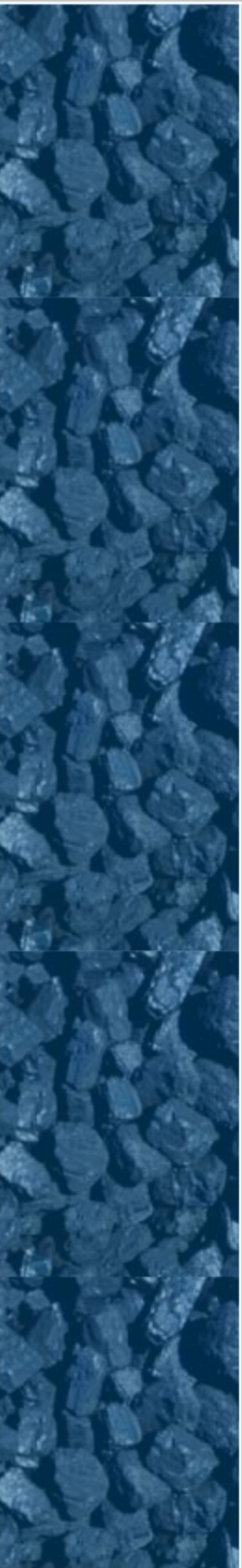
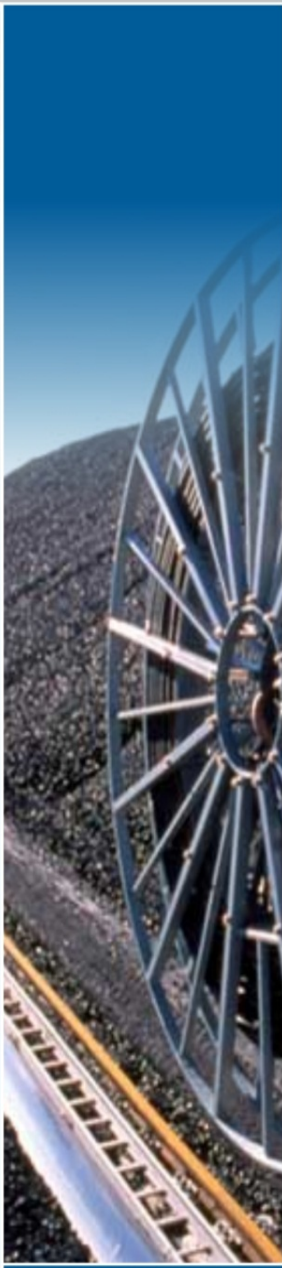
Adani Mining Pty Ltd





Adani Mining Pty Ltd

Report for Carmichael Coal Mine and Rail Project

Air Quality Assessment 25215-D-RP-0025

18 September 2012

Revision 1

This Carmichael Coal Mine and Rail Project: Rail 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).

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- *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.*

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Abbreviations and Glossary

Project Specific Terminology	
Abbreviation	**Term**
the EIS	Carmichael Coal Mine and Rail Project Environmental Impact Statement
the Proponent	Adani Mining Pty Ltd
the Project	Carmichael Coal Mine and Rail Project: Mine component
The Project (Mine)	Carmichael Coal Mine and Rail Project: Rail component
The Project (Rail)	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 (%)
CO_2	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 Concentrations
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	Sulfur 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 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 at Moranbah, and shipped through coal terminal facilities at the Port of Abbot Point and the Port of Hay Point (Dudgeon Point expansion). The Project will have an operating life of approximately 90 years.

The Carmichael Coal Mine and Rail Project (the Project) comprises of two major components:

- The Project (Mine): a greenfield coal mine over EPC1690 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 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) 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 to ensure that all potential environmental, social and economic impacts of the Project are identified and assessed and that adverse impacts so identified are avoided or mitigated.

This air quality assessment is prepared in accordance with the Carmichael Coal Mine and Rail Project Terms of Reference (ToR) for the Project EIS, issued in May 2011 by the State of Queensland Coordinator-General. It is noted that this report addresses the Project (Rail) only.

Potential environmental impacts of emissions from the coal trains, inclusive of locomotive exhaust emissions and fugitive coal dust from the wagons have been assessed against the environmental values from the EPP (Air) that enhance or protect qualities relating to:

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

Schedule 1 of EPP (Air) defines air quality objectives for indicators such that environmental values are enhanced or protected. The indicators relevant to the Project (Rail) are particulate matter (total suspended particulate, PM_{10} and $PM_{2.5}$), hazardous air pollutants from locomotive exhaust emissions and deposited dust. The latter is an important consideration along a coal rail transport corridor but this is not included in the Air Policy for Queensland. The concentrations of pollutants at locations where people are likely to be define the air quality impact so that the objectives of the EPP (Air) are met. Locations inside the Project (Rail) are therefore excluded from assessment. Only eight sensitive receptor locations are within 5 km of the Project (Rail). The nearest receptor on the north side is

1.6 km of the railway line with the nearest receptor on the south side being the Project (Mine) workers accommodation village situated 2.45 km distant.

The remoteness of the area indicates that background air quality measurements are few and expected to be low. The adopted particulate matter background levels for this inland region of Queensland was split between the western and the eastern end of the Project (Rail) while background levels of gaseous pollutants were considered to be negligible.

Existing conditions include a 'Sub-tropical' climate and a sub-classification of 'Moderately dry winter'. The gradient of rainfall, temperature and humidity from east to west suggests a drier climate moving further away (westward) from the coast. There is a clear pattern of decreasing rainfall moving inland. The annual mean rainfall along the Project (Rail) length is dominated by the warm months (December, January and February) producing convectively driven rainfall.

Comparisons of site-specific wind roses for the wider region show how the wind regime subtly changes but an overall pattern of dominant easterly component winds was found for the Project (Rail). Site specific meteorological datasets for the extreme ends of the Project (Rail) were developed and validated against the regional climatic conditions.

The construction of the Project (Rail) will result in dust emissions along the corridor which will be nearby a limited number of sensitive receptors. Given the distances involved (no sensitive receptors within 1.7 km) it is very unlikely that construction dust impacts will be an issue.

Potential sources of air emissions from the operation phase of the Project (Rail) include exhaust emissions from diesel powered locomotive and fugitive coal dust emissions. All of the non-'dust' sources are assessed as Hazardous Air Pollutants with emissions from the locomotives and inclusive of carbon monoxide (CO), oxides of nitrogen (NOx) (assessed as nitrogen dioxide (NO_2)), sulfur dioxide (SO_2), benzene and trace hydrocarbons.

The assessment of the particulate matter requires the addition of the two sources of particulates from both diesel exhausts and the fugitive coal sources. The emissions inventory for the particulate matter of all three sub-types of TSP, PM_{10} and $PM_{2.5}$ were constructed.

The operating power of the locomotive types and the operating speeds were used to give emissions in grams per vehicle kilometre travelled (g/VKT) for a single locomotive. The locomotive diesel exhaust emissions per train consist were derived.

The emission factor of total coal dust from the moving fully loaded coal train was calculated accounting for the speed of the train (and hence wind erosion) and amount of coal hauled. Additionally for particulate matter, allowances were made for return trips (no coal dust but locomotives at less than full load) and for longer term averaging periods when there is actually less than one train per hour (18 return trips per 24 hours).

The Project (Rail) was split into three sections for modelling to assess impacts as a function of distance away from the alignment (west, central and east). The application of AUSROADS to modelling the train line emissions was made by considering the emissions from typical track alignment sections of one km in length oriented in the general direction of the alignment for each representative section (west, central and east). Receptors were placed at varying lateral distances from the line at up to 200 m distance. AUSROADS simulations were conducted for the annual meteorological data at hourly intervals using Cassiopeia for the western section and Moranbah for the central and eastern sections.

For the non-dust locomotives exhaust pollutants, the most influential constituent was found to be NO_2. However, the highest level of NO_2 at any Project (Rail) fence-line was just 58 percent of its assessment criterion with all other products of combustion constituents being lower fractions of their respective assessment criteria.

For the more significant dust considerations, predicted TSP, PM_{10} and $PM_{2.5}$ concentrations from the operation of the diesel locomotives with coal train fugitive dust emissions added demonstrate that the most influential pollutants are PM_{10} and $PM_{2.5}$. At the southern fence-line of the Project (Rail) there are nominal exceedances, of the air quality objectives. But these goals are for human health and the sensitive receptor locations, at greater than 3 km distant, are well outside the impact zone of within 50 m of the fence-line for the daily averaged goals and within 161 m for the annually averaged $PM_{2.5}$ goal.

For the assessment of the amenity impact of dust deposition, AUSPLUME dispersion modelling was used with area sources at 4 m above ground level. The maximum incremental dust deposition level is below the deposition guideline equivalent of 2 g/m^2/month at and beyond 50 m from the track centre line.

While the air quality impact assessment of the Project (Rail) found that air quality objectives would be met within close proximity of the rail line and that a negligible change in ambient air quality is expected at the identified sensitive receptor locations, measures to minimise particulate emissions from coal trains should be examined. Measures to minimise particulates emissions associated with the construction and operation of the Project (Rail) have been identified and discussed in the Project (Rail) Draft Environmental Management Plan, Volume 3 Section 13.

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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.

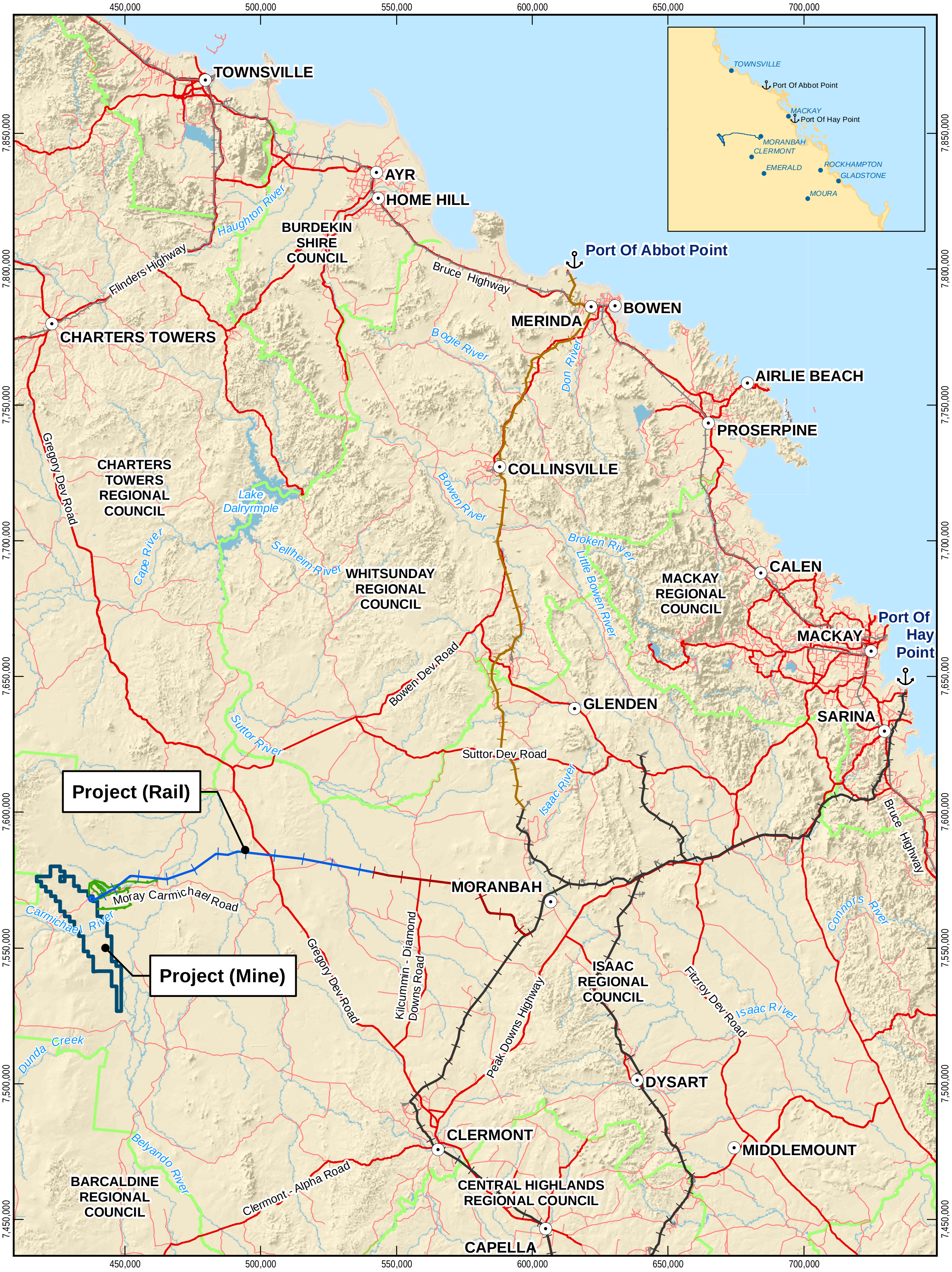
The Project comprises of two major components:

- 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 mine 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): a greenfield rail line connecting the Mine to the existing Goonyella and Newlands rail systems to provide for the export of coal via the Port of Hay Point (Dudgeon Point expansion) and the Port of Abbot Point, respectively; including:
  - Rail (west): a 120 km dual gauge portion from the Mine site running west to east to Diamond Creek
  - Rail (east): a 69 km narrow gauge portion running east from Diamond Creek connecting to the Goonyella rail system south of Moranbah

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).

Figure 1-1 shows the Project location.



LEGEND

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

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.

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Kilometres

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

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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

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 Scope of Reporting

The air quality assessment has been prepared in accordance with the Carmichael Coal Mine and Rail Project terms of reference for the Project EIS, issued in May 2011 by the State of Queensland Coordinator-General. A summary of compliance with the terms of reference is provided in Table 1-1. Appendix A provides a detailed cross-reference of compliance with the terms of reference. It is noted that this report addresses the Project (Rail) only. The Project (Mine) is addressed in Volume 4 Appendix S Mine Air Quality Assessment.

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	Section 3.2 Volume 4 Appendix AE
3.5.2 Potential Impacts and Mitigation Measures	
For air quality impacts and their mitigation	Sections 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6
◗ include an inventory of air emissions	Sections 4.3 and 4.3
◗ identify all expected emissions of the hazardous air pollutants and their emissions from known and fugitive sources	Section 4.2.2
◗ estimate emission retest	Section 3
◗ 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	Sections 3.3 and 3.1
◗ Estimate maximum ground level concentration and monthly average dust deposition values at the nearest sensitive receptor(s).	Sections 4.3 and 4.3
◗ Present the results of the dispersion modelling as concentration contour plots and concentrations at the discrete sensitive receptors	Sections 4.3, 4.4 and 4.5
◗ describe the background ambient air concentration from the existing sources in the airshed and evaluate the cumulative impact on the receiving environment.	Sections 3.2 and 3.1
◗ provide an averaging period for ground level concentrations of pollutants that are modelled.	Sections 4.3, 4.4 and 4.5
◗ 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 2
◗ identify 'worst case' emissions that may occur during operation	Section 4.3
◗ ground level predictions should be made at any sensitive	Section 4.4
◗ discuss dust generation from construction activities	Section 4.2

Terms of Reference Requirement/Section Number	Cross-reference
◗ discuss climatic patterns that could affect dust generation and movement	Section 3.3
◗ discuss vehicle emissions and dust generation along major road and rail haulage routes both internal and external to the project site	Section 4.3
◗ assess human health risk associated with emissions	Section 4.4
◗ discuss impacts on terrestrial flora and fauna	Section 4.6
◗ Discuss potential air quality impacts from emissions with reference to the National Environment Protection (Ambient Air Quality) Measure 1998 and the EPP (Air).	Sections 2.2 and 3.1
◗ 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.	Section 4.4
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.	Section 3.1

2. Approach and Methodology

2.1 Commonwealth Legislation

National air quality guidelines are specified by the National Environment Protection Council (NEPC) through the use and application of National Environmental Protection Measures (NEPM's). The National Environment Protection (Ambient Air Quality Measure) (NEPM (Ambient Air Quality)) sets standards for ambient air quality in Australia. It was released in 1998 and was varied in 2003 to add an advisory reporting standard for particulate matter less than 2.5 µm (PM2.5).

For a rail project involving large scale transport of a dusty commodity (coal), the primary pollutant of concern is the ubiquitous pollutants involving particulate matter (as particulate matter less than 10 µm (PM_{10}) and $PM_{2.5}$, where the number defines the upper limit to the equivalent aerodynamic diameter of the particles involved). For a project involving locomotive hauled transport, the products of combustion and trace gases considered are:

- Carbon monoxide
- Nitrogen dioxide
- Sulfur dioxide
- Benzene
- Benzo(a)pyrene
- Formaldehyde
- Toluene
- Xylenes

In 2004, the National Environment Protection (Air Toxics) Measure (NEPM (Air Toxics)) was released which included monitoring investigation guidelines. The latter five compounds of the above are for the NEPM (Air Toxics) and are included only as monitoring investigation guidelines. All of the above pollutants are addressed in Section 2.2 under the relevant State legislation.

2.2 State Legislation

The *Environmental Protection (Air) Policy 2008* (EPP Air) has the purpose of achieving the objectives of the *Environmental Protection Act 1994* in relation to the air environment. Part 3 of the Policy 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 EPP Air defines air quality objectives for indicators such that environmental values are enhanced or protected. The indicators relevant to the Project (Rail) are particulate matter (total suspended particulate (TSP), PM_{10} and $PM_{2.5}$) and various products of combustion (locomotives)

including benzene, carbon monoxide, formaldehyde, nitrogen dioxide, sulfur dioxide, toluene and xylenes.

The evaluation criteria from the EPP Air for the relevant indicators and objectives are tabulated in Table 2-1. TSPs are included here even though they are not part of the NEPM.

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

Indicator	Environmental value	Air Quality Objective	Period
TSP	Health and wellbeing	90 µg/m^3	1 year
PM_{10}	Health and wellbeing	50 µg/m^3	24 hours
$PM_{2.5}$	Health and wellbeing	25 µg/m^3	24 hours
		8 µg/m^3	1 year
Benzene	Health and wellbeing	10 µg/m^3	1 year
Carbon Monoxide	Health and wellbeing	11,000µg/m^3	8 hours
Formaldehyde	Health and wellbeing	54 µg/m^3	24 hours
	Protecting aesthetic environment	110 µg/m^3	30 minutes
Nitrogen dioxide	Health and wellbeing	250 µg/m^3	1 hour
		62 µg/m^3	1 year
	Health and biodiversity of ecosystems	33 µg/m^3	1 year
Sulfur dioxide	Health and wellbeing	570 µg/m^3	1 hour
		230 µg/m^3	1 day
		57 µg/m^3	1 year
	Protecting agriculture	32 µg/m^3	1 year
	Health and biodiversity of ecosystems (for forests and natural vegetation)	22 µg/m^3	1 year
Toluene	Health and wellbeing	4100µg/m^3	24 hours
		410µg/m^3	1 year
	Protecting aesthetic environment	1100 µg/m^3	30 minutes
Xylenes	Health and wellbeing	1200 µg/m^3	24 hours
		950 µg/m^3	1 year

Deposited dust is an important consideration along a coal rail transport corridor; however it is not included in the EPP Air for Queensland or any current Environmentally Relevant Activities relating to

mining or coal transport activity. "*There is currently no EPP (Air) air quality objective for deposited matter*" (DERM, 2010, p.40). An 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. Since this measure excludes background, it aptly describes the off-site amenity impact of a dust generating operation/source.

A secondary consideration is defined as a maximum level, inclusive of background, of 4.0 g/m^2/month (DEC, 2005). This higher value relates to the original work from the 1980s when investigating the trigger level of community complaints from communities in the coal-mine affected areas of the Hunter Valley of New South Wales. The value can be expressed as a daily averaged guideline of 130 mg/m^2/day. Despite this being meaningless in relation to how the deposition value is actually measured, and how the trigger level was originally derived, it has been variously described as a guideline in use in Queensland at between 120 and 140 mg/m^2/day. A community complaint will only be trigged by a one-off event much higher than this 'daily average' guideline which would elevate a monthly (30-day) measured deposition rate above the 2.0 g/m^2/month quantifiable gauge reading.

2.3 Methodology

2.3.1 Study Area

For the purposes of the Project (Rail) air quality assessment, the alignment has been divided into three sections. Modelling to assess potential impacts as a function of distance away from the alignment has been undertaken for each section. The sections are illustrated on Figure 2-1 and defined as:

- Western section – Project (Mine) to the Cassiopeia homestead (chainage 185 km – 137 km)
- Central section – Cassiopeia homestead to Diamond Creek (chainage 137 km – 69 km)
- Eastern section – Diamond Creek to the rail connection with the QR National rail system, south of Moranbah (chainage 69 km – 0 km)

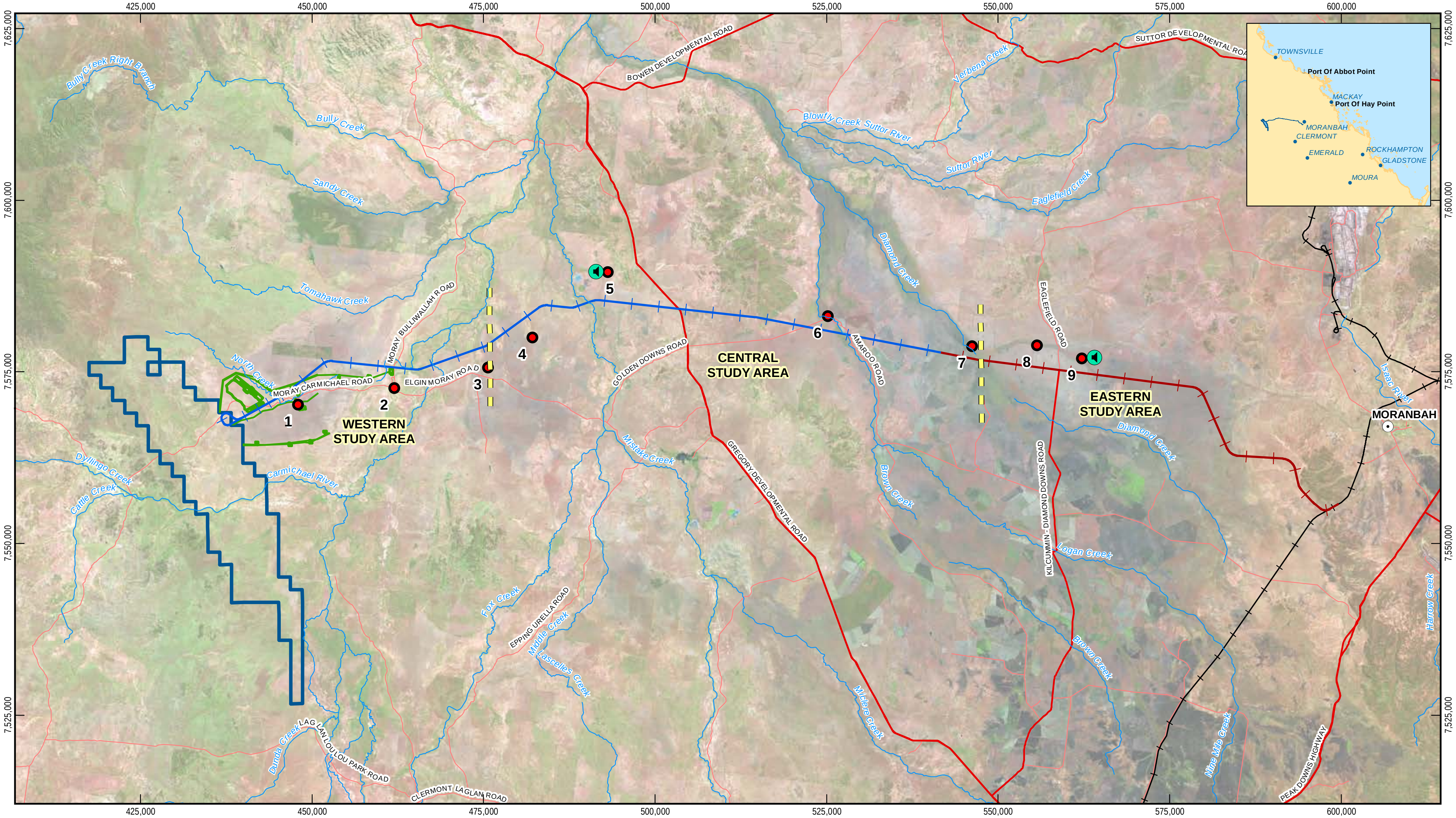
2.3.2 Derived Wind Model

Alternative sources, other than direct measurements, were generated so as to produce synthetic site-representative datasets for representative sections of the Project (Rail). These were derived using a prognostic modelling approach using either TAPM or MM5 with the latter being coupled with a diagnostic wind model (CALMET) to correct for mass consistent flows around topographical features. MM5 and CALMET are freely available international meteorological models while TAPM was developed by, and is supported and available for sale from, the Australian CSIRO.

TAPM has previously been used by GHD Pty Ltd to develop a dispersion modelling dataset for the Moranbah area. This is considered suitable for the eastern end of the Project (Rail). For the western end, the MM5 and CALMET modelling solution was used for the Project (Mine) site and a site from the eastern edge of this domain was selected to be site-representative of the area around the Cassiopeia Homestead (approximately 20 km west of Twin Hills).

2.3.3 Emissions Modelling

The emissions modelling has been developed utilising recognised techniques for dispersion modelling and emission estimation. The line-source Gaussian model AUSROADS V1.0 was selected for this purpose, as this model is designed for linear transport.



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0 5 10 15 20 25

Kilometres

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

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LEGEND

- Town
- Sensitive Receptor
- Noise Logger
- Study Extent
- Watercourse
- State Road
- Local Road
- Other Rail Network
- Rail (West)
- Rail (East)
- Mine (Onsite)
- Mine (Offsite)

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number	41-25215
Revision	B
Date	07-09-2012

Project (Rail) Study Area
and Potential Sensitive Receptors

Figure 2-1

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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: Noise Logger/Sensitive Receptor Locations,Study Extent(2012); DERM: DEM (2008); DME: PC1690 (2010), EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Localities, Railways, Roads, Watercourse (2007); Adani: Alignment Opt9 Rev3 (SP1&2) (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: AF, JVC.MS

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3. Description of Environmental Values

3.1 Introduction

The EPP Air defines air quality objectives, in terms of concentration levels over various averaging periods, such that indicator pollutants do not affect various environmental values. For a rail transport corridor involving coal (and associated emitted dust), particulate matter is the main indicator pollutant of concern for the health and wellbeing of humans and is therefore the environmental value of concern.

Dust deposition may be considered in the context of affecting human amenity and potential impact on flora/fauna and agricultural uses. However, as these are not a consideration for particulate matter in EPP Air, it can be considered that by protecting to the standards of human health (policy levels) and amenity (dust deposition guideline), the other environmental values (e.g. health and biodiversity of ecosystems - including forests and natural vegetation – and agricultural uses) are also protected. Therefore, the concentrations of particulate matter at locations where people are likely to be include, but are not limited to, housing, schools and hospitals. These are sensitive receptor locations and define the air quality impact so that the objectives of the EPP Air are met. Similarly, for the guideline value used for dust deposition, it is informative to assess the annualised dust deposition at any site boundary, as an increment above background, to demonstrate that any dust management practices, if indeed any are required for a specific project, are working to protect amenity based (and by default all) environmental values.

Section 8 (5) of EPP Air 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 (Rail) site perimeter are excluded from assessment.

3.2 Pollutants

3.2.1 Overview

The Project (Rail) is in central Queensland. It links the Project (Mine) in the Galilee Coal Basin to the QR National Goonyella Rail System in the Bowen Basin (refer Figure 1-1), south of Moranbah.

This regional area is remote from significant population centres that would contribute extra pollutant levels above ambient conditions generated by non-anthropogenic sources – although the ‘natural’ dust load in this inland environment would be considered relevant for consideration. Due to the remoteness of the area, background measurements are limited – particularly at the western end of the Project (Rail).

3.2.2 Particulates

The adopted PM_{10} background levels were divided between the western and the eastern end of the Project (Rail).

In the Moranbah area at the eastern end of the Project (Rail), the Caval Ridge Air Quality Impact Assessment Report (URS 2009) has been used to provide a conservative PM_{10} value of 18.8 µg/m^3. This is based on statistics for an 18 month monitoring period. At homestead sites to the downwind side of the Moranbah airport and Bowen Basin mining operations for all of 2008, the 70th percentile PM_{10} value is 18.8 µg/m^3. From April 2007 to October 2008, the 70th percentile PM_{10} value was measured for comparable sites in the Galilee Basin at 11.0 µg/m^3. Comparable background data for the coarse TSP and the finer $PM_{2.5}$ dust fractions were derived by use of suitable ratios relative to the measured and adopted PM_{10} values.

The United State Environmental Protection Agency (USEPA) (1998) suggests a PM_{10}:TSP ratio of 50 per cent is applicable for ambient conditions such as those found in the Project (Rail) area. This is due to an inland Queensland region that experiences a higher proportion of suspended particulates originating from crustal matter, rather than industrial or combustion emission sources that generate a higher ratio of fine and ultrafine particulates less than 2.5 µm . The assumed level for background TSP has been set at 37.6 µg/m^3 for the eastern end of the Project (Rail) and 22.0 µg/m^3 for the western end.

For the respirable particle fraction of $PM_{2.5}$, it can be safely assumed that a background $PM_{2.5}$ level can be set at a ratio of 30 per cent to the background PM_{10} level. This is based on a lower estimate from NEPC work that found that the ratio varies "*depending on season and location, and can range from 0.3 to 0.9*" (NEPC 2002, p.5). The lower end of the spectrum is justified since crustal dust sources in this agricultural/grazing environment are remote from urban populations involving high emission contributions from combustion process, including vehicles. The assumed level for background $PM_{2.5}$ has therefore been set at 5.6 µg/m^3 for the eastern end of the Project (Rail) and 3.3 µg/m^3 for the western end.

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 waste water), the ambient background levels of odours was considered to be negligible, at a level of zero.

3.2.5 Dust Deposition

Since the dust deposition criterion involves insoluble matter averaged over a 30 day period (equivalent to an average deposition rate of 130 mg/m^2/day), measurements of these were sought in available literature. Data from the Ensham Central Project (Katestone 2006), located within the Bowen Basin, has been used. This is to the east and has been applied to the east portion of the Project (Rail). The rolling annual average from a site that showed consistently lower deposition rates had a range from 0.09 to 1.6 g/m^2/month. The higher end of the range would be suitable for the eastern section of the Project (Rail) with the lower level assumed representative for the western section.

3.3 Local Meteorology

3.3.1 Overview

The length of the Project (Rail) is 189 km, and stretches over a latitude belt of inland central Queensland. The climate and prevailing meteorology is estimated to show some differences between the east and west of the Project (Rail). The western end at the Project (Mine) is further inland and more often on the dry side of the inland surface pressure trough often experienced in this region. The available climatic statistics shows that the eastern end of the Project (Rail) is considered as a 'sub-tropical' climate and, due to the inland nature of the region skewing rainfall monthly totals to summer (wet season) rather than winter (dry season), there is a sub-classification of ‘moderately dry winter’. This applies at all of the Bureau of Meteorology (BoM) climatic stations for the length of the rail corridor from Moranbah/Collinsville regions as far west as Twin Hills.

The available climatic statistics also show that while the western end is close to a grassland (hot winter drought) climate, as found at Hughenden, the Carmichael climatic record for monthly rainfall averages (there are no temperature records available) suggest that the western end of the Project (Rail) is still within the ‘sub-tropical’ classification as found to the east.

The above analysis is based on the temperature and rainfall data using the climatic typing scheme of Stern *et al.* (2000).

3.3.2 Temperature and Humidity

The BoM station at Moranbah was used to characterise the temperature regime at the eastern end of the Project (Rail). Temperature and humidity monthly statistics for this location are presented in Figure 3-1. Monthly mean temperatures taken at the Moranbah Water Treatment Plant (Site Number 034038) show daytime summer temperatures are mostly in the low to mid 30s with winter overnight temperatures dropping to between 5 and 15 degrees with a mean centred near 10^{o}C. The temperature record of the last 24 years shows values ranging from +0.2^{o}C to 45.0^{o}C. ‘Hot days’, with temperatures exceeding 35^{o}C, can be expected up to 51 days per year. ‘Frost days’, with screen temperatures below 2^{o}C are rare with an expected return rate of less than once per year. Relative humidity is highest in the mornings and during the month of February and lowest in the late spring (September and October) mornings and afternoons as shown in Figure 3-2.

Twin Hills (Site Number 036047) is the BoM climatic station used to characterise the temperature regime at the western end of the Project (Rail). Temperature and humidity monthly statistics for this location are presented in Figure 3-3. Monthly mean temperatures for Twin Hills Post Office show daytime summer temperatures are mostly in the low to mid 30s with winter overnight temperatures dropping to between 5 and 10 degrees. 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 75 days per year. ‘Frost days’, with screen temperatures below 2^{o}C can be expected up to 10 days per year.

Relative humidity is highest in the mornings and during the month of March and lowest in the late spring mornings and afternoons as shown in Figure 3-4. Not surprisingly, the gradient of temperature and humidity from east to west suggests a hotter summer (24 extra ‘hot days’ at Twin Hills compared to Moranbah) and colder winter nights associated with a drier climate (lower humidity) moving further away (westward) from the coast.

Figure 3-1 Monthly Mean and Decile Maximum and Minimum Temperatures at Moranbah Water Treatment Plant

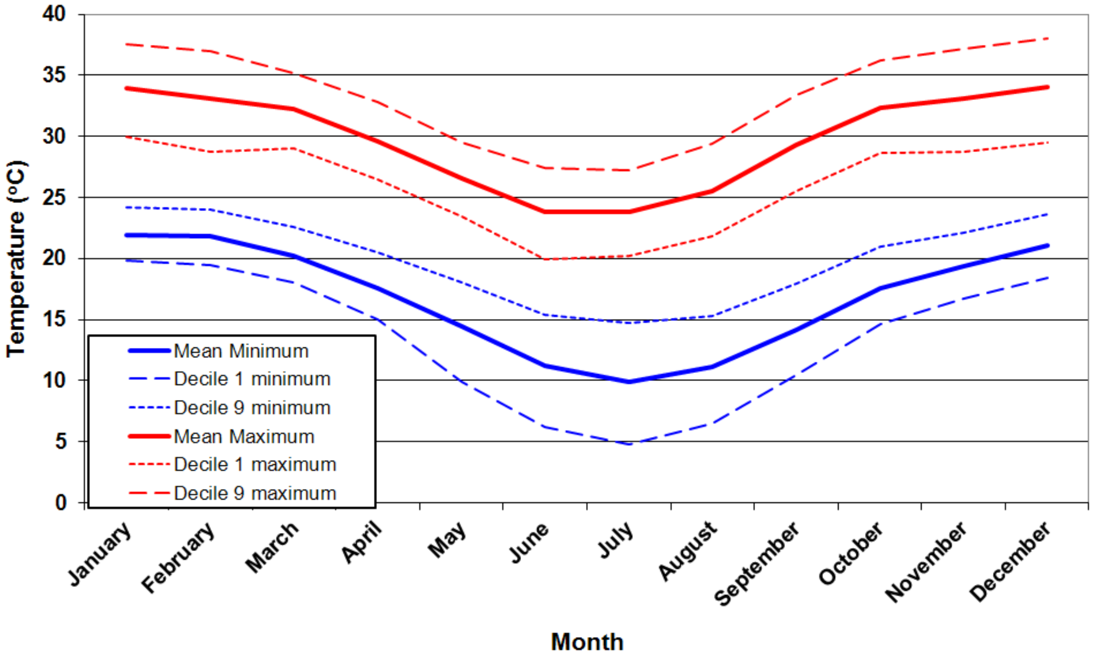


Figure 3-2 Monthly Mean Relative Humidity At Moranbah Water Treatment Plant

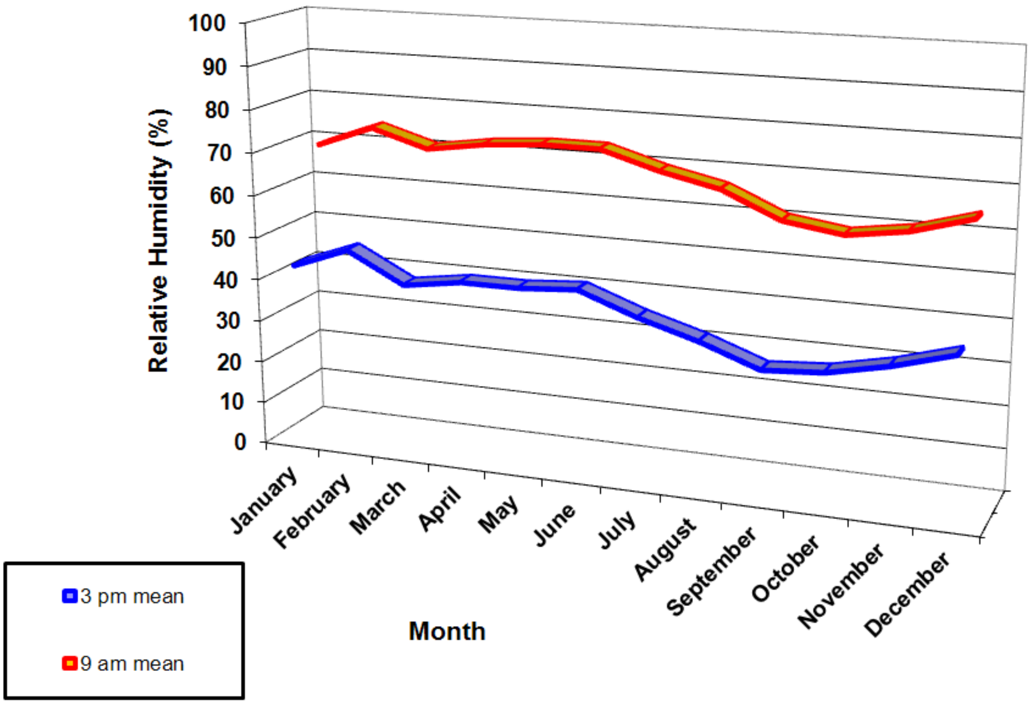


Figure 3-3 Monthly Mean and Decile Maximum and Minimum Temperatures at Twin Hills Post Office

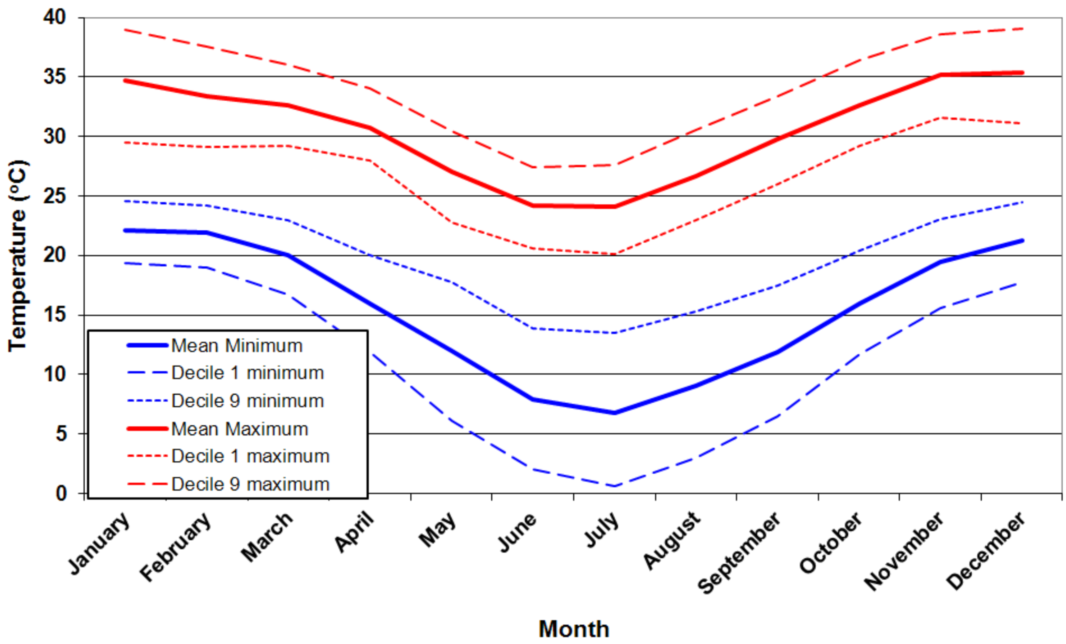
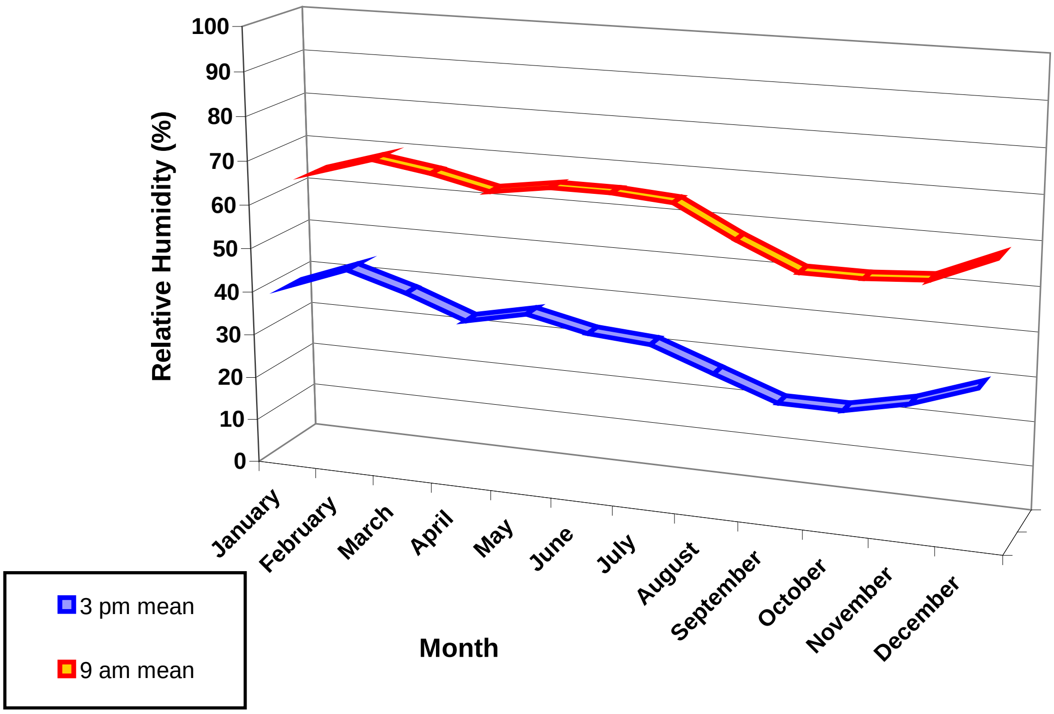


Figure 3-4 Monthly Mean Relative Humidity at Twin Hills Post Office



3.3.3 Rainfall

Analysis of rainfall statistics from the Moranbah Water Treatment Plant (Site number 034038), Twin Hills Post Office (Site number 036047) and Carmichael (Site number 036122) (BoM 2011) indicate a clear pattern of decreasing rainfall moving inland.

The rain record from the Carmichael site is limited, beginning in 2003 with some incomplete monthly records for a number of years to 2010. The annual rainfall at the site ranges from 252 to 700 mm, although the range of rainfall cannot be accurately assessed until further records are collected. The average of complete years is 457 mm. The annual sum of monthly averages is 524 mm. Hughenden is further north-west, and hence inland and in a Grassland climate (rather than subtropical) with an annual average of 492 mm. This suggests that the Carmichael rain record to date is on the dry side and closer to the higher estimate above rather than the lower. Even at 500 to 530 mm of annual rain, the western end of the Project (Rail) is drier by at least 20 per cent than experienced at Twin Hills and Moranbah to the east.

Twin Hills has an annual average of 610 mm over an 80 year record while Moranbah averaged 604 mm over 38 years. The range of annual rainfalls at Twin Hills is 218 mm to 1,477 mm, and at Moranbah is 281 mm to 1,109 mm per year.

The annual mean rainfall at all three sites is dominated by the warm months producing convectively driven rainfall. This is graphically shown in Figure 3-5 with December through February, inclusive, accounting for 57 per cent of the annual mean rainfall at Carmichael, 50 per cent at Twin Hills and 51 per cent at Moranbah.

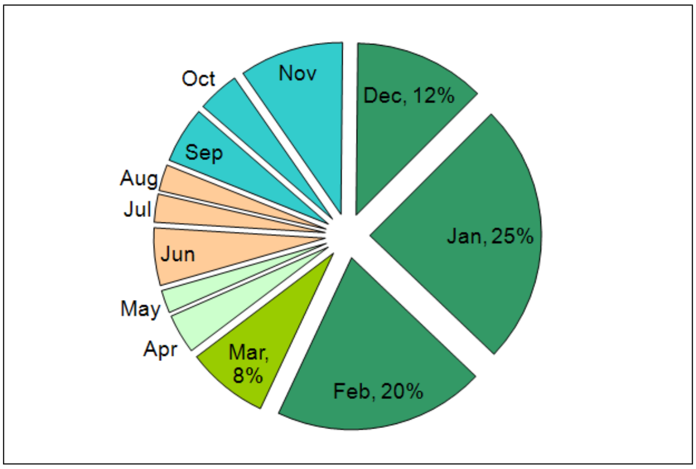
3.3.4 Wind Speed and Direction

The BoM climatic stations at Moranbah and Twin Hills have limited wind data (two or three spot readings per day) which define the wind regime up to 150 km east to west along the Project (Rail). Available Automatic Weather Station (AWS) data from BoM sites in the wider region were considered but only used for comparison purposes due to large separation distances. A brief assessment of these sites in relation to representativeness of the Project (Rail) meteorology is provided below:

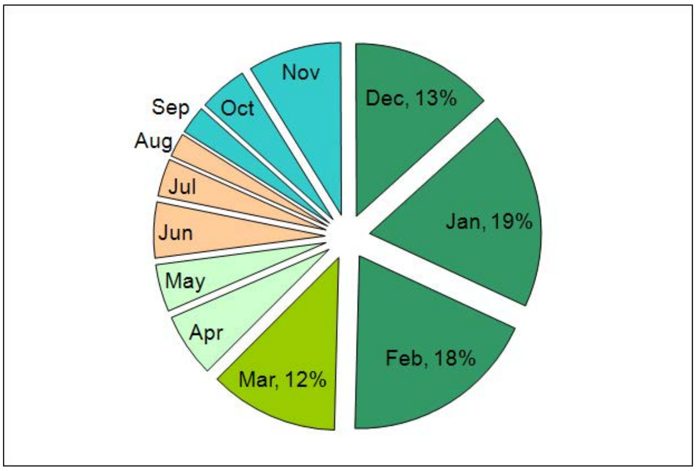
- Winton – too far west
- Hughenden – too far north-west
- Collinsville – too far north-east (and only spot readings three times per day)
- Emerald – too far south-east
- Clermont – to the south but data only since 2010
- Lochington – too far south

Figure 3-5 Comparison Monthly Mean Rainfall (mm) Proportions at Carmichael, Twin Hills Post Office, and Moranbah Water Treatment Plant

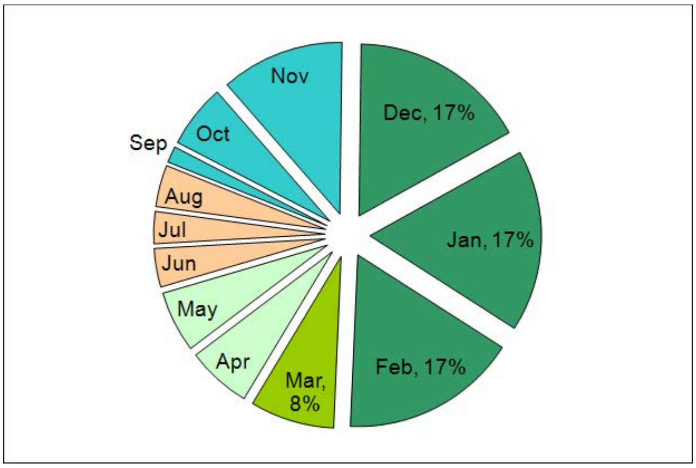
Carmichael - Western



Twin Hills - Central



Moranbah - East



A test of the suitability of these site-representative datasets is to compare the annual wind roses from actual measurement sites from the wider central Queensland region. Figure 3-6 shows the derived site-representative annual wind roses for Cassiopeia (west) and Moranbah (east) used in the dispersion modelling. Note that the east-south-east trade winds have become more evenly spread through the eastern directions as the trade winds move further inland away from the coastal influences. This may also be a reflection of how often the Queensland inland trough is found to influence the more eastern site rather than on the drier inland side of the trough out to the west.

Comparisons of site-specific wind roses are displayed in Figure 3-7 to show how the wind regime subtly changes in this wider region. It can also be seen that the derived datasets of Figure 3-6 correctly define the overall pattern is of dominant easterly component winds.

Figure 3-6 Comparison Annual Wind Roses for Representative Sites

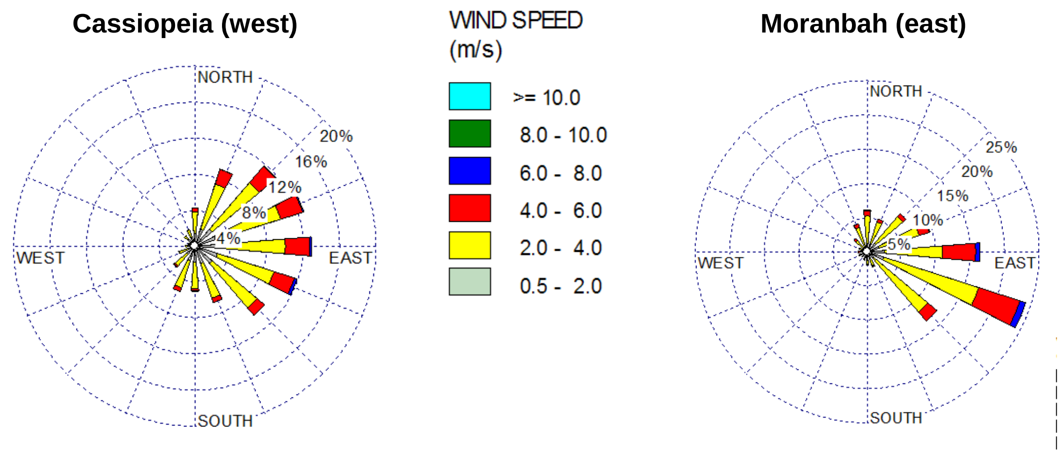
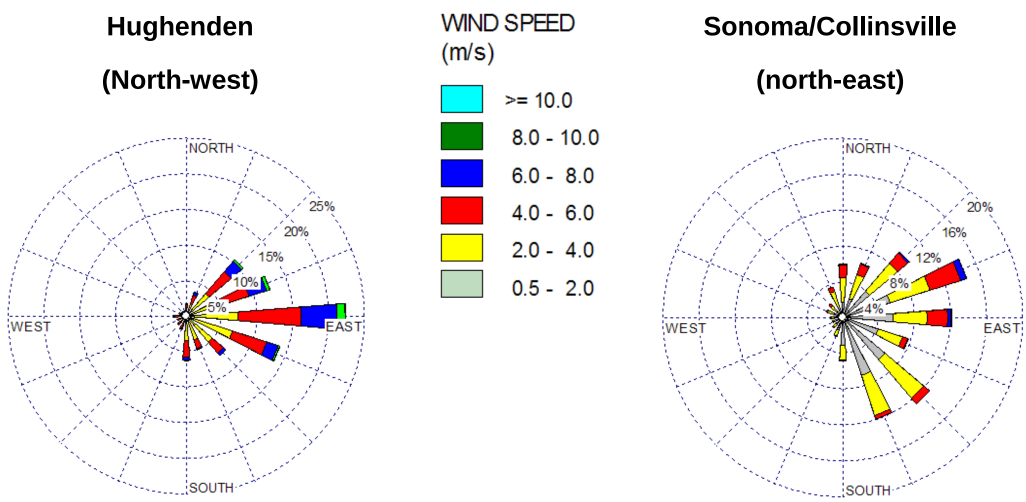
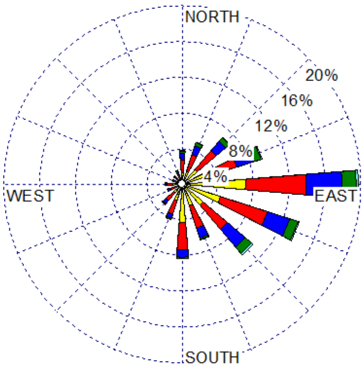


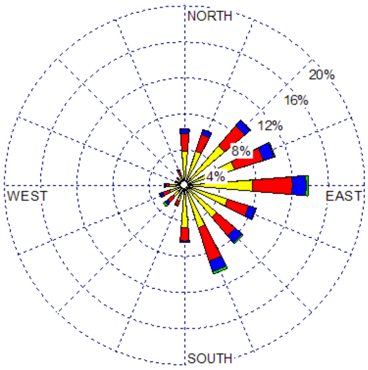
Figure 3-7 Comparison of Site-Specific Annual Wind Roses for the Wider Region



Winton (south-west)



Emerald (south-east)



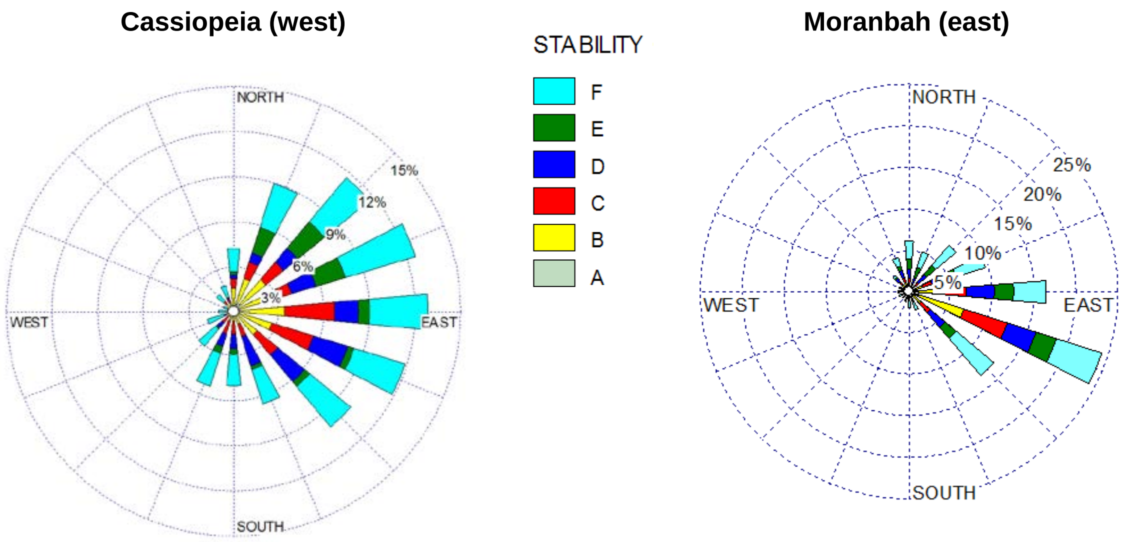
3.3.5 Atmospheric Stability

The modelling of air pollutant dispersion requires meteorological data, or an estimate, on hourly time varying atmospheric stability. This data can be in the form of atmospheric stability using the Pasquill-Gifford classification scheme which assigns letter codes to each stability category:

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

As illustrated in the stability roses shown in Figure 3-8, each representative site, base meteorological data derived in the same way as described in Section 3.3.4, exhibits a dominant F-class stability due to the light winds prevailing most nights (36.4 per cent at Cassiopeia and 31.2 per cent at Moranbah). Both sites show a similar percentage of unstable conditions during the daytime with 39.6 per cent at Cassiopeia and 37.8 per cent at Moranbah. The latter has these conditions, with prevailing winds predominantly from the east-south-east, while at the western site the unstable conditions are spread wider with winds having components from both the south-east and north-east quadrants.

Figure 3-8 Comparison Annual Stability Roses for Representative Sites



3.3.6 Mixing Height

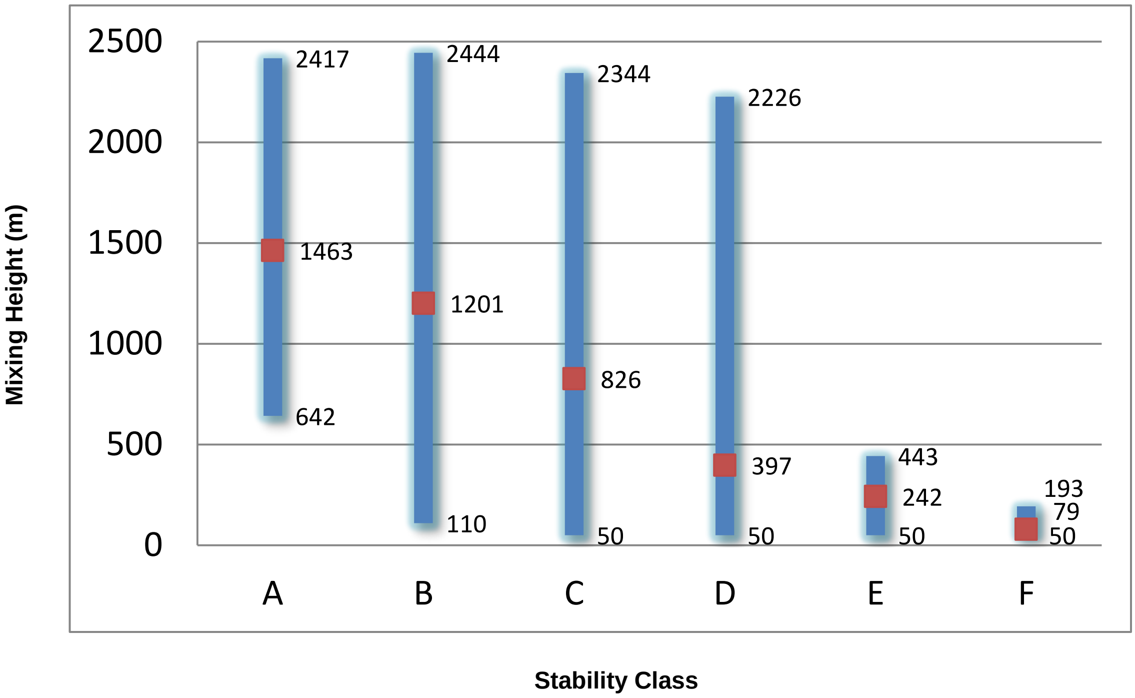
The depth of the mixing height is an indicator of vertical dispersion potential of the atmosphere and is a mixture of mechanical and convective influences. Convective conditions dominate during the day in a near desert climate especially as temperatures are often high in summer. Even the sub-tropical climate in winter has daytime temperatures often above 20°C. Conversely, the night-time mixing height is dominated by the formation of temperature inversions on the vast majority of nights with associated F-class stability.

For the derived mixing heights, as shown in Figure 3-9, using meteorological data for the western and eastern representative sites as described above, the following main points can be noted from the statistical data:

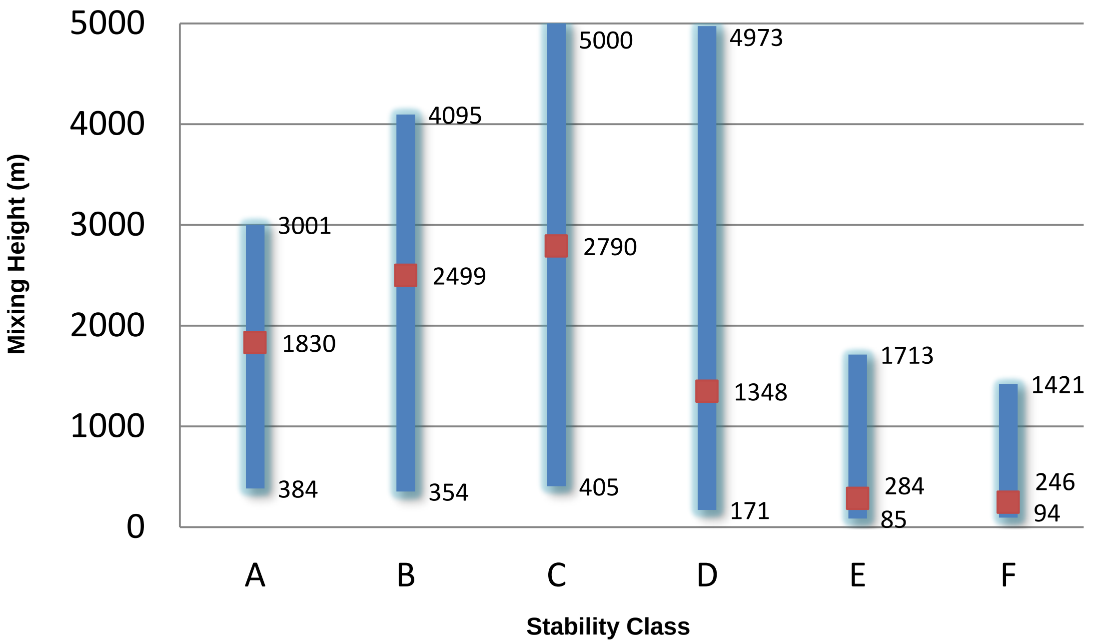
- The eastern site has a higher mean wind speed (3.58 m/s compared to 2.71 m/s) which produces more mechanical mixing
- Minimum daytime mixing heights were in the range of 50 to 640 m metres which is reasonable when at least some days are likely to have cloudy to overcast conditions and for the most unstable conditions (Class A)
- Night-time mixing heights were as low as 50 m during the calmest periods but could reach to above 1,500 m during nights with strongest winds

Figure 3-9 Stability Class Derived Mixing Height: Minimum, Average and Maximum

Cassiopeia – West and Central Sections



Moranbah – East Section



Note: ■ denotes average.

3.4 Sensitive Receptors

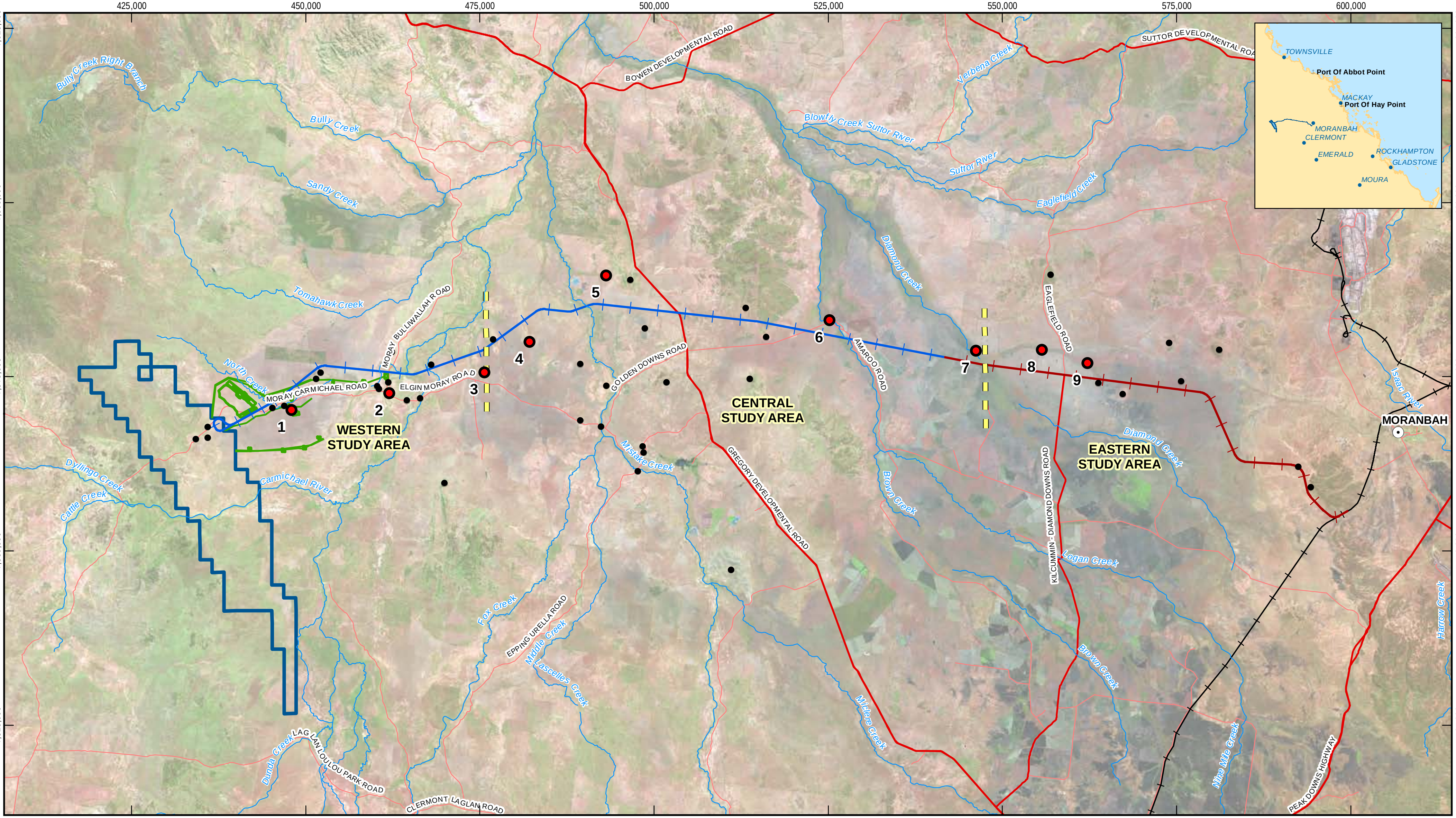
Nine sensitive receptors occur within 5 km of the proposed Project (Rail), as shown in Figure 2-1 and summarised in Table 3-1. The nearest receptor to the Project (Rail) is at 1.6 km to the north. The nearest receptor to the south is the Project (Mine) workers accommodation village at a distance of 2.45 km.

Table 3-1 Summary of Sensitive Receptors

Potential Receptors	Easting	Northing	Approximate Distance from the Project (Rail) (m)	Description/Comment
1	448007	7570210	2,450 (south)	Project (Mine) workers accommodation village
2	462027	7572602	3,300 (south)	Homestead
3	475674	7575617	3,000 (south)	Homestead
4	482139	7579957	3,000 (south)	Homestead
5	494429	7589482	4,200 (north)	Homestead
6	525174	7583086	2,000 (north)	Homestead
7	546218	7578704	1,600 (north)	Homestead
8	555680	7578811	3,000 (north)	Homestead
9	561038	7577015	1,900 (north)	Homestead

3.1 Quarry and Borrow Pits

To facilitate the provision of resource material to the Project, a number of potential quarries and/or borrow areas are being investigated within the landscape (refer Figure 3-10). The Victorian EPA publication AQ 2/86 provides a recommended buffer distance for quarrying operations to provide sufficient separation from industry to sensitive land uses.. Environmental assessment and approvals of quarries and borrow pits will be undertaken outside of the EIS process.



1:750,000 (at A4)

0 5 10 15 20 25

Kilometres

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

N

LEGEND

- Town
- Sensitive Receptor
- Study Extent
- Watercourse
- State Road
- Local Road
- Other Rail Network
- Rail (West)
- Rail (East)
- Mine (Onsite)
- Mine (Offsite)
- Investigation Areas

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Potential Quarry and Borrow Area Locations

Job Number	41-25215
Revision	B
Date	14-09-2012

Figure 3-10

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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: Noise Logger/Sensitive Receptor Locations,Study Extent(2012); DERM: DEM (2008); DME: PC1690 (2010), EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Localities, Railways, Roads, Watercourse (2007);
Adani: Alignment Opt9 Rev3 (SP1&2), Investigation Areas (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: AF, JVC.MS

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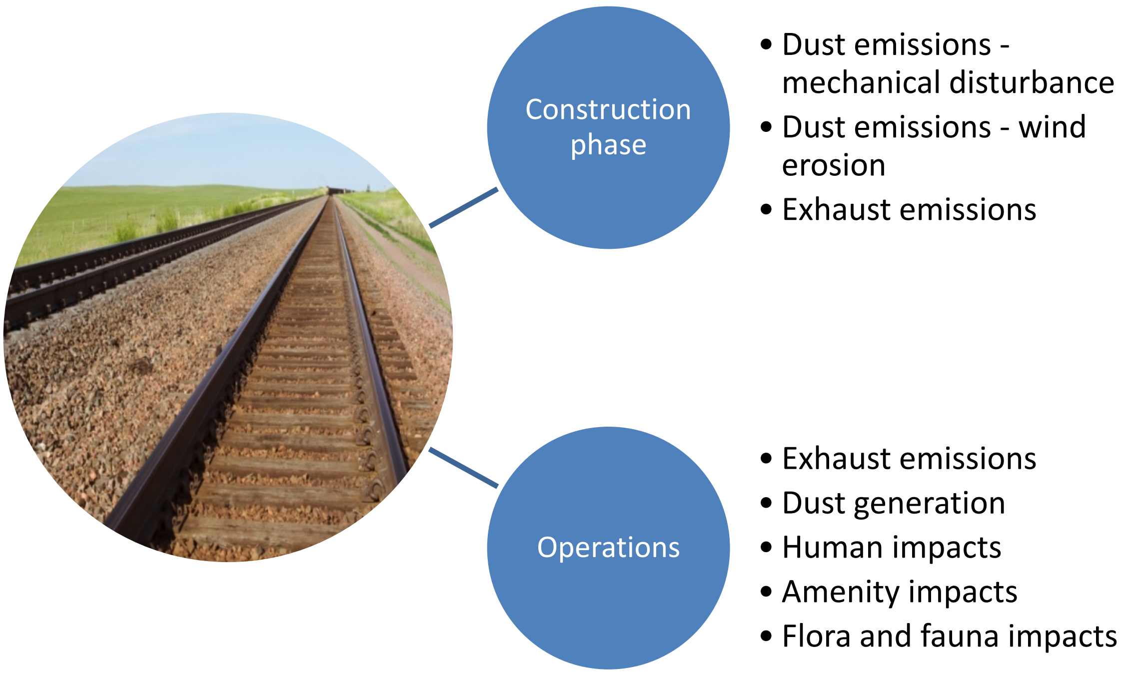
4. Potential Impacts and Mitigation

4.1 Overview

The construction and operation of the Project (Rail) have the potential to cause air quality impacts on the surrounding environment. Figure 4-1 provides a conceptual overview of the potential impacts of the Project (Rail).

Potential impacts have been identified and analysed on the basis of a desktop analysis combined with modelling based on the construction and operation methods, regimes and equipment proposed to be used.

Figure 4-1 Potential Impacts of the Project (Rail)



4.2 Emissions during Construction

4.2.1 Overview

The emissions during the construction phase of the Project (Rail) will primarily consist of:

- Dust emissions from mechanical disturbance by construction and maintenance vehicles and equipment
- Wind erosion of crustal material: dust emissions from exposed disturbed soil surfaces under high wind speeds
- Exhaust emissions from the range of motor vehicle and mobile plant required for the Project (Rail)

4.2.2 Hazardous Air Pollutants

The exhaust emissions are the only emission source from construction that is not dust. However, the scale of construction emissions in this isolated rural environment is considered to be minor, being remote from any sensitive receptor locations for a large proportion of the Project (Rail).

4.2.3 Dust Generation

The major potential dust sources during the construction phase are expected to include the following works:

- Land clearance for site preparation
- Earthworks and excavation and where required, pneumatic rock-breaking
- Top soil and soil/gravel/crushed rock handling (stockpiling, loading, dumping)
- Leveling and grading of disturbed soil surfaces
- Placement of ballast
- Laying of concrete sleepers and rail
- Construction and administrative vehicles travelling over unsealed sections of road or localised unconsolidated surfaces
- Wind erosion of unconsolidated surfaces such as unstable/uncovered cleared land and stockpiles

The dominant sources of dust emissions during the construction phase will be activities that cause large mechanical disturbances such as operation of bulldozers, graders, scrapers, haul trucks and various phases of the track laying process. Track laying processes are considered to have minimal dust generating potential compared to the corridor clearing phase.

Civil works involve general earthworks, drainage work, access track works and bridge work (inclusive of temporary concrete batching plants at some depot locations). Possible equipment sources of dust emissions include bulldozers, excavators, wheel loaders, graders, scrapers, rollers, backhoes, dump trucks, cement delivery trucks, water carts, truck mounted cranes, piling rigs and support vehicles.

Analysis of the local wind climate indicates a higher occurrence of wind from the eastern quadrant, i.e. between the northeast, east and southeast. The potential for air quality impact is greatest at receptors located closest to the edge of the Project (Rail) or at construction camps, with the level of impact decreasing with increasing distance from the construction activity. Notwithstanding this, the separation distances between the Project (Rail) and sensitive receptors in the region are significant and are likely to provide an adequate buffer from any potential dust impact. At this stage of the assessment, only a qualitative assessment has been conducted. While dust generated by construction activities is unlikely to impact air quality at sensitive places in the region, measures to mitigate the generation of dust emissions will be investigated and applied through the Project (Rail) Environmental Management Framework, which will include a Dust Management Plan. The Dust Management Plan will consider the recommendations made in the QR National Coal Dust Management Plan (QR Network, 2010).

4.3 Emissions During Operation

4.3.1 Overview

Potential sources of air emissions from the operation phase of the Project (Rail) include:

- Exhaust emissions from diesel powered locomotive engines, including fine particulate material
- Fugitive coal dust emissions from uncovered coal wagons in transit (loaded or returning unloaded, the latter less likely), any leakage from delivery doors, parasitic sources from wagon sills, couplings, shear plates and bogies of wagons and wind erosion of spilled coal in the corridor.

Relevant exhaust emissions from diesel engines include:

- Carbon monoxide (CO)
- Oxides of nitrogen (NOx) – assessed as nitrogen dioxide (NO_2)
- Sulfur dioxide (SO_2)
- Benzene
- Trace hydrocarbons
- PM_{10} and $PM_{2.5}$

All of the non-‘dust’ sources are assessed as Hazardous Air Pollutants with emissions as defined in Section 4.3.2. The assessment of the particulate matter requires the addition of the two sources of particulates from both diesel exhausts and the fugitive coal sources listed above. The emissions inventory for the particulate matter of all three sub-types (TSP, PM_{10} and $PM_{2.5,}$ used to determine dust deposition/fallout) is defined as Dust Generation in Section 4.3.2.

4.3.2 Locomotives Emissions

Locomotives are likely to be a mixture of those outlined in Table 2-5 of Volume 3, Section 2 Description of the Project (Rail). Brake horse power (bhp) is a measure of the tractive effort available for locomotion from internal combustion engines. As a result of the expected mixture of locomotives, and the potential for alternate locomotive models to be selected, a range of between 3000 and 5000 bhp per locomotive has been considered in the assessment of locomotive emissions.

With four locomotives per train, each train will be able to obtain speeds of up to 100 km/h when unloaded and a maximum speed of 80 km/h when loaded. Trains will be operated in a line-haul mode and emissions as grams per power output are listed in Table 4-1 (DieselNet, 2008). At this point, it is unknown what manufacturing standards will be applied and this results in consideration of Tier 0, Tier 1 and Tier 2 emission standards. It is worth noting that these emission standards are lower than comparable Non-road Diesel Engines of equivalent power.

Table 4-1 Line-Haul Locomotive Emission Standards

Emission Standard	Hydrocarbons (g/bhp-h)	CO (g/bhp-h)	NOx (g/bhp-h)	Particulate matter (g/bhp-h)
Tier 0	1.00	5.0	8.0	0.22
Tier 1	0.55	2.2	7.4	0.22
Tier 2	0.30	1.5	5.5	0.10

It is estimated by USEPA that Volatile Organic Compounds (VO's) are at a ratio of 1.053 to the hydrocarbon emissions in the standards above (USEPA, 2009). For diesel engines, all of the Particulate Matter can be considered to consist of the PM_{10} fraction (USEPA, 2009). A further reasonable assumption is that 98 per cent of the PM_{10} is the finer $PM_{2.5}$ fraction (NPI, 2008a, Table 42, p.69). The range of operating power of the locomotive types and the operating speeds can be used with the above data to give emissions in grams per Vehicle Kilometre Travelled (g/VKT) for a single locomotive. These data are summarised in Table 4-2 (and presented in Appendix C) and it is clear that the oldest (Tier 0) and biggest locomotive (5000 bhp) produces the most emissions.

Table 4-2 Line-Haul Locomotive Emission for a Single Locomotive at Operating Speed

Emission Standard	Hydrocarbons (g/VKT)	CO (g/VKT)	NOx (g/VKT)	PM_{10} (g/VKT)	$PM_{2.5}$ (g/VKT)	VOC (g/VKT)
3000 bhp Locomotive						
Tier 0	37.5	188	300	8.25	8.1	39.5
Tier 1	20.6	82.5	278	8.25	8.1	21.7
Tier 2	11.3	56.2	206	3.75	3.7	11.8
5000 bhp Locomotive						
Tier 0	62.5	312	500	13.8	13.5	65.8
Tier 1	34.4	137	463	13.8	13.5	36.2
Tier 2	18.7	93.7	344	6.25	6.13	19.7

4.3.2.1 Emission Constituents

The oxides of nitrogen data from above needs to be assessed as a ground level impact of nitrogen dioxide. Therefore, an assumed NO_2 to NOx ratio of 20 per cent was used. Sulfur dioxide emissions are highly dependent on the sulfur content of the diesel fuel used. It is assumed that the regulated low-sulfur diesel fuel will be used (maximum of 10 ppm as per Australian Diesel Fuel Standard). SO_2 emissions were estimated by using the same ratio of 0.4 per cent of VOC emissions as found in the emission factor estimation for diesel powered locomotives (NPI 2008b, Table B.1, p.33). In a similar way, the benzene emission factor was estimated by its contribution to 8 per cent of total VOC's.

A research paper for the USEPA provides estimating factors for relevant Hazards Air Pollutant (HAP) constituents using a speciation base of either PM_{10} or VOC (Eastern Research Group, 2011, Table 3-1, p.3-2). The following ratios were used for the (remaining) Air Toxic compounds of interest:

- Formaldehyde is 0.0945 per cent of PM_{10}
- Toluene is 0.32 per cent of VOC
- Xylene is 0.4 per cent of VOC

The locomotive diesel exhaust emissions per train consist are summarised in Table 4-3.

Table 4-3 Line-Haul Locomotive Emissions for Locomotive Consists at Operating Speed

Constituent	3000 bhp Locomotives			5000 bhp Locomotives		
g/VKT	Tier 0	Tier 1	Tier 2	Tier 0	Tier 1	Tier 2
TSP	33	33	15.0	41.3	41.3	18.8
PM_{10}	33	33	15.0	41.3	41.3	18.8
$PM_{2.5}$	32.3	32.3	14.7	40.4	40.4	18.4
Benzene	51.8	28.5	15.5	48.6	26.7	14.6
CO	750	330	225	938	833	281
Formaldehyde	0.03	0.03	0.01	0.04	0.04	0.02
NO2	240	222	165	300	278	206
SO2	0.62	0.34	0.19	0.77	0.42	0.23
Toluene	0.51	0.28	0.15	0.63	0.35	0.19
Xylene	0.76	0.42	0.23	0.95	0.52	0.28

4.3.3 Dust Generation

In addition to the particulate matter emitted by the diesel locomotives, fugitive coal dust emissions will add to the mass per VKT requiring to be assessed. To reach the nominal maximum coal transport rate of 100 Mtpa for the west and central sections of the alignment, an estimated 18 return trips each day is required (i.e. 36 trips) where the net load per train is 24,000 tonnes of coal consisting of 240 wagons. For the eastern section 60 Mtpa will be the maximum transport amount, equating to an estimated 18 return trips each day (i.e. 36 trips) where the net load per train is 10,050 tonnes of coal consisting of 120 wagons.

The emission factor of total coal dust from the moving fully loaded coal train was calculated using the equation detailed in the Coal Dust study from Connell-Hatch (2008), as shown below for g-TSP/km (tonne of loaded coal):

- Emission Factor (loaded coal train) = $0.0000378(V)^2 - 0.000126(V) + 0.000063$
- Where V is the speed of the train (km/h)

The speed of the train is greater than ambient wind speeds; therefore, the primary mechanism for coal dust lift-off from coal trains is forced wind erosion of the coal surface. Other factors that contribute to emissions include mine-specific coal properties (dustiness, moisture content and particle size), wagon vibrations, coal load profile, exposure to wind and precipitation. Since these factors are essentially unquantifiable, a conservative 25 per cent spillage factor was applied to the emission factor. This therefore becomes a fugitive coal and dust re-entrainment emission factor enhancement that is due to displaced coal (other than windblown) from flat surfaces of the wagons and under-carriage.

For Project (Rail), the loaded trains will be hauling between 10,050, 16,072 and 24,000 tonne of coal each at a maximum speed of 80 km/h. The above equation therefore results in an estimated TSP emission factor of 2,957 g/VKT for each train. As there will be up to 18 trains per day, operating 320 days per year (at peak production), it is conservative to model this emission rate for each hour of the modelled year.

The PM_{10} emission factor was taken to be 50 per cent of the TSP rate. This is based on the emission estimation technique for wind erosion of coal stockpiles used by the NPI (2011, Appendix A section 1.1.17, p.57). The same reference does not give a similar ratio for $PM_{2.5}$ to PM_{10} so a conservative assumption of 50 per cent has been used.

For the fully loaded train travelling east from the Mine, the emission factors for dust (TSP, PM_{10} and $PM_{2.5}$) for a coal pay load are added to the corresponding diesel exhaust particulate emissions from the worst-case 5000 bhp locomotive with Tier 0 emission standard. As a numerical example for demonstrative purposes, this will result in a total TSP emission rate for the fully loaded train of 2998 g/VKT, i.e. 2957 + 41 (16,072 tonne pay load).

Accounting for Return Trips

In order to account for the return trips of empty trains, two train movements per hour past any given point along the corridor have been included in the short term modelling as a conservative assumption.

In addition to the movement of the fully loaded train, an empty train travelling west, i.e. returning to the Mine to be re-loaded, will pass the same point. These westbound empty train emissions need to be added to the eastbound full train emissions, considering the following:

- The empty westbound train is much lighter and therefore does not require the same power from the locomotives. Therefore, emissions will be lower.
- The empty westbound train is travelling at a higher speed than the loaded eastbound train (100 km/h as compared to 80 km/h fully loaded) and as such, the emissions will not be directly proportional to the overall mass of the train, as drag air resistance is proportional to the square of the speed.

Assuming that the unloaded locomotives will be able to run at 25 per cent of full power, a reducing factor of 0.25 can be applied to locomotive emissions. However, as air resistance is proportional to the square of the speed, the required extra power to maintain 100 km/h as compared to 80 km/h is 56 per cent (a factor of 1.56). For this generalised estimate, a safety factor of 1.5 has been used. Therefore, an overall unloaded train locomotive emission correction factor of 0.58 (0.25 x 1.56 x 1.5) is applied to the locomotive emissions detailed in Table 4-3.

The resultant locomotive emissions for all trains, both the loaded and empty, passing a single point used for assessing ambient air quality is determined by multiplying emissions in Table 4-3 by a correction factor of 1.58.

With regards to the TSP demonstrative example from above, total TSP emissions from the Project (Rail), the emission factor was calculated to be 3,022 g/VKT, i.e. 2957 + 1.58(41). As such, particulate emissions from the worst case 5000 bhp locomotives can be seen to be a small contributor to the overall dust emissions from the railway operations.

Accounting for Longer Term Averaging Periods

Assuming one train per hour eastbound (loaded) and one train per hour westbound (empty), it is considered too conservative for the assessment of those substances with longer averaging periods, i.e. daily and annual, when there is actually less than one train per hour – 18 return trips per 24 hours.

Long term averaging period correction was not applied to the assessment of gaseous locomotive emissions as there are actually 18 return trips in a day in which gaseous locomotive emissions are produced. However, a long term averaging correction was made to coal dust emissions as there are only 18 trips per day of fully loaded trains, where wind erosion contributes over 98 per cent of the total particulate emissions. Therefore, the emissions for TSP, PM_{10} and $PM_{2.5}$ had a correction factor of 1.33 applied (18/24).

With regards to the TSP example of above, the total modelled TSP emissions were 2266 g/VKT, i.e. (0.75 x [2957 + 1.58 x 41]).

When assuming 50 per cent of TSP coal dust is in the PM_{10} fraction, the emissions factor for PM_{10} is 1133 g/VKT, i.e. (0.75 x [0.5 x 2957 + 1.58 x 41]).

The $PM_{2.5}$ emission factor was calculated to be 567 g/VKT, i.e. (0.75 x [0.5 x 0.5 x 2957 + 1.58 x 41]).

4.4 Human Impacts

4.4.1 Overview

The line-source Gaussian model AUSROADS V1.0 was selected to assess the human impacts. Since this model is designed for linear transport corridors it requires emission factors in g/VKT (see Section 4.3 above) and site-representative meteorology or better (see Section 3.3 above). The Project (Rail) was split into three sections for modelling to assess impacts as a function of distance away from the alignment. This methodology was selected as the nearest known sensitive receptor to the alignment is more than one km away.

4.4.2 Track Alignment

The application of AUSROADS to modelling the train line emissions was made by considering the emissions from typical track alignment sections of one kilometre in length oriented in the general direction of the alignment for each representative section. Receptors were placed at varying lateral distances from the line at up to 200 m distance. The track orientations (blue line) and transect receptor locations (red crosses) are graphically reproduced in Figure 4-2 with the blue line being scaled at 1 km.

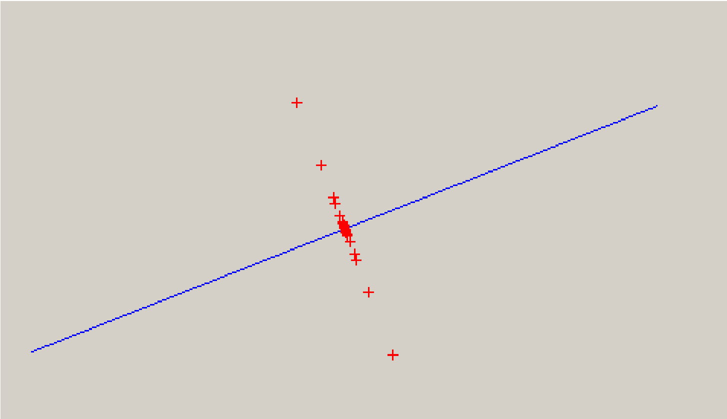
AUSROADS simulations were conducted for the annual meteorological data sets (see Section 3.3) at hourly intervals using Cassiopeia for the western section and Moranbah for the central and eastern sections.

The parameters and input data used for the AUSROADS simulations are:

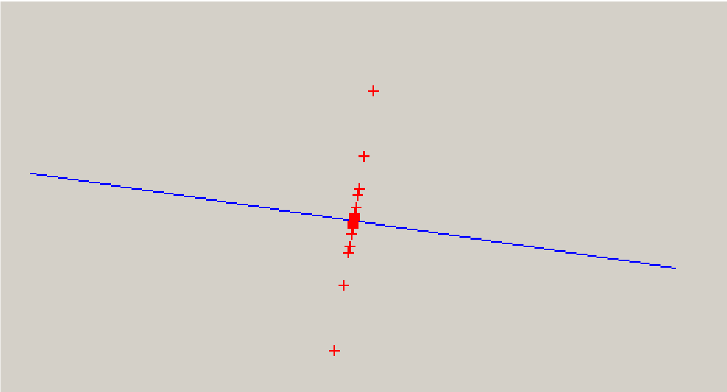
- Site representative 12-month meteorological file as appropriate for each of three sections
- Anemometer height of 10 m (Bureau of Meteorology standard)
- Meteorological site surface roughness of 0.3 m
- Sigma-theta averaging period of 60 minutes
- Pasquill-Gifford horizontal dispersion
- Irwin rural wind exponent
- Link geometry – one single track set to a width of 6 m to allow for turbulent mixing from a fast moving train
- Link geometry consisted of one km track sections with orientation as indicated in Figure 4-2
- Averaging periods of 1-hour, 8-hours, 24-hours and one year were selected as appropriate for assessment against EPP (Air) criteria
- Discrete receptors were set 2, 5, 10, 20, 40, 50, 100, and 200 m intervals in a perpendicular direction away from both sides of the track sections
- Emissions data derived from emission estimation in g/VKT for a one km straight track segment (‘Link’) assuming a fixed number of one loaded train per hour on all days (weekdays and weekends) for a worst case scenario
- Post-processing was performed to obtain worst case ground level concentrations

Figure 4-2 Modelled Representative Track Alignments (blue line) and Transects Receptor Locations (red crosses)

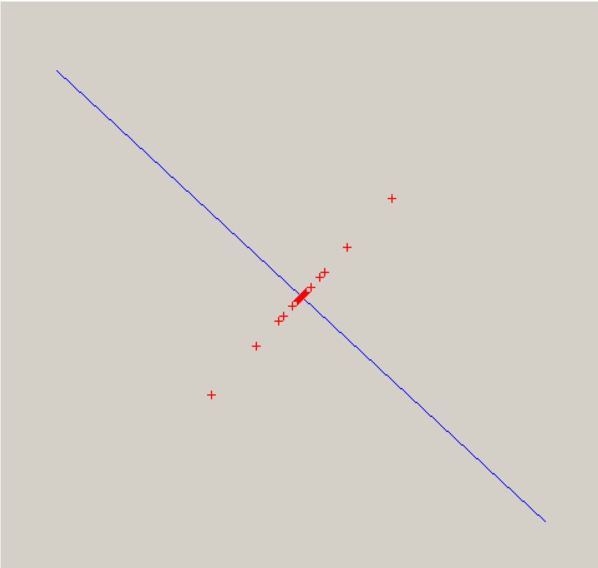
Western section



Central section



Eastern section



4.4.3 Assessment Scenarios

Dispersion modelling of the locomotive engine exhaust plume has been carried out based on worst case emission concentrations data i.e. 5000 bhp locomotives with Tier 0 emission standards. Dispersion modelling of emissions associated with the locomotives and coal wagons has been carried out using the AUSROADS line model to predict plume ground-level concentrations at discrete receptors set at varying distances from the rail line. While the AUSROADS receptor domain is set to a maximum distance from the rail line of 200 m to assess the dispersion of air pollutants at distance from the source, it should be noted that the shortest separation distance between the rail line and sensitive receptors along all sections of the Project (Rail) is 1.6 km. An example of the AUSROADS model configuration file is presented in Appendix B.

The AUSROADS model has been run for three different track sections that represent different track alignments and meteorological datasets in the Project (Rail) regions, namely western, central and eastern.

The air quality impact assessment has been made for:

- Particulate matter associated with locomotive combustion engines combined with coal wagon fugitive releases. A cumulative assessment of particulate matter as TSP, PM_{10} and $PM_{2.5}$ from the Project (Rail) has been made with the inclusion of background levels.
- All other air pollutants released from the Project (Rail), such as NO_2, SO_2, CO, formaldehyde, benzene, toluene and xylenes associated with locomotive combustion engines, have been assessed in isolation.

Due to the remote location and distance from other major industry and urban centres, background levels of the combustion related criteria pollutants are expected to be low. Consequently, background levels have not been included. For VOCs, the air quality objectives are designed for an assessment of predicted ground-level concentrations in isolation with no background levels included.

4.4.4 Interpretation of Air Quality Impacts

The assessment found that ground-level concentrations of all air pollutants released from the Project (Rail) are predicted to be well below the EPP (Air) objectives at the nearest sensitive receptor, (1.6 km from the rail line). The assessment also found that the EPP (Air) objectives are met for all air pollutants within the fence-line of the rail corridor with the exception of PM_{10} and $PM_{2.5}$, which were found to be the most important air pollutants in terms of the predicted ground-level concentration as a percentage of its air quality objective.

The findings of the AUSROADS dispersion modelling assessment of locomotive exhaust emissions are presented in Appendix B. Results are tabulated as ground-level concentrations of air pollutants at a distance (out 200 m) from the rail line. The findings of the AUSROADS dispersion modelling of TSP, PM_{10} and $PM_{2.5}$ for locomotive exhaust and coal wagon fugitive emissions combined are presented in Appendix C.

Measures to mitigate the emissions will be investigated and applied through the Project (Rail) Environmental Management Framework that will consider the recommendations made in the QR National Coal Dust Management Plan (QR Network, 2010).

4.4.4.1 Particulate Matter

A summary of the ground-level concentrations of TSP, PM_{10} and $PM_{2.5}$ for the Project (Rail) are presented in Table 4-4 to Table 4-6. Predicted maximum ground-level concentrations of TSP, PM_{10} and $PM_{2.5}$ at the fence-line on both sides of the rail line combined with background levels have been presented. A scatter plot of the predicted 24-hour average ground-level concentrations of PM_{10} versus distance from the rail line to the north and south is presented in Figure 4-3.

Table 4-4 Predicted Maximum Ground-level Concentrations of PM_{10} at the Fence-line

Section	Background µg/m³	Criterion µg/m³	North Fence µg/m³	South Fence µg/m³	Distance Beyond Fence to Criterion (m)	
					North	South
Averaging Period = 24 hour						
West	11.0	50	107	140	>145	>145
Central	18.8	50	86	98	145	>145
East	18.8	50	46	64	N/A	30

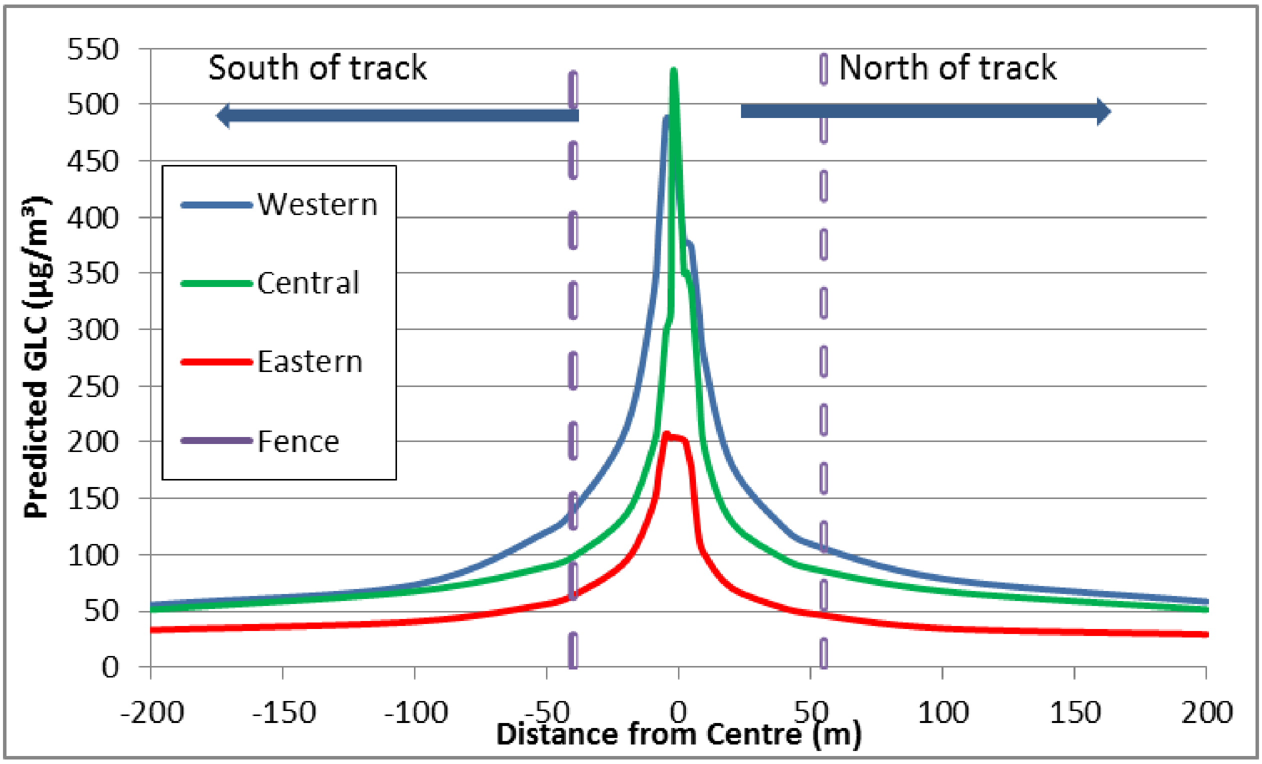
Table 4-5 Predicted Maximum Ground-level Concentrations of TSP at the Fence-line

Section	Background µg/m³	Criterion µg/m³	North Fence µg/m³	South Fence µg/m³	Distance Beyond Fence to Criterion (m)	
					North	South
Averaging Period = Annual						
West	22.0	90	84	77	N/A	N/A
Central	37.6	90	96	105	19	38
East	37.6	90	45	77	N/A	N/A

Table 4-6 Predicted Maximum Ground-level Concentrations of $PM_{2.5}$ at the Fence-line

Section	Background µg/m³	Criterion µg/m³	North Fence µg/m³	South Fence µg/m³	Distance Beyond Fence to Criterion (m)	
					North	South
Averaging Period = 24 hour						
West	3.3	25	51	69	143	158
Central	5.6	25	38	44	83	98
East	5.6	25	20	29	N/A	11
Averaging Period = Annual						
West	3.3	8	18.2	16	146	161
Central	5.6	8	18.1	21	>145	>145
East	5.6	8	7.5	16	N/A	11

Figure 4-3 Predicted Ground-level Concentrations Peak Incremental Impacts of the Daily PM_{10}



Note: Combined from locomotive exhaust emissions and coal wagon fugitive dust (including background of 11 µg/m³ for western and 18.8 µg/m3 for the central and eastern sections).

The assessment found that the predicted maximum 24-hour average ground-level concentration of PM_{10} is 140 µg/m³, at the southern fence-line (i.e. 40 m to the south) in the western railway section. Notwithstanding this, the nearest sensitive receptor in this section of line is located 2.45 km to the south. As can be seen from Figure 4-3 the ground-level concentration of PM_{10} is predicted to diminish rapidly with distance from the rail line and is predicted to meet the EPP (Air) objective of 50 µg/m³ at the nearest sensitive receptors and be within the criterion by approximately 100 m from the track centreline.

For $PM_{2.5}$, the maximum annual average ground-level concentration is predicted to be 21 µg/m³ at the central fence-line of the central section. However, the annual average concentration is predicted to be well below the EPP (Air) criterion at the nearest sensitive receptor location here being at a distance of 1.6 km.

4.4.4.2 Minor Air Pollutants

The assessment found that the most influential constituent emitted from the locomotives exhaust is NO_2. However, the highest level of NO_2 at any Project (Rail) fence line (i.e. 40 m away to south side of the western railway section) is 145 µg/m³, which is well below the 250 µg/m³ hourly criterion (i.e. 58 per cent of its 250 µg/m³ criterion), as illustrated in Figure 4-4. Hence, nitrogen dioxide emissions from Project (Rail) are not expected to be a significant detriment to the total nitrogen dioxide environmental values within the Project (Rail) area. Also it can be seen that for all predicted ground level concentrations at the discrete model receptors decreases rapidly as a function of the distance away from the railway). It is also worth reiterating that the nearest sensitive receptor is at least 1.4 km from the Project (Rail). The predicted ground-level concentrations of NO_2, benzene, CO, formaldehyde, SO_2, toluene and xylene are presented in Table 4-7 to Table 4-13.

Figure 4-4 Predicted Ground-level Concentrations of the Hourly Nitrogen Dioxide Particulate Locomotive Emission Peak Incremental Impacts

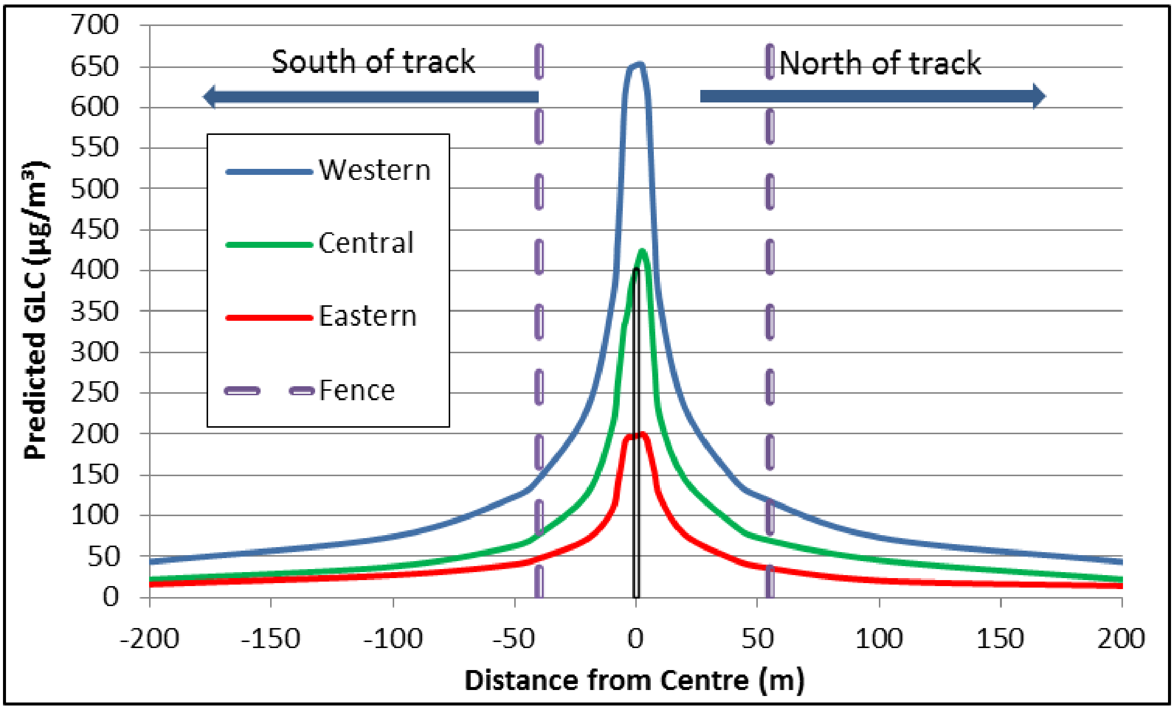


Table 4-7 Predicted Maximum Ground-level Concentrations of NO_2 at the Fence-line

Section	Background µg/m³	Criterion µg/m³	North Fence µg/m³	South Fence µg/m³	Distance Beyond Fence to Criterion (m)	
					North	South
Averaging Period = 1 hour						
West	0	250	119	145	N/A	N/A
Central	0	250	70	77	N/A	N/A
East	0	250	36	48	N/A	N/A
Averaging Period = Annual						
West	0	62	7.5	6.3	N/A	N/A
Central	0	62	5.2	6.7	N/A	N/A
East	0	62	1.1	6.2	N/A	N/A

Table 4-8 Predicted Maximum Ground-level Concentrations of Benzene at the Fence-line

Section	Background µg/m³	Criterion µg/m³	North Fence µg/m³	South Fence µg/m³	Distance Beyond Fence to Criterion (m)	
					North	South
Averaging Period = Annual						
West	0	10	1.21	1.03	N/A	N/A
Central	0	10	0.84	1.09	N/A	N/A
East	0	10	0.18	1.00	N/A	N/A

Table 4-9 Predicted Maximum Ground-level Concentrations of CO at the Fence-line

Section	Background µg/m³	Criterion µg/m³	North Fence µg/m³	South Fence µg/m³	Distance Beyond Fence to Criterion (m)	
					North	South
Averaging Period = 8 hours						
West	0	11000	203	203	N/A	N/A
Central	0	11000	109	127	N/A	N/A
East	0	11000	58	89	N/A	N/A

Table 4-10 Predicted Maximum Ground-level Concentrations of Formaldehyde at the Fence-line

Section	Background µg/m³	Criterion µg/m³	North Fence µg/m³	South Fence µg/m³	Distance Beyond Fence to Criterion (m)	
					North	South
Averaging Period = 30 minutes						
West	0	110	0.02	0.02	N/A	N/A
Central	0	110	0.01	0.01	N/A	N/A
East	0	110	0.005	0.006	N/A	N/A
Averaging Period = 24 hour						
West	0	54	0.004	0.005	N/A	N/A
Central	0	54	0.002	0.003	N/A	N/A
East	0	54	0.0011	0.0018	N/A	N/A

Table 4-11 Predicted Maximum Ground-level Concentrations of SO_2 at the Fence-line

Section	Background µg/m³	Criterion µg/m³	North Fence µg/m³	South Fence µg/m³	Distance Beyond Fence to Criterion (m)	
					North	South
Averaging Period = 1 hour						
West	0	570	0.31	0.37	N/A	N/A
Central	0	570	0.18	0.20	N/A	N/A
East	0	570	0.093	0.12	N/A	N/A
Averaging Period = 24 hour						
West	0	230	0.07	0.10	N/A	N/A
Central	0	230	0.04	0.05	N/A	N/A
East	0	230	0.0219	0.036	N/A	N/A
Averaging Period = Annual						
West	0	22	0.02	0.02	N/A	N/A
Central	0	22	0.01	0.02	N/A	N/A
East	0	22	0.0028	0.016	N/A	N/A

Table 4-12 Predicted Maximum Ground-level Concentrations of Toluene at the Fence-line

Section	Background µg/m³	Criterion µg/m³	North Fence µg/m³	South Fence µg/m³	Distance Beyond Fence to Criterion (m)	
					North	South
Averaging Period = 30 minutes						
West	0	1100	0.25	0.31	N/A	N/A
Central	0	1100	0.15	0.16	N/A	N/A
East	0	1100	0.076	0.100	N/A	N/A
Averaging Period = 24 hour						
West	0	4100	0.06	0.08	N/A	N/A
Central	0	4100	0.04	0.04	N/A	N/A
East	0	4100	0.018	0.029	N/A	N/A
Averaging Period = Annual						
West	0	410	0.02	0.01	N/A	N/A
Central	0	410	0.01	0.01	N/A	N/A
East	0	410	0.002	0.013	N/A	N/A

Table 4-13 Predicted Maximum Ground-level Concentrations of Xylene at the Fence-line

Section	Background µg/m³	Criterion µg/m³	North Fence µg/m³	South Fence µg/m³	Distance Beyond Fence to Criterion (m)	
					North	South
Averaging Period = 24 hour						
West	0	1200	0.051	0.071	N/A	N/A
Central	0	1200	0.032	0.039	N/A	N/A
East	0	1200	0.027	0.044	N/A	N/A
Averaging Period = Annual						
West	0	950	0.0142	0.012	N/A	N/A
Central	0	950	0.0098	0.013	N/A	N/A
East	0	950	0.0035	0.02	N/A	N/A

4.5 Amenity Impact of Dust Deposition

In modelling the dust deposition rate, Ausplume was used with the source release geometry taken to be an area source (1000 m x 6 m sub-area sources) at 4 m above ground level. The total emission rate per kilometre was proportioned between the evenly spaced sub-area sources for the worst case scenario, with discrete receptors again set at 2, 5, 10, 20, 40, 50, 100 and 200 m intervals in a lateral direction away from both sides of the Project (Rail).

The Department of Environment and Heritage Protection (DEHP) has adopted an incremental impact assessment criterion for the maximum incremental dust deposition level equivalent to not exceeding 2 g/m²/month to ensure adequate protection of dust levels for residential amenity.

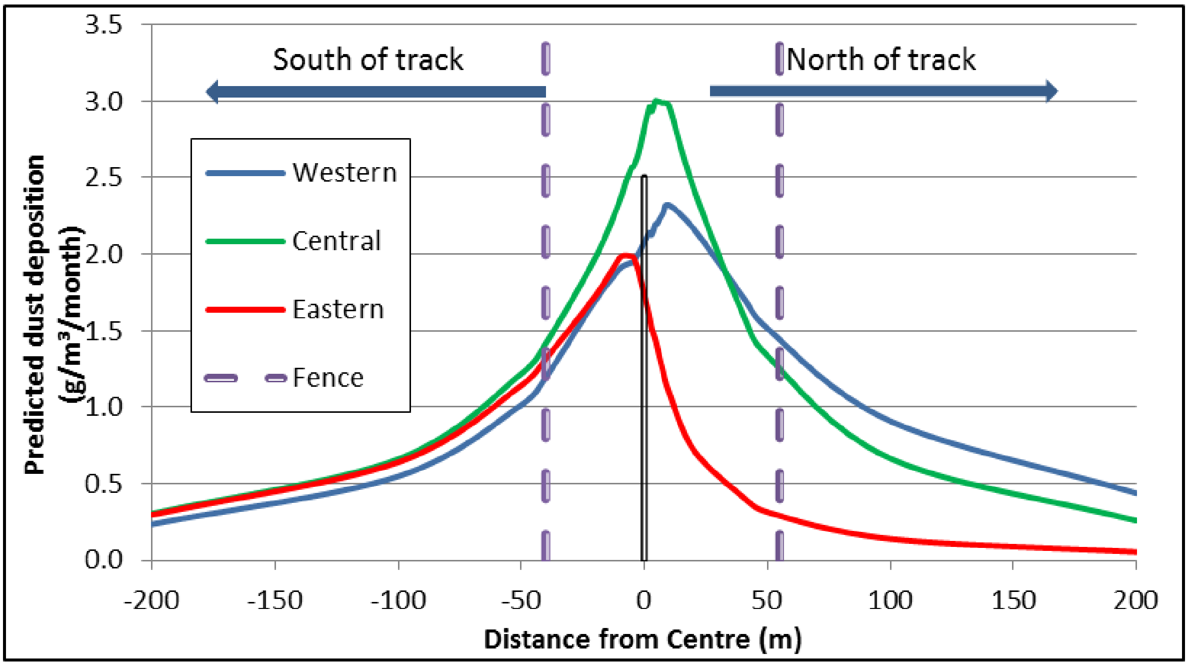
Table 4-14 and Figure 4-5 below show the predicted incremental dust deposition impact for receptors at perpendicular at discrete receptors at distances from the Project (Rail).

Table 4-14 indicates that the maximum incremental dust deposition level is less than the deposition guideline equivalent of 2 g/m^2/month at and beyond 50 m from the track centre line. This also corresponds to the total dust deposition rates (see Section 3.2.5), which is below the total deposition guideline of 4 g/m^2/month.

Table 4-14 Highest Locomotive Exhaust plus Coal Wagon Predicted Peak Incremental Dust Deposition Impacts

Railway Section	Pollutant	Averaging Period	TSP Criteria (g/m^2/month)	Predicted peak incremental concentration at distance from the railway (m)															
				North of railway								South of railway							
				2	5	10	20	40	50	100	200	2	5	10	20	40	50	100	200
West	**Deposited particles**	1 year	2	2.13	2.20	2.32	2.17	1.72	1.52	0.92	0.43	2.02	1.95	1.90	1.70	1.20	1.02	0.55	0.23
Central	**Deposited particles**	1 year	2	2.97	3.00	2.97	2.43	1.62	1.33	0.66	0.27	2.68	2.57	2.35	1.97	1.42	1.22	0.66	0.30
East	**Deposited particles**	1 year	2	1.60	1.41	1.10	0.72	0.41	0.31	0.14	0.05	1.87	1.98	1.98	1.73	1.32	1.14	0.64	0.30

Figure 4-5 Predicted Dust Deposition Annual Averages (g/m²/month)



4.6 Flora and Fauna Impacts

Coal dust emissions from loaded coal trains are emitted by wind erosion mainly dominated by train movement (speed), and have the potential to directly impact flora species and, to a lesser degree, fauna communities adjacent to railway systems. Potential issues within every railway system within central Queensland include economic loss, public nuisance and potential impact on the environment. For example, dust deposition on leaves can reduce the photosynthetic quality of the flora and impede plant growth and affect grazing productivity. Such an impact, if large enough, could degrade the health of the flora (native or pasture related) and cause plant dieback due to prolonged exposure. This in turn may reduce food resources for fauna communities.

An environmental review by Connell Hatch (2008) reviewed available literature for the impacts of coal dust on flora and fauna, crops and livestock. It was argued that air quality goals or standards to protect human health and amenity, such as in the EPP Air, were sufficient for the protection of flora, fauna, crops and livestock against dust impacts, as no goals and standards have otherwise been set for the non-human categories in the policy concerning protecting agriculture or health and biodiversity of ecosystems (including for natural, semi-natural or uncultivated areas).

Coal dust deposition on cotton crops at a rate of 500 mg/m²/day can be used as a threshold for adverse impacts on crops and vegetation (Connell Hatch 2008). It has also been experimentally demonstrated that even with livestock having access to feed containing coal dust at rates up to 8,000 mg/m²/day the following key indicators were not affected:

- Feed preference
- Palatability
- Quantity of feed eaten
- Quantity of milk produced

Connell Hatch (2008) reported on measured values along Queensland coal rail corridors as having values for coal deposition rates being well below values indicated in the literature as potentially having an impact on crops and livestock. Moreover, observational records show that within the rail alignment the highest values of about 90 mg/m²/day occur but this quickly decreases with distance from the corridor, even being as low as one-third below the peak at 30 mg/m²/day at 10 m from the tracks.

Coal dust deposition is unlikely to have a major impact on the flora and fauna within the surrounding region given the low deposition rates at the boundary fences. No literature has been found on the impacts of coal dust on native flora and fauna communities, although the same conclusions are likely to be appropriate.

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5. Conclusion

Potential environmental impacts of emissions from the coal trains, inclusive of locomotive exhaust emissions and fugitive coal dust from the wagons have been assessed against the environmental values identified in the EPP (Air) that enhance or protect qualities relating to:

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

Schedule 1 of EPP (Air) defines air quality objectives for indicators such that environmental values are enhanced or protected. The indicators relevant to the Project (Rail) are particulate matter (total suspended particulate, PM_{10} and $PM_{2.5}$); hazardous air pollutants from locomotive exhaust emissions and deposited dust. The latter is an important consideration along a coal rail transport corridor but this is not included in the Air Policy for Queensland. The concentrations of pollutants at locations where people are likely to be define the air quality impact so that the objectives of the EPP (Air) are met. Locations inside the Project (Rail) are therefore excluded from assessment. Only eight sensitive receptor locations are within 5 km of the Project (Rail). The nearest receptor to the Project (Rail) is 1.6 km to the north. The nearest south side receptor is the Project (Mine) workers accommodation village situated 2.45 km away.

The remoteness of the area indicates that background air quality measurements are few and expected to be low. The adopted particulate matter background levels for this inland region of Queensland was split between the western and the eastern end of the Project (Rail) while background levels of gaseous pollutants were considered to be negqligible.

Existing conditions include a 'Sub-tropical' climate and a sub-classification of ‘Moderately dry winter’. The gradient of rainfall, temperature and humidity from east to west suggests a drier climate moving further away (westward) from the coast. There is a clear pattern of rainfall decreasing as you move inland. The annual mean rainfall along the Project (Rail) length is dominated by the warm months (December, January and February) producing convectively driven rainfall.

Comparisons of site-specific wind roses for the wider region show how the wind regime subtly changes but an overall pattern of dominant easterly component winds was found for the Project (Rail). Site specific meteorological datasets for the different sections of the Project (Rail) were developed and validated against the regional climatic conditions.

The construction of the Project (Rail) will result in dust emissions along the corridor which will be nearby a limited number of sensitive receptors. However given the distances involved, with no sensitive receptors within 1.7 km, it is very unlikely that construction dust impacts will be an issue.

Potential sources of air emissions from the operation phase of the Project (Rail) include exhaust emissions from diesel powered locomotive and fugitive coal dust emissions. Non-‘dust’ emissions from the locomotives included carbon monoxide, oxides of nitrogen (as nitrogen dioxide), sulphur dioxide, benzene and trace hydrocarbons.

The assessment of the particulate matter requires the addition of the two sources of particulates from both diesel exhausts and the fugitive coal sources. The emissions inventory for the particulate matter of all three sub-types of TSP, PM_{10} and $PM_{2.5}$ were constructed.

The operating power of the locomotive types and the operating speeds were used to give emissions in grams per vehicle kilometre travelled (g/VKT) for a single locomotive, thus allowing the locomotive diesel exhaust emissions per train to be derived.

The emission factor of total coal dust from the moving fully loaded coal train was calculated accounting for the speed of the train (and hence wind erosion) and amount of coal hauled. Additionally for particulate matter, allowances were made for return trips (no coal dust but locomotives at less than full load).

The Project (Rail) was split into three sections for modelling to assess impacts as a function of distance away from the alignment. The application of AUSROADS to modelling the train line emissions was made by considering the emissions from typical track alignment sections of one km in length oriented in the general direction of the alignment for each representative section (west, central and east). Receptors were placed at varying lateral distances from the line at up to 200 m distance. AUSROADS simulations were conducted for the annual meteorological data at hourly intervals using Cassiopeia for the western section and Moranbah for the central and eastern sections.

For the non-dust locomotives exhaust pollutants, the most influential constituent was found to be NO_2. However, the highest level of NO_2 at any Project (Rail) fence-line was just 58 per cent of its assessment criterion with all other products of combustion constituents being lower fractions of their respective assessment criteria.

For the more significant dust considerations, predicted TSP, PM_{10} and $PM_{2.5}$ concentrations from the operation of the diesel locomotives with coal train fugitive dust emissions added demonstrate that the most influential pollutants are PM_{10} and $PM_{2.5}$. At the southern fence-line of the Project (Rail) there are nominal exceedances of the air quality objectives. However these objectives are for human health and the sensitive receptor locations are well outside the impact zone of within 50 m of the fence-line for the daily averaged goals and within 161 m for the annually averaged $PM_{2.5}$ objective.

For the assessment of the amenity impact of dust deposition, AUSPLUME dispersion modelling was used with area sources at 4 m above ground level. The maximum incremental dust deposition level is below the deposition guideline equivalent of 2 g/m^2/month at and beyond 50 m from the track centre line.

While the air quality impact assessment of the Project(Rail) found that air quality objectives would be met within close proximity of the rail line and that a negligible change in ambient air quality is expected at the identified sensitive receptor locations, measures to minimise particulate emissions from coal trains should be examined. Measures to minimise particulates emissions associated with the construction and operation of the Project (Rail) have been identified in the QR Limited's *Coal Dust Management Plan* (QR Limited, 2010) and discussed in the Project (Rail) Draft Environmental Management Plan, Volume 3, Section 13.

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Appendix A

Terms of Reference Cross-reference

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Terms of Reference Requirement/Section Number	Section of this Report
3.5 Air Quality	
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	Volume 4 Appendix T
◗ baseline monitoring results	Section 3
◗ gathering data on local meteorology and ambient levels of pollutants to provide a baseline for later studies or for modelling air quality environmental harms.	Sections 3.2 and 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	Sections 4.3 and 4.3
◗ 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	Sections 4.3 and 4.3
◗ 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	Sections 4.3 and 4.3
◗ 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	Volume 2 Section 7
◗ 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 4.3 and 4.3
◗ identify all expected emissions of the hazardous air pollutants and their emissions from known and fugitive sources	Section 4.2.2
◗ 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 3
◗ 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 3.3 Sections 4.3 and 4.3
◗ Estimate maximum ground level concentration and monthly average dust deposition values at the nearest sensitive receptor(s).	Sections 4.3 and 4.3
◗ 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	Sections 4.3, 4.4 and 4.5

Terms of Reference Requirement/Section Number	Section of this Report
3.5 Air Quality	
◗ 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	Sections 3.2 and 3.1
◗ 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	Sections 4.3, 4.4 and 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.	Sections 4.3, 4.4 and 4.5
◗ Describe the dust management plan that will be employed to mitigate adverse air impacts under the worst meteorological conditions	Section 3.1 Volume 3 Section 13
◗ 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 2
◗ 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	Noted.
◗ 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 4.3
◗ 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 4.4
◗ 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 receptors	Section 4.3
◗ discuss climatic patterns that could affect dust generation and movement	Section 3.3
◗ discuss vehicle emissions and dust generation along major road and rail haulage routes both internal and external to the project site	Section 4.2
◗ 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 4.6
◗ Discuss potential air quality impacts from emissions with reference to the National Environment Protection (Ambient Air Quality) Measure 1998 and the EPP (Air).	Sections 2.2 and 3.1

Terms of Reference Requirement/Section Number	Section of this Report
3.5 Air Quality	
◗ 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.	Section 4.4
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.	Section 3.1 Volume 3 Section 13

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Appendix B

AUSROADS Output

Sample file

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Unity_NS_cassio

VARIABLES AND OPTIONS SELECTED FOR THIS RUN

Emission rate units:	g/v-km
Concentration units:	micrograms/m3
Aerodynamic roughness:	0.20 (M)
Aerodynamic roughness at wind vane site:	0.30 (M)
Anemometer height:	10.0 (M)
Read sigma theta values from the met file?	No
Use Pasquill Gifford for horizontal dispersion?	Yes
Sigma theta averaging periods:	60 (min.)
Wind profile exponents set to:	Irwin Rural
Use hourly varying background concentrations?	No
Use constant background concentrations?	Yes
Constant background concentrations set to:	0.00E+00 micrograms/m3
External file for emission rates and traffic volumes?	No

LINK GEOMETRY

LINK NAME	TYPE	LINK COORDINATES (M) X1	Y1	X2	Y2	HEIGHT (M)	MIXING ZONE WIDTH (M)
LNK1	AG	0.0	0.0	932.0	363.0	0.0	12.0

LINK ACTIVITY

NOTE: TF = TRAFFIC VOLUMES; EF = EMISSION FACTORS

LNK1 HOUR	TF WEEK DAY	EM WEEK DAY	TF SATURDAY	EM SATURDAY	TF SUNDAY	EM SUNDAY
1	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
2	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
3	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
4	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
5	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
6	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
7	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
8	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
9	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
10	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
11	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
12	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
13	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
14	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
15	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
16	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
17	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
18	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
19	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
20	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
21	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
22	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
23	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00
24	1.00E+00	1.61E+00	1.00E+00	1.61E+00	1.00E+00	1.61E+00

RECEPTOR LOCATIONS

NAME	No.	COORDINATES (M) X	Y	Z	NAME	No.	COORDINATES (M) X	Y	Z
RCP1	1	465.3	183.4	0.0	RCP2	2	464.9	184.3	0.0
RCP3	3	464.4	185.7	0.0	RCP4	4	464.2	186.2	0.0
RCP5	5	463.3	188.5	0.0	RCP6	6	462.4	190.8	0.0
RCP7	7	458.7	200.1	0.0	RCP8	8	451.5	218.8	0.0
RCP9	9	447.9	228.1	0.0	RCP10	10	429.7	274.7	0.0
RCP11	11	393.4	367.9	0.0	RCP12	12	466.7	179.6	0.0
RCP13	13	467.1	178.7	0.0	RCP14	14	467.6	177.3	0.0
RCP15	15	467.8	176.8	0.0	RCP16	16	468.7	174.5	0.0
RCP17	17	469.6	172.2	0.0	RCP18	18	473.3	162.9	0.0
RCP19	19	480.5	144.2	0.0	RCP20	20	484.1	134.9	0.0
RCP21	21	502.3	88.3	0.0	RCP22	22	538.6	-4.9	0.0

METEOROLOGICAL DATA

Meteorological data entered via the input file:

```
G:\41\23244\Tech\11_Mine\17_Air\Rail\cassio07.met

Title of the meteorological data file is:
Cassiopeia Station for Adani Mine Project07 473,000mE, 7,576,000mN 55K - From
---------------------------------------------------------------------
_____________________________________________________________________________

                   AVERAGE OVER ALL HOURS AND FOR ALL SOURCES
                               in micrograms/m3


Concentrations at the discrete receptors (No. : Value):

   1:6.46E-02    2:6.42E-02    3:6.20E-02    4:6.06E-02    5:4.74E-02    6:3.82E-02    7:2.36E-02
8:1.46E-02
   9:1.25E-02   10:7.37E-03   11:4.08E-03   12:5.96E-02   13:5.68E-02   14:5.11E-02   15:4.87E-02
16:3.52E-02
  17:2.80E-02   18:1.69E-02   19:1.01E-02   20:8.54E-03   21:4.74E-03   22:2.38E-03
_____________________________________________________________________________

      HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3
      AVERAGING TIME =  1 HOUR


At the discrete receptors:

  1: 8.27E-01 @Hr24,02/07/07
  2: 8.15E-01 @Hr04,27/01/07
  3: 7.85E-01 @Hr19,26/04/07
  4: 7.63E-01 @Hr19,26/04/07
  5: 5.64E-01 @Hr21,03/07/07
  6: 4.50E-01 @Hr21,03/07/07
  7: 2.94E-01 @Hr04,04/07/07
  8: 1.84E-01 @Hr20,23/11/07
  9: 1.57E-01 @Hr20,23/11/07
 10: 9.28E-02 @Hr05,28/07/07
 11: 5.49E-02 @Hr23,02/07/07
 12: 8.21E-01 @Hr06,16/10/07
 13: 8.15E-01 @Hr06,16/10/07
 14: 7.82E-01 @Hr06,16/10/07
 15: 7.57E-01 @Hr06,16/10/07
 16: 5.58E-01 @Hr05,02/05/07
 17: 4.56E-01 @Hr05,02/05/07
 18: 2.93E-01 @Hr06,03/07/07
 19: 1.84E-01 @Hr07,05/05/07
 20: 1.56E-01 @Hr07,20/04/07
 21: 9.41E-02 @Hr05,25/03/07
 22: 5.51E-02 @Hr05,14/01/07
___________________________________________________________________________

      HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3
      AVERAGING TIME =  8 HOURS


At the discrete receptors:

  1: 3.05E-01 @Hr24,07/07/07
  2: 3.02E-01 @Hr24,07/07/07
  3: 2.88E-01 @Hr24,07/07/07
  4: 2.79E-01 @Hr24,07/07/07
  5: 2.18E-01 @Hr08,14/08/07
  6: 1.79E-01 @Hr08,28/07/07
  7: 1.27E-01 @Hr08,11/08/07
  8: 9.36E-02 @Hr08,11/08/07
  9: 8.51E-02 @Hr08,11/08/07
 10: 5.77E-02 @Hr08,11/08/07
 11: 3.38E-02 @Hr08,11/08/07
 12: 3.69E-01 @Hr08,03/07/07
 13: 3.78E-01 @Hr08,03/07/07
 14: 3.80E-01 @Hr08,03/07/07
 15: 3.76E-01 @Hr08,03/07/07
 16: 2.99E-01 @Hr08,03/07/07
 17: 2.42E-01 @Hr08,03/07/07
 18: 1.53E-01 @Hr08,03/07/07
 19: 9.14E-02 @Hr08,03/07/07
 20: 7.44E-02 @Hr08,03/07/07
 21: 4.86E-02 @Hr08,14/01/07
 22: 3.07E-02 @Hr08,14/01/07
___________________________________________________________________________

      HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3
      AVERAGING TIME = 24 HOURS


At the discrete receptors:

  1: 1.76E-01 @Hr24,12/08/07
  2: 1.76E-01 @Hr24,14/08/07
  3: 1.75E-01 @Hr24,14/08/07
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  4: 1.72E-01 @Hr24,14/08/07
  5: 1.47E-01 @Hr24,02/07/07
  6: 1.24E-01 @Hr24,02/07/07
  7: 7.96E-02 @Hr24,02/07/07
  8: 5.17E-02 @Hr24,02/07/07
  9: 4.49E-02 @Hr24,02/07/07
 10: 2.97E-02 @Hr24,02/07/07
 11: 1.96E-02 @Hr24,17/07/07
 12: 2.23E-01 @Hr24,03/07/07
 13: 2.28E-01 @Hr24,03/07/07
 14: 2.31E-01 @Hr24,03/07/07
 15: 2.29E-01 @Hr24,03/07/07
 16: 1.84E-01 @Hr24,03/07/07
 17: 1.50E-01 @Hr24,03/07/07
 18: 9.51E-02 @Hr24,03/07/07
 19: 5.95E-02 @Hr24,03/07/07
 20: 5.02E-02 @Hr24,03/07/07
 21: 2.70E-02 @Hr24,03/07/07
 22: 1.83E-02 @Hr24,04/07/07
___________________________________________________________________________

      SECOND-HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3
      AVERAGING TIME =  1 HOUR


At the discrete receptors:

  1: 8.26E-01 @Hr04,27/01/07
  2: 8.11E-01 @Hr24,02/07/07
  3: 7.75E-01 @Hr04,27/01/07
  4: 7.57E-01 @Hr21,03/07/07
  5: 5.41E-01 @Hr04,04/07/07
  6: 4.45E-01 @Hr04,04/07/07
  7: 2.65E-01 @Hr20,23/11/07
  8: 1.73E-01 @Hr05,11/08/07
  9: 1.55E-01 @Hr05,11/08/07
 10: 9.24E-02 @Hr07,12/08/07
 11: 5.36E-02 @Hr06,05/03/07
 12: 7.98E-01 @Hr24,02/07/07
 13: 7.67E-01 @Hr24,02/07/07
 14: 7.02E-01 @Hr05,02/05/07
 15: 6.99E-01 @Hr05,02/05/07
 16: 5.50E-01 @Hr19,12/03/07
 17: 4.50E-01 @Hr19,12/03/07
 18: 2.93E-01 @Hr01,04/07/07
 19: 1.78E-01 @Hr07,20/04/07
 20: 1.56E-01 @Hr07,05/05/07
 21: 9.36E-02 @Hr23,03/07/07
 22: 5.49E-02 @Hr01,12/08/07
___________________________________________________________________________

      SECOND-HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3
      AVERAGING TIME =  8 HOURS


At the discrete receptors:

  1: 2.95E-01 @Hr08,03/07/07
  2: 2.77E-01 @Hr08,14/08/07
  3: 2.80E-01 @Hr08,14/08/07
  4: 2.78E-01 @Hr08,14/08/07
  5: 2.14E-01 @Hr08,28/07/07
  6: 1.75E-01 @Hr08,11/08/07
  7: 1.19E-01 @Hr08,28/07/07
  8: 7.96E-02 @Hr08,28/07/07
  9: 7.03E-02 @Hr08,28/07/07
 10: 4.95E-02 @Hr08,28/07/07
 11: 3.18E-02 @Hr24,17/07/07
 12: 2.78E-01 @Hr24,07/07/07
 13: 2.62E-01 @Hr24,07/07/07
 14: 2.44E-01 @Hr24,21/06/07
 15: 2.37E-01 @Hr24,21/06/07
 16: 1.90E-01 @Hr08,04/07/07
 17: 1.60E-01 @Hr08,04/07/07
 18: 1.12E-01 @Hr08,04/07/07
 19: 7.58E-02 @Hr08,04/07/07
 20: 6.67E-02 @Hr08,14/01/07
 21: 3.98E-02 @Hr08,02/08/07
 22: 2.91E-02 @Hr08,22/04/07
___________________________________________________________________________

      SECOND-HIGHEST RECORDINGS FOR EACH RECEPTOR - in micrograms/m3
      AVERAGING TIME = 24 HOURS


At the discrete receptors:

  1: 1.76E-01 @Hr24,03/07/07
  2: 1.73E-01 @Hr24,12/08/07
  3: 1.70E-01 @Hr24,02/07/07
  4: 1.71E-01 @Hr24,02/07/07
  5: 1.34E-01 @Hr24,14/08/07
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  6: 1.05E-01 @Hr24,14/08/07
  7: 6.54E-02 @Hr24,01/07/07
  8: 4.47E-02 @Hr24,17/07/07
  9: 3.99E-02 @Hr24,17/07/07
 10: 2.79E-02 @Hr24,17/07/07
 11: 1.60E-02 @Hr24,02/07/07
 12: 1.65E-01 @Hr24,12/08/07
 13: 1.57E-01 @Hr24,12/08/07
 14: 1.38E-01 @Hr24,12/08/07
 15: 1.39E-01 @Hr24,04/07/07
 16: 1.22E-01 @Hr24,04/07/07
 17: 1.03E-01 @Hr24,04/07/07
 18: 6.99E-02 @Hr24,04/07/07
 19: 4.75E-02 @Hr24,04/07/07
 20: 4.17E-02 @Hr24,04/07/07
 21: 2.62E-02 @Hr24,04/07/07
 22: 1.62E-02 @Hr24,22/04/07
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Peak values for the 100 worst cases - in micrograms/m3
AVERAGING TIME = 1 HOUR

Rank	Value	Time Recorded hour,date	Coordinates		
1	8.27E-01	@Hr24,02/07/07	(465.3,	183.4,	0.0)
2	8.26E-01	@Hr04,27/01/07	(465.3,	183.4,	0.0)
3	8.21E-01	@Hr06,16/10/07	(466.7,	179.6,	0.0)
4	8.10E-01	@Hr19,26/04/07	(465.3,	183.4,	0.0)
5	7.76E-01	@Hr21,03/07/07	(464.9,	184.3,	0.0)
6	7.35E-01	@Hr04,28/07/07	(466.7,	179.6,	0.0)
7	7.23E-01	@Hr06,06/05/07	(465.3,	183.4,	0.0)
8	7.16E-01	@Hr07,03/07/07	(464.9,	184.3,	0.0)
9	7.02E-01	@Hr05,02/05/07	(467.6,	177.3,	0.0)
10	6.78E-01	@Hr19,12/03/07	(467.6,	177.3,	0.0)
11	6.57E-01	@Hr04,04/07/07	(464.4,	185.7,	0.0)
12	6.31E-01	@Hr06,03/07/07	(467.8,	176.8,	0.0)
13	6.31E-01	@Hr01,04/07/07	(467.8,	176.8,	0.0)
14	6.27E-01	@Hr04,13/02/07	(464.9,	184.3,	0.0)
15	6.09E-01	@Hr01,22/06/07	(466.7,	179.6,	0.0)
16	5.73E-01	@Hr19,04/05/07	(467.1,	178.7,	0.0)
17	5.61E-01	@Hr04,03/07/07	(467.6,	177.3,	0.0)
18	5.60E-01	@Hr05,12/08/07	(465.3,	183.4,	0.0)
19	5.50E-01	@Hr24,05/04/07	(467.6,	177.3,	0.0)
20	5.50E-01	@Hr07,18/05/07	(467.6,	177.3,	0.0)
21	5.49E-01	@Hr23,28/04/07	(464.2,	186.2,	0.0)
22	5.20E-01	@Hr19,03/05/07	(466.7,	179.6,	0.0)
23	5.19E-01	@Hr01,13/08/07	(465.3,	183.4,	0.0)
24	5.15E-01	@Hr07,05/05/07	(467.8,	176.8,	0.0)
25	4.99E-01	@Hr20,23/11/07	(464.2,	186.2,	0.0)
26	4.90E-01	@Hr19,21/04/07	(467.1,	178.7,	0.0)
27	4.80E-01	@Hr05,06/05/07	(467.6,	177.3,	0.0)
28	4.80E-01	@Hr24,21/06/07	(467.6,	177.3,	0.0)
29	4.75E-01	@Hr20,28/09/07	(466.7,	179.6,	0.0)
30	4.57E-01	@Hr20,21/06/07	(464.9,	184.3,	0.0)
31	4.57E-01	@Hr19,07/07/07	(464.9,	184.3,	0.0)
32	4.51E-01	@Hr05,17/05/07	(465.3,	183.4,	0.0)
33	4.51E-01	@Hr05,03/07/07	(467.8,	176.8,	0.0)
34	4.51E-01	@Hr01,16/04/07	(466.7,	179.6,	0.0)
35	4.50E-01	@Hr07,20/04/07	(467.8,	176.8,	0.0)
36	4.50E-01	@Hr01,06/04/07	(467.8,	176.8,	0.0)
37	4.47E-01	@Hr05,05/03/07	(464.4,	185.7,	0.0)
38	4.47E-01	@Hr21,11/08/07	(464.4,	185.7,	0.0)
39	4.46E-01	@Hr05,13/02/07	(464.4,	185.7,	0.0)
40	4.29E-01	@Hr19,22/04/07	(467.8,	176.8,	0.0)
41	4.26E-01	@Hr02,14/08/07	(465.3,	183.4,	0.0)
42	4.25E-01	@Hr20,07/07/07	(466.7,	179.6,	0.0)
43	4.24E-01	@Hr03,15/05/07	(466.7,	179.6,	0.0)
44	4.24E-01	@Hr03,14/08/07	(466.7,	179.6,	0.0)
45	4.24E-01	@Hr05,11/08/07	(464.2,	186.2,	0.0)
46	4.19E-01	@Hr19,28/03/07	(464.4,	185.7,	0.0)
47	4.19E-01	@Hr03,10/09/07	(465.3,	183.4,	0.0)
48	4.14E-01	@Hr05,02/03/07	(467.1,	178.7,	0.0)
49	4.14E-01	@Hr19,07/08/07	(467.1,	178.7,	0.0)
50	4.08E-01	@Hr01,09/02/07	(464.9,	184.3,	0.0)
51	4.08E-01	@Hr04,01/08/07	(464.9,	184.3,	0.0)
52	4.03E-01	@Hr23,21/06/07	(467.8,	176.8,	0.0)
53	4.02E-01	@Hr01,11/04/07	(464.4,	185.7,	0.0)
54	3.95E-01	@Hr19,19/04/07	(465.3,	183.4,	0.0)
55	3.94E-01	@Hr19,25/04/07	(464.4,	185.7,	0.0)
56	3.91E-01	@Hr06,12/08/07	(467.8,	176.8,	0.0)
57	3.84E-01	@Hr07,21/05/07	(467.8,	176.8,	0.0)
58	3.80E-01	@Hr03,07/05/07	(467.1,	178.7,	0.0)
59	3.78E-01	@Hr21,21/06/07	(467.8,	176.8,	0.0)
60	3.76E-01	@Hr20,27/10/07	(467.8,	176.8,	0.0)
61	3.76E-01	@Hr01,14/08/07	(464.2,	186.2,	0.0)
62	3.69E-01	@Hr07,01/08/07	(467.8,	176.8,	0.0)
63	3.67E-01	@Hr07,01/07/07	(464.4,	185.7,	0.0)
64	3.65E-01	@Hr24,26/03/07	(467.6,	177.3,	0.0)
65	3.63E-01	@Hr04,21/05/07	(464.2,	186.2,	0.0)
66	3.62E-01	@Hr21,30/06/07	(465.3,	183.4,	0.0)
67	3.62E-01	@Hr07,12/08/07	(464.2,	186.2,	0.0)

68	3.60E-01	@Hr06,08/03/07	(466.7, 179.6, 0.0)
69	3.58E-01	@Hr06,14/08/07	(464.2, 186.2, 0.0)
70	3.58E-01	@Hr04,10/09/07	(464.2, 186.2, 0.0)
71	3.56E-01	@Hr22,07/11/07	(465.3, 183.4, 0.0)
72	3.55E-01	@Hr19,03/08/07	(464.4, 185.7, 0.0)
73	3.53E-01	@Hr22,30/06/07	(467.6, 177.3, 0.0)
74	3.53E-01	@Hr02,22/06/07	(464.2, 186.2, 0.0)
75	3.52E-01	@Hr21,06/04/07	(467.1, 178.7, 0.0)
76	3.47E-01	@Hr04,25/01/07	(464.9, 184.3, 0.0)
77	3.46E-01	@Hr04,28/08/07	(467.6, 177.3, 0.0)
78	3.45E-01	@Hr06,05/01/07	(466.7, 179.6, 0.0)
79	3.44E-01	@Hr05,21/05/07	(467.8, 176.8, 0.0)
80	3.44E-01	@Hr19,18/05/07	(464.2, 186.2, 0.0)
81	3.44E-01	@Hr04,12/08/07	(464.2, 186.2, 0.0)
82	3.43E-01	@Hr06,05/07/07	(466.7, 179.6, 0.0)
83	3.39E-01	@Hr05,25/03/07	(467.8, 176.8, 0.0)
84	3.39E-01	@Hr04,27/03/07	(465.3, 183.4, 0.0)
85	3.39E-01	@Hr02,07/06/07	(466.7, 179.6, 0.0)
86	3.35E-01	@Hr05,14/02/07	(464.4, 185.7, 0.0)
87	3.35E-01	@Hr03,16/05/07	(464.4, 185.7, 0.0)
88	3.35E-01	@Hr20,16/05/07	(467.1, 178.7, 0.0)
89	3.35E-01	@Hr24,30/06/07	(464.9, 184.3, 0.0)
90	3.35E-01	@Hr06,03/03/07	(464.4, 185.7, 0.0)
91	3.35E-01	@Hr19,13/09/07	(464.4, 185.7, 0.0)
92	3.33E-01	@Hr06,02/03/07	(464.2, 186.2, 0.0)
93	3.33E-01	@Hr22,04/04/07	(464.2, 186.2, 0.0)
94	3.32E-01	@Hr02,24/11/07	(467.8, 176.8, 0.0)
95	3.30E-01	@Hr20,06/02/07	(464.9, 184.3, 0.0)
96	3.30E-01	@Hr24,12/08/07	(464.9, 184.3, 0.0)
97	3.29E-01	@Hr06,14/02/07	(465.3, 183.4, 0.0)
98	3.29E-01	@Hr22,16/05/07	(465.3, 183.4, 0.0)
99	3.29E-01	@Hr24,08/02/07	(467.6, 177.3, 0.0)
100	3.29E-01	@Hr23,30/06/07	(464.4, 185.7, 0.0)

Peak values for the 100 worst cases - in micrograms/m3
AVERAGING TIME = 8 HOURS

Rank	Value	Time Recorded hour,date	Coordinates
1	3.80E-01	@Hr08,03/07/07	(467.6, 177.3, 0.0)
2	3.05E-01	@Hr24,07/07/07	(465.3, 183.4, 0.0)
3	2.80E-01	@Hr08,14/08/07	(464.4, 185.7, 0.0)
4	2.60E-01	@Hr08,12/08/07	(466.7, 179.6, 0.0)
5	2.58E-01	@Hr24,21/06/07	(466.7, 179.6, 0.0)
6	2.53E-01	@Hr08,28/07/07	(464.2, 186.2, 0.0)
7	2.49E-01	@Hr24,16/05/07	(467.1, 178.7, 0.0)
8	2.32E-01	@Hr24,02/07/07	(464.4, 185.7, 0.0)
9	2.29E-01	@Hr24,30/06/07	(466.7, 179.6, 0.0)
10	2.28E-01	@Hr08,04/07/07	(467.6, 177.3, 0.0)
11	2.19E-01	@Hr08,01/08/07	(467.6, 177.3, 0.0)
12	2.19E-01	@Hr08,01/07/07	(464.4, 185.7, 0.0)
13	2.15E-01	@Hr08,06/05/07	(466.7, 179.6, 0.0)
14	2.11E-01	@Hr08,11/08/07	(464.2, 186.2, 0.0)
15	2.10E-01	@Hr08,22/06/07	(464.2, 186.2, 0.0)
16	2.09E-01	@Hr24,03/07/07	(467.1, 178.7, 0.0)
17	2.07E-01	@Hr08,02/05/07	(464.4, 185.7, 0.0)
18	2.05E-01	@Hr24,11/08/07	(466.7, 179.6, 0.0)
19	2.04E-01	@Hr24,26/04/07	(466.7, 179.6, 0.0)
20	2.00E-01	@Hr08,16/05/07	(464.2, 186.2, 0.0)
21	1.95E-01	@Hr24,07/11/07	(464.9, 184.3, 0.0)
22	1.95E-01	@Hr08,24/11/07	(467.8, 176.8, 0.0)
23	1.89E-01	@Hr08,03/10/07	(464.4, 185.7, 0.0)
24	1.88E-01	@Hr08,08/06/07	(467.1, 178.7, 0.0)
25	1.87E-01	@Hr24,08/08/07	(464.9, 184.3, 0.0)
26	1.87E-01	@Hr24,08/02/07	(465.3, 183.4, 0.0)
27	1.85E-01	@Hr08,16/10/07	(467.6, 177.3, 0.0)
28	1.85E-01	@Hr08,15/08/07	(464.4, 185.7, 0.0)
29	1.84E-01	@Hr08,27/03/07	(464.9, 184.3, 0.0)
30	1.84E-01	@Hr24,12/08/07	(464.4, 185.7, 0.0)
31	1.84E-01	@Hr08,14/01/07	(467.8, 176.8, 0.0)
32	1.83E-01	@Hr08,05/07/07	(467.1, 178.7, 0.0)
33	1.83E-01	@Hr08,13/02/07	(466.7, 179.6, 0.0)
34	1.81E-01	@Hr08,26/10/07	(466.7, 179.6, 0.0)
35	1.80E-01	@Hr08,18/05/07	(467.8, 176.8, 0.0)
36	1.79E-01	@Hr08,13/08/07	(464.2, 186.2, 0.0)
37	1.78E-01	@Hr08,28/06/07	(467.6, 177.3, 0.0)
38	1.77E-01	@Hr08,02/03/07	(466.7, 179.6, 0.0)
39	1.77E-01	@Hr08,10/06/07	(464.2, 186.2, 0.0)
40	1.74E-01	@Hr08,09/08/07	(464.2, 186.2, 0.0)
41	1.73E-01	@Hr08,06/03/07	(465.3, 183.4, 0.0)
42	1.73E-01	@Hr24,08/06/07	(466.7, 179.6, 0.0)
43	1.73E-01	@Hr24,27/08/07	(466.7, 179.6, 0.0)
44	1.73E-01	@Hr24,07/08/07	(465.3, 183.4, 0.0)
45	1.72E-01	@Hr08,09/02/07	(464.2, 186.2, 0.0)
46	1.71E-01	@Hr08,14/02/07	(465.3, 183.4, 0.0)
47	1.71E-01	@Hr08,16/04/07	(464.2, 186.2, 0.0)
48	1.70E-01	@Hr08,08/03/07	(467.1, 178.7, 0.0)
49	1.70E-01	@Hr08,17/05/07	(466.7, 179.6, 0.0)
50	1.68E-01	@Hr08,10/09/07	(466.7, 179.6, 0.0)
51	1.68E-01	@Hr24,14/08/07	(464.9, 184.3, 0.0)

52	1.67E-01	@Hr08,21/05/07	(466.7,	179.6,	0.0)
53	1.67E-01	@Hr08,05/01/07	(465.3,	183.4,	0.0)
54	1.66E-01	@Hr24,06/07/07	(464.2,	186.2,	0.0)
55	1.66E-01	@Hr08,15/05/07	(465.3,	183.4,	0.0)
56	1.66E-01	@Hr24,16/06/07	(464.9,	184.3,	0.0)
57	1.66E-01	@Hr08,03/03/07	(466.7,	179.6,	0.0)
58	1.65E-01	@Hr08,27/01/07	(466.7,	179.6,	0.0)
59	1.62E-01	@Hr08,02/07/07	(464.2,	186.2,	0.0)
60	1.62E-01	@Hr24,26/03/07	(467.6,	177.3,	0.0)
61	1.61E-01	@Hr08,02/10/07	(466.7,	179.6,	0.0)
62	1.61E-01	@Hr24,07/06/07	(465.3,	183.4,	0.0)
63	1.59E-01	@Hr24,23/03/07	(465.3,	183.4,	0.0)
64	1.59E-01	@Hr08,28/08/07	(465.3,	183.4,	0.0)
65	1.59E-01	@Hr08,12/06/07	(464.2,	186.2,	0.0)
66	1.59E-01	@Hr08,04/04/07	(464.2,	186.2,	0.0)
67	1.59E-01	@Hr08,15/10/07	(464.2,	186.2,	0.0)
68	1.58E-01	@Hr24,24/02/07	(464.4,	185.7,	0.0)
69	1.58E-01	@Hr24,17/07/07	(464.2,	186.2,	0.0)
70	1.57E-01	@Hr08,07/05/07	(466.7,	179.6,	0.0)
71	1.54E-01	@Hr08,30/06/07	(467.8,	176.8,	0.0)
72	1.54E-01	@Hr08,08/07/07	(464.2,	186.2,	0.0)
73	1.54E-01	@Hr24,21/10/07	(464.4,	185.7,	0.0)
74	1.53E-01	@Hr24,07/04/07	(465.3,	183.4,	0.0)
75	1.53E-01	@Hr24,06/11/07	(467.6,	177.3,	0.0)
76	1.53E-01	@Hr24,29/06/07	(467.6,	177.3,	0.0)
77	1.53E-01	@Hr08,03/12/07	(466.7,	179.6,	0.0)
78	1.52E-01	@Hr08,17/10/07	(467.8,	176.8,	0.0)
79	1.51E-01	@Hr24,27/06/07	(464.4,	185.7,	0.0)
80	1.51E-01	@Hr24,16/10/07	(467.8,	176.8,	0.0)
81	1.51E-01	@Hr24,03/05/07	(467.1,	178.7,	0.0)
82	1.51E-01	@Hr08,06/01/07	(466.7,	179.6,	0.0)
83	1.50E-01	@Hr24,10/04/07	(464.2,	186.2,	0.0)
84	1.49E-01	@Hr24,18/05/07	(467.1,	178.7,	0.0)
85	1.49E-01	@Hr08,20/04/07	(467.8,	176.8,	0.0)
86	1.49E-01	@Hr24,22/04/07	(467.8,	176.8,	0.0)
87	1.48E-01	@Hr08,25/01/07	(466.7,	179.6,	0.0)
88	1.46E-01	@Hr24,28/03/07	(466.7,	179.6,	0.0)
89	1.46E-01	@Hr24,21/04/07	(467.8,	176.8,	0.0)
90	1.44E-01	@Hr24,05/07/07	(464.9,	184.3,	0.0)
91	1.43E-01	@Hr08,08/04/07	(464.2,	186.2,	0.0)
92	1.43E-01	@Hr08,06/04/07	(464.2,	186.2,	0.0)
93	1.43E-01	@Hr08,02/08/07	(467.8,	176.8,	0.0)
94	1.41E-01	@Hr08,16/01/07	(465.3,	183.4,	0.0)
95	1.41E-01	@Hr24,04/02/07	(464.9,	184.3,	0.0)
96	1.41E-01	@Hr08,27/07/07	(464.2,	186.2,	0.0)
97	1.41E-01	@Hr24,15/03/07	(465.3,	183.4,	0.0)
98	1.40E-01	@Hr08,16/02/07	(467.8,	176.8,	0.0)
99	1.39E-01	@Hr24,01/09/07	(464.4,	185.7,	0.0)
100	1.38E-01	@Hr24,10/11/07	(464.4,	185.7,	0.0)

Peak values for the 100 worst cases - in micrograms/m3
AVERAGING TIME = 24 HOURS

Rank	Value	Time Recorded hour,date	Coordinates		
1	2.31E-01	@Hr24,03/07/07	(467.6,	177.3,	0.0)
2	1.76E-01	@Hr24,14/08/07	(464.9,	184.3,	0.0)
3	1.76E-01	@Hr24,12/08/07	(465.3,	183.4,	0.0)
4	1.71E-01	@Hr24,02/07/07	(464.2,	186.2,	0.0)
5	1.65E-01	@Hr24,07/07/07	(464.4,	185.7,	0.0)
6	1.60E-01	@Hr24,16/05/07	(465.3,	183.4,	0.0)
7	1.52E-01	@Hr24,01/07/07	(464.2,	186.2,	0.0)
8	1.49E-01	@Hr24,11/08/07	(464.9,	184.3,	0.0)
9	1.42E-01	@Hr24,13/08/07	(464.2,	186.2,	0.0)
10	1.39E-01	@Hr24,04/07/07	(467.8,	176.8,	0.0)
11	1.38E-01	@Hr24,08/06/07	(466.7,	179.6,	0.0)
12	1.37E-01	@Hr24,28/07/07	(464.2,	186.2,	0.0)
13	1.37E-01	@Hr24,01/08/07	(467.8,	176.8,	0.0)
14	1.34E-01	@Hr24,30/06/07	(466.7,	179.6,	0.0)
15	1.33E-01	@Hr24,08/03/07	(467.6,	177.3,	0.0)
16	1.32E-01	@Hr24,18/05/07	(467.6,	177.3,	0.0)
17	1.31E-01	@Hr24,22/04/07	(467.8,	176.8,	0.0)
18	1.31E-01	@Hr24,26/04/07	(467.6,	177.3,	0.0)
19	1.30E-01	@Hr24,06/05/07	(466.7,	179.6,	0.0)
20	1.29E-01	@Hr24,10/06/07	(464.2,	186.2,	0.0)
21	1.29E-01	@Hr24,22/06/07	(464.2,	186.2,	0.0)
22	1.25E-01	@Hr24,07/11/07	(464.4,	185.7,	0.0)
23	1.21E-01	@Hr24,16/10/07	(467.1,	178.7,	0.0)
24	1.20E-01	@Hr24,07/06/07	(466.7,	179.6,	0.0)
25	1.20E-01	@Hr24,27/03/07	(464.9,	184.3,	0.0)
26	1.19E-01	@Hr24,21/06/07	(464.9,	184.3,	0.0)
27	1.18E-01	@Hr24,17/05/07	(466.7,	179.6,	0.0)
28	1.18E-01	@Hr24,15/05/07	(464.4,	185.7,	0.0)
29	1.18E-01	@Hr24,17/07/07	(464.2,	186.2,	0.0)
30	1.18E-01	@Hr24,13/02/07	(467.1,	178.7,	0.0)
31	1.17E-01	@Hr24,05/07/07	(465.3,	183.4,	0.0)
32	1.15E-01	@Hr24,08/08/07	(464.4,	185.7,	0.0)
33	1.15E-01	@Hr24,11/06/07	(464.2,	186.2,	0.0)
34	1.15E-01	@Hr24,02/05/07	(465.3,	183.4,	0.0)
35	1.13E-01	@Hr24,14/01/07	(467.8,	176.8,	0.0)

36	1.13E-01	@Hr24,16/04/07	(	464.2,	186.2,	0.0)
37	1.11E-01	@Hr24,10/09/07	(	466.7,	179.6,	0.0)
38	1.11E-01	@Hr24,17/10/07	(	467.6,	177.3,	0.0)
39	1.10E-01	@Hr24,24/04/07	(	467.8,	176.8,	0.0)
40	1.10E-01	@Hr24,03/10/07	(	465.3,	183.4,	0.0)
41	1.09E-01	@Hr24,04/04/07	(	464.2,	186.2,	0.0)
42	1.09E-01	@Hr24,07/03/07	(	466.7,	179.6,	0.0)
43	1.09E-01	@Hr24,19/04/07	(	466.7,	179.6,	0.0)
44	1.09E-01	@Hr24,02/03/07	(	465.3,	183.4,	0.0)
45	1.08E-01	@Hr24,25/01/07	(	467.1,	178.7,	0.0)
46	1.07E-01	@Hr24,28/06/07	(	467.1,	178.7,	0.0)
47	1.07E-01	@Hr24,29/06/07	(	467.6,	177.3,	0.0)
48	1.07E-01	@Hr24,30/11/07	(	466.7,	179.6,	0.0)
49	1.06E-01	@Hr24,17/04/07	(	466.7,	179.6,	0.0)
50	1.05E-01	@Hr24,28/03/07	(	467.1,	178.7,	0.0)
51	1.05E-01	@Hr24,20/04/07	(	467.8,	176.8,	0.0)
52	1.05E-01	@Hr24,21/04/07	(	467.8,	176.8,	0.0)
53	1.05E-01	@Hr24,24/11/07	(	467.8,	176.8,	0.0)
54	1.04E-01	@Hr24,27/10/07	(	467.8,	176.8,	0.0)
55	1.04E-01	@Hr24,06/07/07	(	464.2,	186.2,	0.0)
56	1.03E-01	@Hr24,25/04/07	(	467.1,	178.7,	0.0)
57	1.03E-01	@Hr24,26/10/07	(	465.3,	183.4,	0.0)
58	1.03E-01	@Hr24,16/08/07	(	464.9,	184.3,	0.0)
59	1.03E-01	@Hr24,08/07/07	(	464.2,	186.2,	0.0)
60	1.03E-01	@Hr24,03/05/07	(	467.6,	177.3,	0.0)
61	1.02E-01	@Hr24,06/03/07	(	465.3,	183.4,	0.0)
62	1.02E-01	@Hr24,15/08/07	(	465.3,	183.4,	0.0)
63	1.01E-01	@Hr24,28/08/07	(	464.9,	184.3,	0.0)
64	1.01E-01	@Hr24,27/01/07	(	467.6,	177.3,	0.0)
65	1.00E-01	@Hr24,03/12/07	(	466.7,	179.6,	0.0)
66	1.00E-01	@Hr24,24/03/07	(	464.9,	184.3,	0.0)
67	1.00E-01	@Hr24,04/05/07	(	467.6,	177.3,	0.0)
68	9.97E-02	@Hr24,07/04/07	(	465.3,	183.4,	0.0)
69	9.96E-02	@Hr24,22/11/07	(	467.8,	176.8,	0.0)
70	9.93E-02	@Hr24,14/02/07	(	464.9,	184.3,	0.0)
71	9.92E-02	@Hr24,17/08/07	(	464.2,	186.2,	0.0)
72	9.91E-02	@Hr24,02/10/07	(	467.1,	178.7,	0.0)
73	9.89E-02	@Hr24,23/04/07	(	467.8,	176.8,	0.0)
74	9.73E-02	@Hr24,27/06/07	(	464.2,	186.2,	0.0)
75	9.70E-02	@Hr24,23/03/07	(	464.9,	184.3,	0.0)
76	9.67E-02	@Hr24,15/10/07	(	464.9,	184.3,	0.0)
77	9.65E-02	@Hr24,10/08/07	(	464.2,	186.2,	0.0)
78	9.57E-02	@Hr24,05/05/07	(	467.1,	178.7,	0.0)
79	9.51E-02	@Hr24,21/11/07	(	464.9,	184.3,	0.0)
80	9.48E-02	@Hr24,11/04/07	(	464.4,	185.7,	0.0)
81	9.47E-02	@Hr24,03/03/07	(	466.7,	179.6,	0.0)
82	9.46E-02	@Hr24,26/03/07	(	465.3,	183.4,	0.0)
83	9.42E-02	@Hr24,05/04/07	(	464.4,	185.7,	0.0)
84	9.40E-02	@Hr24,03/08/07	(	467.8,	176.8,	0.0)
85	9.39E-02	@Hr24,07/08/07	(	464.9,	184.3,	0.0)
86	9.38E-02	@Hr24,21/05/07	(	466.7,	179.6,	0.0)
87	9.37E-02	@Hr24,27/08/07	(	465.3,	183.4,	0.0)
88	9.36E-02	@Hr24,01/03/07	(	465.3,	183.4,	0.0)
89	9.33E-02	@Hr24,05/03/07	(	464.9,	184.3,	0.0)
90	9.30E-02	@Hr24,12/04/07	(	464.4,	185.7,	0.0)
91	9.23E-02	@Hr24,16/06/07	(	464.2,	186.2,	0.0)
92	9.22E-02	@Hr24,02/08/07	(	467.8,	176.8,	0.0)
93	9.22E-02	@Hr24,08/02/07	(	464.4,	185.7,	0.0)
94	9.15E-02	@Hr24,07/05/07	(	466.7,	179.6,	0.0)
95	9.13E-02	@Hr24,05/01/07	(	464.9,	184.3,	0.0)
96	9.12E-02	@Hr24,16/07/07	(	464.2,	186.2,	0.0)
97	9.11E-02	@Hr24,10/11/07	(	466.7,	179.6,	0.0)
98	9.11E-02	@Hr24,16/03/07	(	465.3,	183.4,	0.0)
99	9.11E-02	@Hr24,27/07/07	(	464.2,	186.2,	0.0)
100	9.08E-02	@Hr24,23/06/07	(	464.2,	186.2,	0.0)

Simulation started at 09:38:28 on 05/01/2012
Simulation finished at 09:38:32 on 05/01/2012

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Appendix C

Dispersion Modelling Results for Locomotive Exhaust Emissions

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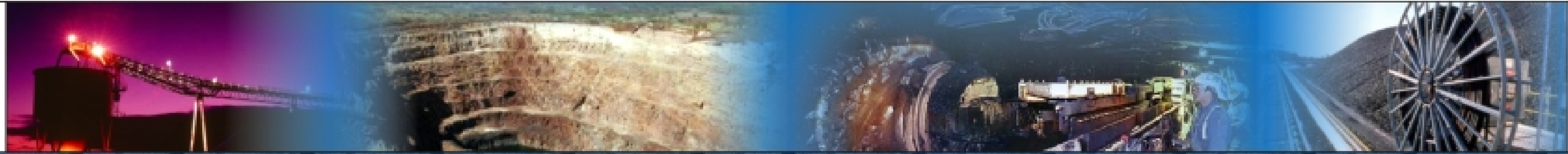
Highest Line-Haul Locomotive Emissions Predicted Peak Incremental Impacts ($\mu g/m^3$) – Western Railway Section

Pollutant	Averaging Period	EPP (Air) Criteria ($\mu m/m^3$)	Predicted peak incremental concentration at distance from the railway (m)															
			North of railway								South of railway							
			2	5	10	20	40	50	100	200	2	5	10	20	40	50	100	200
TSP	1 year	90	41.68	41.68	40.01	38.34	38.34	38.34	36.67	36.67	41.68	41.68	38.34	38.34	38.34	36.67	36.67	36.67
PM_{10}	24 hours	50	33.34	33.34	28.34	25.01	23.34	21.67	21.67	20.00	36.67	38.34	31.67	26.67	23.34	23.34	20.00	20.00
$PM_{2.5}$	24 hours	25	20.00	20.00	16.67	11.67	10.00	10.00	8.34	7.17	25.01	25.01	18.34	13.34	10.00	10.00	8.34	6.67
	1 year	8	11.67	10.00	8.34	6.67	6.67	6.67	6.67	6.67	10.00	10.00	8.34	6.67	6.67	6.67	6.67	5.00
Benzene	1 year	10	6.50	6.17	3.83	2.33	1.50	1.33	0.67	0.33	6.00	5.00	2.83	1.67	1.00	0.83	0.50	0.17
CO	8 hours	11,000	751.82	688.47	443.42	315.06	231.71	210.04	141.70	83.35	911.85	928.52	596.79	378.41	225.05	183.37	120.02	76.68
Formaldehyde	24 hours	54	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00
NO_2	1 hour	250	653.46	603.45	355.07	231.71	145.03	125.03	73.35	43.34	648.46	598.45	360.07	231.71	145.03	123.36	75.02	43.34
	1 year	62	40.01	38.34	23.34	15.00	8.34	8.34	5.00	3.33	36.67	30.01	16.67	10.00	6.67	5.00	3.33	1.67
SO_2	1 hour	570	1.68	1.55	0.92	0.60	0.37	0.32	0.19	0.11	1.67	1.54	0.93	0.60	0.38	0.32	0.19	0.11
	24 hours	230	0.28	0.28	0.20	0.13	0.08	0.07	0.05	0.03	0.35	0.37	0.23	0.15	0.10	0.08	0.05	0.03
	1 year	57	0.10	0.10	0.06	0.04	0.02	0.02	0.01	0.01	0.10	0.08	0.05	0.03	0.02	0.01	0.01	0.00
Toluene	24 hours	4100	0.23	0.23	0.17	0.10	0.07	0.07	0.03	0.03	0.30	0.30	0.20	0.13	0.08	0.07	0.03	0.02

Pollutant	Averaging Period	EPP (Air) Criteria (µm/m³)	Predicted peak incremental concentration at distance from the railway (m)															
			North of railway								South of railway							
			2	5	10	20	40	50	100	200	2	5	10	20	40	50	100	200
	1 year	410	0.09	0.08	0.05	0.03	0.02	0.02	0.01	0.01	0.08	0.06	0.04	0.02	0.01	0.01	0.01	0.00
Xylene	24 hours	1200	0.35	0.33	0.25	0.15	0.10	0.08	0.07	0.03	0.43	0.45	0.30	0.18	0.12	0.10	0.05	0.03
	1 year	950	0.13	0.12	0.08	0.05	0.03	0.03	0.02	0.01	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

Highest Line-Haul Locomotive Emissions Predicted Peak Incremental Impacts (µg/m³) – Central Railway Section

Pollutant	Averaging Period	EPP (Air) Criteria (µm/m³)	Predicted peak incremental concentration at distance from the railway (m)															
			North of railway								South of railway							
			2	5	10	20	40	50	100	200	2	5	10	20	40	50	100	200
TSP	1 year	90	68.35	66.68	65.01	63.35	63.35	63.35	63.35	63.35	68.35	66.68	65.01	65.01	63.35	63.35	63.35	63.35
PM_{10}	24 hours	50	45.01	43.34	38.34	35.01	33.34	33.34	33.34	31.67	43.34	41.68	38.34	35.01	33.34	33.34	33.34	31.67
$PM_{2.5}$	24 hours	25	23.34	21.67	16.67	13.34	11.67	11.67	11.67	10.00	21.67	20.00	16.67	13.34	11.67	11.67	11.67	10.00
	1 year	8	15.00	13.34	11.67	10.00	10.00	10.00	10.00	10.00	15.00	13.34	11.67	11.67	10.00	10.00	10.00	9.50
Benzene	1 year	10	5.83	5.00	2.83	1.67	1.00	0.83	0.50	0.17	5.83	5.17	3.00	1.83	1.17	0.83	0.50	0.33
CO	8 hours	11,000	750.15	553.44	290.06	185.04	128.36	113.36	75.02	41.68	825.17	756.82	411.75	233.38	126.69	111.69	78.35	43.34
Formaldehyde	24 hours	54	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
NO_2	1 hour	250	423.42	396.75	216.71	145.03	90.02	73.35	45.01	21.67	380.08	333.40	208.38	128.36	76.68	63.35	38.34	21.67
	1 year	62	36.67	31.67	16.67	10.00	6.67	5.00	3.33	1.67	36.67	31.67	18.34	11.67	6.67	5.00	3.33	1.67
SO_2	1 hour	570	1.09	1.02	0.56	0.37	0.23	0.19	0.12	0.06	0.98	0.86	0.54	0.33	0.20	0.16	0.10	0.06
	24 hours	230	0.25	0.23	0.13	0.08	0.05	0.05	0.03	0.02	0.23	0.20	0.13	0.08	0.05	0.05	0.03	0.02
	1 year	57	0.09	0.08	0.05	0.03	0.02	0.01	0.01	0.00	0.09	0.08	0.05	0.03	0.02	0.02	0.01	0.01
Toluene	24 hours	4100	0.20	0.20	0.10	0.07	0.05	0.03	0.02	0.02	0.18	0.17	0.10	0.07	0.05	0.03	0.02	0.02
	1 year	410	0.08	0.07	0.04	0.02	0.01	0.01	0.01	0.00	0.08	0.07	0.04	0.02	0.01	0.01	0.01	0.00
Xylene	24 hours	1200	0.32	0.28	0.15	0.10	0.07	0.05	0.03	0.02	0.28	0.25	0.15	0.10	0.07	0.05	0.03	0.02
	1 year	950	0.12	0.10	0.06	0.03	0.02	0.02	0.01	0.01	0.12	0.10	0.06	0.04	0.02	0.02	0.01	0.01



Highest Line-Haul Locomotive Emissions Predicted Peak Incremental Impacts (µg/m³) – Eastern Railway Section

Pollutant	Averaging Period	EPP (Air) Criteria (µm/m³)	Predicted peak incremental concentration at distance from the railway (m)															
			North of railway								South of railway							
			2	5	10	20	40	50	100	200	2	5	10	20	40	50	100	200
TSP	1 year	90	40	39	38	38	38	38	38	37.6	41	41	40	39	38	38	38	38
PM_{10}	24 hours	50	27	25	22	21	20	20	19.5	19.2	27	27	24	22	21	20	20	19
$PM_{2.5}$	24 hours	25	13	12	9	8	7	7	6	6	13	13	11	9	7	7	7	6
	1 year	8	8	7	6	6	6	6	6	6	**9**	**9**	8	7	6	6	6	5.8
Benzene	1 year	10	3.1	2.0	0.9	0.5	0.2	0.2	0.1	0.0	4.0	4.1	2.7	1.7	1.0	0.9	0.5	0.2
CO	8 hours	11,000	344	316	169	110	72	62	30	21	348	320	220	140	89	78	46	30
Formaldehyde	24 hours	54	0.0073	0.0061	0.0032	0.0021	0.0013	0.0012	0.0006	0.0004	0.0074	0.0075	0.0049	0.0030	0.0018	0.0015	0.0009	0.0006
NO_2	1 hour	250	200	185	121	77	47	38	20	14	196	184	106	72	48	40	27	16
	1 year	62	19	12	5.3	2.8	1.4	1.2	0.6	0.3	25	25	17	10	6	5	3	2
SO_2	1 hour	570	0.514	0.477	0.312	0.197	0.120	0.098	0.052	0.036	0.505	0.474	0.274	0.184	0.123	0.104	0.070	0.041
	24 hours	230	0.14	0.12	0.06	0.04	0.03	0.02	0.01	0.01	0.15	0.15	0.10	0.06	0.04	0.03	0.02	0.01
	1 year	57	0.049	0.032	0.014	0.007	0.004	0.003	0.0014	0.00066	0.063	0.065	0.043	0.026	0.016	0.014	0.008	0.004
Toluene	24 hours	4100	0.12	0.10	0.05	0.03	0.02	0.02	0.01	0.01	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
	1 year	410	0.040	0.026	0.011	0.0059	0.0031	0.0024	0.0012	0.0005	0.052	0.054	0.035	0.022	0.013	0.011	0.006	0.003
Xylene	24 hours	1200	0.18	0.15	0.08	0.05	0.03	0.03	0.015	0.010	0.18	0.18	0.12	0.07	0.04	0.04	0.02	0.01
	1 year	950	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077

Appendix D

Dispersion Modelling Results for Particulates associated with Locomotive Exhaust and Coal Wagon Fugitive Emissions

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Predicted Maximum Incremental Ground-level Particulate Concentrations due to Locomotive Exhaust and Coal Wagon Fugitive Emissions at Distance from the Rail Line (µg/m³) – Western Railway Section

Pollutant	Averaging Period	EPP (Air) Criteria (µm/m³)	Predicted peak incremental concentration at distance from the railway (m)															
			North of railway								South of railway							
			2	5	10	20	40	50	100	200	2	5	10	20	40	50	100	200
TSP	1 year	90	293	278	188	132	95	87	67	53	275	232	148	103	77	70	55	47
PM_{10}	24 hours	50	378	370	270	180	123	110	78	58	472	483	323	212	140	120	73	55
$PM_{2.5}$	24 hours	25	193	188	137	90	60	53	37	26	242	248	165	107	68	58	33	25
	1 year	8	73	70	47	30	22	18	13	10	68	57	35	23	17	15	10	8

Predicted Maximum Incremental Ground-level Particulate Concentrations due to Locomotive Exhaust and Coal Wagon Fugitive Emissions at Distance from the Rail Line(µg/m³) – Central Railway Section

Pollutant	Averaging Period	EPP (Air) Criteria (µm/m³)	Predicted peak incremental concentration at distance from the railway (m)															
			North of railway								South of railway							
			2	5	10	20	40	50	100	200	2	5	10	20	40	50	100	200
TSP	1 year	90	293	260	173	132	103	97	82	72	295	265	183	135	105	98	83	73
PM_{10}	24 hours	50	350	328	192	130	97	88	68	52	318	293	193	135	98	90	68	52
$PM_{2.5}$	24 hours	25	175	163	93	60	43	38	28	20	158	147	93	63	43	40	28	20
	1 year	8	70	62	38	28	20	18	15	12	72	63	42	28	20	18	15	12

Predicted Maximum Incremental Ground-level Particulate Concentrations due to Locomotive Exhaust and Coal Wagon Fugitive Emissions at Distance from the Rail Line ($\mu g/m^3$) – Eastern Railway Section

Pollutant	Averaging Period	EPP (Air) Criteria ($\mu m/m^3$)	Predicted peak incremental concentration at distance from the railway (m)															
			North of railway								South of railway							
			2	5	10	20	40	50	100	200	2	5	10	20	40	50	100	200
TSP	1 year	90	159	117	71	55	47	45	41	39.2	194	200	144	103	77	71	57	47
PM_{10}	24 hours	50	202	172	99	71	52	48	34.6	29.2	205	207	142	95	64	56	41	33
$PM_{2.5}$	24 hours	25	101	86	48	33	23	21	14	11	102	104	70	45	29	25	17	13
	1 year	8	38	27	15	10	8	8	7	6	47	49	34	23	16	15	11	8.2

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A	D Featherstone	B Cook	On file	J Keane	On file	30/01/2012
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