperature (Degrees C) for years 1955 to 2010	27.4	26.8	25.6	23.5	20.2	16.9	16.1	18.5	22.1	25.4	27	27.9	23.1
Mean 9am wet bulb temperature (Degrees C) for years 1955 to 2010	23	23.1	21.9	19.9	17.2	14.2	13.3	14.9	17.2	19.6	21.2	22.6	19
Mean 9am dew point temperature (Degrees C) for years 1957 to 2010	20.7	21.2	19.8	17.7	14.9	11.7	10.5	11.5	13.4	15.7	17.9	19.7	16.2
Mean 9am relative humidity (%) for years 1955 to 2010	68	72	71	71	73	73	71	65	60	56	58	62	67
Mean 9am cloud cover (okas) for years 1955 to 2010	4.4	4.4	3.6	2.9	2.8	2.3	1.9	1.7	1.9	2.5	3.2	3.7	2.9
Mean 9am wind speed (km/h) for years 1957 to 2010	5.3	4.9	5.2	5.8	5	4.4	4.7	5.3	6.6	7.4	7.4	6.2	5.7
Mean 3pm temperature (Degrees C) for years 1955 to 2010	31.7	31.2	30.7	29	26.4	24.2	24.1	25.9	28.6	31	32.1	32.6	29
Mean 3pm wet bulb temperature (Degrees C) for years 1955 to 2010	23.7	23.8	22.9	21	19	16.9	16.1	16.9	18.4	20.3	21.9	23.1	20.3
Mean 3pm dew point temperature (Degrees C) for years 1957 to 2010	19.3	19.8	18.5	16.1	13.4	10.5	8.8	8.9	10.1	12.7	15.8	17.7	14.3
Mean 3pm relative humidity (%) for years 1955 to 2010	51	53	50	48	47	44	40	37	34	35	40	44	44
Mean 3pm cloud cover (oktas) for years 1955 to 2010	5.3	5.6	5	4.7	4.3	3.4	2.9	2.7	2.7	3.1	3.9	4.5	4
Mean 3pm wind speed (km/h) for years 1957 to 2010	7.1	7	7.6	8.4	7.4	7	8	7.7	8.5	8.9	9.2	8	7.9

Appendix 2 Dust Emission Rate Calculation Methodology

Extract from NPI Emission Estimation Technique Manual for Mining V3.1 January 2012

Table 2: Emission Factor Equations and Default Emission Factors for Various Operations at Coal Mines 1, 2

Operation/Activity	TSP Equation	PM_{10} Equation	TSP Default Emission Factor	PM_{10} Default Emission Factor	PMR_{10} PM_{10}/TSP Ratio based on Emission Factors	Units	EFR
Draglines (on overburden).	$EF_{TSP} = 0.0046 \times \left(d^{1.1} / M^{0.3} \right)$	$EF_{PM_{10}} = 0.0022 \times \left(d^{0.7} / M^{0.3} \right)$	0.06	0.026	0.43	kg/bcm	B
Excavators/Shovels/ Front-end loaders (on overburden).	See Appendix A Section 1.1.2	See Appendix A Section 1.1.2	0.025	0.012	0.47	kg/t	U
Excavators/Shovels/ Front-end loaders (on coal).	$EF_{TSP} = 0.580 / (M)^{1.2}$	$EF_{PM_{10}} = 0.0447 / M^{0.9}$	0.029	0.014	0.48	kg/t	C
Bulldozers on coal.	$EF_{TSP} = 35.6 \times (s)^{1.2} / (M)^{1.4}$	$EF_{PM_{10}} = 6.33 \times \left((s)^{1.5} / (M)^{1.4} \right)$	102	32.5	0.32	kg/h/vehicle	B
Bulldozer on material other than coal.	$EF_{TSP} = 2.6 \times (s)^{1.2} / (M)^{1.3}$	$EF_{PM_{10}} = 0.34 \times \left((s)^{1.5} / (M)^{1.4} \right)$	17	4.1	0.24	kg/h/vehicle	B
Trucks (dumping overburden).	See Appendix A Section 1.1.6	See Appendix A Section 1.1.6	0.012	0.0043	0.35	kg/t	U
Trucks (dumping coal).	See Appendix A Section 1.1.7	See Appendix A Section 1.1.7	0.010	0.0042	0.42	kg/t	
Drilling.	See Appendix A Section 1.1.8	See Appendix A Section 1.1.8	0.59	0.31	0.52	kg/hole	C
Blasting[3].	$EF_{TSP} = 0.00022 \times A^{1.5}$	$EF_{PM_{10}} = 0.000114 \times A^{1.5}$			0.52	kg/blast	C

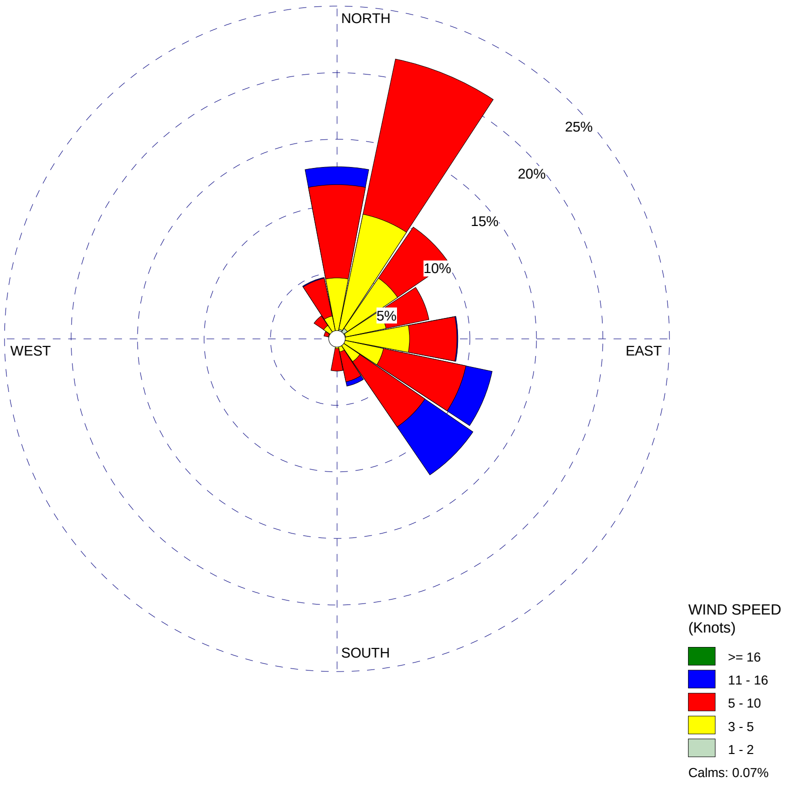
			Default Emission Factor	Default Emission Factor	PM_{10}/TSP Ratio based on Emission Factors		
Wheel and bucket[4]	$EF_{TSP} = 0.74 \times 0.0016 \times \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$	$EF_{PM_{10}} = 0.35 \times 0.0016 \times \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$	0.00032	0.00015	0.47	kg/t	C
Wheel generated dust from unpaved roads at industrial sites	$EF_{TSP} = \frac{0.4536}{1.6093} \times 4.9 \times \left(\frac{s}{12}\right)^{0.7} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	$EF_{PM_{10}} = \frac{0.4536}{1.6093} \times 1.5 \times \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	4.23	1.25	0.30	kg/VKT	B
Wheel generated dust from unpaved roads (used by light duty vehicles)	$EF_{TSP} = 1.69 \times \frac{(s/12) \times (S/48)^{0.3}}{(M/0.5)^{0.3}} - 0.0013$	$EF_{PM_{10}} = 0.51 \times \frac{\left(s/12\right) \times \left(S/48\right)^{0.5}}{\left(M/0.5\right)^{0.2}} - 0.0013$	0.94	0.33	0.35	kg/VKT	B
Scrapers (travel mode)	$EF_{TSP} = 9.6 \times 10^{-6} \times s^{1.3} \times W^{2.4}$	$EF_{PM_{10}} = 1.32 \times 10^{-6} \times s^{1.3} \times W^{2.4}$	2.08	0.52	0.25	kg/VKT	A
Scrapers (removing topsoil)	See Appendix A Section 1.1.13	See Appendix A Section 1.1.13	0.029	0.0073	0.25	kg/t	E
Graders	$EF_{TSP} = 0.0034 \times S^{2.5}$	$EF_{PM_{10}} = 0.0034 \times S^{2.0}$	0.19	0.085	0.31	kg/VKT	B
Loading stockpiles	See Appendix A Section 1.1.15	See Appendix A Section 1.1.15	0.004	0.0017	0.42	kg/t	U
Unloading from stockpiles	See Appendix A Section 1.1.15	See Appendix A Section 1.1.15	0.03	0.013	0.42	kg/t	U
Loading to trains	See Appendix A Section 1.1.15	See Appendix A Section 1.1.15	0.0004	0.00017	0.42	kg/t	U
Miscellaneous transfer points (including conveying)	$EF_{TSP} = 0.74 \times 0.0016 \times \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$	$EF_{PM_{10}} = 0.35 \times 0.0016 \times \frac{\left(U/2.2\right)^{1.3}}{\left(M/2\right)^{1.4}}$	0.00032	0.00015	0.47	kg/t/transfer point	U
Wind erosion	See Appendix A Section 1.1.17 to 1.1.18	See Appendix A Section 1.1.17 to 1.1.18	0.4	0.2	0.50	kg/ha/h	U

Operation/Activity	TSP Equation	PM_{10} Equation	TSP Default Emission Factor	PM_{10} Default Emission Factor	PMR_{10} PM_{10}/TSP Ratio based on Emission Factors	Units	EFR
Highwall Mining	See Appendix A Section 1.1.19	See Appendix A Section 1.1.19	0.00032	0.00015	0.47	kg/t/transfer point	U

1. See Appendix A for details of the sources of these emission factors and emission estimation equations
2. d = drop distance in metres;
   M = moisture content in % (by weight, in natural state, i.e. prior to addition of H_2O for dust control);
   bcm = bank cubic metres;
   t = tonne;
   s = silt content in % (by weight);
   A = area blasted in m^2;
   D = depth of blast holes in metres;
   U = mean wind speed in m/s
   W = vehicle gross mass in tonnes
   VKT = vehicle kilometres travelled;
   S = mean vehicle speed in km/h
   $PMR_{10} = PM_{10}$ / TSP ratio
3. Additional guidance on the characterisation of emissions of PM_{10} and other substances is provided in the Emission Estimation Technique manual for Explosives Detonation.
4. A significant proportion of open-cut coal mining for softer brown coals is carried out using bucket wheel excavators.
5. Exponents for "Wheel generated dust from unpaved roads at industrial sites": A = 0.9 (for PM_{10}) & 0.7 (for TSP)
6. Exponents for "Wheel generated dust from unpaved roads used by light duty vehicles": B = 0.5 (for PM_{10}) & 0.3 (for TSP), C = 0.2 (for PM_{10}) & 0.3 (for TSP)
7. emission factors quoted in Table 2 apply to all operations typically associated with the process. Therefore, emissions from a primary crushing activity include emissions from the screens, the crusher, the surge bin, the apron feeder, and conveyor belt transfer points that are integral to the crusher.

Appendix 3 Windroses For project - From TAPM

WIND ROSE PLOT:	DISPLAY:
Byerwen Coal Project - QCoal	**Wind Speed** **Direction (blowing from)**

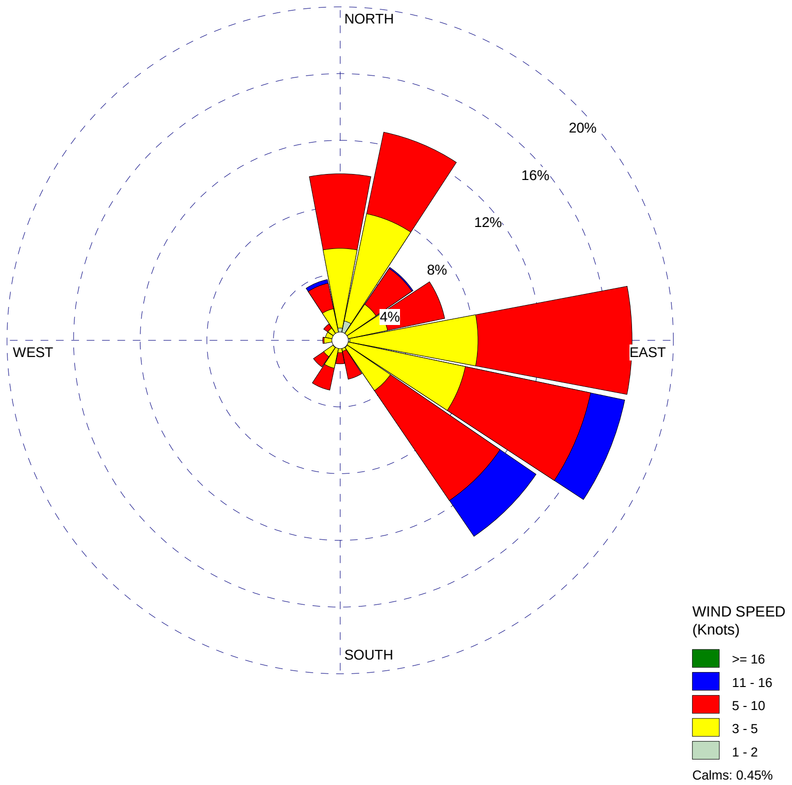


COMMENTS:	DATA PERIOD:	COMPANY NAME:	
Wind Rose for Janurary	**Start Date: 1/01/2004 - 00:00** **End Date: 31/01/2005 - 23:00**	**Noise Mapping Australia**	
		MODELER: **C Simpson**	
	CALM WINDS: **0.07%**	TOTAL COUNT: **1488 hrs.**	
	AVG. WIND SPEED: **6.29 Knots**	DATE: **18/02/2013**	PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:
Byerwen Coal Project - QCoal

DISPLAY:
Wind Speed
Direction (blowing from)

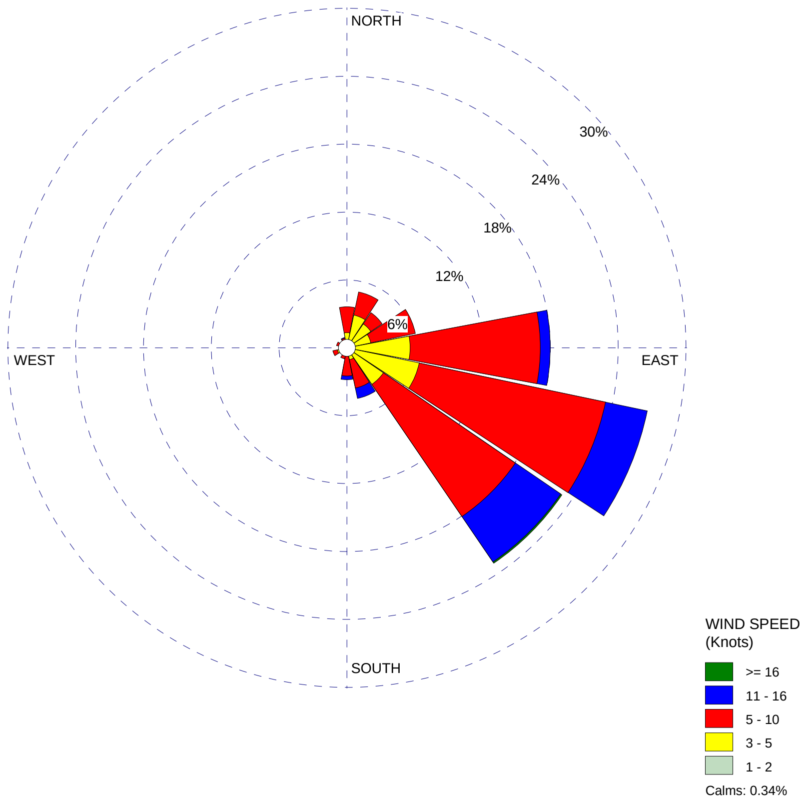


COMMENTS: Wind Rose for February	DATA PERIOD: **Start Date: 1/02/2004 - 00:00** **End Date: 28/02/2005 - 23:00**	COMPANY NAME: **Noise Mapping Australia**	
		MODELER: **C Simpson**	
	CALM WINDS: **0.45%**	TOTAL COUNT: **1344 hrs.**	
	AVG. WIND SPEED: **5.75 Knots**	DATE: **18/02/2013**	PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:
Byerwen Coal Project - QCoal

DISPLAY:
Wind Speed
Direction (blowing from)

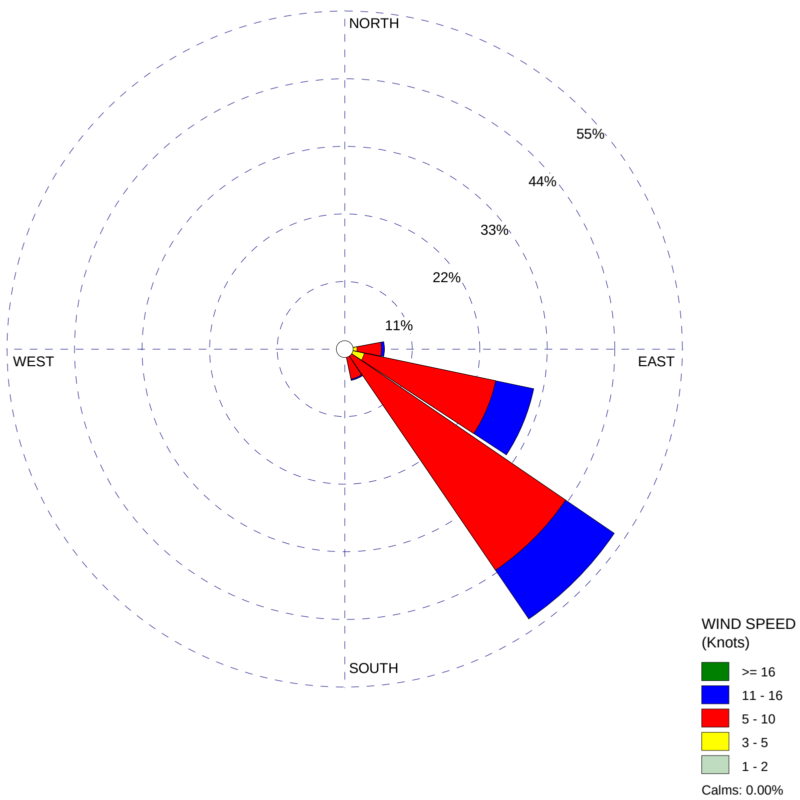


COMMENTS: Wind Rose for March	DATA PERIOD: **Start Date: 1/03/2004 - 00:00** **End Date: 31/03/2005 - 23:00**	COMPANY NAME: **Noise Mapping Australia**	
		MODELER: **C Simpson**	
	CALM WINDS: **0.34%**	TOTAL COUNT: **1488 hrs.**	
	AVG. WIND SPEED: **6.87 Knots**	DATE: **18/02/2013**	PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:
Byerwen Coal Project - QCoal

DISPLAY:
Wind Speed
Direction (blowing from)

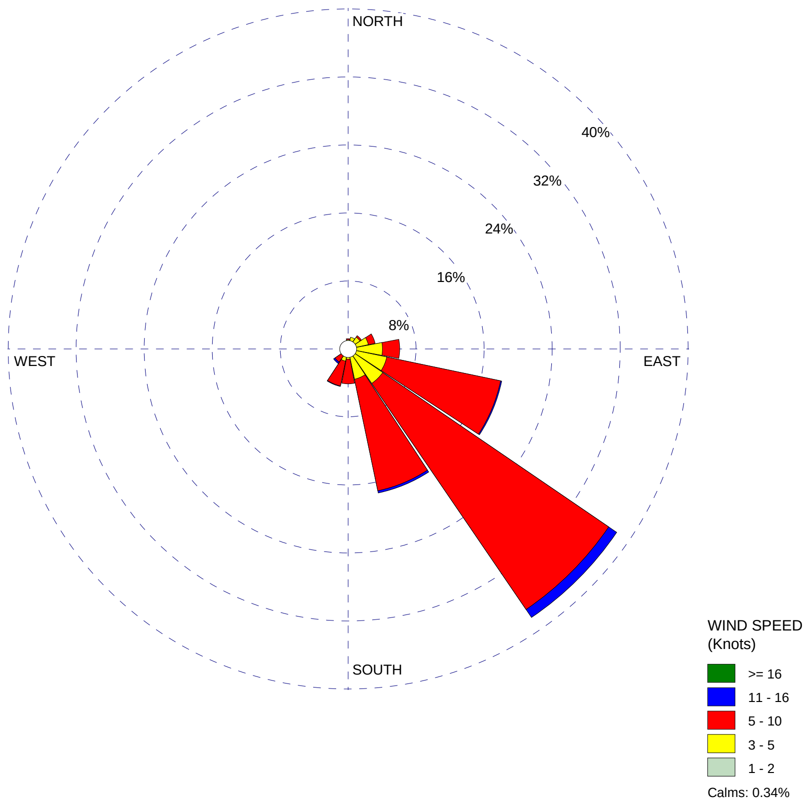


COMMENTS: Wind Rose for April	DATA PERIOD: **Start Date: 1/04/2004 - 00:00** **End Date: 30/04/2005 - 23:00**	COMPANY NAME: **Noise Mapping Australia**	
		MODELER: **C Simpson**	
	CALM WINDS: **0.00%**	TOTAL COUNT: **1440 hrs.**	
	AVG. WIND SPEED: **7.80 Knots**	DATE: **18/02/2013**	PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:
Byerwen Coal Project - QCoal

DISPLAY:
Wind Speed
Direction (blowing from)

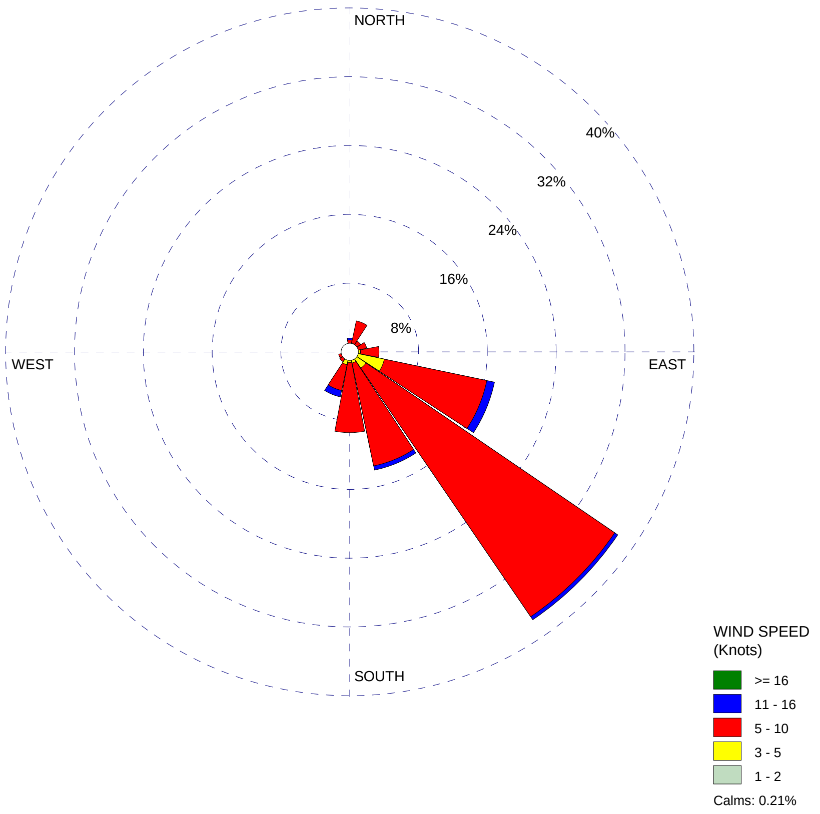


COMMENTS: Wind Rose for May	DATA PERIOD: **Start Date: 1/05/2004 - 00:00** **End Date: 31/05/2005 - 23:00**	COMPANY NAME: **Noise Mapping Australia**	
		MODELER: **C Simpson**	
	CALM WINDS: **0.34%**	TOTAL COUNT: **1488 hrs.**	
	AVG. WIND SPEED: **6.32 Knots**	DATE: **18/02/2013**	PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:
Byerwen Coal Project - QCoal

DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:
Wind Rose for June

DATA PERIOD:
Start Date: 1/06/2004 - 00:00
End Date: 30/06/2005 - 23:00

COMPANY NAME:
Noise Mapping Australia

MODELER:
C Simpson

CALM WINDS:
0.21%

TOTAL COUNT:
1440 hrs.

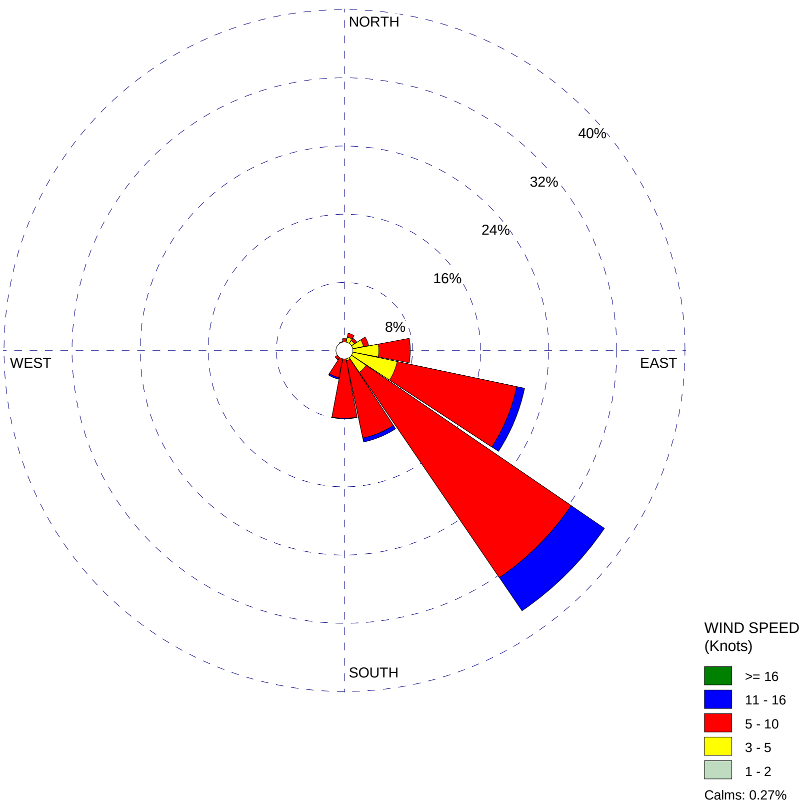
AVG. WIND SPEED:
6.76 Knots

DATE:
18/02/2013

PROJECT NO.:
101112

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:	DISPLAY:
Byerwen Coal Project - QCoal	**Wind Speed** **Direction (blowing from)**

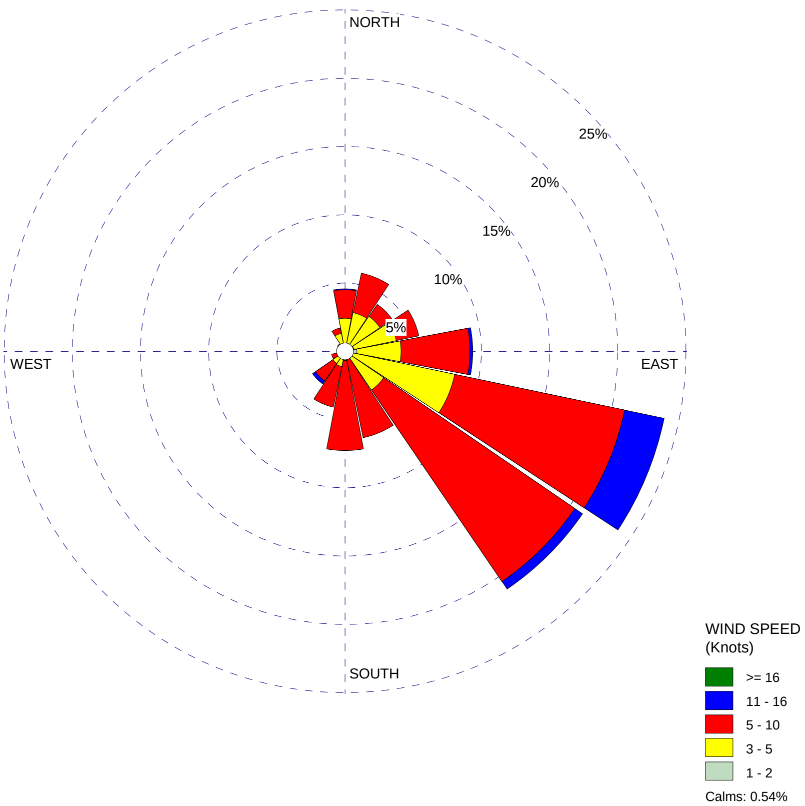


COMMENTS:	DATA PERIOD:	COMPANY NAME:	
Wind Rose for July	**Start Date: 1/07/2004 - 00:00** **End Date: 31/07/2005 - 23:00**	**Noise Mapping Australia**	
		MODELER: **C Simpson**	
	CALM WINDS: **0.27%**	TOTAL COUNT: **1488 hrs.**	
	AVG. WIND SPEED: **6.75 Knots**	DATE: **18/02/2013**	PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:
Byerwen Coal Project - QCoal

DISPLAY:
Wind Speed
Direction (blowing from)

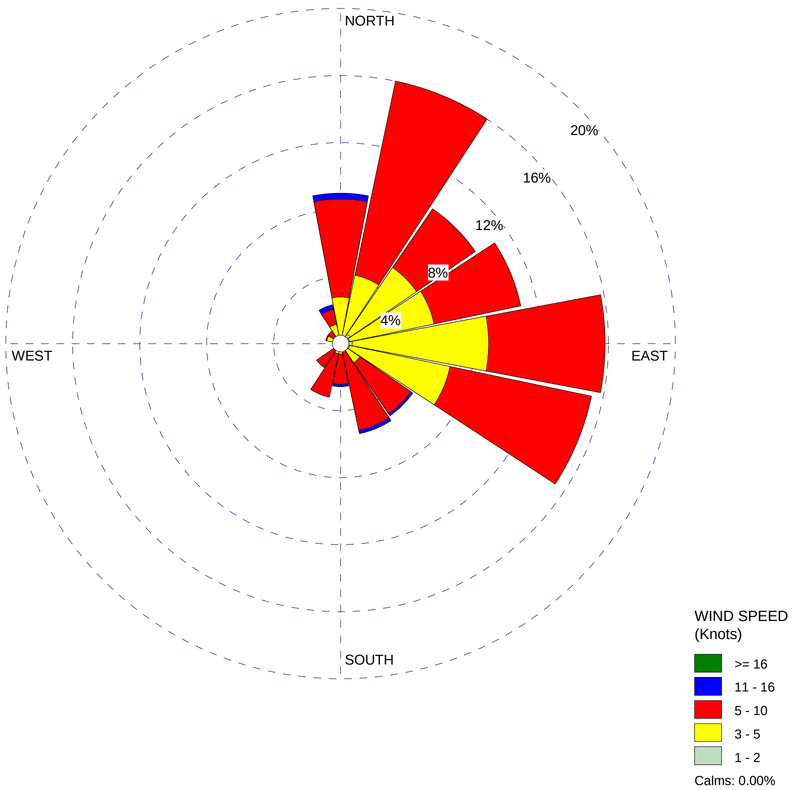


COMMENTS: Wind Rose for August	DATA PERIOD: **Start Date: 1/08/2004 - 00:00** **End Date: 31/08/2005 - 23:00**	COMPANY NAME: **Noise Mapping Australia**	
		MODELER: **C Simpson**	
	CALM WINDS: **0.54%**	TOTAL COUNT: **1488 hrs.**	
	AVG. WIND SPEED: **6.10 Knots**	DATE: **18/02/2013**	PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:
Byerwen Coal Project - QCoal

DISPLAY:
Wind Speed
Direction (blowing from)

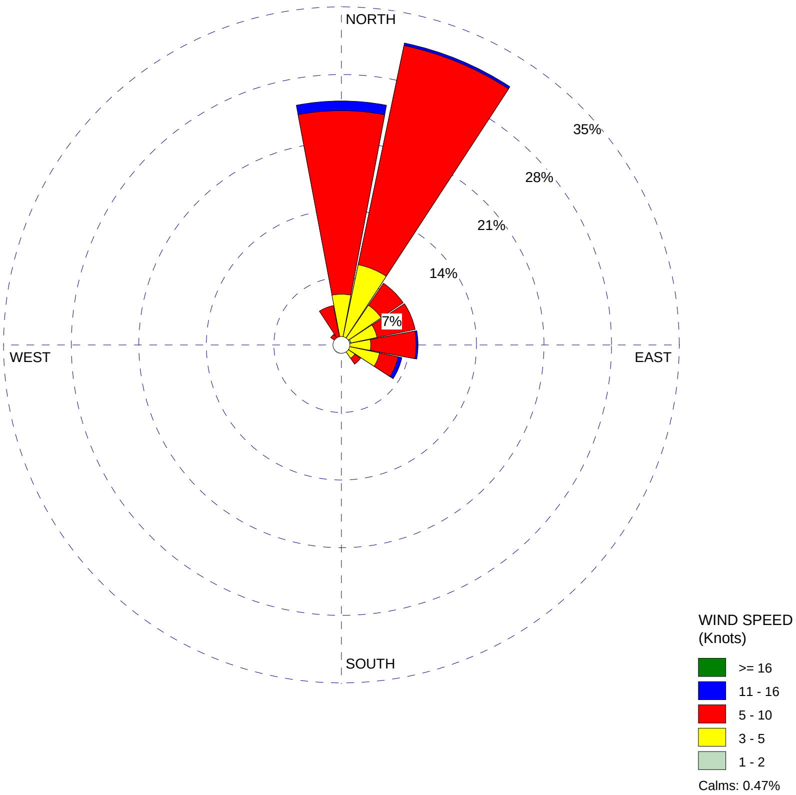


COMMENTS:	DATA PERIOD:	COMPANY NAME:	
Wind Rose for September	**Start Date: 1/09/2004 - 00:00** **End Date: 30/09/2005 - 23:00**	**Noise Mapping Australia**	
		MODELER: **C Simpson**	
	CALM WINDS: **0.00%**	TOTAL COUNT: **1440 hrs.**	
	AVG. WIND SPEED: **5.84 Knots**	DATE: **18/02/2013**	PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:
Byerwen Coal Project - QCoal

DISPLAY:
Wind Speed
Direction (blowing from)

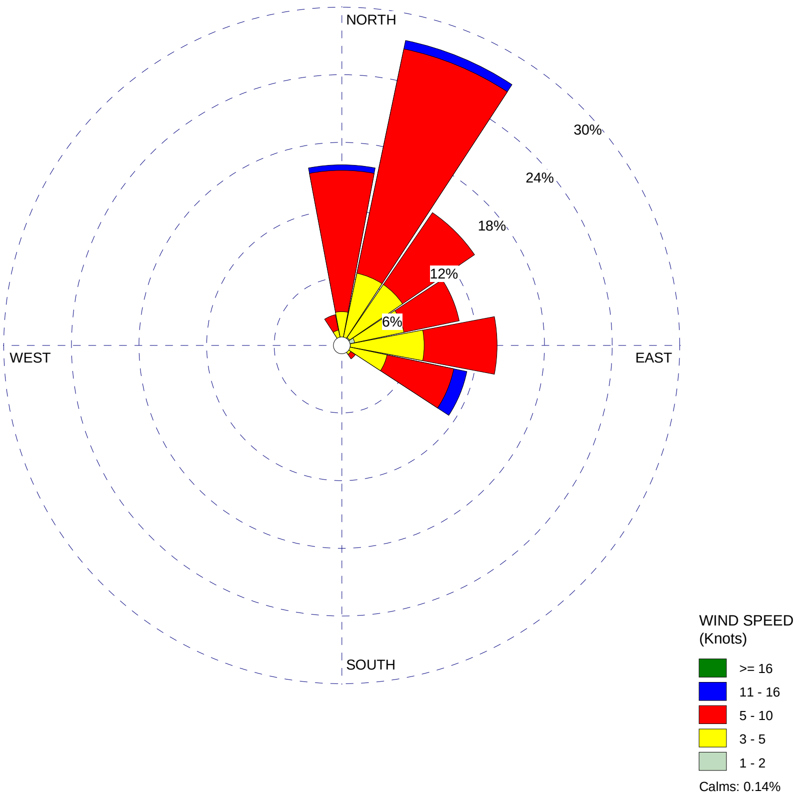


COMMENTS: Wind Rose for October	DATA PERIOD: **Start Date: 1/10/2004 - 00:00** **End Date: 31/10/2005 - 23:00**	COMPANY NAME: **Noise Mapping Australia**	
		MODELER: **C Simpson**	
	CALM WINDS: **0.47%**	TOTAL COUNT: **1488 hrs.**	
	AVG. WIND SPEED: **6.18 Knots**	DATE: **18/02/2013**	PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:
Byerwen Coal Project - QCoal

DISPLAY:
Wind Speed
Direction (blowing from)

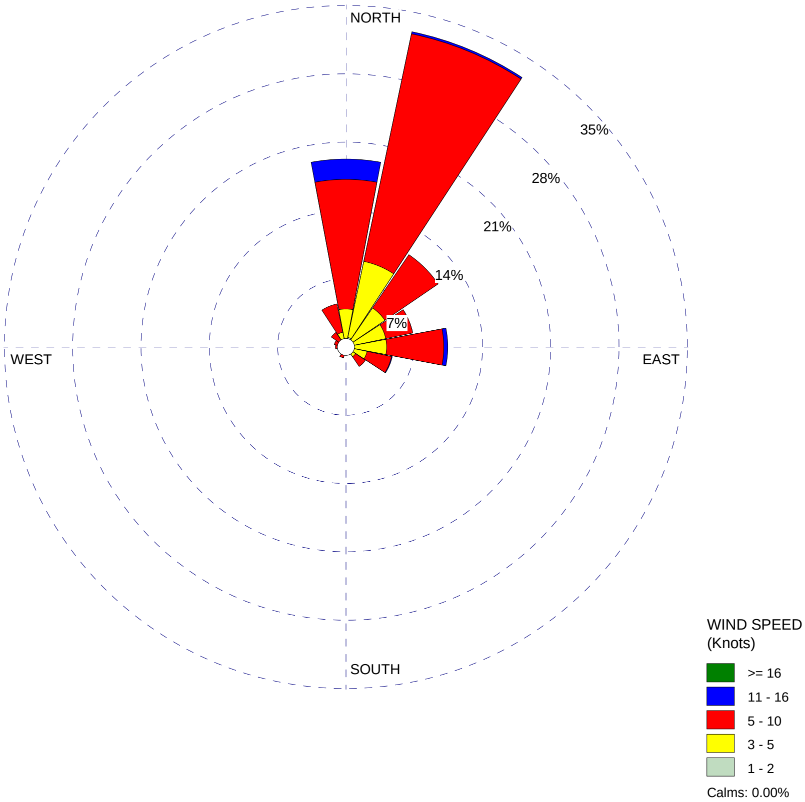


COMMENTS: Wind Rose for November	DATA PERIOD: **Start Date: 1/11/2004 - 00:00** **End Date: 30/11/2005 - 23:00**	COMPANY NAME: **Noise Mapping Australia**
		MODELER: **C Simpson**
	CALM WINDS: **0.14%**	TOTAL COUNT: **1440 hrs.**
	AVG. WIND SPEED: **6.00 Knots**	DATE: **18/02/2013**
		PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:
Byerwen Coal Project - QCoal

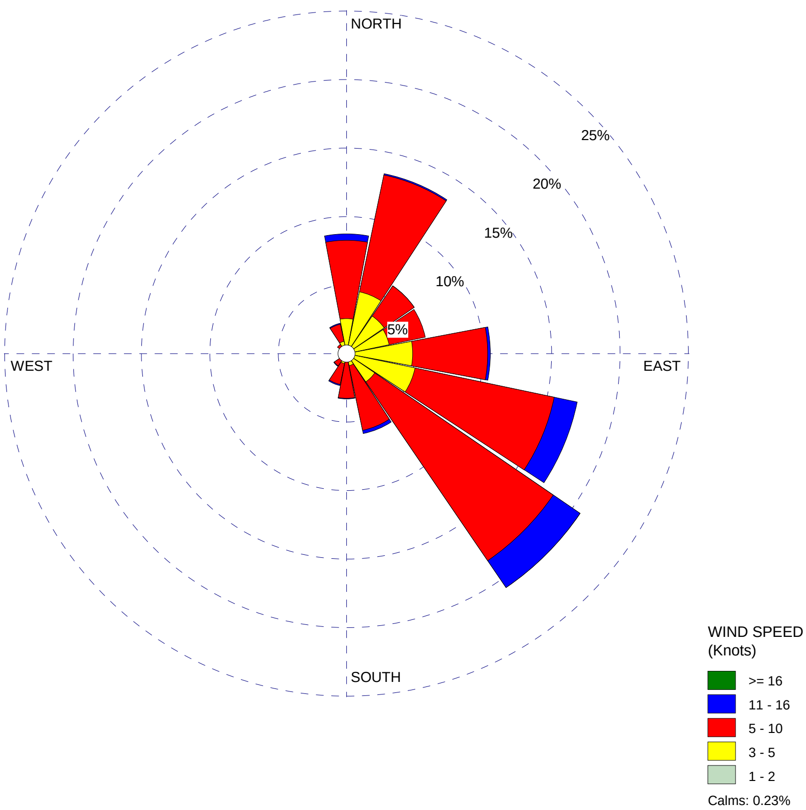
DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
Wind Rose for December	**Start Date: 1/12/2004 - 00:00** **End Date: 31/12/2005 - 23:00**	**Noise Mapping Australia**	
		MODELER: **C Simpson**	
	CALM WINDS: **0.00%**	TOTAL COUNT: **1488 hrs.**	
	AVG. WIND SPEED: **6.22 Knots**	DATE: **18/02/2013**	PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:	DISPLAY:
Byerwen Coal Project - QCoal	**Wind Speed** **Direction (blowing from)**



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
Wind Rose for All Months	**Start Date: 1/01/2004 - 00:00** **End Date: 31/12/2005 - 23:00**	**Noise Mapping Australia**	
		MODELER: **C Simpson**	
	CALM WINDS: **0.23%**	TOTAL COUNT: **17544 hrs.**	
	AVG. WIND SPEED: **6.41 Knots**	DATE: **18/02/2013**	PROJECT NO.: **101112**

WRPLOT View - Lakes Environmental Software