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Gunlake Quarries
Gunlake Quarry Project

ENVIRONMENTAL ASSESSMENT

VOLUME III

Part 5
Heggies Pty Ltd
Air Quality Impact Assessment. Proposed Gunlake Quarry – Marulan.

February 2008

HEGGIES

REPORT 10-5107-R1

Revision 1

Air Quality Impact Assessment

Proposed Gunlake Quarry - Marulan

PREPARED FOR

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Air Quality Impact Assessment

Proposed Gunlake Quarry - Marulan

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DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
10-5107-R1	Revision 1	12 February 2008	Ronan Kellaghan	Martin Doyle	Ronan Kellaghan
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EXECUTIVE SUMMARY

Gunlake Quarries proposes to establish and operate a hard rock quarry located approximately 8 km northwest of Marulan, NSW. Heggies Pty Ltd has been commissioned by the Gunlake, to undertake an Air Quality Impact Assessment of the proposed Marulan Gunlake Quarry Project.

It is proposed that the quarry will produce 500,000 tonnes per annum of finished product and will be operated as a conventional hard rock, open cut quarry. Products from this process will include a range of concrete and sealing aggregates, rail ballast, and road base.

The pollutant dispersion modelling carried out in the assessment utilises the Ausplume Gaussian Plume Dispersion Model software developed by EPA Victoria, Version 6.0.

Dispersion meteorology uses input data from the nearest Bureau of Meteorology automatic weather station to the Site at Goulburn, located approximately 30 km to the south-southwest of the Site. The Air Pollution Model (TAPM) has been used to supplement this data for indirect parameters not recorded at Goulburn (stability class, mixing height and sigma theta). TAPM under predicted calm wind speed conditions at the site and a more conservative approach was to use the actual wind recorded at Goulburn.

A scenario was modelled to reflect operations at the proposed quarry for Year 20 operations, selected to represent mining activities in the southern end of the pit, mining at full hourly production with 100 daily product truck movements and reflecting worst case operations at the quarry.

The results of the modelling indicate that annual average dust deposition, annual average PM_{10} concentrations and 24-hour average PM_{10} concentrations associated with the Site are predicted to satisfy the air quality goals, provided specific operation controls are adhered to.

A semi-quantitative assessment of $PM_{2.5}$ concentrations attributable to the Site has been conducted based on modelling of PM_{10} concentrations. Both the 24-hour and annual average air quality goals for $PM_{2.5}$ are easily satisfied.

A semi-quantitative assessment of respirable crystalline silica attributable to the Site has been conducted based on modelling of PM_{10} concentrations. Both the short term occupational and longer term exposure levels are easily satisfied.

An assessment of the effects of dust on vegetation and livestock indicates that operations on the Site are unlikely to result in significant impacts.

It is noted that a worst-case scenario was modelled, in terms of particulate emission rates and operational conditions. As a result, all predictions in the assessment should be viewed as conservatively high, with levels expected to be lower than those modelled during normal operation of the Site.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

1 INTRODUCTION

Gunlake Quarries (hereafter, “the Proponent”), a division of Rollers Australia Pty Ltd, proposes to establish and operate a hard rock quarry located approximately 8 km northwest of Marulan, NSW. The rock, a tuffaceous rhyodacite, will be drilled and blasted and processed in an on-site crushing and screening plant. Products from this process will include a range of concrete and sealing aggregates, rail ballast and road base.

Heggies Pty Ltd (hereafter, “Heggies”) has been commissioned by the Proponent, to undertake an Air Quality Impact Assessment (hereafter, “AQIA”) of the proposed Marulan Gunlake Quarry Project (hereafter, “the Site”).

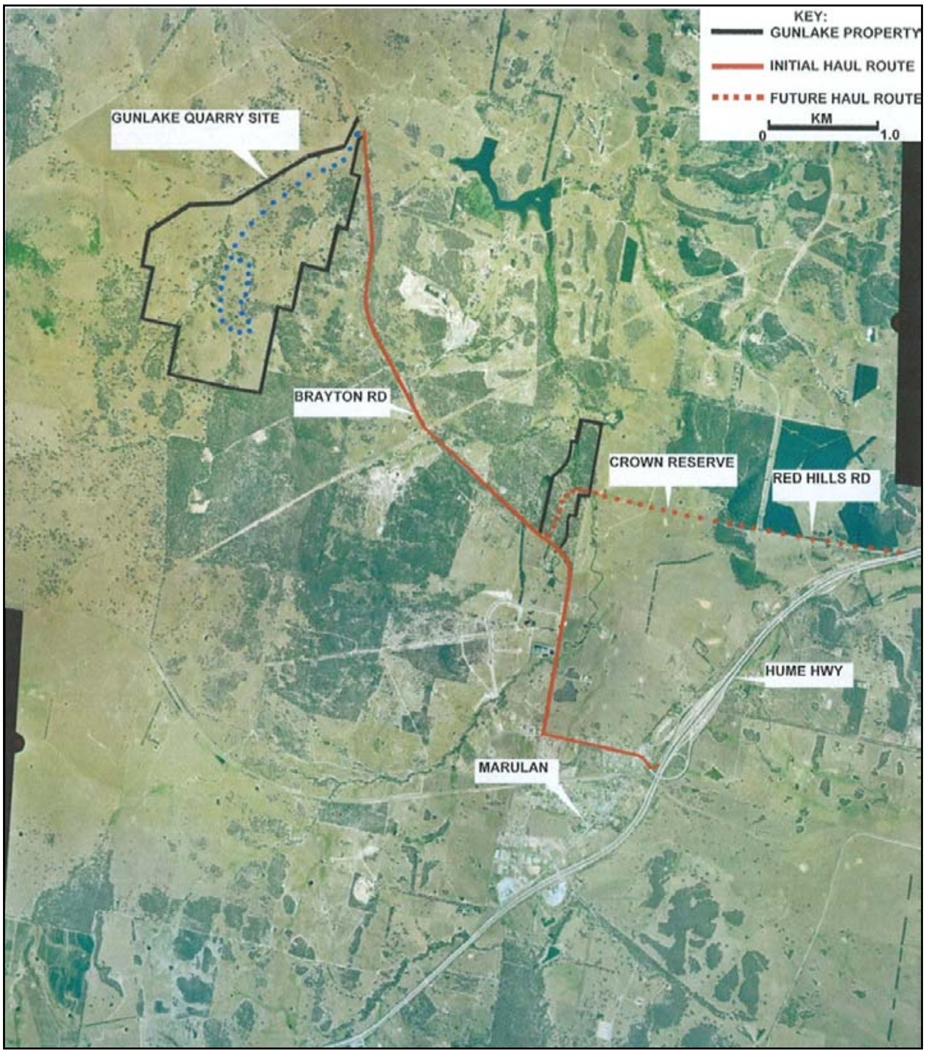
2 LOCAL SETTING AND SITE OVERVIEW

2.1 Site Location

The Proponent proposes to develop and operate a hard rock quarry located approximately 8 km northwest of Marulan, in the Southern Highlands of NSW. The Site is currently accessed via Brayton Road, a two-lane sealed road servicing existing quarry operations and communities west of Marulan.

The regional setting of the Site is given in **Figure 1**.

Figure 1 Regional Setting of the Site



2.2 Sensitive Receptor Locations

Pollutant concentrations can be predicted at the nearest potentially affected sensitive receptors. The closest sensitive receptors to the site are four residences located within a distance of approximately 1 km – 2 km from the processing plant.

In addition, a potential residence has been identified to the southwest of the site. Although it is unclear if this residence is occupied, it has been included in this assessment.

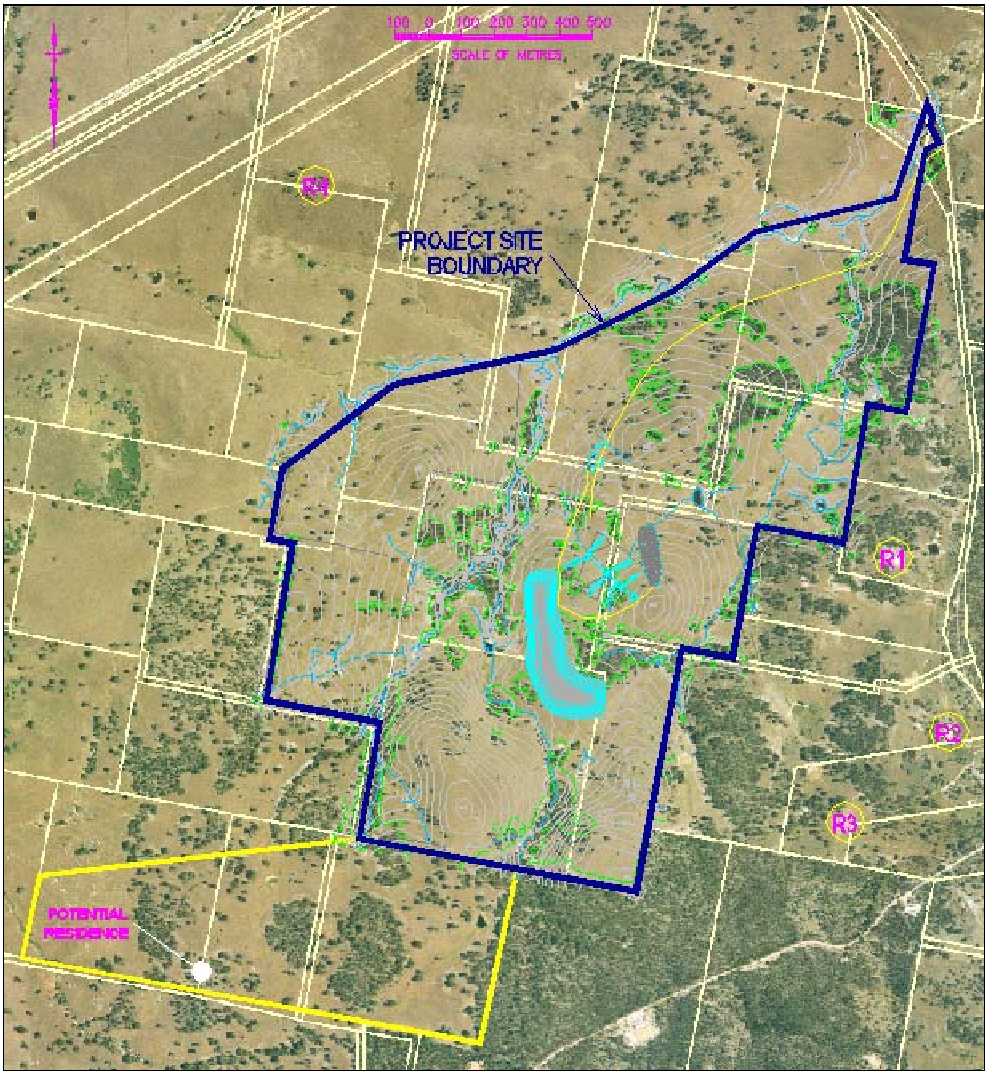
Pollutant concentrations are predicted at these five locations. Receptor locations and distances to the Site boundary and the processing plant are given in **Table 1**.

Table 1 Closest Sensitive Receptors

Sensitive Receptor	Easting(m)	Northing(m)	Distance to Site boundary (km)	Distance to processing plant (km)
R1	772741	6159492	0.2	0.7
R2	772892	6159005	0.7	1
R3	772486	6158729	0.5	0.9
R4	770698	6160742	0.6	1.4
R5	770646	6158064	0.6	1.7

Locations of sensitive receptors in relation to the Site are shown in **Figure 2**.

Figure 2 Locations of Sensitive Receptors in the Site Vicinity



2.3 Proposed Development

It is proposed that the quarry will produce 500,000 tonnes per annum of finished product and will be operated as a conventional hard rock, open cut quarry. The proposed development will incorporate the following:

- Overburden removal using excavators and dump trucks, stockpiled initially on the eastern side of the crushing plant area to create a bund wall extending the line of an existing ridge.
- Conventional drill and blast techniques will be used to quarry the stone from face heights of approximately 13 metres, commencing at the northern end of the 30 year quarry site and proceeding in a southerly direction.
- Any secondary breaking required will be done by hydraulic rock breaker within the quarry void.
- The quarried stone will be loaded by front end loaders and hauled by dump trucks to the crushing and screening plant.

2.3.1 Processing

The crushing plant will be a three-stage plant with crushing and screening resulting in final product, including concrete and sealing aggregates, manufactured sand, rail ballast and road base. The three crushing stages will most likely be done with a primary jaw crusher, a secondary gyratory crusher and tertiary cone crushers. The permanent crushing plant is planned to have an annual production of 500,000 tonnes of saleable product.

It is envisaged that a portable crushing plant might be used in order initially to product road making materials for the on-site roadways.

2.3.2 Transport

It is proposed that the crushed products will be hauled by road from the quarry site direct to the Sydney market, and to other markets to the north and south of Marulan. Initially haulage would be via existing truck routes through the outskirts of Marulan (Brayton Road) to the Hume Highway interchange near the truck checking station at an average of 25 truck movements per day. Products will be hauled both north and south on the highway, with approximately 80% or more to the north.

As production increases, a bypass route around Marulan will be constructed to allow product destined for northern markets to bypass Marulan. This route is shown on **Figure 1** together with the quarry and plant site.

The bypass route involves the construction of a haul road over land owned by the Proponent to link with a new road to be constructed along a Crown Road Reserve to Red Hills Road. The proposed construction of the bypass road will be timed for when quarry sales growth would result in truck movements through Marulan exceeding the average of 25 truck movements per day. It is anticipated that this will occur within 3 to 5 years from commencement of aggregate production on the site.

When constructed, all traffic for northern markets will use this route. Returning trucks from the north will not turn right at the Hume Highway to enter Red Hills Road, but will continue to the Marulan exit near the truck checking station, pass under the Highway, pass through a new roundabout at the intersection of Brayton Road and George Street, and return via the Highway to turn left into Red Hills Road. This will require some modification to the existing Highway underpass road near its intersection with George Street, Marulan.

Trucks travelling south will continue to use Brayton Road to the Hume Highway interchange but returning trucks will turn left into Red Hills Road. Truck movements using the Brayton Road route will continue to be an average of 25 per day for the life of the quarry.

2.3.3 Hours of Operation

The proposed hours are operation are given in **Table 2**.

Table 2 Proposed Hours of Operation

Task	Proposed Hours
Overburden Removal	7am to 6pm Monday to Saturday
Drilling	7am to 6pm Monday to Saturday
Quarrying and Processing	7am to 6pm Monday to Saturday
Blasting	9am to 5pm Monday to Friday
Maintenance	24 hours 7 days
Truck Loading and Haulage [1]	9pm Sunday to 6pm Saturday

Note: [1] After construction of the bypass route, there will be no haulage through Marulan outside the hours of 6am to 6pm Monday to Saturday. Truck movements through Marulan will not exceed an average of 25 truck movements per day at any stage

3 AIR QUALITY CRITERIA

3.1 Goals Applicable to Particulate Matter Less than 10 Microns (PM_{10})

Emissions of PM_{10} and $PM_{2.5}$ are considered important pollutants in terms of impact due to their ability to penetrate into the respiratory system. In the case of the $PM_{2.5}$ category, recent health research has shown that this penetration can occur deep into the lungs (NSW DEC, 1998). Potential adverse health impacts associated with exposure to PM_{10} and $PM_{2.5}$ include increased mortality from cardiovascular and respiratory diseases, chronic obstructive pulmonary disease and heart disease, and reduced lung capacity in asthmatic children.

One of the difficulties in dealing with air quality goals governing fine particles such as PM_{10} and $PM_{2.5}$ is that the medical community has not been able to establish a threshold value (for either PM_{10} or $PM_{2.5}$) below which there are no adverse health impacts.

The NSW DECC PM_{10} assessment goals as expressed in their document *"Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales"* (2005) (hereafter, "the Approved Methods") are:

- A 24-hour maximum of 50 µg/m^3; and
- An annual average of 30 µg/m^3.

The 24-hour PM_{10} reporting standard of 50 µg/m^3 is numerically identical to the equivalent National Environment Protection Measure (or NEPM) reporting standard except that the NEPM reporting standard allows for five exceedances per year. These NEPM goals were developed by the National Environmental Protection Council (NEPC) in 1998 to be achieved within 10 years of commencement.

3.2 Goal Applicable to Total Suspended Particulates (TSP)

The annual goal for Total Suspended Particulates (or TSP) is given as 90 µg/m^3, as recommended by the National Health and Medical Research Council (NHMRC) at their 92nd session in October 1981.

It was developed before the more recent results of epidemiological studies suggested a relationship between health impacts and exposure to PM_{10} concentrations.

3.3 Goals Applicable to Particulate Matter Less than 2.5 Microns ($PM_{2.5}$)

In December 2000, the NEPC initiated a review to determine whether a new ambient air quality goal for particulates of 2.5 microns or less in aerodynamic diameter ($PM_{2.5}$) was needed in Australia, and the feasibility of developing such a goal. The review found that:

- there are health effects associated with fine particles;
- the health effects observed overseas are supported by Australian studies; and
- fine particle standards have been set in Canada and the USA, and an interim goal proposed for New Zealand.

The review concluded that there is sufficient community concern regarding $PM_{2.5}$ to consider it an entity separate from PM_{10}.

As such, in July 2003 a variation to the Ambient Air Quality NEPM was made to extend its coverage to $PM_{2.5}$. This document references the following goals for $PM_{2.5}$.

- A 24-hour maximum of 25 µg/m^3; and
- An annual average of 8 µg/m^3.

3.4 Nuisance Impacts of Fugitive Emissions

The preceding sections are concerned in large part with the health impacts of particulate matter. Nuisance impacts also need to be considered, mainly in relation to dust. In NSW, accepted practice regarding the nuisance impact of dust is that dust-related nuisance can be expected to impact on residential areas when annual average dust deposition levels exceed 4 g/m^2/month.

To avoid dust nuisance the DECC has developed assessment goals for dust fallout. **Table 3** presents the allowable increase in dust deposition relative to the ambient levels.

Table 3 DECC Goals for Allowable Dust Deposition

Averaging Period	Maximum Increase in Deposited Dust Level	Maximum Total Deposited Dust Level
Annual	2 g/m^2/month	4 g/m^2/month

Source: Approved Methods, 2005

3.5 Site Air Quality Goals

The air quality goals adopted in this report are those specified in the NSW DECC Approved Methods.

In summary, the specific goals being applied to this study are as follows:

- PM_{10}: A 24-hour maximum of 50 µg/m^3; and An Annual average of 30 µg/m^3.
- $PM_{2.5}$: A 24-hour maximum of 25 µg/m^3; and An annual average of 8 µg/m^3.
- TSP: An Annual Average of 90 µg/m^3
- Dust: An incremental annual average dust deposition level of 2 g/m^2/month; and A total annual average dust deposition level of 4 g/m^2/month.

4 EXISTING AIR QUALITY ENVIRONMENT

4.1 Background Particulate Matter Environment

The term "particulate matter" refers to a category of airborne particles typically less than 50 microns (µm) in aerodynamic diameter and ranging down to 0.1 µm in size. Particles less than 10 µm and 2.5 µm are referred to in this report as PM_{10} and $PM_{2.5}$ respectively.

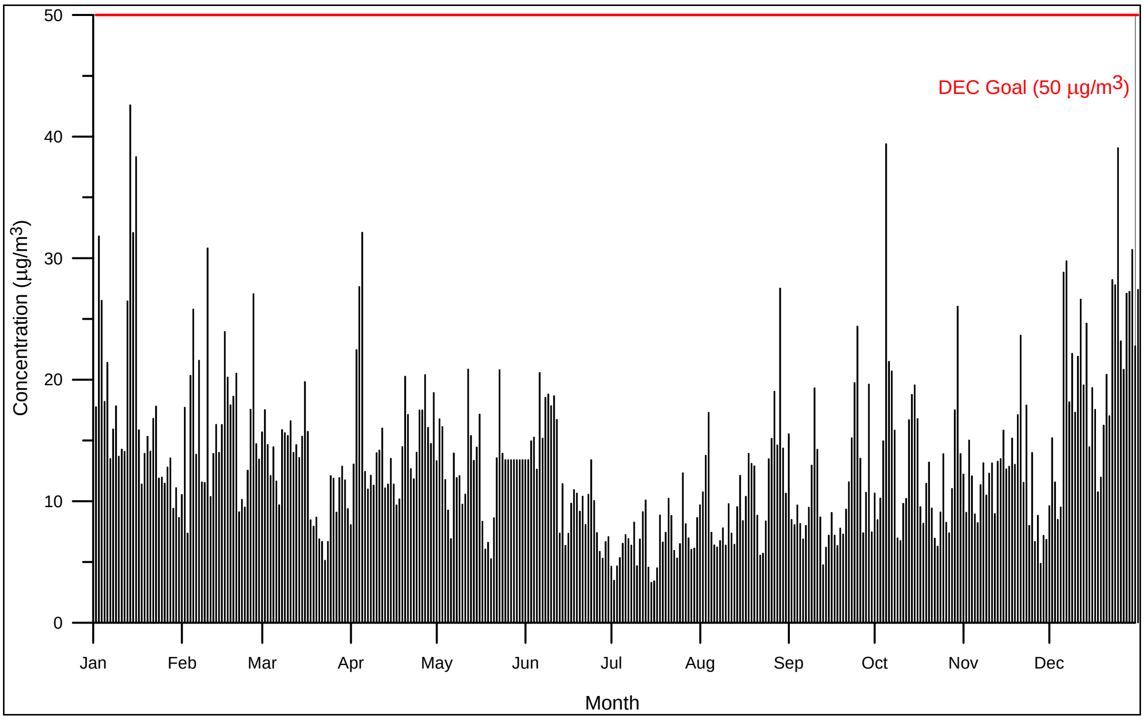
The closest NSW Department of Environment and Climate Change (DECC) air quality monitoring station to the Site is the Oakdale air quality monitoring site, located on a residential property at Ridge Road, Oakdale. The following air quality parameters are recorded at the monitoring station:

- O_3
- NO, NO_2 & NO_x
- Fine particles (by nephelometry)
- Fine particles (PM_{10} using a tapered element oscillating microbalance)
- Wind speed, wind direction and sigma theta
- Ambient temperature
- Relative humidity
- Solar radiation

The monitoring site is located in a rural area on the far south-west edge of the Sydney basin and is at an elevation of 457 metres. It is situated within the DECC's South-west Sydney region. Located 95 km to the northeast of the Site, it is considered to be most representative of background conditions.

The 24 hour average PM_{10} concentrations recorded at Oakdale for the year 2005 are presented in **Figure 3**.

Figure 3 24 Hour Average PM_{10} Concentration (µg/m³) Oakdale, 2005



The results indicate that the highest 24-hour average PM_{10} concentration recorded at the DECC's Oakdale monitoring site was 42.6 µg/m³, recorded on 13 January 2005. The annual average PM_{10} concentration at Oakdale was 13.4 µg/m³. No exceedances of the NSW DECC criterion of 50 µg/m³ were recorded during 2005.

Measurement of background PM_{10} concentrations has been undertaken for Lynwood Quarry, located approximately 2km south of the Site. As reported in the Air Quality Assessment for the Lynwood Quarry (Holmes, 2005), two High Volume Air Samplers (hereafter, "HVAS") were deployed at the quarry site. Data is available for the period 11 June 2004 to 27 February 2005. Monitoring occurred every six days for a 24 hour period. The highest 24-hour average PM_{10} concentration recorded at the Lynwood site was 61.4 ug/m³ while the second highest was 35.8 ug/m³. The average PM_{10} concentration for the monitoring period was reported as 13.5 ug/m³.

On the basis of the annual average concentrations recorded at each site, the Oakdale data is considered to be reasonable representative of ambient air quality at a rural location such as Marulan.

4.1.1 TSP

It is noted that the PM_{10} sub-set is typically 50% of total suspended particulate (TSP) mass in regions where road traffic is not the dominant particulate source (USEPA, 2001).

The existing ambient TSP concentration can therefore be estimated from the annual average PM_{10} concentration for the area (derived from the Lynwood Annual Average PM_{10} concentration of 13.5 µg/m³).

4.2 Background Dust Deposition Environment

A total of three dust deposition gauges have been installed at the site to determine the likely background at the site. Dust deposition data has been provided by the Proponent and is presented in **Table 4**.

Table 4 Dust Deposition Monitoring Data

Location	Sample Period	Insoluble Solids (g/m^2/month)	Ash Residue (g/m^2/month)
DDG 1:	20/12/2006 - 18/01/2007	0.5	0.4
	18/01/2007 - 19/02/2007	1.6	0.6
	19/02/2007 – 22/03/2007	1.0	0.7
	22/03/2007 – 26/04/2007	0.4	0.4
	26/04/2007 – 22/05/2007	0.3	0.3
	22/05/2007 – 18/06/2007	0.6	0.2
DDG 2:	20/12/2006 - 18/01/2007	0.8	0.5
	18/01/2007 - 19/02/2007	1.9	1.0
	19/02/2007 – 22/03/2007	0.8	0.6
	22/03/2007 – 26/04/2007	2.3	1.2
	26/04/2007 – 22/05/2007	1.4	1.2
	22/05/2007 – 18/06/2007	0.6	0.3
DDG 3:	20/12/2006 - 18/01/2007	5.1	3.7
	18/01/2007 - 19/02/2007	1.9	1.0
	19/02/2007 – 22/03/2007	1.0	0.9
	22/03/2007 – 26/04/2007	3.6	3.0
	26/04/2007 – 22/05/2007	1.2	1.0
	22/05/2007 – 18/06/2007	1.1	0.8
Average		**1.5**	**1.0**

An estimation of the ambient dust deposition rate at the Site for assessment purposes may therefore be assumed to be of the order of 1.5 g/m^2/month expressed as an annual average. This is the average deposition rate for insoluble solids from the three sites.

Dust deposition data is also available from the Lynwood Quarry, located approximately 2km south of the Site. As reported in the Air Quality Assessment for the Lynwood Quarry (Holmes, 2005), dust deposition gauges were deployed at eight site relevant locations. Insoluble solids for the period June 2004 to January 2005 indicate a background level of dust deposition of 1.8 g/m^2/month.

4.3 Background Air Quality Environment for Assessment Purposes

Based on the data and discussion in **Section 4.1** and **Section 4.2**, the site-specific background air quality levels presented in **Table 5** have been adopted for the assessment of the proposed Gunlake Quarry.

Table 5 Background Air Quality Environment for Assessment Purposes

Air Quality Parameter	Averaging Period	Assumed Background Level
TSP	Annual	26.8 µg/m^3
PM_{10}	24-Hour	Daily varying [1]
	Annual	13.4 µg/m^3
Dust	Annual	1.5 g/m^2/month
Note 1: Daily varying 24-hour average PM_{10} concentrations were used for modelling purposes.		

5 DISPERSION MODELLING

5.1 Methodology

The pollutant dispersion modelling carried out in the assessment utilises the Ausplume Gaussian Plume Dispersion Model software developed by EPA Victoria, Version 6.0.

Ausplume is the approved dispersion model for use in the majority of applications in NSW. Default options specified in the Technical Users Manual (EPA Victoria, 2000) have been used, as per NSW DECC Approved Methods.

5.2 Regional Climate Averages

The nearest Bureau of Meteorology (hereafter, “BoM”) automatic weather station (hereafter, “AWS”) to the Site that contains historic climate averages is the Goulburn (Progress St) AWS (station no. 070263), located approximately 30 km to the south-southwest of the Site. Validated data is available from this station since records began in 1971 until 2007.

A detailed summary of the climatic average observations for this monitoring site is presented in **Appendix A**.

5.3 Dispersion Meteorology

In the absence of site specific meteorological observations, The Air Pollution Model (hereafter, “TAPM”) was used to generate a meteorological data set, using the data assimilation option to incorporate observations from the Bureau of Meteorology’s (hereafter, “BoM”) Goulburn Airport Automatic Weather Station (hereafter, “AWS”) (Station Number 070330), located approximately 30 km south-southwest of the Site. The data set selected for the modelling was 2005 given it was the most recent complete data set concurrent with the continuous PM_{10} monitoring data (see **Section 4.1**) that was available during the preparation of this report

The model predicts wind speed and direction, temperature, air pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations, with no local inputs required.

Additionally, the TAPM model may assimilate wind observations so that they can optionally be included in a model solution. The wind speed and direction observations are used to realign the predicted solution towards the observation values. This function of accounting for actual meteorological observations within the region of interest is referred to as “data assimilation”.

Further background on the TAPM model, including details of validation exercises, is presented in **Appendix B**.

A summary of the 2005 annual wind behaviour, predicted by TAPM, for the Site presented as a wind rose is included in **Appendix C**. This wind rose displays occurrences of winds from all quadrants.

The annual wind rose indicates that westerly winds dominate at the Site. The seasonal variation in wind behaviour at the Site is also presented in **Appendix C**. The seasonal wind roses indicate that:

- in spring the prevailing wind directions are from the west and northwest;
- in summer the prevailing wind directions are from the west and northeast;
- in autumn the prevailing wind directions are from the west; and
- in winter the prevailing wind directions are from the west and northwest.

The wind roses for the data recorded by the Goulburn Airport AWS have also been included in **Appendix C**. While the wind roses demonstrate that both the Goulburn Airport AWS and TAPM generated Site data sets display similar wind characteristics, the wind speeds are generally higher at Goulburn. Similarly, the percentage calms are significant less for the TAPM dataset (0.4%) than at Goulburn (~11%).

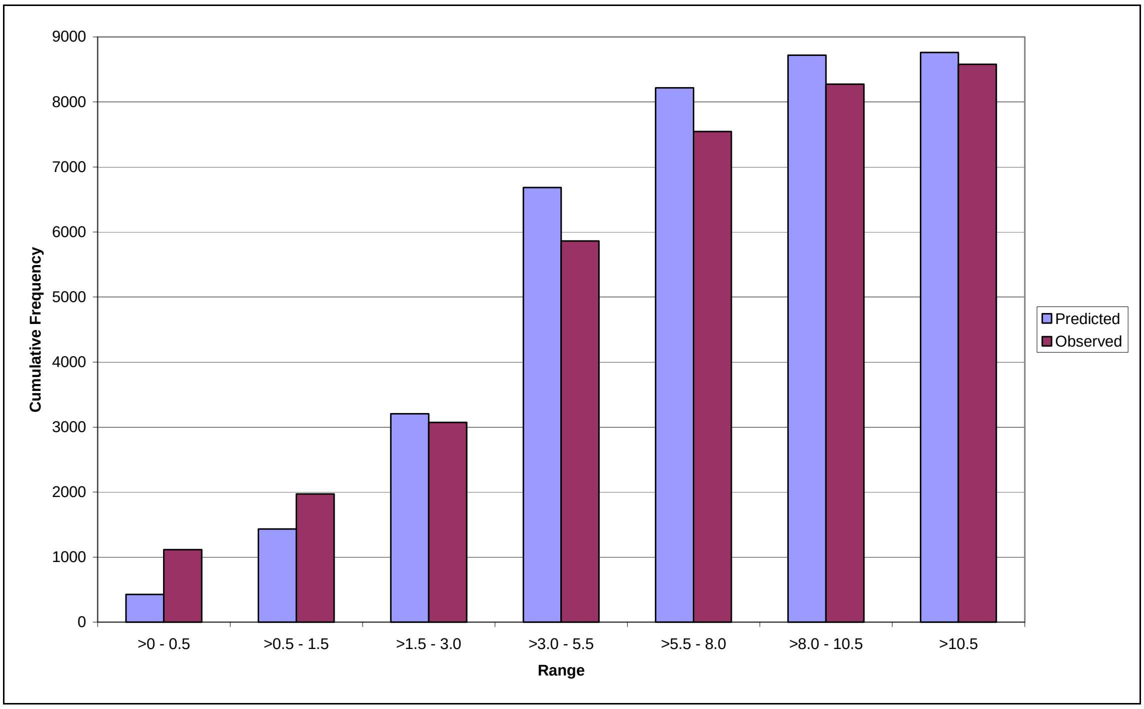
Based on information presented in Holmes (2005), the percentage calms expected at the Site are likely to be of the order of 7 - 8 %. Calm conditions are important in dispersion meteorology as it is under these conditions that dispersion is minimal and higher concentrations can be experienced at off site receptors.

In order to provide a more meaningful comparison and to determine the scale at which TAPM may be misinterpreting conditions at the Site, a TAPM generated meteorological data file has been extracted over Goulburn Airport for 2005 to allow direct comparison with the observational data from the BoM AWS at Goulburn Airport.

The data sets show relatively comparable wind characteristics in terms of wind direction and wind speeds above 3.0 m/s. However TAPM appears to under predict occurrences of wind speeds less than 1.5 m/s.

A cumulative frequency distribution of the observed wind speeds at Goulburn compared to the TAPM predicted wind speeds at Goulburn is presented in **Figure 4**.

Figure 4 Cumulative Frequency of Wind Speed – Observed vs. Predicted



Based on the information presented above it was determined that the TAPM predicted wind speeds were under representing conditions at the site and a more conservative approach would be to use the actual wind speeds recorded at Goulburn. For indirect parameters not recorded at Goulburn (stability class, mixing height and sigma theta) the TAPM predicted data was used.

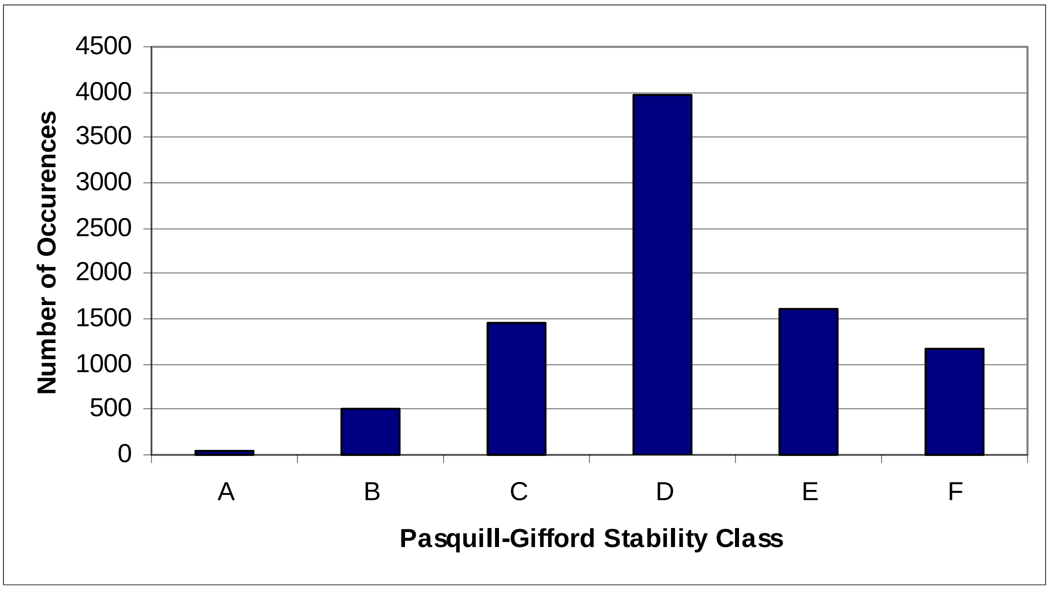
Therefore the wind roses presented in **Appendix C** for Goulburn Airport are representative of the Ausplume met file used in this assessment.

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford-Turner assignment scheme identifies six Stability Classes, "A" to "F", to categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions.

Stability Class "A" represents highly unstable conditions that are typically found during summer, categorised by strong winds and convective conditions. Conversely, Stability Class "F" relates to highly stable conditions, typically associated with clear skies, light winds and the presence of a temperature inversion. Classes "B" through to "E" represent conditions intermediate to these extremes.

The frequency of occurrence of each Stability Class for 2005 is presented in **Figure 5**. The results indicate a high frequency of conditions typical to Stability Class "D" throughout the year at the Site. This is indicative of moderately stable conditions, conducive to a moderate level of pollutant dispersion due to mechanical mixing.

Figure 5 Annual Stability Class Distribution for the Site



Appendix D illustrates the seasonal variation in atmospheric stability class at the Site. The frequency distribution of stability class varies relatively little with season, with Stability Class "D" dominating in all seasons.

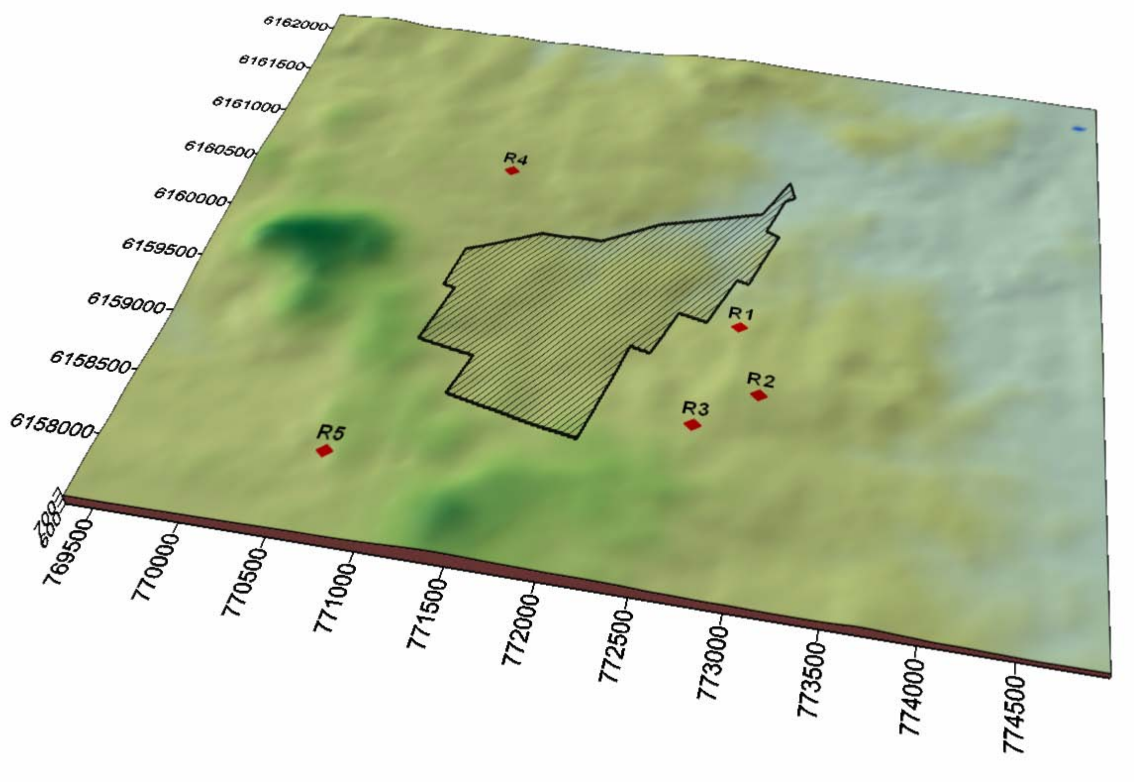
5.4 Site Topography

Topography plays an important role in atmospheric dispersion of pollutants by allowing or obstructing the free movement of air and mechanically forcing the circulation of air masses.

Air pollutants emitted into the lowest layers of the atmosphere can show complex behaviour as a result of the influence of local and regional scale terrain features such as night-time katabatic drainage flows from elevated terrain or channelling effects in valleys or gullies.

The Site and surrounding residences are located in mildly undulating terrain as shown in **Figure 6**.

Figure 6 Local Topography



There is no substantial variation in topography between the Site and the nearest residences that would significantly impact atmospheric dispersion. All residences in the vicinity of the Site are located at comparable altitudes to the altitude range of the Site.

In view of the foregoing, the topography of the area has not been considered in the atmospheric dispersion model, as significant impacts on modelled concentrations at the nearest receptors will not be seen with the inclusion of such uncomplicated near-field topography.

Further, it is noted that when area and volume pollutant sources are incorporated within the Ausplume model, terrain effects are ignored by the software. It is noted, however, that terrain effects have been taken into account when generating the site specific meteorological input files using TAPM.

5.5 Modelling Scenarios

A modelling scenario has been created to reflect various processes at the proposed quarry for Year 20 operations, selected to represent quarrying activities in the southern end of the pit, quarrying at full hourly production with an estimated 100 daily truck movements and reflecting worst case operations at the quarry.

5.6 Emission Factors

A review has been carried out of the potentially particulate-generating activities associated with the proposed quarry. For the modelled scenario, the following activities have been included in the particulate emissions inventory, namely:

- excavating activities on overburden within the proposed extraction area;
- haulage of overburden to overburden emplacement;
- unloading to overburden emplacement;

- drilling, blasting of hard rock and rock breaking in pit;
- front end loader loading product to trucks in pit
- haulage to processing plant and unloading to dump hopper;
- materials processing (primary, secondary and tertiary crushing and screening);
- loading stockpiles;
- front end loader loading product trucks;
- wind erosion from open pit / stockpiles / overburden emplacement; and
- movement of heavy vehicles on unsealed roads within the site (haul trucks and product trucks).

Table 6 presents the emission factors for the key atmospheric pollutants used in the dispersion modelling carried out for this report. These estimate the emissions expected under worse case operating conditions at full production. The ratio of the PM_{10} fraction of the TSP ranges from 50% (eg wind erosion) down to 25% (eg wheel-generated dust).

The proportion of the PM_{10} fraction for each activity was derived primarily from the Environment Australia (2001) document, "*Emission Estimation Technique Manual for Mining, Version 2.3*". (hereafter, EETMM)

Table 6 Particulate Emission Factors for Air Quality Dispersion Modelling

Activity	**TSP Emission Factor**	**PM_{10} Emission Factor**	**Emission Factor Units**
Overburden Extraction / Removal			
Excavator	0.003	0.001	kg/t
Wheel Dust (Unpaved Roads)	3.1	0.8	kg/VKT
Truck Unloading	0.003	0.001	kg/t
Open Pit / Stockpile Wind Erosion	38,660	15,464	kg/ha/year
Hard Rock Extraction Area			
Drilling	0.59	0.31	kg/hole
Blasting	27.5	14.3	kg/blast
Rock Breaker	0.003	0.001	kg/t
FEL to Trucks	0.0008	0.0004	kg/t
Wheel Dust (Unpaved Roads)	3.1	0.8	kg/VKT
Processing Plant			
Unloading to Hopper	0.0008	0.0004	kg/t
Primary Crusher	0.01	0.004	kg/t
Secondary Crusher	0.03	0.012	kg/t
Tertiary Crusher	0.03	0.01	kg/t
FEL to Product Truck	0.0008	0.0004	kg/t
Wheel Dust (Unpaved Roads)	3.1	0.8	kg/VKT
Stockpile Loading	0.004	0.002	kg/t

In general, emission factors have been used as contained in Table 1 of the EETMM. Where the moisture content of materials at the Site was not adequately reflected within the default emission factors contained in Table 1 of the document and the equations given in the same table were used to derive representative emission factors. Emission factors for the following plant and equipment were derived using this method:

- front-end loader;
- excavator;
- dozer;
- blasting; and

The equation for wheel-generated dust is taken from the Chapter 13.2.2 Unpaved Roads (2003) of the USEPA AP42 which has not been incorporated into the NPI as yet.

5.6.1 Wind Erosion

Wind erosion from exposed surfaces has been estimated using the USEPA AP-42 Emission Factor for wind erosion (Chapter 13, Section 13.2.5 Industrial Wind Erosion).

The threshold friction velocity is an important parameter which is needed in the estimate of wind erosion from both "limited" and "unlimited" erosion potential sites. Threshold friction velocity U_t^* is the friction velocity at which wind erosion is initiated.

When the actual friction velocity at the site is greater than the threshold friction velocity, wind erosion can be expected; however, when the threshold friction velocity is equal to or greater than the actual friction velocity at the site then wind erosion will not occur.

The threshold friction velocity for the site was determined from the modelled relationship proposed by Marticorena & Bergametti (1995) based on the relationship between erosion threshold and aerodynamic roughness length. The roughness height was determined by taking 1/30 of the diameter of the particles on the bed surface (Bagnold, 1941).

The friction velocity was determined from the following expression:

$$u^* = A\ u_{10}$$

where A is a function of the roughness height (Z_0) and U_{10} is the wind speed measured at a height of 10 meters. Assuming a typical surface roughness height of 0.5 cm, A is given as 0.053.

Mean atmospheric wind speeds are not generally sufficient to sustain wind erosion from flat surfaces and estimated emissions should be related to the gusts of highest wind. The variable that best reflects the magnitude of wind gusts is the fastest mile of wind. Fastest mile of wind is not routinely recorded by the Bureau of Meteorology. An alternative approach is to use a “gust factor” to convert hourly wind speed data to the fastest mile of wind. The fastest mile of wind has been shown to range from 1.18 to 1.27 times the hourly wind speed (Krayer & Marshall (1992) in SKM (2005)).

The erosion potential from exposed surfaces is then calculated using:

$$P = 58\ (U^* - U_t^*)^2 + 25\ (U^* - U_t^*) \qquad (P = 0 \text{ for } U^* <= U_t^*)$$

5.7 Emission Inventory for the Proposed Operation

Appendix E provides details of the emission inventory associated with the modelling scenario for the proposed quarry, using the emission factors detailed in **Table 6**.

5.7.1 Assumptions

The following assumptions have been made in deriving the emission inventory for the model.

- Annual production is taken as 500,000 t per annum equating to an hourly production rate of 180 tonnes based on operations occurring for 11 hours a day, six days a week.
- For modelling purposes, only the off-site product transport is assumed to occur 24 hours a day for 365 days a year.
- A total area of 1.6 ha has been modelled as a wind erosion source for the open pit in the southernmost area of the proposed pit footprint. This equates to approximately 1/5 of the total pit footprint.
- Stockpile areas modelled are as follows:
  - 7mm Stockpile – 0.3 ha
  - 10mm Stockpile – 0.3 ha
  - 20mm Stockpile – 0.3 ha
  - Roadbase Stockpile – 0.3 ha
  - Surge Pile– 0.3 ha
- The overburden emplacement has been modelled as a source for wind erosion (total Area 1.8 ha), however it was given a 99% control factor as it is assumed that it will be stabilised / revegetated.
- For modelling purposes only, the working days available are based on 7 days a week, for 52 weeks per annum. All extractive and processing operations are assumed to operate between 6am and 6pm, while the product loading and haulage are assumed to operate 24 hours a day. These are conservative assumptions.
- Based on data obtained from the nearby Lynwood quarry (Holmes 2005), the following silt and moisture contents have been used to derived emission rates.
  - Overburden - 15% silt content and 2% moisture content.
  - Rock - 15% silt content and 5% moisture content.
- Quartz content of the rock is taken as 7%.
- In the absence of site specific or site representative data, an estimate of the road surface silt content of 5% has been obtained from the Chapter 13.2.2 Unpaved Roads (2003) of the USEPA AP42 corresponding to plant road at sand and gravel processing industries.
- An (annual) average wind speed of 4.2 m/s based on the meteorological input file.
- For modelling purposes, blasting is assumed to occur approximately once a week. On any one day drilling is assumed to occur for the 5 hours prior to a blast which is assumed to occur at mid-day.
- Further rock breaking is assumed to take place using an excavator operating within the Quarry void.
- All haul trucks are assumed to have a capacity of 50 t. A Front end loader is assumed to be used in the loading of these trucks within the quarry void.
- An active quarry bench is assumed to have a depth of 13 m and an area of 625 m^2. A quarry bench is assumed to be serviced by blasting, a rock breaker and a front end loader.
- A typical blast will have 3 rows of holes to a length of 25 meters at a burden of 8.4m.

- In order to represent worst case emissions, it is assumed that during the operation of a quarry bench, an equal and adjacent area is being cleared of topsoil in order for the next bench to be established. Topsoil removal is assumed to be undertaken via an excavator to a haul truck. In order to estimate tonnage of topsoil removal, clearing is assumed to occur to a depth of 2 m, with a soil density of 1.8 t/m^3.
- The movement of haul trucks has been represented as a simulated line source using the “volume source” Ausplume input. Each volume source is located along the centreline of the real line source with separations less than one quarter of the distance to the nearest residential receptor (in this case, at 183 m intervals for the quarry pit area and 215 m intervals for the site access route).
- A water truck will operate on haul routes and consequently a 75% reduction has been applied to the emission rate based on Level 2 watering (>2 litres/m^2/application).
- A front end loader is assumed to be used in the loading of trucks at the processing area.
- A “Pit Retention” control factor has been applied to emission rates / fluxes corresponding to activities occurring in the quarry void, based on 50% control for dust and 5% for PM_{10}, in accordance with Table 3 of the EETMM.
- All components associated with the processing plant are assumed to be operating at a throughput of 180 t per hour with the exception of the tertiary crusher. 50% of the material passing through the secondary crusher is assumed to pass through the tertiary crusher.

5.8 Operational Dust Controls

- Water sprays are assumed to operate at all discharge points at the processing plant, at the tipping point to the apron feeder and at the primary crusher. Consequently a 50% reduction has been applied to the emission rate for these sources.
- In order to control wind erosion from the product stockpiles, a wind break along the western edge of the processing area is required. This is particularly important during periods of moderate (>5.4 m/s) westerly winds. It is recommended that a wind break, comprising of a hessian fabric fence (or similar) be initially installed as a temporary measure. Following a suitable period of monitoring (nominally 3 months), dust and PM_{10} data (refer **Section 8.1**), should be assessed, in conjunction with onsite weather data, to determine if a wind break needs to be permanently maintained onsite.
- Use of the water truck is assumed not to generate an emission of particulate as its use will act to suppress emissions.

6 AIR QUALITY EMISSIONS ASSESSMENT

6.1 Dust Deposition

Table 7 presents the results of the Ausplume predictions for dust deposition using the emission rates calculated in **Appendix E**, at the residences nominated in **Section 2.2**.

The results show the monthly average dust deposition predicted at the residences surrounding the Site over a one-year time frame.

Table 7 Background and Incremental Dust Deposition at Nearest Non-Site Related Residences

	Dust – Annual Average (g/m^2/month)			
Receptor	**Background**	**Increment**	**Background + Increment**	**Air Quality Goal**
R1	1.5	1.5	3.0	4
R2	1.5	1.2	1.7	4
R3	1.5	1.0	2.5	4
R4	1.5	0.2	1.7	4
R5	1.5	0.1	1.6	4

It can be seen from **Table 7** that the highest predicted monthly dust deposition (background plus increment) associated with the Site is 3.0 g/m^2/month. As such, levels of dust deposition are predicted to satisfy the dust deposition goal.

A contour plot of the modelled incremental increase in dust deposition attributable to the Site is presented in **Appendix F.**

6.2 TSP

Modelling of TSP emissions from the site has been conducted using the emission rates calculated in **Appendix E**. **Table 8** presents the results of the Ausplume predictions for Annual Average TSP concentrations at the closest residential receptors.

As detailed in **Section 4**, it has been assumed that the annual average background concentration of TSP is 27 µg/m^3 for the area (derived by doubling the Lynwood Annual Average PM_{10} concentration of 13.5 µg/m^3).

Table 8 Predicted Annual Average TSP Concentration (µg/m^3)

Receptor	**Annual Average Incremental TSP**	**Background**	**Total TSP**	**Air Quality Goal**
R1	5.6	27	32.6	90
R2	2.9	27	29.9	90
R3	4.9	27	31.9	90
R4	0.8	27	27.8	90
R5	0.5	27	27.5	90

It can be seen in **Table 8** that the total annual average TSP concentrations (background plus increment) associated with the Site are predicted to be less than 32.6 µg/m^3 at all nearest non-site related residences. As such, annual concentrations of TSP are predicted to easily satisfy the air quality goal of 90 µg/m^3.

A contour plot of the modelled annual average TSP concentrations (background plus increment) attributable to the Site is presented in **Appendix F**.

6.3 PM_{10} (24-hour Average)

Table 9 presents the results of the Ausplume predictions for 24-hour PM_{10} concentrations using the emission rates calculated in **Appendix E**.

As detailed in **Section 4.1**, it has been assumed that background levels of PM_{10} vary on a daily basis. These background levels have been incorporated into the model.

Table 9 Maximum Predicted (Background + Increment) 24-Hour PM_{10} Concentration (µg/m^3)

	PM_{10} – 24-hour Average (µg/m^3)			
Receptor	**Background (Date)**	**Increment**	**Background + Increment**	**Air Quality Goal**
R1	39.1 (24/12/05)	9.3	48.4	50
R2	42.6 (13/01/05)	1.5	44.1	50
R3	42.6 (13/01/05)	3.3	45.9	50
R4	42.6 (13/01/05)	0.1	42.7	50
R5	42.6 (13/01/05)	0.0	42.6	50

It can be seen from **Table 9** that the maximum 24-hour average PM_{10} concentrations (background plus increment) are predicted to be less than 48.4 µg/m^3 at all the nearest non-Site related residences.

For information purposes, the maximum predicted incremental 24-hour average PM_{10} concentrations (from the project alone) are presented in **Table 10**.

Table 10 Maximum Predicted Incremental (no background) 24-hour PM_{10} Concentrations (µg/m^3)

Receptor	**PM_{10} – 24-hour Average (µg/m^3)**
R1	11.4
R2	7.2
R3	9.9
R4	2.6
R5	3.0

A contour plot of the maximum predicted 24-hour PM_{10} concentration (background plus increment) attributable to the Site is presented in **Appendix F**.

6.4 PM_{10} (Annual Average)

Table 11 presents the results of the Ausplume predictions for 24-hour PM_{10} concentrations using the emission rates calculated in **Appendix E**.

As detailed in **Section 4.1**, it has been assumed that the annual average background concentration of PM_{10} is 13.4 µg/m^3 at the nearest residences. This background level has been incorporated into the model.

Table 11 Predicted Annual Average (Background + Increment) PM_{10} Concentration (µg/m³)

	PM_{10} – Annual Average (µg/m³)			
Receptor	**Background**	**Increment**	**Background + Increment**	**Air Quality Goal**
R1	13.4	4.2	17.6	30
R2	13.4	2.1	15.5	30
R3	13.4	3.3	16.7	30
R4	13.4	0.5	13.9	30
R5	13.4	0.7	13.7	30

It can be seen in **Table 11** that the total annual average PM_{10} concentrations (background plus increment) associated with the Site are predicted to be less than 17.6 µg/m³ at all nearest non-site related residences. As such, annual concentrations of PM_{10} are predicted to satisfy the air quality goal of 30µg/m³.

A contour plot of the modelled annual average PM_{10} concentrations (background plus increment) attributable to the Site is presented in **Appendix F**.

6.5 $PM_{2.5}$

In the absence of published emission factors for $PM_{2.5}$, a semi-quantitative assessment of $PM_{2.5}$ concentrations attributable to activities at the Site has been conducted based on modelling of PM_{10} concentrations.

Chapter 4 (Watson et al) of the *Air Quality Engineering Manual*, (Davis, W. T. (ed.), 2000), details size distributions of several particulate source emissions, which are quoted as the following:

- Fugitive dust from road and soil dust - approximately 20% of the PM_{10} particle size fraction would constitute $PM_{2.5}$.
- Fugitive dust from construction dust - approximately 17% of the PM_{10} particle size fraction would constitute $PM_{2.5}$.

Additionally, it is important to recognise the contribution of vehicle traffic to ambient concentrations of fine particulates. Recent studies of differing Australian airsheds have been carried out for the National Pollutant Inventory. The percentage contribution of motor vehicle PM_{10} emissions to the total ambient PM_{10} concentrations within the airshed of focus are detailed for each study. A summary of these percentage contributions is detailed in

Table 12.

The airsheds reported in

Table 12 represent a varied range of land-use types, from industrial (Port Phillip) to semi-rural (Regional South Australia). An average of these values has been used to determine the percentage contribution of motor vehicular emitted PM_{10}, stated as follows.

- PM_{10} from vehicles may contribute in the order of 9.5 % to the total emission inventory of PM_{10}.

Finally, the size distributions from diesel truck exhaust are quoted by Watson et al (2000) as the following:

- Approximately 96% of PM_{10} from diesel combustion would be emitted as $PM_{2.5}$.

Table 12 Percentage Contribution of Motor Vehicles to Total PM_{10} - Australian Airsheds

NPI Study Title	Airshed of Interest	% of PM_{10} Attributable to Vehicles
NPI Summary Report: Adelaide and Regional Airsheds 1998 - 1999	Adelaide	8
	Regional South Australia	2
NPI Summary Report of Fifth Year Data 2002 - 2003	South East Queensland	10
NPI Summary Report of Sixth Year Data 2003 - 2004	Port Phillip	18

A simple calculation based on the above assumptions, combined with the maximum and annual average predicted PM_{10} concentrations in **Table 9** and **Table 11** above (48.4 µg/m^3 and 17.6 µg/m^3 respectively), indicates that, inclusive of the Site activities:

- 24-hour average $PM_{2.5}$ is predicted to be of the order of 13 µg/m^3, thus satisfying the 24-hour average goal for $PM_{2.5}$ of 25 µg/m^3.
- Annual average $PM_{2.5}$ is predicted to be of the order of 5 µg/m^3, thus satisfying the annual average goal for $PM_{2.5}$ of 8 µg/m^3.

6.6 Respirable Crystalline Silica

Silica occurs in a crystalline or non-crystalline form. Epidemiological studies indicate that occupational exposure to high concentrations of respirable crystalline silica has associated adverse health effects. There are no known adverse health effects associated with exposure to respirable crystalline silica in non-occupational settings (IARC, 1997; CICAD, 2000).

As crystalline silica has its fibrogenic effects in the deeper areas of the respiratory system, it is the particles which are able to penetrate to the alveoli which are of prime concern (NIOSH, 2002; US EPA, 1996). It is generally considered that particles less than 3 – 5µm have a greater potential to reach the alveolar region (US EPA, 2004; IARC 1997; CICAD 2000).

The US EPA (1996) concluded that an inferential method to estimate the crystalline silica fraction in ambient PM_{10} is to assess the nearby soil and that an inherent assumption is that the percentage of crystalline silica within the emitted PM_{10} is equivalent to the fraction within the parent source (USEPA, 1996). Based on information provided by the Proponent it is assumed that the quartz content of the rock is of the order of 7 %.

The National Occupational Health and Safety Commission (NOHSC) in Australia has established an exposure standard of 0.1 mg/m^3 for crystalline silica (expressed as Respirable Quartz), effective from 1 January 2005.

While the NOHSC standard can be used as a guide, the California Office of Environmental Health Hazard Assessment (OEHHA) has adopted a chronic Reference Exposure Level (REL) of 3 µg/m^3 for respirable crystalline silica. A chronic REL is an airborne level of a substance at or below which no adverse health effects are anticipated in individuals indefinitely exposed to that level. RELs are developed from the best available published scientific data, based solely on health considerations.

The maximum predicted 24 Hour average PM_{10} resulting from the operation of the proposed quarry is not anticipated to exceed 50 µg/m^3 at the nearest residences over a 24 hour period (refer **Section 6.2**). Assuming a 7 % quartz content, this would result in a maximum 24 Hour respirable crystalline silica concentration of less than 3.5 µg/m^3. This would indicate that the National Occupational Health and Safety Commission (NOHSC) exposure standard of 0.1 mg/m^3 will be easily satisfied.

The maximum predicted annual average PM_{10} (refer **Section 6.4**) resulting from the operation of the proposed quarry is 17.6 µg/m^3. Assuming 7 % quartz content, this would result in a maximum annual average respirable crystalline silica concentration of 1.2 µg/m^3. This would indicate that the OEHHA REL of 3 µg/m^3 will be easily satisfied.

Further, it is noted that the crystalline silica component of ambient emissions has been observed to be higher within larger size particle size fractions (>10µm) then those fractions less than 10µm. It is suggested that this unequal distribution may be due to quartz, which is harder than most minerals, resisting comminution to finer particle sizes (USEPA, 1996).

As discussed in **Section 3.2** the PM_{10} sub-set of TSP is typically 50% in regions where road traffic is not the dominant particulate source. As the maximum annual average PM_{10} is predicted as 17.6 ug/m^3, this would indicate that TSP mass concentration would be of the order of 35 ug/m^3. Again assuming 7 % quartz content, this would result in a maximum annual average TSP crystalline silica concentration of 2.5 µg/m^3 which would still comply with the OEHHA REL of 3 ug/m^3. It is noted that the respirable fraction dust is in the size range of < 7 microns, and TSP is generally considered to include particles up to 30 microns. As such only a small proportion of TSP is considered respirable.

6.7 Cumulative Impacts

It is noted that a number of existing quarries are located within the regional context of the proposed site. Readymix operates 1 km to the east of the proposed hard rock quarry on the Johniefelds property and proposes to operate 2 km to the south on the Lynwood property. The Readymix Lynwood Quarry is significantly larger that the Marulan Gunlake Quarry with a proposed operating throughput of 5 million tonnes per annum (Holmes, May 2005). The Readymix Johniefelds Quarry is likely to be similar in scale to the proposed Marulan Gunlake Quarry given that the EPA Licence (EPL 1371) indicates a scale of >100,000 - 500,000 tonnes obtained. It is assumed that this refers to the annual production from the quarry.

6.7.1 Existing Ambient Air Quality

As discussed in **Section 4**, three Dust Deposition Gauges have been installed at the site and monitoring has been ongoing since January 2007. Monitoring of background dust during this period at the site, accounts for the cumulative contribution of all existing dust sources in the region, including the existing Johniefelds Quarry, unsealed roads and natural sources of dust.

It is noted that two of the Dust Deposition monitoring locations are located on the eastern site boundary closest to operations at the Readymix Johniefields site, one of which is located 400 m north of residence R1 and approximately 600 m northwest of the Readymix Johniefelds site. It is noted that under certain wind conditions, the dust contribution from the Readymix Johniefelds Quarry at R1, could be higher than levels recorded to date at this monitoring location.

Therefore, a conservative approach is to take the dust deposition results from monitoring on the Marulan Gunlake Quarry Site as the background dust level (without the Readymix Johniefelds site) and assess, on top of this, the cumulative increase from all proposed and existing quarries.

As discussed in **Section 4** existing monitoring data exists for the area (High Volume Air Sampling for PM_{10} on the Lynwood property) which can be used as an indication of the background level of PM_{10} and TSP (derived from published PM_{10} / TSP ratios).

6.7.2 Cumulative Impact Assessment

Dust Deposition

The highest predicted Dust Deposition level for the proposed Marulan Gunlake Quarry is 1.5 g/m^2/month. Working on the assumption that the Readymix Johniefeld Quarry is similar in scale (refer **Section 6.7**), the maximum predicted dust deposition from this site could also be of the order of 1.5 g/m^2/month.

An Air Quality Assessment has been conducted for the Readymix Lynwood Quarry (Holmes, 2005) with revised modelling conducted following a request from the DECC to use site specific weather data. On the basis of this assessment, the predicted dust deposition from the Lynwood Quarry at residences to the north of the site (and closest to the Marulan Gunlake Quarry) would not exceed 0.12 g/m^2/month.

The total cumulative predicted impact is presented in **Table 13**. The results indicate a slight exceedance of the Air Quality Goal (4 g/m^2/month), however this is based on the conservative assumption that the background concentration does not account for the contribution from the existing Johniefelds Quarry and a certain amount of double counting will be evident. On the basis of this small increase, the total cumulative impact is not anticipated to be significant.

It is noted that the DoP and the DECC in their Assessment Report for the Proposed Lynwood Quarry were satisfied that the proposal would not have a significant impact on the air quality of the area, despite slight exceedances of the dust deposition goal.

It is noted that the predicted increment from the Marulan Gunlake Quarry of 1.5 g/m^2/month satisfies the maximum incremental increase goal of 2 g/m^2/month.

Table 13 Cumulative Dust Deposition Assessment

Predicted Increment from Marulan Gunlake Quarry	1.5 g/m^2/month
Predicted Increment from Johniefeld Quarry	~ 1.5 g/m^2/month
Predicted Increment from Lynwood Quarry	~ 0.12 g/m^2/month
Estimated Background	1.5 g/m^2/month
Total Cumulative Impact	**4.62**

Particulate Matter

The maximum incremental 24 hour PM_{10} concentration from the Gunlake Quarry is of the order of 11 $\mu g/m^3$. Working on the assumption that the Readymix Johniefeld Quarry is similar in scale (refer **Section 6.7**), the maximum incremental 24 hour PM_{10} concentration from this site could also be of the order of 11 $\mu g/m^3$.

An Air Quality Assessment has been conducted for the Readymix Lynwood Quarry (Holmes, 2005) with revised modelling conducted following a request from the DECC to use site specific weather data. On the basis of this assessment, the predicted 24-hour PM_{10} concentration from the Lynwood Quarry at residences to the north of the site (and closest to the Marulan Gunlake Quarry) would not exceed 6 $\mu g/m^3$.

The total cumulative predicted impact is presented in **Table 14**. The results indicate a total incremental 24 hour PM_{10} concentration of less than 30 $\mu g/m^3$ from all three sources. Daily varying concentrations of PM_{10} may result in higher background concentrations on given days, however this is difficult to quantify for this semi-quantitative cumulative assessment. The average 24-hour PM_{10} concentration for the area is of the order of 13 $\mu g/m^3$.

The results of the semi-quantitative cumulative assessment of annual average PM_{10} and TSP concentrations indicated air quality goals are unlikely to be compromised.

Table 14 Cumulative PM Assessment

	24 hr PM_{10}	Annual Average PM_{10}	Annual Average TSP
Predicted Increment from Marulan Gunlake Quarry	11 $\mu g/m^3$	4.2 $\mu g/m^3$	5.6 $\mu g/m^3$
Predicted Increment from Johniefeld Quarry	11 $\mu g/m^3$	4.2 $\mu g/m^3$	5.6 $\mu g/m^3$
Predicted Increment from Lynwood Quarry	6 $\mu g/m^3$	1.8 $\mu g/m^3$	2.5 $\mu g/m^3$
Estimated Background	13 $\mu g/m^3$ [a]	13 $\mu g/m^3$	33 $\mu g/m^3$
Total Cumulative Impact	**41 $\mu g/m^3$**	**23.2 $\mu g/m^3$**	**46.7 $\mu g/m^3$**

Note: [a] This is the average 24-hour PM_{10} recorded at the Lynwood site for the monitoring period. Daily varying concentrations of PM_{10} may result in higher background concentrations, however this is difficult to quantify for this semi-quantitative cumulative assessment.

6.8 Dust Impacts on Vegetation

The area surrounding the Site has been mainly cleared of native vegetation with scattered pockets of bush and scrub remaining as indicated in **Figure 7**.

Figure 7 Vegetation of Site and Surrounds

Dust can have both physical and chemical effects on plants. Physical effects include blockage and damage to stomata, shading, abrasion of leaf surface or cuticle. The chemical effects of dust, working either directly on the plant surface or by changing the chemistry of the soil, are likely to be more important than any physical effects. Changes in soil chemistry may have long-term effects on species competition and community structure.

Thus, the impact of dust on vegetation is dependent on the rate of dust deposition and the chemical composition of the dust. There have been very few recent studies conducted regarding the vegetative health impacts of dust deposition. Farmer (1993) summarised results from studies of vegetation exposed to dust deposition from nearby limestone quarries, cement plants, and other sources such as roads and coal quarries and concluded that dust may affect photosynthesis, respiration, transpiration and allow the penetration of phytotoxic pollutants. Flow on effects include reduced productivity and changes in floral and faunal community structure.

Yang (1988) noted that dust deposition levels of 0.75 to 1.5 g/m²/day (i.e. 22 to 45 g/m²/month) would not result in adverse effects on plant production. Decreased respiration rates were noted to occur for cereals when cement dust deposition rates exceeded 7 g/m²/day (Environment Canada, 1998).

However, there is no single minimum dust deposition rate at which impacts were experienced due to the different chemical composition of dusts studied and the variety of plant species studied.

The dust deposition criterion given in **Section 3.4** applies to "sensitive receivers" which are defined as locations where people are likely to work or reside, including known or likely future locations.

Vegetative communities are not explicitly considered as sensitive receivers, except in relation to impacts of hydrogen fluoride where the sensitivity of grapevines and stone fruit species to this compound is considered relevant. Areas of high ecological value or agricultural resources may be more sensitive to dusts than other areas.

However, documented levels given for potential impacts on vegetation, including sensitive natural vegetation and crops, are orders of magnitude higher than were predicted to occur in the vicinity of the Site.

6.9 Dust Impacts on Livestock

It is noted that areas surrounding the Site are primarily used for sheep grazing, predominantly to the north and west of the site.

There is little published literature regarding the impacts of dust deposition relative to wool yield and quality. Some studies have suggested that a relationship exists between wool value and dust content and that dust can affect wool quality after events such as dust storms and from other natural sources. However, this relationship never been quantified.

A recent study has shown that dust content of wool is in fact a heritable trait (Schlink, 2003) and that sheep may be bred to produce better quality wool that is less susceptible to adverse effects from dust.

Mentor Consulting (1993), as quoted in Hunt (2003), undertook grazing trials in NSW with dairy cattle. The trails were designed to determine the impact of coal mine dust contamination of pasture on pasture intake, grazing behavior and milk production of dairy cattle. Coal dust added to a pasture equivalent to 8 g/m²/day had no effect on pasture palatability or cattle production. Hunt (2003) cites a study by Marek and Hais (1970) which investigated dust inhalation and ingestion of contaminated pastures by dairy cattle. According to this study, production levels were reduced by about 10% when deposition levels reached 48 to 96 g/m²/month but not detectable at lower dust deposition rates.

The predicted incremental increase in dust deposition from the Site is less than 0.2 g/m^2/month to the north and west of the Site which is unlikely to have a noticeable effect on dust levels in wool.

The health impacts on livestock are similarly not considered to be an issue as levels given for potential impacts on livestock are orders of magnitude higher than were predicted to occur in the vicinity of the Site.

6.10 Construction Phase Emissions

The air quality impacts during the operation of the Gunlake Quarry would be greater than those during construction and site establishment. Therefore the intention of this report is to demonstrate that if operational phase activities do not result in exceedances of relevant air quality criteria, construction phase emissions similarly would not result in adverse air quality.

Further, localised air quality impacts associated with the construction can largely be controlled through technical means including good site management, vehicle maintenance and applying appropriate dust mitigation measures.

6.11 Vehicle Emissions

Vehicle exhaust emissions of oxides of nitrogen (NO_X), sulphur dioxide (SO_2) and hydrocarbons from construction and vehicles are not expected to be significant given the relatively small scale nature of the quarry and limited equipment inventory. Emissions from these sources are expected to be easily assimilated into the local airshed and unlikely to cause exceedances of air quality goals even at residences close to the transport route. Additionally, the low sulphur content of Australian diesel is expected to ensure air quality goals for sulphur dioxide (SO_2) would not be exceeded.

7 DESIGN AND OPERATIONAL SAFEGUARDS

A dust control strategy will be implemented at the Site to minimise potential emissions, particularly during adverse weather condition days when excessive amounts of dust could be generated. Adverse weather conditions from an air quality perspective include moderate to strong winds prevailing from the western quadrant (blowing in the direction of the closest non-Site related residence).

Specific design and operational safeguards have been planned for implementation at the Site, including the following.

- Water spraying in excess of 2 litres/m^2/application applied to internal haul roads;
- Temporary partial enclosure of stockpiles and processing area through installation of wind breaks (Hessian screen) along the western side of the processing area (subject to monitoring results;
- Stabilisation and / or revegetation of the overburden emplacement;
- Installation of water sprays at the tipping point to the apron feeder and at the primary crusher input;
- Instigation of water spraying at discharge points to stockpiles when winds in excess of 8 m/s are recorded on the on site weather station; and
- Minimising of exposed surfaces where possible.

8 MONITORING, REPORTING, COMPLAINTS HANDLING & NON-COMPLIANCE

8.1 Air Quality Monitoring

The assessment above indicates that fugitive particulate emissions are likely to be acceptable for the operation phases of the quarry and as such air quality is not anticipated to be adversely affected at the nearest residences.

However, to demonstrate compliance with the air quality goals it is recommended that monitoring be conducted at appropriate locations and frequencies throughout the life of the quarry with an annual review of the extent of monitoring conducted.

It is recommended that the dust deposition monitoring currently undertaken at the site be continued.

Further, it is recommended that monitoring of 24-hour concentrations of PM_{10} be undertaken at one location for an appropriate period, as agreed with the DECC. It is recommended that monitoring be conducted on a one-day-in-six cycle using a High Volume Air Sampler (HVAS). A suitable location would be at resident R1, the closest residence to the Site. Monitoring for PM_{10} should be conducted for a period of at least one year and at maximum quarry throughput. Should no exceedance of the 24-Hour PM_{10} criteria (directly attributable to the Marulan Quarry) occur during this period, monitoring can be reviewed and discontinued as appropriate.

It is also recommended that an on-site Weather Station be established to monitor wind speed and wind direction. The weather station should be fitted with either an alarm / automatic notification system for when wind speeds exceed 8 m/s.

Monitoring should be undertaken according to the DECC document *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales,* 2005.

Specifically, monitoring should be conducted in accordance with the following Australian Standards:

- AS/NZS 3580.1.1:2007 *"Methods for Sampling and Analysis of Ambient air - Guide for the siting air monitoring equipment*"
- AS 3580.9.6-2003 Particulate Matter - PM_{10} - high volume sampler with size-selective inlet.
- AS 3580.10.1-2003 Methods for Sampling and Analysis of Ambient Air - Determination of Particulates - Deposited Matter - Gravimetric Method (NSW DEC Method AM-19).

8.2 Responsibilities and Accountabilities

An organisational structure for the management of environmental control and reporting procedures will be implemented. The Site Manager (SM) will oversee the environmental management of the site, liaise as necessary with other on-site personnel and report directly to the overall Project Manager (PM).

The purpose of this structure is to ensure the following:

- The environmental procedures are effectively implemented and have the intended outcome, that is, no off-site nuisance or other effects due to air pollution are experienced; and
- Non-compliance with any of the desired environmental outcomes will be reported promptly and corrective action will be taken to mitigate any impacts.

Many of the dust-control procedures will be implemented as required and compliance checked by daily visual inspection. All site personnel and subcontractors will undergo appropriate induction training courses and individual responsibilities for ensuring that procedures are adhered to will be clearly defined.

The management and reporting of environmental aspects of activities will be the responsibility of the SM, with specific tasks delegated to on-site personnel. Simple daily visual checks will be made by on-site personnel for most parameters and any non-conformances shall be reported immediately to the PM.

8.3 Reporting

Monthly dust deposition gauge and HVAS results will be reported to the PM so that dust control and operational procedures can be reviewed and modified, if required.

Results of monitoring will be reported through the Annual Environmental Monitoring Report which would be made available to the DECC and local community groups if relevant.

8.4 Non Compliance and Corrective Action

Where the air quality monitoring identifies non-compliance with the relevant criteria, the Site Manager will plan and carry out corrective action.

If monitoring indicates that the air quality objectives are being significantly exceeded on multiple occasions the Site Manager will:

- Identify the activities that were occurring at the time of the exceedance;
- Determine the activities that were most likely contributing to the exceedance (employing continuous monitoring techniques);
- Review work procedures and environmental controls in place for this activity;
- Implement an agreed alternative to more adequately control dust generation; and
- Inform the DECC and local community groups of the exceedance and planning corrective action.

The corrective action may involve supplementary monitoring to identify the source of the non-conformance, and/or may involve modification of work procedures, techniques or programmes to avoid any recurrence or minimise its adverse effects.

8.5 Complaints Handling

A complaints handling procedure shall be drawn up by Gunlake Quarries Management. An effective complaint investigation shall determine the likely cause of the complaint. A review of the air quality monitoring results will be undertaken following a complaint to determine if air quality goals are also being exceeded.

A review of work procedures and / or dust control procedures shall be undertaken in response to complaints and supplementary monitoring undertaken if deemed necessary.

9 CONCLUSION

Atmospheric dispersion modelling was carried out for this assessment to quantitatively determine the impact, in terms of particulate matter, of worst case operations for the Site.

The results of the modelling indicate that the predicted PM_{10} concentrations comply with the air quality goals, provided specific operation controls detailed in **Section 7** are adhered to.

Dust deposition, or nuisance related dust impacts, were also assessed and the annual average dust deposition at each receptor location is predicted to comply with the air quality goals, provided specific operation controls detailed in **Section 7** are adhered to.

A semi-quantitative assessment of $PM_{2.5}$ concentrations attributable to the Site has been conducted based on modelling of PM_{10} concentrations. Both the 24-hour and annual average air quality goals for $PM_{2.5}$ are easily satisfied.

A semi-quantitative assessment of respirable crystalline silica attributable to the Site has been conducted based on modelling of PM_{10} concentrations. Both the short term occupational and longer term exposure levels are easily satisfied.

Air quality impacts associated with the construction phase of the proposed development would be short lived and are anticipated to be largely controllable through technical means.

It is noted that a worst-case scenario was modelled, in terms of particulate emission rates and operational conditions. As a result, all predictions in the assessment should be viewed as conservatively high, with levels expected to be lower than those modelled during normal operation of the Site.

An assessment of the effects of dust on vegetation and livestock indicates that operations on the Site are unlikely to result in significant impacts.

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11 GLOSSARY OF ACRONYMS AND SYMBOLS

AQIA	Air Quality Impact Assessment
AWS	Automatic Weather Station
BoM	Australian Bureau of Meteorology
CICAD	Concise International Chemical Assessment
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DECC	NSW Department of the Environment and Climate Change
FEL	Front End Loader
Heggies	Heggies Australia Pty Ltd
IARC	International Agency for Research on Cancer
mg	Milligram (g x 10^{-3})
µg	Microgram (g x 10^{-6})
µm	Micrometre or micron (metre x 10^{-6})
m^3	Cubic metre
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NIOSH	National Institute for Occupational Safety and Health
NOHSC	National Occupational Health and Safety Commission
NPI	National Pollutant Inventory
OEHHA	Office of Environmental Health Hazard Assessment (California)
PM_{10}	Particulate matter less than 10microns in aerodynamic diameter
$PM_{2.5}$	Particulate matter less than 2.5microns in aerodynamic diameter
REL	Reference Exposure Level
TAPM	“The Air Pollution Model”
TSP	Total Suspended Particulate
USEPA	United States Environmental Protection Agency
WHO	World Health Organisation

Climate Averages - Goulburn

Climate Averages - Goulburn

Climate averages for Station: 070263 GOULBURN (PROGRESS ST) Commenced: 1971; Last record: 2007; Latitude (deg S): -34.7208; Longitude (deg E): 149.7420; State: NSW

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily maximum temperature - deg C	27.5	26.5	24	20.1	16	12.4	11.5	13.1	16.2	19.3	22.2	25.8	19.5
Mean no. of days where Max Temp >= 40.0 deg C	0.1	0	0	0	0	0	0	0	0	0	0	0	0.1
Mean no. of days where Max Temp >= 35.0 deg C	2.9	1.8	0.2	0	0	0	0	0	0	0	0.3	1	6.2
Mean no. of days where Max Temp >= 30.0 deg C	10.2	7.4	3.3	0.2	0	0	0	0	0	0.3	2	6.9	30.4
Highest daily Max Temp - deg C	40.1	39.2	36.9	32.6	25	20	18.6	24	28.2	32.7	40.1	38.4	40.1
Mean daily minimum temperature - deg C	13.4	13.6	11.1	7.8	4.8	2.4	1.3	2	4.6	6.7	9.1	11.6	7.3
Mean no. of days where Min Temp <= 2.0 deg C	0	0	0.3	2.4	8.6	14.3	17.8	15.4	7.8	3.5	1	0.1	71.2
Mean no. of days where Min Temp <= 0.0 deg C	0	0	0.1	0.9	4.4	8.7	12	10	3.4	1.1	0.1	0	40.7
Lowest daily Min Temp - deg C	4.2	3.3	-0.6	-4.4	-5.5	-7.4	-8.5	-6.8	-6	-2	-0.5	0.9	-8.5
Mean 9am air temp - deg C	18.4	17.5	15.8	12.8	9	5.9	5	6.6	10.5	13.8	15	17.7	12.4
Mean 9am wet bulb temp - deg C	15.4	15.5	13.6	11	7.9	5.1	4	5.3	8.3	10.9	12.1	14.1	10.1
Mean 9am dew point - deg C	13.1	13.7	12	9.4	6.9	4	2.8	3.5	5.9	7.9	9.6	11.2	8.2
Mean 9am relative humidity - %	73	79	80	81	86	88	86	81	75	70	72	68	78
Mean 9am wind speed - km/h	7.8	6.9	6.8	6.9	6.3	7	8.2	9.7	11.1	11.4	9.2	9.2	8.4
Mean 3pm air temp - deg C	26	25.1	22.6	18.8	14.7	11.2	10.4	12	15	18	21	24.3	18.3
Mean 3pm wet bulb temp - deg C	17.9	18.2	16.3	13.5	11	8.4	7.5	8.3	10.5	12.8	14.6	16.3	12.8
Mean 3pm dew point - deg C	11.8	12.9	11.4	8.7	7.3	5.1	4	3.7	5.8	7.8	9.1	9.9	8.1
Mean 3pm relative humidity - %	45	50	52	54	62	67	65	59	56	54	51	45	55
Mean 3pm wind speed - km/h	13.5	12.5	11.9	10.8	10.5	11.7	13.4	15.2	14.8	14.6	13.5	14.1	13.1
Mean monthly rainfall - mm	60.7	59.1	55.6	51.1	47.8	45.7	44.6	57.7	50.2	56.6	66	54.4	649.5
Median (5th decile) monthly rainfall - mm	58.3	49.6	52.2	33.5	39.4	35.1	43.4	47.2	46.4	53.2	66.6	45.4	641.6
9th decile of monthly rainfall - mm	136.2	127.6	113.6	136.2	101.8	114.5	84.4	133.2	93.6	102.9	108.3	121.3	833.4
1st decile of monthly rainfall - mm	11.2	13	9.6	4	4.6	12.3	13	11.4	20	17	19	10.5	385.7
Mean no. of raindays	10	9.2	9	9.2	10.6	11.2	12.2	11.9	10.8	11.4	11.5	9.2	126
Highest monthly rainfall - mm	181.1	167	180.8	208.2	124.6	185.2	97.2	215	97.8	148.4	116.6	131.4	
Lowest monthly rainfall - mm	3	2.5	2.4	0.2	2.6	9.4	4	5.2	4.4	5	4.6	0.9	
Highest recorded daily rainfall - mm	63	73.4	93.4	92	61.2	114	40.4	99.2	33.6	51.6	58.6	56.6	114
Mean no. of clear days	7.6	6.1	7.1	7.1	6.2	5.1	6.5	8.5	7.6	7	6.3	8	83.3
Mean no. of cloudy days	10.9	11.8	11.7	11.1	13.3	13.7	12.1	10.9	9.6	10.8	11.5	10.8	138.3
Mean daily evaporation - mm	6.3	5.5	4.1	2.6	1.6	1.1	1.2	1.9	2.8	3.8	5	6.2	3.5

TAPM Validation

B1 Introduction

This appendix clarifies the use of The Air Pollution Model (TAPM) in the generation of site-specific meteorological data.

B2 Meteorology and Dispersion Modelling

Air pollutant dispersion models, such as the Ausplume Gaussian Plume Dispersion Model software developed by EPA Victoria, require meteorological data inputs to simulate the potential impacts of pollutants on the nearest receptors. In the past, this has been achieved using observations from the nearest meteorological monitoring station and converting these into a format suitable for dispersion modelling (Martin & Cook, 2002).

However, there are a number of problems inherent in this approach. Upper air parameters such as mixing height are often inaccurately estimated due to the small number of upper air stations in Australia (Martin & Cook, 2002). Additionally, there is often a significant geographical separation between study areas and the nearest meteorological stations, particularly in rural areas.

The Air Pollution Model (TAPM) software, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), is often used simulate the meteorology of an area where insufficient on-site meteorological data is available. TAPM is a prognostic model which may be used to predict three-dimensional meteorological data, with no local data inputs required.

The model predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations. TAPM is often used to drive the regulatory Ausplume model where insufficient on-site meteorology data is available.

The TAPM model also allows for the assimilation of wind observations to be optionally included in a model simulation. The wind speed and direction observations are used to “nudge” the predicted solution towards the observation values.

B3 TAPM Verification Studies

There exists a number of studies that investigate the effectiveness of the TAPM software in simulating site-specific meteorological data. These verification studies demonstrate that TAPM performs well in a variety of regions throughout Australia and for a range of important phenomena such as convective dispersion (Hurley *et al*., 2002). A select number of these studies are detailed below:

- The TAPM software was used to simulate the meteorology in Melbourne for winter (July 1998) and summer (December 1998). These predictions were compared with observational data measured as part of the EPA Victoria air quality monitoring. The results of this comparison indicate that TAPM predicts both winds and temperature very well, with no significant biases (Hurley *et al*., 2002).
- The effectiveness of TAPM in estimating annual urban meteorology was assessed by comparing a TAPM-simulated data set for Perth with meteorological observations. An analysis of ambient temperature, wind speed and wind direction demonstrates that the meteorology of Perth was well-simulated by the TAPM software throughout the year (Hurley *et al*., 2002).

- A comparison of observed and predicted meteorology was undertaken for Kwinana, a coastal industrial region south of Perth, Western Australia. A comparison of these data sets indicates that TAPM simulates the meteorology of the area well, particularly with respect to wind speed and wind direction (Luhar & Hurley, 2002). **Figure A** demonstrates the comparison of observed results with TAPM predictions for these parameters.

Figure A Hourly Average Wind Speed and Wind Direction (Observed and TAPM-Generated) at Kwinana, WA (Source: Luhar & Hurley, 2002)

- TAPM predictions of wind speed, wind direction, temperature and relative humidity were compared with observational data for the Pilbara region, WA. The comparison indicates that there is a strong correlation between predicted and observed results at this site, demonstrating that TAPM-generated meteorology is a useful tool in dispersion modelling (Hurley *et al.,* 2003).

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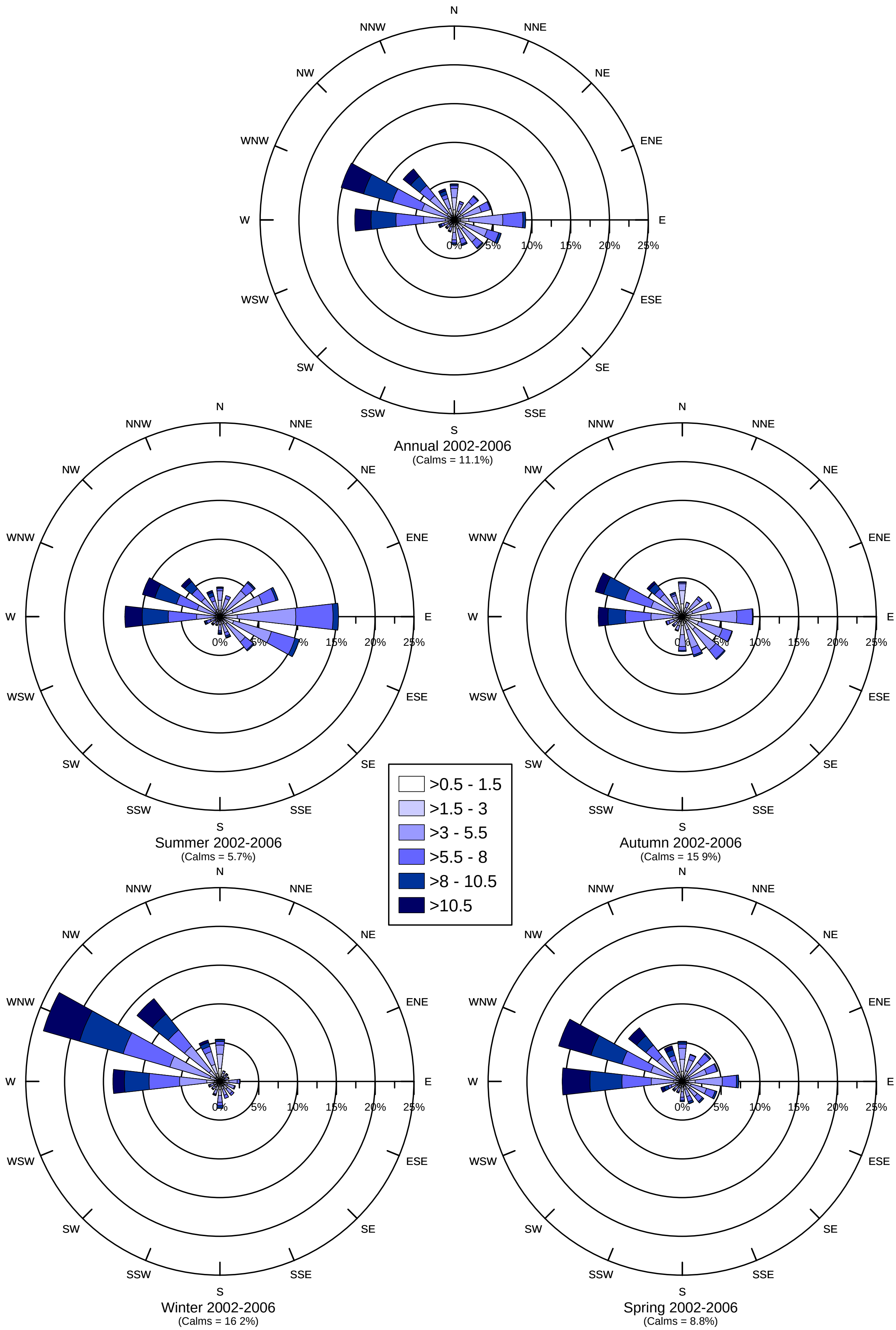
Annual and Seasonal Windroses, Project Site and Goulburn AWS 2005



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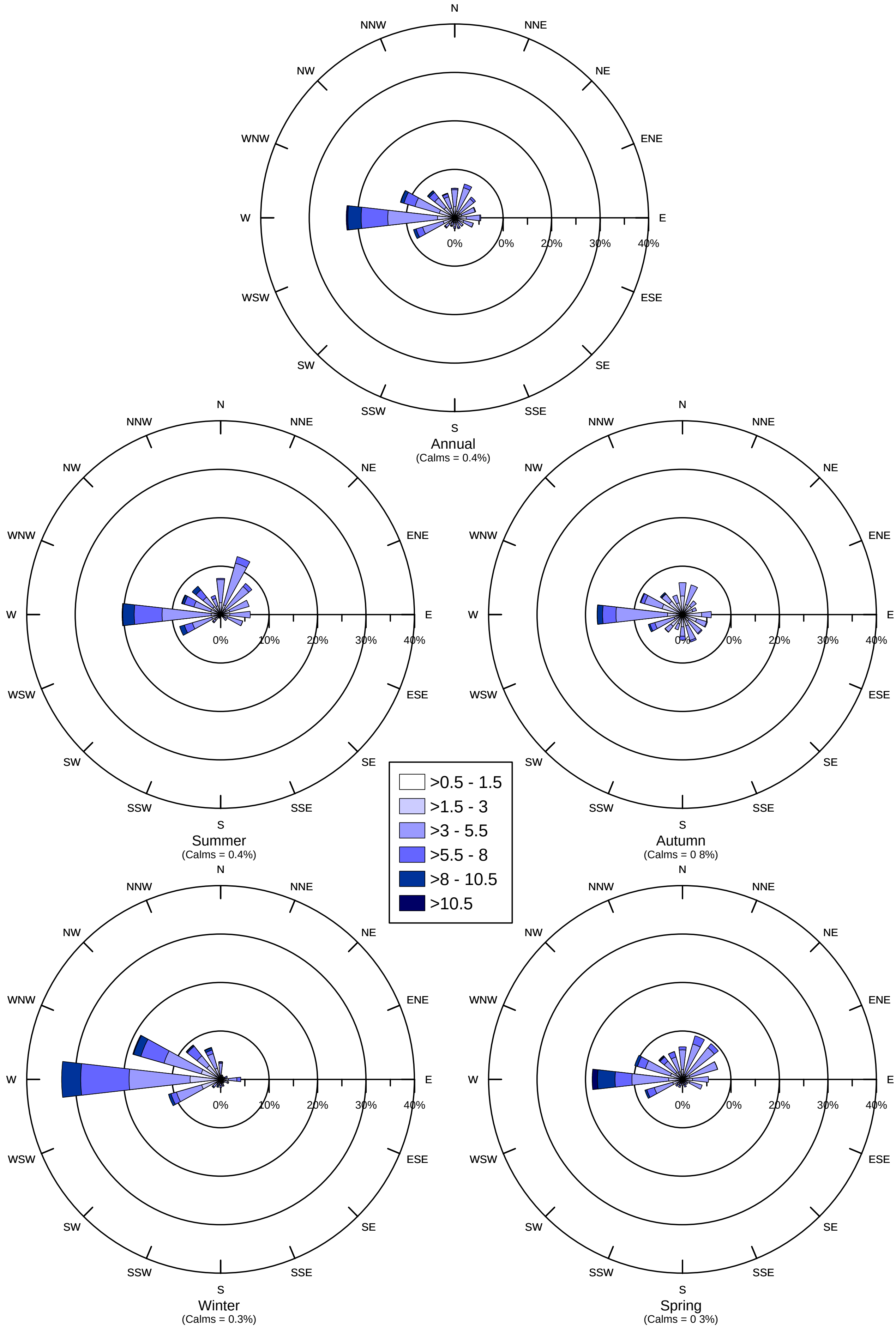
Designed by	Checked by	Approved by - date	Filename	Dated
MD	SF		10-5107	30/03/07

Appendix C: Annual and Seasonal Wind Roses for Goulburn Airport AWS (2002-2006)



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MD	SF		10-5107	30/03/07

Appendix C: TAPM-Predicted Annual and Seasonal Wind Roses for Project Site (2005)

Emissions Inventory

GUNLAKE QUARRY Hard Rock Extraction and Processing Operations	TSP Emission Factor	PM_{10} Emission Factor	Emission Factor Units	Hourly Throughput	Working days available	Working hours per day	Average number of kms per hour	TSP Emission Rate (mg/s)	Long Term TSP Emission Rate (mg/s)		Short Term PM_{10} Emission Rate (mg/s)	Long Term PM_{10} Emission Rate (mg/s)
Overburden Removal												
Excavator (on Overburden)	0 003	0.001	kg/t	9	312	12	N/A	6.9	5.9		3.3	2.8
Truck Haulage (Pit to Overburden Emplacement	3.1	0.8	kg/VKT	N/A	312	12	0.1	9.5	8.1		4.6	4.0
Truck Unloading	0 003	0.001	kg/t	9	312	12	N/A	6.9	5.9		3.3	2.8
Hard Rock Extraction												
Drilling	0 59	0.31	kg/Hole	27 Holes/Blast	104	5	N/A	442.5	126.1		442	126
Blasting	27.5	14.3	kg/blast	NA	104	1	N/A	3826.4	1090.3		3780	1077
Rock Breaker (Ex)	0 003	0.001	kg/t	180	312	12	N/A	68.6	58.6		61.7	52.7
FEL to Trucks	0 0008	0.0004	kg/t	180	312	12	N/A	19.0	16.3		17.1	14.6
Truck Haulage Pit to Processing	3.1	0.8	kg/VKT	N/A	312	12	1.8	138.3	118.3		67 5	57.7
Processing Plant												
Truck Unloading to Hopper	0 0008	0.0004	kg/t	180	312	12	N/A	13.3	11.4		6.3	10.8
Primary Crusher	0 01	0.004	kg/t	180	312	12	N/A	175.0	149.6		70 0	119.7
Secondary Crusher	0 03	0.012	kg/t	180	312	12	N/A	1050.0	897.5		420.0	359.0
Tertiary Crusher	0 03	0.01	kg/t	90	312	12	N/A	525.0	448.8		175.0	149.6
FEL to Product Trucks	0 0008	0.0004	kg/t	180	365	24	N/A	26.6	N/A		12.6	N/A
Product Haulage (Processing to Site Entrance)	3.1	0.8	kg/VKT	N/A	365	24	7.7	165.3	N/A		60.7	121.4
Stockpile Loading	0 004	0.002	kg/t	180	312	12	N/A	70.0	59.8		29 8	50.9
Wind Erosion	**TSP Emission Flux (mg/s/m2)**			**Short Term PM10 Emission Flux (mg/s/m2)**			**Long Term PM10 Emission Flux (mg/s/m2)**					
Wind Band	**<8.3**	**8.3-10.8**	**>10.8**	**<8.3**	**8.3-10.8**	**>10.8**	**<8.3**	**8.3-10.8**	**>10.8**			
Open Pit	0.00	0.03	0.29	0	0.01	0.1	0	0.01	0.1			
Overburden Emplacement	0.00	0.03	0.29	0	0.01	0.1	0	0.01	0.1			
Stockpiles	0.00	0.24	1.05	0	0.05	0.4	0	0.1	0.8			

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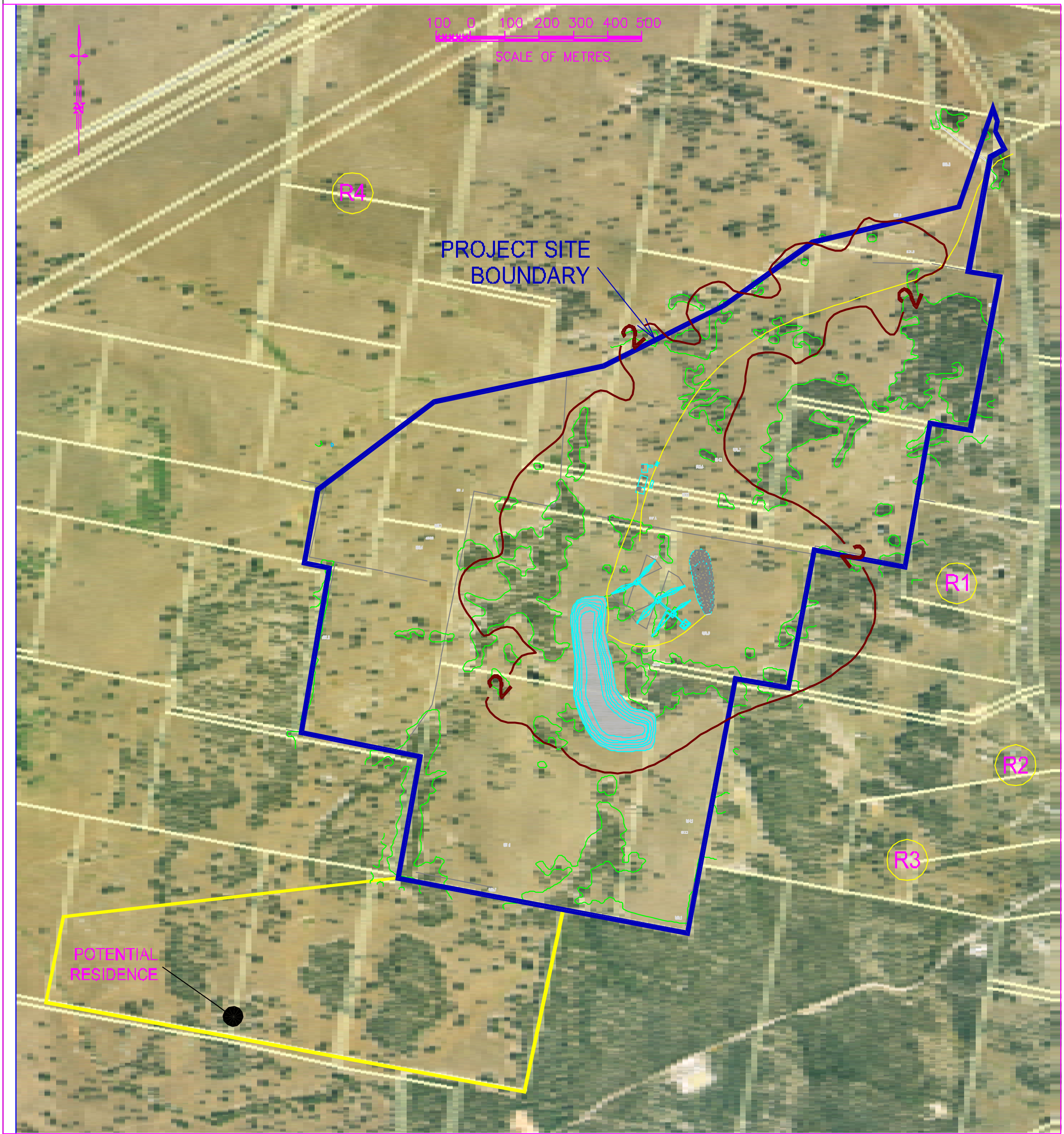
Designed by	Checked by	Approved by - date		Filename	Dated
RK	DR	26/06/2007			26/06/2007

Emissions Inventory for Operations at Project Site - Year 20

Monthly Dust Deposition, Annual Average TSP, Annual Average PM_{10} & 24-Hour PM_{10} Contours



REV	DATE	AMENDMENT / ISSUE DESCRIPTION	PREPARED	CHECKED
1	12/02/18			

Heggies Pty Ltd
2 Lincoln Street
Lane Cove NSW 2066 Australia
PO Box 176 Lane Cove NSW 1595
Email address sydney@heggies.com.au
Telephone 02 9427 8100 Facsimile 02 9427 8200

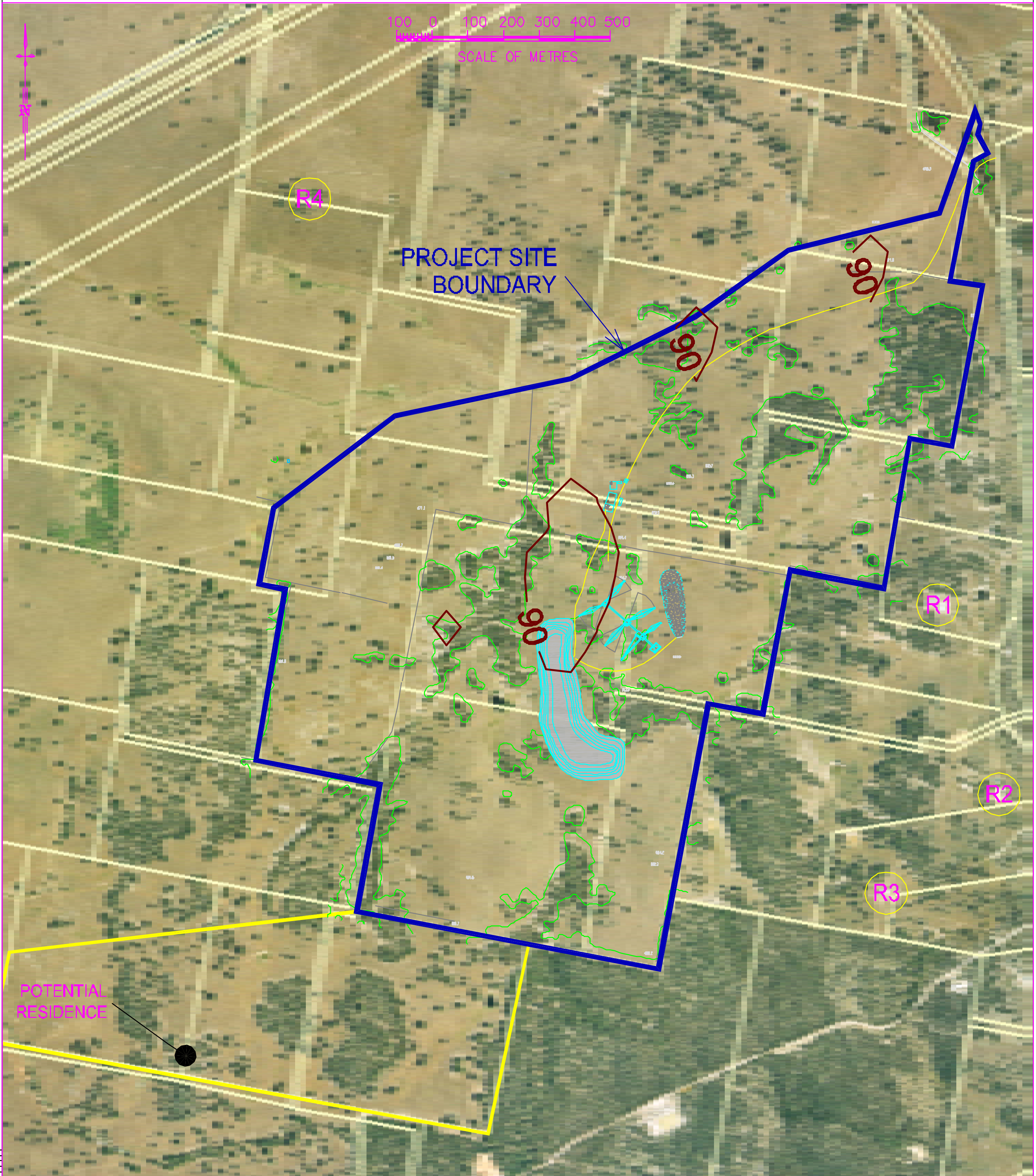
Proposed Gunlake Quarry
Predicted Dust Deposition
2 g/m2/month Contour

FILE NAME: 4B_16RevA_R2000.dwg

DRAWING No. ----

REVISION 0

50 mm ON ORIGINAL



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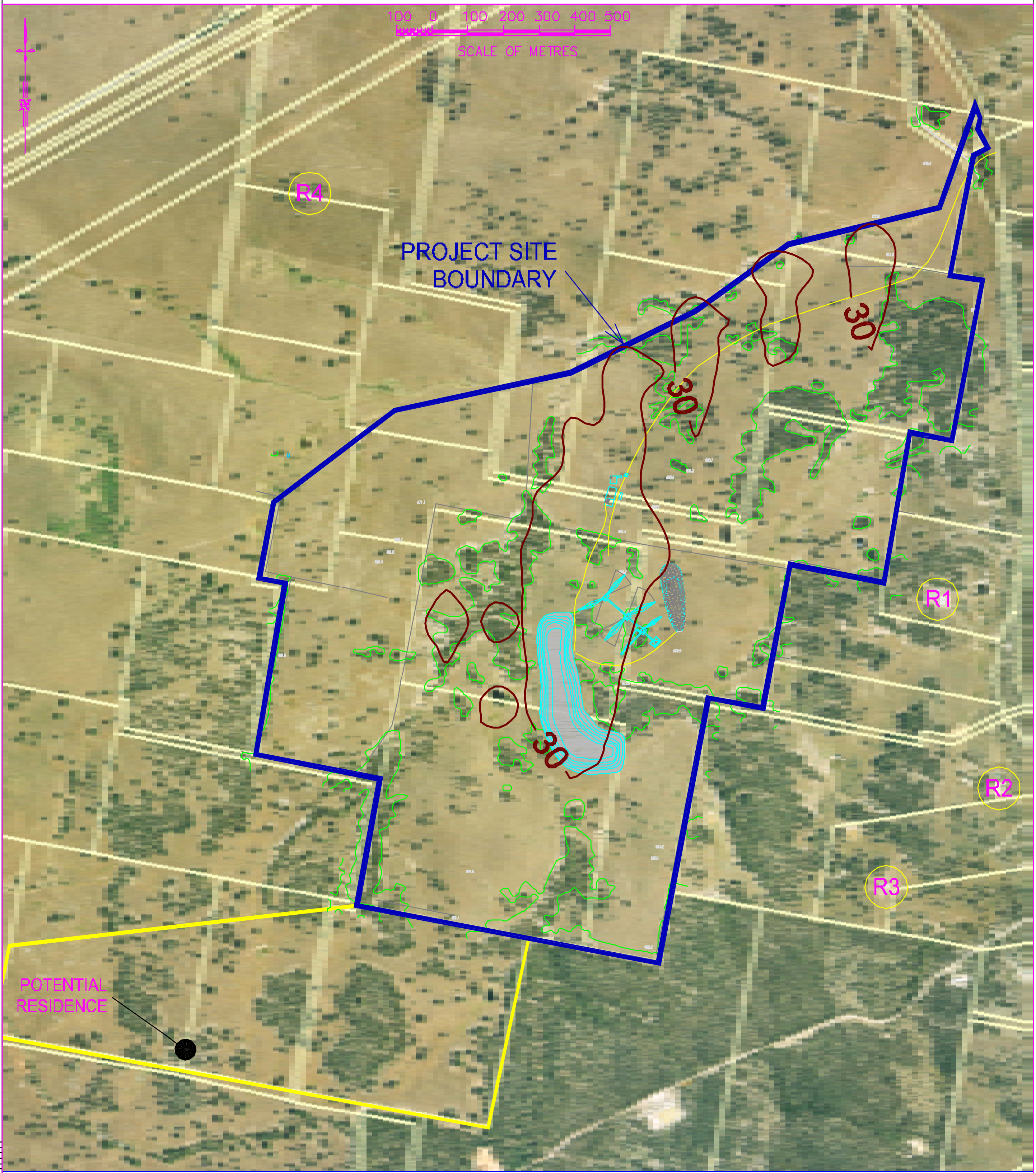
Proposed Gunlake Quarry
Predicted AA TSP Concentration
90 ug/m3 Contour

FILE NAME:	DRAWING No.	REVISION
4B_16RevA_R2000.dwg	----	0



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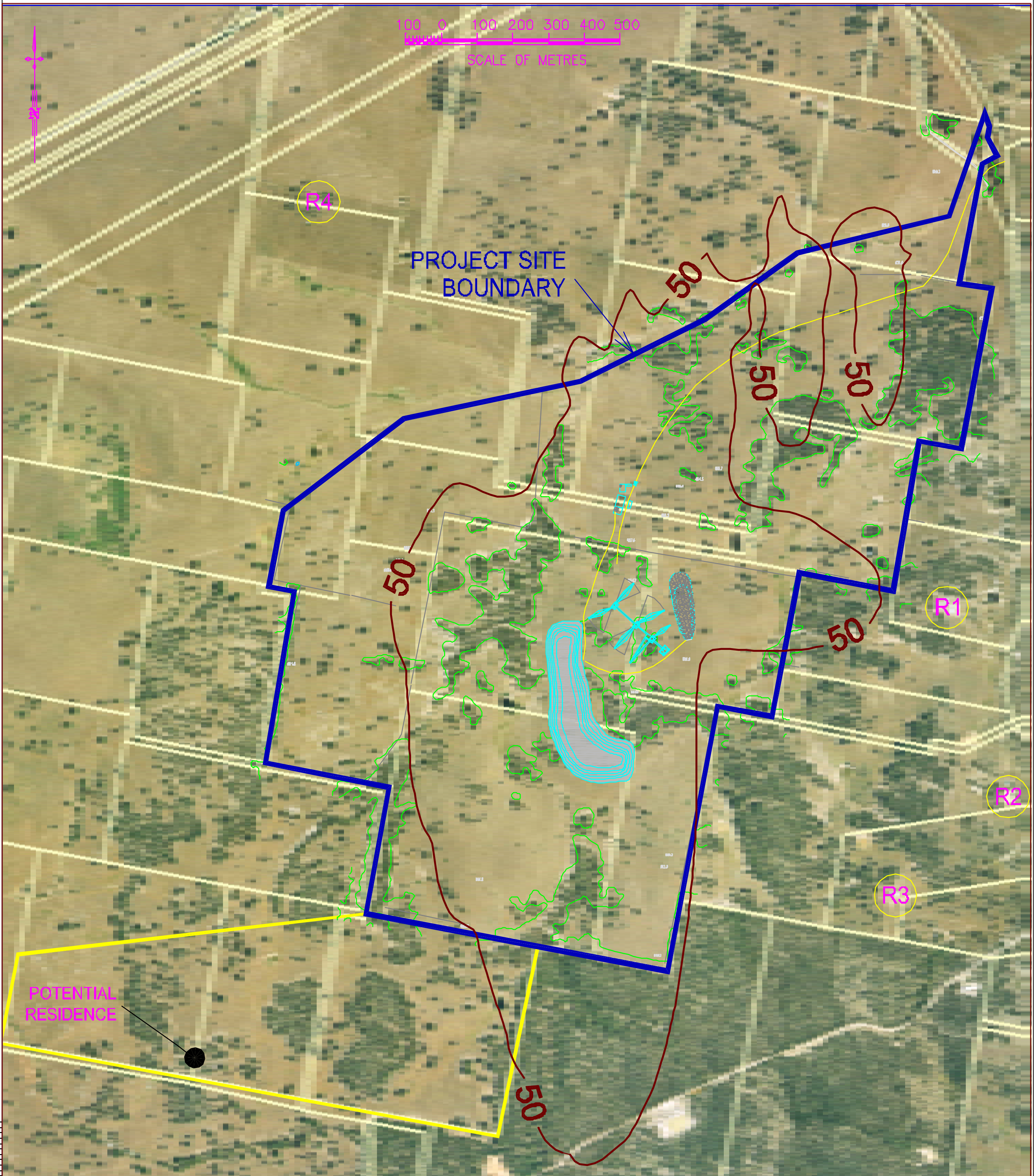
Proposed Gunlake Quarry
Predicted AA PM10 Concentration
30 ug/m3 Contour

FILE NAME: 4B_16RevA_R2000.dwg

DRAWING No. ----

REVISION 0



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Proposed Gunlake Quarry
Predicted 24-Hr PM10 Concentration
50 ug/m3 Contour

FILE NAME: 4B_16RevA_R2000.dwg

DRAWING No. ----

REVISION 0

50 mm ON ORIGINAL