Adani Mining Pty Ltd

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Air Quality Assessment 25215-D-RP-0026

16 October 2012

Revision 1

This Carmichael Coal Mine and Rail Project: Mine Air Quality Assessment ("the Report") has been prepared by GHD Pty Ltd ("GHD") on behalf of and for Adani Mining Pty Ltd ("Adani") in accordance with an agreement between GHD and Adani.

The Report may only be used and relied on by Adani for the purpose of informing environmental assessments and planning approvals for the proposed Carmichael Coal Mine and Rail Project (Purpose)and may not be used by, or relied on by any person other than Adani.

The services undertaken by GHD in connection with preparing the Report were limited to those specifically detailed in Section 1.2 of the Report and excluded meteorological or ambient air pollutant sampling, moisture testing/analysis for transported coal, and assessment of odour.

The Report is based on conditions encountered and information reviewed, including assumptions made by GHD, at the time of preparing the Report. Assumptions made by GHD are contained through the Report, including (but not limited to) mine planning information provided by Adani, ambient air quality monitoring and meteorological data (see Section 3.2), the coding of regulatory approved computer models (TAPM, Ausroads and Ausplume) and meteorological models (MM5 and CALMET), and emissions estimation methods and techniques (see Section 4.2).

To the maximum extent permitted by law GHD expressly disclaims responsibility for or liability arising from:

- *any error in, or omission in connection with assumptions, or*
- *reliance on the Report by a third party, or use of this Report other than for the Purpose*

.

Contents

Table Index

Figure Index

Plate Index

Appendices

Abbreviations and Glossary

Project Specific Terminology	
Abbreviation	**Term**
the EIS	Carmichael Coal Mine and Rail Project Environmental Impact Statement- refers to the particular document that GHD is preparing to facilitate approval of the Project
the Proponent	Adani Mining Pty Ltd
the Project	Carmichael Coal Mine and Rail Project
Generic Terminology	
Abbreviation	**Term**
A	Activity data (units dependent on emission factors)
AP-42	US EPA Database on Air Pollutant Emission Factors
AWS	Automatic Weather Station
bcm	Bank Cubic Metres
bhp	Brake Horse Power
BoM	Bureau of Meteorology
CALPUFF	Gaussian puff modelling system for the simulation of atmospheric pollution dispersion distributed
CALMET	Atmospheric meteorological modelling system
CE	Control efficiency (%)
CO2	Carbon Dioxide
CSIRO	Australian Government agency Commonwealth Scientific and Industrial Research Organisation
DERM	Former Queensland Department of Environment and Resource Management
E_i	Emission rate of pollutant i (kg per activity)
EAD	Equivalent aerodynamic diameter
EF_i	Uncontrolled emissions factor for pollutant i (kg per activity)
EPA	Environment Protection Act
EPP	Environment Protection Policy
ERA	Environmentally Relevant Activities
GHD	GHD Pty Ltd

Generic Terminology	
Abbreviation	**Term**
GLC	Ground Level Concentration
ha	hectare
k	Proportional constant to maintain total annual emissions as constant
kg	Kilogram
M	Soil moisture content
MM5	Mesoscale Model for weather forecasts and climate projections (Fifth Generation Penn State)
NCAR	National Centre for Atmospheric Research
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NOx	Oxides of nitrogen
NO_2	Nitrogen dioxide
NPI	National Pollutant Inventory
OCM	Open Cut Mine
OH&S	Occupation Health and Safety
$PM_{2.5}$	Particulate Matter less than 2.5 µm
PM_{10}	Particulate Matter less than 10 µm
PSU/NCAR	Pennsylvania State University/National Center for Atmospheric Research
ROM	Run-Of-Mine
SO_2	Sulphur dioxide
TSP	Total Suspended Particulates
U	Wind speed at the reference height of 10 m
UGM	Underground Mine
veh	Vehicle
VKT	Vehicle Kilometres Travelled
VOC	Volatile Organic Compound

Executive Summary

Adani Mining Pty Ltd (Adani) is proposing to develop a 60 million tonne (product) per annum (Mtpa) thermal coal mine in the north Galilee Basin approximately 60 kilometres north-west of the town of Clermont, Central Queensland. All coal will be railed via a privately owned rail line connecting to the existing Goonyella rail system south of Moranbah, and shipped through coal terminal facilities at the Port of Abbot Point and/or the Port of Hay Point (Dudgeon Point expansion). The Carmichael Coal Mine and Rail Project (the Project) will have an operating life of approximately 90 years.

The Project is comprised of two major components:

- The Project (Mine): a greenfield coal mine over exploration permit for coal (EPC) 1690 and part of EPC1080, which includes both open cut and underground mining, on mine infrastructure and associated mine processing facilities (the Mine) and offsite infrastructure.
- The Project (Rail): a greenfield rail line connecting the Mine to the existing Goonyella rail system south of Moranbah to provide for export of coal via the Port of Abbot Point and/or the Port of Hay Point (Dudgeon Point expansion).

The Project has been declared a 'significant project' under the *State Development and Public Works Organisation Act 1971* (SDPWO Act) for which an Environmental Impact Statement (EIS) is required. The Project is also a 'controlled action' and requires assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Project (Mine) has an expected operational life of 90 years during which a mixture of underground and open-pit mining operations will occur and significant dust generating potential exists.

This air quality assessment is prepared in accordance with the Project EIS Terms of Reference, issued in May 2011 by the State of Queensland Coordinator-General. This report addresses emissions from Project (Mine) activities. This report also addresses the combined effect of emissions from the Project (Mine) with windblown coal dust from the Project (Rail), to the extent to which the railway overlaps with dust contours of the Project (Mine).

The Environmental Protection (Air) Policy 2008 (Air EPP) defines air quality objectives such that indicator pollutants do not adversely affect environmental values. The indicators relevant to the Project (Mine) are Particulate Matter (total suspended particulate – TSP, PM_{10} and $PM_{2.5}$) with health and wellbeing of humans being the environmental value of concern. Air quality impacts are measured against the objectives of the Air EPP, which are defined as concentrations of particulate matter at receptor locations that people are likely to occupy for extended periods of time. Locations inside the Mine site perimeter are therefore excluded from this assessment.

Existing environmental conditions were defined for background (or ambient) dust levels and dispersion meteorology. Available background data assessed was concerned with PM_{10} and dust deposition rates from similar exposed central Queensland mining areas (Bowen Basin). Comparable background information for TSP and the finer $PM_{2.5}$ dust fractions were derived by use of dust fraction ratios.

Dispersion meteorology characteristics are driven by the various climatic indicators. Climatically, the inland areas surrounding the Project Area can be described as 'subtropical' with a sub-classification of ‘moderately dry winter’. The prevailing wind directions have a strong easterly component associated with the trade winds. A derived dispersion modelling dataset for the Mine site using the prognostic meteorological model MM5 and further enhanced by the diagnostic model CALMET was found to be site-representative for the Project.

Air emissions during the operation of the open cut and underground mines have been estimated using standard techniques from the Australian National Pollutant Inventory and the USEPA AP-42 database. The estimates relied heavily on the information provided by the client in the Mine plan (Runge Limited 2011).

Dust was modelled from the entire Mine site as emanating from a total of 51 individual mining activity sources and 35 area sources associated with wind erosion. The regulatory dispersion model CALPUFF was used for this purpose involving area and volume sources as appropriate. In addition to predicting ambient levels of particulate matter, dust deposition was also assessed. For completeness, dust emissions from the coal train hauling to the east of the Mine site were included. It was found that the greatest single source of dust emissions is from haul trucks and being responsible for over 75 per cent of dust emissions due to active coal production.

Dispersion modelling was established for the three phases of the life of the Mine determined to be worst-case scenarios – start-up, full operations and maximum emissions. In the Mine plan (Runge Limited 2011), these had nominal operating years of 2016, 2037 (both the underground and open-pit mining are at full operations) and 2067 (not the year of maximum output of coal but representative of maximum amount of dust being emitted due to overburden stripping).

The air quality assessment required the estimation of maximum ground-level concentrations and monthly average dust deposition values at the nearest sensitive receptors with a total of seven offsite sensitivity receptor locations being identified within the model domain.

Ambient PM_{10} levels have been assessed to Air EPP regulations with a criterion of 50 µg/m^3 (including background) averaged over 24 hours. Results at the existing offsite sensitive receptors for the start-up, full operations and maximum emission phases of the Mine show worst case impacts do not exceed 83 per cent of the criterion. Results for the proposed location of the workers accommodation village is compliant with Air EPP regulations for all mine phases. However, areas of the proposed industrial and airport amenities are predicted to have increasing levels of dust as the mine capacity is increased. Non-compliance with Air EPP objectives in these proposed areas is predicted for full operations and maximum emission phases of the mine, if effective mitigation measures are not implemented.

Contour plots of predicted maximum 24 hour average PM_{10} GLCs for the three modelled phases of the Mine indicate that the criterion is complied with at identified sensitive receptors, but not all locations beyond the Mine boundary. The extent of non-compliance is considered manageable during early operations, but expands generally south as full operation is reached, due to activity on the rail corridor and southern open-cut pits.

For averaged $PM_{2.5}$ levels, all existing off-site sensitive receptors were equal or below the assessment criteria. Levels at Doongmabulla (ID 6) to the west, equalled the annual average criterion for the full operations phase when it is affected by the ventilation emissions from the underground Mine infrastructure. Subsequently, the predicted annual average $PM_{2.5}$ levels are at least 16 per cent below the criterion when ventilation emissions from the underground Mine infrastructure cease and the activity in open-cut pits has moved south.

For the proposed workers village site, all predicted $PM_{2.5}$ levels were below regulatory objectives. However, parts of the industrial area and airport were predicted to have exceedances of the regulatory objectives for the 24 hour averaged criterion. No exceedances of the annual $PM_{2.5}$ criterion were predicted at any of the proposed off-site infrastructure.

Ambient TSP levels have been assessed for all three phases, and it was found that the annual average criterion was met at all of the identified off-site sensitive receptors, including those of the proposed off-site infrastructure. Deposited dust levels were found to decrease rapidly beyond the source so that at all offsite sensitive receptor location deposition rates were significantly below the assessment criteria.

The impact assessment has demonstrated that the dust impacts arising from the proposed Carmichael Coal mine are consistent with the goals of the Air EPP. This is with respect to human health effects at 'remote' existing off-site receptor locations, being homesteads of surrounding grazing properties. Dust impacts beyond the site boundary, including for some proposed off-site infrastructure locations may require management at the peak production phases of the Mine life. As these areas are only intermittently used by humans, exposure to adverse health effects due to dust levels is not expected to be significant. In the event that further control measures are required, the simple dust management tool of ambient air quality and dust deposition monitors being installed to quantify the actual dust impacts near the site boundaries can be used to quantify actual dust impacts rather than the theoretical levels assessed in this report. A system of monitors can be installed in which up-wind stations measure background dust levels, while down-wind stations are able to quantify the impact from Mine operations. Adani have commissioned the installation of ambient dust monitoring equipment at four regional receptor locations in order to obtain air quality data to assist in ongoing monitoring requirements.

If dust levels are demonstrated to be significantly detrimental due to mining operations beyond the site boundary additional options for reducing emissions include:

- Increased use of conveyors rather than trucks to move coal
- Use of conveyors to haul a proportion of overburden
- Sealing of haul roads with bitumen or similar
- Implementation of a dust management plan including the use of a meteorological forecasting system coupled with a dust impact index for the management and control of significant dust sources during adverse conditions.

1. Introduction

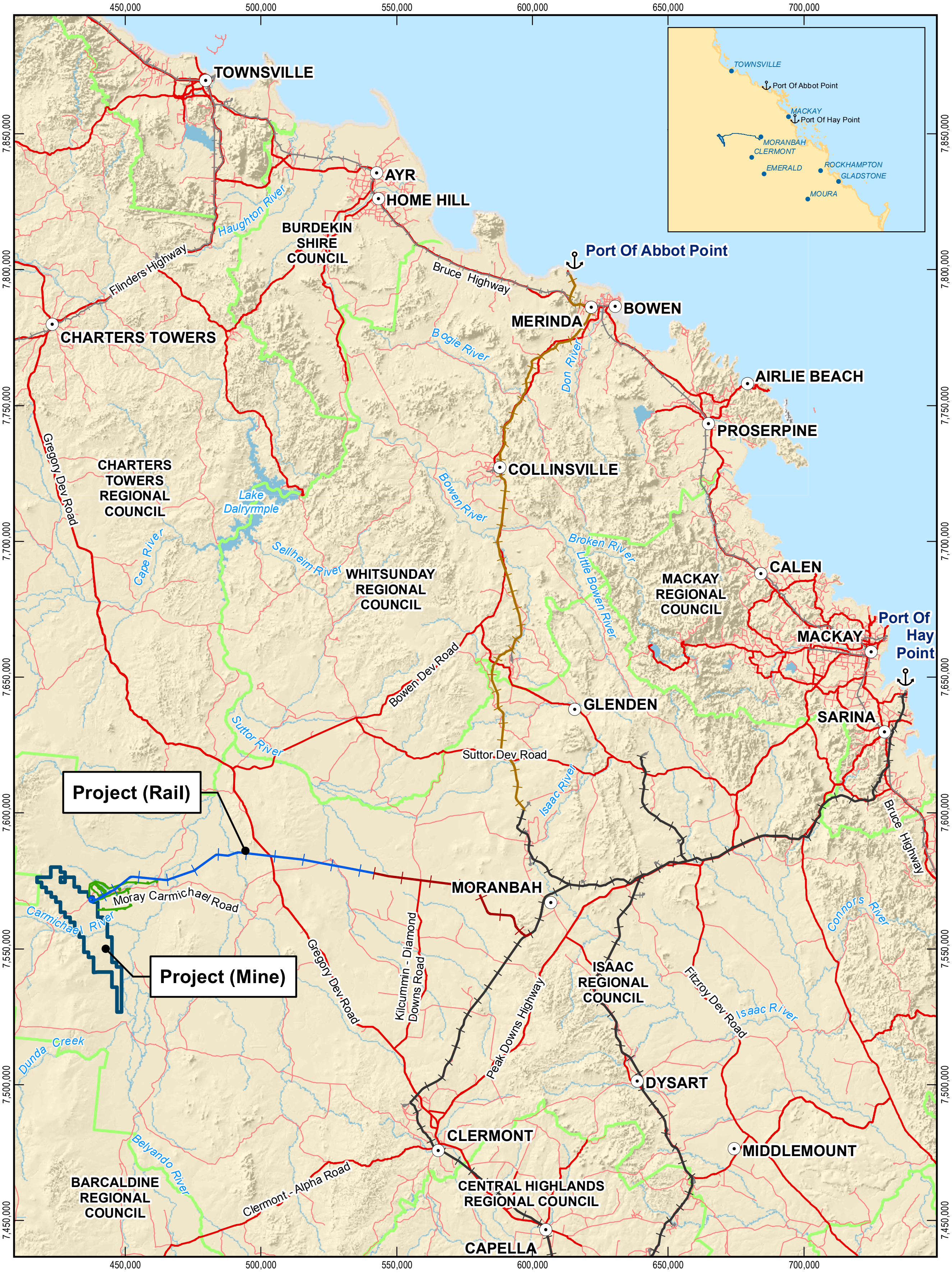
1.1 Project Overview

Adani Mining Pty Ltd (Adani) is proposing to develop a 60 million tonne (product) per annum (Mtpa) thermal coal mine in the north Galilee Basin approximately 160 kilometres (km) north-west of the town of Clermont, Central Queensland. All coal will be railed via a privately owned rail line connecting to the existing QR National rail infrastructure, and shipped through coal terminal facilities at the Port of Abbot Point and the Port of Hay Point (Dudgeon Point expansion). The Carmichael Coal Mine and Rail Project (the Project) will have an operating life of approximately 90 years. The Project comprises of two major components:

- The Project (Mine): a greenfield coal mine over EPC1690 and the eastern portion of EPC1080, which includes both open cut and underground mining, on mine infrastructure and associated coal processing facilities (the Mine) and the Mine (offsite) infrastructure including:
  - A workers accommodation village and associated facilities
  - A permanent airport site
  - Water supply infrastructure
- The Project (Rail): greenfield rail lines connecting the Mine to the existing Goonyella and Newlands rail systems; including:
  - Rail (west): a 120 km dual gauge portion from the Mine site running west to east to a junction with proposed lines running south-east to the Goonyella rail system and north-east to the Newlands rail system
  - Rail (east): a 69 km narrow gauge portion connecting to the Goonyella rail system south of Moranbah to provide for export of coal via the Port of Hay Point (Dudgeon Point expansion)

The Project has been declared a ‘significant project’ under the *State Development and Public Works Organisation Act 1971* (SDPWO Act) and as such, an Environmental Impact Statement (EIS) is required for the Project. The Project is also a ‘controlled action’ and requires assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Project EIS has been developed with the objective of avoiding or mitigating all potential adverse impacts to environmental, social and economic values and enhancing positive impacts. Detailed descriptions of the Project are provided in Volume 2 Section 2 Project Description (Mine) and Volume 3 Section 2 Project Description (Rail). The location of the Project is illustrated in Figure 1-1.



LEGEND

- Town
- Major Port
- Other Rail Network
- Goonyella System
- Newlands System
- State Road
- Local Road
- Watercourse
- Local Government Area
- Project (Rail)
  - Rail (West)
  - Rail (East)
- Project (Mine)
- Mine (Offsite)

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:2,000,000 (at A4)

0 10 20 30 40 50

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Job Number	41-25215
Revision	L
Date	28-08-2012

Project Location

Figure: 1-1

G:\41\25215\GIS\Maps\MXD\100_Planning\41-25215_117_rev_l.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Watercourses (2007); DERM: LGA, (2011), Hillshade (2009); DMR: State Roads (2008); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3 (2012). Created by: BW, JVC

1.2 Project Location

The Project (Mine) is located in the Galilee Basin, Central Queensland located approximately 160 km north-west of the town of Clermont, Central Queensland (refer to Figure 1-1). The Project (Mine) is predominantly within the Local Government Area (LGA) of Isaac Regional Council (IRC), with the exception of 167 ha within the north-western corner of the EPC1690, which is located within the LGA of Charters Towers Regional Council (CTRC). The IRC is located within the Isaac, Mackay and Whitsunday Region while the CTRC is located within the Northern Region of Queensland.

1.3 Scope of Reporting

This report addresses emissions from Project (Mine) activities. The combined effect of emissions from Project (Mine) activities with windblown coal dust from the Project (Rail) are also addressed, to the extent that dust contours from the Project (Mine) and Project (Rail) overlap.

This air quality assessment is prepared in accordance with the Project EIS Terms of Reference, issued in May 2011 by the State of Queensland Coordinator-General. A summary cross reference with the ToR is provided in Table 1-1 (refer to Appendix A for a detailed cross reference).

Greenhouse gas emissions associated with the Project (Mine) are addressed in Volume 4 Appendix T Mine Greenhouse Gas Emissions Report. Emissions from Project (Rail) activities are addressed separately in Volume 4 Appendix AD Rail Air Quality Assessment and Volume 4 Appendix AE Rail Greenhouse Gas Emissions Report.

Table 1-1 Terms of Reference Cross Reference

Terms of Reference Requirement/Section Number	Cross-reference
3.5.1 Description of Environmental Values	
Discuss the existing air shed environment, both local and regional, including: background levels and sources of particulates, pollutants, baseline monitoring and local meteorology and ambient levels of pollutants	Section 3.2, 3.3
3.5.2 Potential Impacts and Mitigation Measures	
For air quality impacts and their mitigation:	
◗ accurately describe the activities carried out on the site	Section 4.3.3
◗ describe all pollution control equipment and pollution control techniques	Section 4.6
◗ describe the back-up measures that will act in the event of primary measures failing, to minimise the likelihood of upsets and adverse air impacts	Section 5.7.3
◗ provide an air emission inventory of the proposed site for all potential points, area and volume sources including fugitive emissions of dusts	Sections 4.7
◗ estimate emission rates, based on actual measurements of samples taken from similar facilities	Section, 4.7.4
◗ provide an impact assessment with relevant inputs of emissions and local meteorology to an air dispersion model to estimate the likely impacts on the surrounding environment	Section 5

Terms of Reference Requirement/Section Number	Cross-reference
◗ Estimate maximum ground level concentration and monthly average dust deposition values at the nearest sensitive receptor(s).	Section 4.7.4
◗ present the results of the dispersion modelling as concentration contour plots and concentrations at the discrete sensitive receptors	Figure 5-2, Figure 5-3 and Figure 5-4
◗ describe the background ambient air concentration from the existing sources in the airshed and evaluate the cumulative impact on the receiving environment	Section 4.5
◗ identify the worst case meteorological conditions based on the modelled ground level predictions and, using this information, develop dust mitigation measures for the mining activities	Section 4.4.3
◗ describe the dust management plan that will be employed to mitigate adverse air impacts under the worst meteorological conditions	Section 5.7
◗ identify 'worst case' emissions that may occur during operation	Section 4.4
◗ discuss dust generation from construction activities, especially in areas where construction activities are adjacent to existing road networks or are in close proximity to sensitive receivers	Section 4.3.4
◗ discuss climatic patterns that could affect dust generation and movement	Section 3.3.1
◗ discuss vehicle emissions and dust generation along major road and rail haulage routes both internal and external to the project site	Section 4.3.7, 4.3.11
◗ assess human health risk associated with emissions from the facility of all hazardous or toxic pollutants	Section 4.4
◗ discuss impacts on terrestrial flora and fauna	Section 5.6

2. Approach and Methodology

2.1 Commonwealth Legislation

The Environment Protection and Heritage Council, formerly known as the National Environment Protection Council, specify national air quality guidelines. The National Environment Protection (Ambient Air Quality) Measure sets standards for ambient air quality in Australia. The measure was released in 1998 and was varied in 2003 to include an advisory reporting standard for $PM_{2.5}$.

The National Environment Protection (Ambient Air Quality) Measure (NEMP) specifies national ambient air quality standards and goals for the following common air pollutants:

- Carbon monoxide
- Nitrogen dioxide
- Sulphur dioxide
- Ozone
- Particulates (as PM_{10} and $PM_{2.5}$)
- Lead

In 2004, the National Environment Protection (Air Toxics) Measure was released which included monitoring investigation guidelines, principally for large cities with significant traffic emissions, for five compounds classified as air toxics:

- Benzene
- Benzo(a)pyrene
- Formaldehyde
- Toluene
- Xylenes

These toxic air pollutants would only be released in significant quantities from the Project (Mine) if significant on-site power generation is installed. However, the principal power source for the Project (Mine) will be offsite and will be the subject of a separate air quality assessment, pending confirmation from the client on the outcome of the power source feasibility study. Onsite power generation is therefore deemed to be negligible and not considered further in this report.

Ambient concentrations of $PM_{2.5}$ are included as advisory reporting standards in the NEPM. These finer fraction particulates are typically emitted from combustion sources, including vehicle engines. Emissions from mining operations are dominated by the PM_{10} (and deposited dust) fraction of particulate matter. Potential particulate emissions and impacts are addressed within this report through consideration of the impacts of total suspended particulates (TSPs) and PM_{10}.

All of the above air pollutants have been included in the Queensland Government Environmental *Protection (Air) Policy 2008* (Air EPP). This is discussed further in the next section.

2.2 State Legislation and Policy

The Air EPP commenced 1 January 2009 and is still current in the state of Queensland. The policy has the purpose of achieving the objectives of the *Environmental Protection Act 1994* in relation to the air environment. Part 3 of Air EPP sets environmental values for the air environment that enhance or protect qualities relating to:

- Health and biodiversity of ecosystems
- Human health and wellbeing
- Aesthetics
- Agricultural use

Schedule 1 of the policy defines air quality objectives for indicators such that environmental values are enhanced or protected. The indicators relevant to the Project (Mine) are Particulate Matter (TSP, PM_{10} and $PM_{2.5}$). As outlined in Section 2.1, various products of combustion (principally from any large, megawatt (MW) rated power station sources of diesel generator sets or gas fired turbines – benzene, carbon monoxide, formaldehyde, nitrogen dioxide, sulphur dioxide, toluene and xylenes) have not been assessed for the Project (Mine). Table 2-1 contains the evaluation criteria for the relevant indicators and objectives from the air policy. Note that the non-'dust' air quality objective indicators are only included for completeness if the Project (Mine) is expanded to include a power generation source.

Deposited dust is not included in the Air EPP for Queensland or any current Environmentally Relevant Activity (ERA) relating to mining or coal transport. "*There is currently no EPP (Air) air quality objective for deposited matter*" (DERM, 2010, p.40). The New Zealand Ministry for the Environment has a recommended dust deposition investigation level (insoluble solids fraction) of 4.0 g/m^2 over a 30 day averaging period (equivalent to an average daily deposition rate of 130 mg/m^2) to minimise nuisance complaints (Ministry for the Environment, 2001). This NZ recommended trigger level is for "*above background concentration* (sic)" (*ibid*. Table 7.1, p.32). The originating, comparable standard is the long established deposited dust impact assessment criteria used in New South Wales of 2.0 g/m^2/month (insoluble solids, annually averaged) of maximum increase in deposited matter with the maximum level, inclusive of background, of 4.0 g/m^2/month (DEC, 2005). For the air quality assessment, the NSW deposited dust impact assessment criteria of 2.0 g/m^2/month (insoluble solids, annually averaged) has been used for the maximum incremental increase in deposited matter.

Table 2-1 Indicator Objective Criteria to Protect the Air Environment in Queensland

Indicator	Environmental value	Air Quality Objective (µg/m^3)	Period
Total suspended particles (TSP)	Health and wellbeing	90	1 year
PM_{10}	Health and wellbeing	50	24 hours
$PM_{2.5}$	Health and wellbeing	25	24 hours
		8	1 year
Benzene	Health and wellbeing	10	1 year
Carbon Monoxide	Health and wellbeing	11,000	8 hours
Formaldehyde	Health and wellbeing	54	24 hours
	Protecting aesthetic environment	110	30 minutes
Nitrogen dioxide	Health and wellbeing	250	1 hour
		62	1 year
	Health and biodiversity of ecosystems	33	1 year
Sulphur dioxide	Health and wellbeing	570	1 hour
		230	1 day
		57	1 year
	Protecting agriculture	32	1 year
	Health and biodiversity of ecosystems (for forests and natural vegetation)	22	1 year
Toluene	Health and wellbeing	4,100	24 hours
		410	1 year
	Protecting aesthetic environment	1,100	30 minutes
Xylenes	Health and wellbeing	1,200	24 hours
		950	1 year

2.3 Methodology

2.3.1 Model Considerations

Due to the large geographical extent of the mine operations, especially in the north-south direction, standard, steady state, Gaussian plume dispersion models do not adequately simulate the dispersion of air emissions for the prediction of ground-level concentrations. Consequently, the three-dimensional, non-steady state, lagrangian puff model, CALPUFF, was used to simulate the long-range (in this case greater than 15 km for which Gaussian assumptions become invalid) transport of plumes with concentrations carried over from one hour to the next. CALPUFF also allows for the varying terrain, land uses and meteorology (wind direction, wind speed and atmospheric stability change) enabling the model to track releases (puff modelling) across the model domain is required. This provides for the tracking of the plume over varying terrain and land uses.

The model of choice to couple with CALPUFF is the diagnostic mass consistent CALMET model. The large model domain and lack of substantive smaller scale terrain features that would influence or diverge the broader regional flows introduced via the prognostic Pennsylvania State University/National Centre for Atmospheric Research (PSU/NCAR) mesoscale meteorological model (known as MM5) mean that a three-dimensional wind-field model with a grid resolution of one kilometre is justified. Various aspects of the model features are discussed in the following sections.

2.3.2 Derived Wind Model

A synthetic site-representative dataset was derived using a prognostic modelling approach coupled with a diagnostic wind model to correct for mass consistent flows around topographical features. The prognostic model used was MM5 which is a limited-area, non-hydrostatic, terrain-following sigma-coordinate meteorological model designed to simulate and predict atmospheric circulation to near one kilometre resolution (PSU/NCAR 2008). The MM5 modelling system software is freely provided and supported by the Mesoscale Prediction Group in the Mesoscale and Microscale Meteorology Division of NCAR (Boulder, Colorado). The MM5 data were obtained from the Atmospheric Studies Group at TRC Environmental Corp (ASG 2011) for the modelling year 2007. Available years for the data were 2006, 2007 and 2008. The middle year was selected as it involved the least number of extreme individual monthly rainfall totals (compared to the long-term average although an unseasonal rain event occurred during June) and the annual rain was the closest to the long-term annual mean (2006 was very dry and 2008 was wetter than average).

The diagnostic wind model used was the freely available CALMET meteorological model with Version 5.8 approved by the US Environmental Protection Agency (US EPA 2011) and includes an MM5 interface to incorporate the above prognostic modelling in a ‘no-observations’ mode. A CALMET modelling domain was established to have coverage of the Project Area from Eastings 400 to 476 km and Northings 7,525 to 7,601 km with a one kilometre resolution. The model therefore had an extent of 75 by 75 one kilometre grid points that fully included the mining operations. Additionally, the model extended 10 to 15 kilometres beyond the perimeter of dust generating activity in all directions (excluding the rail spur). Vertical levels were defined to be concentrated in the lower levels (especially up to 500 m) with ten levels at 0, 20, 40, 80, 120, 210, 300, 500, 1,000, 2,000 and 3,000 m. Terrain and land use data with one kilometre resolution were modified to reflect actual ground surface land use as determined by aerial imagery.

2.3.3 Emissions Modelling

The emissions modelling has been developed utilising recognised techniques for dispersion modelling and emission estimation. The CALPUFF dispersion model was used in the assessment to estimate ground-level concentrations of air pollutants emitted by the activities of the Project (Mine). CALPUFF is a Gaussian puff modelling system used to simulate the dispersion of atmospheric pollutants.

Emissions have been developed for three phases of the Mine's projected 90 year lifespan. These phases are identified as start-up, full operations and maximum emissions. Further details on these phases are provided in Section 4.

3. Description of Environmental Values

3.1 Introduction

This section describes the existing air quality that may be affected by the Project (Mine) in the context of environmental values as defined by the Air EPP.

As discussed in Section 2.2, the Air EPP defines air quality objectives, in terms of concentration levels over various averaging periods (refer to Table 2-1), such that indicator pollutants do not affect various environmental values. The main indicator pollutant of concern for a coal mining project is particulate matter and the health and wellbeing of humans is the environmental value of concern. Therefore, the concentrations of particulate matter at locations people are likely to occupy for extended periods of time, such as, but not solely, housing, schools and hospitals (known as sensitive receptor locations) define the air quality impact so that the objectives of the Air EPP are met.

Section 8 (5) of Air EPP specifies that air quality objectives for indicator pollutants do not apply for a workplace if the emission is released from that workplace. Therefore, locations inside the Project (Mine) site perimeter are excluded from assessment. Workplace air quality will be managed according to appropriate workplace health and safety guidelines.

3.2 Pollutants

3.2.1 Regional Overview

The Project (Mine) is located in the Galilee Basin, Central Queensland (refer Figure 1-1). This Project Area is remote from sources of non-natural pollutant loads. The remoteness of the area also indicates that existing background air quality measurements are very limited.

3.2.2 Particulates

'Particulate matter' and 'dust' are used as interchangeable terms for convenience. There is a lack of publically available datasets that concern particulate matter levels in the general region of the Galilee Basin. Further east there is some data on existing and proposed projects in the Bowen Basin. There is also some data available from monitoring undertaken by the Government regulator, the Department of Environment and Heritage Protection (DEHP), at west Mackay and Townsville on the coast. However, particulate matter data collected at coastal locations may not be directly comparable to the air environment at the Galilee Basin due to influences of seaborne salt particulates which would not be present inland. Available data assessed were concerned with PM_{10} and dust deposition rates. Comparable background information for TSP and the finer $PM_{2.5}$ dust fractions were derived by use of suitable ratios found for agricultural-use dominated dust sources.

For an estimate of background PM_{10} levels, the Caval Ridge Air Quality Impact Assessment Report (URS 2009) in the Moranbah region gives statistics for up to 18 months of PM_{10} monitoring. During a monitoring period involving two dry seasons, April 2007 to October 2008, homestead sites generally upwind of mining operations at Caval Ridge had a 70^{th} percentile statistic of 11.0 µg/m^3. The area of the Project (Mine) has a drier climate than the Bowen Basin but less existing mining operations and other anthropogenic sources. Therefore, ambient (or background) dust levels for the Project (Mine) are likely to be similar to this level rather than higher estimates closer to 20 µg/m^3 in some inland agricultural areas of Australia. Particulate matter levels in coastal areas can be higher such as 26 µg/m^3 at west Mackay (PAE-Holmes 2011) or a 75th percentile of 16.2 µg/m^3 at Townsville (DERM 2011).

To determine background TSP levels, a PM_{10} to TSP ratio of 50 per cent is preferred for ambient conditions for the Project (Mine) (NPI 2012, Table 2, p,16). This is due to the location where a higher proportion of suspended matter will originate from crustal dust rather than from the main sources of the finer particles associated with the sources that are industrial or combustion related. The assumed level for background TSP has been set at 22 µg/m^3.

For the respirable particle fraction of $PM_{2.5}$, it is assumed that a background $PM_{2.5}$ level can be based on a ratio to the background PM_{10} level. However, even with well documented studies involving co-located instruments, the ratio has been shown to vary "*depending on season and location, and can range from 0.3 to 0.9*" (NEPC 2002, p.5) across a range of conditions within Australia. Since the Project Area is remote from urban populations, involving high emission contributions from vehicle and other combustion process, the ratio of $PM_{2.5}$ to PM_{10} adopted for this report is at 30 per cent which is the lower estimate from the NEPC study . The adopted $PM_{2.5}$ background level for the Project (Mine) is therefore set at 3.3 µg/m^3.

The dust deposition criterion for the Project (Mine) is 4.0 g/m^2 of insoluble matter over a 30 day averaging period (equivalent to an average daily deposition rate of 133 mg/m^2).

To characterise the background level of deposited dust, the Ensham Central Project (Katestone 2006) within the Bowen Basin (to the east of the Galilee Basin) was assessed as having the most comprehensive data in the publically available literature. The Ensham Central Project EIS reported on a number of dust deposition monitoring sites around the Ensham Coal Mine, one of which showed consistently low deposition rates thought to be representative of places relatively unaffected by coal mining activities. As such this site which would therefore be appropriate to represent the true ambient 'background' away from existing mine and other sources (such as found currently in the Galilee Basin). The rolling annual average ranged from 0.09 to 1.6 g/m^2/month with the conservatively highest level assumed for this assessment.

3.2.3 Gaseous Compounds

Due to the inland location and lack of any concentrated form of emission sources (such as industrial, urban or combustion sources), the ambient background levels of gaseous pollutants was considered to be negligible, at a level of zero.

3.2.4 Odorous Compounds

Due to the inland location and lack of any concentrated form of emission sources (such as intensive animal husbandry or wastewater), the ambient background levels of odours was considered to be negligible, at a level of zero.

3.3 Local Meteorology

3.3.1 Climate

The Project Area is located near Latitude 21.960 ^{o}S, Longitude 146.090 ^{o}E, which is around 350 km southwest of Townsville by road and approximately 160 km north-west of Clermont. The local and regional context of the existing air shed can be described by the closest site-representative observations of temperature, rainfall and wind speed and direction. The closest BoM stations to the Project Area with sufficient data were Twin Hills to the east and Hughenden to the west. The important air dispersion parameters of atmospheric stability and mixing depth are derived parameters best described by reported or calculated conditions over a larger regional context (inland central Queensland).

Visually, through map referencing (Stern *et al*. 2000), the inland areas surrounding the Project (Mine) can be described as between a ‘grassland’ climate with a sub-classification of ‘hot (winter drought)’ or ‘hot (persistently dry)’such as found in Hughenden to the west and a ‘subtropical’ climate with a sub-classification of ‘moderately dry winter’ such as found at Twin Hills to the east. The lowest average monthly rain is in May at 11.2 mm.

The climate in Hughenden is summarised as follows. The lowest average monthly rain in winter is 7.9 mm. This area has an annual mean maximum temperature of 31.6 ^{o}C. The Hughenden Post Office has acted as a Bureau of Meteorology (Site number: 030024) climatic observing site since 1884 and remains operational. It is located approximately 239 km north-west of the Project Area, at Latitude 20.84 °S and Longitude 144.20 °E (elevation: 324 m). The rainfall record at Hughenden spans 117 years while the temperature record spans 113 years.

The climate in Twin Hills area is slightly hotter on average per month than Moranbah, however, on an annual basis it has slightly more rainfall at 609.8 mm. The Twin Hills Post Office had acted as a Bureau of Meteorology (Site number: 036047) climatic observing site since 1905. It is located approximately 53 km east of the Project Area, at Latitude 21.95 °S and Longitude 146.95 °E (elevation: 195 m). The station closed on 31 December 1985, however, the rainfall record spans 80 years with a temperature record of 20 years.

The Carmichael meteorological station has acted as a Bureau of Meteorology (Site number: 036122) rainfall only observing site since January 2003. It is located in proximity to the Project Area, at Latitude 21.96 °S and Longitude 146.09 °E (elevation: 260 m), approximately 12 km from the Project (Mine). The Carmichael meteorological station has the operational status of ‘open’ however data records cease at 31 December 2010 with patchy data returns for all years except 2004-06 and 2008-09. The rainfall record therefore dates back for approximately 8 years. There is no temperature record. Hence, this site cannot be used to classify the climate albeit the limited record can be compared to the nearby climatic sites of Hughenden (grassland – hot winter drought) and Twin Hills (subtropical – moderately dry winter). The rainfall pattern at Carmichael suggests subtropical rather than grassland.

3.3.2 Air Temperature and Humidity

Monthly mean temperatures for the two relevant regional sites (Hughenden and Twin Hills) are displayed in Figure 3-1 to Figure 3-4. These show the seasonal variation in the temperature range. Mean monthly minimums with their associated upper and lower 10 percentiles (decile) are shown in blue and maximums are in red. Monthly mean relative humidity throughout the year is also displayed with both 9 am in the morning (red) and 3 pm in the afternoon (blue) observing times shown. These show both seasonal and diurnal patterns in humidity.

Monthly mean temperatures for Hughenden Post Office (Site Number 030024) show daytime summer temperatures are mostly in the mid-30s with winter overnight temperatures most commonly between 7 and 12 degrees (see Figure 3-1). The temperature record of approximately 36 years shows values ranging from -2 ^{o}C to 44 ^{o}C. 'Hot days', with temperatures exceeding 35^{o}C, can be expected up to 101 days per year. 'Frost days' with screen temperatures (white wooden box acts as radiation screen to the thermometers) below 2 ^{o}C can be expected up to 1.4 days per year. Relative humidity is highest in the mornings and during the February while the lowest is in the mid to late spring mornings and afternoons (see Figure 3-3).

Monthly mean temperatures for Twin Hills Post Office (Site Number 036047) show daytime summer temperatures are mostly in the early to mid-30s with winter overnight temperatures dropping to between 5 and 10 degrees (see Figure 3-3). The temperature record of approximately 20 years shows values ranging from -3.2 ^{o}C to 43.8 ^{o}C. 'Hot days', with temperatures exceeding 35 ^{o}C, can be expected up to 74.6 days per year. 'Frost days' with screen temperatures below 2 ^{o}C can be expected up to 10.4 days per year. Relative humidity is highest in the mornings and during the month of February and lowest in the late spring mornings and afternoons (see Figure 3-4).

Figure 3-1 Monthly Mean and Decile (10% And 90%) Maximum and Minimum Temperatures (^{0}C) at Hughenden Post Office

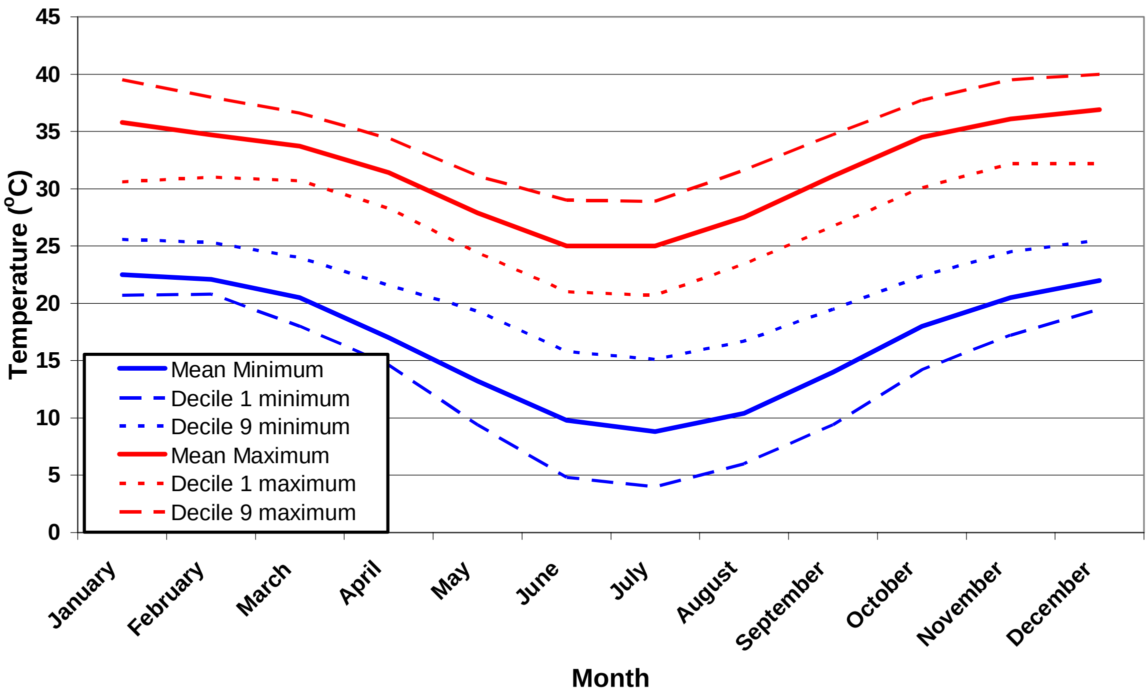


Figure 3-2 Morning and Afternoon Monthly Mean Relative Humidity (%) at Hughenden Post Office

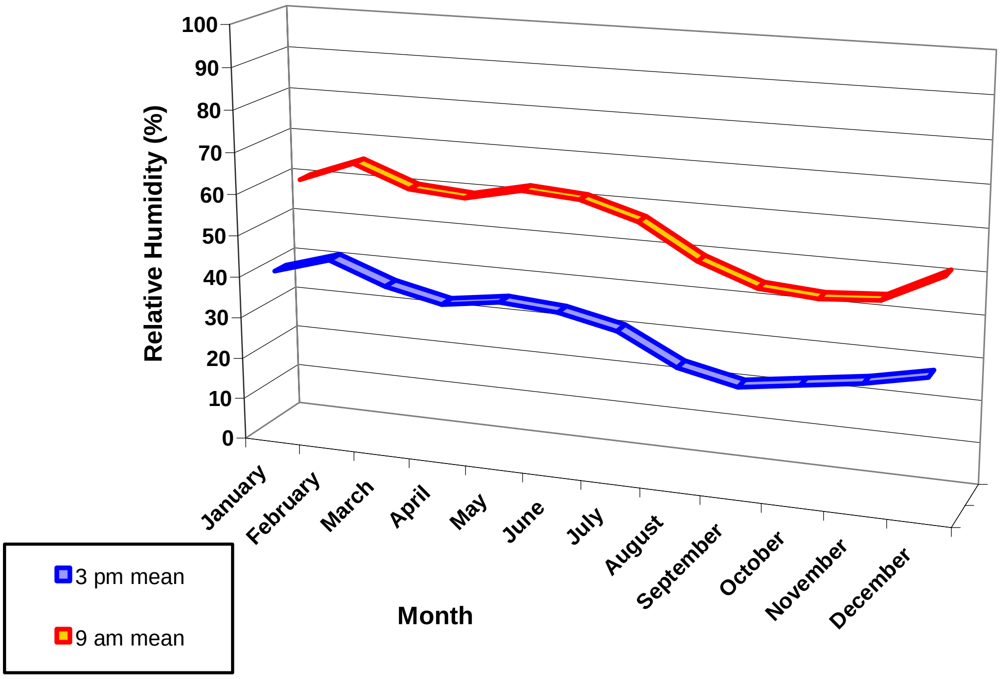


Figure 3-3 Monthly Mean and Decile (10% And 90%) Maximum and Minimum Temperatures (^{0}C) at Twin Hills Post Office

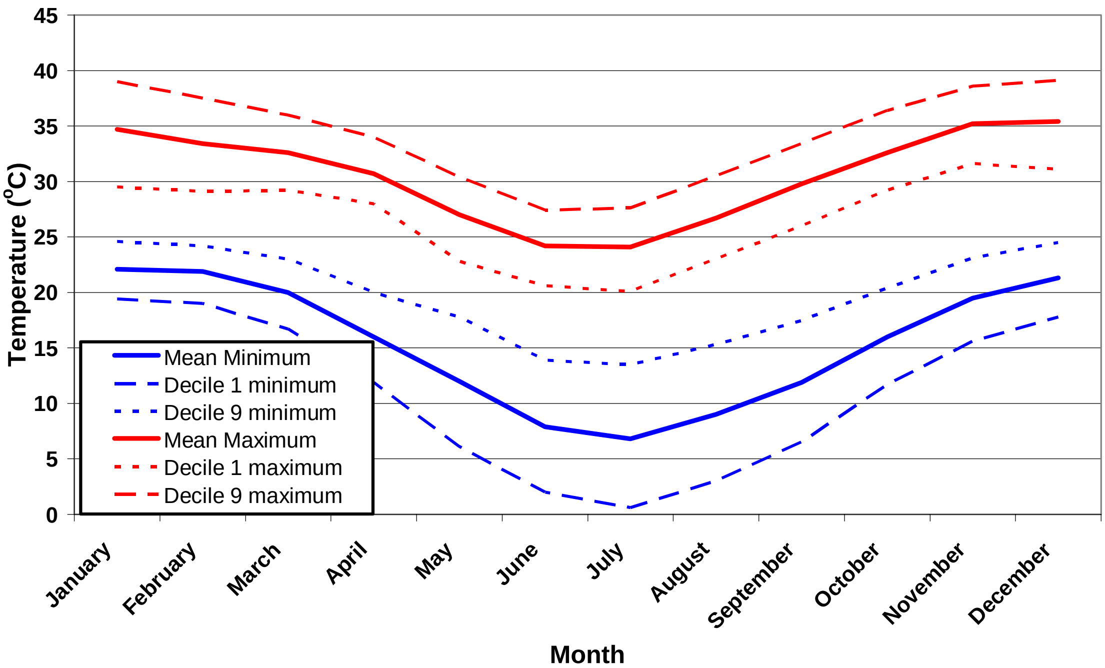
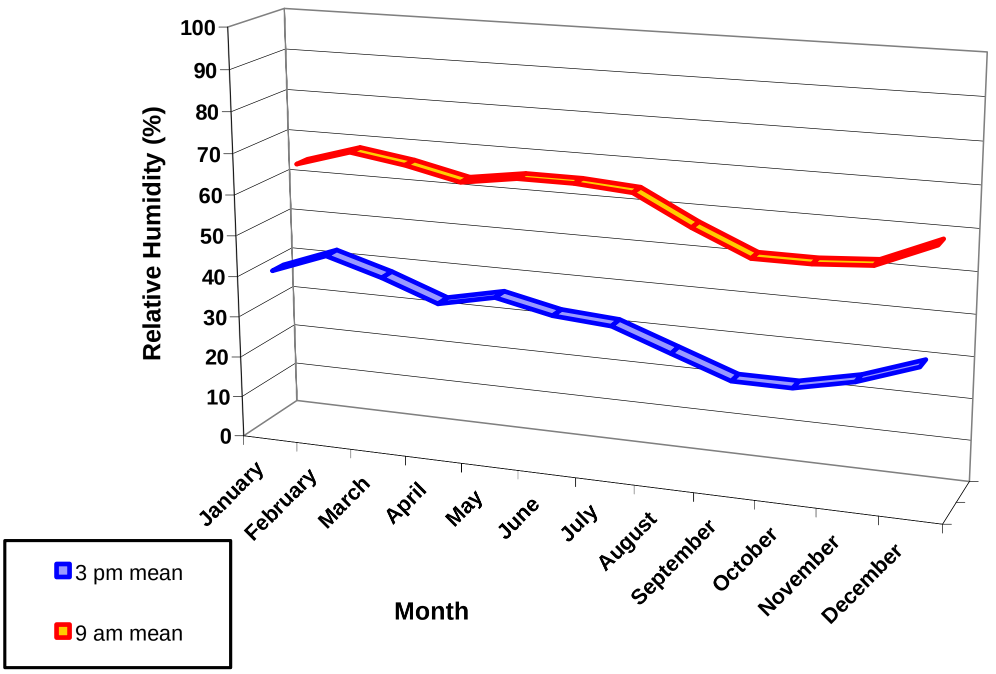


Figure 3-4 Morning and Afternoon Monthly Mean Relative Humidity (%) at Twin Hills Post Office



3.3.3 Rainfall

The annual mean rainfall at Carmichael meteorological station 036122 is just over 524 mm and is dominated by the warm months producing convectively driven rainfall. This is graphically shown in Figure 3-5 with December through March, inclusive, accounting for 65 per cent of the annual mean rainfall. The wettest month is January with a mean of 129.1 mm and the driest month is May with a mean of 11.2 mm.

The annual rainfall from the Carmichael site ranges from 252 to 700 mm, although the rain record for this site is quite limited, beginning in 2003, and so the range of rainfall cannot be accurately gauged from this site as yet.

Similar rainfall patterns can be seen at the other two regional sites, see Figure 3-6, with December through March inclusive accounting for the majority of the annual mean rainfall in the region. November is also a significant month for rainfall, although to a lesser extent at all regional sites.

The annual mean rainfall at the comparison sites is 610 mm for Twin Hills, and 492 mm at Hughenden. As would be expected, there is a clear pattern of rainfall decreasing with distance inland with the mean number of rain days per year at 46 and 43 days per year respectively.

The range of annual rainfall at Twin Hills is 218 mm to 1,477 mm and Hughenden is 150 mm to 1085 mm per year, with the least amount of rain falling further inland at Hughenden.

Figure 3-5 Monthly Mean Rainfall (mm) Proportions at Carmichael Site Number 036122 (January 2003 to December 2010)

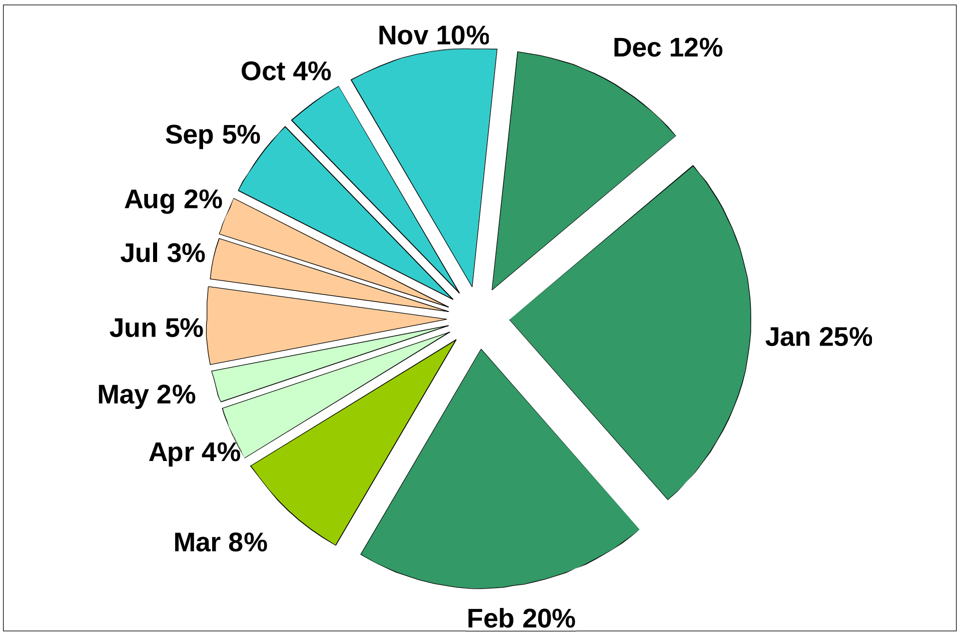
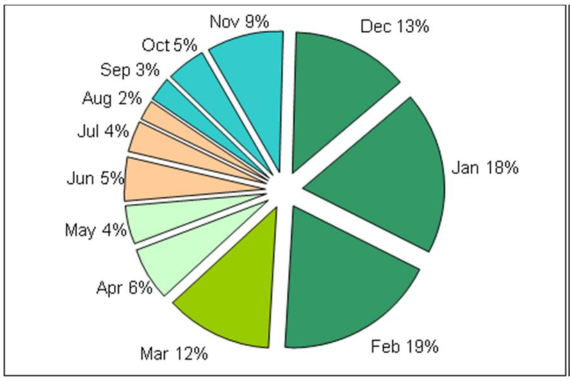
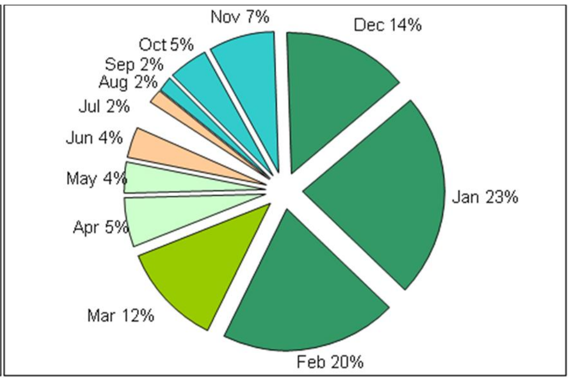


Figure 3-6 Comparison Monthly Mean Rainfall (mm) Proportions at Twin Hills Post Office (1905 to 1985) and Hughenden Post Office (1884 – 2010) (from left to right)





3.3.4 Wind Speed and Direction

The effect of wind on pollutant dispersion patterns can be examined using the general wind climate and atmospheric stability class distribution. The general wind climate at a site is most readily displayed by means of wind rose plots, giving the incidence of winds from different directions for various wind speed ranges.

The nearest available comprehensive dispersion climatology available is at the Sonoma Mine in the Bowen Basin south of Collinsville, approximately 230 km north-east of the Project (Mine). For the June 2008 to May 2009 period, hourly meteorological data from the on-site Automatic Weather Station (AWS) was used to develop a dispersion meteorological file for a full year. The Sonoma AWS recorded raw data on temperature, wind speed and direction and sigma-theta (standard deviation of wind direction). However, these data are considered to be too far east of the Project (Mine) and a synthetic site-representative dataset was derived using a prognostic modelling approach coupled with a diagnostic wind model to correct for mass consistent flows around topographical features. The derived wind data was produced using the MM5 and CALMET model described in Section 2.3.2.

Figure 3-7 represents the annual wind rose for the Project (Mine) as derived using the above meteorological modelling tools. The prevailing wind directions have a strong easterly component. This is expected at this latitude of near 22 ° south being dominated by the (south-east) southern hemisphere trade winds. The strongest winds, those above 4.0 m/s, continue the pattern of being mostly out of the east. The annual average wind speed for this dataset is 2.64 m/s.

A test of how well the modelling system has represented the wind pattern is to compare annual wind roses from the nearest wind monitoring stations in the wider region (Sonoma as above, Hughenden January 2006 to November 2011 and Emerald February 2006 to Jan 2007). These are shown as annual wind roses below in Figure 3-8, and can be compared to the Mine wind rose of Figure 3-7.

The wind climate of the wider geographic region of inland central Queensland shows that the patterns identified have common themes of an inland sub-tropical climate. These are consistent across the Bowen Basin and Galilee Basin, with measured data consistently showing the lack of westerly component winds and the trade wind south-easterlies at times coming out of the north-east sector, mostly associated with wet season disruption to the prevailing trade winds.

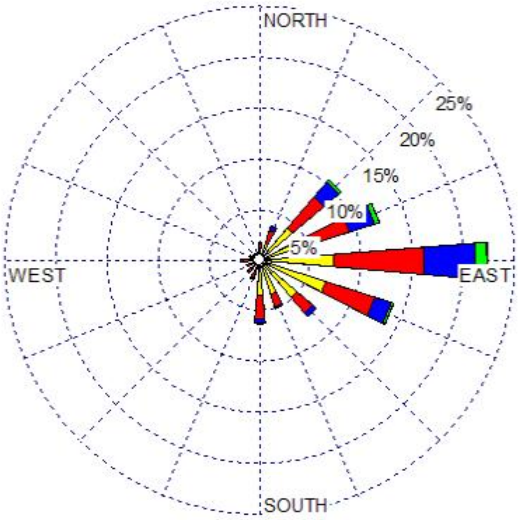
The above analysis suggests that the derived Project (Mine) wind data, for dispersion modelling purposes, is site-representative.

On-site Automatic Weather Station

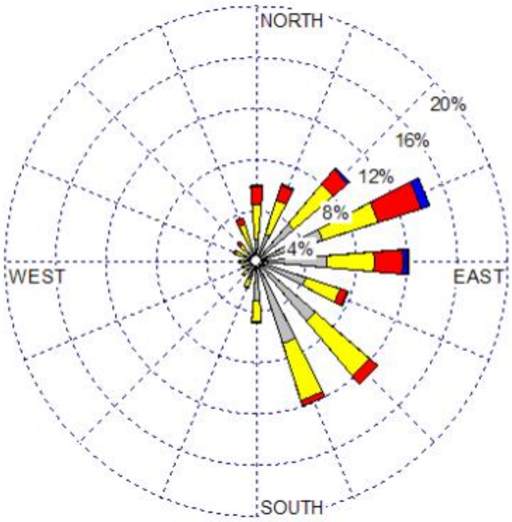
A further check on the site-representativeness of the prognostic (MM5)/diagnostic (CALMET) wind field modelling is available by comparing wind roses that are predicted and newly available data from an AWS. Adani had an AWS installed on-site on 27 October 2011 to measure temperature (2 m and 10 m), wind speed and direction, pressure and solar radiation. Due to a solar panel fault no data was recorded from 22 January to 3 May 2012.

The 10-minute recorded wind data was converted to hourly averaged values so as to be comparable to the synthetic wind data displayed in the wind roses above. Due to the loss of data during the later part of the 2011/12 wet season, seasonal wind roses have been compared between the measurements and synthesised data periods of the wet season (November to January) and the dry season (May to August).

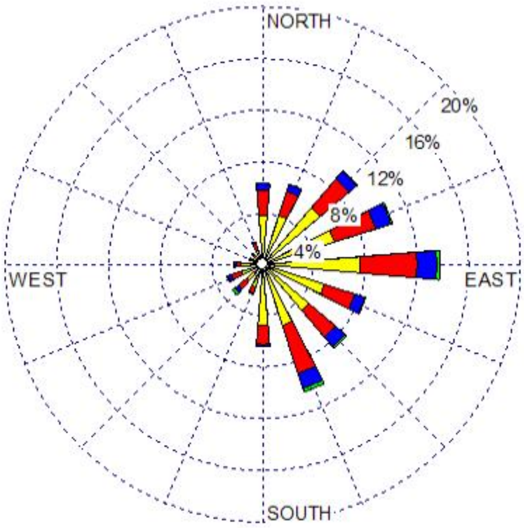
Hughenden (North-west)



Sonoma (North east)



Emerald (South-east)



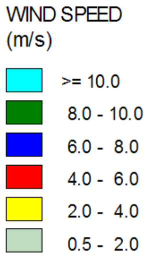


Figure 3-9 shows that the wind has been correctly modelled to be predominantly from the north-east sector during the wet season and predominantly from the south-east sector during the dry season. Overall, the modelled wind speeds, representative of the entire mine site, are higher than the observed wind speeds. This can be attributed to the measurement site being well vegetated with a higher surface roughness than the corresponding roughness used in the whole-of-mine model assumptions.

Figure 3-7 Derived Annual Wind Rose Project (Mine)

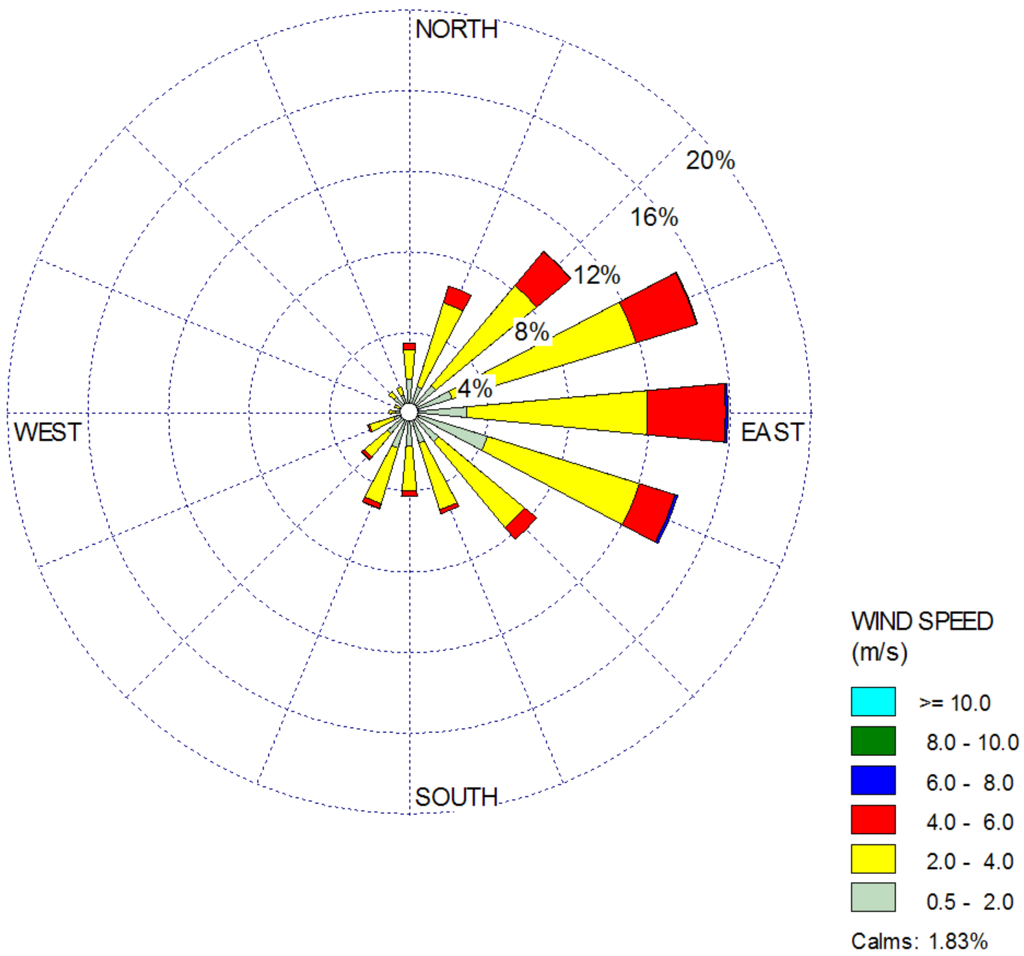
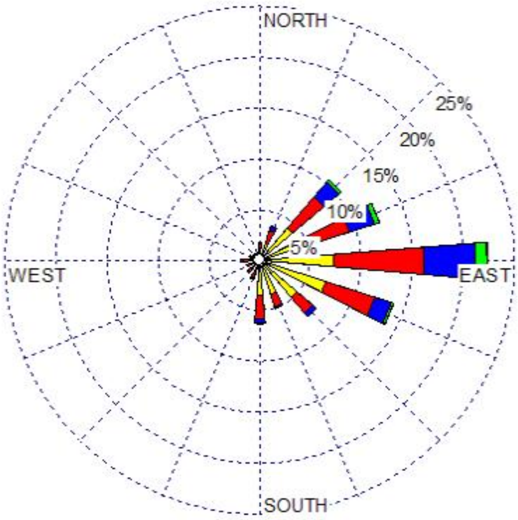
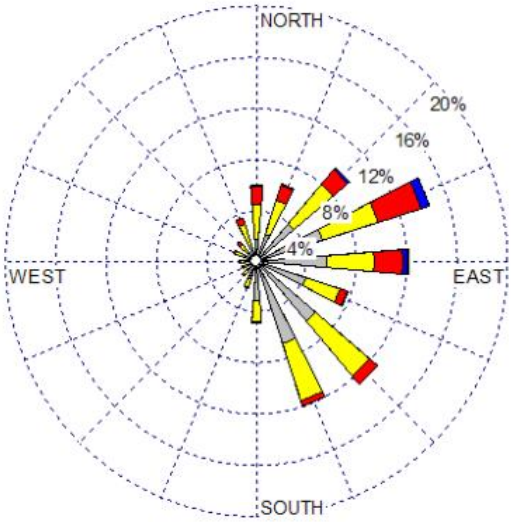


Figure 3-8 Comparison Annual Wind Roses for Inland Central Queensland

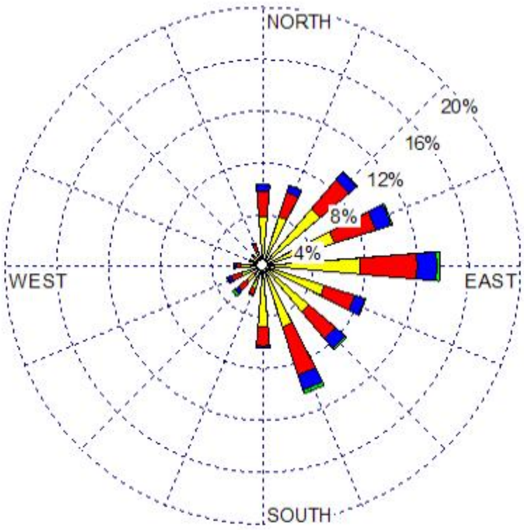
Hughenden (North-west)



Sonoma (North east)



Emerald (South-east)



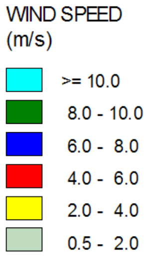
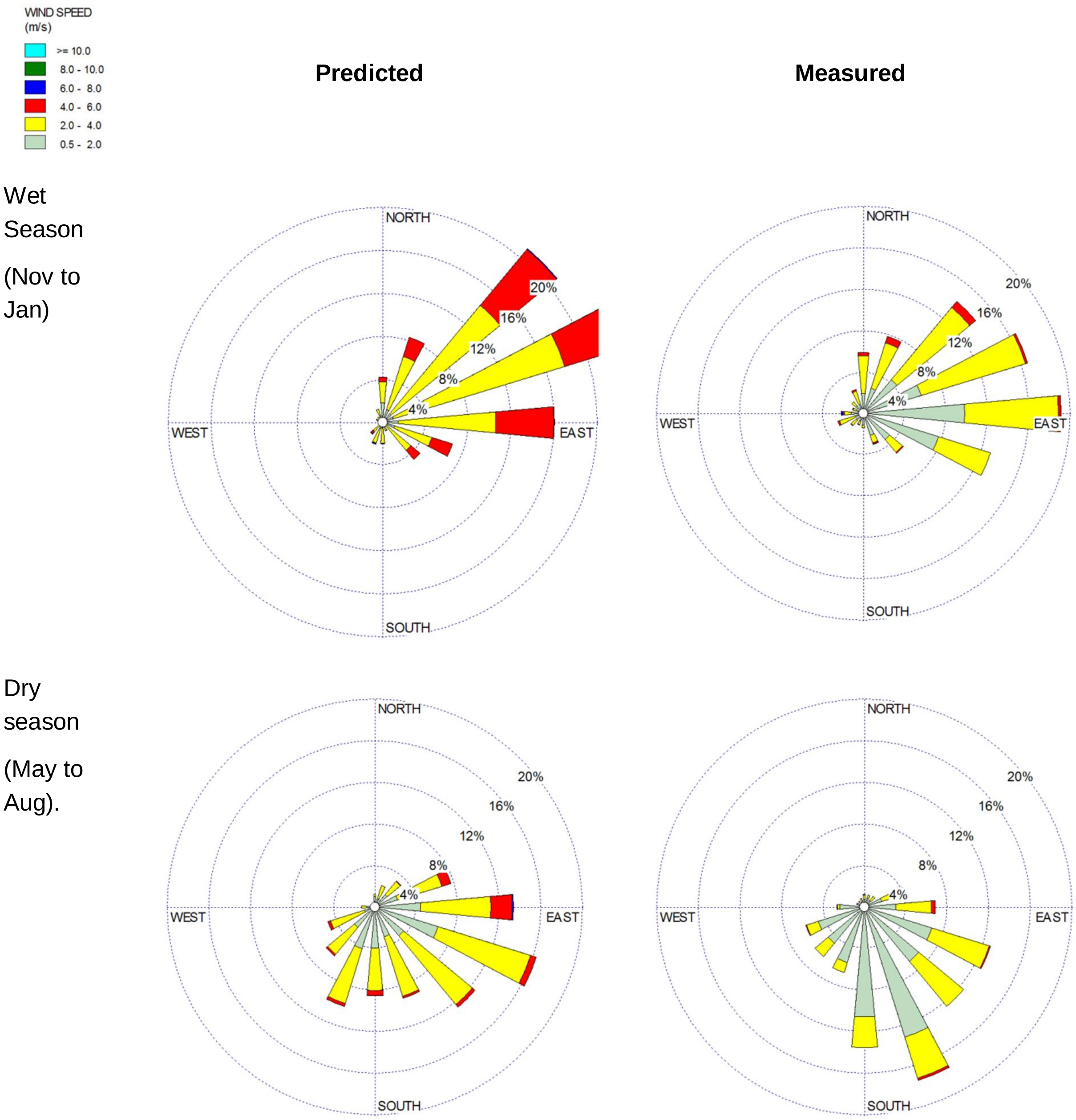


Figure 3-9 Comparison Derived and Measured Wind Roses



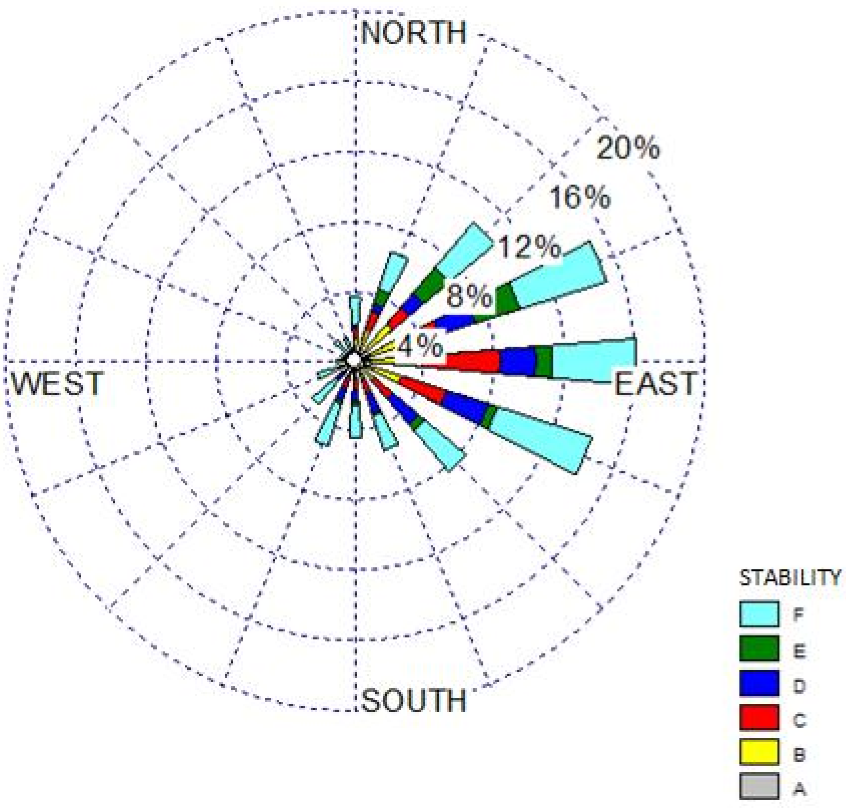
3.3.5 Atmospheric Stability

Dispersion meteorology required for modelling air pollutants requires a time varying measure, or estimate, of atmospheric stability. The derived Project (Mine) meteorological data includes stability in the form of Pasquill-Gifford stabilities. This stability scheme assigns letter codes to varying degrees of atmospheric stability:

- A, B and C for unstable condition (very, moderate and slight, respectively)
- D for neutral stability
- E and F for stable conditions (moderate and slight, respectively)

As can be seen in the stability rose shown in Figure 3-10, the Project Area exhibits a dominant F-class which prevails most nights due to the light winds producing stable night-time conditions. In tropical regions, prognostic models such as MM5, which are themselves reliant on global scale Numerical Weather Prediction models with grid scales of tens of kilometres, tend to under-predict the higher wind speeds and therefore fall short with the determination of neutral conditions of D-class stability. North of the Tropic of Capricorn, strong solar radiation will result in most unstable conditions being highly convective, hence the derived stability class data frequency is under predicted for both the A and B class stability. The above two under-predictions are considered low in importance as this is a conservative consideration for dust dispersion for ground and near-ground sources.

Figure 3-10 Derived Annual Stability Rose for the Project (Mine)



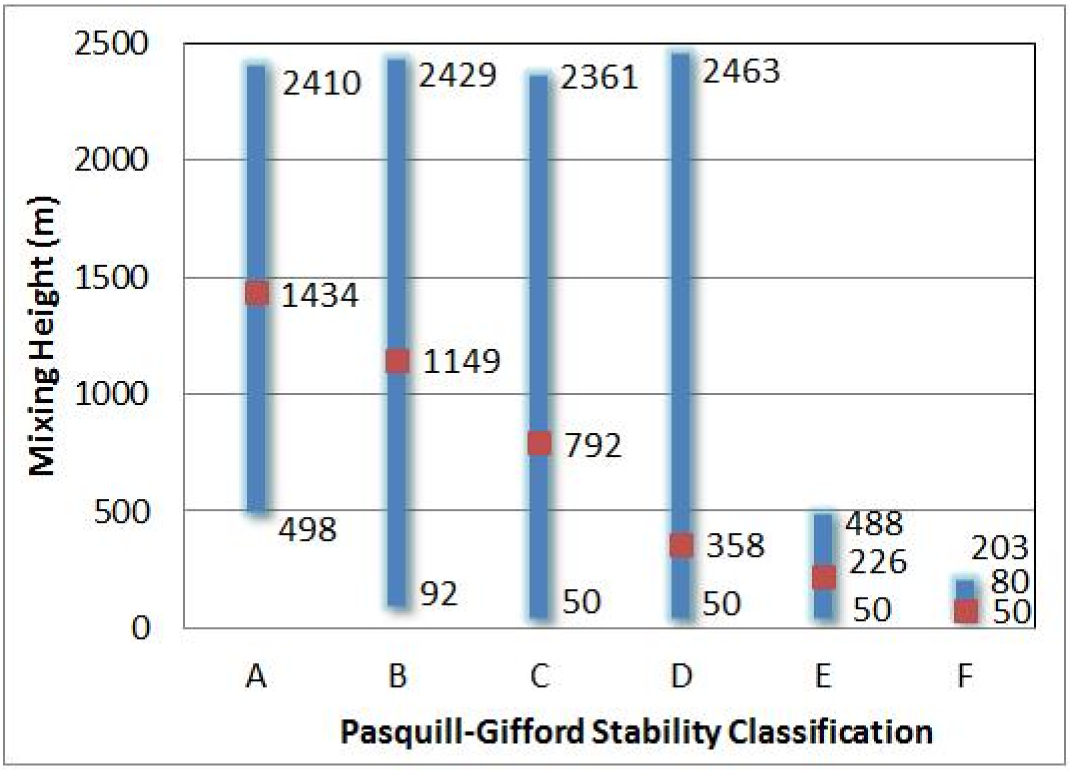
3.3.6 Mixing Depth

The mixing depth is an important atmospheric parameter for air dispersion modelling. The mixing depth is an indicator of vertical dispersion potential of the atmosphere and is a mixture of mechanical and convective influences. The convective conditions will dominate during the day as temperature can become high in this tropical climate while the night-time mixing height is dominated by the strength of the vertical temperature gradient (and the formation of temperature inversions on most nights in a near desert climate) but which may be moderated by the mechanical mixing of wind speeds that occasionally continues beyond sunset.

No direct measurements of mixing depth are available for the Project Area. Therefore, CALMET was configured so as to calculate a suitable mixing height to be used in the dispersion modelling. The minimum daytime mixing heights were in the range of 50 to 500 m which is reasonable for the most unstable conditions (Class A) and some days likely to have cloudy to overcast skies. Night-time mixing heights were as low as 50 m during the calmest of conditions but could reach to near 500 m during nights with stable conditions but with stronger winds. A statistical analysis of mixing heights for each of the stability classes is shown in Figure 3-11.

The derived mixing heights are conservative for the circumstances of the Project (Mine) as the mining emission sources will be at, or near, ground level. Daytime mixing heights reaching no more than 2,500 m using this approach is technically an underestimate during highly convective conditions.

Figure 3-11 Stability Class Derived Mixing Heights - Minimum, Average and Maximum



3.4 Baseline Monitoring Results

An AWS was installed at the Project (Mine) site monitoring the following parameters:

- Temperature at 2 m and 10 m
- Solar radiation (in W/m2)
- Wind speed and direction
- Rain

The Carmichael AWS (site number: 333300) was commissioned on 27 of October 2011. The coordinates are S 21.99971º, E 146.37653º. The AWS is shown in Plate 3-1.

Plate 3-1 Carmichael AWS (Site number 333300)

4. Project Emissions

4.1 Introduction

Project emissions have been identified based on the outcomes of the Macro-conceptual Mine Plan (Runge Limited 2011) and known similar emissions data. Emissions have been developed for three phases of the Mine's projected 90 year lifespan. These are identified as start-up, full operations and maximum emissions. Emissions from the Project (Mine) offsite infrastructure will be assessed during the detailed design phase.

Quantities and types of equipment, the location and sequence of mining are based on indicative mine planning. There is potential for changes to these parameters as detailed mine planning progresses, however, the overall production rate is not expected to change. The Project (Mine) layout, to which the below described project emissions refer, is illustrated in Figure 4-1.

4.2 Emissions During Construction

The construction of the Mine will require land clearing and civil works. The land clearing is part of the overburden stripping operation and the latter, with associated large truck haulage, generates significant dust emissions. As this is part of the Mine operations assessment, construction is considered as part of the actual worst case mine operation.

4.3 Emissions During Operation

4.3.1 Emission Sources

Air emissions during the operation of the open cut and underground mines have been estimated for the following activities for the three distinct phases of the operation of the mine:

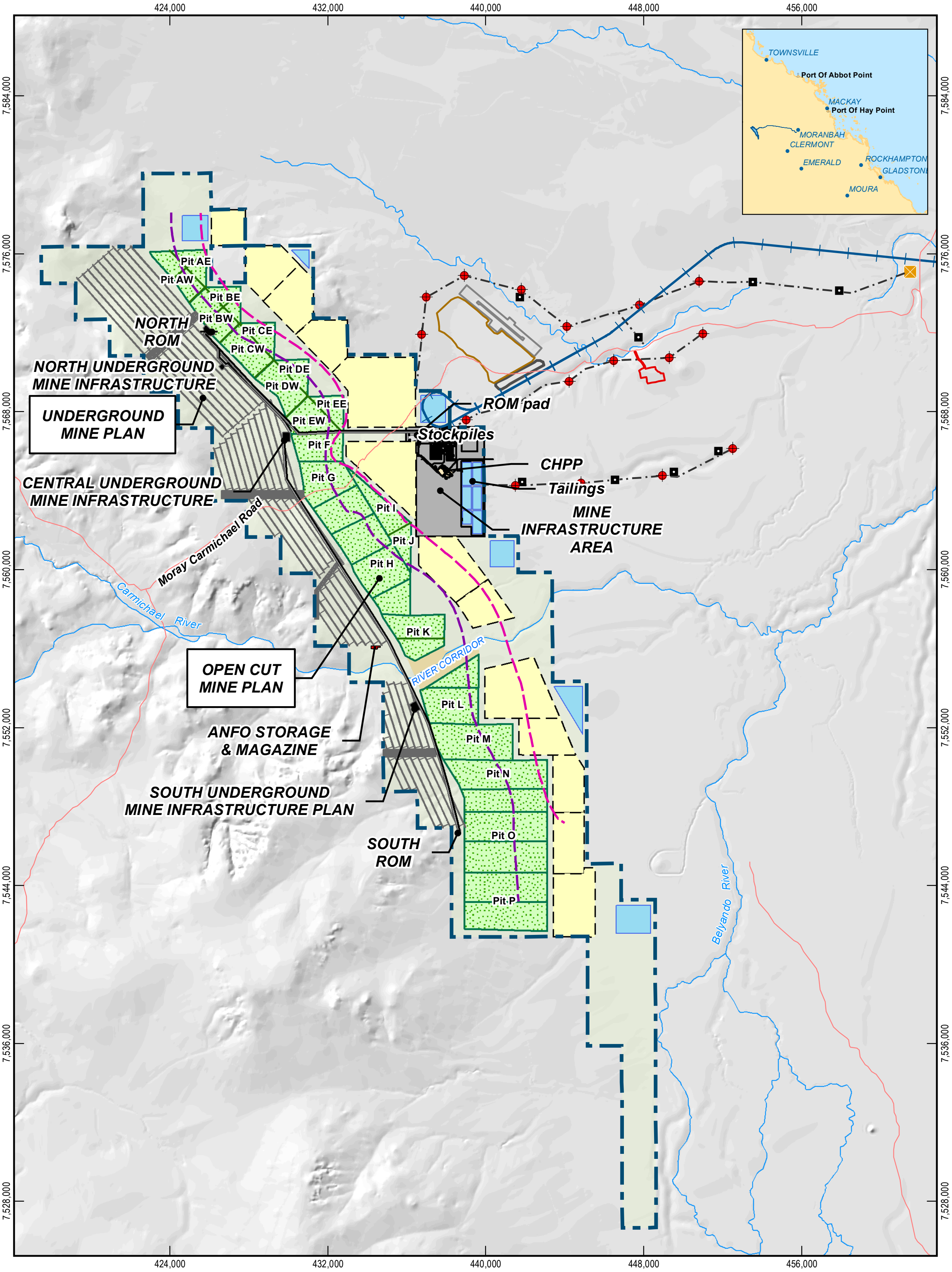
- Blasting
- Removal of topsoil (overburden) in the open cut mine (OCM) pits
- Removal of overburden by truck-shovels
- Removal of overburden by bulldozer
- Removal of overburden by draglines
- Excavators mining coal and loading haul trucks
- Loading of haul trucks with overburden
- Transportation of coal by haul truck to nearest Run-Of-Mine (ROM) pad
- Transportation of overburden by haul truck to nearest waste dump
- Dumping of waste material at nearest out of pit waste dumps
- Coal handling (loading, unloading etc.) at the OCM and underground mine (UGM) ROMs
- Coal handling at the coal handling preparation plant (CHPP)
- Underground mine ventilation
- Primary, secondary and tertiary crushing of coal
- Coal conveying from northern and southern ROMs to Central ROM

- Wind erosion from active coal stockpiles
- Wind erosion from exposed waste dumps
- Wind erosion from active OCM pits
- Train loading
- Dust emissions from train transport of coal within the vicinity of mine
- Grading of haul roads, waste dumps and OCM pits

Dust was modelled as emanating from a total of 51 dust sources within the Mine site, as shown in Figure 4-1. These are summarised as follows:

- OCM pits AE to P – 21 area sources
- Waste dumps – 13 area sources
- Railway line – 10 area sources
- Main Mine infrastructure – 1 area source
- North, South and Central ROM pads – 3 volume sources
- North, South and Central UGM infrastructure – 3 volume sources

Combined with the above 51 dust sources, there were another 35 area sources associated with wind dependent wind erosion dust emissions for the 21 OCM pits, 13 waste dumps and the main mine infrastructure area (MIA) (where significant stockpiling is assumed to be occurring). This brought the total number of dust emitting sources in the CALPUFF model to 86. Not all of the sources were modelled as emitting dust at the same time. Whether a dust source actually was modelled as emitting dust depended on the modelled year and the details of the Mine plan.



LEGEND

- Local Road
- River / Watercourse
- AB1 Cropline
- D1 Cropline
- Overland Conveyors
- Rail (West)
- Mine (Onsite)
- Open Cut Blocks
- Out of Pit Waste Dumps
- Water Management Dams
- Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

1:275,000 (at A4)

0 2 4 6 8

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number	41-25215
Revision	C
Date	04-09-2012

General Mine Layout

Figure 4-1

G:\41\25215\GIS\Maps\MXD\100_Planning\41-25215_170_rev_c.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: GA: Road, River / Watercourse (2007); DME:EPC1690 (2010), EPC1080 (2011); Adani: Mine Layout / Infrastructure, Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: JVC

4.3.2 Target Air Pollutants

The follow air pollutants have been assessed:

- Total Suspended Particles (TSP)
- Particulate matter less than 10 µm in equivalent aerodynamic diameter (EAD) (PM10)
- Particulate matter less than 2.5 µm in EAD (PM2.5)

In addition to predicting ambient levels of particulate matter, dust deposition was also assessed as this can cause nuisance and impacts on visual amenity.

Note that as per the Air EPP, TSP is defined as particles with an EAD of less than or equal to 50 µm.

Sulphur dioxide (SO_2) was not assessed. The current low sulphur content of Australian diesel fuel (maximum of 10 ppm as per Australian Diesel Fuel Standard), in combination with the widely dispersed equipment over many kilometres, makes it unlikely that SO_2 goals will be exceeded off-site or at any identified sensitive receptors.

Oxides of nitrogen, carbon monoxide and any other potentially harmful gaseous substances were assessed as unlikely to exceed air quality goals off-site, or at identified receptors, due to the comparatively low emission rates (with respect to dust impact) and the large distances between significant sources. Accordingly, no further assessment was of these emissions has been carried out.

4.3.3 Unit Operations

The dust from the operations at the Mine was divided into eight different categories based on their locality. These are summarised as:

- OCM pits
- ROM pads
- Haul roads
- CHPP
- Coal transfer points
- Waste dumps
- Railway line
- Underground mine infrastructure

Emissions from the different dust generation processes are described below in Section 4.3.4. Sources can be related to one of the eight locations identified above, with the exception of haul roads within and linking certain source types and areas and wind erosion, which was considered separately due to its dependency on wind speed.

4.3.4 Dust Generation

The general equation used to estimate TSP, PM_{10} and $PM_{2.5}$ emissions from mining activities is described mathematically as:

$$E_i = A \times EF_i \times \left(\frac{100 - CE}{100}\right)$$

Where:

E_i = Emission rate of pollutant *i* (kg per activity)

A = Activity data (units dependent on emission factors)

EF_i = Uncontrolled emissions factor for pollutant *i* (kg per activity)

CE = Control efficiency (%)

Where possible, the activity data and control efficiencies used in the modelling to estimate emissions from the sources described in Section 4.3 were based on the Mine plan (Runge Limited 2011). Where required, emission factors used to estimate emissions of TSP and PM_{10} have been sourced from the publically available National Pollutant Inventory (NPI) Emissions Estimation Technique Manual for Mining (NPI, 2011).

Activity data is usually dependent on the amount of earth moved as kilograms of TSP/PM_{10} per tonne of material or on the total distance of a vehicle travelled (Vehicle Kilometres Travelled, VKT). Therefore, a reduction in the total gross amount of earth processed, or in the total number of kilometres travelled by vehicles will reduce emissions. Dust emissions, as per NPI (2011), are independent of vehicle speeds except for dust emissions from small vehicle movements, such as 4WD's, utility vehicles and graders.

NPI (2011) does not contain emission factors for $PM_{2.5}$. Therefore, emissions of $PM_{2.5}$ have been estimated as 25 per cent of TSP from coal sources and 11.6 per cent of TSP from overburden sources. The overburden value was based on site-specific soil type testing, while the coal value is based on good practice. These values are conservative when compared against other reported values in EIS coal projects for the region (PAE-Holmes, 2011, p.7), which applies a generic value of 12.5 per cent of $PM_{2.5}$, which is significantly less than the value used for this modelling.

The moisture content for coal and overburden used in this modelling is described as follows:

- Coal: 16 per cent (Runge 2011)
- Overburden: 2 per cent (PAE-Holmes, 2011, p.A-7)

The silt content for the modelling was based on results from a medium intensity (1:100,000) soil survey over EPC1690 and associated soil testing, which put the average silt content for the surveyed area at 7.7 per cent (see Volume 4 Appendix L Mine Soils Assessment). The average silt content for EPC1690 was judged a conservative estimate for dust modelling purposes over the Project (Mine), including EPC1080. This will be confirmed as part of surveys of EPC1080 during detailed design of the Project (Mine).

A description of the sources of the emissions is provided in the following sections. A summary of the emission factors used for the modelling is provided in Table 4-1 with more detailed method derivation discussed in Sections 4.3.5 to 4.3.12.

Wind erosion was based on the AP-42 emissions estimation equation provided in the NPI Mining Manual (NPI, 2011, p.57-58, equation 22). This equation relates the annual average wind erosion rate to the silt content (7.7 per cent), the number of days per year when the rainfall is greater than 0.25 mm and the percentage of the time when the wind speed is greater than 5.4 m/s at the mean height of a stockpile.

Bureau of Meteorology data for Clermont Post Office indicates that the mean number of rain days is 57.2. Clermont Post Office was the preferred site for collecting data on mean rain days as the record was longer and more recent than at Twin Hills Post Office. Analysis of the CALMET data indicates that the wind speed is greater than 5.4 m/s (at a reference height of 10 m) 1.53 per cent of the time. This 1.53 per cent value is conservative since most wind erosion takes place at ground level, where the wind speed is lower.

Furthermore, wind erosion was modelled as wind speed dependent, based on a third order relationship with respect to wind speed. That is:

$EF_i = kU^3$

Where:

EF_i = Uncontrolled emissions factor for pollutant *i* (kg per hectare per year)

U = the wind speed at the reference height of 10 m and

k = a proportional constant to maintain total annual emissions as constant.

In effect, the annualised emissions as determined by AP-42 are distributed throughout the year based on a wind dependent relationship. As the dispersion model CALPUFF does not allow a continuous function with respect to wind speed to be entered via the DEFAULT methods, a "binned" approach to the wind erosion EF's was determined. The uncontrolled wind erosion EF's are summarised in Table 4-1.

Table 4-1 Summary of Uncontrolled Emissions Factors

Activity	Required Information	Pollutant	Emission Factor	Units	Derivation
Draglines	Bank cubic metres (bcm) moved	TSP PM10 PM2.5	0.06 0.026 0.007	kg/bcm	Default
Graders	Operational hours	TSP PM10 PM2.5	0.19 0.085 0.035	kg/VKT	Calculated from operational hours and default speed
Excavators/shovels on overburden	Tonnes of overburden moved	TSP PM10 PM2.5	0.0015 0.00071 0.00017	kg/tonne	Calculated from moisture content and mean wind speed
Loading coal to trucks by shovel	Tonnes of coal moved	TSP PM10 PM2.5	0.029 0.014 0.0073	kg/tonne	Default
Bulldozers on overburden	Operational hours	TSP PM10 PM2.5	12.2 2.75 1.42	kg/h/veh	Calculated from moisture and silt content
Bulldozers on coal	Operational hours	TSP PM10 PM2.5	8.50 2.79 2.13	kg/h/veh	Calculated from moisture and silt content
Unpaved haul roads	Total kilometres travelled	TSP PM10 PM2.5	5.2 1.6 0.95	kg/VKT	Calculated from silt content and average vehicle weight
Blasting	Number of blasts	TSP PM10 PM2.5	19.7 10.2 5.1	kg/blast	Calculated from blast area

Activity	Required Information	Pollutant	Emission Factor	Units	Derivation
Trucks dumping overburden	Tonnes of overburden moved	TSP PM10 PM2.5	0.012 0.0043 0.0014	kg/tonne	Default
Trucks loading ROM coal stockpiles	Tonnes of coal moved	TSP PM10 PM2.5	0.004 0.0017 0.001	kg/tonne	Default
Unloading ROM coal stockpiles	Tonnes of coal moved	TSP PM10 PM2.5	0.03 0.013 0.008	kg/tonne	Default
Loading primary crusher	Tonnes of coal processed	TSP PM10 PM2.5	0.029 0.014 0.007	kg/tonne	Default
Primary crushing	Tonnes of coal processed	TSP PM10 PM2.5	0.01 0.004 0.0025	kg/tonne	Default for high moisture
Secondary crushing	Tonnes of coal processed	TSP PM10 PM2.5	0.03 0.012 0.0075	kg/tonne	Default for high moisture
Tertiary crushing	Tonnes of coal processed	TSP PM10 PM2.5	0.03 0.01 0.0075	kg/tonne	Default for high moisture
Overland coal conveyors	Tonnes of coal moved	TSP PM10 PM2.5	8.2×10^{-5} 3.9×10^{-5} 2.0×10^{-5}	kg/tonne	Calculated from moisture content and mean wind speed
Loading coal to trains		TSP PM10 PM2.5	0.0004 0.00017 0.0001	kg/tonne	Default

Activity	Required Information	Pollutant	Emission Factor	Units	Derivation
Dust from trains	Tonnes of coal moved	TSP PM10 PM2.5	0.29 0.15 0.07	g/km/tonne @ 80 km/h	Train speed dependent
Wind erosion	Disturbed area	TSP PM10 PM2.5	475.5 237.8 87.0	kg/ha/y	Wind speed dependent

Table 4-2 Summary of Uncontrolled Wind Erosion Emissions Factors

CALPUFF Wind Speed Upper Value (m/s)	Category Fraction	Emission Factor (kg/ha/h)		
		TSP	PM_{10}	$PM_{2.5}$
1.54	0.176	0.00071	0.00035	0.00013
3.09	0.500	0.0192	0.00961	0.00352
5.14	0.297	0.108	0.054	0.0198
8.23	0.027	0.463	0.232	0.0847
10.80	0.000	–	–	–
10.8+	0.000	–	–	–

4.3.5 Open Cut Mine Operations

The following activities were identified as occurring inside of the OCM pits:

- Draglines on overburden
- Bulldozers on overburden
- Bulldozers on coal
- Loading overburden onto trucks
- Loading coal onto trucks
- Blasting
- Graders

The dust emissions from the OCM operations were based on the information provided in the Mine plan (Runge 2011). This specified the amount of material (overburden and coal) that was estimated to be moved and the number and type of operational equipment for each year that the Mine was operational. Dragline emissions were based on the NPI (2011) default values. The option of the application of an emission estimation equation was investigated; however, bucket drop height would have to be known. As this information was unknown, the NPI defaults were applied. Earth moved by dragline in bcm was based on the Mine plan.

Bulldozer operations were based on the estimated number of operational hours and the number of operating vehicles in the Mine plan. As both silt and moisture content were known, the most accurate method to estimate dust emissions was by the use of the equations as opposed to the default values.

Loading overburden into haul trucks was assumed to be undertaken by front end and shovel loaders. NPI (2011) equations 10 and 11 were applied as information regarding the average moisture content and the average wind speed were known. The amount of overburden moved was provided in the Mine plan. This method was considered conservative as wind speeds inside the pit are likely to be lower than those outside of it, for which the average wind speed was determined. Furthermore, a 2 per cent assumed moisture content for the overburden is unlikely to be representative of moisture levels at depths beyond 30 cm, which can be rapidly removed using modern earth moving equipment.

For estimation of the dust emissions from excavating and loading coal into haul trucks, the default NPI (2011) values were used. Application of the NPI (2011) equations 12 and 13 were investigated, however, for the high moisture content coal (at 16 per cent), the equations predicted TSP emissions to be greater than PM_{10}. Therefore, for high moisture content coal, NPI (2011) equations 12 and 13 are considered unreliable compared to the default values. The total amount of coal moved was supplied by the Mine plan.

Blasting is not the primary mining method, but will be used as required. As such, a detailed blasting schedule was not available. It was assumed for the purposes of estimating air emissions that blasting was to occur once every two days, with an average blast area of 2,000 m^2. The current NPI emission estimation technique (NPI, 2011, equation 19, p.51) does not require information regarding blast hole depth or moisture content as older NPI Mining versions did to estimate emissions.

Dust emissions from grader operations were estimated from the number of operational hours of all graders and an average grader speed of 5 km/h, which was used to estimate annual VKT. The total earth moved (overburden and coal) in the OCM pits was assumed to be evenly distributed across all of the active pits.

Operational equipment hours inside the OCM pits, as defined in the Mine plan (Runge Limited 2011), were assumed to be evenly distributed across all active OCM pits. All other operational equipment hours defined in the Mine Plan (Runge, 2011) were allocated evenly inside and outside the OCM pits.

4.3.6 Run-of-Mine Pads

The following activities were identified as occurring at the ROM pads:

- Loading ROM stockpiles
- Unloading ROM stockpiles

Wind erosion from stockpiles was considered as a separate item.

The Mine plan specifies that there will be up to three ROM pads in operation for the duration of mining operations, north, south and central. It was assumed that all coal from either the UGM or the OCM pits would be processed at the closest ROM pad to which the coal was mined. The coal would be conveyed to the CHPP where it would be put through the crushers and loaded onto a train using a "just-in-time" process. As such, minimal stockpiling, especially at the northern and southern ROM pads was assumed, which removes the need for haul truck dumping onto a stockpile prior to a front-end loader loading the conveyor, thereby eliminating a potential dust source.

Emissions from the ROM pads were assumed to be evenly distributed, unless otherwise specified, i.e. south ROM not operational in 2016. Default NPI (2011) dust emission factors were assumed.

4.3.7 Haul Roads

Dust emissions from haul roads were assumed to be 100 per cent generated from the movement of large haul vehicles. Wind erosion emissions from the haul roads were not modelled as it was assumed that the haul roads would be within the confines of either an OCM pit or a waste dump. Therefore, haul road wind erosion emissions were not double accounted. Likewise, the dust emissions from haul truck movement were assumed to originate from either an OCM pit or a waste dump source.

Emissions were assumed to be evenly distributed across all of the active OCM pits and waste dumps as specific haul road paths have not been determined at this time, and would be likely to change during the Mine's entire planned operation.

The dust generated from the movement of light vehicles was not modelled as:

- It was considered negligible in comparison to the heavy vehicle emissions
- For safety, it is unlikely that frequently traversed light vehicle roads would be combined with haul truck routes

Haul trucks were modelled with an empty weight of 65 tonnes, and a payload capacity of 175 tonnes (full load weight of 240 tonnes). Some haul trucks may have a full load weight of 550 tonnes. NPI (2011) emission factors for mining, unlike previous NPI Mining Manual versions, separate heavy and light vehicle wheel generated dust into separate categories. Using the lightest capacity emission factor results in a conservative assessment of overall dust emissions from haul vehicles on unpaved roads as the bigger capacity trucks are more efficient and have a lower VKT to offset higher emissions due to total weight. Even with the best mine plan available, it is unrealistic to know exactly where each type of haul truck will be for each modelled hour – so a conservative adoption of worst-case dust emission was factored into the emission factor derivation. The default values specified in the NPI (2011) could be used a s a generic mine plan spread of vehicles across the operations but it weas deemed inappropriate for use as it is based on an assumption that the average vehicle weight (mass) is 48 tonnes.

The VKT of the haul trucks was estimated using information for the truck capacity, the amount of overburden and coal removed from the OCM pits and the straight line distance between the centres of the OCM pit and the nearest ROM pad or waste dump. It was assumed that the coal and overburden removal was evenly distributed to all of the active OCM pits and waste dumps. It is estimated that VKT will be lower than modelled as the larger trucks will perform fewer trips between the OCM pits, ROM pad and waste dump. As such, actual PM_{10} dust emissions from haul road trucks are likely to be lower than predicted with a slightly lower off-site impact.

4.3.8 Coal Handling Preparation Plant (CHPP)

The following activities were identified as occurring at the CHPP:

- Loading primary crusher
- Primary crushing
- Secondary crushing
- Tertiary crushing

Wind erosion from any stockpiles or exposed surfaces was considered as a separate item.

Default NPI (2011, Table 3) emission factors for each process were assumed. The coal is considered as "high moisture" content (NPI 2011, p.60). Screening processes for the coal does occur at the CHPP; however, as per NPI (NPI 2011, p.60) "…*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*."

4.3.9 Coal Transfer Points

The following activities were identified as occurring at coal transfer points:

- Conveyor transfers
- Loading to trains

Default NPI (NPI 2011) emission factors for each process were assumed.

4.3.10 Waste Dumps

The following activity was identified as occurring at the out-of-pit waste dumps:

- Dumping of overburden

The default NPI (2011) factor was assumed

Wind erosion from the exposed areas of the waste dumps was considered as a separate item.

Dust emissions from grader operations were modelled at the waste dumps; however, they were calculated for OCM operations and assumed to be equally distributed between the Mine and the waste dumps.

4.3.11 Railway Line

Dust emissions from the railway line were limited to those associated with windblown coal dust from the train as it moves away from the mine, fully loaded. These emissions were assessed cumulatively with those from the Project (Mine), to the extent to which the railway overlaps with dust contours of the Project (Mine). It was assumed that an individual train contained 10,020 tonnes of coal.

Wind erosion from exposed areas of the railway line was not considered as a dust source as any exposed areas during the construction phase are likely to have been revegetated by the time operations commence.

The emission factor of coal dust from the train motion was calculated using the equation detailed in Connell-Hatch (Connell-Hatch 2008), as shown below:

$$EF_{train} = 0.0000378(V)^2 - 0.000126(V) + 0.000063 \quad \text{[g/km/tonne of coal]}$$

Where V is the speed of the train (km/h).

The railway line was modelled in CALPUFF as 10 individual length segments representing the nominal 40 km path from the Mine to the edge of the CALPUFF model domain. The majority of the segments were approximately 4 km long. The train was modelled as accelerating away from the loading area at a rate of 0.05 m/s^2 (initially), easing to 0.03 m/s^2 at 4 km from the mine site (Steimel, 2008, p.25), from a nominal starting speed of 10 km/h. This resulted in the maximum speed of 80 km/h being reached approximately 5.5 km from the rail loop at the mine site. The dust emissions from the rail sections of the model were calculated based on the average speed along each of the individual sections.

4.3.12 Underground Mine Infrastructure

The dust emissions from the UGM were assumed to be from the exhaust ventilation system and a single conveyor transfer point from the UGM to the overland conveyors. NPI (2011) default values were applied to the conveyor transfer point dust emissions, with the mass of coal for each of the three UGM infrastructure points as specified in the Mine plan. The exhaust ventilation for the UGM was based on dust concentration measurements for an existing UGM operated by Illawarra Coal (PAE-Holmes, 2010). This information has been used in previous EIS air quality assessments (PAE-Holmes, 2011) and is considered as a reasonable estimate for UGM ventilation emissions, which consist mostly of dust.

The calculated dust mass emissions rates for the Illawarra Coal mine were scaled pro-rata with the extracted coal capacity difference of the mine and that estimated for the Project (Mine) UGM. This assumes that for any given UGM, a doubling of the size of the mine requires twice the ventilation requirements, and therefore twice the mass emission of dust. In lieu of detailed ventilation specifications for the Project (Mine) UGM, this is considered as a reasonable approach for the estimation of ventilation emissions.

4.4 Modelled Scenarios – No Emissions Controls

4.4.1 Overview

Three scenarios were modelled to represent the dust emissions from Mine operations during its projected 90 year lifespan. These are identified as start-up, full operations and maximum emissions. A summary of the phases is provided in Table 4-3.

The start-up phase is represented by the year 2016 in the Mine plan. This represented the situation, in the near future, when both the UGM and OCM are commencing operations. Estimates of equipment operational hours and earth moved are most likely to have the least amount of error. Likewise, current mining technology is being utilised. Therefore, predictions of dust levels have the greatest degree of accuracy in terms of applied technology and mine capacity.

The full operation phase is represented by the year 2037 in the Mine plan, at which stage, both the UGM and OCM are at full operations producing 60 mtpa with numerous OCM pits active and some being rehabilitated. Estimates of operational equipment hours and types start to have increased error, while technology is likely to be similar to current levels.

The maximum emissions phase is represented by the year 2067 in the Mine plan. This is not the year that the mine is at maximum capacity, i.e. maximum output of coal, but is representative of the maximum amount of dust being emitted from mining operations primarily due to the extent of disturbed areas. By this time, nominally 55 years into the future, the UGM has been closed and all identified OCM pits and waste dumps are either active or under rehabilitation. While there is potential for dust emission control technology to have advanced by 2067, this has not been factored into the assessment. Beyond the year 2067, the dust emissions continue to decline as more of the OCM pits are closed and rehabilitated and the overall amount of coal being produced by the mine decreases.

Table 4-3 Summary of Modelled Mine Operational Phases (Includes Pit Retention Passive Controls and Excludes Wind Erosion)

Phase	Representative Year	UGM Capacity (M-tonnes)	OCM Capacity (M-tonnes)	OCM Total Earth Moved (M-tonnes)	Uncontrolled PM_{10} Production Emissions (tonne/y)
Start-up	2016	7.2	8.6	176.6	12,352
Full Operations	2037	18.9	41.9	314.9	25,497
Maximum Emissions	2067	0.0	63.9	399.9	32,427

4.4.2 Uncontrolled Emissions Estimates

A breakdown of the estimated PM_{10} dust emissions for the three phases of the Project (Mine) are provided in Table 4-4. These estimates are for uncontrolled PM_{10} emissions, excluding wind erosion emissions. Passive controls for pit retention have been applied, which equates to a 5 per cent reduction for PM_{10} generated sources inside of any OCM pit, as per NPI (2011) guidelines. The summary in Table 4-4 clearly shows that the greatest single source of dust emissions is from haul trucks. The haul trucks are estimated to account for at least 75 per cent of production related PM_{10} emissions.

Dust emissions from haul trucks can be minimised using various control techniques (discussed in subsequent sections), however, emissions from dumping waste rock and draglines have no controls. Only unquantifiable operational controls can be applied to waste rock dumping and draglines. These operational controls include minimising bucket drop height for draglines and gentle dumping of overburden on the waste rock dumps.

Dust emissions from crushing activities can be substantially reduced by enclosing equipment. The other two dozen dust generating activities at the Mine site, including UGM ventilation and coal train emissions, comprise less than 10 per cent of total uncontrolled PM_{10} emissions.

Table 4-4 Summary of Uncontrolled PM_{10} Dust Source Proportion (Includes Pit Retention Passive Controls and Excludes Wind Erosion)

Phase	Production Emissions (tonne/y)	Percentage of Total Annual Emissions (%)				
		Haul Roads	Dumping Waste Rock	Draglines	Crushing Activities	Other Activities
Start-up	12,352	82.5	5.8	2.7	2.9	6.1
Full Operations	25,497	75.0	4.6	5.8	5.5	9.1
Maximum Emissions	32,427	76.2	4.5	6.2	4.5	8.6

4.4.3 Uncontrolled Wind Erosion

Uncontrolled PM_{10} dust emissions from exposed areas due to wind erosion are summarised in Table 4-5 for the three stages of the life of the Mine. It was found that wind erosion accounts for approximately 10 per cent of the total dust emissions from the mine, during all stages of its life. As wind erosion has the potential to be the second largest individual dust source, implementing appropriate and effective control measures is vital.

Passive controls for pit retention have been applied to the figure in Table 4-5, which equates to a 5 per cent reduction for PM_{10} generated sources inside of any OCM pit, as per NPI (NPI 2011) emission estimation guidelines.

Table 4-5 Summary of Uncontrolled PM_{10} Wind Erosion Emissions

Phase	Production Emissions (tonne/y)	Wind Erosion Emissions (tonne/y)	Total Emissions (tonne/y)	Wind Erosion percentage of Total (%)
Start-up	12,352	1,480	13,832	10.7
Full Operations	25,497	3,067	28,564	10.7
Maximum Emissions	32,427	3,222	35,649	9.0

4.5 Cumulative Impacts

As there are no other known existing or proposed significant dust sources in the vicinity of the proposed Project (mine), cumulative impacts are considered by including (ambient) background levels (see Section 3.2) being added to the modelled increment levels to be compared to the assessment criteria.

Particulate matter from the train diesel exhaust is minor when compared to mine dust, hence this minor contribution has not been assessed. Cumulative impacts of the proposed rail operation have been incorporated into the model by considering dust emissions from railway operations to the extent which the railway overlaps with dust contours produced by the mine.

4.6 Pollution Control

4.6.1 Overview

The modelling has been conducted with potential dust emissions from each of the three modelled phases without consideration of specific dust control measures. In line with normal mining practice, dust control techniques have been assumed and modelled for each of the sources identified at each phase of the Mine operations. Some processes have no controls, while other dust sources can be completely removed through the application of full enclosures.

4.6.2 Control Techniques

A summary of the controls applied for the air emissions modelling are provided in Table 4-6.

Of the identified control measures, these have been applied and used to calculate emissions before and after application. A nominal 75 per cent reduction in emissions from production activities was found to be achievable with the application of the control measures as summarised in Table 4-7. The control measure is further discussed in this section.

Table 4-6 Summary of Applied Controls

Activity	Applied Controls	Percentage Reduction (%)
Draglines	None	0
Graders	Moist soil	50
Excavators/shovels on overburden	None	0
Loading coal to trucks by shovel	None	0
Bulldozers on overburden	None	0
Bulldozers on coal	None	0
Unpaved haul roads	Chemical Sprays and Sealant	90
Blasting	None	0
Trucks dumping overburden	None	0
Trucks loading ROM coal stockpiles	Water Sprays	50
Unloading ROM coal stockpiles	Water Sprays	50
Loading primary crusher	Water Sprays	50
Primary crushing	Enclosed	100
Secondary crushing	Enclosed	100
Tertiary crushing	Enclosed	100
Overland coal conveyors	Partly enclosed	70
Loading coal to trains	Partly enclosed	70
Dust from trains	None	0
Wind erosion (Inactive areas)	Revegetation	90
Wind erosion (Active areas)	None	0
UGM Ventilation	None	0

1 Where water supply is limited an equivalent control is assumed.

Table 4-7 Summary of PM_{10} Dust emissions with Maximum Controls Applied (Excluding Wind Erosion)

Phase	Uncontrolled Production Emissions (tonne/y)	Controlled Production Emissions (tonne/y)	Percentage Reduction (%)
Start-up	12,352	2,853	77
Full Operations	25,497	6,968	73
Maximum Emissions	32,427	8,648	73

4.6.2.1 Pit Retention Factors

Pit retention is a passive control in that it emissions are mitigated by pit retention as a feature of the environment, rather than an applied mitigation measure. As such, pit retention factors were included in both the uncontrolled and controlled model scenarios.

NPI (2011) default pit retention factors were applied based on the following reduction factors:

- TSP – 50 per cent pit reduction
- PM10 – 5 per cent pit reduction
- PM2.5 – 5 per cent pit reduction

Pit retention factors were applied to all dust sources, including wind erosion, from within any OCM pit. This includes 50 per cent of the emissions from the following sources:

- Haul roads
- Bulldozers on overburden
- Graders

4.6.2.2 Crushing Operations

Crushing operations (primary, secondary and tertiary) have full enclosure controls applied. This model assumption is based on information supplied in the Mine plan indicating that the crushers are to be housed in building structures.

4.6.2.3 Wind Erosion

No controls have been applied to wind erosion from exposed surfaces in active OCM pits, waste dumps and the MIA. The MIA includes a large stockpile of coal for loading onto trains for export.

However, the second to highest control measure has been applied to all OCM pit and waste dumps identified as being under rehabilitation in the Mine plan. This involves the area being returned to a state of revegetation as rapidly as possible. This allows a 90 per cent dust reduction factor to be applied.

4.6.2.4 Haul Roads

As haul roads have been identified as being responsible for over 75 per cent of dust emissions arising from active coal production, special attention has been applied to controlling these emissions.

Preliminary analysis indicated that Level 2 watering, as described in NPI (2011) as greater than 2 litre/m^2/h, was found to be inadequate for reducing dust levels for the maximum emissions phase of the Mine. The other control option specified in the NPI (2011) manual is for sealed or salt-encrusted roads. However, the requirements for sealing a roadway for 240+ tonne haul trucks is considered excessive, especially when the haul roads are likely to change over the life of the Mine. Furthermore, it is also considered unlikely that a potential dust source which may account for greater than 75 per cent of uncontrolled emissions could be reduced to zero.

Upon further investigation, a more realistic, reasonable and achievable approach, investigated by Kinsey and Cowherd (Buonicore and Davis, 1992, p.144) showed that dust emissions from unpaved roads can be reduced by greater than 90 per cent by using chemical stabilisation. The chemicals generally have a petroleum resin basis, and need to be regularly re-applied.

4.7 Summary of Emissions

4.7.2 Emissions with embedded control factors

A summary of the emission rates for each of the source types input into the model for the three phases of the Project (Mine) is provided in Table 4-8, Table 4-9 and Table 4-10. All emissions are "as modelled", and as such include control measures and pit retention factors, e.g. TSP emissions from pit sources have been halved as 50 per cent of emissions do not escape the pit. Therefore, the summary of emissions is a summary of the emissions which will impact on the predicted GLCs.

Table 4-8, Table 4-9 and Table 4-10 are segregated to in-pit sources and non-pit sources for each category of emissions. Wind erosion is summarised as a separate item – with controls applied (either revegetation or pit retention). Modelled emissions rates from area sources – pits and waste dumps – were evenly distributed around the modelled active sources.

A total of 86 individual sources were used in the CALPUFF modelling to represent the emissions from the mine.

Table 4-8 Modelled Emissions Rates with Full Controls Applied (Including Pit Retention) for Start-up Phase (2016)

Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)		Total PM_{10} Emissions (kg/y)	Total $PM_{2.5}$ Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
TOTALS				2,230,347	6,617,776	8,848,123	1,524,650	2,788,196	4,312,845	1,958,846
Open Cut Mine	Excavators/shovels on overburden	120,000,000	bcm/y	126,057	0	126,057	113,281	0	113,281	27,759
Open Cut Mine	Loading coal to trucks by shovel	8,581,323	tonne/y	124,429	0	124,429	114,132	0	114,132	59,104
Open Cut Mine	Blasting	182.5	blasts/y	1,796	0	1,796	1,774	0	1,774	887
Open Cut Mine	Draglines	13,602,129	bcm/y	408,064	0	408,064	335,973	0	335,973	89,860
Open Cut Mine	Bulldozers on coal	33,446	veh.h	142,163	0	142,163	23,692	0	23,692	67,527
Open Cut Mine	Bulldozers on overburden	63,315	veh.h	193,584	387,168	580,753	82,789	87,146	169,936	87,502
Open Cut Mine	Graders	116,355	VKT	2,764	5,529	8,293	2,349	2,473	4,821	1,972
ROM Pads	Trucks loading ROM coal stockpiles	8,581,323	tonne/y	0	8,581	8,581	0	3,647	3,647	2,145
ROM Pads	Unloading ROM coal stockpiles	8,581,323	tonne/y	0	128,720	128,720	0	55,779	55,779	32,180
Haul Roads	Unpaved haul roads In-pit: Out-of-pit:	 655,345 5,986,068	VKT	858,816	1,717,632	2,576,447	496,620	522,757	1,019,377	612,769

Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)		Total PM_{10} Emissions (kg/y)	Total $PM_{2.5}$ Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
CHPP	Loading primary crusher	15,821,280	tonne/y	0	229,409	229,409	0	110,749	110,749	57,352
	Primary crushing	15,821,280	tonne/y	0	0	0	0	0	0	0
	Secondary crushing	5,537,448	tonne/y	0	0	0	0	0	0	0
	Tertiary crushing	1,107,490	tonne/y	0	0	0	0	0	0	0
Transfer Points	Overland coal conveyors	15,821,280	tonne/y	0	194	194	0	92	92	48
	Loading coal to trains	15,821,280	tonne/y	0	949	949	0	403	403	237
Waste Dump	Trucks dumping overburden	120,000,000	bcm/y	0	2,016,000	2,016,000	0	722,400	722,400	233,654
Train – Coal Dust	Section 1	15,821,280 2.8	tonne/y km	0	144	144	0	72	72	36
	Section 2	15,821,280 3.8	tonne/y km	0	4,241	4,241	0	2,121	2,121	1,060
	Section 3	15,821,280 3.8	tonne/y km	0	15,346	15,346	0	7,673	7,673	3,836
	Section 4	15,821,280 3.4	tonne/y km	0	15,604	15,604	0	7,802	7,802	3,901

Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)		Total PM_{10} Emissions (kg/y)	Total $PM_{2.5}$ Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
	Section 5	15,821,280 3.4	tonne/y km	0	15,604	15,604	0	7,802	7,802	3,901
	Section 6	15,821,280 1.3	tonne/y km	0	5,845	5,845	0	2,922	2,922	1,461
	Section 7	15,821,280 4.3	tonne/y km	0	19,566	19,566	0	9,783	9,783	4,891
	Section 8	15,821,280 4.3	tonne/y km	0	19,566	19,566	0	9,783	9,783	4,891
	Section 9	15,821,280 4.3	tonne/y km	0	19,566	19,566	0	9,783	9,783	4,891
	Section 10	15,821,280 10.1	tonne/y km	0	46,111	46,111	0	23,056	23,056	11,528
UGM Infrastructure	North Conveyor Transfer	6,600,000	tonne/y	0	81	81	0	38	38	20
	Central Conveyor Transfer	939,957	tonne/y	0	89	89	0	42	42	22
	South Conveyor Transfer	0	tonne/y	0	0	0	0	0	0	0
	North Ventilation	5.3	g/s	0	167,554	167,554	0	115,193	115,193	115,193
	Central Ventilation	0.5	g/s	0	16,247	16,247	0	11,170	11,170	11,170

Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)		Total PM_{10} Emissions (kg/y)	Total $PM_{2.5}$ Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
	South Ventilation	0	g/s	0	0	0	0	0	0	0
Sub-Total				1,857,672	4,839,744	6,697,417	1,170,609	1,712,686	2,883,294	1,439,802
Wind Erosion	All Sources	63,046,441	m^2	372,675	1,838,115	2,210,790	354,041	1,105,552	1,459,593	534,065
TOTAL				2,230,347	6,677,859	8,908,207	1,524,650	2,818,238	4,342,887	1,973,867

NOTE: Assumed overburden conversion: 1 bcm = 1.4 tonne

Table 4-9 Modelled Emissions Rates with Full Controls Applied (Including Pit Retention) for Full Operations Phase (2037)

Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)		Total PM_{10} Emissions (kg/y)	Total $PM_{2.5}$ Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
TOTALS				6,355,834	12,925,184	19,281,018	4,616,322	5,193,160	9,809,483	4,512,445
Open Cut Mine	Excavators/shovels on overburden	195,000,000	bcm/y	204,842	0	204,842	184,081	0	184,081	45,108
	Loading coal to trucks by shovel	41,936,357	tonne/y	608,077	0	608,077	557,754	0	557,754	288,837
	Blasting	182.5	blasts/y	1,796	0	1,796	1,774	0	1,774	887
	Draglines	60,000,000	bcm/y	1,800,000	0	1,800,000	1,482,000	0	1,482,000	396,378
	Bulldozers on coal	111,292	veh.h	473,048	0	473,048	78,835	0	78,835	224,698
	Bulldozers on overburden	120,814	veh.h	369,386	738,772	1,108,158	157,973	166,288	324,261	166,966
	Graders	237,770	VKT	5,649	11,298	16,947	4,800	5,053	9,853	4,031
ROM Pads	Trucks loading ROM coal stockpiles	41,936,357	tonne/y	0	41,936	41,936	0	17,823	17,823	10,484
	Unloading ROM coal stockpiles	41,936,357	tonne/y	0	629,045	629,045	0	272,586	272,586	157,261
Haul Roads	Unpaved haul roads In-pit: Out-of-pit:	 1,677,632 10,789,079	VKT	1,612,098	3,224,196	4,836,294	932,213	981,277	1,913,490	1,150,240
CHPP	Loading primary crusher	60,794,842	tonne/y	0	881,525	881,525	0	425,564	425,564	220,381

Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM10 Emissions (kg/y)		Total PM10 Emissions (kg/y)	Total PM2.5 Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
	Primary crushing	60,794,842	tonne/y	0	0	0	0	0	0	0
	Secondary crushing	21,278,195	tonne/y	0	0	0	0	0	0	0
	Tertiary crushing	4,255,639	tonne/y	0	0	0	0	0	0	0
Transfer Points	Overland coal conveyors	60,764,842	tonne/y	0	745	745	0	352	352	186
	Loading coal to trains	60,764,842	tonne/y	0	3,648	3,648	0	1,550	1,550	912
Waste Dump	Trucks dumping overburden	195,000,000	bcm/y	0	3,276,000	3,276,000	0	1,173,900	1,173,900	379,688
Train – Coal Dust	Section 1	60,794,842 2.8	tonne/y km	0	554	554	0	277	277	138
	Section 2	60,794,842 3.8	tonne/y km	0	16,297	16,297	0	8,148	8,148	4,074
	Section 3	60,794,842 3.8	tonne/y km	0	58,968	58,968	0	29,484	29,484	14,742
	Section 4	60,794,842 3.4	tonne/y km	0	59,960	59,960	0	29,980	29,980	14,990
	Section 5	60,794,842 **3.4**	tonne/y km	0	59,960	59,960	0	29,980	29,980	14,990

Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)		Total PM_{10} Emissions (kg/y)	Total $PM_{2.5}$ Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
	Section 6	60,794,842 1.3	tonne/y km	0	22,459	22,459	0	11,229	11,229	5,615
	Section 7	60,794,842 4.3	tonne/y km	0	75,184	75,184	0	37,592	37,592	18,796
	Section 8	60,794,842 4.3	tonne/y km	0	75,184	75,184	0	37,592	37,592	18,796
	Section 9	60,794,842 4.3	tonne/y km	0	75,184	75,184	0	37,592	37,592	18,796
	Section 10	60,794,842 10.1	tonne/y km	0	177,187	177,187	0	88,593	88,593	44,297
UGM Infrastructure	North Conveyor Transfer	9,500,000	tonne/y	0	116	116	0	55	55	29
	Central Conveyor Transfer	9,358,485	tonne/y	0	231	231	0	109	109	58
	South Conveyor Transfer	0	tonne/y	0	0	0	0	0	0	0
	North Ventilation	7.6	g/s	0	241,176	241,176	0	165,809	165,809	165,809
	Central Ventilation	7.5	g/s	0	237,584	237,584	0	163,339	163,339	163,339
	South Ventilation	0	g/s	0	0	0	0	0	0	0
Sub-Total				5,074,896	9,907,208	14,982,104	3,399,431	3,684,173	7,083,603	3,530,526

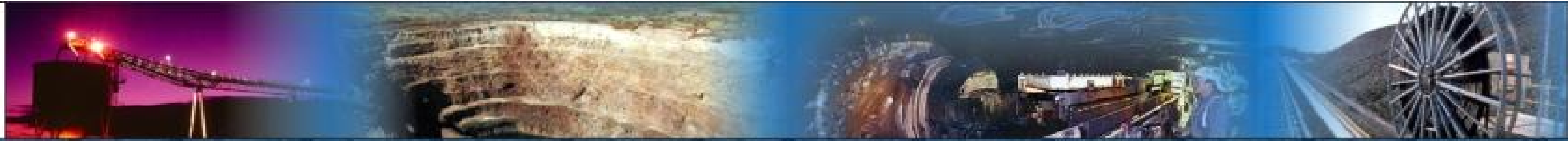
Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)		Total PM_{10} Emissions (kg/y)	Total $PM_{2.5}$ Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
Wind Erosion	All Sources	131,855,119	m^2	1,280,939	3,248,853	4,529,792	1,216,892	1,624,427	2,841,318	1,039,638
TOTAL				6,355,834	13,156,061	19,511,896	4,616,322	5,308,599	9,924,921	4,570,164

NOTE: Assumed overburden conversion: 1 bcm = 1.4 tonne

Table 4-10 Modelled Emissions Rates with Full Controls Applied (Including Pit Retention) for Maximum Emissions Phase (2067)

Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)		Total PM_{10} Emissions (kg/y)	Total $PM_{2.5}$ Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
TOTALS				6,980,659	16,293,248	23,273,907	4,660,037	7,307,038	11,967,075	5,353,545
Open Cut Mine	Excavators/shovels on overburden	195,000,000	bcm/y	252,114	0	252,114	226,562	0	226,562	55,518
	Loading coal to trucks by shovel	41,936,357	tonne/y	926,834	0	926,834	850,131	0	850,131	440,246
	Blasting	182.5	blasts/y	1,796	0	1,796	1,774	0	1,774	887
	Draglines	60,000,000	bcm/y	2,446,645	0	2,446,645	2,014,405	0	2,014,405	538,776
	Bulldozers on coal	111,292	veh.h	724,752	0	724,752	120,783	0	120,783	344,257
	Bulldozers on overburden	120,814	veh.h	463,689	927,379	1,391,068	198,304	208,741	407,044	209,592
	Graders	237,770	VKT	7,652	15,303	22,955	6,502	6,844	13,345	5,459

Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)		Total PM_{10} Emissions (kg/y)	Total $PM_{2.5}$ Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
ROM Pads	Trucks loading ROM coal stockpiles	41,936,357	tonne/y	0	63,920	63,920	0	27,166	27,166	15,980
	Unloading ROM coal stockpiles	41,936,357	tonne/y	0	958,794	958,794	0	415,477	415,477	239,698
Haul Roads	Unpaved haul roads In-pit: Out-of-pit:	 1,677,632 10,789,079	VKT	2,082,643	4,165,286	6,247,929	1,204,311	1,267,696	2,472,007	1,485,976
CHPP	Loading primary crusher	60,794,842	tonne/y	0	926,834	926,834	0	447,437	447,437	231,709
	Primary crushing	60,794,842	tonne/y	0	0	0	0	0	0	0
	Secondary crushing	21,278,195	tonne/y	0	0	0	0	0	0	0
	Tertiary crushing	4,255,639	tonne/y	0	0	0	0	0	0	0
Transfer Points	Overland coal conveyors	60,764,842	tonne/y	0	783	783	0	370	370	196
	Loading coal to trains	60,764,842	tonne/y	0	3,835	3,835	0	1,630	1,630	959
Waste Dump	Trucks dumping overburden	195,000,000	bcm/y	0	4,032,000	4,032,000	0	1,444,800	1,444,800	467,309
Train – Coal Dust	Section 1	60,794,842 2.8	tonne/y km	0	582	582	0	291	291	146



Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)		Total PM_{10} Emissions (kg/y)	Total $PM_{2.5}$ Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
	Section 2	60,794,842 3.8	tonne/y km	0	17,134	17,134	0	8,567	8,567	4,284
	Section 3	60,794,842 3.8	tonne/y km	0	61,999	61,999	0	31,000	31,000	15,500
	Section 4	60,794,842 3.4	tonne/y km	0	63,041	63,041	0	31,521	31,521	15,760
	Section 5	60,794,842 3.4	tonne/y km	0	63,041	63,041	0	31,521	31,521	15,760
	Section 6	60,794,842 1.3	tonne/y km	0	23,613	23,613	0	11,807	11,807	5,903
	Section 7	60,794,842 4.3	tonne/y km	0	79,048	79,048	0	39,524	39,524	19,762
	Section 8	60,794,842 4.3	tonne/y km	0	79,048	79,048	0	39,524	39,524	19,762
	Section 9	60,794,842 4.3	tonne/y km	0	79,048	79,048	0	39,524	39,524	19,762
	Section 10	60,794,842 10.1	tonne/y km	0	186,294	186,294	0	93,147	93,147	46,573
UGM Infrastructure	North Conveyor Transfer	0	tonne/y	0	0	0	0	0	0	0
	Central Conveyor Transfer	0	tonne/y	0	0	0	0	0	0	0
	South Conveyor Transfer	0	tonne/y	0	0	0	0	0	0	0
	North Ventilation	0	g/s	0	0	0	0	0	0	0

Location	Activity	Activity Data	Units	TSP Emissions (kg/y)		Total TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)		Total PM_{10} Emissions (kg/y)	Total $PM_{2.5}$ Emissions (kg/y)
				Pit Sources	Non-Pit Sources		Pit Sources	Non-Pit Sources		
	Central Ventilation	0	g/s	0	0	0	0	0	0	0
	South Ventilation	0	g/s	0	0	0	0	0	0	0
Sub-Total				6,906,124	11,746,984	18,653,109	4,622,769	4,146,586	8,769,355	4,199,775
Wind Erosion	All Sources	198,395,548	m^2	74,535	4,789,008	4,863,543	37,267	3,281,825	3,319,092	1,214,456
TOTAL				6,980,659	16,535,992	23,516,652	4,660,037	7,428,411	12,088,447	5,414,231

NOTE: Assumed overburden conversion: 1 bcm = 1.4 tonne

4.7.3 Emissions Not Modelled

Potential emissions from the following sources have not been modelled in the assessment:

- Tailings dams, as tailing are assumed to be maintained as a wet paste
- Diesel combustion from vehicles and equipment, as particulate matter generation is small in comparison with wheel generated dust
- Light vehicle movements, general movement and employees arriving for work

4.7.4 Emission Estimation Errors

Emissions have been estimated using the methods and techniques described and detailed in NPI (NPI 2011) emission estimating techniques for Mining. All of the values in the NPI manual have associated errors due to either a lack of monitoring information or numerous different techniques which can be applied to achieve the same outcome. For example, the default values for wind erosion dust emissions are “Unclassified”. Therefore, this source has the greatest amount of potential error in its estimate.

Within the next 55 years, it is likely that the methods for estimation of emissions will improve, as they have over the previous 55 years. Therefore, emissions estimates, especially for the full operations and maximum emissions phases of the life of the mine should be assessed with an understanding that circumstances are more than likely going to change. Estimates can only be considered as indicative, based on 2012 technology and knowledge.

5. Impact Assessment

5.1 Identified Sensitive Receptors

The air quality assessment requires the estimation of maximum ground level concentrations and monthly average dust deposition values at the nearest sensitive receptors. A total of eight existing sensitive receptors, excluding Project (Mine) offsite infrastructure, have been identified, as summarised in Table 5-1 and illustrated in Figure 5-1. These are currently established locations, pastoral lease homesteads, for which the ambient air quality was assessed with regards to dust emissions from the Mine and the short section of the railway line present inside of the modelled domain. The Labona homestead is located within the proposed Mine footprint (lease boundary) and will be relocated once mining activities start.

A workers accommodation village, permanent airport, and industrial area is proposed to be established east of the Mine site, adjacent to and straddling the Project (Rail). The infrastructure size is greater than a single receptor location but indicative receptors on the near side to the mine site and adjacent railway line were selected to be representative, as summarised in Table 5-1, and identified by alpha-numeric identifiers.

Ambient air quality has been assessed at all nearby identified sensitive receptors. The majority of the existing sensitive receptors are at the extremes of the CALPUFF model domain, reflecting the isolated nature of the Mine site.

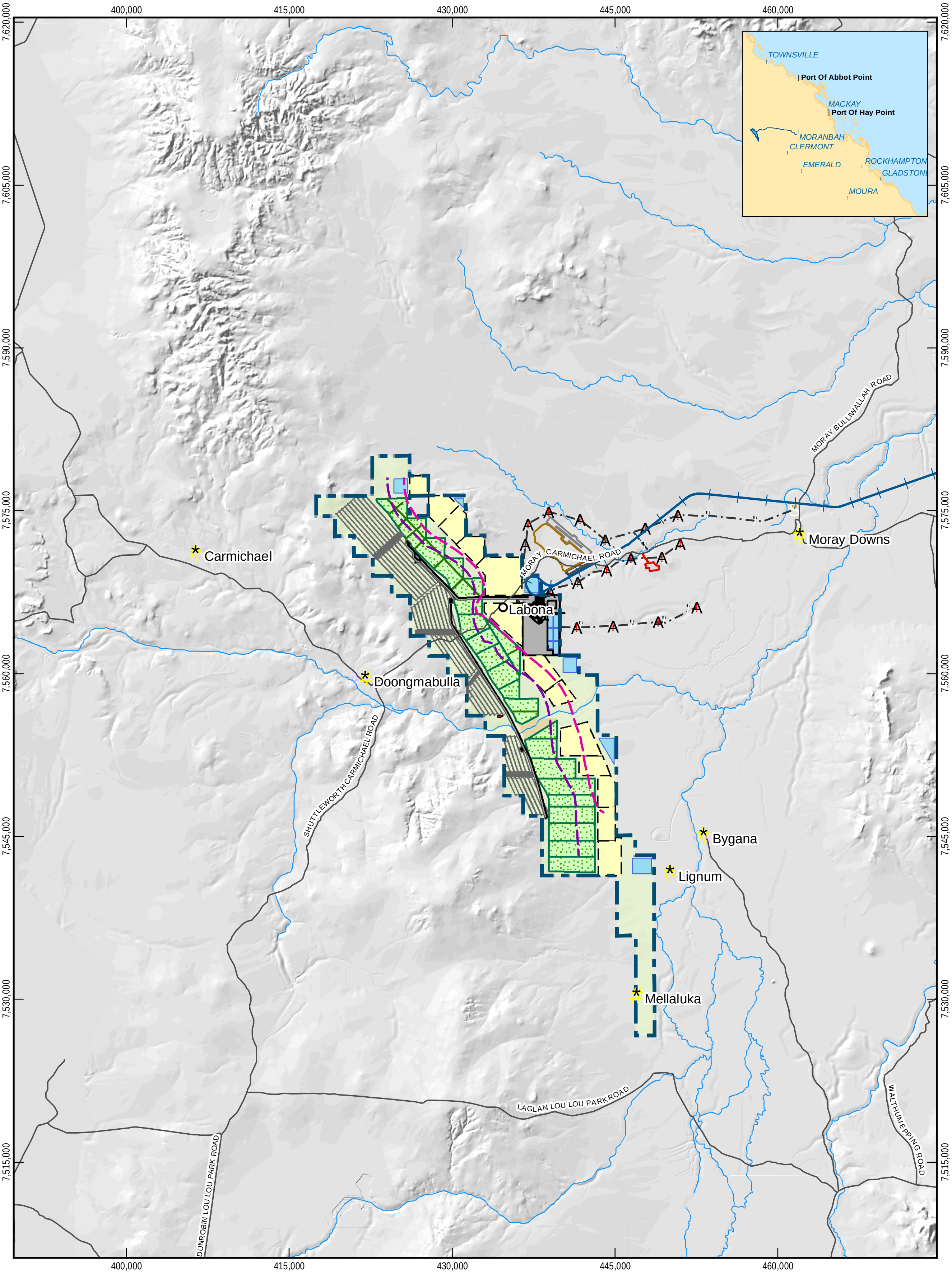
Lignum (ID 32) Homestead is the closest to the mine boundary but on the upwind side of prevailing winds (from the east-south-east). The existing receptors most remote from the Mine and are on the eastern side are associated with emissions from the railway line segment and are included for completeness. These three sensitive receptors, Moray Downs (ID 18), Cassiopeia (ID 20) and Beenboona (ID 28), are potentially exposed to emissions from both the railway and the Mine and have been included to take into account cumulative impacts from mine and rail operations. Therefore, the ambient air quality at all identified nearby existing receptors has been assessed.

Figure 5-1 shows the location of the identified sensitive receptors with regards to the modelled Mine. Bimbah East, Moonoomoo and Albinia homesteads (refer to Volume 2 Section 2 Project Description) were not considered sensitive receptors as they were a significant distance from modelled dispersion contours.

Table 5-1 Summary of Existing and Proposed Future Sensitive Receptors

ID	Name	Distance (m)	Nearest Feature	Easting (km)	Northing (km)
1	Mellaluka	11,800	Mine Site	446.973	7530.251
2	Bygana	7,800	Mine Site	453.157	7544.999
6	Doongmabulla	7,100	Mine Site	422.016	7559.462
17	Carmichael	16,900	Mine Site	406.412	7571.007
18	Moray Downs	3,298	Rail Segment	462.027	7572.602

ID	Name	Distance (m)	Nearest Feature	Easting (km)	Northing (km)
20	Cassiopeia	3,090	Rail Segment	475.674	7575.617
28	Beenboona	5,786	Rail Segment	468.989	7582.756
32	Lignum	4,800	Mine Site	450.080	7541.530
Vc	Village centre	2,950	Rail Segment	448.412	7569.905
V1	Village north west	2,400	Rail Segment	447.835	7570.065
V2	Village south west	3,180	Rail Segment	448.219	7569.456
A1	Airport Terminal centre	3,180	Rail Segment	440.512	7572.324
I1	Industrial Zone rail centre	660	Rail Segment	441.505	7570.081
I2	Industrial Zone north west	2,800	Mine Site	437.708	7572.132
I3	Industrial Zone south west	660	Rail Segment	440.304	7569.536



LEGEND

Sensitive Receptor	Overland Conveyors	Open Cut Blocks	Mine (Offsite)	Airport Location
Local Road	Rail (West)	Out of Pit Waste Dumps	Borehole	Rail Siding
River / Watercourse	Mine (Onsite)	Water Management Dams	Storage Site (Instream)	Industrial Area
AB1 Cropline			Storage Facility (Offstream)	Workers Accommodation Village
D1 Cropline			Pipeline Network	

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:500,000 (at A4)

0 5 10 15

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision B
Date 16-10-2012

Nearest Receptor Locations with respect to CALPUFF Modelled Layout

Figure 5-1

G:\41\25215\GIS\Maps\MXD\700_Environment\41-25215_724_rev_b.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: GHD: Sensitive Receptors (2012); GA: Road, River / Watercourse (2007); DME:EPC1690 (2010), EPC1080 (2011); Adani: Mine Layout / Infrastructure, Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: JVC

5.2 Assessment of Ambient PM_{10} Levels

5.2.1 Sensitive Receptors

Ambient PM_{10} levels have been assessed with regards to Air EPP, which are assessed against a maximum ambient level criterion of 50 µg/m³ (including background) with an averaging period of 24 hours. There is an exceedance allowance of five days, which is designed to take into account high background dust levels due to 'natural events' such as dust storms and bushfires. A constant 70th percentile background level of 11 µg/m³ has been added to the predicted incremental PM_{10} GLCs.

Results at the existing sensitive receptors for the start-up, full operations and maximum emission phases of the mine are shown in Table 5-2, Table 5-3 and Table 5-4 respectively. During the maximum emissions phase for year 2067, the Lignum Homestead equals the PM_{10} GLCs criterion of 50 µg/m³. No other exceedences are predicted at any phase of the Project for any sensitive receptor.

Table 5-2 Start-Up Phase (2016) – Summary of Existing Sensitive Receptor Predicted PM_{10} GLCs

ID	Name	Maximum Predicted Incremental PM_{10} (24hr avg) (µg/m³)	Background PM_{10} (µg/m³)	Maximum Total PM_{10} (24hr avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	4	11	15	30
2	Bygana	5	11	16	32
6	Doongmabulla	13	11	24	49
17	Carmichael	9	11	20	39
18	Moray Downs	8	11	19	38
20	Cassiopeia	3	11	14	29
28	Beenboona	6	11	17	34
32	Lignum	7	11	18	36

Note: Criterion = 50 µg/m³ (24 hour average)

Table 5-3 Full Operations Phase (2037) – Summary of Existing Sensitive Receptor Predicted PM_{10} GLCs

ID	Name	Maximum Predicted Incremental PM_{10} (24hr avg) (µg/m³)	Background PM_{10} (µg/m³)	Maximum Total PM_{10} (24hr avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	20	11	31	61
2	Bygana	21	11	32	64
6	Doongmabulla	27	11	38	76
17	Carmichael	17	11	28	56
18	Moray Downs	16	11	27	54
20	Cassiopeia	12	11	23	45
28	Beenboona	12	11	23	46
32	Lignum	25	11	36	71

Note: Criterion = 50 µg/m³ (24 hour average)

Table 5-4 Maximum Emissions Phase (2067) – Summary of Existing Sensitive Receptor Predicted PM_{10} GLCs

ID	Name	Maximum Predicted Incremental PM_{10} (24hr avg) (µg/m³)	Background PM_{10} (µg/m³)	Maximum Total PM_{10} (24hr avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	30	11	41	83
2	Bygana	24	11	35	70
6	Doongmabulla	24	11	35	71
17	Carmichael	12	11	23	46
18	Moray Downs	15	11	26	52
20	Cassiopeia	12	11	23	47
28	Beenboona	12	11	23	46
32	Lignum	39	11	**50**	100

Note: Criterion = 50 µg/m³ (24 hour average)

Contour plots of predicted maximum 24 hour average PM_{10} GLCs for the three phases of the Mine, including background, are shown in Figure 5-2, Figure 5-3 and Figure 5-4. It can be seen that the Air EPP criterion of 50 µg/m³ is not complied with at all locations beyond the site boundary of the Mine.

A relatively small area is affected by the start-up scenario, however as mining intensifies, the contours move further out and affect larger areas of adjacent properties. As these areas are only intermittently occupied by workers on these grazing properties, adverse impacts are not expected.

For the maximum emissions scenario in year 2067, the 50 µg/m^3 contour is close to the Lignum homestead, indicating that on the worst day, the criterion may be reached. As this is currently a residential location, it will be important to undertake ongoing monitoring while it remains inhabited to determine whether predicted levels of concern occur, and, if a criterion is exceeded, develop management measures to address this.

Once full mine operations commence (refer to Figure 5-3) the extent of the criterion contour has grown substantially in all directions. When maximum emissions are expected, the criterion contour begins to extend further towards the south (Figure 5-4) as the southern OCM pits become more active. Even though the Lignum (ID 32) location is in the direction of the prevailing winds (nominally upwind), the worst case day can result in the daily averaged peak PM_{10} modelled values reaching the EPP (Air) criterion. Predicted PM_{10} GLCs along the rail line segment, when combined with Mine impacts, are shown to increase substantially from the start-up phase to the other two modelled phases due to increased coal transport.

5.2.2 Workers Accommodation Village and Offsite Infrastructure

The Air EPP expressly excludes operational health and safety (OH&S) considerations with Part 3 Clause 8(5) stating it "does not apply to an air emission that may be experienced within a dwelling or workplace if the air emission is released within the dwelling or workplace." Here a “workplace” takes on the meaning defined in the *Workplace Health and Safety Act 1995*. In such a dwelling or workplace, dust is typically assessed via direct personal monitoring and dust management strategies as part of regulated workplace requirements including exposure to air pollutants.

Emissions released within the Mine site boundary may be present within the workers accommodation village. As such air quality at the workers accommodation village must comply with the Air EPP objectives. The workers accommodation village does not qualify as the workplace as workers will be off-duty when present.

With respect to the airport and proposed off-site industrial area, these may be considered commercial or public spaces so that air quality will also be required to comply with the Air EPP objectives. As with the Lignum homestead, it will be important to undertake ongoing monitoring of the industrial area and to determine whether predicted levels of concern occur, and, if a criterion is exceeded, develop management measures to address this.

Sensitive Receptor Locations

The Air EPP contains no definition of sensitive receptor, however the Queensland Odour Impact Assessment from Developments Guideline provides a definition as “… *any such place known or likely to become a sensitive place in the future”* (DERM, 2004, p.24). This definition is consistent with other Australian states (DEC, 2005, p.59).

To be consistent with Queensland air quality guidelines, predicted dust levels were determined at those locations closest to the mine that had been identified as ‘proposed Carmichael Community and Industrial land use’ in Gassman (2012, p.241, Figure 36).

Industrial Area Assessment

The proposed industrial area, adjacent to the proposed airport, shown in Figure 36 of Gassman (2012, p.241) abuts the railway corridor. For this adjacent boundary, air quality will be more significantly affected by emissions from the railway line. Therefore, the assessment of mine impact at the industrial area site should be examined with consideration of the Air Quality Assessment for the Rail project (Volume 4, Appendix AD).

Air Quality Goal

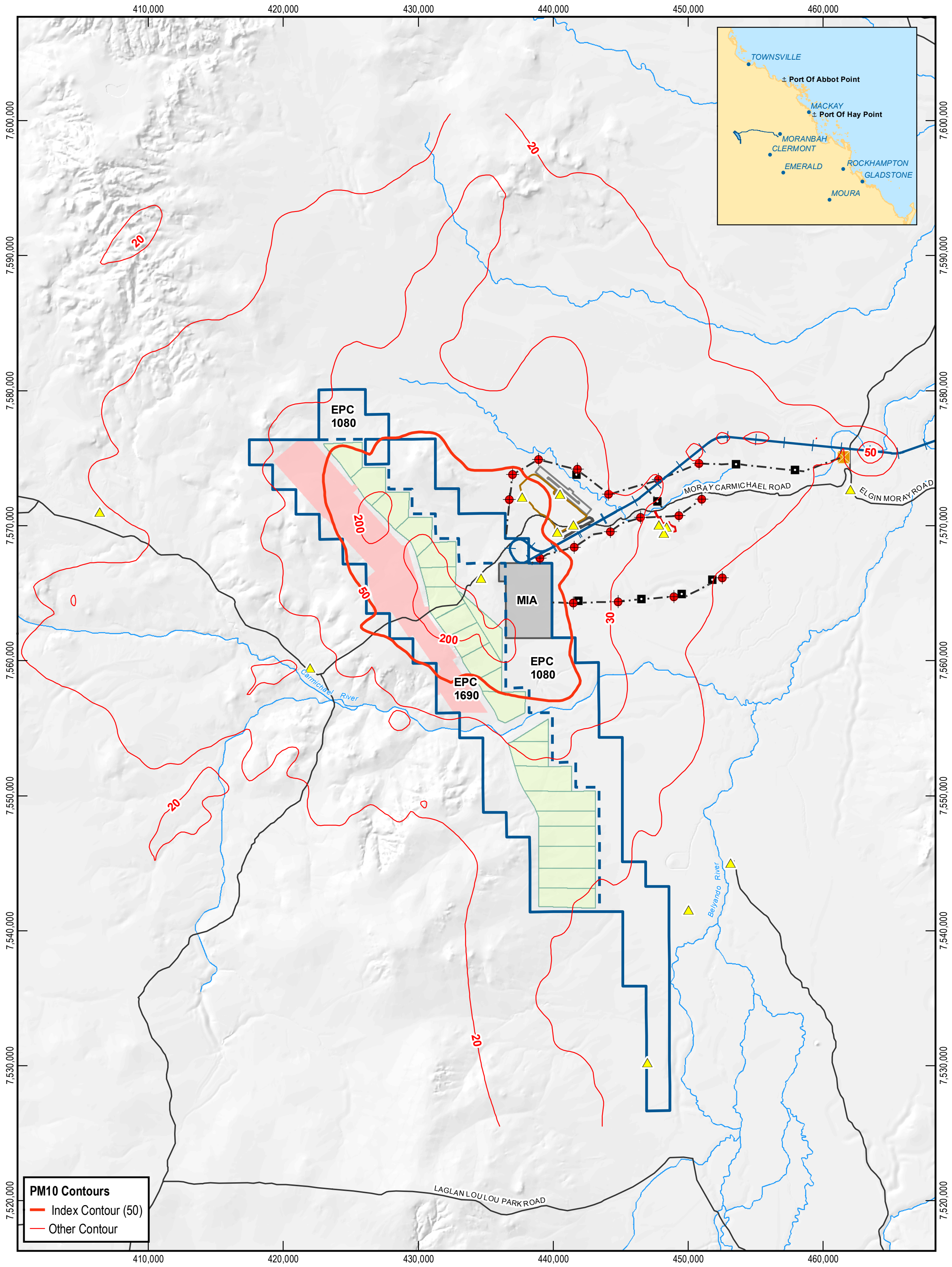
The NEPM goal and Air EPP objective is to have no more than five days per year with PM_{10} concentrations exceeding 50 µg/m³. Now this is an ambient monitoring standard but the only way it can be assessed before the project commences is to use modelling. For each of the three mine plan phases, daily PM_{10} average concentrations were predicted for the four different zoned areas and these are summarised in Table 5-5. . Results for only the most affected sensitive receptors for each piece of Project (Mine) offsite infrastructure are presented. Note that these values are inclusive of the 11 µg/m³ background increment.

During the early years of mine start-up, the predicted levels are safely within the required goal. Only the north west corner of the industrial zone is predicted to have any exceedances of the 24 hour averaged PM_{10} goal. However, as the mine reaches full operational levels, the predicted ground level impact of emissions from the mine steadily rise. Non-compliance with the five days per year goal of greater than 50 µg/m³ ambient dust levels is first predicted to occur in the industrial zone, followed by the airport when emissions are expected to be at their maxima. It is noted that the requirement of no more than five days per year above the standard monitoring level is predicted to be always achieved at the workers village.

Table 5-5 Predicted Off-site Mine Infrastructure Exposure to PM_{10} Ground Level Concentrations (including background level of 11 µg/m³), 24 hour averaged, µg/m³.

Zone	Village	Village	Airport	Industrial	Industrial
Location	SW corner	NW corner	Terminal (centre)	NW corner	SW corner
ID	V2	V1	A1	I2	I3
Coords (mE, mN)	(448,219, 7,569,456)	(447,835, 7,570,065)	(440,512, 7,572,324)	(437,708, 7,572,132)	(440,304, 7,569,536)
			Start-up (2016)		
Max PM_{10}	27.9	28.7	45.2	58.4	43.0
2^{nd} Rank	25.3	25.7	36.9	51.4	41.9
6^{th} Rank	22.1	22.8	34.3	40.1	34.2
10^{th} Rank	20.8	21.3	29.9	38.0	32.7

Zone	Village	Village	Airport	Industrial	Industrial
Full Operations (2037)					
Max PM_{10}	40.0	40.6	68.7	76.5	80.9
2nd Rank	38.7	39.5	60.2	64.9	69.7
6th Rank	34.2	35.2	47.7	55.4	56.0
10th Rank	33.6	34.0	43.6	50.2	51.7
Maximum Emissions (2067)					
Max PM_{10}	40.8	42.1	66.3	73.9	74.9
2nd Rank	38.4	38.9	58.7	72.5	74.4
6th Rank	34.2	35.7	50.5	61.0	62.0
10th Rank	31.3	31.8	46.9	54.7	58.2



LEGEND

Sensitive Receptor
Watercourse
Local Road
Rail (West)
Mine (Onsite)
Mine Infrastructure Area
Open Cut Blocks
Underground Mine Plan
Mine (Offsite)
Borehole
Storage Site (Instream)
Storage Facility (Offstream)
Pipeline Network
Airport Location
Rail Siding
Industrial Area
Workers Accommodation Village

1:400,000 (at A4)

0 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project
Predicted PM10 Maximum GLC
Year 2016 - 24hr Avg Including Background
Controls Applied

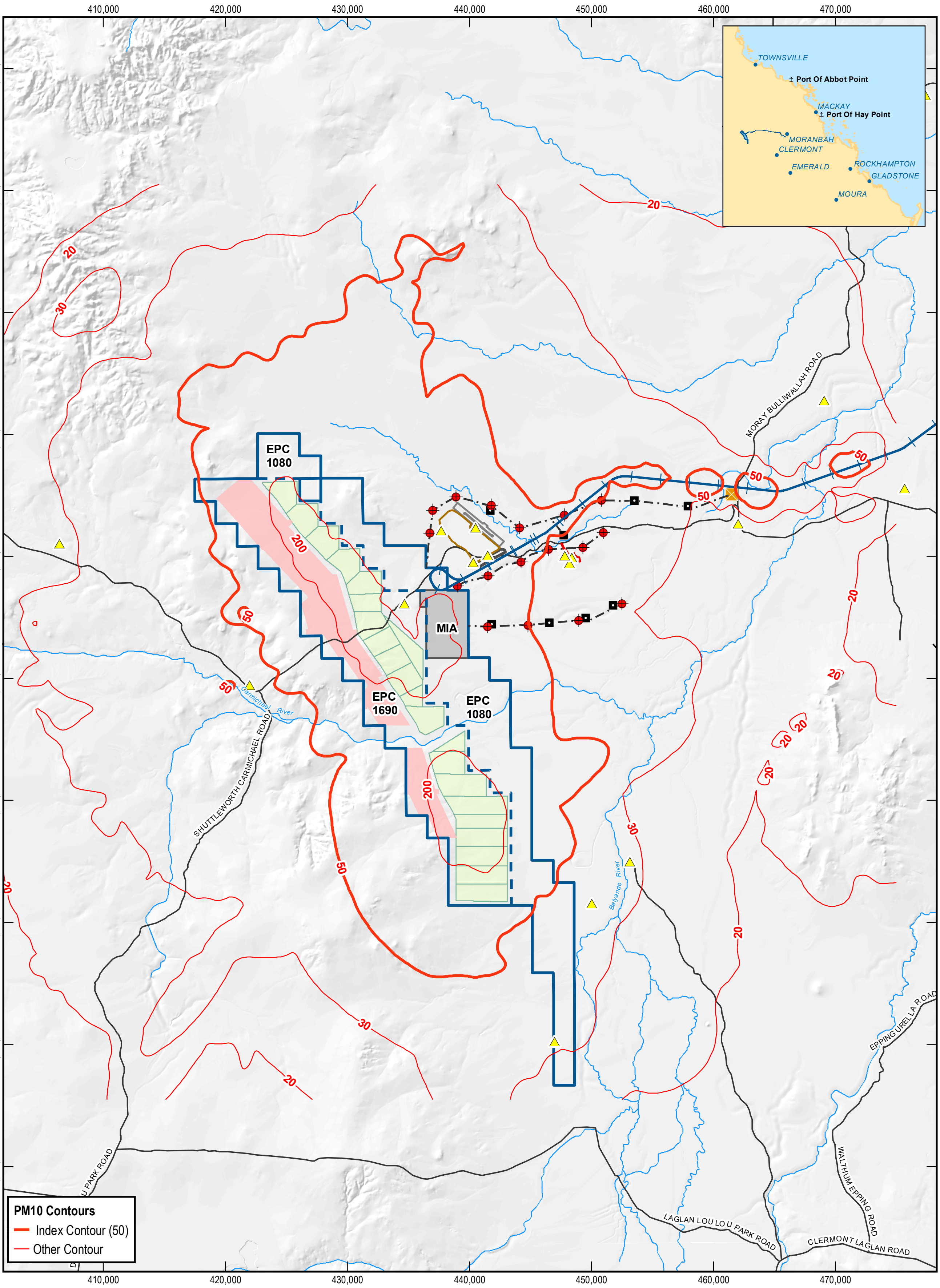
Job Number	41-25215
Revision	B
Date	15-10-2012

Figure 5-2

G:\41\25215\GIS\Maps\MXD\700_Environment\41-25215_731_rev_b.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC 1690 (2010)/EPC 1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); Adani: Adani: Mine Layout, Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); GHD: Sensitive Receptor (2012), Modelling Contours (2012). Created by: AJ, CA



LEGEND

- Sensitive Receptor
- Watercourse
- Local Road
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Open Cut Blocks
- Underground Mine Plan
- Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:450,000 (at A4)

0 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Predicted PM10 Maximum GLC
Year 2037 - 24hr Avg Including Background
Controls Applied

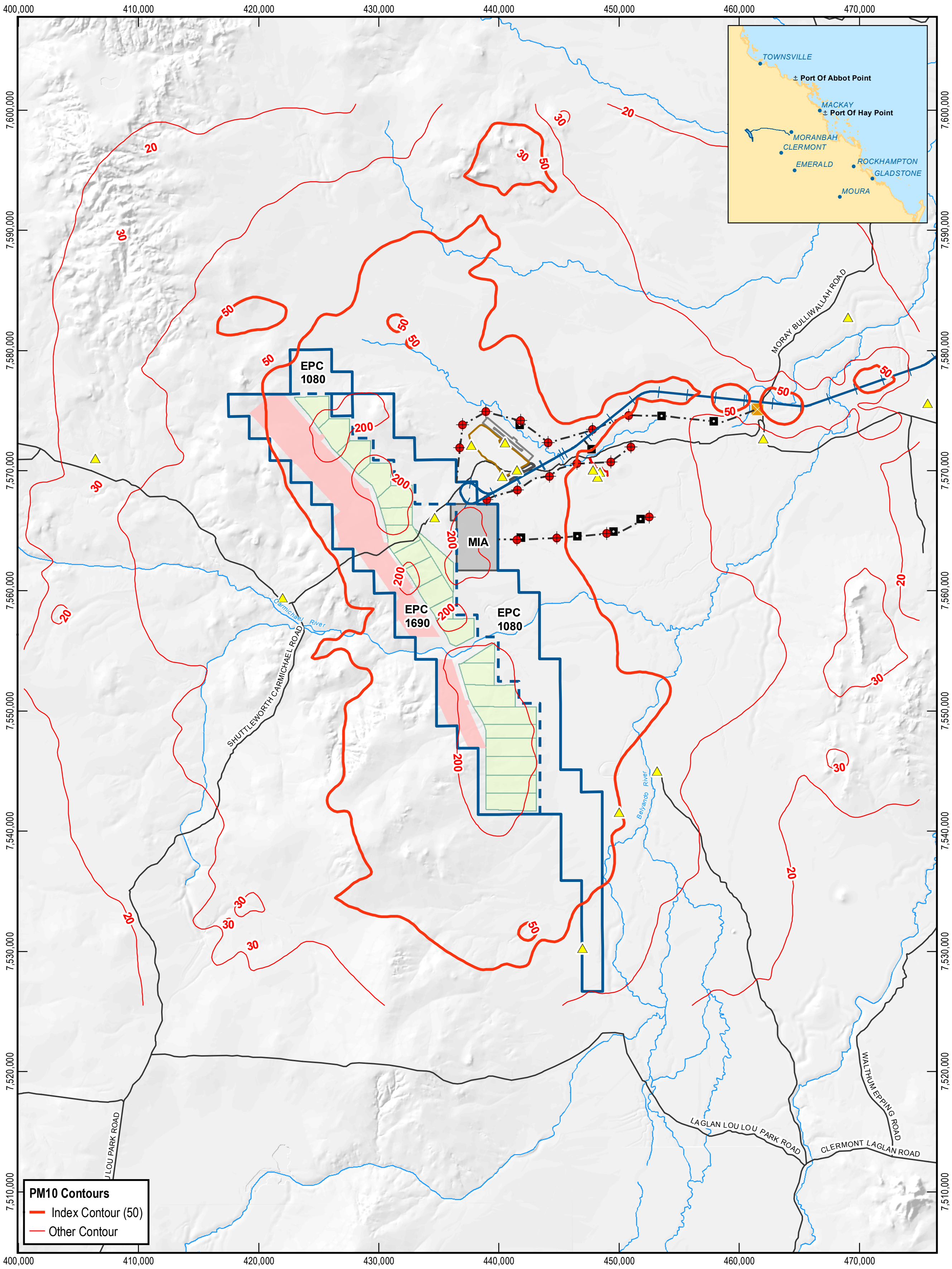
Job Number	41-25215
Revision	B
Date	15-10-2012

Figure 5-3

G:\41\25215\GIS\Maps\MXD\700_Environment\41-25215_732_rev_b.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC 1690 (2010)/EPC 1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); Adani: Adani: Mine Layout, Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); GHD: Sensitive Receptor (2012), Modelling Contours (2012). Created by: AJ, CA



LEGEND

- Sensitive Receptor
- Watercourse
- Local Road
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Open Cut Blocks
- Underground Mine Plan
- Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:450,000 (at A4)

0 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project
Predicted PM10 Maximum GLC
Year 2067 - 24hr Avg Including Background
Controls Applied

Job Number	41-25215
Revision	B
Date	15-10-2012

Figure 5-4

G:\41\25215\GIS\Maps\MXD\700_Environment\41-25215_733_rev_b.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC 1690 (2010)/EPC 1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); Adani: Adani: Mine Layout, Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); GHD: Sensitive Receptor (2012), Modelling Contours (2012). Created by: AJ, CA

5.3 Assessment of Ambient $PM_{2.5}$ Levels

Ambient $PM_{2.5}$ levels have been assessed against the Air EPP maximum ambient level criteria, a 24 hour average of 25 µg/m³ (including background), and an annual average of 8 µg/m³ (including background). There is no exceedance allowance for these assessment criteria.

A constant 70th percentile background level of 3.3 µg/m³ has been added to the predicted incremental $PM_{2.5}$ GLCs to account for background levels. Results at the identified highest existing and future off-site infrastructure sensitive receptors for the $PM_{2.5}$ assessment for the start-up, full operations and maximum emission phases of the mine are shown in Table 5-6 to Table 5-11 for all years and both assessment criteria.

For all three phases, the maximum predicted $PM_{2.5}$ GLCs at the northwest corner of the industrial zone (ID 12) exceeded the 24 hour averaged criteria. All existing off-site sensitive receptors were equal or below the assessment criteria. However, like the PM_{10} emissions assessment, as the mine stages progress, the predicted exceedances for the 24 hour averaged criterion at the proposed off-site mine infrastructure; excluding the workers village, increase. Results for only the most affected sensitive receptors for each piece of Project (Mine) offsite infrastructure are presented.

The only existing sensitive receptor to equal an Air EPP $PM_{2.5}$ annual criterion was Doongmabulla (ID 6), during the full operations phase of the Mine (refer to Table 5-10). During this phase, Doongmabulla (ID) is affected by ventilation emissions from UGM infrastructure and the active OCM pits in the central portion of the Mine. Modelled emissions at Doongmabulla (ID 6) are, however, less than the assessment criteria during the maximum emissions phase, nominally 2067, once Mine operations move southward in the modelling scenario and UGM emissions have ceased.

All receptors except Doongmabulla (ID 6), including those at the proposed off-site mine infrastructure, comply with Air EPP $PM_{2.5}$ annual criterion.

Table 5-6 Start-Up Phase (2016) – Summary of Sensitive Receptor Predicted Daily $PM_{2.5}$ GLCs

ID	Name	Maximum Predicted Incremental $PM_{2.5}$ (24 hr avg) (µg/m³)	Background $PM_{2.5}$ (µg/m³)	Maximum Total $PM_{2.5}$ (24 hr avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	2.0	3.3	5.3	21
2	Bygana	2.4	3.3	5.7	23
6	Doongmabulla	6.4	3.3	9.7	39
17	Carmichael	4.0	3.3	7.3	29
18	Moray Downs	3.6	3.3	6.9	27
20	Cassiopeia	1.5	3.3	4.8	19
28	Beenboona	2.8	3.3	6.1	24
32	Lignum	3.2	3.3	6.5	26

ID	Name	Maximum Predicted Incremental $PM_{2.5}$ (24 hr avg) (µg/m³)	Background $PM_{2.5}$ (µg/m³)	Maximum Total $PM_{2.5}$ (24 hr avg) (µg/m³)	Percentage of EPP (%)
V1	Village NW corner	8.2	3.3	11.5	46
A1	Airport Terminal	16.3	3.3	19.6	78
I2	Industrial Zone NW corner	22.5	3.3	**25.8**	**103**

Note: Criterion = 25 µg/m³ (24 hour average)

Table 5-7 Full Operations Phase (2037) – Summary of Sensitive Receptor Predicted $PM_{2.5}$ GLCs

ID	Name	Maximum Predicted Incremental $PM_{2.5}$ (24 hr avg) (µg/m³)	Background $PM_{2.5}$ (µg/m³)	Maximum Total $PM_{2.5}$ (24 hr avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	9.3	3.3	12.6	50
2	Bygana	10.2	3.3	13.5	54
6	Doongmabulla	12.6	3.3	15.9	64
17	Carmichael	8.3	3.3	11.6	46
18	Moray Downs	7.6	3.3	10.9	43
20	Cassiopeia	5.9	3.3	9.2	37
28	Beenboona	5.8	3.3	9.1	36
32	Lignum	11.6	3.3	14.9	60
V1	Village NW corner	14.1	3.3	17.4	70
A1	Airport Terminal	28.3	3.3	**31.6**	126
I2	Industrial Zone NW corner	32.3	3.3	**35.6**	142

Note: Criterion = 25 µg/m³ (24 hour average)

Table 5-8 Maximum Emissions Phase (2067) – Summary of Sensitive Receptor Predicted Daily $PM_{2.5}$ GLCs

ID	Name	Maximum Predicted Incremental $PM_{2.5}$ (24 hr avg) (µg/m³)	Background $PM_{2.5}$ (µg/m³)	Maximum Total $PM_{2.5}$ (24 hr avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	14.0	3.3	17.3	69

2	Bygana	11.0	3.3	14.3	57
6	Doongmabulla	11.5	3.3	14.8	59
17	Carmichael	5.8	3.3	9.1	36
18	Moray Downs	7.1	3.3	10.4	42
20	Cassiopeia	6.3	3.3	9.6	38
28	Beenboona	5.6	3.3	8.9	36
32	Lignum	18.6	3.3	21.9	88
V1	Village NW corner	15.0	3.3	18.3	73
A1	Airport Terminal	26.5	3.3	**29.8**	119
I2	Industrial Zone NW corner	29.6	3.3	**32.9**	131

Note: Criterion = 25 µg/m³ (24 hour average)

Table 5-9 Start-Up Phase (2016) – Summary of Sensitive Receptor Predicted Annual $PM_{2.5}$ GLCs

ID	Name	Maximum Predicted Incremental $PM_{2.5}$ (Annual avg) (µg/m³)	Background $PM_{2.5}$ (µg/m³)	Maximum Total $PM_{2.5}$ (Annual avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	0.1	3.3	3.4	42
2	Bygana	0.1	3.3	3.4	42
6	Doongmabulla	1.9	3.3	5.2	65
17	Carmichael	0.7	3.3	4.0	51
18	Moray Downs	0.2	3.3	3.5	44
20	Cassiopeia	0.1	3.3	3.4	42
28	Beenboona	0.1	3.3	3.4	43
32	Lignum	0.1	3.3	3.4	42
V1	Village NW corner	0.5	3.3	3.8	47
A1	Airport Terminal	1.2	3.3	4.5	56
I2	Industrial Zone NW corner	1.8	3.3	5.1	64

Note: Criterion = 8 µg/m³ (Annual average)

Table 5-10 Full Operations Phase (2037) – Summary of Sensitive Receptor Predicted Annual $PM_{2.5}$ GLCs

ID	Name	Maximum Predicted Incremental $PM_{2.5}$ (Annual avg) (µg/m³)	Background $PM_{2.5}$ (µg/m³)	Maximum Total $PM_{2.5}$ (Annual avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	0.4	3.3	3.7	46
2	Bygana	0.3	3.3	3.6	46
6	Doongmabulla	4.7	3.3	8.0	100
17	Carmichael	1.8	3.3	5.1	64
18	Moray Downs	0.7	3.3	4.0	50
20	Cassiopeia	0.2	3.3	3.5	44
28	Beenboona	0.4	3.3	3.7	46
32	Lignum	0.5	3.3	3.8	47
V1	Village NW corner	1.5	3.3	4.8	60
A1	Airport Terminal	2.7	3.3	6.0	75
I2	Industrial Zone NW corner	3.3	3.3	6.6	82

Note: Criterion = 8 µg/m³ (Annual average)

Table 5-11 Maximum Emissions Phase (2067) – Summary of Sensitive Receptor Predicted Annual $PM_{2.5}$ GLCs

ID	Name	Maximum Predicted Incremental $PM_{2.5}$ (Annual avg) (µg/m³)	Background $PM_{2.5}$ (µg/m³)	Maximum Total $PM_{2.5}$ (Annual avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	0.6	3.3	3.9	49
2	Bygana	0.6	3.3	3.9	48
6	Doongmabulla	3.4	3.3	6.7	84
17	Carmichael	1.3	3.3	4.6	57
18	Moray Downs	0.8	3.3	4.1	51
20	Cassiopeia	0.2	3.3	3.5	44
28	Beenboona	0.4	3.3	3.7	46
32	Lignum	0.7	3.3	4.0	50

V1	Village NW corner	1.6	3.3	4.9	61
A1	Airport Terminal	2.7	3.3	6.0	75
I2	Industrial Zone NW corner	3.3	3.3	6.6	82

Note: Criterion = 8 µg/m³ (Annual average)

5.4 Assessment of Ambient TSP Levels

Ambient TSP levels have been assessed with regards to the Air EPP regulations, which are assessed against a maximum ambient level criterion of 90 µg/m³ (including background), annually averaged. There is no exceedance allowance for this assessment criterion.

A constant 70th percentile background level of 22 µg/m³ has been added to the predicted incremental TSP GLCs. Results at the identified highest existing and future off-site infrastructure sensitive receptors for the TSP assessment for the start-up, full operations and maximum emission phases of the mine are shown in Table 5-12, Table 5-13 and Table 5-14 respectively. For all three phases, all of the identified sensitive receptors were compliant with the annual average criterion.

Table 5-12 Start-Up Phase (2016) – Summary of Sensitive Receptor Predicted TSP GLCs

ID	Name	Maximum Predicted Incremental TSP (Annual avg) (µg/m³)	Background TSP (µg/m³)	Maximum Total TSP (Annual avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	0.1	22.0	22.1	25
2	Bygana	0.2	22.0	22.2	25
6	Doongmabulla	4.1	22.0	26.1	29
17	Carmichael	1.5	22.0	23.5	26
18	Moray Downs	0.4	22.0	22.4	25
20	Cassiopeia	0.1	22.0	22.1	25
28	Beenboona	0.3	22.0	22.3	25
32	Lignum	0.2	22.0	22.2	25
V1	Village NW corner	1.0	22.0	23.0	26
A1	Airport Terminal	2.5	22.0	24.5	27
I2	Industrial Zone NW corner	4.1	22.0	26.1	29

Note: Criterion = 90 µg/m³ (Annual average)

Table 5-13 Full Operations Phase (2037) – Summary of Sensitive Receptor Predicted TSP GLCs

ID	Name	Maximum Predicted Incremental TSP (Annual avg) (µg/m³)	Background TSP (µg/m³)	Maximum Total TSP (Annual avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	0.8	22.0	22.8	25
2	Bygana	0.7	22.0	22.7	25
6	Doongmabulla	10.2	22.0	32.2	36
17	Carmichael	3.8	22.0	25.8	29
18	Moray Downs	1.5	22.0	23.5	26
20	Cassiopeia	0.4	22.0	22.4	25
28	Beenboona	0.9	22.0	22.9	25
32	Lignum	1.0	22.0	23.0	26
V1	Village NW corner	3.2	22.0	25.2	28
A1	Airport Terminal	5.8	22.0	27.8	31
I2	Industrial Zone NW corner	7.4	22.0	29.4	33

Note: Criterion = 90 µg/m³ (Annual average)

Table 5-14 Maximum Emissions Phase (2067) – Summary of Sensitive Receptor Predicted TSP GLCs

ID	Name	Maximum Predicted Incremental TSP (Annual avg) (µg/m³)	Background TSP (µg/m³)	Maximum Total TSP (Annual avg) (µg/m³)	Percentage of EPP (%)
1	Mellaluka	1.3	22.0	23.3	26
2	Bygana	1.2	22.0	23.2	26
6	Doongmabulla	7.6	22.0	29.6	33
17	Carmichael	2.8	22.0	24.8	28
18	Moray Downs	1.7	22.0	23.7	26
20	Cassiopeia	0.4	22.0	22.4	25
28	Beenboona	0.9	22.0	22.9	25
32	Lignum	1.5	22.0	23.5	26

V1	Village NW corner	3.4	22.0	25.4	28
A1	Airport Terminal	5.8	22.0	27.8	31
I2	Industrial Zone NW corner	7.3	22.0	29.3	33

Note: Criterion = 90 µg/m³ (Annual average)

5.5 Assessment of Deposited Dust

Deposited dust has been assessed with regards to NSW Approved Methods (DEC, 2005), which specifies a maximum incremental deposited dust level of 2 g/m²/month (annually averaged). No background level has been applied as the criterion is of an incremental nature.

Results at the identified existing and future off-site infrastructure sensitive receptors with the highest deposited dust during the start-up, full operations and maximum emission phases of the mine are shown in Table 5-15. For all three phases, each of the sensitive receptors were significantly below the assessment criteria as deposited dust levels were found to decrease rapidly beyond their source. With the addition of a background dust deposition of a conservative 1.6 g/m^2/month, deposited dust at all sensitive receptors is compliant with the 2 g/m²/month (annually averaged) criterion.

Table 5-15 Summary of Sensitive Receptor Predicted Incremental Deposited Dust

ID	Name	Predicted Incremental Deposited Dust (Annual average) (g/m²/month)		
		Start Up	Full Operations	Maximum Emissions
1	Mellaluka	0.001	0.004	0.012
2	Bygana	0.001	0.005	0.012
6	Doongmabulla	0.041	0.110	0.075
17	Carmichael	0.016	0.032	0.021
18	Moray Downs	0.003	0.009	0.010
20	Cassiopeia	0.002	0.007	0.007
28	Beenboona	0.003	0.012	0.012
32	Lignum	0.001	0.005	0.022
V1	Village NW corner	0.005	0.016	0.015
A1	Airport Terminal	0.024	0.038	0.038
I2	Industrial Zone NW corner	0.123	0.322	0.188

Note: Criterion = 2 g/m²/month (Annual average)

5.6 Flora and Fauna Impacts

The pollutants of interest in this assessment are related to dust. In the Air EPP, all 'dust' indicators are concerned with impacts associated with 'health and wellbeing' (of humans). Impacts to flora and fauna are captured in the Air EPP under the clauses that protect the health and biodiversity of ecosystems (7 a) and the agricultural use of the environment (7 b).

A discussion relating to impacts of dust generation on flora and fauna is provided in Volume 4 Appendix N Mine Terrestrial Ecology Report and Appendix O Mine Aquatic Ecology Report.

5.7 Management and Mitigation

5.7.1 Best Practice Dust Control

The following best practice dust control measures should be employed, where practical:

- Disturb only the minimum area necessary for mining
- Reshape topsoil and rehabilitate completed overburden dumps as soon as practicable
- Revegetate long term stockpiles not regularly used
- Clearly define edges of haul roads and designated paths on overburden dumps
- Revegetate dis-used haul roads
- Minimise hauling distance
- Set appropriate vehicle speed limits
- Limit the number of minor roads
- Water frequently used minor roads and if possible, seal
- Assess meteorological conditions prior to any blasting and delay (if possible) during periods of higher wind speeds
- Limit the activities and drop heights of draglines (if possible) during periods of high wind speed

5.7.2 Dust Monitoring

Dust monitoring will be undertaken to determine whether predicted emissions levels occur. In order to monitor background dust levels, a system of dust monitors will be installed upwind and downwind of the Project (Mine). Dust monitors will also be installed at sensitive receptors predicted to receive dust levels close to or reaching the EPP Air objectives. Dust monitoring will also be performed in the industrial area. By monitoring dust upwind of the Project (Mine), downwind of the Project (Mine) and at sensitive receptor locations, dust impacts will be quantified. The Carmichael AWS will record local wind conditions at Project (Mine) during a high-dust event. Management measures will be applied to mitigate emissions impacts wherever a criterion is shown to be exceeded.

5.7.3 Further Mitigation

The control measures applied to the potential emissions from the Mine operations are considered to be near to the maximum that could be practicably applied to a mine of such large capacity and physical size. These measures have been found to be sufficient for all phases of the Mine except the maximum emissions phase, which is marginal for some areas just beyond the site boundary. This is reflected in the predicted elevated dust levels at the proposed off-site industrial area to the east of the

Mine, adjacent to the railway line. Predicted PM_{10} and $PM_{2.5}$ also approach or reach the EPP Air objective at a number of sensitive receptors during the Project (Mine) maximum emissions phase.

In the event that further control measures are required, increasing the conveyor system network and application of a filtration system to the underground mine venting are seen as potential measures.

Where dust monitoring indicates actual or potential exceedences of dust criterion at any of the sensitive receptors, additional mitigation measures may include:

- Increased use of conveyors rather than trucks to move coal
- Use of conveyors to haul a proportion of overburden
- Sealing of haul roads with bitumen or similar
- Implementation of a dust management plan including the use of a meteorological forecasting system coupled with a dust impact index for the management and control of significant dust sources during adverse conditions

Increased use of conveyors for coal and overburden haulage would be expected to produce a substantial reduction in emissions. Such a system would entail the coal conveyor system being integrated into the OCM pits as currently exists in other coal mines, e.g. Loy Yang OCM in the Latrobe Valley, Victoria. As the amount of overburden removed is far greater than the amount of coal being extracted, estimated to be in excess of five to one in the year 2067, a substantial reduction in dust emissions due to haulage would be obtained.

6. Conclusion

The Project (Mine) has an expected operational life of 90 years during which a mixture of underground and open-pit mining operations will occur and significant dust generating potential exists.

The Air EPP defines air quality objectives such that indicator pollutants do not adversely affect environmental values. The indicators relevant to the Project (Mine) are Particulate Matter (total suspended particulate – TSP, PM_{10} and $PM_{2.5}$) with health and wellbeing of humans being the environmental value of concern. It is the concentrations of particulate matter at locations where people are likely to occupy for extended periods of time that define the air quality impact of the objectives of the Air EPP. Locations inside the Mine site perimeter are therefore excluded from assessment.

Existing environmental conditions were defined for background (or ambient) dust levels and dispersion meteorology. Available background data assessed was concerned with PM_{10} and dust deposition rates from similar exposed central Queensland mining areas (Bowen Basin). Comparable background information for TSP and the finer $PM_{2.5}$ dust fractions were derived by use of dust fraction ratios.

Dispersion meteorology characteristics are driven by the various climatic indicators. Climatically, the inland areas surrounding the Project Area can be described as ‘subtropical’ with a sub-classification of ‘moderately dry winter’. The prevailing wind directions have a strong easterly component associated with the trade winds. A derived dispersion modelling dataset for the Mine site using the prognostic meteorological model MM5 and further enhanced by the diagnostic model CALMET was found to be site-representative for the Project.

Air emissions during the operation of the open cut and underground mines have been estimated using standard techniques from the Australian National Pollutant Inventory and the USEPA AP-42 database. The estimates relied heavily on the information provided by the client in the mine plan (Runge Limited 2011).

Dust was modelled from the entire mine site as emanating from a total of 51 individual mining activity sources and 35 area sources associated with wind dependent wind erosions. The regulatory dispersion model CALPUFF was used for this purpose involving area and volume sources as appropriate. In addition to predicting ambient levels of particulate matter, dust deposition was also assessed. For completeness, dust emissions from the coal train hauling to the east of the Mine site were included. It was found that the greatest single source of dust emissions is from haul trucks and being responsible for over 75 per cent of dust emissions due to active coal production.

Dispersion modelling was established for the three phases of the life of the Mine determined to be worst-case scenarios – start-up, full operations and maximum emissions. In the Mine plan (Runge Limited 2011), these had nominal operating years of 2016, 2037 (both the underground and open-pit mining are at full operations) and 2067 (not the year of maximum output of coal but representative of maximum amount of dust being emitted due to overburden stripping).

The air quality assessment required the estimation of maximum ground level concentrations and monthly average dust deposition values at the nearest sensitive receptors with a total of nine offsite existing sensitivity receptor locations being identified. Future sensitive receptors were identified as the off-site Workers accommodation village, airport and industrial area.

Ambient PM_{10} levels have been assessed to Air EPP regulations with a criterion of 50 µg/m³ (including background) averaged over 24 hours. Results at the existing offsite sensitive receptors for the start-up, full operations and maximum emission phases of the mine show worst case impacts do not exceed the criterion. However, results did indicate that the criterion is reached at the Lignum receptor during the maximum emissions phase of the Project (Mine). Results for the proposed location of the workers village are compliant with Air EPP objectives for all mine phases. However, areas of the proposed industrial and airport zones are predicted to have increasing levels of dust as the mine capacity is increased. Non-compliance with Air EPP objectives in these zones is predicted for full operations and maximum emission phases of the mine. Contour plots of predicted maximum 24 hour average PM_{10} GLCs for the three phases of the Mine indicate that the criterion is not complied with at all locations beyond the Mine boundary. However, the extent of the non-compliance in uninhabited areas is considered manageable during the start-up phase of the mine. By the time of full mine operations the extent of the nominal non-compliance has grown substantially in all directions (and potentially to one sensitive receptor location), but mostly further towards the south as the southern open-cut pits become more active, and along the rail corridor.

For averaged $PM_{2.5}$ levels, all existing off-site sensitive receptors were equal or below the assessment criteria with Doongmabulla (ID 6) to the west, equalling the annual average criterion for the full operations phase when it is effected by the ventilation emissions from the underground mine infrastructure. Later on, during the maximum emissions phase, the predicted annual average $PM_{2.5}$ levels are at least 16 per cent below the criterion when the underground mine emissions have ceased and the active open-cut pits have moved to the south. For the proposed workers accommodation village site, all $PM_{2.5}$ levels were below regulatory requirements. However, areas of the proposed industrial area and permanent airport were predicted to have exceedances of the regulatory objectives for the 24 hour averaged criterion. No exceedances of the annual $PM_{2.5}$ criterion were predicted at any of the proposed off-site infrastructure.

Ambient TSP levels have been assessed for all three phases, and it was found that all of the identified off-site sensitive receptors, including those of the proposed off-site infrastructure, were compliant with the annual average criterion. Deposited dust levels were found to decrease rapidly beyond their source so that at all offsite sensitive receptor locations rates were significantly below the assessment criteria.

The impact assessment has demonstrated that the dust impacts are consistent with the goals of the Air EPP. This is with respect to human health effects at 'remote' off-site receptor locations. Dust impacts beyond the site boundary may require management at the peak production phases of the mine life. In the event that further control measures are required, the simple dust management tool of ambient air quality and dust deposition monitors being installed to quantify the actual dust impacts near the site boundaries can be used to quantify actual dust impacts rather than the theoretical levels assessed in this report. A system of monitors can be installed in which up-wind stations measure background dust levels, while down-wind stations are able to quantify the impact from mine operations. If dust levels are demonstrated to be significantly detrimental due to mining operations beyond the site boundary additional options for reducing emissions include:

- Increased use of conveyors rather than trucks to move coal
- Use of conveyors to haul a proportion of overburden
- Sealing of haul roads with bitumen or similar
- Implementation of a dust management plan including the use of a meteorological forecasting system coupled with a dust impact index for the management and control of significant dust sources during adverse conditions.

7. References

Argus Media, 2011, BHP Billiton prepares for Illawarra coal upgrade. Available from: http://www.argusmedia.com/pages/NewsBody.aspx?id=774760&menu=yes (Accessed 10.12.11).

Atmospheric Studies Group (ASG), 2011, MM5 World Wide Data, TRC. Available from: http://www.src.com/mm5/MM5_Main_Page.html (Accessed 15.12.11).

Buonicore and Davis, 1992, 'Fugitive Emissions' in Air Pollution Engineering Manual, Ed. A. J. Buonicore and W. T. Davis, Air & Waste Management Association, New York, 1992.

Bureau of Meteorology (BOM), 2007, Climate Statistics For Australian Locations. Available from: http://www.bom.gov.au/climate/cdo/about/definitionstemp.shtml (Accessed 24.06.11).

Connell-Hatch, 2008, Final Report Environmental Evaluation of Fugitive Coal Dust Emission from Coal Trains Goonyella, Blackwater and Moura Coal Rail Systems. Queensland Rail Limited, 31 March 2008 Revision 1. Reference H327578-N00-EE00.00.

Department of Environment and Conservation (NSW) (DEC), 2005, Approved Methods for the Modelling and Assessment of Air Pollutants. Available from: http://www.environment.nsw.gov.au/resources/air/ammodelling05361.pdf (Accessed 11.09.2012).

DERM, 2004, Guideline – Odour Impact Assessment from Developments. Queensland Government. Environmental Protection Agency. Document No. 040720. 20 July 2004. Available from: http://www.derm.qld.gov.au/register/p01344aa.pdf (Accessed 11.09.2012).

DERM, 2010, Townsville Dust Monitoring Program, March 2008 to December 2009, Air Quality Sciences, Department of Environment and Resource Management, State of Queensland, March 2010.

DERM, 2011, Queensland 2010 air monitoring report, Air Quality Sciences, Department of Environment and Resource Management, State of Queensland, June 2011.

Environment Protection (Air) Policy 2008. Queensland Government.

Environment Protection Act 1994. Queensland Government.

Gassman, 2012. Carmichael Community Land Use Study. Lot 662 on Crown Plan PH1491 'Moray Downs'. Prepared by Gassman Development Perspectives Pty Ltd. for Adani Mining Pty Ltd. July 2012.

Katestone, 2006. Air Quality Impact Assessment Study of the Proposed Ensham Central Project, Katestone Environmental, Toowong, May 2006.

Ministry for Environment (New Zealand), 2001, Good practice guide for assessing and managing the environmental effects of dust emissions. Available from: http://www.mfe.govt.nz/publications/air/dust-guide-sep01.pdf (Accessed 11.09.2012).

NEPC, 2002, Impact Statement for $PM_{2.5}$ Variation, National Environment Protection (Ambient Air Quality) Measure, National Environment Protection Council, October 2002.

National Pollution Inventory (NPI), 2011, Emission Estimation Technique Manual for Mining, Version 3.0, National Pollutant Inventory, Canberra, June 2011.

PAE-Holmes, 2010, Air Quality impact assessment – BHP Billiton Illawarra Coal – Ventilation Shaft No.6 Project, October 2010.

PAE-Holmes, 2011, China First Project EIS - Air Quality Assessment, Waratah Coal, August 2011.

PSU/NCAR, 2008, Pennsylvania State University/ National Centre for Atmospheric Research - MM5 Community Model. Available from: http://www.mmm.ucar.edu/mm5/ (Accessed 15.12.11).

Runge Limited, 2011, Carmichael Coal Project Macro-conceptual Mine Plan. Report prepared for Adani Mining Limited.

Steimel, A., 2008, Electric Traction – Motive Power and Energy Supply, Basics and Practical Experience. Oldenbourg Industrieverlag GmbH. Munich 2008.

Stern, H., Hoedt, G., & Ernst, J., 2000. Objective Classification of Australian Climates. Australian Meteorological Magazine, 49(2), p. 87-96.

United States Environmental Protection Agency (US EPA), 2011, CALPUFF Regulatory Updates and Consequence Analysis, Available from: http://www.epa.gov/ttn/scram/dispersion_prefrec.htm (Accessed 15.12.11).

URS, 2009, Caval Ridge Air Quality Impact Assessment - Technical Report. Available from: http://www.bhpbilliton.com/home/aboutus/regulatory/Documents/creisAppLAirQualityReport.pdf (Accessed 11.09.2012).

Appendix A
Terms of Reference Cross Reference

Page intentionally left blank

Terms of Reference Cross Reference

Terms of Reference Requirement/Section Number	Cross-reference
3.5.1 Description of Environmental Values	
Discuss the existing air shed environment, both local and regional, including: ◗ background levels and sources of particulates, gaseous and odorous compounds and any major constituent	Section 3.2
◗ pollutants including greenhouse gases which may be affected by the project	Section 3.2, See Volume 4 Appendix T for GHG
◗ baseline monitoring results	Section 3.4
◗ gathering data on local meteorology and ambient levels of pollutants to provide a baseline for later studies or for modelling air quality environmental harms.	Section 3.3
3.5.2 Potential Impacts and Mitigation Measures	
For air quality impacts and their mitigation:	
◗ include an inventory of air emissions from the project expected during construction and operational activities	Section 4.2, 4.3, 4.3.4
◗ accurately describe the activities carried out on the site; include a process flow diagram clearly showing all unit operations to be carried out on the premises; and provide a detailed discussion of all unit operations	Section 4.3.3
◗ describe all pollution control equipment and pollution control techniques employed on the premises and the features of the proposal designed to suppress or minimise emissions, including dusts	Section 4.6
◗ describe the back-up measures that will act in the event of primary measures failing, to minimise the likelihood of upsets and adverse air impacts	Section 5.7.3
◗ provide an air emission inventory of the proposed site for all potential points, area and volume sources including fugitive emissions of dusts; provide a complete list of emissions to the atmosphere including SOx, NOx, CO2 , particulates, PM10 and PM2.5	Sections 4.7
◗ identify all expected emissions of the hazardous air pollutants and their emissions from known and fugitive sources	Section 4.7
◗ estimate emission rates, based on actual measurements of samples taken from similar facilities—either full-scale facilities operating elsewhere, or experimental or demonstration-scale facilities. Where this is not possible, use published emission factors and/or data supplied by manufacturers of process and control equipment	Section, 4.7.4
◗ provide an impact assessment with relevant inputs of emissions and local meteorology to an air dispersion model to estimate the likely impacts on the surrounding environment. The model inputs should be as detailed as possible, reflecting any variation of emissions with time and including at least a full year of representative hourly meteorological data.	Section 5
◗ Estimate maximum ground level concentration and monthly average dust deposition values at the nearest sensitive receptor(s).	Section 4.7.4

Terms of Reference Requirement/Section Number	Cross-reference
◗ Present the results of the dispersion modelling as concentration contour plots and concentrations at the discrete sensitive receptors. The predicted ground level concentration should be made for both normal and expected maximum emission conditions and the worst case meteorological conditions should be identified and modelled where necessary	Figure 5-2 Figure 5-3 and Figure 5-4
◗ describe the background ambient air concentration from the existing sources in the airshed and evaluate the cumulative impact on the receiving environment. Address both acute and cumulative impacts by considering the project in conjunction with existing and known future emission sources within the region	Section 4.5
◗ provide an averaging period for ground level concentrations of pollutants that are modelled. This should be consistent with the relevant averaging periods for air quality indicators and goals in the EPP (Air) and the National Environment Protection (Ambient Air Quality) Measure 1998. For example, the modelling of PM10 must be conducted for 1 hour, 24 hours and annual averaging periods	Section 4.6
◗ identify the worst case meteorological conditions based on the modelled ground level predictions and, using this information, develop dust mitigation measures for the mining activities.	Section 4.4.3
◗ Describe the dust management plan that will be employed to mitigate adverse air impacts under the worst meteorological conditions	Section 5.7
◗ discuss the limitations and accuracy of the applied atmospheric dispersion models. The air quality modelling results should be discussed in light of the limitations and accuracy of the applied models	Section 4.4
◗ where there is no single atmospheric dispersion model that can handle the different atmospheric dispersion characteristics exhibited in the proposal area (e.g. sea breezes, strong convection, terrain features, temperature inversions and pollutant re-circulation), a combination of acceptable models will need to be applied	N/A
◗ identify 'worst case' emissions that may occur during operation. If these emissions are significantly higher than those for normal operations, it will be necessary to evaluate the worst-case impact as a separate exercise to determine whether the planned buffer distance between the facility and neighbouring sensitive receptors will be adequate	Section 4.4
◗ ground level predictions should be made at any sensitive receptor including proposed accommodation camps and any residential, industrial, agricultural, commercial and community developments believed to be sensitive to the effects of predicted emissions	Section 4.3
◗ discuss dust generation from construction activities, especially in areas where construction activities are adjacent to existing road networks or are in close proximity to sensitive receivers	Section 4.3.4
◗ discuss climatic patterns that could affect dust generation and movement	Section 3.3.1
◗ discuss vehicle emissions and dust generation along major road and rail haulage routes both internal and external to the project site	Section 4.3.7, 4.3.11
◗ assess human health risk associated with emissions from the facility of all hazardous or toxic pollutants	Section 4.4
◗ discuss impacts on terrestrial flora and fauna	Section 5.6

Terms of Reference Requirement/Section Number	Cross-reference
◗ Discuss potential air quality impacts from emissions with reference to the National Environment Protection (Ambient Air Quality) Measure 1998 and the EPP (Air).	Section 5
◗ If an emission is not addressed in these legislative instruments, the emission should be discussed with reference to its risks to human health, including appropriate health-based guidelines/standards.	N/A
To ensure that appropriate coal rail transport-related dust mitigation measures are implemented at the project, the proponent should consult with QR National's Network Division to determine the likely requirements for new or upgraded coal-loading facilities, load controls and spray-on coal dust suppressant systems as a result of implementing the Transitional Environmental Program and QR Coal Dust Management Plan across all coal railways in Queensland.	See Volume 4 Appendix AD

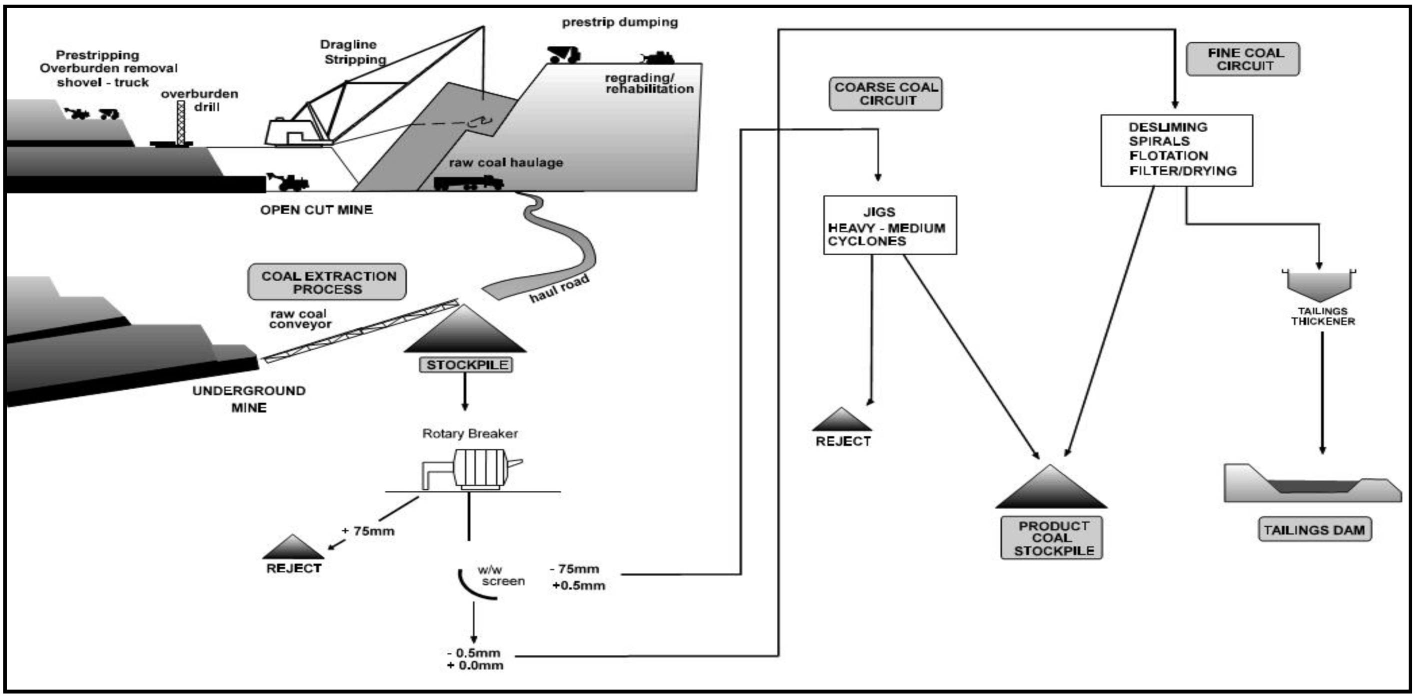
Appendix B

Mine Operations Emissions Estimates

Emissions Inventory Calculations

Page intentionally left blank

A1.0 Process Flow Diagram



A1.1 Blasting

Emissions from blasting were estimated using the following equation:

$$E_i = n\,EF_i$$

where

E_i = emission rate of species i (kg/y)

n = number of blasts per year (blasts/y)

EF_i = Uncontrolled emissions factor for species i (kg/blast)

The number of blasts per year, n, was assumed to be 182.5, or one every second day.

The uncontrolled emission factor for TSP was calculated using NPI (2011, equation 19, p.51):

= 0.00022 = 0.00022[kg/blast]

where

A = blast area, assumed to be 2000 m².

PM_{10} was assumed to be 52 per cent of TSP, as per NPI (2011).

$PM_{2.5}$ was assumed to be 50 per cent of PM_{10}.

Blasting emissions were modelled as evenly distributed throughout the year and across active OCM pit sources.

A1.2 Draglines

Emissions from dragline operations on overburden were estimated using the default equation:

EF_{TSP} = 0.06 [kg/bcm]

= bcm ×

where

bcm = number of bank cubic metres of overburden removed per year (bcm/y)

The number of bank cubic metres of overburden assumed removed per year are:

- Start-up phase: 13,602,129 bcm/y
- Full operations phase: 60,000,000 bcm/y
- Maximum emissions phase: 81,554,839 bcm/y

The default uncontrolled emission factor for TSP as per NPI (2011, p.44) was used as specific information regarding drop height was not known.

PM_{10} was assumed to be 43 per cent of TSP, as per NPI (2011, p.45).

$PM_{2.5}$ was assumed to be 11.6 per cent of TSP.

Dragline emissions were modelled as evenly distributed throughout the year and across active OCM pit sources.

A1.3 Graders

Emissions from grader operations were estimated using the following equation:

= VKT × where

E_i = emission rate of species i (kg/y)

VKT = number of vehicle kilometres travelled per year (VKT/y)

EF_i = Uncontrolled emissions factor for species i (kg/VKT)

The number of VKT's for the graders was based on an assumed mean vehicle speed of 5 km/h and the total number of operational hours graders were to operate, as detailed in the mine plan (Runge Limited 2011, Appendix K). The operational grader hours per year for each phase of the mine are summarised as:

- Start-up phase: 23,271 h/y
- Full operations phase: 47,554 h/y
- Maximum emissions phase: 64,412 h/y

The uncontrolled emission factors for TSP and PM_{10} used the specified vehicle speed related equations as per NPI (2011, p.56).

EF_{TSP} = 0.0034 $S^{2.5}$ [kg/VKT]

EF_{PM10} = 0.0034 $S^{2.0}$ [kg/VKT]

where

S = vehicle speed in km/h.

$PM_{2.5}$ was assumed to be 18.3 per cent of TSP, which is the average of site specific overburden measurements (11.6 per cent) and coal (25 per cent).

Grader emissions were modelled as evenly distributed throughout the year and across active OCM pits and waste dump sources.

A1.4 Shovel Excavators on Overburden

Emissions from shovel excavator operations inside the pit to load haul trucks with overburden were estimated using the following equation:

$$E_i = (bcm \times \rho) \times EF_i$$

where

E_i = emission rate of species i (kg/y)

bcm = number of bank cubic metres of overburden removed per year (bcm/y)

ρ = nominal overburden density, assumed to be 1.4 tonne/bcm.

EF_i = Uncontrolled emissions factor for species i (kg/tonne)

The number of bcm's of overburden removed from the pits – to access the coal reserves – was based on details in the mine plan (Runge Limited 2011). The overburden volume (bcm's) per year for each phase of the mine are:

- Start-up phase: 120,000,000 bcm/y
- Full operations phase: 195,000,000 bcm/y
- Maximum emissions phase: 240,000,000 bcm/y

The uncontrolled emission factors for TSP and PM_{10} used the specified site average wind speed, U (m/s), and soil moisture content, M (%), related equations as per NPI (2011, p.46).

$$EF_{TSP} = 0.74 \times 0.0016 \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2.0}\right)^{-1.4} \text{ [kg/tonne]}$$

$$EF_{PM10} = 0.35 \times 0.0016 \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2.0}\right)^{-1.4} \text{ [kg/tonne]}$$

where

U = average wind speed of 2.64 m/s (From CALMET Modelling).

M = soil moisture content of 2 per cent by weight (PAE-Holmes, 2011, p.A-7).

$PM_{2.5}$ was assumed to be 11.6 per cent of TSP

Shovel excavator emissions were modelled as evenly distributed throughout the year and across active OCM pits sources.

A1.5 Shovel Excavators on Coal

Emissions from shovel excavator operations inside the pit to load haul trucks with coal can be estimated using the following equations:

EF_{TSP} = 0.580 × $(M)^{-1.2}$ [kg/tonne]

EF_{PM10} = 0.441 × $(M)^{-0.9}$[kg/tonne]

where

M = total mass of coal (in tonnes) removed per year (tonne/y)

The number of tonnes of coal removed from the pits was based on details in the mine plan (Runge Limited 2011). The coal extraction rate per year for each phase of the mine are summarised below:

- Start-up phase: 8,581,323 tonne/y
- Full operations phase: 41,936,357 tonne/y
- Maximum emissions phase: 63,919,589 tonne/y

The usage of the equations from above was examined to be consistent with the removal of overburden, however, the results of the equations for coal produced illogical results. With a coal site specific moisture content of 16 per cent, the equations specified in NPI (2011) indicated that PM_{10} emissions were greater than TSP. Therefore, the uncontrolled emission factors for TSP and PM_{10} used the default values as per NPI (2011, p.15).

EF_{TSP} = 0.029 [kg/tonne]

EF_{PM10} = 0.014 kg/tonne]

$PM_{2.5}$ was assumed to be 25 per cent of TSP

Shovel excavator emissions were modelled as evenly distributed throughout the year and across active OCM pits sources.

A1.6 Bulldozers on Overburden

Emissions from bulldozer operations inside and outside of the OCM pits on overburden were estimated using the following equation:

= n ×

where

E_i = emission rate of species i (kg/y)

n = total number of operational hours of all bulldozers per year (veh.h/y)

EF_i = Uncontrolled emissions factor for species i (kg/veh.h)

The total number of hours of bulldozer operations on overburden was based on details in the mine plan (Runge Limited 2011). The operational hours per year for each phase of the mine are summarised below:

- Start-up phase: 63,315 veh.h/y
- Full operations phase: 120,814 veh.h/y
- Maximum emissions phase: 151,658 veh.h/y

The uncontrolled emission factors for TSP and PM_{10} used the specified site silt content, s (%), and soil moisture content, M (%), EF_i, related equations as per NPI (2011, p.48).

$EF_{TSP} = 2.6\,(s)^{1.2}(M)^{-1.3}$ [kg/veh.hr]
$EF_{PM10} = 0.34\,(s)^{1.5}(M)^{-1.4}$ [kg/veh.hr]

where

s = average overburden silt content of 7.7 precent (Site specific soil testing).

M = soil moisture content of 2 per cent by weight (PAE-Holmes, 2011, p.A-7).

$PM_{2.5}$ was assumed to be 11.6 per cent of TSP

Bulldozer operation emissions on overburden were modelled as evenly distributed throughout the year and across active OCM pits and waste dump sources.

A1.7 Bulldozers on Coal

Emissions from bulldozer operations inside the OCM pits on coal were estimated using the following equation:

= n ×

where

E_i = emission rate of species i (kg/y)

n = total number of operational hours of all bulldozers per year (veh.h/y)

EF_i = Uncontrolled emissions factor for species i (kg/veh.h)

The total number of hours of bulldozer operations on coal was based on details in the mine plan (Runge Limited 2011). The operational hours per year for each phase of the mine are summarised below:

- Start-up phase: 33,446 veh.h/y
- Full operations phase: 111,292 veh.h/y
- Maximum emissions phase: 170,510 veh.h/y

The uncontrolled emission factors, EF_i, for TSP and PM_{10} used the specified site silt content, s (%), and soil moisture content, M (%), related equations as per NPI (2011, p.48).

EF_{TSP} = 35.6 $(s)^{1.2}(M)^{-1.4}$ [kg/hr]
EF_{PM10} = 6.33 $(s)^{1.5}(M)^{-1.4}$ [kg/hr]

where

s = average silt content of 7.7 precent (Assumed the same as the overburden).

M = soil moisture content of 16 per cent by weight (PAE-Holmes, 2011, p.A-7).

$PM_{2.5}$ was assumed to be 25 per cent of TSP

Bulldozer operation emissions on coal were modelled as evenly distributed throughout the year and across active OCM pits sources.

A1.8 Trucks Dumping Overburden

Emissions from haul trucks dumping overburden at the waste dumps were estimated using the following equation:

$E_i = (bcm \times \rho) \times EF_i$

where

E_i = emission rate of species i (kg/y)

bcm = number of bank cubic metres of overburden dumped per year (bcm/y)

ρ = nominal overburden density, assumed to be 1.4 tonne/bcm.

EF_i = Uncontrolled emissions factor for species i (kg/tonne)

The volume of overburden removed (bcm's) from the pits and dumped on the waste dumps was based on details in the mine plan (Runge Limited 2011). The overburden bcm's per year for each phase of the mine are summarised below:

- Start-up phase: 120,000,000 bcm/y
- Full operations phase: 195,000,000 bcm/y
- Maximum emissions phase: 240,000,000 bcm/y

The uncontrolled emission factors, EF_i, for TSP and PM_{10} used the default factors as per NPI (2011, p.49).

EF_{TSP} = 0.012 [kg/tonne]
EF_{PM10} = 0.0043 [kg/tonne]

$PM_{2.5}$ was assumed to be 11.6 per cent of TSP

Overburden dumping operation emissions were modelled as evenly distributed throughout the year and across active waste dump sources.

A1.9 Trucks Unloading Coal at ROM Pads

Emissions from haul trucks unloading coal at ROM pads were estimated using the following equation:

$E_i = M \times EF_i$

where

E_i = emission rate of species i (kg/y)

M = total mass of coal (in tonnes) removed per year (tonne/y)

EF_i = Uncontrolled emissions factor for species i (kg/tonne)

The number of tonnes of coal unloaded at all of the ROM pads from the pits was based on details in the mine plan (Runge Limited 2011). The coal extraction rate per year for each phase of the mine are summarised below:

- Start-up phase: 8,581,323 tonne/y
- Full operations phase: 41,936,357 tonne/y
- Maximum emissions phase: 63,919,589 tonne/y

The uncontrolled emission factors, EF_i, for TSP and PM_{10} used the default values as per NPI (2011, p.16).

EF_{TSP} = 0.004 [kg/tonne]
EF_{PM10} = 0.0017 [kg/tonne]

$PM_{2.5}$ was assumed to be 25 per cent of TSP

Coal unloading from truck emissions was modelled as evenly distributed throughout the year and across all active ROM pad sources.

It was assumed that each ROM pad would have dedicated coal feed systems whereby unloaded coal would be moved to the conveyor and sent to the main mine infrastructure for processing at the CHPP, thereby, minimising emissions through stockpiling at the outer ROM pads.

A1.10 Unloading Coal Stockpiles at ROM Pads

Emissions from unloading of coal stockpiles at ROM pads were estimated using the following equation:

$E_i = M \times EF_i$

where

E_i = emission rate of species i (kg/y)

M = total mass of coal (in tonnes) removed per year (tonne/y)

EF_i = Uncontrolled emissions factor for species i (kg/tonne)

The number of tonnes of coal unloaded at all of the ROM pads from the pits was based on details in the mine plan (Runge Limited 2011). The coal extraction rate per year for each phase of the mine are summarised below:

- Start-up phase: 8,581,323 tonne/y

- Full operations phase: 41,936,357 tonne/y
- Maximum emissions phase: 63,919,589 tonne/y

The uncontrolled emission factors, EF_i, for TSP and PM_{10} used the default values as per NPI (2011, p.16).

EF_{TSP} = 0.03 [kg/tonne]

EF_{PM10} = 0.013 [kg/tonne]

$PM_{2.5}$ was assumed to be 25 per cent of TSP.

Coal stockpile unloading emissions were modelled as evenly distributed throughout the year and across all active ROM pad sources.

It was assumed that all coal would be stockpiled at some stage and then loaded onto a conveyor for further processing. This is conservative to assume all the coal is stockpiled and re-processed.

A1.11 Loading Primary Crusher

Emissions from loading of the primary crusher at the CHPP was estimated using the following equation:

$E_i = M \times EF_i$

where

E_i = emission rate of species i (kg/y)

M = total mass of coal (in tonnes) process per year (tonne/y)

EF_i = Uncontrolled emissions factor for species i (kg/tonne)

The number of tonnes of coal processed by the primary crusher from the OCM pits and underground mine was based on details in the Mine plan (Runge Limited 2011). The coal extraction rate per year for each phase of the Mine are summarised below:

- Start-up phase: 15,821,280 tonne/y
- Full operations phase: 60,794,842 tonne/y
- Maximum emissions phase: 63,919,589 tonne/y

The uncontrolled emission factors, EF_i, for TSP and PM_{10} used the default values assuming that the primary crusher was being loaded by a front end loader as per NPI (2011, p.15, row 3).

EF_{TSP} = 0.029 [kg/tonne]

EF_{PM10} = 0.014 [kg/tonne]

$PM_{2.5}$ was assumed to be 25 per cent of TSP

Loading of the primary coal crusher was modelled as evenly distributed throughout the year and occurring at the Mine infrastructure area source, where the CHPP is to be located.

It was assumed that all coal would be processed by the primary crusher.

A1.12 Primary Crusher Emissions

Emissions from the primary crusher at the CHPP was estimated using the following equation:

$$E_i = M \times EF_i$$

where

E_i = emission rate of species i (kg/y)

M = total mass of coal (in tonnes) process per year (tonne/y)

EF_i = Uncontrolled emissions factor for species i (kg/tonne)

The number of tonnes of coal processed by the primary crusher from the OCM pits and underground Mine was based on details in the Mine plan (Runge Limited 2011). The coal extraction rate per year for each phase of the Mine are summarised below:

- Start-up phase: 15,821,280 tonne/y
- Full operations phase: 60,794,842 tonne/y
- Maximum emissions phase: 63,919,589 tonne/y

The uncontrolled emission factors, EF_i, for TSP and PM_{10} used the default values assuming that the coal was "high" in moisture as per NPI (2011, p.60) guidelines.

EF_{TSP} = 0.01 [kg/tonne]

EF_{PM10} = 0.004 [kg/tonne]

$PM_{2.5}$ was assumed to be 25 per cent of TSP.

The primary crusher was modelled as having operational hours evenly distributed throughout the year and occurring at the Mine infrastructure area source, where the CHPP is to be located.

It was assumed that all coal would be processed by the primary crusher.

A1.13 Secondary Crusher Emissions

Emissions from secondary crusher at the CHPP was estimated using the following equation:

$$E_i = M \times EF_i$$

where

E_i = emission rate of species i (kg/y)

M = total mass of coal (in tonnes) process per year (tonne/y)

EF_i = Uncontrolled emissions factor for species i (kg/tonne)

The number of tonnes of coal processed by the secondary crusher from the OCM pits and underground Mine was based on details in the Mine plan (Runge Limited 2011, p.110), which was indicated to be 35 per cent of the coal. The coal extraction rate per year for each phase of the Mine are summarised below:

- Start-up phase: 5,537,448 tonne/y
- Full operations phase: 21,278,195 tonne/y
- Maximum emissions phase: 22,371,856 tonne/y

The uncontrolled emission factors, EF_i, for TSP and PM_{10} used the default values assuming that the coal was "high" in moisture as per NPI (2011, p.60) guidelines.

EF_{TSP} = 0.03 [kg/tonne]
EF_{PM10} = 0.012 [kg/tonne]

$PM_{2.5}$ was assumed to be 25 per cent of TSP.

The secondary crusher was modelled as having operational hours evenly distributed throughout the year and occurring at the Mine infrastructure area source, where the CHPP is to be located.

It was assumed that 35 per cent of the coal would be processed by the secondary crusher.

A1.14 Tertiary Crusher Emissions

Emissions from tertiary crusher at the CHPP was estimated using the following equation:

$$E_i = M \times EF_i$$

where

E_i = emission rate of species i (kg/y)

M = total mass of coal (in tonnes) process per year (tonne/y)

EF_i = Uncontrolled emissions factor for species i (kg/tonne)

The number of tonnes of coal processed by the secondary crusher from the OCM pits and underground Mine was based on details in the Mine plan (Runge Limited 2011, p.110), which was indicated to be 7 per cent of the coal. The coal extraction rate per year for each phase of the Mine are summarised below:

- Start-up phase: 1,107,490 tonne/y
- Full operations phase: 4,255,639 tonne/y
- Maximum emissions phase: 4,474,371 tonne/y

The uncontrolled emission factors, EF_i, for TSP and PM_{10} used the default values assuming that the coal was "high" in moisture as per NPI (2011, p.60) guidelines.

EF_{TSP} = 0.03 [kg/tonne]
EF_{PM10} = 0.01 [kg/tonne]

$PM_{2.5}$ was assumed to be 25 per cent of TSP.

Tertiary crusher was modelled as having operational hours evenly distributed throughout the year and occurring at the Mine infrastructure area source, where the CHPP is to be located.

It was assumed that 7 per cent of the coal would be processed by the tertiary crusher.

A1.15 Overland Conveyor Emissions

Emissions from overland conveyors were estimated using the following equation:

$$E_i = M \times EF_i$$

where

E_i = emission rate of species i (kg/y)

M = total mass of coal (in tonnes) transported per year (tonne/y)

EF_i = Uncontrolled emissions factor for species i (kg/tonne)

The number of tonnes of coal transported by the overland conveyor from the outer ROM pads to the central Mine infrastructure from the OCM pits and underground Mine was based on details in the Mine plan (Runge Limited 2011). The coal extraction rate per year for each phase of the Mine are summarised below:

- Start-up phase: 15,821,280 tonne/y
- Full operations phase: 60,794,842 tonne/y
- Maximum emissions phase: 63,919,589 tonne/y

The uncontrolled emission factors, EF_i, for TSP and PM_{10} used the average wind speed and moisture content equations as per NPI (2011, p16).

$$EF_{TSP} = 0.74 \times 0.0016 \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2.0}\right)^{-1.4} \text{[kg/tonne]}$$

$$EF_{PM10} = 0.35 \times 0.0016 \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2.0}\right)^{-1.4} \text{[kg/tonne]}$$

where

U = average wind speed of 2.64 m/s. (From CALMET Modelling.)

M = soil moisture content of 16 per cent by weight (PAE-Holmes, 2011, p.A-7).

$PM_{2.5}$ was assumed to be 25 per cent of TSP.

Overland conveyor emissions were modelled as evenly distributed throughout the year and occurring at from all active OCM pits and waste dumps. This approach was selected as a separate area or line source did not need to be defined for such a relatively small amount of emissions, especially with applied enclosure controls.

It was assumed that all coal would be transported by the overland conveyor at some stage.

A1.16 Loading Coal to Trains

Emissions from loading trains with coal were estimated using the following equation:

$$E_i = M \times EF_i$$

where

E_i = emission rate of species i (kg/y)

M = total mass of coal (in tonnes) loaded to trains per year (tonne/y)

EF_i = Uncontrolled emissions factor for species i (kg/tonne)

The number of tonnes of coal loaded to trains at the central Mine infrastructure from the OCM pits and underground Mine was based on details in the Mine plan (Runge Limited 2011). The coal extraction rate per year for each phase of the Mine are summarised below:

- Start-up phase: 15,821,280 tonne/y
- Full operations phase: 60,794,842 tonne/y
- Maximum emissions phase: 63,919,589 tonne/y

The uncontrolled emission factors, EF_i, for TSP and PM_{10} used the default NPI (2011, p16) emissions factors.

$$EF_{TSP} = 0.0004 \text{ [kg/tonne]}$$

$$EF_{PM10} = 0.00017 \text{ [kg/tonne]}$$

$PM_{2.5}$ was assumed to be 25 per cent of TSP.

Train loading operations were modelled as evenly distributed throughout the year and occurring at the Mine infrastructure area. The exact location of the train load out facility was not known at the time of this assessment.

It was assumed that all coal would be transported away from site by train.

A1.17 Unpaved Haul Roads

Emissions from haul trucks travelling along unpaved haul roads were estimated using the following equation:

$$E_i = VKT \times EF_i$$

where

E_i = emission rate of species i (kg/y)

VKT = total vehicle kilometres travelled by all haul vehicles (in km) per year (VKT/y)

EF_i = Uncontrolled emissions factor for species i (kg/VKT)

The uncontrolled emission factors, EF_i, for TSP and PM_{10} used the as per NPI (2011, p.16) equations which relate to heavy vehicle movement at industrial sites.

$$EF_{TSP} = 1.38 \left(\frac{s}{12}\right)^{0.9} \left(\frac{W}{3}\right)^{0.45} \text{ [kg/VKT]}$$

$$EF_{PM10} = 0.42 \left(\frac{s}{12}\right)^{0.9} \left(\frac{W}{3}\right)^{0.45} \text{ [kg/VKT]}$$

where

s = average silt content of 7.7 precent. (Site specific soil testing.)

W = haul truck total mass (tonne).

It is assumed that the haul roads will not be on areas of coal.

$PM_{2.5}$ was assumed to be 11.6 per cent of TSP, based on site measurements of soil.

The NPI Mining (2011) emissions estimation equations separate emissions from heavy vehicles and light vehicles, with heavy vehicle movement generated dust emissions independent of vehicle speed and soil moisture content, unlike previous versions of the NPI Mining manual.

Haul truck movements were modelled as evenly distributed throughout the year and across all active OCM pits and waste dump sources as the exact location of the haul roads are not known. Furthermore, haul truck movement generated dust from within an OCM pit has been assumed to be "released from the pit" at ground level and in an homogenised state. The number of truck movements required to determine the total annual VKT were based on a 240 tonne fully loaded truck removing coal and overburden from the OCM pits and returning empty with a weight of 65 tonnes – a truck coal/overburden carrying capacity of 175 tonnes. Emission factors for both the fully loaded haul truck and empty returning haul truck were determined separately. An overall average dust emissions factor was determined from a weighted average of the amount of kilometres travelled (annually) of loaded and empty haul trucks.

The number of tonnes of coal and overburden required to be removed from the OCM pits was based on details in the Mine plan (Runge Limited 2011). The total earth extraction rate per year for each phase of the Mine are summarised below:

- Start-up phase:
  - Coal: 8,581,323 tonne/y
  - Overburden: 120,000,000 bcm/y
- Full operations phase:
  - Coal: 41,936,357 tonne/y
  - Overburden: 195,000,000 bcm/y
- Maximum emissions phase:
  - Coal: 63,919,589 tonne/y
  - Overburden: 240,000,000 bcm/y

A nominal overburden density of 1.4 tonne/bcm was assumed.

It was assumed that equal amounts of coal and overburden were removed from each of the active OCM pits for the Mine phases investigated. Estimates of the required VKTs were made based on the straight line distance between the centre of each of the active OCM pits and either the closest ROM pad (for coal) or the closest active waste dump (for overburden). A summary of the calculated VKTs for the each of the modelled Mine phases is given below.

- Start-up phase:
  - Coal haulage trips: 49,036 trips/y
  - Overburden haulage trips: 960,000 trips/y
  - Coal loaded VKT: 327,673 km/y
  - Overburden loaded VKT: 2,993,034 km/y
  - Coal total VKT: 655,345 km/y
  - Overburden total VKT: 5,986,068 km/y
- Full operations phase:
  - Coal haulage trips: 239,636 trips/y
  - Overburden haulage trips: 1,560,000 trips/y
  - Coal loaded VKT: 838,816 km/y
  - Overburden loaded VKT: 5,394,539 km/y
  - Coal total VKT: 1,677,632 km/y
  - Overburden total VKT: 10,789,079 km/y
- Maximum emissions phase:
  - Coal haulage trips: 365,255 trips/y
  - Overburden haulage trips: 1,920,000 trips/y
  - Coal loaded VKT: 1,391,531 km/y
  - Overburden loaded VKT: 6,661,239 km/y
  - Coal total VKT: 2,783,061 km/y
  - Overburden total VKT: 13,322,478 km/y

A1.18 Dust from Trains

Emissions from the wind erosion of coal from trains travelling along the railway were estimated using the following equation:

$$E_i = M \times D \times EF_i$$

where

E_i = emission rate of species i (g/y)

M = total amount of coal transported by train (tonnes) per year (tonne/y)

D = distance travelled by train (km)

EF_i = Uncontrolled emissions factor for species i (g/km/tonne)

The uncontrolled emission factor for TSP used the equation detailed in Connell-Hatch (2008).

EF_{TSP} = $0.0000378(V)^2 - 0.000126(V) + 0.000063$ [g/km/tonne of coal]

where

V = train speed (km/h).

The net load per train is 10,020 tonne of coal consisting of 120 wagons with maximum load per wagon of 85 tonne.

A 25 per cent spillage factor was applied to the emission factor EF_{TSP}. This represents fugitive coal and dust re-entrainment that is displaced from flat surfaces of the wagons and under-carriage that is deposited during the filling of coal wagons.

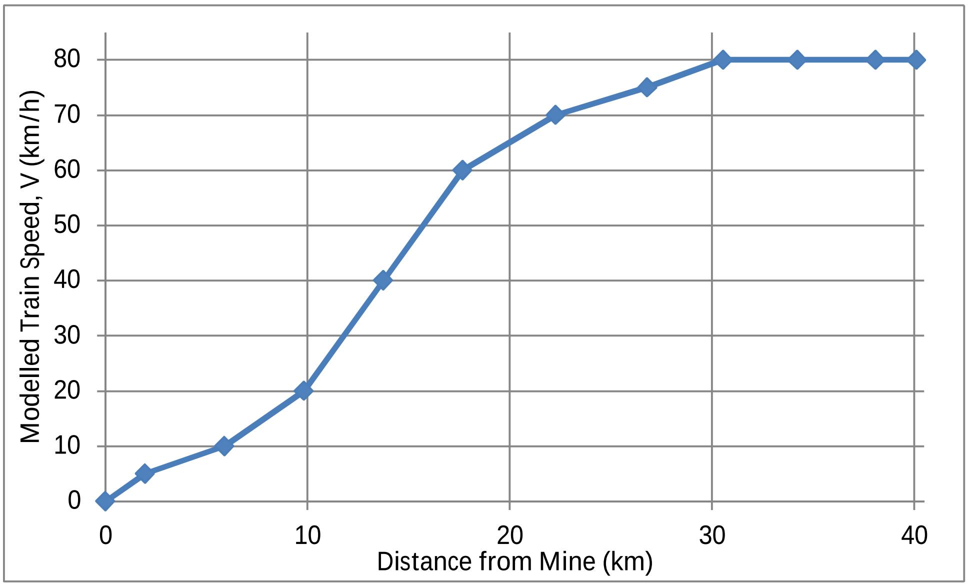
PM_{10} was assumed to be 50 per cent of TSP.

$PM_{2.5}$ was assumed to be 25 per cent of TSP.

The number of tonnes of coal transported by train from the Mine infrastructure area from the OCM pits and underground Mine was based on details in the Mine plan (Runge Limited 2011). The coal extraction rate per year for each phase of the Mine are summarised below:

- Start-up phase: 15,821,280 tonne/y
- Full operations phase: 60,794,842 tonne/y
- Maximum emissions phase: 63,919,589 tonne/y

The railway line was modelled in CALPUFF as 10 individual length segments representing the nominal 40 km path from the Mine to the edge of the CALPUFF model domain. Each segment was approximately 4 km long. The train was modelled as accelerating away from the loading area at a rate of 0.05 m/s^2 (initially), easing to 0.03 m/s^2 at 4 km from the mine site (Steimel, 2008, p.25), from a nominal starting speed of 10 km/h. This resulted in the maximum speed of 80 km/h being reached approximately 5.5 km from the rail loop at the mine site, as shown in the figure below. The dust emissions from the rail sections of the model were calculated based on the average speed along each of the individual sections.



The velocity profile was used to determine the EF for each of the railway line segments, which was then multiplied by the length of each segment, d_n, where the summation of segment lengths d_n equated to the total modelled railway length D.

A1.19 Wind Erosion

Emissions by wind erosion from exposed surfaces were estimated using the following equation:

$$E_i = A \times EF_i$$

where

E_i = emission rate of species i (kg/y)

A = total amount of exposed or disturbed surface area (plan) (ha)

EF_i = Uncontrolled emissions factor for species i (kg/ha/y)

Wind erosion was based on the AP-42 emissions estimation equation provided in NPI (2011, pp.57-58, equation 22). This equation relates the annual average wind erosion rate to the silt content (7.7 per cent), the number of days per year when the rainfall is greater than 0.25 mm and the percentage of the time when the wind speed is greater than 5.4 m/s at the mean height of a stockpile.

$$EF_{TSP} = 1.9\left(\frac{s}{1.5}\right) \times 365 \times \left(\frac{365-p}{235}\right)\left(\frac{f}{15}\right) \text{ [kg/ha/y]}$$

where

s = silt content (%), assumed to be 7.7 per cent.

p = number of days per year when rainfall is greater than 0.25 mm.

f = percentage of the time that wind speed is greater than 5.4 m/s at the mean height of the stockpile.

PM_{10} was assumed to be 50 per cent of TSP.

$PM_{2.5}$ was assumed to be 18.3 per cent of TSP, assuming half of the exposed areas consist of coal ($PM_{2.5}$:TSP = 25 per cent) and the other half consists of overburden ($PM_{2.5}$:TSP = 11.6 per cent).

BoM data for Clermont Post Office indicates that the mean number of rain days, p, for the region is 57.2.

Analysis of the CALMET data indicates that the wind speed is greater than 5.4 m/s (at a reference height of 10 m) 1.53 per cent of the time. This 1.53 per cent value is conservative since most wind erosion takes place at ground level, where the wind speed is lower.

Furthermore, wind erosion was modelled as wind speed dependent, based on a third order relationship with respect to wind speed. That is:

$EF_{iTSP} = k\,U^3$ (kg/ha/y)

Where U is the wind speed at the reference height of 10 m and k is a proportional constant to maintain total annual emissions as a fixed total. In effect, the annualised emissions as determined by AP-42 are distributed throughout the year based on a wind dependent relationship. As CALPUFF does not allow a continuous function with respect to wind speed to be entered via the DEFAULT methods, a "binned" approached to the wind erosion EF's was determined. The uncontrolled wind erosion EF's are summarised below.

CALPUFF Wind Speed Upper Value (m/s)	Category Fraction	Emission Factor (kg/ha/h)		
		TSP	PM_{10}	$PM_{2.5}$
1.54	0.176	0.00071	0.00035	0.00013
3.09	0.500	0.0192	0.00961	0.00352
5.14	0.297	0.108	0.054	0.0198
8.23	0.027	0.463	0.232	0.0847
10.8	0.000	–	–	–
10.8+	0.000	–	–	–

The amount of exposed area modelled for each phase of the Mine, and the amount of this area assumed to be under revegetation rehabilitation are summarised below:

- Start-up phase:
  - Total exposed area: 6,305 ha
  - Area under rehabilitation: 0 ha
- Full operations phase:
  - Total exposed area: 13,186 ha
  - Area under rehabilitation: 1,073 ha
- Maximum emissions phase:
  - Total exposed area: 19,840 ha

- Area under rehabilitation: 6,072 ha

A1.20 Underground Mine Ventilation Emissions

The exhaust ventilation for the UGM was based on dust concentration measurements for an existing UGM operated by Illawarra Coal (PAE-Holmes, 2010). This information has been used in previous EIS air quality assessments (PAE-Holmes, 2011) and is considered as a reasonable estimate for UGM ventilation emissions, which consist mostly of dust.

The calculated dust mass emissions rates for the Illawarra Coal mine were scaled pro-rata with the extracted coal capacity difference of the Mine and that estimated for the Carmichael UGM. This assumes that for any given UGM, a doubling of the size of the Mine requires twice the ventilation requirements, and therefore twice the mass emission of dust. In-lieu of detailed ventilation specifications for the Project UGM, this is considered as a reasonable approach for the estimation of ventilation emissions.

A summary of the UGM ventilation emissions rates is provided in the table below.

PM_{10} was assumed to be 68.8 per cent of TSP, which was based on matching TSP and PM_{10} measurements from Illawarra Coal.

$PM_{2.5}$ was assumed to be 100 per cent of PM_{10}, which was based on matching $PM_{2.5}$ and PM_{10} measurements from Illawarra Coal.

Nominal OH&S requirements for Time Weighted Average (8 hour) exposure concentration limit for PM_{10} dust levels is 10 mg/m³. Therefore, applying an average exhaust concentration of 5.35 mg/m³ appears reasonable.

Emissions from the different UGM infrastructure sources were scaled proportionally to the amount of coal extracted from each of the UGM – north, central or south.

The exhaust ventilation emissions were modelled as volume sources as details regarding stack configurations have not been determined as at the time of this assessment. This is considered a conservative approach as model emissions are released near ground level.

Mine	UGM Coal Capacity (M-tonne/y)	PM_{10} Ventilation Exhaust Concentration (mg/m³)	Ventilation Exhaust Flow Rate (m³/s)	PM_{10} Emission Rate (g/s)
Illawarra Coal	5,800[a]	5.35[b]	600[b]	3.21
Carmichael – Start-up	7,240	5.35	749	4.01
Carmichael – Full Operations	18,858	5.35	1951	10.44
Carmichael – Maximum Emissions	0	5.35	0	0

[a] http://www.argusmedia.com/pages/NewsBody.aspx?id=774760&menu=yes

[b] Average of two on-site measurements.

Appendix C

CALPUFF Model Source Inputs

Page intentionally left blank

CALPUFF Model Source Inputs

The source input details to the CALPUFF model are provided in the following table. Note that the specified height information refers to height above the local ground level. Base elevation data has not been provided here.

Initial vertical dispersion values, Sigma-z, are provided for all area sources. The values of Sigma-z for the volume sources are given for initial vertical and lateral dispersion, Sigma-y.

Wind erosion sources were modelled as area sources.

Pits and waste dumps were modelled, as close as possible, as a single quadrilateral in shape.

Source Type	ID	Height (m)			Initial Sigma Z (m)			Easting (km)				Northing (km)			
		Start-up	Full	Max	Start-up	Full	Max	NW	NE	SE	SW	NW	NE	SE	SW
Pit Area	**P-AW**	0.0	0.0	0.0	1.0	1.0	1.0	422.972	424.420	425.820	424.981	7576.078	7576.140	7574.298	7573.509
Pit Area	**P-AE**	0.0	0.0	0.0	1.0	1.0	1.0	424.420	425.869	425.820	425.120	7576.140	7576.201	7574.298	7575.219
Pit Area	**P-BW**	0.0	0.0	0.0	1.0	1.0	1.0	424.981	425.820	427.568	426.521	7573.509	7574.298	7572.475	7571.490
Pit Area	**P-BE**	0.0	0.0	0.0	1.0	1.0	1.0	425.820	427.584	427.568	426.694	7574.298	7574.345	7572.475	7573.386
Pit Area	**P-CW**	0.0	0.0	0.0	1.0	1.0	1.0	426.521	427.568	429.256	428.278	7571.490	7572.475	7570.598	7569.680
Pit Area	**P-CE**	0.0	0.0	0.0	1.0	1.0	1.0	427.568	429.327	429.256	428.412	7572.475	7572.522	7570.598	7571.537
Pit Area	**P-DW**	0.0	0.0	0.0	1.0	1.0	1.0	428.278	429.256	431.030	429.869	7569.680	7570.598	7568.836	7567.702
Pit Area	**P-DE**	0.0	0.0	0.0	1.0	1.0	1.0	429.256	431.030	431.030	430.143	7570.598	7570.658	7568.836	7569.717
Pit Area	**P-EW**	0.0	0.0	0.0	1.0	1.0	1.0	429.869	431.030	432.791	430.115	7567.702	7568.836	7567.006	7566.869
Pit Area	**P-EE**	0.0	0.0	0.0	1.0	1.0	1.0	431.030	432.773	432.791	431.910	7568.836	7568.836	7567.006	7567.921
Pit Area	**P-F**	0.0	0.0	0.0	1.0	1.0	1.0	430.115	432.791	432.735	430.533	7566.869	7567.006	7565.507	7565.474
Pit Area	**P-G**	0.0	0.0	0.0	1.0	1.0	1.0	430.533	432.735	434.343	432.176	7565.474	7565.507	7562.861	7561.796
Pit Area	**P-H**	0.0	0.0	0.0	1.0	1.0	1.0	432.176	434.343	436.181	434.717	7561.796	7562.861	7559.554	7557.777
Pit Area	**P-I**	0.0	0.0	0.0	1.0	1.0	1.0	434.343	432.964	436.220	435.263	7562.861	7565.131	7562.352	7561.349
Pit Area	**P-J**	0.0	0.0	0.0	1.0	1.0	1.0	435.263	436.220	436.203	436.185	7561.349	7562.352	7561.104	7559.857
Pit Area	**P-K**	0.0	0.0	0.0	1.0	1.0	1.0	434.717	437.932	437.881	435.920	7557.777	7557.744	7555.847	7555.638
Pit Area	**P-L**	0.0	0.0	0.0	1.0	1.0	1.0	436.656	439.658	439.602	437.152	7553.908	7555.904	7552.145	7552.240
Pit Area	**P-M**	0.0	0.0	0.0	1.0	1.0	1.0	437.152	441.373	441.349	437.836	7552.240	7552.204	7550.334	7550.402
Pit Area	**P-N**	0.0	0.0	0.0	1.0	1.0	1.0	437.836	443.125	443.123	438.913	7550.402	7550.392	7547.754	7547.739
Pit Area	**P-O**	0.0	0.0	0.0	1.0	1.0	1.0	438.913	443.123	443.123	438.914	7547.739	7547.754	7544.660	7544.647
Pit Area	**P-P**	0.0	0.0	0.0	1.0	1.0	1.0	438.914	443.123	443.120	438.926	7544.647	7544.660	7541.704	7541.827
Dump Area	**D01**	0.0	50.0	50.0	1.0	25.0	25.0	426.144	427.860	427.860	426.144	7578.212	7578.212	7576.452	7576.452
Dump Area	**D02**	0.0	10.0	50.0	1.0	5.0	25.0	427.860	430.528	428.784	427.860	7576.452	7575.440	7573.592	7574.516
Dump Area	**D03**	5.0	50.0	50.0	2.5	25.0	25.0	428.784	430.528	431.232	430.396	7573.592	7575.440	7572.640	7571.848
Dump Area	**D04**	0.0	10.0	50.0	1.0	5.0	25.0	431.232	432.904	432.200	430.396	7572.640	7572.640	7570.000	7571.848
Dump Area	**D05**	5.0	30.0	50.0	2.5	15.0	25.0	432.200	436.408	436.408	433.036	7570.000	7570.748	7567.272	7567.272
Dump Area	**D06**	5.0	30.0	50.0	2.5	15.0	25.0	433.036	436.408	436.408	433.036	7566.496	7566.496	7562.536	7565.792
Dump Area	**D07**	5.0	30.0	50.0	2.5	15.0	25.0	436.584	438.520	440.088	438.520	7560.264	7561.672	7559.516	7558.416
Dump Area	**D08**	0.0	10.0	50.0	1.0	5.0	25.0	438.520	440.088	441.408	439.400	7558.416	7559.516	7557.640	7557.096
Dump Area	**D09**	0.0	10.0	50.0	1.0	5.0	25.0	440.000	442.376	443.784	440.000	7555.000	7555.528	7552.536	7552.536
Dump Area	**D10**	0.0	10.0	50.0	1.0	5.0	25.0	441.760	443.784	444.516	441.760	7552.536	7552.536	7550.704	7550.704
Dump Area	**D11**	0.0	0.0	50.0	1.0	1.0	25.0	443.432	444.912	444.912	443.432	7550.704	7550.000	7547.800	7547.800
Dump Area	**D12**	0.0	0.0	50.0	1.0	1.0	25.0	443.432	444.912	444.912	443.432	7547.800	7547.800	7544.648	7544.648
Dump Area	**D13**	0.0	0.0	50.0	1.0	1.0	25.0	443.432	445.528	445.528	443.432	7544.648	7544.912	7541.436	7541.436
Main Infrastructure Area	**Ma-in**	5.0	5.0	5.0	2.5	2.5	2.5	436.760	440.000	440.000	436.760	7567.272	7567.272	7561.892	7561.892

Source Type	ID	Height (m)			Initial Sigma Z (m)			Easting (km)				Northing (km)			
		Start-up	Full	Max	Start-up	Full	Max	NW	NE	SE	SW	NW	NE	SE	SW
Rail Area	**Ra-01**	2.0	2.0	2.0	1.0	1.0	1.0	436.843	439.657	439.657	436.843	7568.061	7568.276	7568.246	7568.031
Rail Area	**Ra-02**	2.0	2.0	2.0	1.0	1.0	1.0	439.657	442.946	442.946	439.657	7568.276	7570.115	7570.085	7568.246
Rail Area	**Ra-03**	2.0	2.0	2.0	1.0	1.0	1.0	442.946	446.235	446.235	442.946	7570.115	7571.954	7571.924	7570.085
Rail Area	**Ra-04**	2.0	2.0	2.0	1.0	1.0	1.0	446.235	448.894	448.894	446.235	7571.954	7574.077	7574.047	7571.924
Rail Area	**Ra-05**	2.0	2.0	2.0	1.0	1.0	1.0	448.894	451.552	451.552	448.894	7574.077	7576.200	7576.170	7574.047
Rail Area	**Ra-06**	2.0	2.0	2.0	1.0	1.0	1.0	451.552	452.756	452.756	451.552	7576.200	7576.618	7576.588	7576.170
Rail Area	**Ra-07**	2.0	2.0	2.0	1.0	1.0	1.0	452.756	457.003	457.003	452.756	7576.618	7576.210	7576.180	7576.588
Rail Area	**Ra-08**	2.0	2.0	2.0	1.0	1.0	1.0	457.003	461.250	461.250	457.003	7576.210	7575.802	7575.772	7576.180
Rail Area	**Ra-09**	2.0	2.0	2.0	1.0	1.0	1.0	461.250	465.496	465.496	461.250	7575.802	7575.394	7575.364	7575.772
Rail Area	**Ra-10**	2.0	2.0	2.0	1.0	1.0	1.0	465.496	475.000	475.000	465.496	7575.394	7578.675	7578.645	7575.364
Pit Erosion	**E-AW**	0.0	0.0	0.0	1.0	1.0	1.0	422.972	424.420	425.820	424.981	7576.078	7576.140	7574.298	7573.509
Pit Erosion	**E-AE**	0.0	0.0	0.0	1.0	1.0	1.0	424.420	425.869	425.820	425.120	7576.140	7576.201	7574.298	7575.219
Pit Erosion	**E-BW**	0.0	0.0	0.0	1.0	1.0	1.0	424.981	425.820	427.568	426.521	7573.509	7574.298	7572.475	7571.490
Pit Erosion	**E-BE**	0.0	0.0	0.0	1.0	1.0	1.0	425.820	427.584	427.568	426.694	7574.298	7574.345	7572.475	7573.386
Pit Erosion	**E-CW**	0.0	0.0	0.0	1.0	1.0	1.0	426.521	427.568	429.256	428.278	7571.490	7572.475	7570.598	7569.680
Pit Erosion	**E-CE**	0.0	0.0	0.0	1.0	1.0	1.0	427.568	429.327	429.256	428.412	7572.475	7572.522	7570.598	7571.537
Pit Erosion	**E-DW**	0.0	0.0	0.0	1.0	1.0	1.0	428.278	429.256	431.030	429.869	7569.680	7570.598	7568.836	7567.702
Pit Erosion	**E-DE**	0.0	0.0	0.0	1.0	1.0	1.0	429.256	431.030	431.030	430.143	7570.598	7570.658	7568.836	7569.717
Pit Erosion	**E-EW**	0.0	0.0	0.0	1.0	1.0	1.0	429.869	431.030	432.791	430.115	7567.702	7568.836	7567.006	7566.869
Pit Erosion	**E-EE**	0.0	0.0	0.0	1.0	1.0	1.0	431.030	432.773	432.791	431.910	7568.836	7568.836	7567.006	7567.921
Pit Erosion	**E-F**	0.0	0.0	0.0	1.0	1.0	1.0	430.115	432.791	432.735	430.533	7566.869	7567.006	7565.507	7565.474
Pit Erosion	**E-G**	0.0	0.0	0.0	1.0	1.0	1.0	430.533	432.735	434.343	432.176	7565.474	7565.507	7562.861	7561.796
Pit Erosion	**E-H**	0.0	0.0	0.0	1.0	1.0	1.0	432.176	434.343	436.181	434.717	7561.796	7562.861	7559.554	7557.777
Pit Erosion	**E-I**	0.0	0.0	0.0	1.0	1.0	1.0	434.343	432.964	436.220	435.263	7562.861	7565.131	7562.352	7561.349
Pit Erosion	**E-J**	0.0	0.0	0.0	1.0	1.0	1.0	435.263	436.220	436.203	436.185	7561.349	7562.352	7561.104	7559.857
Pit Erosion	**E-K**	0.0	0.0	0.0	1.0	1.0	1.0	434.717	437.932	437.881	435.920	7557.777	7557.744	7555.847	7555.638
Pit Erosion	**E-L**	0.0	0.0	0.0	1.0	1.0	1.0	436.656	439.658	439.602	437.152	7553.908	7555.904	7552.145	7552.240
Pit Erosion	**E-M**	0.0	0.0	0.0	1.0	1.0	1.0	437.152	441.373	441.349	437.836	7552.240	7552.204	7550.334	7550.402
Pit Erosion	**E-N**	0.0	0.0	0.0	1.0	1.0	1.0	437.836	443.125	443.123	438.913	7550.402	7550.392	7547.754	7547.739
Pit Erosion	**E-O**	0.0	0.0	0.0	1.0	1.0	1.0	438.913	443.123	443.123	438.914	7547.739	7547.754	7544.660	7544.647
Pit Erosion	**E-P**	0.0	0.0	0.0	1.0	1.0	1.0	438.914	443.123	443.120	438.926	7544.647	7544.660	7541.704	7541.827
Dump Erosion	**E-01**	0.0	50.0	50.0	1.0	25.0	25.0	426.144	427.860	427.860	426.144	7578.212	7578.212	7576.452	7576.452
Dump Erosion	**E-02**	0.0	10.0	50.0	1.0	5.0	25.0	427.860	430.528	428.784	427.860	7576.452	7575.440	7573.592	7574.516
Dump Erosion	**E-03**	5.0	50.0	50.0	2.5	25.0	25.0	428.784	430.528	431.232	430.396	7573.592	7575.440	7572.640	7571.848
Dump Erosion	**E-04**	0.0	10.0	50.0	1.0	5.0	25.0	431.232	432.904	432.200	430.396	7572.640	7572.640	7570.000	7571.848
Dump Erosion	**E-05**	5.0	30.0	50.0	2.5	15.0	25.0	432.200	436.408	436.408	433.036	7570.000	7570.748	7567.272	7567.272

Source Type	ID	Height (m)			Initial Sigma Z (m)			Easting (km)				Northing (km)			
		Start-up	Full	Max	Start-up	Full	Max	NW	NE	SE	SW	NW	NE	SE	SW
Dump Erosion	**E-06**	5.0	30.0	50.0	2.5	15.0	25.0	433.036	436.408	436.408	433.036	7566.496	7566.496	7562.536	7565.792
Dump Erosion	**E-07**	5.0	30.0	50.0	2.5	15.0	25.0	436.584	438.520	440.088	438.520	7560.264	7561.672	7559.516	7558.416
Dump Erosion	**E-08**	0.0	10.0	50.0	1.0	5.0	25.0	438.520	440.088	441.408	439.400	7558.416	7559.516	7557.640	7557.096
Dump Erosion	**E-09**	0.0	10.0	50.0	1.0	5.0	25.0	440.000	442.376	443.784	440.000	7555.000	7555.528	7552.536	7552.536
Dump Erosion	**E-10**	0.0	10.0	50.0	1.0	5.0	25.0	441.760	443.784	444.516	441.760	7552.536	7552.536	7550.704	7550.704
Dump Erosion	**E-11**	0.0	0.0	50.0	1.0	1.0	25.0	443.432	444.912	444.912	443.432	7550.704	7550.000	7547.800	7547.800
Dump Erosion	**E-12**	0.0	0.0	50.0	1.0	1.0	25.0	443.432	444.912	444.912	443.432	7547.800	7547.800	7544.648	7544.648
Dump Erosion	**E-13**	0.0	0.0	50.0	1.0	1.0	25.0	443.432	445.528	445.528	443.432	7544.648	7544.912	7541.436	7541.436
Infrastructure Erosion	**E-Min**	5.0	5.0	5.0	2.5	2.5	2.5	436.760	440.000	440.000	436.760	7567.272	7567.272	7561.892	7561.892
Central ROM Volume	**CROM**	5.0	5.0	5.0	1.25 1.25	1.25 1.25	1.25 1.25	436.760	-	-	-	7561.892	-	-	-
North ROM Volume	**NROM**	5.0	5.0	5.0	1.25 1.25	1.25 1.25	1.25 1.25	425.792	-	-	-	7571.980	-	-	-
South ROM Volume	**SROM**	5.0	5.0	5.0	1.25 1.25	1.25 1.25	1.25 1.25	438.564	-	-	-	7546.628	-	-	-
Central UGM Volume	**UGCIN**	5.0	5.0	5.0	1.25 1.25	1.25 1.25	1.25 1.25	429.692	-	-	-	7566.452	-	-	-
North ROM Volume	**UGNIN**	5.0	5.0	5.0	1.25 1.25	1.25 1.25	1.25 1.25	426.496	-	-	-	7570.264	-	-	-
South ROM Volume	**UGSIN**	5.0	5.0	5.0	1.25 1.25	1.25 1.25	1.25 1.25	436.364	-	-	-	7552.772	-	-	-

GHD

145 Ann Street Brisbane QLD 4000
GPO Box 668 Brisbane QLD 4001
T: (07) 3316 3000 F: (07) 3316 3333 E: bnemail@ghd.com.au

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	B Cook D Featherston	B Cook	On file	J Keane	On file	30/01/2012
1	B Cook D Featherston	B Cook	On file	J Keane		15/10/2012