REPORT

CHINA FIRST PROJECT EIS – AIR QUALITY ASSESSMENT

Waratah Coal

Job No: 3015f

10 August 2011

A PEL Company

PROJECT TITLE:	**CHINA FIRST PROJECT EIS – AIR QUALITY ASSESSMENT**
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VERSION	DATE	PREPARED BY	REVIEWED BY
Draft	09.08.10	L Fitzmaurice, J Steele & M Fogarty	P D'Abreton
Final	17.08.10	L Fitzmaurice, J Steele & M Fogarty	Mark Imber
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LIST OF ABBREVIATIONS

Abbreviation	Meaning
Abbot Point X110	the Abbot Point Coal Terminal Expansion X110 project
Air Toxics NEPM	National Environment Protection (Air Toxics) Measure
AP-42	Compilation of Air Pollutant Emission Factors published by the USEPA
bcm	bank cubic metres
BOM	Bureau of Meteorology
CFCT	China First Coal Terminal
CHPP	coal handling and preparation plant
CO	carbon monoxide
DERM	Department of Environment and Resource Management (Queensland)
EET	Emissions Estimation Technique
EIS	environmental impact statement
EP Act	*Environmental Protection Act 1994*
EPA	Environmental Protection Agency
EPC	Exploration Permit Coal
EPP (Air)	Environmental Protection (Air) Policy 2008
g	grams
g/L	grams per litre
$g/m^2/month$	grams per metre squared per month
$g/m^2/s$	grams per metre squared per second
h	hour
ha	hectare
hPa	Hector Pascal (100 Pascal)
kg	kilograms
km	kilometre
kV	kilovolts
L/h	litres per hour
m	metre
MCF	Multi Cargo Facility
mm	millimetre
Mm^3	million metres cubed
Mtpa	million tonnes per annum
NEPM	National Environmental Protection Measure
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
NPI	National Pollutant Inventory
°C	degrees Celsius
OCM	open cut mine
PAE	Pacific Air and Environment (now PAEHolmes)
PM	particulate matter (fine dust)
PM_{10}	particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$	particulate matter with an aerodynamic diameter less than 2.5 microns
QR	Queensland Rail
ROM	run of mine coal
s	second
SO_2	sulfur dioxide

Abbreviation	Meaning
t	tonnes
TAPM	The Air Pollution Model
tpa	tonnes per annum
TSP	total suspended particles
UGM	underground mine
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VKT	vehicle kilometres travelled
VOC	volatile organic compounds
µg	microgram
$\mu g/m^3$	micrograms per cubic metre
µm	micrometre
y	year

LIST OF TERMINOLOGIES

Term	Meaning
Air dispersion modelling	Mathematical simulation of how air pollutants disperse in the atmosphere.
Airshed	An airshed is a part of the atmosphere that behaves in a coherent way with respect to the dispersion of emissions.
Ambient air quality	The state of quality as it exists in the outdoor environment.
Anthropogenic sources	Sources derived from human activities, as opposed to those occurring in biophysical environments without human influence.
Biogenic	Produced by living organisms or biological processes.
CALMET	CALMET is part of air dispersion modelling, preparing meteorology for CALPUFF.
CALPUFF	An air dispersion model
Control efficiency	The fraction of total emissions that is removed when a measure is put in place to control emissions from the source.
Convective mixing	Convective mixing is the entrainment and deepening of the mixed layer in a lake due to heat loss generally in combination with wind forcing.
Dry deposition	The process of particles dropping from the atmosphere to the surface by gravity without influence of rain
Dust deposition	Dust deposition is the process of particles settling and accumulating on surfaces.
Emissions	Release of pollutants to air.
Environmental impact statement (EIS)	The information document prepared by the proponent when undertaking an environmental impact assessment. It is prepared in accordance with terms of reference prepared or approved by government. EIS is the term used by the Environment Protection and Biodiversity Conservation Act 1999 and the Environmental Protection Act 1994, and it is defined in Part 4 of the State Development and Public Works Organisation Act 1971.
Environmental Management Plan	A document developed by proponents during a project's planning and design. An Environmental management plan (EMP) provides life-of-project control strategies in accordance with agreed performance criteria for specified acceptable levels of environmental harm. It may continue through the whole life of a project (e.g. preconstruction, construction, operation and decommissioning).
GAMS	Gladstone Airshed Modelling System (GAMS)
Gaussian models	It assumes that the air pollutant dispersion has a Gaussian distribution
Mixing height	The height of the mixing layer in the lower atmosphere.
NOx	Oxides of nitrogen (NO_x) is a generic term for mono-nitrogen oxides (NO and NO_2). The oxides of nitrogen are predominantly (greater than 90%) nitric oxide (NO).
Overburden	Any loose material which overlies bedrock (often used as a synonym for Quaternary sediments and/or surficial deposits) or any barren material, consolidated or loose, that overlies an ore body.
Particulate matter (PM)	Dust particles in the air
Percentile	A value on a scale that indicates the percent of a distribution that is equal to it or below it. For example, the 95^{th} percentile is a value below which 95 percent of the data reside.
RGSQ	Royal Geographical Society of Queensland (RGSQ)
Sensitive receptors	Locations that may be sensitive to air quality
Temperature inversion	Refers to a layer of air in the atmosphere in which the temperature cools at a much lower rate (or even warms) with height than in other parts of the atmosphere.
Terms of Reference	As defined by Part 4 of the *State Development and Public Works Organisation Act 1971*.

Volatile Organic Compounds (VOCs)	Any organic compound which participates in atmospheric photochemical reactions
Wind roses	Wind roses show the frequency of occurrence of winds by direction and strength.

EXECUTIVE SUMMARY

This report provides an air quality assessment for the China First Project proposed by Waratah Coal. It includes assessment of the three proposed components: a coal mine at Galilee Basin, a new railway system from the mine to the Port of Abbot Point, and a new coal terminal at Abbot Point. The assessment is based on an annual Run-of-Mine (ROM) coal production of 56 Mtpa to produce 40 Mtpa of saleable export product coal. However, for the railway, the assessment was based on 400 Mtpa product coal being transported, on a dual track shared with other mines in the Galilee Basin.

The air quality assessment was conducted by predicting potential air quality impacts from the proposed development, in the context of environmental values as defined by *Queensland Environmental Protection Act 1994* (*EP Act*) and *Environmental Protection (Air) Policy 2008 (EPP (Air))*. Ambient air quality conditions resulting from emissions of particulate matter have been assessed for sensitive localities such as residences. In addition, dust deposition rates have also been assessed. The potential impacts from emissions of other air pollutants have been discussed and no exceedances of guidelines are expected.

The findings of the air quality assessment are summarised below for each component of the proposed development.

For the Mine

The impacts to air quality from the activities at the China First Mine have been assessed against *EPP (Air)* ground-level dust concentration guidelines for total suspended particles (TSP), particulate matter with an aerodynamic diameter less than 10 microns (PM_{10}) and particulate matter with an aerodynamic diameter less than 2.5 microns ($PM_{2.5}$). Dust deposition rates have also been assessed against relevant guidelines.

Air dispersion modelling has been used to predict ground-level concentrations of pollutants and rates of dust deposition, based on 2008 meteorological data for the mine region and estimated emission rates for the mine's activities. The USEPA regulatory dispersion models CALMET/CALPUFF were selected, driven by TAPM-generated meteorological data.

Emission rates were estimated using methodologies sourced from the NPI and USEPA. To assess the worst case conditions, emissions were estimated for year 19 of the mine's life, as this represents peak emissions. The major sources of emissions were waste handling by the draglines, the transport of waste to the out of pit waste dumps, hauling of coal and wind erosion of exposed areas.

Background concentrations were estimated based on air quality monitoring conducted at West Mackay by Queensland Department of Environment and Resources Management (DERM). They are likely higher than the actual background dust level at the mine.

Results from the air dispersion modelling show that:

- No exceedances of *EPP (Air)* guidelines for particulate matters are predicted for the nearby townships of Jericho and Alpha.
- PM_{10} concentrations are predicted to exceed the 24-hour guidelines of 50 µg/m^3 beyond the mine boundary from both the mine impacts only and the mine plus background. The exceedances are predicted to occur at five sensitive receptors identified in the region of the

mine. Two of these (Receptors 2 and 4) are within the mine boundary, while another one is likely located within the boundary of another proposed coal mine.

- Predicted ground level dust concentrations from only the mining activities exceed the relevant guidelines for TSP, $PM_{2.5}$ and dust deposition, but the areas of exceedance are all within the boundary of the mine.
- When the conservative background concentrations are included, TSP and dust deposition are not predicted to exceed guidelines beyond the boundary of the mine. Annual and 24-hour $PM_{2.5}$ concentrations are predicted to exceed the guideline level of 8 µg/m^3 just beyond the northern mine boundary, however this does not affect any sensitive receptors.

Due to the likelihood of over-prediction from using conservative approaches in the assessment, air quality monitoring is proposed as part of the environmental management commitment to quantify the true background dust levels at the mine and validate the model predictions of dust impacts from the mine.

For the Rail

Modelling the entire length of the rail corridor between the mine and coal terminal was not practical due to the length of the corridor. A representative section of track 12.4 m in length was therefore modelled to assess the impact of dust emissions on air quality and to assess dust deposition levels in the vicinity of the rail corridor. AUSPLUME was run with TAPM meteorological extracts from both the coal terminal and mine sites to assess impacts at either end of the rail link.

Potential impacts of fugitive dust emissions from the coal trains have been assessed against relevant guidelines.

The results of air quality modelling show that:

- TSP and $PM_{2.5}$ ground-level concentrations are predicted to be below the *EPP (Air)* guidelines. Similarly, dust deposition due to the passing of coal trains is not predicted to exceed the relevant guideline.
- Near the coal mine, modelling of PM_{10} showed that maximum ground-level concentrations may exceed the EPP 24-hour air quality guideline up to 300 m west and 150 m east of the railway line if the trains are heading north. When trains head east and northeast, the dust impacts are lower. Near the coal terminal, assessment shows no exceedances of the EPP PM_{10} guideline.
- The closest sensitive receptor is approximately 70 m away to the railway near the coal terminal. While exceedance of the PM_{10} guideline is not predicted for this receptor, it is important to make sure this receptor to be located as far away as possible from the both train tracks. All other receptors are at least 500 m away from the track.

For the Coal Terminal

In the air quality impact assessment of China First Coal Terminal (CFCT), a combined meteorological and air dispersion modelling approach has been used to predict dust concentrations and dust deposition in the Abbot Point study area. The dust emissions from CFCT were estimated based on NPI and USEPA methodologies.

Impacts from the coal terminal have been assessed, based on air dispersion modelling using background dust levels from DERM's West Mackay air quality monitoring data. An over-estimation of the background levels is expected as West Mackay is situated within an industrial area. In order to assess the cumulative impacts in the study area, impacts from the CFCT and the Abbot Point Coal Terminal X110 expansion proposal (with a coal handling capacity of 110 Mtpa) have been modelled. Emission rates for the Abbot Point Coal Terminal X110 project were sourced from published data in its EIS document, with emission rates found to be much high than the CFCT.

The results of air quality modelling show that:

- CFCT impacts alone will not lead to any air quality exceedances of relevant dust related air quality guidelines in Queensland.
- When combined the impacts from Abbot Point X110 and conservatively estimated background levels, the guidelines for PM_{10}, $PM_{2.5}$, TSP and dust deposition have been exceeded. For $PM_{2.5}$, TSP and dust deposition, the exceedances are only limited to the areas within the dust generating facilities such as stockyards, jetty, and coal transfer points.
- For PM_{10}, with the cumulative impacts, 24-hour *EPP (Air)* guideline of 50 µg/m³ is predicted to be exceeded over a broad area at Abbot Point. This prediction may be exaggerated due to the conservative background PM_{10} level (26 µg/m³) based on DERM's West Mackay air quality data and other conservative approaches in the assessment.

Due to the likelihood of over-prediction from using conservative approaches in the assessment, air quality monitoring is proposed as part of the environmental management commitment to quantify the actual dust impacts from the proposed China First Coal Terminal and the existing Abbot Point Coal Terminal.

1 INTRODUCTION

Waratah Coal proposes to mine 1.4 billion tonnes of raw coal from its existing tenements, EPC 1040 and EPC 1079. The mine development involves the construction of four 9 Mtpa underground long-wall coal mines, two 10 million tonnes per annum (Mtpa) open cut pits, two coal preparation plants with raw washing capacity of 28 Mtpa.

The annual Run-of-Mine (ROM) coal production will be 56 Mtpa to produce 40 Mtpa of saleable export product coal. At this scale of operation, the capital expense of constructing the required rail and port infrastructure is economically viable over the life of the project.

Processed coal will be transported by a new 447 km railway system from the Galilee Basin to the existing Port of Abbot Point. The railway component includes a state of the art, heavy haul, standard gauge railway to support 25,000 tonne train units. The final railway easement is expected to be approximately 60-80 m wide and will be confirmed at detailed design.

The Port of Abbot is undergoing an extensive expansion program to facilitate coal export to the growing world market. The China First Project will be integrated within the planned expansion strategies to further consolidate the operability of the Port of Abbot Point as a state of the art export facility. Waratah Coal is in current negotiations with North Queensland Bulk Ports (NQBP) to develop two new terminals, estimated to cost approximately $2 billion and have capacity of 30 Mtpa, as well as a new stockyard and unloading facilities within the Abbot Point State Development Area.

The auxiliary facilities for the project include the provision of new power supply infrastructure, water supply and wastewater treatment facilities, fire fighting and first aid infrastructure, machinery maintenance centre, accommodation and an airport. The construction period for the project is estimated to last 36 months.

2 AIR QUALITY ASSESSMENT – THE MINE

2.1 Introduction

2.1.1 Study Area

The proposed China First Mine is located in central Queensland, approximately 400 km due west of Rockhampton. The closest townships are Alpha and Jericho, which are located approximately 30 km to the southeast and southwest of the mine respectively.

Figure 2.1 shows the study area for the air quality assessment for the mine. On this map, seven sensitive receptor locations are shown, labelled as 1-7. Receptors 1-5 are single residences within close proximity to the mine. Receptor 6 represents the township of Jericho, and 7 represents the township of Alpha. It should be noted that Receptor 1 will potentially be within the boundary of another coal mine currently in the EIS stage (this is discussed further in relation to the cumulative impacts of the project (Section 2.2.6)), and that Receptors 2 and 4 are located within the mine lease boundary.

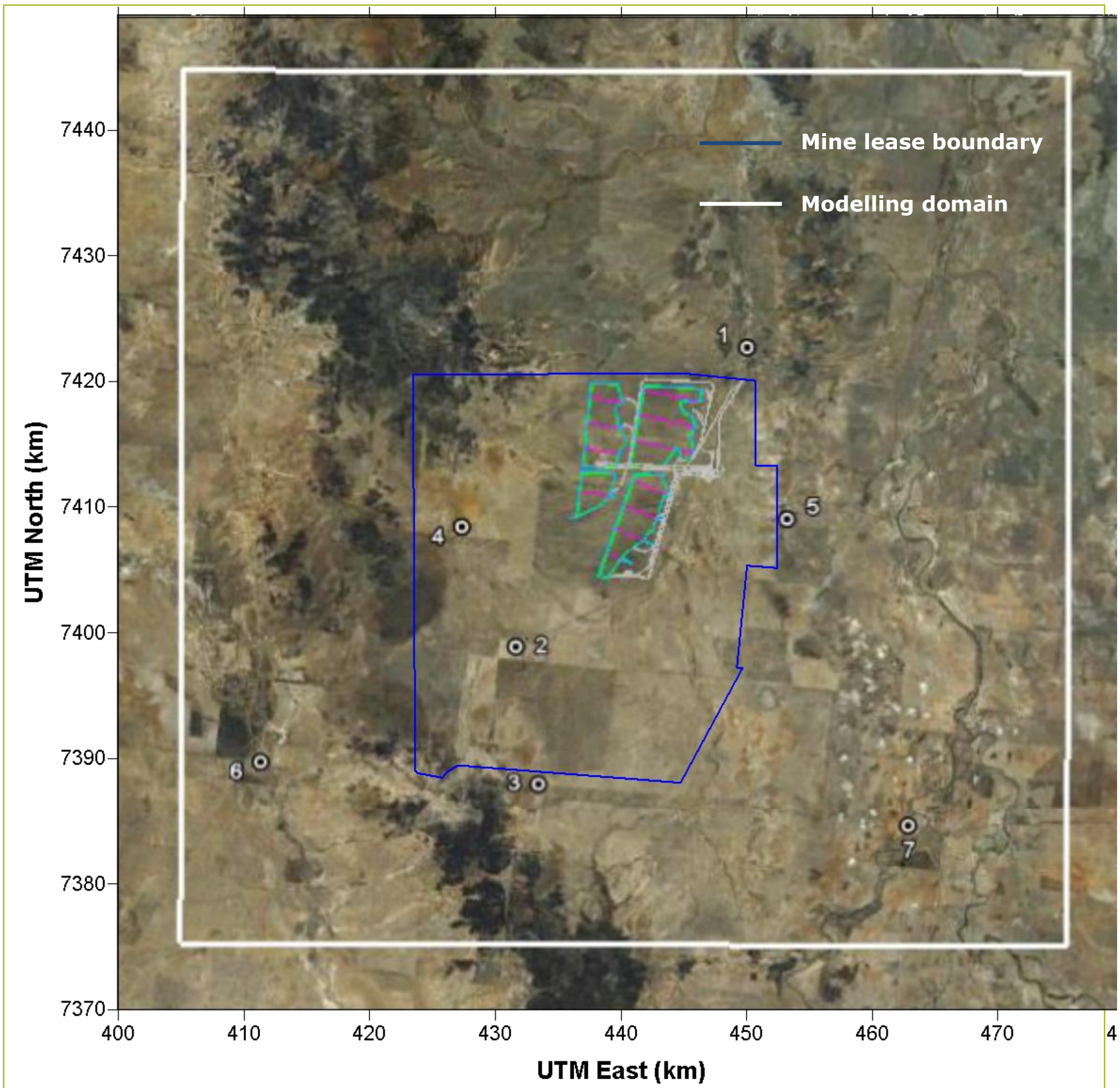


Figure 2.1: Study Area of the China First Coal Mine

2.1.2 Purpose of Study

The purpose of this study is to assess potential air quality impacts from the proposed China First Mine, in the context of environmental values as defined by *Queensland Environmental Protection Act 1994* (*EP Act*) and *Environmental Protection (Air) Policy 2008 (EPP Air)*. Ambient air quality conditions in terms of particulate matter and any other major constituents of the air environment that may be affected by the proposal are to be assessed for any sensitive localities such as residences. The assessment should include cumulative impacts from any existing emission sources and other proposed developments.

2.1.3 Scope of Work

To assess the impact of air emissions from the proposed coal terminal, the scope of work includes:

- estimating air emissions within the project area expected during construction and operation;
- describing project features to suppress or minimise emissions;
- identifying climatic patterns that could affect dust generation and movement;
- predicting changes to existing air quality from operational activities including processing, stockpiling and loading of coal, transport of coal, vehicle emissions and shipping; and
- assessing cumulative impacts within the air shed.

2.1.4 Legislative Framework

Air discharges in Queensland are currently regulated through the:

- *Queensland Environmental Protection Act 1994* (*EP Act*); and
- *Environmental Protection Policy (Air) 2008* (*EPP (Air)*).

The Queensland *EP Act* provides for long-term protection for the environment in Queensland in a manner that is consistent with the principles of ecologically sustainable development.

Ambient air quality guidelines in Queensland are provided in *EPP (Air)*. These guidelines are consistent with guideline values published in the *National Environment Protection Measure (NEPM) (Ambient Air Quality)* and the *NEPM (Air Toxics)*. For the air quality impacts from the proposed mine, the major air quality concern is dust. The *EPP (Air)* objectives for dust include those for Total Suspended Particulate (TSP), particulate matter less than 10 μm in aerodynamic diameter (PM_{10}), and particulate matter less than 2.5 μm in aerodynamic diameter ($PM_{2.5}$). These objectives are listed in Table 2.1.

For some substances the *EPP (Air)* has air quality objectives set to protect agriculture and/or the health and biodiversity of forests and natural vegetation in addition to the protection of human health and well being. TSP, PM_{10} and $PM_{2.5}$ only have air quality objectives that have been set to protect human health and wellbeing. There are no additional guidelines to separately assess the impact of particulate concentrations on agriculture.

Note that the *EPP (Air)* applies "…to Queensland's air environment" but the air quality objectives specified in it do not extend to workplaces covered by the *Workplace Health* *and Safety Act (1995)*. Hence, the air quality assessment presented in this report addresses off-site ambient air quality impacts only and does not consider workplace health and safety exposure.

The Queensland government typically considers a draft guideline for dust deposition of 4 g/m²/month, and the maximum increase in deposited dust due to new activities is 2 g/m²/month, to ensure adequate protection from nuisance levels of dust. This level is similar to a guideline adopted in New South Wales, based on ambient monitoring of dust conducted in the Hunter Valley, NSW in the 1980's. The former NSW State Pollution Control Commission set the level to avoid a loss of amenity in residential areas, based on the levels of dust fallout that cause complaints. The current guideline level adopted in NSW is that the maximum total dust deposition level should not exceed 4 g/m²/month, and that the maximum increase in deposited dust is 2 g/m²/month. Due to a lack of reliable background data for the study area, the incremental guideline of 2 g/m²/month was used in this assessment.

Table 2.1 Air Quality Guidelines for Particulate Matter in Queensland

Pollutant	Objective (µg/m³)	Protection Category	Averaging Period	Regulatory Agency	Allowable Exceedances
Total Suspended Particulate (TSP)	90	Health and well being	Annual	*EPP (Air)*	
Particulate Matter <10 µm (PM_{10})	50	Health and well being	24 hr	*EPP (Air)* & NEPM	5 days each year[a]
Particulate Matter <2.5 µm ($PM_{2.5}$)	25	Health and well being	24 hr	*EPP (Air)*	
	8	Health and well being	Annual	*EPP (Air)*	
Dust Deposition	2 g/m²/month (incremental)	Amenity of residential area	Monthly	QLD and NSW	

[a] The 5 days each year allowable exceedances are considered to exclude days with regional dust storms, as those events are not impacted by local pollution sources.

2.2 Methodology

2.2.1 Sources of Emissions

2.2.1.1 Construction

Construction of the China First Mine will include the development of:

- internal road network, including light-vehicle access roads, heavy-vehicle haul roads and a site access road;
- overland conveyors and transfer stations;
- the coal handling preparation plants and associated stockpiles;
- tailings storage facilities;
- administrative buildings;
- equipment workshop facilities;
- 275 kV electricity transmission line, electrical power substations and associated facilities;
- a water supply pipeline;
- on and off-site water retention dams;
- 2000 person accommodation village;
- onsite airstrip; and
- cut and cover operations for the underground mines.

The emissions associated with the development of the open cut mines have been considered as part of the ongoing operation of the mine.

Emissions from construction activities will be primarily dust related, with some minor emissions of combustion pollutants, such as nitrogen oxides, due to diesel and petrol combustion in vehicles and construction equipment.

Construction emissions will be minor in comparison with emissions from the operation of the mine. In addition, the emissions will be temporary in duration and the location of emissions will change. Therefore these emissions have not been estimated (with the exception of the cut and cover operations), and their impacts have not been modelled. The impacts of construction activities will be managed through the Environmental Management Plan, based on the recommendations from this study (refer to Section 2.5.1). This will include measures to minimise dust emissions and procedures that will be implemented to mitigate off-site impacts.

The emissions associated with the cut and cover operations for the underground mines have been estimated (refer to Appendix A). However, as the mine is not fully operational during the development of the cut and cover operations, emissions from these sources do not occur during peak emissions from the mine. As such, these emissions have not been modelled. Further justification for this approach is provided in Section 2.2.5.2.

2.2.1.2 Operation

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

- scrapers removing topsoil in the open cut mine (OCM) pits;
- blasting and drilling;
- truck-shovels and draglines removing waste material;
- excavators mining coal and loading haul trucks;
- haul trucks transporting coal to the sizing stations;
- haul trucks transporting waste material and waste material;
- dumping of waste material at out of pit waste dumps;
- coal handling (loading, unloading etc.) at the OCM and underground mine (UGM) sizing stations and the coal handling preparation plant (CHPP);
- UGM venting;
- bulldozing at the OCM pits, UGM drift stockpiles and CHPP;
- wind erosion of active coal stockpiles – drift stockpiles, raw coal stockpiles, product coal stockpiles and reject coal stockpiles;
- dumping of reject coal; and
- wind erosion of exposed areas in the OCMs and the out of pit waste dumps.

2.2.2 Pollutants of Interest

The pollutants of interest in this assessment are:

- particulate matter less than 2.5 microns ($PM_{2.5}$);
- particulate matter less than 10 microns (PM_{10}); and
- total suspended particles (TSP).

In addition to predicting ambient levels of particulate matter specified above, dust deposition will also be assessed.

The low sulfur content of Australian diesel, in combination with the fact that mining equipment is widely dispersed over mine sites, makes it unlikely that the sulfur dioxide (SO_2) goals will be exceeded off-site, even in mining operations that use large quantities of diesel. For this reason, no detailed study is required to demonstrate that emissions of SO_2 from the China First Mine will not significantly affect ambient SO_2 concentrations. Similarly, NO_x, CO and volatile organic compound emissions from the mine's activities are too small and too widely dispersed to require a detailed modelling assessment.

Emissions of TSP, PM_{10} and $PM_{2.5}$ estimated for mining equipment (scrapers, bulldozers etc.) include emissions produced from diesel combustion.

2.2.3 Emission Estimate Methods

The general equation used to estimate TSP and PM_{10} emissions from mining activities is as follows:

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

where:

E_i	=	Emission rate of pollutant i	(kg/a)
A	=	Activity data	(units dependent on emission factors)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/activity)
CE	=	Control efficiency	(%)

Where possible, the activity data and control efficiencies used to estimate emissions from the sources described in Section 2.2.1.2 were provided by Waratah Coal.

Emission factors used to estimate emissions of TSP and PM_{10} have been sourced from the following:

- National Pollutant Inventory (NPI) Emissions Estimation Manual (EET) for Mining v2.3 (2004); and
- USEPA AP-42 - Compilation of Air Pollutant Emission Factors, Fifth Edition, Volume 1 (Chapter 11 for Western Surface Coal Mining).

A summary of the emission factors used is provided in Figure 2.2.

The NPI EET Manual for Mining v2.3 does not contain emission factors for $PM_{2.5}$. Therefore emissions of $PM_{2.5}$ have been estimated as 12.5% of PM_{10} emissions. This is based on the following $PM_{2.5}$ fractions of PM_{10}, sourced from Chapter 13.2.2.5 of the USEPA AP-42 - Compilation of Air Pollutant Emissions:

- 10% for unpaved road emissions; and
- 15% for aggregate handling and storage piling.

These are the two major sources of dust emissions at the mine, and hence the average of these fractions, 12.5%, has been used throughout the mine site.

A description of the sources of emissions is provided below. A detailed description of the methodology used to estimate each source of emissions is provided in Appendix A.

Table 2.2 Summary of Emission Factors

Operation/Activity	Activity Data Required	Pollutant	Emission Factor [a]	Units	Default/Calculated
Scrapers	total VKT	TSP	1.64	kg/VKT	Default
		PM_{10}	0.53	kg/VKT	
Draglines	bcm moved	TSP	0.05	kg/bcm	Calculated based on moisture content of waste material
		PM_{10}	0.02	kg/bcm	
Excavators/shovels on overburden	tonnes moved	TSP	0.0016	kg/t	Calculated based on moisture content of waste material and mean wind speed
		PM_{10}	0.0008	kg/t	
Loading coal to trucks by shovel [b]	tonnes loaded	TSP	0.031	kg/t	Calculated based on moisture content of coal
		PM_{10}	0.005	kg/t	
Bulldozers on coal	hours of operation	TSP	11.89	kg/h	Calculated based on moisture content and silt content of coal
		PM_{10}	3.79	kg/h	
Bulldozers on other material	hours of operation	TSP	17	kg/h	Default
		PM_{10}	4	kg/h	
Unpaved roads	total VKT	TSP	3.88	kg/VKT	Default
		PM_{10}	0.96	kg/VKT	
Drilling	number of holes drilled	TSP	0.59	kg/hole	Default
		PM_{10}	0.31	kg/hole	
Blasting [c]	number of blasts	TSP	0.33	kg/blast	Calculated area of blast
		PM_{10}	0.17	kg/blast	
Trucks dumping overburden	tonnes dumped	TSP	0.0016	kg/t	Default
		PM_{10}	0.0008	kg/t	
Trucks dumping coal	tonnes dumped	TSP	0.01	kg/t	Calculated based on moisture content of waste material and mean wind speed
		PM_{10}	0.0042	kg/t	
Miscellaneous transfer (loading/unloading etc)	tonnes transferred	TSP	1.43E-04	kg/t	Calculated based on moisture content of coal and mean wind speed
		PM_{10}	6.78E-05	kg/t	
		PM_{10}	0.012	kg/t	
Wind erosion of exposed areas [d]	exposed area and total hours exposed	TSP	850	kg/ha/y	Default for overburden
		PM_{10}	425	kg/ha/y	
Wind erosion	exposed area and total hours exposed	TSP	0.4	kg/ha/h	Default
		PM_{10}	0.2	kg/ha/h	

[a] All emission factors sourced from National Pollutant Inventory (NPI) Emissions Estimation Manual (EET) for Mining v2.3 (2004), except where stated.

[b,c,d] Emission factors sourced from USEPA AP-42 - Compilation of Air Pollutant Emission Factors, Fifth Edition, Volume 1 (Chapter 11 for Western Surface Coal Mining)

2.2.3.1 Waste Handling

Emissions associated with prime waste handling were attributed to each dragline system. Sources of emissions estimated were:

- scrapers removing topsoil;
- truck shovels and truck excavators removing waste (predominately tertiary waste);
- draglines removing waste (predominately Permian prime waste); and
- bulldozer activities.

Emissions from scraping were estimated based the default NPI emission factor for 'scraping', an assumed vehicle speed of 8 km/hour and total operating hours per annum, giving total vehicle kilometres travelled (VKT) per annum.

Emissions from the shovels/excavators and draglines were estimated based on the amount of material moved per annum and the calculated emission factors for 'excavators/shovels on overburden' and 'draglines' respectively. The Mine Project Description chapter of the EIS shows total prime waste moved per dragline system per annum. To represent a worst case scenario, the peak total prime waste removal values for year 19 of the mine development were taken.

The amount of material waste moved by the draglines was 28 Mm^3 per annum, based on the maximum capacity of the draglines, as provided by Waratah Coal.

The amount of material moved by the shovels and excavators is the difference between the total prime waste moved and the waste moved by the draglines. For the shovels and excavators, the amount of material moved in m^3 was converted to tonnes based on an assumed density of 2.6 tonnes/bcm (URS, 2009).

Emission from bulldozing were estimated based on the default NPI emission factor for 'bulldozers on other material' and two bulldozers per dragline system operating 24 hours per day, as provided by Waratah Coal.

2.2.3.2 Waste Transport and Dumping

Waste material is transported by dump truck to the out-of-pit spoil dumps. Unpaved road emissions have been estimated based on the default NPI emission factor for 'unpaved roads' and the total distance travelled by the trucks per annum.

As the haul roads will be watered, a control factor of 75% was applied to the unpaved road emissions, taken for level 2 watering of haul roads, as sourced from Table 3, NPI EET Manual for Mining v2.3, with the level of watering provided by Waratah Coal.

Emissions from the dumping of waste material were estimated based on the emission factor for 'trucks dumping overburden' and the tonnes of material dumped per annum.

2.2.3.3 Drilling and Blasting

Blasting is required for the Permian overburden and interburden at each of the four mining pits. There are emissions associated with both the drilling of holes for blasting, and the blasting itself.

Emissions of both drilling and blasting are based on the number of holes drilled per annum. This has been calculated based on the total average amount of material blasted per annum (Mm³/annum) and the blasting efficiency (m³/hole), as provided by Waratah Coal. The emissions from drilling were estimated using the default NPI emission factor for 'drilling'. The emission factor for 'blasting' was calculated based on the area blasted, in accordance with the USEPA AP-42 methodology.

Total emissions associated with drilling and blasting have been attributed evenly to each dragline system. It is noted that the amount of material blasted per dragline changes with respect to time, however given that drilling and blasting is a small source of emissions this will not affect modelling results.

2.2.3.4 Coal Mining

Emissions associated with coal being mined by hydraulic excavators and loaded to haul trucks were estimated based on each dragline system uncovering 5 Mtpa ROM. The emission factor for 'loading coal to trucks by shovel' was calculated using the average moisture content of the coal, as provided by Waratah Coal, in accordance with the USEPA AP-42 methodology.

2.2.3.5 Haul Roads

Emissions of wheel generated dust on haul roads have been estimated based on the default NPI emission factor for 'unpaved roads' and the total VKT per annum for the haul trucks transporting coal from each dragline system to the OCM sizing stations.

Total distance travelled per annum was estimated based on the total amount of coal mined per dragline, the capacity of the haul trucks and the estimated return distance from each dragline system to the relevant OCM sizing station.

As the haul roads will be watered, a control factor of 75% was applied to the unpaved road emissions, taken for level 2 watering of haul roads, as sourced from Table 3, NPI EET Manual for Mining v2.3.

Emissions from other vehicles travelling on haul roads were considered, but were estimated to be insignificant in comparison with haul trucks, and as such their emissions have not been presented.

2.2.3.6 Primary Crusher and Sizing Stations – Open Cut Mines

Coal mined from OCMs 1 and 2 is trucked to ROM feed bins, with primary crushers located directly beneath the bins. The coal and is then conveyed to secondary and tertiary sizing stations.

Emissions from the following sources have been estimated for the primary crushers and sizing stations:

- unloading trucks;
- loading and unloading apron feeders;
- primary crushing;
- secondary sizing; and
- tertiary sizing.

For all emission sources the key activity data is the tonnes of ROM coal handled, which has been taken as 15 Mtpa for OCM 1, and 5 Mtpa for OCM 2. This is based on the dragline systems 1-3 being located in OCM 1, and dragline system 4 being located in OCM 2 (each dragline system produces 5 Mtpa ROM coal), as provided by Waratah Coal.

Emissions for unloading trucks have been estimated using the NPI emission factor for 'trucks dumping coal'. For all other sources, emissions have been estimated using the emission factor for 'miscellaneous transfer', which was calculated based on the average moisture content of coal, as provided by Waratah Coal. Direct emissions from primary crushing, secondary sizing and tertiary sizing have not been estimated. The NPI EET Manual for Mining v2.3 states that emissions from primary and secondary crushing contribute very little to overall particulate matter emissions at typical coal mines (Appendix A1.1.13), and as such, treating the primary crusher and secondary and tertiary sizing stations as 'miscellaneous' transfer points was considered to sufficiently cover their emissions.

2.2.3.7 Drift Stockpiles and Sizing Stations – Underground Mines

Coal mined from underground mines 1, 2, 3 and 4 is conveyed to above ground drift stockpiles, and then conveyed to secondary and tertiary sizing stations.

Emissions from the following sources have been estimated for the sizing stations:

- loading drift stockpiles;
- unloading drift stockpiles to conveyors;
- wind erosion from the drift stockpiles;
- bulldozing at drift stockpiles;
- secondary sizing; and
- tertiary sizing.

Emissions associated with the load/unloading of stockpiles and the sizing stations are based on the tonnes of ROM coal handled, which has been taken as 9 Mtpa for each of the underground mines 1-4, as provided by Waratah Coal. As for the OCM sizing stations, these emission have been estimated using the emission factors for 'miscellaneous' transfer.

Emissions from bulldozing are based on the total operating hours of the bulldozers, which has been taken as 1 bulldozer per underground mine operating 2 days per week, as provided by Waratah Coal. The emission factor for 'bulldozers on coal' was calculated, based on the moisture content (as provided by Waratah Coal) and silt content of the coal (taken as the default silt content of 7%, sourced from the NPI EET Manual for Mining v2.3).

Wind erosion emissions from the drift stockpiles have been estimated based on the default NPI emission factor for 'wind erosion' and the exposed area of the stockpiles, which was estimated based on the mining infrastructure plan provided by Waratah Coal.

2.2.3.8 Stockpiles of Raw, Product and Reject Coal

Coal is stored before and after the coal handling preparation plant in the following stockpiles:

- 3 x raw coal stockpiles, consisting of
  - o raw stockpile A (18 Mtpa, based on ROM coal from UGM 1 and UGM 2)

- raw stockpile B (14 Mtpa, based on ROM coal from OCM 2 and UGM 4)
- raw stockpile C (24 Mtpa, based on ROM coal from OCM 1 and UGM 3);

- 2 x product coal stockpiles (20 Mtpa each); and
- 2 x rejects coal stockpiles (8 Mtpa each, based on the difference between raw coal and product coal).

For each of these stockpiles emissions from the following sources have been estimated:

- loading stockpiles;
- reclaiming coal;
- bulldozing (one per product coal stockpiles);
- loading trucks (reject stockpiles only) and
- wind erosion from active stockpiles.

Emissions from loading, reclaiming and loading trucks coal have been estimated using the NPI emission factor for 'miscellaneous transfer' and the total coal throughput at the stockpiles.

Bulldozing emissions at the product coal stockpiles have been estimated based on one bulldozer per stockpile operation 24 hours per day, as provided by Waratah Coal.

Wind erosion emissions have been estimated based on the area of the stockpiles and the default NPI emission factor for 'wind erosion', which was determined based on information and the mining infrastructure plan provided by Waratah Coal.

2.2.3.9 Dumping Reject Coal

Coal rejects are trucked back to the OCMs for disposal.

Emissions associated with dumping coal at the open cut mine sites have been estimated using the emission factor for 'trucks dumping coal' and the amount of coal dumped. It has been assumed that 16 Mtpa of coal (the difference between the annual ROM coal (56 Mtpa) and product coal (40 Mtpa)) is dumped in total and distributed evenly between the open cut mine sites where draglines 1-4 are located (4 Mtpa at each site).

The empty haul trucks will be used to transport the reject coal, and as such their unpaved road emissions have not been calculated separately as they are included in the return journey of the trucks hauling ROM coal.

2.2.3.10 Underground Mine Vents

There are no emission factors for TSP and PM_{10} from from underground mine vents. Therefore, emissions from venting have been estimated using

- a volumetric flowrate of 150 m^3/s per vent, as provided by Waratah Coal, which equates to 4,730,400,000 m^3/annum per vent;
- 3 vent per underground mine, based on a range of 2-3 vents per mine, as provided by Waratah Coal; and
- concentrations of 0.0016 g/m^3 and 0.0012 g/m^3 for TSP and PM_{10} respectively in the vented air, based on monitoring undertaken at an existing underground coal mine (Holmes Air Sciences, 2005).

2.2.3.11 Wind Erosion from Exposed Areas

Wind erosion from exposed surfaces has been estimated based on the size of the exposed area, which has been taken as 2000 ha for OCM 1 and 1500 ha for OCM 2, as provided by Waratah Coal. As the open cut mines progress west, rehabilitation of the mined areas is expected to occur at approximately the same rate as the clearing of new areas of mining. The areas of exposed surfaces - 2000 ha and 1500 ha – have been conservatively estimated by Waratah Coal to account for any lag in the rate of rehabilitation.

Emissions factors for wind erosion areas in the mine pit have been sourced from Table 11.9-4 of USEPA AP-42. The emission factor presented is designed for 'seeded land, stripped overburden, and graded overburden' at a dry (rainfall 280 to 420 mm/y), windy (average 4.8 to 6 m/s) coal mine. This was considered to give a more accurate representation of wind erosion in the China First OCM pits than the default NPI emission factor, which does not specify the type of material that is exposed. A comparison with the meteorological conditions at the China First Mine site indicates that the mine site has slightly higher average rainfall and lower average wind speeds than the conditions for the USEPA emission factor, meaning that the emission factor is expected to be conservative.

Total exposed areas per OCM have been split into two areas – *recently disturbed areas*, and *not recently disturbed areas*. The size of the *recently disturbed area* per OCM was estimated based on the approximately size of the area mined per annum, as provided by Waratah Coal. The size of the *not recently disturbed areas* is the remainder of the total exposed areas. A control factor of 50% was assumed for the *not recently disturbed areas* to account for silt depletion, which cannot be considered to be unlimited.

Emissions from wind erosion have been modelled using a scaling factor that relates wind speed to emissions. The scaling factors were developed based on the total emissions for the hour and hourly wind speed data for the mine site (Shao 197, 2000).

2.2.3.12 Emission Sources Not Considered

Emissions from the following sources have not been considered:

- the CHPP, as all activities are enclosed (including loading) and the CHPP uses a wet process;
- conveying, and conveyor transfer points (excluding loading/unloading), as all conveyors are fully enclosed;
- loading coal to trains, as train loading is fully enclosed; and
- tailings dams, as the tailings will be maintained as a wet paste.

2.2.4 Summary of Emissions

A summary of the estimated emissions is presented in Table 2.3.

As can be seen the majority of emission are associated with the waste handling by the draglines, the transport of waste to the out-of-pit waste dumps, hauling of coal and wind erosion of exposed areas. The emissions presented in Table 2.3 represent peak emissions at year 19 of the life of the mine.

Table 2.3: Summary of Emissions

	Source of emissions		Activity data	Units	Emission Factor TSP	Emission Factor PM10	Emission Factor Units	Control factor	Emissions TSP	Emissions PM10	Units	% of total TSP	% of total PM10
Open cut mines	Scrapers	OCM pits	280,320	VKT/a	1.64	0.53	kg/VKT	-	459,725	148,570	kg/a	3%	2%
	Truck shovels/truck excavators[a]	DL1	28,600,000	tonnes/a	0.002	0.001	kg/t	-	45,879	21,699	kg/a	3.1%	3.9%
		DL2	72,800,000	tonnes/a	0.002	0.001	kg/t	-	116,782	55,235	kg/a		
		DL3	109,200,000	tonnes/a	0.002	0.001	kg/t	-	175,173	82,852	kg/a		
		DL4	104,000,000	tonnes/a	0.002	0.001	kg/t	-	166,832	78,907	kg/a		
	Blasting	OCMs	313,335	holes/year	0.15	0.08	kg/blast	-	46,577	24,220	kg/a	0.3%	0.4%
	Drilling	OCMs	313,335	holes/year	0.59	0.31	kg/hole	-	184,868	97,134	kg/a	1.1%	1.6%
	Draglines	All dragline systems	112,000,000	bcm/a	0.05	0.02	kg/bcm	-	5,380,505	2,313,617	kg/a	33%	38%
	Bulldozers	OCM pits	70,080	hrs/year	17	4	kg/h	-	1,191,360	280,320	kg/a	7%	5%
	Hauling - overburden	DL1	228,800	VKT/a	3.88	0.96	kg/VKT	75%	221,936	54,912	kg/a	15%	10%
		DL2	582,400	VKT/a	3.88	0.96	kg/VKT	75%	564,928	139,776	kg/a		
		DL3	873,600	VKT/a	3.88	0.96	kg/VKT	75%	847,392	209,664	kg/a		
		DL4	832,000	VKT/a	3.88	0.96	kg/VKT	75%	807,040	199,680	kg/a		
	Waste dumping	DL1	28,600,000	tonnes/a	0.002	0.001	kg/t	-	45,879	21,699	kg/a	3.1%	3.9%
		DL2	72,800,000	tonnes/a	0.002	0.001	kg/t	-	116,782	55,235	kg/a		
		DL3	109,200,000	tonnes/a	0.002	0.001	kg/t	-	175,173	82,852	kg/a		
		DL4	104,000,000	tonnes/a	0.002	0.001	kg/t	-	166,832	78,907	kg/a		
	Coal excavating/loading	OCMs	20,000,000	tonnes/a	0.03	0.00	kg/tonne	-	612,503	98,475	kg/a	4%	2%
	Hauling - coal	DL1	340,000	km/annum	3.88	0.96	kg/VKT	75%	329,800	81,600	kg/a	8%	5%
		DL2	240,000	km/annum	3.88	0.96	kg/VKT	75%	232,800	57,600	kg/a		
		DL3	420,000	km/annum	3.88	0.96	kg/VKT	75%	407,400	100,800	kg/a		
		DL4	300,000	km/annum	3.88	0.96	kg/VKT	75%	291,000	72,000	kg/a		
	Coal handling/sizing[b]	OCM sizing stations	20,000,000	t/annum	0.01	0.00	kg/t	-	227,383	96,951	kg/a	1%	2%
	Bulldozers	OCM sizing stations	17,520	hrs/year	11.89	3.79	kg/h	-	208,382	66,427	kg/a	1.3%	1.1%
	Reject coal dumping	OCM pits	16,000,000	tonnes/annum	0.01	0.00	kg/t	-	160,000	67,200	kg/a	1.0%	1.1%
Underground mines	Coal handling/sizing[c]	UGM sizing stations	36,000,000	t/annum	0.0007	0.0003	kg/t	-	24,644	11,656	kg/a	0.2%	0.2%
	Bulldozers	UGM sizing stations	9,984	hrs/year	11.89	3.79	kg/h	-	118,749	37,854	kg/a	0.7%	0.6%
	Wind erosion - coal stockpiles	UGM drift stockpiles	8	ha	0.40	0.20	kg/ha/hour	-	27,471	13,736	kg/a	0.2%	0.2%
	Vents	UGMs	56,764,800,000	m3/annum	0.0016	0.0011	g/m3	-	90,824	62,441	kg/a	0.6%	1.0%
CHPP and stockpiles	Coal loading/reclaiming[d]	Raw coal stockpiles	56,000,000	tonnes/annum	0.0003	0.0001	kg/t	-	15,334	7,253	kg/a	0.1%	0.1%
	Wind erosion - coal stockpiles	Raw coal stockpiles	11	ha	0.40	0.20	kg/ha/hour	-	38,894	19,447	kg/a	0.2%	0.3%
	Coal loading/reclaiming[e]	Product coal stockpiles	40,000,000	tonnes/annum	0.0003	0.0001	kg/t	-	10,953	5,181	kg/a	0.07%	0.08%
	Wind erosion - coal stockpiles	Product coal stockpiles	8	ha	0.40	0.20	kg/ha/hour	-	29,434	14,717	kg/a	0.2%	0.2%
	Coal loading/reclaiming[f]	Reject coal stockpiles	16,000,000	tonnes/annum	0.0004	0.0002	kg/t	-	6,572	3,108	kg/a	0.0%	0.1%
	Wind erosion - coal stockpiles	Reject coal stockpiles	5	ha	0.40	0.20	kg/ha/hour	-	18,922	9,461	kg/a	0.1%	0.2%
	Bulldozers	CHPP	17,520	hrs/year	11.89	3.79	kg/h	-	208,382	66,427	kg/a	1.3%	1.1%
Wind erosion of exposed areas	Wind erosion - recently disturbed exposed areas	OCMs	600	ha	850	425	kg/ha/y	-	510,000	255,000	kg/a	3%	4%
	Wind erosion - not recently disturbed exposed areas	OCMs	2,900	ha	850	425	kg/ha/y	50%	1,232,500	616,250	kg/a	8%	10%
	Wind erosion	Out of pit waste dumps	993	ha	850	425	kg/ha/y	-	844,066	422,033	kg/a	5%	7%
								TOTAL EMISSIONS	**16,359,675**	**6,130,895**	**kg/a**	**100%**	**100%**

a DL1-4 refers to dragline systems 1-4

b Emission factors presented are the sum of emission factors for 'trucks dumping coal' and 10 x 'miscellaneous transfer' to account for all steps of material handling at OCM sizing stations. Refer to Section 2.2.3.6.

c Emission factors presented are the sum of 5 x 'miscellaneous transfer' emission factors to account for all steps of material handling at UGM sizing stations. Refer to Section 2.2.3.7.

d,e Emission factors presented are the sum of 2 x 'miscellaneous transfer' emission factors to account for coal loading and reclaiming. Refer to Section 2.2.3.8.

f Emission factors presented are the sum of 3 x 'miscellaneous transfer' emission factors to account for coal loading, reclaiming and loading to haul trucks. Refer to Section 2.2.3.8.

2.2.5 Air Dispersion Modelling

2.2.5.1 Model Description and Configuration

In order to quantify the ground-level concentrations and dust deposition at locations near the emission sources, air quality dispersion modelling has been performed. This modelling assessment uses a suite of modelling tools to estimate air quality impacts.

First, The Air Pollution Model (TAPM) (Hurley, 2008a; Hurley et al., 2008; Hurley, 2008b) and CALMET (Scire *et al*., 2000a) were used in combination to generate a fine-resolution, three-dimensional meteorological fields for 2008; and then CALPUFF (Scire *et al.,* 2000b) was used to simulate the transport, dilution and deposition of emissions from the sources in the atmosphere. In 1999 PAE (now PAEHolmes) devised this suit of dispersion modelling methodology, which has since been used widely throughout Australia and elsewhere. Generic technical details of these methods are provided in Appendix B.

In this assessment, the representative year for meteorology is 2008. The most recent version of TAPM (version 4) and CALMET/CALPUFF (version 6.0) has been used.

TAPM was configured as follows:

- 50 X 20 horizontal grids, with an outer grid resolution of 30 km, and nested grid resolutions of 10 km, 3 km and 1 km;
- 30 vertical grid levels;
- grid centred near the project site at -22deg-53.5min latitude, 146deg31min longitude; and

No assimilation of observational meteorological data was included in the modelling due to lack of such data for the area.

CALMET was configured as follows:

- surface and upper air data were derived from TAPM was used to drive CALMET run, with no additional observational data assimilation;
- horizontal grids of 140 x 140 were used, with a resolution of 500 m;
- raw terrain and land use data of approximately 250 m in resolution were used to derive input data for CALMET grids; and
- ten vertical grid levels were used, with finer resolution near the surface to resolve the fine boundary structures (vertical grid face levels are 0, 20, 40, 60, 90, 120, 280, 720, 1250, 2500, 3450 m).

To model the air dispersion of pollution sources, CALPUFF:

- used the CALMET output as the input for meteorological conditions;
- used the same computational grids as the CALMET run; and
- incorporated plume depletion into the modelling to account for fallout of dust particles.

In addition, for the calculation of dust deposition, total TSP was divided into emissions from particles sizes 0-10 µm and 10-30 µm to account for the varying deposition rates from these particle size ranges.

2.2.5.2 Model Scenario

A single scenario was modelled, based on the estimated maximum emissions from the mine. This was taken as year 19 of the mine's life, as the total amount of waste moved per dragline system peaks in this year.

Based on information provided by Waratah Coal, 56 mtpa of ROM coal is expected to be mined per annum. As such, emissions associated with coal handling are not expected to vary per year.

In addition to the amount of waste material moved per dragline system, the key variables that change with during the mine's life are:

- the distance travelled by trucks hauling waste and coal; and
- the extent of wind erosion from exposed areas in the OCM pits.

Based on the staged mine plan for the OCMs, the distance that waste and coal is hauled at year 19 will be close to the maximum distances for the life of the mine. It can also be assumed that by year 19 the size of the exposed area for wind erosion will have reached the maximum extent estimated (as described in Section 2.2.3.11).

Emission from the cut and cover operations for the development of the underground mines have not been modelled as they do not occur during peak emissions. The emissions from cut and cover operations are significant (approximately 451,000 kg for TSP and 123,333 kg for PM_{10} for all UGMs), however they are outweighed by emissions from wind erosion of exposed areas for the OCM pits and out of pit waste dumps. Emissions from wind erosion cannot be assumed to occur at the same time as the cut and cover operations, as the OCM mines will not have progressed to create the exposed areas.

2.2.6 Cumulative Impacts

Several projects have been proposed in the region of the China First Mine which will impact the air quality of the region. These proposed new coal mines include:

- Alpha Coal Project (Hancock Prospecting Pty Ltd);
- Kevin's Corner (Hancock Prospecting Pty Ltd); and
- South Galilee Coal Project (AMCI Pty Ltd).

These projects have the potential to impact air quality in the region of the China First mine by increasing background concentrations of TSP, PM_{10} and $PM_{2.5}$. No published EIS reports are available for these projects yet; therefore, their impacts cannot currently be quantitatively assessed due to a lack of activity data.

2.3 Existing Environment

2.3.1 Meteorology

The climate of the study area has a sub-tropical continental climate and in general winter days are warm and sunny and nights are cold (BOM, 2010). Summer days tend to be hot and nights warm. Summer weather is influenced by a semi-permanent trough that lies roughly north-south through the interior of the state. The trough is normally the boundary between relatively moist air to the east and dry air to the west. It is best developed and generates most weather during spring and summer months. The position of the trough fluctuates diurnally due to vertical mixing and from day to day due to interaction with broad-scale synoptic influences. The trough often triggers convection with showers and thunderstorms on its eastern side. A climate summary relevant to air quality is provided below. For a detailed description of climate at the project area, please refer to Appendix C.1.

Based on meteorological data collected twice a day at 9am and 3pm at multiple BOM stations near the mine site, the climate for the project area can be summarised as below. These stations are Barcaldine, Emerald, Claremont and Blackall stations, as these are the closest to the location of the China First Project mine site.

- Long term wind roses from two representative locations in the study area (one from the east at Emerald Airport and one from the west of the study area at Barcaldine Airport) show very different wind strengths although similar wind directions across the study area. Emerald has winds that are frequently from the east with more moderate winds. Barcaldine has a higher frequency of winds from the east but also has a higher frequency of low wind speeds than Emerald.
- The rainfall is the highest during summer and lowest during winter, with a total annual rainfall approximately 500 to 600 mm. Rainfall data shows a consistent pattern across the study region of 80-120 mm of rain per month on average during the summer months, dropping to average lows of 15-20 mm during winter.
- The long term monthly average temperatures within the study area display typical ranges for subtropical regions. Longreach, being further inland, is generally hotter than the other monitoring stations in the region although it can be cooler during mid-winter. Mean monthly minimum temperatures can be as high as 19°C to 22°C in the summer and drop as low as 7°C in the winter. The mean maximum temperatures can range between 33 to 36°C in the hottest months and drop to between 22 and 25°C during the coldest part of the year.
- Relative humidity in the study area is typically higher during the summer and autumn months and lower during the spring months. During the summer months the higher temperatures allow greater saturated vapour pressures resulting in lower relative humidity. Finally the relative humidity is also affected by the distance from the sea with stations further from the ocean having less water vapour available and hence lower relative humidity.

The temperature inversion strength and frequency have been estimated based on TAPM meteorological modelling output (for the year 2008) for a central location within the project area. Analysis of the inversions (see Table 2.4) show that strong inversions occur in 13% of occasions.

Table 2.4 Temperature Inversion at Night Time – Mine Site (2008)

Night Time Inversion Strength	Percentage of occurrence (%)	Number of hours
>3ºC per 100 m	13	1169
>2ºC per 100 m	20	1750
>1ºC per 100 m	30	2595
>0ºC per 100 m	50	4410

2.3.2 Existing Air Quality

2.3.2.1 Existing Emission Sources

Currently, there are no other mines and major human settlements in the nearby area. The main existing dust sources are those typical for a rural area: the naturally blown dust from the landscape, potential agricultural burning, natural bush fires, and biogenic emissions.

2.3.2.2 Background Air Quality

Background air quality refers to the current air quality environment in the project area.

As the mine is located in a rural area without existing mines and urban pollution, the air quality should be typical a central Queensland rural area. The dust levels should be fairly low, with occasional impacts from dust storms and fires.

No regulatory ambient air quality monitoring stations are located in the vicinity of the mine. Air quality monitoring data from West Mackay, the nearest DERM site, have been used to represent the background dust levels at the mine. It is a very conservative approach as there are additional industrial and urban pollution sources near the West Mackay monitoring station. West Mackay is located in a light industrial area, often with observed high dust levels attributed to the impacts from local industries.

West Mackay Monitoring Data

The air quality data for recent years at West Mackay are summarised in Table 2.5.

Table 2.5: Recent Dust Monitoring Data at West Mackay

Year	PM_{10} concentrations (µg/m³) 24-hour Max	95th percentile	70th percentile	Annual Average
2006	106	31	22	19.6
2007	58	37	25	21.5
2008	94	43	27	23.3
2009	515	48	28	24.4*
EPP (Air) guideline	50			No guideline

*All data from 23 – 30 September in 2009, extremely high values due to regional dust storms, are not included in the calculation of annual average.

Note that in late September 2009, West Mackay recorded extreme high PM_{10} levels for multiple days, influenced by two major large-scale dust storms. The magnitude of the dust storms has been attributed to fine sediment from inland evaporation pans and floodplains in central Australia deposited by floods early in the year (Geoscience Australia, 2009). Strong winds associated with the passage of two weather fronts whipped up the dry sediment into extensive dust storms that affected much of eastern Australia.

Table 2.5 shows that the ambient 24-hour PM_{10} guideline of 50 µg/m³ has been exceeded for every year since 2006, with multiple exceedances per year.

The causes of these exceedances were collated for 2008 using the published analyses by DERM (Monthly Air Quality Bulletins). Among eight days with 24-hour PM_{10} exceedances, five days were due to local sources - dust generated by activities taking place at a premises close to the West Mackay monitoring station, one day due to agriculture burning, and two days due to regional dust storms. It shows that the impacts of local emission sources are very significant.

Estimates of Background Air Quality

For the purposes of this EIS assessment and considering the predominantly rural environment within the study area, the estimated background levels of dust are:

- 26 µg/m³ for 24-hour average PM_{10} levels (70^{th} percentile of 24-hour concentrations, averaged during 2006-2009);
- 22 µg/m³ for annual average PM_{10} levels (annual average concentrations, averaged during 2006-2009);
- 5.2 µg/m³ for 24-hour average $PM_{2.5}$ levels (20% of PM_{10} values, based on Midwest Research Institute, 2006);
- 4.4 µg/m³ for annual average $PM_{2.5}$ levels (20% of PM_{10} values, based on Midwest Research Institute, 2006); and
- 44 µg/m³ for annual average TSP levels (twice PM_{10} values, based on Midwest Research Institute, 2006).

The estimates from using West Mackay data for background PM_{10} values are likely to be conservative as air quality at the monitoring station West Mackay should be much worse due to local industrial and urban pollution, which is not consistent with the proposed mine area. For this reason, the 70^{th} percentile recommended by Victoria EPA (Victoria Government, 2001) was used to estimate background 24-hour average PM_{10} levels to eliminate the local influences on the monitoring data.

The use of 20% of PM_{10} to estimate $PM_{2.5}$ background concentrations is based on Midwest Research Institute (2006), in which the recommended ratio of $PM_{2.5}$ to PM_{10} is 0.2 for agriculture activities, which is applicable to the mine where terrestrial wind erosion is presumably the major source of background dust emissions.

There are no known measurements of TSP in the region. AP-42 and NPI manual show that for dust emitted from terrestrial wind erosion, the ratio of PM_{10} and TSP is about 0.5. We use this value to derive the background TSP level from PM_{10} value in the proposed mine area.

Existing dust deposition rates have not been quantified for the mine region as deposition from the mine has been assessed against an incremental guideline. This guideline relates to the dust deposition a particular activity (i.e. the mine site) adds to a region.

Accuracy of the Estimates

From the above analyse of West Mackay data, the estimates are fairly conservative as the monitoring station West Mackay does not represent the mine area in terms of location and local pollution influences.

The approach used to estimate background levels is further complicated by the facts that background levels vary with atmospheric conditions such as wind speed, wind direction and seasons. This may suggest that a spatially and temporal varying background level is more representative than a single value applied to all sites within the project area. Using a single value is generally more conservative.

2.4 Potential Impacts

2.4.1 Construction

The air quality impacts during the construction phase of the coal mine will be primarily dust related. The major construction activity will be the initial construction of the access portal to underground coal mine. The associated air quality impacts are expected be transient and much smaller than the combination of open cut mining and underground mining activities during the normal operation of the mine. For this reason, these impacts have not been predicted through air dispersion modelling. Rather, they will be managed through the mine's Environmental Management Plan, based on management recommendations detailed in Section 2.5.1.

2.4.2 Operation

The emissions during the operation phase of the project, as summarised in Section 2.2.4, have been modelled with CALPUFF. The predicted ground-level concentrations and dust deposition are analysed and presented in this section, in the context of relevant regulatory air quality objectives (refer to Section 2.1.4).

Due to the conservative estimates of background levels (refer to Section 2.3.2), the conservative estimates in dust emissions, and the uncertainties in meteorology and air quality modelling (refer to Section 2.2.5), the predicted ground-level concentrations and dust deposition values should not be interpreted as the exact impacts in the future. With potential significant over-prediction due to conservatism in the assessment, the modelling results should be used as an approximate tool at the EIS stage to assess the potential air quality impacts in the region.

2.4.2.1 At Sensitive Receptors

Seven sensitive receptors have been identified in the vicinity of China First Mine. Their locations are shown in Figure 2.1. The predicted ground-level dust concentrations and deposition at these receptors are summarised in Table 2.6. It shows that:

- the predicted ground-level concentrations, including background, are well below the *EPP (Air)* objectives for TSP and $PM_{2.5}$;
- for PM_{10}, the 24-hour *EPP (Air)* objective of 50 µg/m³ is exceeded at Receptors 1-5 when background PM_{10} concentration is included - impacts from the mine, excluding background, exceed the guidelines at Receptors 2 and 4; and
- the dust deposition is well below the recommended guideline of 2 g/m^2/month.

It should be noted that Receptors 2 and 4 are within the mining boundary, and Receptor 1 is likely to be within the boundary of another proposed coal mine.

Table 2.6: Predicted Air Quality Impacts at Sensitive Receptor Near the China First Coal Mine During Operation

Dust Group	Sources	Receptor #1	Receptor #2	Receptor #3	Receptor #4	Receptor #5	Receptor #6	Receptor #7	Objectives
PM_{10} 24-hour Max ($\mu g/m^3$)	Project	39.6	73.6	35.5	57.9	48.3	12.0	4.2	50, *EPP (Air)*
	Project + background	65.6	99.6	61.5	83.9	74.3	38.0	30.2	
$PM_{2.5}$ 24-hour Max ($\mu g/m^3$)	Project	5.0	9.2	4.4	7.2	6.0	1.5	0.5	25, *EPP (Air)*
	Project + background	10.2	14.4	9.6	12.4	11.2	6.7	5.7	
$PM_{2.5}$ Annual ($\mu g/m^3$)	Project	0.4	1.4	0.4	2.3	0.1	0.2	0.01	8, *EPP (Air)*
	Project + background	4.8	5.1	4.8	6.7	4.5	4.6	4.4	
TSP Annual ($\mu g/m^3$)	Project	3.8	13.6	3.9	20.1	1.1	1.6	0.1	90, *EPP (Air)*
	Project + background	47.8	57.6	47.9	64.7	45.1	45.6	44.1	
Dust Deposition Monthly Max (g/m^2/month)	Project	0.15	0.43	0.16	0.40	0.07	0.04	0.01	2, (recommended guideline)

2.4.2.2 Contour Plots

The predicted impacts over the modelling grids are shown as contour plots. Impacts predicted from only the mine site are presented, as well as the impacts predicted from the mine site plus background concentrations of pollutants.

PM_{10}

Figure 2.2 and Figure 2.3 present the maximum ground-level 24-hour PM_{10} concentrations for the mine site and mine site plus background respectively. It can be seen that impacts from the mine only are predicted to exceed the guideline of 50 µg/m³ beyond the mine boundary, including at Receptors 2 and 4. When background concentrations are included there is a larger area of exceedance, including Receptors 1, 2, 3, 4 and 5.

$PM_{2.5}$

Figure 2.4 and Figure 2.5 present maximum ground-level 24-hour $PM_{2.5}$ concentrations for the mine site and mine site plus background respectively. The impacts from the mine only are not predicted to exceed the guideline of 25 µg/m³ outside the mine boundary. The impacts, including background concentrations, exceed the guidelines in an area just beyond the northern mine boundary. $PM_{2.5}$ concentrations are not predicted to exceed guideline levels at any of the Receptors.

Figure 2.6 and Figure 2.7 present ground-level annual $PM_{2.5}$ concentrations for the mine site and mine site plus background respectively. As with the 24-hour $PM_{2.5}$ concentrations, the impacts of the mine plus background concentrations exceed the guidelines of 8 µg/m³ in an area just beyond the northern mine boundary, however $PM_{2.5}$ concentrations are not expected to exceed the guideline levels at any of the sensitive Receptors.

TSP

Figure 2.8 and Figure 2.9 present ground-level annual TSP concentrations for the mine site and mine site plus background respectively. TSP concentrations, including background, are not predicted to exceed the guideline of 90 µg/m³ outside the mine boundary, nor at any of the Receptors.

Dust Deposition

The extent of dust deposition from the mine site is presented in Figure 2.10. As can be seen, dust deposition rates are not predicted to exceed the incremental guideline level of 2 g/m²/month outside the mine boundary, nor at any of the Receptors.

2.5 Mitigation and Management

Waratah Coal is committed to develop and implement an Environmental Management Plan. The Plan will include measures to minimise dust emissions during both the construction and operational phases of the mine.

2.5.1 Construction

Dust emissions during construction will be mitigated and managed by implementing the following strategies:

- water sprays on unsealed roads;
- restricting vehicle speeds on unsealed haul roads to reduce dust generation and keep vehicles to well-defined roads;
- minimise haul distances between construction sites to spoil stockpiles;
- treat or cover stockpiled material to prevent wind erosion;
- regularly clean machinery and vehicle tyres to prevent wheel entrained dust emissions;
- route roads away from sensitive receptors wherever practical;
- minimise topsoil and vegetation removal, and revegetate disturbed areas as soon as possible; and
- ongoing visual monitoring of dust on a daily basis, with ramping down of activities in the instance of high dust emissions.

In addition dust emissions during construction can be managed by considering the coordination of the construction schedules. Ensuring that there are no delays in construction activities will decrease the amount of time that disturbed land remains exposed for wind erosion.

2.5.2 Operation

The following dust control measures are included in the design of the China First mine, and have been considered when assessing the impacts from the project:

- watering of haul roads;
- water sprays at primary, secondary and tertiary sizing station stockpiles;
- fully enclosed conveyor systems;
- underground loading of coal at the preparation and preparation facilities;
- wet process for the coal handling facility; and
- ongoing revegetation of stripped areas in the open cut mine pits.

In addition to these control measures, further recommendations for the ongoing management of dust from the mine site are presented in Table 2.7. These measures have been adapted from best practice dust control techniques outlined by Environment Australia (1998) and the Victorian Environmental Protection Agency (1996). Prevention of dust emissions is preferable to suppression. Therefore a key aspect of dust management is that mitigation measures be considered during the planning of activities.

Table 2.7: Best Practice Dust Control

Source	Control Procedures
Areas disturbed by mining	Disturb only the minimum area necessary for mining. Reshape, topsoil and rehabilitate completed overburden emplacement areas as soon as practicable after the completion of overburden tipping.
Topsoil stockpiling	Revegetate long term topsoil stockpiles not regularly used.
Haul roads	Clearly define edges of all haul roads with marker posts or equivalent to control their locations, especially when crossing large overburden emplacement areas. Rip and revegetate obsolete roads. Minimise hauling distance. Minimise vehicle speed, especially during periods of high wind (> 7 m/s).
Minor roads	Development of minor roads will be limited and the locations of these will be clearly defined. Water minor roads that are frequently used. If practical, pave/seal minor roads.
Blasting	Assess meteorological conditions prior to blasting, with periods of high wind speed increasing dust dispersion.
Draglines	Ramp down activities and/or reduce drop height during periods of high wind speed, if practical.

2.5.2.1 Dust Monitoring

As a dust management tool during the operational phase of the project, ambient air quality and deposition dust monitors should be installed and maintained to quantify actual dust impacts near the mine. A careful design of monitoring types and locations is necessary to quantify the upwind and downwind air quality of the mine. The upwind station data would represent the background dust level, and the downwind station data would represent the cumulative impacts. When considering air monitoring locations, sensitive receptors and distance to mining activities such as haul roads and draglines should also been taken into consideration. Air quality monitoring combined with more accurate activity data during the operation would also provide an opportunity to validate emission estimates and dispersion modelling.

In addition, a meteorological monitor is recommended to provide a direct measure of weather conditions that are associated with dusty events.

2.5.3 Decommissioning

Commitments to rehabilitate disturbed areas after the closure of the mine will prevent ongoing wind erosion. Revegetation according to agreed criteria, and supported with ongoing monitoring and maintenance programs, will occur for the following potential sources of wind erosion:

- mine voids;
- overburden and waste rock dumps;
- tailings dams; and
- haul roads and access tracks.

2.6 Conclusions

2.6.1 Assessment Outcomes

The impacts to air quality from the activities at the China First Mine have been assessed against Qld EPP ground-level concentration guidelines for TSP, PM_{10} and $PM_{2.5}$. Dust deposition rates have also been assessed against relevant guidelines.

Air dispersion modelling has been used to predict ground-level concentrations of pollutants and rates of dust deposition, based on 2008 meteorological data for the mine region and estimated emission rates for the mine's activities. The USEPA regulatory dispersion models, CALMET/CALPUFF were selected, driven by TAPM generated meteorological data.

Emission rates were estimated using methodologies sourced from the NPI and USEPA. To assess worst case conditions, emissions were estimated for year 19 of the mine's life, as this represents peak emissions. The major sources of emissions were waste handling by the draglines, the transport of waste to the out of pit waste dumps, hauling of coal and wind erosion of exposed areas.

Results from the air dispersion modelling show that emission from only the mining activities exceed the relevant guidelines for TSP, PM_{10}, $PM_{2.5}$ and dust deposition, however only for PM_{10} does the area of exceedance extend beyond the boundary of the mine. When background concentrations (based on 70^{th} percentile recorded PM_{10} concentrations at West Mackay) are included, the area of exceedance for all substances increases.

For TSP and dust deposition, it is not predicted that guidelines will be exceeded beyond the boundary of the mine. Annual and 24-hour $PM_{2.5}$ concentrations from only the mining activities are not predicted to exceed guidelines beyond the boundary of the mine, however, when background concentrations are included it is predicted that guideline levels will be exceeded just beyond the northern mine boundary, however this does not affect any sensitive receptors.

PM_{10} concentrations are expected to exceed the 24-hour guidelines beyond the mine boundary for both the mine only and the mine plus background. PM_{10} concentrations are also expected to exceed guidelines at five sensitive receptors identified in the region of the mine. Two of these (Receptors 2 and 4) are within the mine boundary, while one (Receptor 1) is likely located within the boundary of another proposed coal mine. However, while these receptors are inhabited, it can be expected that any exceedance of the *EPP (Air)* guidelines will impact human health and wellbeing.

No exceedance of guidelines is predicted for the nearby townships of Jericho and Alpha.

2.6.2 Commitments

Waratah Coal is committed to implement various control measures to reduce dust emissions during the construction and operation of the China First Mine.

During the construction phase, the short term dust emissions will be managed through a comprehensive Environmental Management Plan.

During operation, the following dust control measures will be implemented:

- watering of haul roads;
- water sprays at primary, secondary and tertiary sizing station stockpiles;
- fully enclosed conveyor systems;

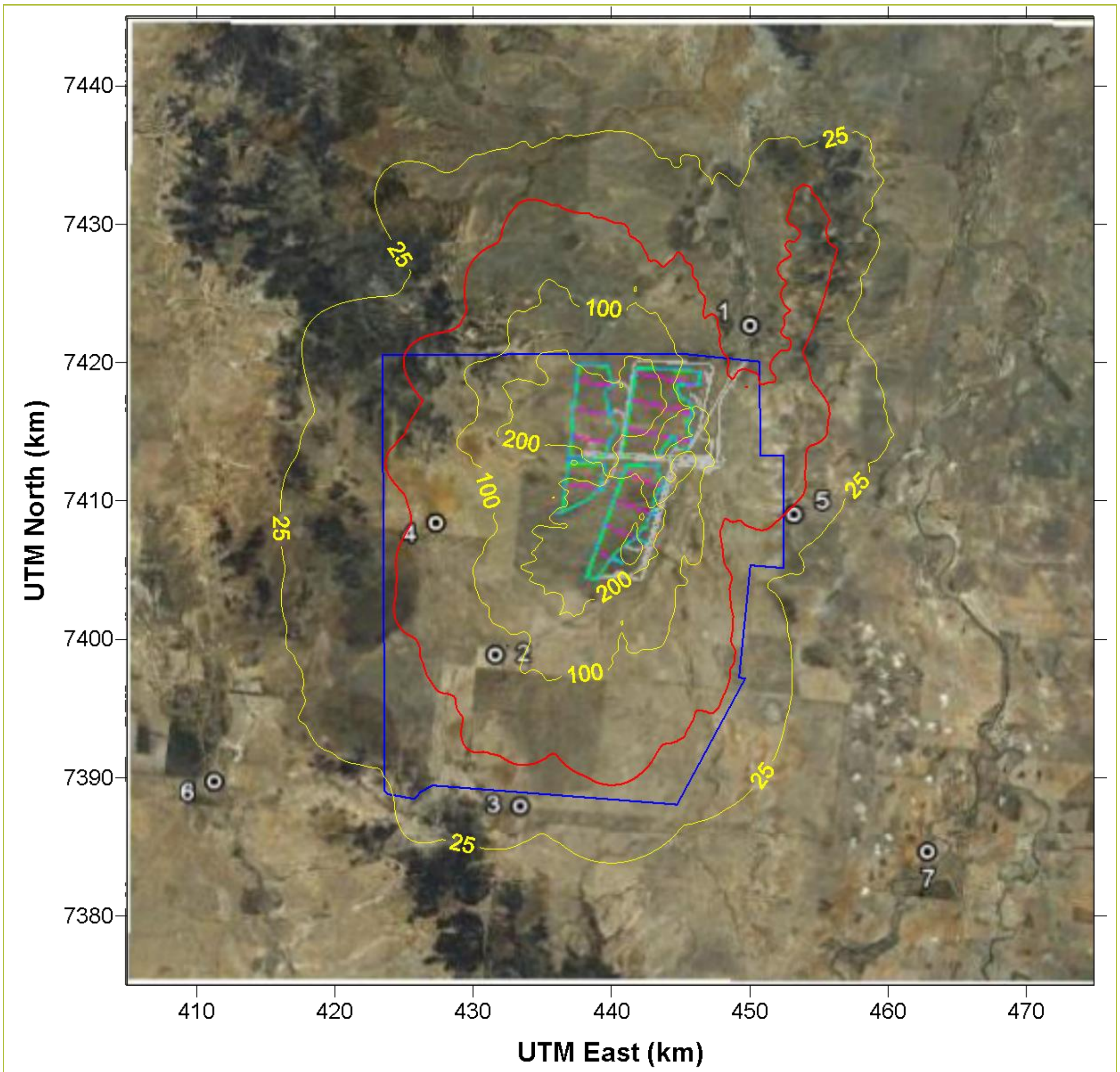
- underground loading of coal at the preparation and preparation facilities;
- wet process for the coal handling facility; and
- ongoing revegetation of stripped areas in the open cut mine pits.

In addition, dust management will be achieved through appropriate planning and awareness of conditions that produce peak dust emissions. This includes this includes:

- disturbing only the minimum area necessary for mining;
- minimising haul distances;
- controlling vehicle speeds on haul roads; and
- ramping down some mining activities during periods of high wind speed.

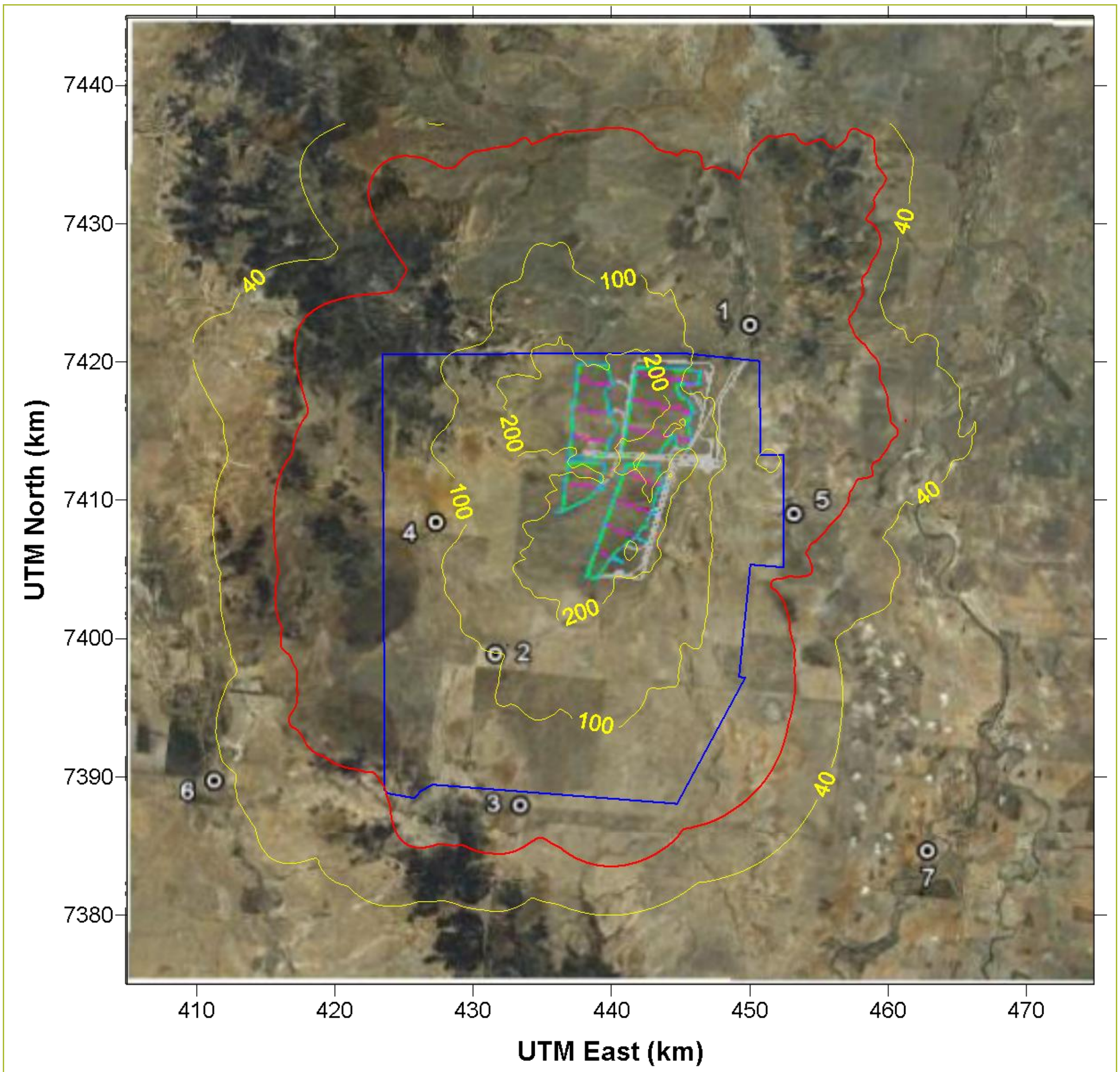
It is recommended that ongoing dusting monitoring occur near the mine, with a meteorological monitor also installed to provide a measure of weather conditions that are associated with dusty events.

If other large coal mines are developed in the region of the China First Mine, a cooperative effort from all operators will be required to manage dust emissions in the area.



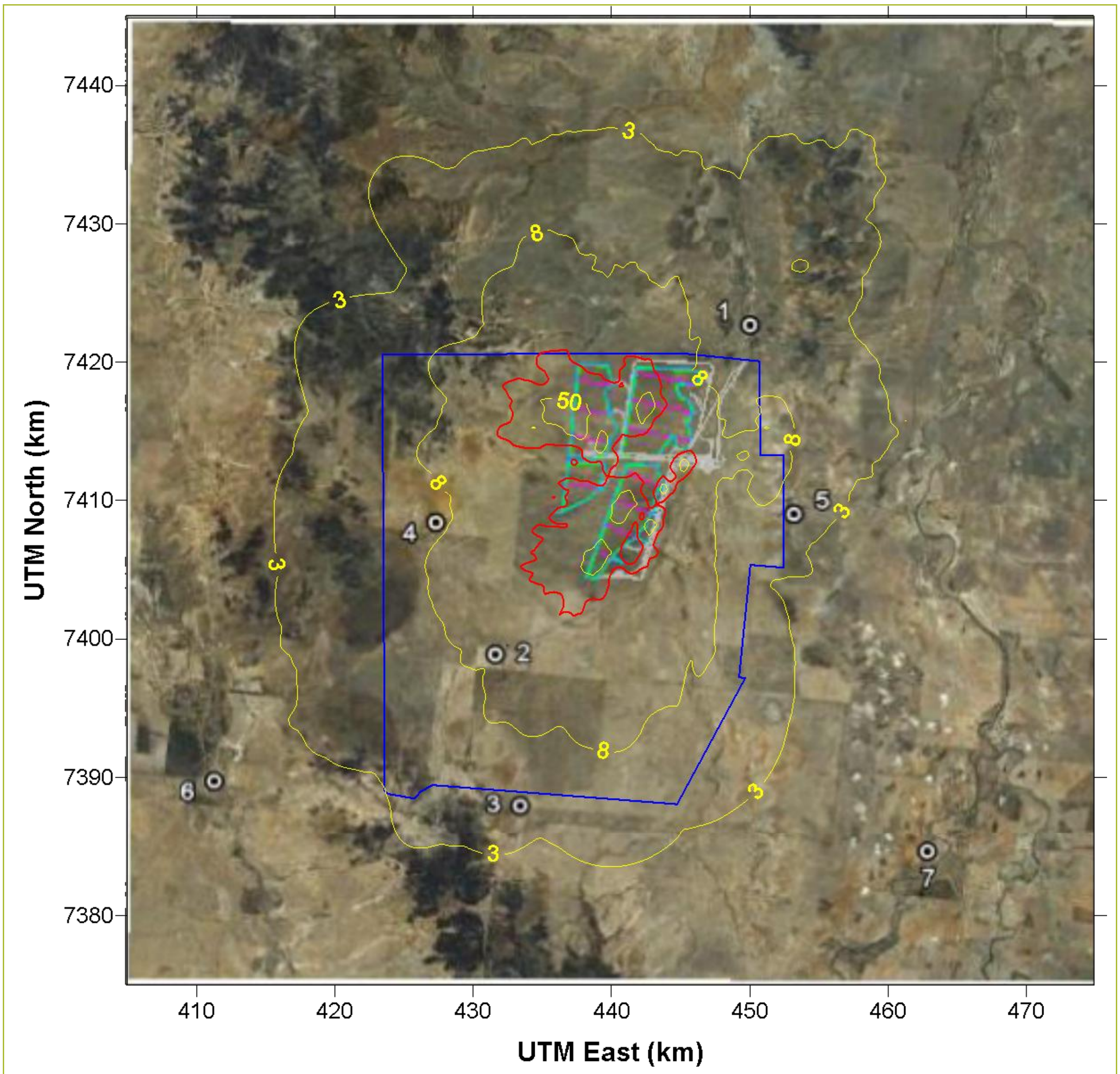
Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Mine site	Project only	Maximum	24-hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF V6	$\mu g/m^3$	EPP (Air) = 50 $\mu g/m^3$	TAPM Generated	J Steele

Figure 2.2: Predicted Maximum 24-hour Ground-level Concentrations of PM_{10} – Mine Only



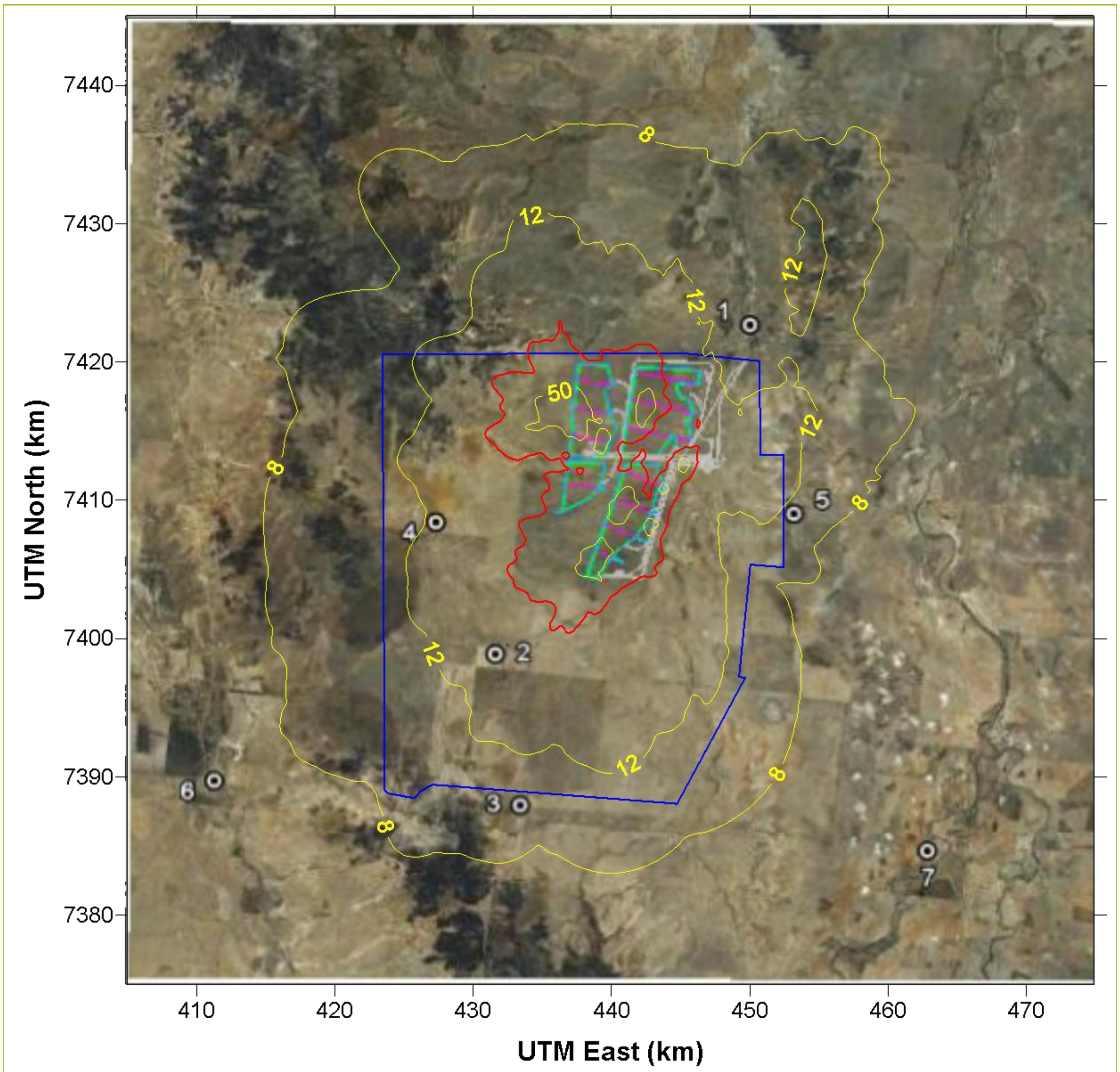
Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Mine site	Project + background	Maximum	24-hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF V6	µg/m^3	EPP (Air) = 50 µg/m^3	TAPM Generated	J Steele

Figure 2.3: Predicted Maximum 24-hour Ground-level Concentrations of PM_{10} – Mine + Background



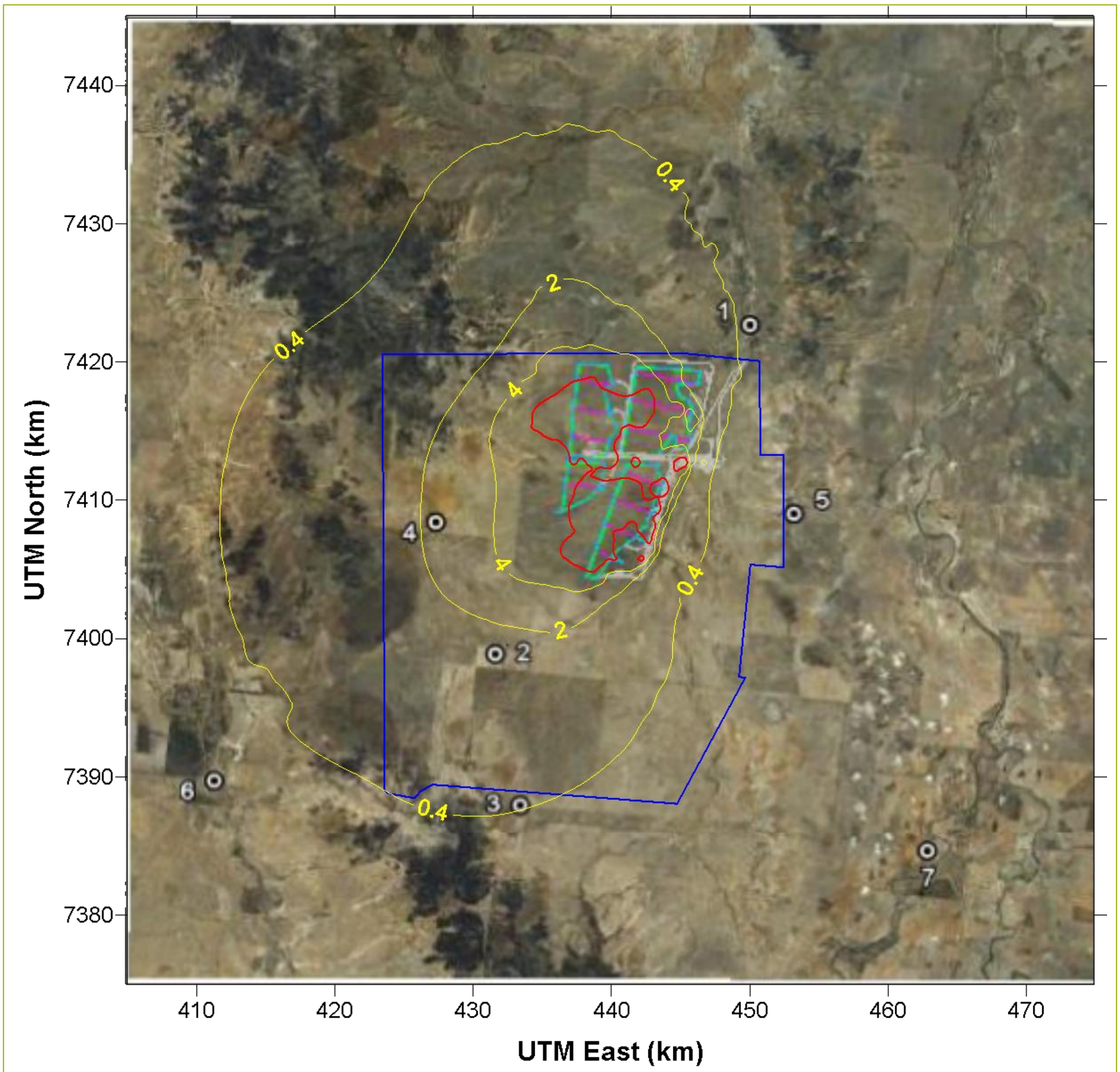
Species: PM2.5	**Location:** Mine site	**Scenario:** Project	**Percentile:** Maximum	**Averaging Time:** 24-hour
Model Used: CALPUFF V6	**Units:** µg/m^3	**Guideline:** EPP (Air) = 25 µg/m^3	**Met Data:** TAPM Generated	**Plot:** J Steele

Figure 2.4: Predicted Maximum 24-hour Ground-level Concentrations of $PM_{2.5}$ – Mine Only



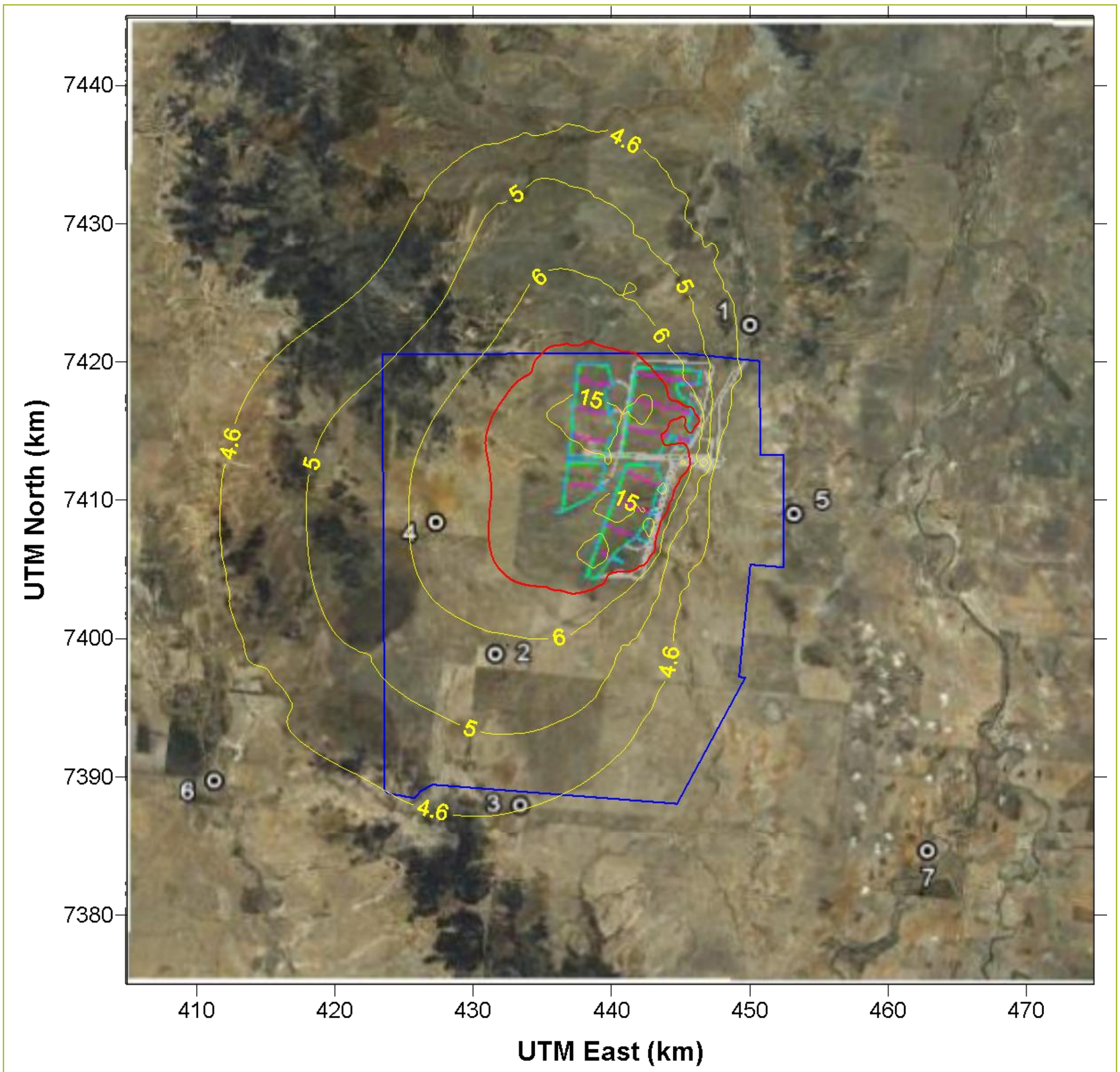
Species: PM$_{2.5}$	**Location:** Mine site	**Scenario:** Project + background	**Percentile:** Maximum	**Averaging Time:** 24-hour
Model Used: CALPUFF V6	**Units:** µg/m^3	**Guideline:** EPP (Air) = 25 µg/m^3	**Met Data:** TAPM Generated	**Plot:** J Steele

Figure 2.5: Predicted Maximum 24-hour Ground-level Concentrations of PM$_{2.5}$ – Mine + Background



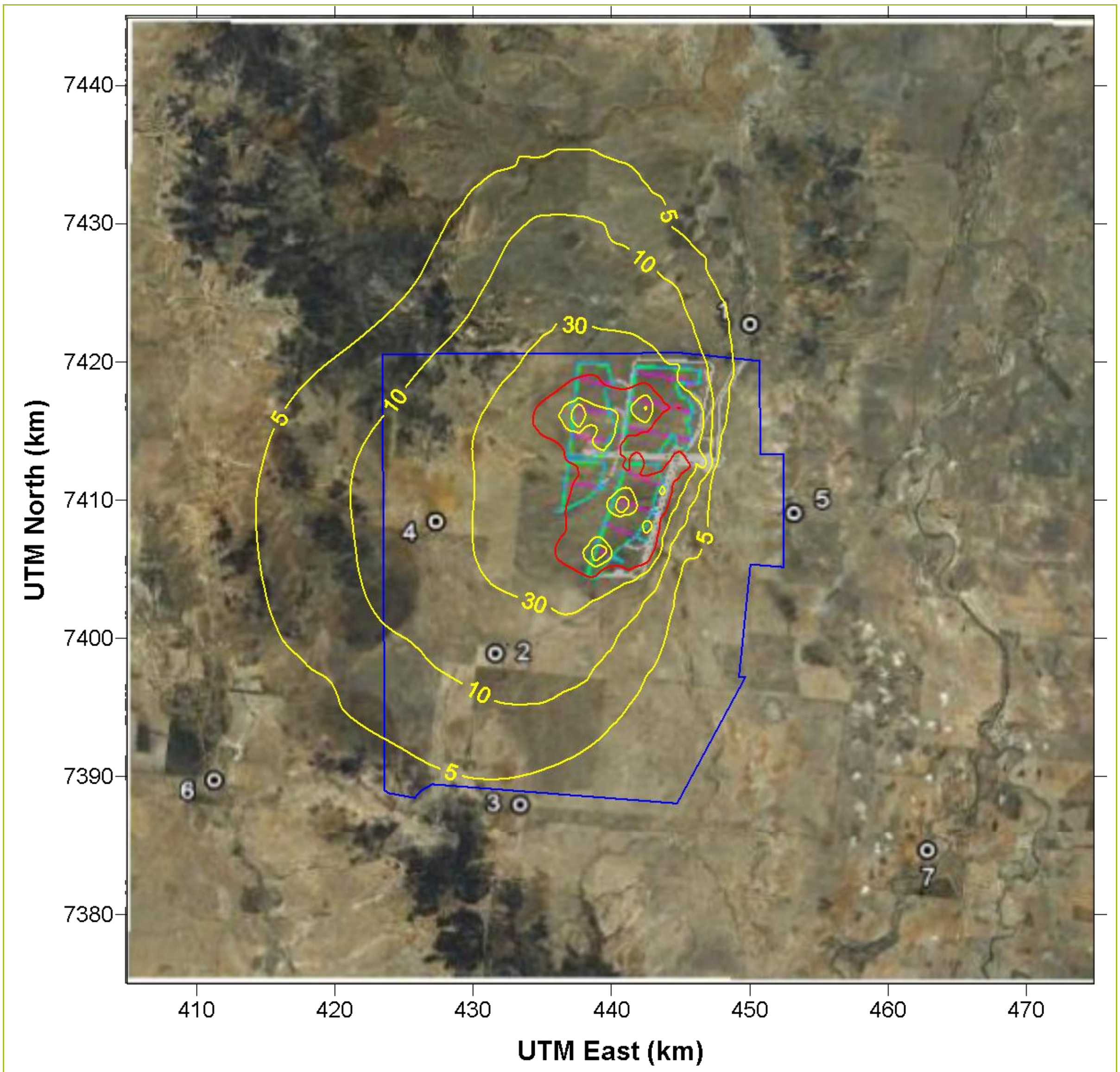
Species: PM$_{2.5}$	Location: Mine site	Scenario: Project	Percentile: Average	Averaging Time: Annual
Model Used: CALPUFF V6	**Units:** µg/m^3	**Guideline:** EPP (Air) = 8 µg/m³	**Met Data:** TAPM Generated	**Plot:** J Steele

Figure 2.6: Predicted Maximum Annual Ground-level Concentrations of PM$_{2.5}$ – Mine Only



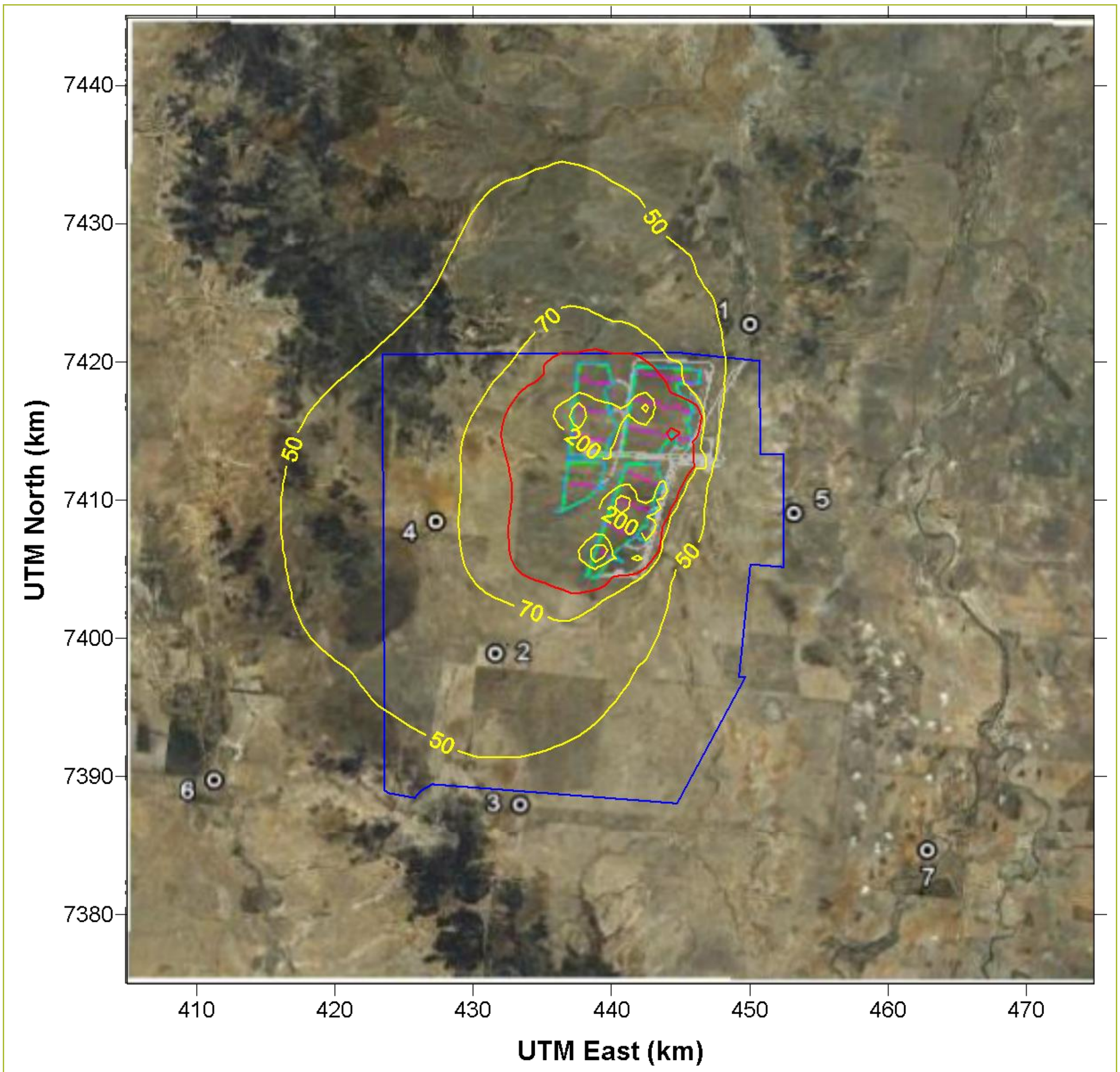
Species: PM$_{2.5}$	Location: Mine site	Scenario: Project + background	Percentile: Average	Averaging Time: Annual
Model Used: CALPUFF V6	**Units:** µg/m^3	**Guideline:** EPP (Air) = 8 µg/m³	**Met Data:** TAPM Generated	**Plot:** J Steele

Figure 2.7: Predicted Maximum Annual Ground-level Concentrations of PM$_{2.5}$ – Mine + Background



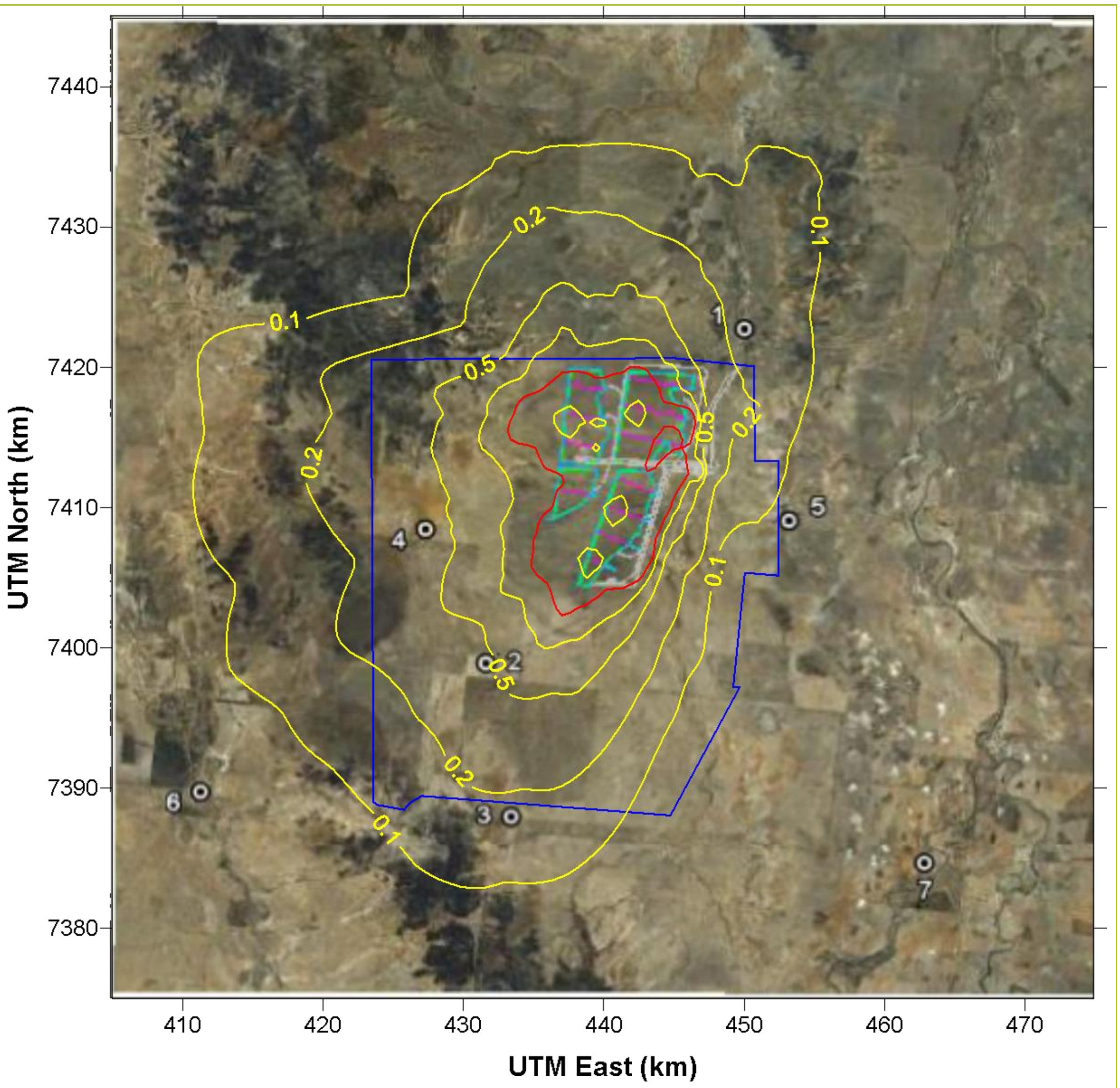
Species:	Location:	Scenario:	Percentile:	Averaging Time:
TSP	Mine site	Project	Average	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF V6	µg/m^3	EPP (Air) = 90 µg/m^3	TAPM Generated	J Steele

Figure 2.8: Predicted Maximum Annual Ground-level Concentrations of TSP – Mine Only



Species:	Location:	Scenario:	Percentile:	Averaging Time:
TSP	Mine site	Project + background	Average	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF V6	µg/m^3	EPP (Air) = 90 µg/m^3	TAPM Generated	J Steele

Figure 2.9: Predicted Maximum Annual Ground-level Concentrations of TSP – Mine + Background



Species:	Location:	Scenario:	Percentile:	Averaging Time:
Dust deposition	Mine site	Project	Maximum	Month
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF V6	g/m²/month	EPP (Air) = 2 g/m²/month	TAPM Generated	J Steele

Figure 2.10: Predicted Maximum Monthly Dust Deposition – Mine Only

3 AIR QUALITY ASSESSMENT – THE RAIL

3.1 Introduction

3.1.1 Study Area

A new 447 km railway system will transport product coal from the Galilee Basin to the existing Port of Abbot Point. The railway component includes a state of the art, heavy haul, standard gauge railway to support 25,000 tonne train units. A dual track is proposed, with empty and loaded coal trains travelling on each track. The worst case emissions scenario is based on 400 Mtpa product coal being transferred from the mine to the coal terminal at Abbot Point.

The final railway easement is expected to be approximately 100 m wide, to be confirmed during the detailed design phase of the project.

A map of the rail and sensitive receptors nearby are provided in Figure 3.1.

3.1.2 Purpose of Study

The objectives of this study are to estimate potential air quality impacts of dust emissions from the coal trains and their open coal wagons, and to quantify dust deposition fluxes in the vicinity of the rail line.

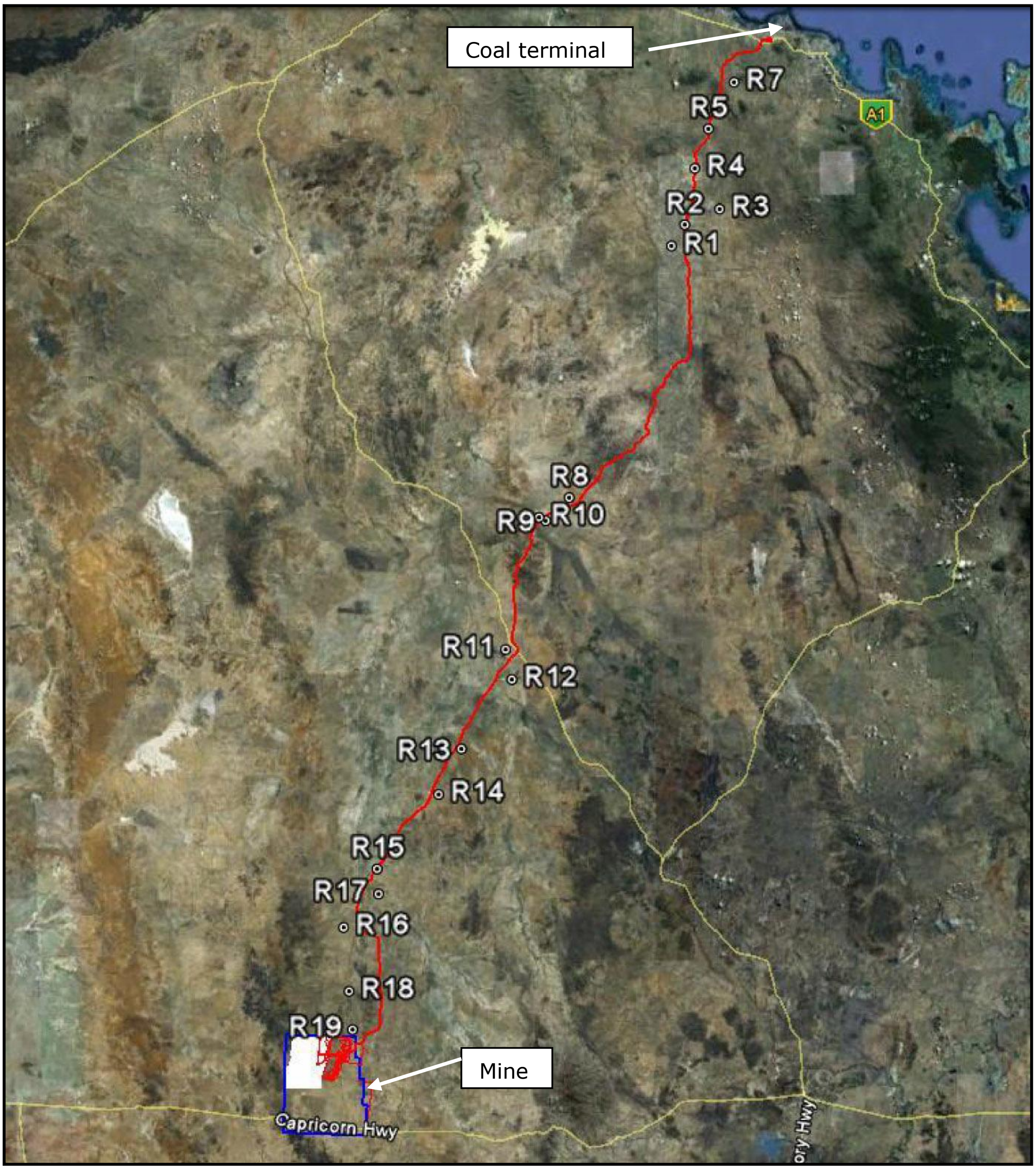
3.1.3 Scope of Work

To assess the impact of dust emissions from the proposed rail corridor, the scope of work includes:

- identifying relevant regulatory criteria for air quality and dust deposition;
- identifying the existing environment of the study area, with respect to climate and ambient air quality;
- estimating air emissions from the rail corridor expected during construction and operational activities;
- identifying project emission control strategies that could affect dust generation and movement;
- presenting predicted changes to existing air quality from rail operational activities;
- the human health risk associated with emissions from the project of all hazardous or toxic pollutants whether they are or are not covered by the *National Environmental Protection Council (Ambient Air Quality) Measure* or the *EPP (Air)* that may reasonably be expected to impact human health;
- cumulative impacts within the airshed; and
- identifying mitigation measures to manage and reduce the impacts from dust emission.

3.1.4 Legislative Framework

Please refer to Section 2.1.4 for a description of the legislative framework for this assessment.



Location of sensitive receptors provided by Waratah Coal.

Figure 3.1: Location of the Railway and the nearby sensitive receptors identified

3.2 Methodology

3.2.1 Sources of Emissions

3.2.1.1 Construction

Air emissions during the construction phase of the rail corridor will be primarily dust related, with some minor emissions of combustion pollutants such as nitrogen oxides due to diesel and petrol vehicles and construction equipment.

The sources of dust emission include:

- clearing of vegetation and topsoil;
- excavation and transport of earth material;
- blasting;
- vehicles travelling on unpaved roads;
- vehicles and machinery exhausts; and
- activities from temporary hard rock and gravel quarries situated along the alignment.

The impacts of construction activities will be managed through the Environmental Management Plan. This will include measures to minimise dust emissions and procedures that will be implemented to mitigate off-site impacts. Further information is provided in section 3.5.1.

3.2.1.2 Operation

Emissions of dust from the open coal wagons were estimated and modelled for this assessment. Emissions due to the coal surface of open coal wagons have been identified as the major source of dust emissions from coal transport on rail corridors (Connell Hatch, 2008).

Emissions resulting from entrainment of particulate matter from the tracks, leakage of dust from the doors of loaded wagons and wind erosion from dust spilled on the rail corridor were not included in this assessment as they were not considered significant sources compared to the emissions of particulate matter from the open coal wagons (Connell Hatch, 2008).

Particulate matter emitted from diesel combustion in the locomotives was also assessed.

3.2.2 Pollutants of Interest

The pollutants of interest in the current assessment are:

- particulate matter less than 2.5 microns ($PM_{2.5}$);
- particulate matter less than 10 microns (PM_{10}); and
- total suspended particles (TSP).

In addition to predicting ambient levels of particulate matter specified in the bullet points above, dust deposition is also assessed.

3.2.3 Emission Estimation

3.2.3.1 Fugitive Dust Emissions from Open Coal Wagons

Emissions of TSP were estimated using the methodology presented in the *Interim Report Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains Goonyella, Blackwater and Moura Coal Rail Systems* prepared for Queensland Rail Limited (Connell Hatch, 2008).

The following equation was used to estimate fugitive TSP emissions from the coal trains:

$$E_{TSP} = \frac{A \times TrackLenth \times EF_{TSP}}{1000}$$

where:

E_{TSP}	=	Emission rate of TSP	(kg/a)
A	=	Total amount of coal transported	(tonnes/a)
TrackLength	=	Length of the railway track	(km)
EF_{TSP}	=	Emission factor	(g/km/tonne)

The following parameters were used in the equation:

- 400,000,000 tonnes (400 Mtpa) of coal transported per annum; and
- railway track length of approximately 447 km, based on the assumed track route, as sourced from Waratah Coal.

The emission factor was calculated using the following equation (Connell Hatch, 2008):

$$EF_{TSP} = k_1.v^2 + k_2.v + k_3$$

where:

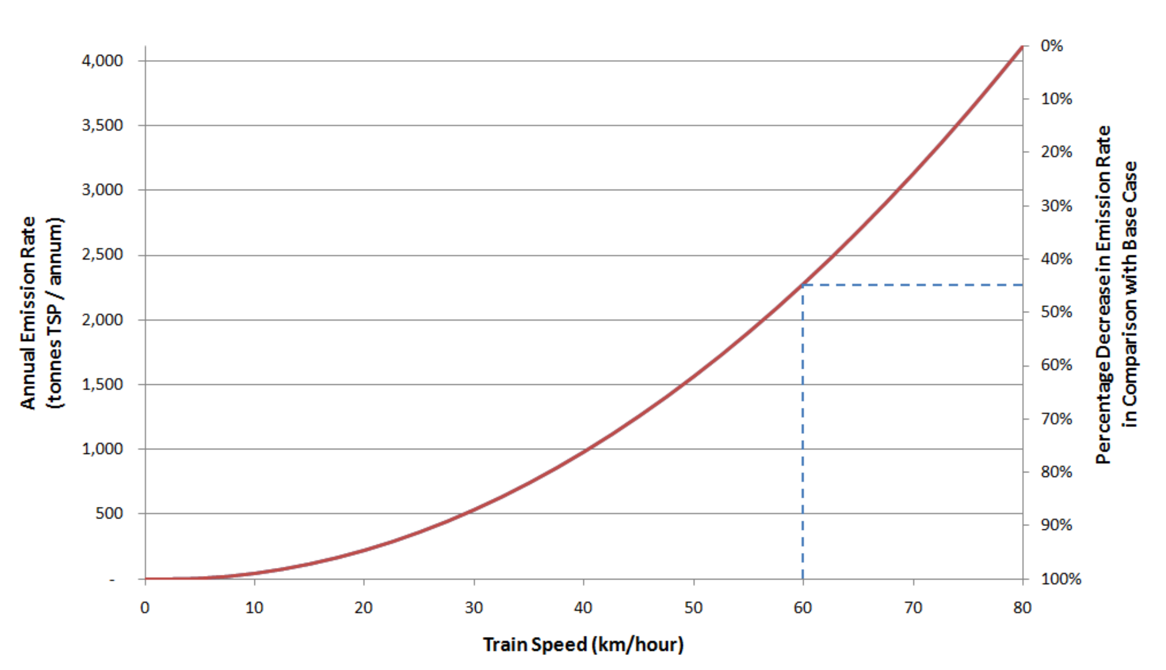
EF_{TSP}	=	Emission factor	(g/km/tonne)
k_1-k_3	=	Constants	(-)
v	=	Air velocity over the surface of the train	(km/h)

The following parameters were used to determine the TSP emission factor (Connell Hatch, 2008):

- constants of
  - k_1 = 0.0000378
  - k_2 = -0.000126
  - k_3 = 0.000063
- air velocity over the surface of the train of 80 km/hour, which is the maximum laden speed of the coal train, sourced from Waratah Coal.

It is noted that the value for air velocity does not take into account wind speed. If the train travels directly into the wind, wind speed can have a significant effect on the air velocity over the surface of the train. However if the direction of the wind is perpendicular to, or blowing in the same direction as the train, the effect is minor (Connell Hatch, 2008). The predominant wind direction in the railway region is easterly, and the train predominately travels north, meaning that the wind is predominantly perpendicular to the direction of travel.

The relationship between train speed and emissions is illustrated in Figure 3.2. If the train speed reduces, for example, from the base speed of 80 km/hour to 60 km/hour, the TSP emissions will reduce by approximately 45%.



Note: Base case represents train speed of 80 km/hour, as used in the emissions estimation and dispersion modelling

Figure 3.2: Relationship between Train Speed and TSP Emissions

3.2.3.2 Diesel Combustion in Locomotives

PM_{10} and $PM_{2.5}$ emissions from the combustion of diesel in locomotives were estimated using the following parameters:

- rate of fuel consumption of 60 L/h, based on PAEHolmes' analysis of freight train data provided by Queensland Rail for the Port of Brisbane Corporation (PAEHolmes, 2010);
- emission factors of 3.51 g/L and 3.37 g/L for total uncontrolled PM_{10} and $PM_{2.5}$ emissions from diesel combustion in locomotives, (PAEHolmes, 2010); and
- estimated annual operating hours of all locomotives.

Annual emissions of both PM_{10} and $PM_{2.5}$ from diesel combustion were found to represent less than 1% of annual PM_{10} and $PM_{2.5}$ emissions from the coal trains, and were therefore not included in the modelling.

3.2.3.3 Control Factors

Typical control techniques for dust emissions involve increasing the coal's moisture content. This can be achieved through wetting or washing the coal (which will occur in the coal handling preparation plant). Alternatively, wetting may occur due to rainfall during the coal's transport.

The emission factor described in Section 3.2.3 is based on monitored emission rates from a coal rail system in Portugal, as no relevant data from Australia were available. Portugal has some similarities in climate to Queensland (Connell Hatch, 2008), in that both regions are characterised by a marked wet and dry season.

The following dust control methods are proposed, aiming to reduce dust emissions by 80%:

- Implementing partial covers for the coal wagons; and/or
- Wetting down the coal in each wagon before leaving the coal mine.

Based on Connell Hatch (2008), a full cover of coal wagons (wagon lids) reduces dust emissions by 99%, and applying water and dust suppressant solution on the coal surface can reduce dust emissions by 75% depending on amount and frequency of water applied. Wetting down the coal may occur at locations other than the mine, such as before a major community.

As a conservative assumption, reduced emissions during periods of rainfall of the coal have not been considered.

3.2.4 Emissions Summary

Annual fugitive emissions rates of TSP, PM_{10} and $PM_{2.5}$ from the railway are presented in Table 3.1. PM_{10} emissions have been estimated using a 50% fraction of TSP, adapted from the PM_{10} ratio of TSP for wind erosion, as sourced from the NPI EET Manual for Mining v2.3 (2004). $PM_{2.5}$ emissions have been estimated assuming a fraction of 12.5% of PM_{10}. Justification of for the use of this $PM_{2.5}$ ratio is provided in Section 2.2.3.

Table 3.1: Estimated Annual Emissions

Pollutant	Emissions (kg/annum)	% of TSP
TSP	8,229,774	100%
PM_{10}	4,114,887	50%[a]
$PM_{2.5}$	514,360	6.25%[b]

[a] Adapted from PM_{10} ratio for emission factors for wind erosion, sourced from the *National Pollutant Inventory Emission Estimation Technique Manual for Mining v2.3*, Commonwealth of Australia, 2004.

[b] Refer to Section 2.2.3 of this assessment for justification.

3.2.5 Modelling Methodology

3.2.5.1 Meteorology

A steady-state Gaussian dispersion model, AUSPLUME, was run with two annual meteorological datasets to compare the maximum time-averaged concentrations to their relevant guidelines. The two meteorological datasets were generated using TAPM, a meteorological model developed by CSIRO. Hourly averaged meteorological time series were extracted close to Alpha, near the start mine-site (for year 2008), and near Bowen, near the coal terminal facility. Technical details on AUSPLUME and TAPM are provided in Appendix B.

3.2.5.2 Modelling Domain and Emission Sources

It was assumed that the entire length of the track was emitting at the rates presented in Table 3.2. As it was not feasible to model the entire length of the proposed railway, a representative section of the railway was modelled. Terrain effects were not accounted for in AUSPLUME as a non-specific section of track was modelled. The length of the rail modelled was 12.4 km as a straight line.

The dust emissions were modelled as a series of joined area sources that represented the dust plumes generated from trains running on two proposed tracks. Each source was 20 m wide, and 120 sources were modelled for the length of 12.4 km. This was to simulate a scenario where the two tracks are located within a land strip of 20 m wide, well within the proposed 100 m rail alignment.

A line of receptors was set up, perpendicular to the modelled rail line, crossing the rail line at the middle. The gap between receptors was 25 m near the rail line, and 50 m further away. The furthest receptors are 2 km away from the track on both sides of the rail.

An illustration of the configuration of the modelling setup is shown in Figure 3.3.

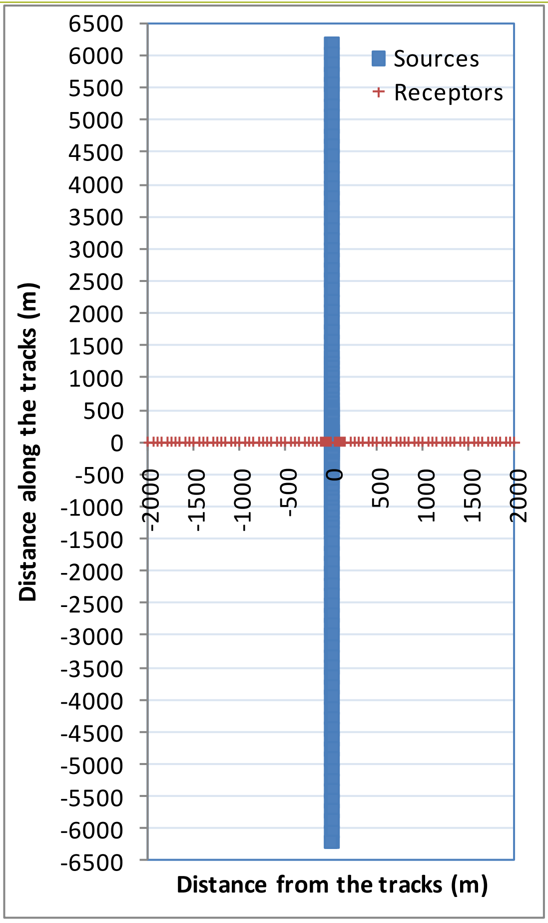


Figure 3.3: Illustration of the Modelling Setup

Given that the train predominantly travels in a northerly direction the model sources were aligned so that train is heading in a northerly direction. This was expected to be the worst case scenario, as the predominant wind direction in the study region is from the east, meaning that the full length of the train is exposed to the predominant winds.

To confirm this expectation, the scenarios in which trains are heading northeast or east were also modelled.

3.2.5.3 Emission Rates

AUSPLUME was configured to run with emissions as calculated in Section 3.2.3.

Emission rates for the total length of the track were converted from kg/annum to g/m²/s, based on the length of the track (447 km) and width of the trains (20 m) representing a total emitting area of approximately 8,940,000 m². This methodology assumes that the entire length of the track is emitting dust for 100% of the year.

The emission rates used in AUSPLUME are shown in Table 3.2.

Table 3.2: Emission Rates of the Speciated Dust Components as Entered in AUSPLUME

TSP ($g/m^2/s$)	PM_{10} ($g/m^2/s$)	$PM_{2.5}$ ($g/m^2/s$)
2.93×10^{-6}	1.47×10^{-6}	1.83×10^{-7}

In reality dust emissions will vary greatly with respect to time. Emissions at a given point along the track will occur only as a train passes. Waratah Coal estimates that there will be 70 trains travelling along the track per day, and that each train will take approximately 2-3 minutes (travelling at 80 km/hour) to pass a single point. This is a total of 100-180 minutes per day.

The exact time during the day when these emission peaks will occur is unknown. Therefore, emissions have been modelled for the total length of the track to account for all possible meteorological conditions, including worst case scenarios. However, the probability of a train passing a point along the track at the same time as worst case meteorological conditions is occurring is low.

3.2.6 Cumulative Impacts

Several projects have been proposed that have the potential to affect the air quality impacts predicted in this assessment. These include:

- BMA Bowen Coal Growth project (BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd (BMA)) – coal mines located within close proximity to the rail line near Moranbah;
- Alpha Coal Project and Kevin's Corner (Hancock Prospecting Pty Ltd) – coal mines directly competing for railway line and port facilities; and
- South Galilee Coal Project (AMCI Pty Ltd) – a coal mine that plans to utilise common-user rail and port facilities developed by either Waratah Coal or Hancock Prospecting.

These proposed mines potentially share this same rail line. The total modelled transport coal capacity of 400 Mtpa, rather than the 40 Mtpa from Waratah Coal only, reflects the projected cumulative impacts along this rail corridor.

3.3 Existing Environment

3.3.1 Meteorology

The 447 km rail track is subject to a tropical climate, with hot and wet summers, and cool and dry winters. Summers are monsoonal, frequently influenced by tropical cyclones and lows, which can cause heavy rainfall in the coastal areas. The wind direction is predominantly from the east, south east and north east. There are gradual changes of climate from the coastal end to the mine end of the rail track, with average annual rainfall and relative humidity decreasing as the track moves inland, and average annual temperature increasing as the track moves inland.

A climate summary relevant to air quality is provided below. For a detailed description of climate at the project area, refer to Appendix C.2.

Climate conditions for the China First Project railway have been assessed for three project locations:

- China First Coal Terminal at Abbot Point (the coal terminal) – the start of the railway
- central region of the railway; and
- China First Mine site (the mine) – the end of the railway.

For a description of the meteorology at the coal terminal, refer to Section 4.3.1, and for a description of the meteorology at the mine site, refer to Section 2.3.1.

Based on meteorological data collected twice a day at 9am and 3pm at Moranbah Water Treatment Plant, and Collinsville (two BOM weather stations), the climate for the central part of the rail is summarised as below, in comparison with the mine inland and the coal terminal at the coast.

- Based on wind roses from Proserpine and Moranbah, long term average 9am winds for the central section of the railway are predominately from the south-east to east, with calms between 7-24% of the monitored period. Long term average 3pm winds are generally stronger than for 9am, and from the south-east to east. Calms form 0.5-15% of 3pm winds.
- Relative humidity is the highest during the summer, autumn and winter months, and lowest during the spring months. Relative humidity is typically the highest at the coal terminal and the lowest at the mine site. Relative humidity is affected by the distance from the sea with stations further from the ocean having less water vapour available and hence lower relative humidity.
- Rainfall is highest during summer and lowest during winter, with a total annual rainfall approximately 590 mm at Moranbah and 710 mm at Collinsville. Rainfall is higher towards the coast.
- It is warm year-round. In the hot summer months, the mean daily maximum temperature reaches over 31°C at the coal terminal, over 35°C at the mine site. The daily temperature ranges are smaller at the Coal terminal (about 7 – 8 °C) and are larger near the mine (about 13 – 15°C). In the cooler winter months, the mean daily maximum temperature drops to 23 – 25 °C at these locations.Mean daily minimum temperature drops to 13.5°C at the Coal terminal and as low as 7.6°C at the mine site. For sites between the mine and port, conditions are expected to be intermediate.

Temperature inversion strength and frequency have been estimated based on TAPM meteorological modelling output for the year 2008 for the mine and coal terminal. Table 3.3

shows that inversions occur for a greater percentage of the time at the mine site than at the coal terminal. This is because temperature inversions are more pronounced over land than near water, as water holds its heat for longer than land does. Therefore, it can be expected that the frequency of inversions will increase as the railway moves inland from the coal terminal to the mine site.

Table 3.3: Temperature Inversion at Night Time – Mine Site and Coal Terminal (2008)

Night Time Inversion Strength	Mine Site		Port	
	Percentage of occurrence (%)	Number of hours	Percentage of occurrence (%)	Number of hours
>3ºC per 100 m	13	1169	1	63
>2ºC per 100 m	20	1750	2	210
>1ºC per 100 m	30	2595	12	1056
>0ºC per 100 m	50	4410	34	2974

3.3.2 Existing Air Quality

3.3.2.1 Existing Emission Sources

Over the 437 km rail track, the major background dust emission sources include those typical for a rural area: naturally blown dust from the landscape; potential agricultural burning; natural bush fires; and biogenic emissions. At the proposed new coal terminal site, the existing Abbot Point Coal Terminal is the additional background source of dust. There are no other existing mines at the Waratah Coal mine site.

3.3.2.2 Background Air Quality

Background air quality generally refers to the current air quality environment in the project area.

Air quality monitoring data from West Mackay, the nearest DERM site, have been used to represent the background dust levels for the study area along the rail track. It is a very conservative approach as there are far more industrial and urban pollution sources near the West Mackay monitoring station, as well as a sea salt component that can be very significant in coastal areas at times.

Summaries of West Mackay air quality data are presented in Section 2.3.2.2.

For the purposes of this EIS assessment and considering the predominantly rural environment along the rail track, the estimated background levels of dust are:

- 26 µg/m³ for 24-hour average PM_{10} levels (70^{th} percentile of 24-hour concentrations, at West Mackay during 2006-2009);
- 22 µg/m³ for 24-hour average PM_{10} levels (annual average concentrations, at West Mackay during 2006-2009);
- 5.2 µg/m³ for 24-hour average $PM_{2.5}$ levels (20% of PM_{10} values, based on Midwest Research Institute, 2006);
- 4.4 µg/m³ for annual average $PM_{2.5}$ levels (20% of PM_{10} values, based on Midwest Research Institute, 2006); and
- 44 µg/m³ for annual average TSP levels (twice of PM_{10} values, based on Midwest Research Institute, 2006).

The use of 20% of PM_{10} to estimate $PM_{2.5}$ background concentrations is based on Midwest Research Institute (2006), in which the recommended ratio of $PM_{2.5}$ to PM_{10} is 0.2 for agriculture activities, which is applicable to the rural area along the rail track, where terrestrial wind erosion is presumably the major source of background dust emissions.

There are no known measurements of TSP in the region. AP-42 and NPI manuals show that for dust emitted from terrestrial wind erosion, the ratio of PM_{10} and TSP is about 0.5. We use this value to derive the background TSP level from the PM_{10} value.

See section 2.3.2.2 for further discussion regarding background air quality estimates.

3.4 Potential Impacts

3.4.1 Construction

Potential impacts associated with the construction of the railway have not been directly assessed. However, any impacts will be short term in comparison with the coal trains, and can be minimised through effective dust management.

3.4.2 Operation

3.4.2.1 Contour Plots

Contour plots for the Railway are presented in Figure 3.4 to Figure 3.8. All air quality results include background concentrations.

PM_{10}

Figure 3.4 shows the maximum 24-hour averaged ground-level concentration of PM_{10} based on AUSPLUME results for the meteorological data extracted near the mine and port. A background level of 26 µg/m^3 is included in the figure.

For the modelled location close to the mine, the modelling impacts were assessed for three scenarios: trains heading north, northeast or east. This was done to determine the effect of changing the train direction on the modelled ground-level concentrations. For the modelled location close to the coal terminal, only the north pointing scenario was modelled.

Close to the mine site, the results indicate that the *EPP (Air)* PM_{10} guideline is exceeded up to 300 metres west of the train line and 150 metres east of the train line when the train is heading north. The modelled impacts are lower when the train is heading in the other two modelled directions.

Close to the coal terminal, the modelled impacts are lower than those near the mine, with no exceedances predicted.

$PM_{2.5}$

Figure 3.5 and Figure 3.6 show 24-hour and annual $PM_{2.5}$ ground-level concentrations based on AUSPLUME results, run with meteorological data extracted from sites close to the mine and port respectively, with the train heading north. A background level of 5.2 µg/m^3 for 24-hour average or 4.4 µg/m^3 for annual average is included in the figures.

$PM_{2.5}$ concentrations have been compared to both the 24-hour and annual average *EPP (Air)* guidelines. The results show that the $PM_{2.5}$ concentrations are not predicted to exceed either the 24-hour or annual average guidelines, both when the train is close to the mine site and close to the coal terminal.

$PM_{2.5}$ concentrations have not been predicted when the train is heading northeast or east as results from the 24-hour PM_{10} modelling show that the maximum concentrations occur when the train is heading north. Given that the maximum $PM_{2.5}$ concentrations do not exceed the relevant guidelines when the train is heading north, it is expected that no exceedances will occur when the train is heading northeast or east.

TSP

Figure 3.7 shows the annual averaged ground-level concentrations of TSP based on AUSPLUME results, run with meteorological data extracted from sites close to the mine and port respectively, when the train is heading north.

The results show that the TSP concentrations when the train is close to both the mine site and the coal terminal are below the *EPP (Air)* guideline. As with PM_{10} concentrations, TSP concentrations are predicted to be higher when the train is close to the mine site, than when the train is close to the coal terminal.

Coal Dust Deposition

The dust deposition rate due to TSP emissions from the coal wagons was calculated using AUSPLUME for both the port and mine site. The deposition rate was determined as an annual average from AUSPLUME. From this the required 30-day average deposition was calculated.

Figure 3.8 presents the modelling results for 30-day total dust deposition when the train is pointing north, based on meteorology for the mine site and the coal terminal site respectively. There is no exceedance of the "dark dust" draft guideline limit based on the AUSPLUME modelling at the mine or port site.

The dust deposition modelling does not include background levels as it is not envisaged that there are other sources of coal dust in the vicinity of the rail corridor.

Similarly to $PM_{2.5}$ concentrations, as dust deposition guidelines are not exceeded when the train is heading north, modelling was not conducted for scenarios when the train is heading northeast or east.

3.4.2.2 At Sensitive Receptors

Along nearly all of the track, the coal trains will be travelling through sparsely inhabited regions. Nineteen sensitive receptors have been identified by Waratah Coal along the length of the track. Of these, all but one are located at distances where the impacts of dust emissions from the railway will be small. The locations of the sensitive receptors are provided in Figure 3.1, with their approximate distances from the railway track provided in Table 3.4.

Sensitive Receptor 4 (highlighted in Table 3.4) is located approximately 70 m east of the railway. This receptor is located near a section of the track where the laden coal trains travel in a northerly direction near the coal terminal. The modelling indicates that the maximum ground-level concentrations will not exceed guidelines. While this is encouraging and it is true that the basis of the modelling areis conservative, it is important to make sure this sensitive receptor is located as far as possible from both train tracks.

Table 3.4: Location of Sensitive Receptors and Predicted Exceedances

Receptor	Longitude	Latitude	Distance from Track (m)	Exceedance
1	147.6632	-20.672139	> 4,900	None predicted
2	147.7109	-20.599801	> 500	None predicted
3	147.836	-20.546075	> 9,800	None predicted
4	147.7469	-20.408694	≈ 70	None predicted
5	147.7958	-20.273937	> 400	None predicted
6	147.7761	-20.214708	> 3,000	None predicted
7	147.8882	-20.11437	> 4,000	None predicted
8	147.296	-21.519461	> 3,100	None predicted
9	147.2111	-21.597091	> 1,300	None predicted
10	147.1875	-21.586234	> 500	None predicted
11	147.0668	-22.028334	> 700	None predicted
12	147.0897	-22.12867	> 5,200	None predicted
13	146.907	-22.360906	> 2,200	None predicted
14	146.8245	-22.513251	> 2,700	None predicted
15	146.6006	-22.762723	> 600	None predicted
16	146.4777	-22.958648	> 4,300	None predicted
17	146.6054	-22.846446	> 5,500	None predicted
18	146.4961	-23.173543	> 2,100	None predicted
19	146.5084	-23.302817	> 1,000	None predicted

Location of sensitive receptors provided by Waratah Coal.

Distances estimated based on railway track design map provided by Waratah Coal.

3.5 Mitigation and Management

Waratah Coal has stated a commitment to develop and implement an Environmental Management Plan. The Plan will include measures to minimise dust emissions during both the construction and operational phases of the railway.

3.5.1 Construction

Dust emissions during construction will be mitigated and managed by implementing the following strategies:

- water sprays on unsealed roads;
- restricting vehicle speeds on unsealed haul roads to reduce dust generation;
- minimising haul distances between construction sites to spoil stockpiles;
- treating or covering stockpiled material to prevent wind erosion;
- regularly cleaning machinery and vehicle tyres to prevent wheel entrained dust emissions;
- routing roads away from sensitive receptors wherever practical;
- minimising topsoil and vegetation removal and revegetating disturbed areas as soon as possible; and
- ongoing visual monitoring of dust on a daily basis, with ramping down of activities when high dust emissions occur.

These strategies have been adapted from the dust management plan detailed in the Queensland Rail's *Moura Link – Aldoga Rail Project* Environmental Impact Assessment, which was approved in 2009, and will be incorporated into the China First Project's Environment Management Plan.

3.5.2 Operation

3.5.2.1 Queensland Rail Dust Management Plan

To meet the air quality objectives during the operational phase of the rail, the following dust control measures have been proposed for this project. They are

- Implementing partial covers for the coal wagons; and/or
- Wetting down the coal in each wagon before leaving the coal mine (to bind surface coal particles and provide a crust that is resistant to dust lift off).

In addition, the following dust mitigation measures may be considered for this project, as adapted from the Queensland Rail's *Dust Management Plan* (February 2010).

Mitigation Method	Description
Wagon loading practices and policies	The loading of coal should be designed so that coal surfaces are near flat. This will reduce the available surface for wind erosion, and reduce coal spillage.
Coal type testing for dustiness	Determining the dustiness of coal being transported can allow for preventative measures to be taken to reduce dust emissions.
Coal moisture regulating system	Maintaining optimum moisture content of coal (that does not attract moisture penalties for customers) reduces dust emissions and improves veneer effectiveness. A system can be implemented that measures the moisture content of coal and automatically adds water to maintain the optimum moisture content.
Sill brushes	Brushes that remove excess coal on wagon sill immediately after the coal is loaded can minimise parasitic coal that dislodges and falls off the wagon during transit.

3.5.2.2 Altering the Design of the Railway

The only potential impact of dust emissions from the coal trains to sensitive receptors is at Receptor 4, which is located approximately 70 m east of the railway. As the receptor appears to be located in an area with no other dwellings or infrastructure in close proximity, moving this section of the railway to the west by several hundred metres would decrease the impact of dust emissions to negligible levels.

3.5.2.3 Train Speed

Dust emissions are estimated to increase significantly as air velocity over the surface of the train increases. If the air velocity over the surface of the train is taken as the speed of the train, decreasing train speed from 80 km/hour to 60 km/hour results in a decrease in TSP emissions of approximately 45%, as shown previously in Figure 3.2.

It is possible for the China First Railway to manage its dust emissions from coal trains through managing train speed. But this management will be complicated by other operational and cost issues related to train speed. Hence this should be the last resort if other measures fail to produce a satisfactory outcome.

3.5.2.4 Ambient Dust Monitors

If the dust presents significant problems for some communities after the rail line becomes operational, dust monitors can be installed to accurately quantify the impacts, with mitigation measures selected based on the outcome of monitoring.

3.6 Conclusions

3.6.1 Assessment Outcomes

Modelling the entire length of the rail corridor between the mine and port sites was not practical due to the length of the corridor involved. A representative section of track 12.4 km in length was therefore modelled to assess the impact of dust emission on air quality and to assess dust deposition levels in the vicinity of the rail corridor. AUSPLUME was run with TAPM meteorological extracts from both the port and mine sites to assess impacts at either end of the rail link.

Potential impacts of fugitive dust emissions from the coal trains have been assessed against relevant guidelines.

The results of air quality modelling show that TSP and $PM_{2.5}$ ground-level concentrations are expected to be below air quality guidelines set by the Queensland Government. Similarly, dust deposition from the coal trains is not predicted to exceed the relevant guideline.

Near the coal mine, modelling of PM_{10} showed that maximum ground-level concentrations may exceed the EPP 24-hour air quality guideline up to 300 m west and 150 m east of the railway line if the trains are heading north. When trains head east and northeast, the dust impacts are lower. Near the coal terminal, assessment shows no exceedances of the EPP PM_{10} guideline.

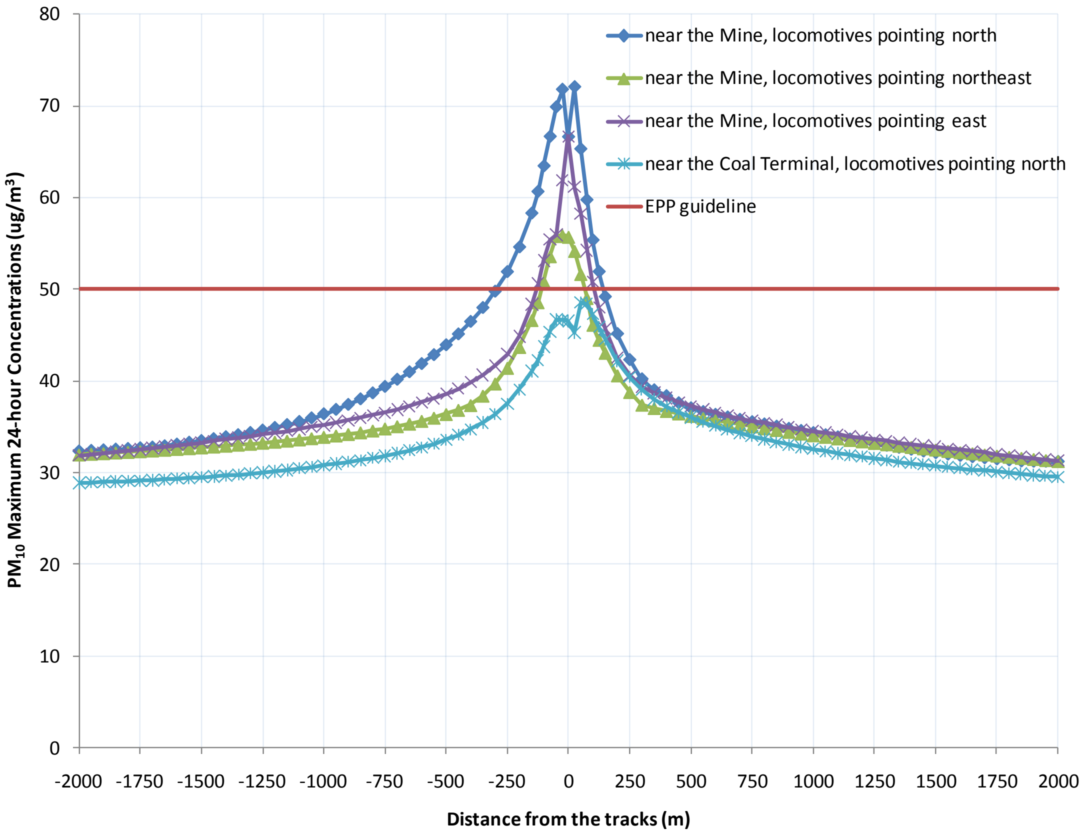
The closest sensitive receptor is approximately 70 m away to the railway, located close to the coast near the coal terminal. While exceedance of the PM_{10} guideline is not predicted for this receptor, it is important to make sure this receptor to be located as far away as possible from the both train tracks.

3.6.2 Commitments

Recommended mitigation measures during the rail operation include:

- ongoing consultation with the community;
- investigating the use of partial cover of train wagons;
- investigating the use of water sprays and coal moisture regulating systems;
- ensuring that coal loading systems are designed to minimise exposed areas and coal spillage;
- cleaning coal wagons of spilled coal;
- monitoring the dustiness of coal being transported;
- possibly managing train speed; and
- installing and maintaining dust monitoring equipment at sensitive locations if the need arises.

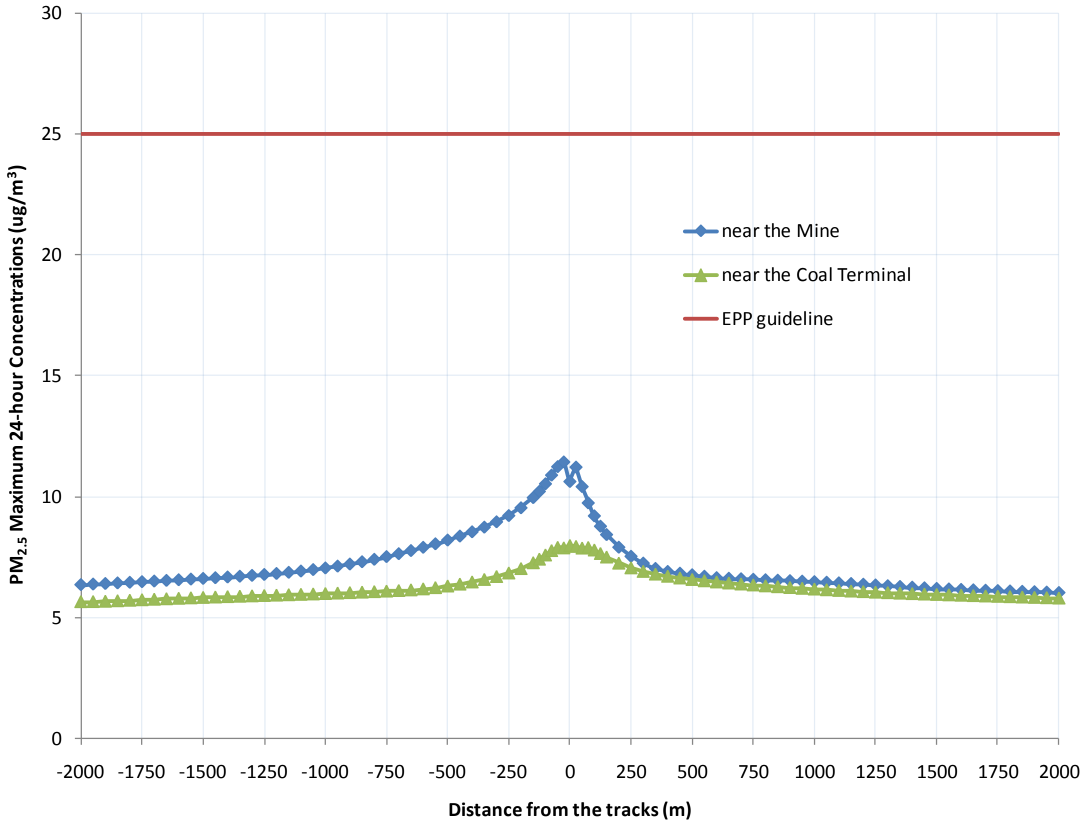
The short term dust emissions associated with construction have not been quantified. These emissions are to be effectively managed through a dust management plan for construction.



* including a background level of 26 µg/m³

Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
PM_{10}	Mine site	**Multiple**	Maximum	24-Hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
AUSPLUME v6	µg/m³	EPP =50 µg/m3 (shown as a red line)	TAPM Generated	L Fitzmaurice

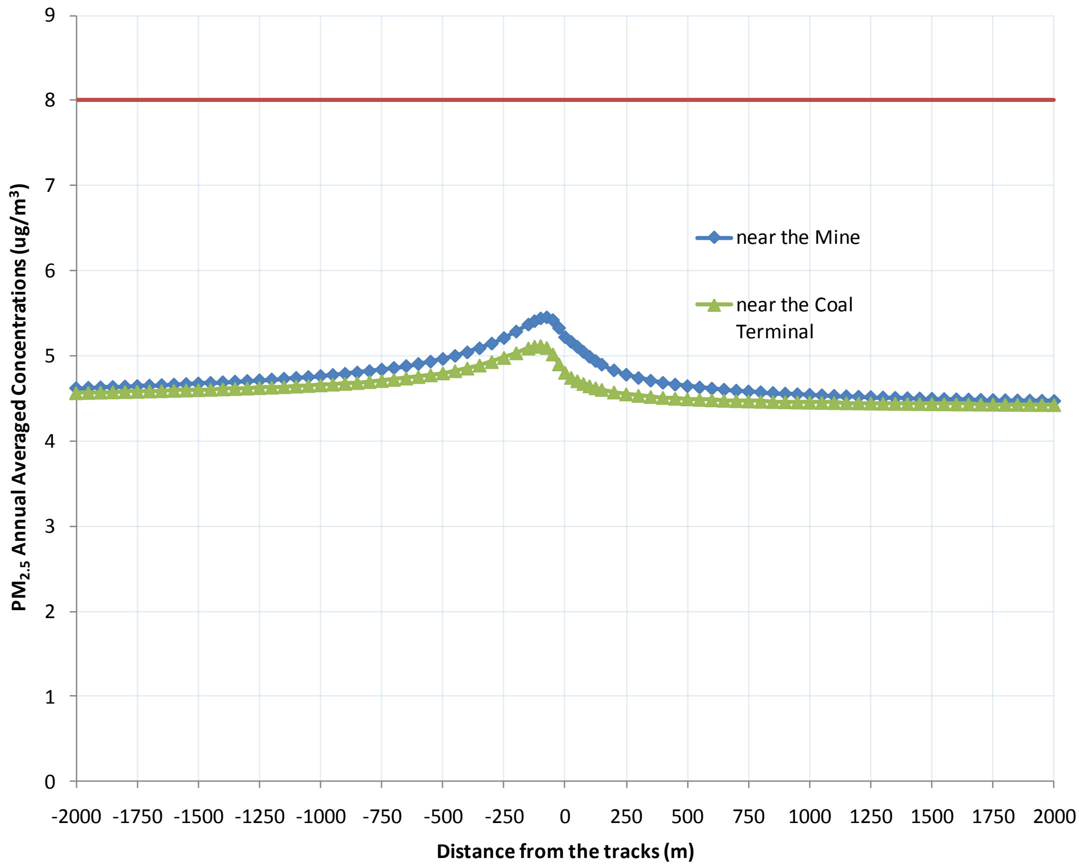
Figure 3.4: Maximum 24-hour Averaged PM_{10} Concentration



* including a background level of 5.2 µg/m^3

Species: PM$_{2.5}$	**Location:** Mine	**Scenario:** Train heading ***NORTH***	**Percentile:** Maximum	**Averaging Time:** 24-Hour
Model Used: AUSPLUME v6	**Units:** µg/m^3	**Guideline:** EPP =25 µg/m3 (shown as a red line)	**Met Data:** TAPM Generated	**Plot:** L Fitzmaurice

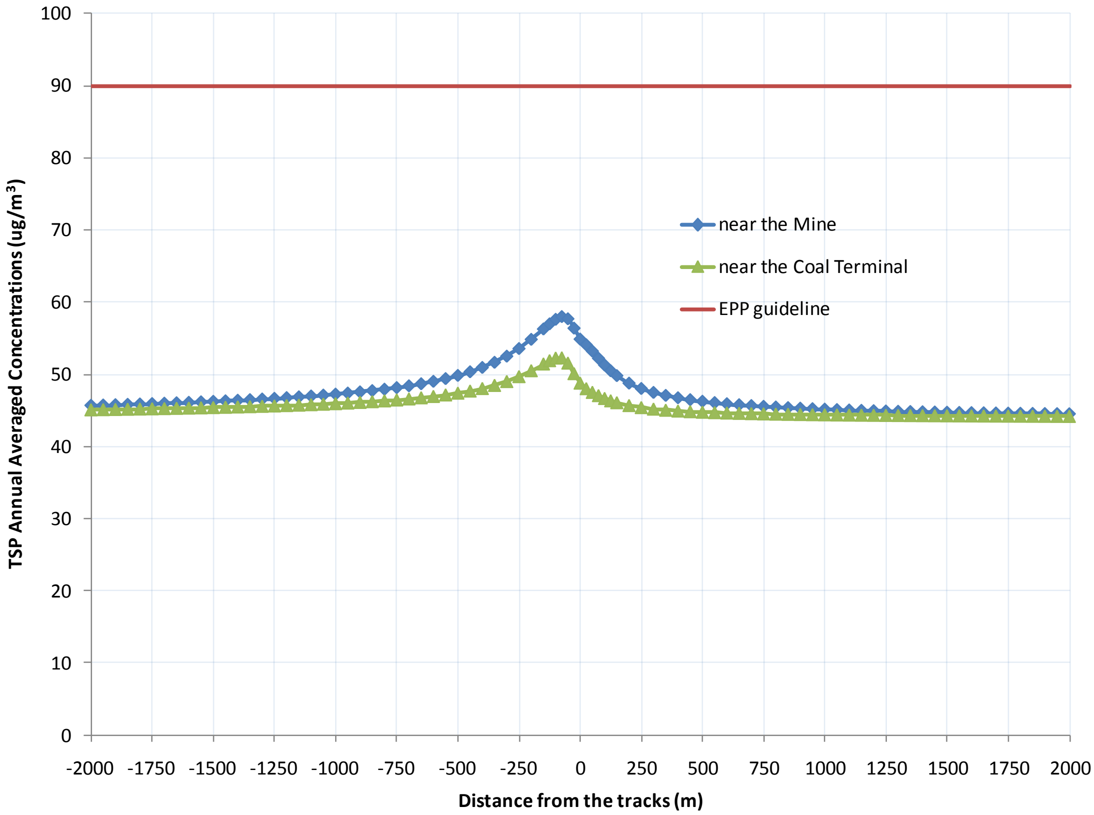
Figure 3.5: Maximum 24-hour Averaged PM$_{2.5}$ Concentration



* including a background level of 4.4 µg/m^3

Species: $PM_{2.5}$	**Location:** Mine	**Scenario:** Train heading ***NORTH***	**Percentile:** Maximum	**Averaging Time:** Annual
Model Used: AUSPLUME v6	**Units:** µg/m^3	**Guideline:** EPP =8 µg/m3 (shown as a red line)	**Met Data:** TAPM Generated	**Plot:** M Fogarty

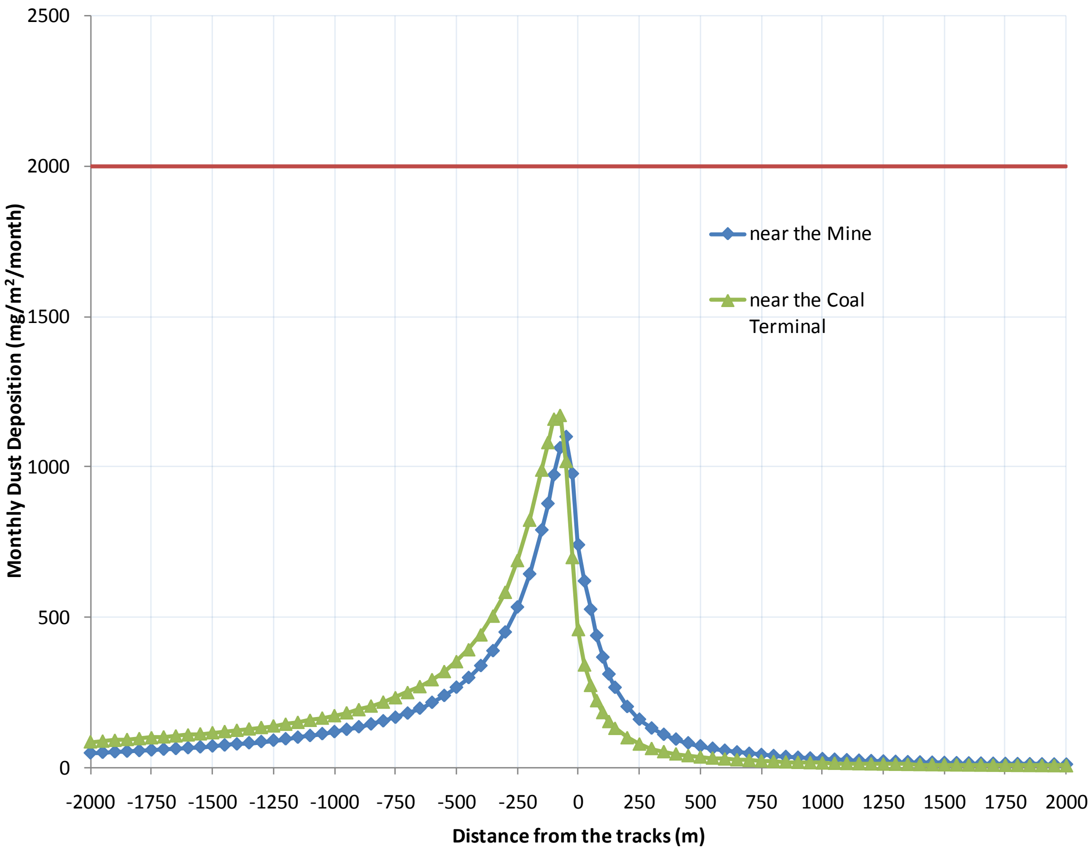
Figure 3.6: Annual Averaged $PM_{2.5}$ Concentration



* including a background level of 44 µg/m^3

Species: TSP	**Location:** Mine	**Scenario:** Train heading ***NORTH***	**Percentile:** Maximum	**Averaging Time:** Annual
Model Used: AUSPLUME v6	**Units:** µg/m^3	**Guideline:** EPP =90 µg/m3 (shown as a red line)	**Met Data:** TAPM Generated	**Plot:** L Fitzmaurice

Figure 3.7: Annual Averaged TSP Concentration



Species: TSP	**Location:** Mine	**Scenario:** Train heading ***NORTH***	**Percentile:** Maximum	**Averaging Time:** 30-Day
Model Used: AUSPLUME v6	**Units:** $mg/m^2/month$	**Guideline:** EPP =2000 $mg/m^2/month$ (shown as a red line)	**Met Data:** TAPM Generated	**Plot:** L Fitzmaurice

Figure 3.8: 30-day Total Deposited Dust

4 AIR QUALITY ASSESSMENT – THE COAL TERMINAL

4.1 Introduction

4.1.1 Study Area

The proposed China First Coal Terminal (CFCT) is located at Abbot Point, to the north of the existing Abbot Point Coal Terminal. This Abbot Point Coal Terminal has been proposed to expand to increase the coal handling capacity to 110 Mtpa (Abbot Point X110, in short). Details of the expansion are available in its EIS document.

Figure 4.1 shows the study area for the CFCT air quality assessment. On this map, two sensitive receptor locations are shown, labelled as Receptors 1 and 2. Receptor 1 is about 1 km to the east of the China First Stock Yards, and Receptor 2 is located about 4km to the south west.

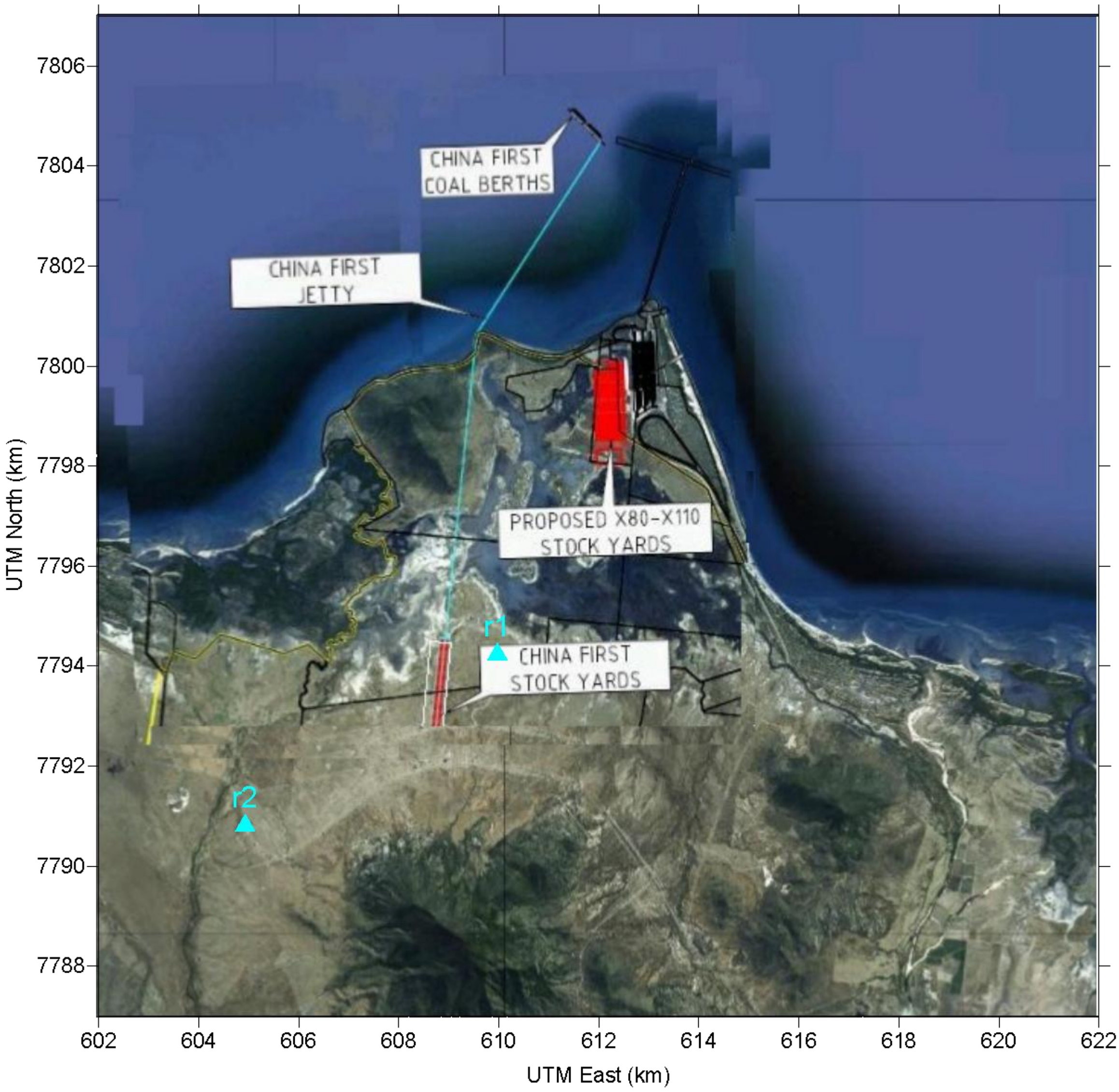


Figure 4.1 Study Area of the China First Coal Terminal at Abbot Point

4.1.2 Purpose of Study

The purpose of study is to assess potential air quality impacts from the proposed CFCT, in the context of environmental values as defined by the *EP Act* and *EPP (Air)*. Ambient air quality conditions in terms of particulate matter and any other major constituents of the air environment that may be affected by the proposal are to be assessed for any sensitive localities such as residences. The assessment should include cumulative impacts from any existing emission sources and other proposed developments.

4.1.3 Scope of Work

To assess the impact of air emissions from the proposed coal terminal, the scope of work includes:

- estimating air emissions within the project area expected during construction and operation;
- describing project features to suppress or minimise emissions;
- identifying climatic patterns that could affect dust generation and movement;
- predicting changes to existing air quality from operational activities including processing, stockpiling and loading of coal, transport of coal, vehicle emissions and shipping; and
- assessing cumulative impacts within the air shed.

4.1.4 Legislative Framework

Refer to section 2.1.4.

4.2 Methodology

4.2.1 Sources of Emissions

4.2.1.1 Construction

Air emissions during the construction phase of the CFCT will be primarily dust related, with some minor emissions of combustion pollutants such as nitrogen oxides and volatile organic compounds due to diesel and petrol vehicles and construction equipment.

The sources of dust emission include:

- clearing of vegetation and topsoil;
- excavation and transport of earth material;
- vehicles travelling on unpaved roads; and
- vehicles and machinery exhausts.

The impacts of construction activities will be managed through the Environmental Management Plan. This will include measures to minimise dust emissions and procedures that will be implemented to mitigate off-site impacts.

4.2.1.2 Operation

Activities that generate dust during the operational phase of the CFCT include the transportation of coal around the coal terminal and coal stockpiling within the coal stockpiling area.

Dust emission sources from coal transportation include:

- wind erosion from incoming coal wagons;
- coal unloading at the rail receiving point;
- wharf loading activities using a travelling ship loader; and
- the movement of coal via conveyor belts.

Dust emission sources from stockpiling include:

- stacking of coal;
- reclaiming of coal; and
- wind erosion from standing coal stockpiles.

4.2.2 Pollutants of Interest

The pollutants of interest in this assessment are:

- particulate matter less than 2.5 microns ($PM_{2.5}$);
- particulate matter less than 10 microns (PM_{10}); and
- total suspended particles (TSP).

In addition to predicting ambient levels of particulate matter specified in the bullet points above, dust deposition will also be assessed.

Nitrogen oxides and organic compounds, which will be emitted from vehicles and machinery using diesel and petrol fuel, are not of concern because their emissions are expected to be very low.

4.2.3 Emission Estimate Methods

The emissions of TSP and PM_{10} at CFCT during operation are estimated based on the *NPI EET Manual for Mining v2.3, 2001*.

The NPI Manual does not have an emission factor for $PM_{2.5}$. In the absence of this data, emissions of $PM_{2.5}$ are assumed to be 12.5% of PM_{10} emissions (See section 2.2.3 for justification of the use of this ratio).

Emission calculation methods are provided below for the major dust generating activities at the CFCT:

- wind erosion from incoming coal wagons:
  - the emissions are assumed from stationary coal wagons as a result of wind erosion from exposed area, using the NPI default emission factor;
- coal unloading at rail receiving points:
  - use NPI emission estimate method for miscellaneous transfer point;
- wharf loading activities using a travelling ship loader:
  - use NPI emissions for miscellaneous transfer point;
- the movement of coal via conveyor belts (due to wind erosion):

- emissions are treated as negligible as the conveyor belts have small surface areas and will be covered;
- stacking and reclaiming of coal:
  - use NPI emissions for miscellaneous transfer point; and
- wind erosion from standing coal stockpiles:
  - use NPI default emission factors for wind erosion from exposed area.

Detailed emission estimate formulas used for this project are provided in Appendix A.2.

4.2.4 Summary of Emissions

The emissions from the CFCT during operation are provided in Table 4.1.

Table 4.1 Dust Emissions from the China First Coal Terminal

Sources	Emissions kg/annum (percentage)					
	TSP		PM_{10}		$PM_{2.5}$	
Rail receiving points	5,212	(4%)	2,465	(8%)	308	(8%)
Conveyor Belt Transfer stations (3)	15,636	(13%)	7,395	(24%)	924	(24%)
Ship loading	5,212	(4%)	2,465	(8%)	308	(8%)
Reclaiming of coal at Stockpile	8,687	(7%)	4,109	(13%)	514	(13%)
Stacking of coal at Stockpile	8,687	(7%)	4,109	(13%)	514	(13%)
Incoming coal wagons	3,180	(3%)	1,590	(5%)	199	(5%)
Stockpiles Wind Erosion	70,052	(60%)	9,247	(29%)	1,156	(29%)
Total	**116,665**	**(100%)**	**31,380**	**(100%)**	**3,922**	**(100%)**

Values in parenthesis indicate percentage contribution of each source to the total emission.

When estimating the Emission from CFCT, the following emission control measures as provided by the Waratah Coal have been used:

- enclosure for rail receiving facility (70% dust control);
- cover for conveyor belts (the emissions are assume to be negligible);
- enclosure for ship loading facility (70% dust control);
- water spray applied at stockyard (50% dust control); and
- cover for conveyor belt transfer points (70% dust control).

To assess the cumulative impacts, the emissions from Abbot Point Coal Terminal X110 Expansion are also modelled, with the total emissions as 1,158,317 kg per annum for TSP and 606,753 for PM_{10}, and 87,985 for $PM_{2.5}$ (Katestone Environment 2009). These emissions are significantly higher than the proposed emissions from CFCT.

4.2.5 Air Quality Dispersion Modelling

Air quality dispersion modelling has been performed to quantify the ground-level concentrations and dust deposition at gridded and discrete locations surrounding the emission sources. This modelling assessment has used a suite of modelling tools. First, TAPM (Hurley, 2008a; Hurley et al., 2008; Hurley, 2008b) and CALMET (Scire *et al*., 2000a) were used in combination to generate three-dimensional meteorological fields for a representative year; and then CALPUFF (Scire *et al.,* 2000b) was used to simulate the atmospheric transport, dilution and deposition of emissions from the sources. In 1999 PAE (now PAEHolmes) devised this suit of dispersion modelling methodology, which has since been used widely throughout Australia and elsewhere. Technical descriptions of these methods are provided in Appendix B.

In this assessment, the representative year for meteorology is 2008. The most recent version of TAPM (version 4) and CALMET/CALPUFF (version 6.0) has been used.

TAPM was configured as follows:

- grid points of 25 X 25 in horizontal directions, with an outer grid resolution of 20 km, and nested grid resolutions of 7.2 km, 2.4 km and 0.8 km;
- 25 vertical grid levels;
- grid centred near the project site at -19deg-55.5min latitude, 148deg4min longitude; and
- no meteorological assimilation was included in the modelling due to lack of such data for the area.

CALMET was configured as follows:

- surface and upper air data were derived from TAPM was used to drive CALMET run, with no extra data assimilation;
- horizontal grids of 70 x 70 were used, with a resolution of 300 m;
- raw terrain and land use data of approximately 250 m in resolution were used, but modelled as 300 m in resolution; and
- ten vertical grid levels were used, with finer resolution near the surface to resolve the fine boundary structures (vertical grid face levels are 0, 20, 40, 60, 90, 120, 280, 720, 1250, 2500, 3450 m).

To model the air dispersion of pollution sources, CALPUFF was set up as follows:

- CALMET output was used as the input for meteorological conditions;
- computational grids were the same as the CALMET run;
- no chemical transformation was modelled;
- plume depletion was excluded in order to present conservative (i.e. worst case) predicted dust concentrations;
- for deposition calculation, total TSP was divided into emissions from different particle size bins;
- an area source was used for modelling wind erosion from stockpiles;
- line source was used to model wind erosion from stationary train wagons (with extremely small buoyancy factor used to negate the CALPUFF model design limitations for line sources);
- volume sources were used for all other emissions; and
- gridded receptors were set as the same as computational grids, and two discrete receptors at sensitive locations were included.

4.2.6 Cumulative Impacts Assessment

In order to assessment the cumulative impacts in the study area, the air quality impacts due to the emission sources from the proposed Abbot Point X110 were also modelled. The emissions data were extracted from the published Abbot Point X110 EIS. The combined modelling predictions from both impacts of CFCT and Abbot Point X110 for the same meteorological year were then added to the background air quality estimates (presented later in Section 4.3.2) to form the cumulative impacts.

Note that there is also another proposed project in the study area: the Abbot Point Multiple Cargo Facilities (MCF). As MCF cannot coexist with CFCT (they are proposed to be constructed in the same area) the MCF impacts have not been included in the cumulative impact assessment.

4.3 Existing Environment

4.3.1 Meteorology

The climate of the study area has a tropical climate, with a hot, wet summer, and a mild, dry winter. Summer has a monsoonal weather, influenced by tropical cyclones and lows, which may bring substantial rainfall in the coastal areas. A climate summary relevant to air quality is provided below. For a detailed description of climate at the project area, please refer Appendix C.3.

Based on meteorological data collected twice a day at 9am and 3pm at Bowen Airport (a BOM weather station), the climate for the project area can be summarised as below.

- The wind direction is predominant from the east, south east and north east, influenced by the trade wind (see wind rose plots in Appendix C.3). The 9am wind roses show that winds are predominately moderate to strong from the south-east, with calm conditions occurring for 7% of the monitored period. The 3pm wind is stronger, predominately from the east, with wind from the north, north-east and south-east also common. Calm conditions occur for 0.5% of the time at 3pm.
- The rainfall is the highest during summer and lowest during winter, with a total annual rainfall of approximately 850 mm.
- It is warm year-round, with mean daily maximum temperature ranging from 32°C during summer to 25°C during winter. Mean minimum temperatures range from 24°C during summer to 14°C during winter.
- Relative humidity in the study area is typically higher during the summer and autumn months and lower during the winter and spring months.

The temperature inversion strength and frequency have been estimated based on TAPM meteorological modelling output for the year 2008 for the study area. Analysis of the inversions (see Table 4.2) show that inversions occur for 49% of the time with strong inversions occurring for 1% of year.

Table 4.2 Temperature Inversion at Night Time - Port (2008)

Night Time Inversion Strength	Percentage of occurrence (%)	Number of hours
>3ºC per 100 m	1	63
>2ºC per 100 m	2	210
>1ºC per 100 m	12	1056
>0ºC per 100 m	34	2974

4.3.2 Existing Air Quality

4.3.2.1 Existing Emission Sources

The major existing dust emission source in the study area is the existing Abbot Point Coal Terminal, currently with a coal handling capacity of 50 Mtpa. The proposed CFCT is located to the north of APCT. In addition, existing dust sources also include those typical for a rural area: the naturally blown dust from the landscape, potential agricultural burning, natural bush fires, and biogenic emissions, and sea water sprays for a coastal area.

4.3.2.2 Background Air Quality

Background air quality generally refers to the current air quality environment in the project area. However, for this EIS assessment of the CFCT, it is best to explicitly model the impacts of both the APCT and the proposed CFCT, and treat the background air quality as the air quality without both APCT and the proposed CFCT.

As no regulatory ambient air quality monitoring stations are located in the vicinity of CFCT, air quality monitoring data from West Mackay, which is the nearest DERM site and located approximately 180 km south of Abbot Point on the coast, have been used to represent the background dust levels for the study area at Abbot Point. It is a very conservative approach as West Mackay is located in a light industrial area, often with observed high dust levels attributed to impacts from local industries.

Summaries of West Mackay air quality data are presented in Section 2.3.2.2.

For the purposes of this EIS assessment and considering the predominantly rural environment within the study area, the estimated background levels of dust without the influence from Abbot Point Coal Terminal are:

- 26 µg/m³ for 24-hour average PM_{10} levels (70th percentile of 24-hour concentrations, at West Mackay during 2006-2009);
- 22 µg/m³ for 24-hour average PM_{10} levels (annual average concentrations, at West Mackay during 2006-2009);
- 5.2 µg/m³ for 24-hour average $PM_{2.5}$ levels (20% of PM_{10} values, based on Midwest Research Institute, 2006);
- 4.4 µg/m³ for annual average $PM_{2.5}$ levels (20% of PM_{10} values, based on Midwest Research Institute, 2006); and
- 44 µg/m³ for annual average TSP levels (twice of PM_{10} values, based on Midwest Research Institute, 2006).

In Queensland a conservative approach to estimating background 24-hour averaging levels has typically been adopted where a single value corresponding to the 95th percentile of the data. For the assessment of CFCT, the 70th percentile recommended by Victoria EPA (Victoria Government, 2001) was used because the 95th percentile of West Mackay monitoring data would give realistically high background dust levels for Abbot Point.

The use of 20% of PM_{10} to estimate $PM_{2.5}$ background concentrations is based on Midwest Research Institute (2006), in which the recommended ratio of $PM_{2.5}$ to PM_{10} is 0.2 for agriculture activities, which is applicable to the Abbot Point where terrestrial wind erosion is presumably the major source of background dust emissions.

There are no known measurements of TSP in the region. AP-42 and NPI show that for dust emitted from terrestrial wind erosion, the ratio of PM_{10} to TSP is about 0.5. This value was used to derive the background TSP level from PM_{10} value.

4.4 Potential Impacts

4.4.1 Construction

The air quality impacts during the construction phase of the coal terminal will be primarily dust related, with some minor impacts related to nitrogen oxides and volatile organic compounds (by-product of combustion processes, such as onsite vehicles and construction equipment that use petrol or diesel fuel). These impacts are not modelled through air dispersion modelling due to the short duration and variable nature of the emission sources. Rather, they will be managed through an Environmental Management Plan. This will include measures to minimise dust emissions and procedures that will be implemented to mitigate off-site impacts.

4.4.2 Operation

The emissions during the operation phase of the project, as summarised in Section 4.2.4, have been modelled with CALPUFF. The predicted ground-level concentrations and dust deposition are analysed and presented in this section, in the context of relevant regulatory air quality objectives (refer to Section 2.1.4).

Due to the conservative estimates of background levels (refer to Section 4.3.2), the conservative estimates in dust emissions, and the uncertainties in meteorology and air quality modelling (refer to Section 4.2.5), the predicted ground-level concentrations and dust deposition values should not be interpreted as the exact impacts in the future. With potential significant over-prediction due to conservatism in the assessment, the modelling results should be used as an approximate tool at the EIS stage to assess the potential air quality impacts in the region.

4.4.2.1 At Sensitive Receptors

Two sensitive receptors have been identified in the vicinity of CFCT. Their locations are shown in Figure 4.1. The predicted ground-level dust concentrations and deposition at these receptors are summarised in Table 4.3. It shows that

- the cumulative impacts are well below the *EPP (Air)* objectives for TSP and $PM_{2.5}$;
- for PM_{10}, the 24-hour *EPP (Air)* objective of 50 µg/m³ is exceeded at Receptor 1, which is a residence in close proximity to the proposed CFCT stock stockyards; and
- the dust deposition is far below the recommended guideline of 2 g/m^2/month.

Note that even without the impacts from the proposed CFCT, the predicted PM_{10} 24-hour concentrations at Receptor 1 still exceeds the *EPP (Air)* guideline of 50 µg/m³, with a predicted value of 51.0 µg/m³, in which 35.0 µg/m³ is the impact from Abbot Point X110 and 26 µg/m³ is the background level.

Hence, to bring the concentration at the Receptor 1 to below guideline values would require a joint effort from both the proposed CFCT and Abbot Point X110 projects.

Table 4.3 Predicted Air Quality Impacts at Sensitive Receptor near the China First Coal Terminal During Operation

Dust Group	Sources	Receptor #1	Receptor #2	Objectives
PM_{10} 24-hour Max (µg/m³)	Project[a] Alone	17.91	5.34	50, *EPP (Air)*
	Project + X110	35.02	15.06	
	Cumulative Impacts	61.02	41.06	
$PM_{2.5}$ 24-hour Max (µg/m³)	Project Alone	2.24	0.67	25, *EPP (Air)*
	Project + X110	4.38	1.88	
	Cumulative Impacts	9.58	7.08	
$PM_{2.5}$ Annual (µg/m³)	Project Alone	0.03	0.07	8, *EPP (Air)*
	Project + X110	0.24	0.14	
	Cumulative Impacts	4.64	4.54	
TSP Annual (µg/m³)	Project Alone	0.50	1.08	90, *EPP (Air)*
	Project + X110	3.62	2.13	
	Cumulative Impacts	47.62	46.13	
Dust Deposition Monthly Max (g/m²/month)	Project Alone	0.01	0.03	2
	Project + X110	0.06	0.05	

[a] "Project" in this table means the CFCT project.

4.4.2.2 Contour Plots

The predicted impacts over the modelling domain are presented in this section as contour plots, based on predictions at modelling grid points. In additional to the predictions from the CFCT impacts only, the cumulative impacts that include the combined impacts from CFCT, Abbot Point X110, and the estimated background levels are also presented.

PM_{10}

Figure 4.2 and Figure 4.3 present the ground-level maximum 24-hour PM_{10} concentrations, with Figure 4.2 showing results with sources from the CFCT project only and Figure 4.3 showing results of cumulative impacts. With only CFCT impacts included, the predicted 24-hour PM_{10} concentrations only exceed the *EPP (Air)* guideline of 50 µg/m³ over a small area within the China First Stock Yards. Considering cumulative impacts, there is a much larger area of exceedances, due to the inclusion of the rather conservative background level of 26 µg/m³ and much higher emissions from Abbot Point X110.

$PM_{2.5}$

Figure 4.4 and Figure 4.5 present the ground-level maximum 24-hour $PM_{2.5}$ concentrations. The contour plots show that with impacts from CFCT only, 24-hour $PM_{2.5}$ concentrations are well below the *EPP (Air)* guideline of 25 µg/m³, with highest impacts outside China First Stock Yards being approximately 5 µg/m³. Considering cumulative impacts, only areas very close to the Abbot Point X110 facilities exceed the *EPP (Air)* guideline for 24-hour $PM_{2.5}$.

Figure 4.6 and Figure 4.7 present the ground-level annual average $PM_{2.5}$ concentrations. The contour plots show that with the impacts from CFCT only, annual average $PM_{2.5}$ concentrations are below the *EPP (Air)* guideline of 8 µg/m³, with the highest impacts of about 1 µg/m³ occurring outside China First Stock Yards. Considering cumulative impacts, only areas very close to the Abbot Point X110 facilities exceed the *EPP (Air)* guideline for annual average $PM_{2.5}$.

TSP

Figure 4.8 and Figure 4.9 present the ground-level annual average TSP concentrations. The contours show that with the impacts from CFCT only, annual average TSP concentrations are well below the *EPP (Air)* guideline of 90 µg/m³. With cumulative impacts, only areas within the China First Stock Yard and several Abbot Point X110 facilities exceed the *EPP (Air)* guideline.

Dust Deposition

Figure 4.10 presents the predicted maximum monthly dust deposit, due to the impacts from both CFCT and Abbot Point X110 projects. The predictions are well below the recommended guideline of 2 g/m^2/month in the study area, except for areas within the China First Stock Yard and several Abbot Point X110 facilities.

4.4.2.3 Conclusions

Based on the results of dispersion modelling predictions, CFCT impacts alone will not lead to any air quality exceedances of relevant dust related air quality guidelines in Queensland.

However, when combined the impacts from Abbot Point X110 (having much higher dust emissions) and conservatively estimated background levels, the guidelines for PM_{10}, $PM_{2.5}$, TSP and dust deposition are exceeded. For $PM_{2.5}$, TSP and dust deposition, the exceedances are only limited to the areas within the dust generating facilities such as stockyards, jetty, and coal transfer points.

However, for PM_{10}, with the cumulative impacts, 24-hour *EPP (Air)* guideline of 50 µg/m³ is predicted to be exceeded over a broad area at Abbot Point. This prediction may be exaggerated due to the conservative estimates of background PM_{10} level (26 µg/m³) based on DERM's West Mackay air quality data and other conservative approaches used in the assessment.

4.5 Mitigation and management

Waratah Coal is committed to develop and implement an Environmental Management Plan. The Plan will include measures to minimise dust emissions during both the construction and operational phases of CFCT.

4.5.1 Construction

Dust emissions during construction will be mitigated and managed by implementing the following strategies:

- water sprays on unsealed roads;
- restricting vehicle speeds on unsealed haul roads to reduce dust generation;
- minimise haul distances between construction sites to spoil stockpiles;
- treat or cover stockpiled material to prevent wind erosion;
- regularly clean machinery and vehicle tyres to prevent wheel entrained dust emissions;
- route roads away from sensitive receptors wherever practical;
- minimise topsoil and vegetation removal, and revegetate disturbed areas as soon as possible; and
- ongoing visual monitoring of dust on a daily basis, with ramping down of activities in the instance of high dust emissions.

These strategies have been adapted from the dust management plan for the railway section of this project (refer to Section 3.5.1), and will be incorporated into the China First Project's Environment Management Plan.

4.5.2 Operation

Dust mitigation for the operation of CFCT involves engineering and dust suppression measures and management practices to ensure adequate management of air quality in the vicinity of the coal terminal.

The following dust control measures are included in the design of the CFCT, and have been considered when assessing the impacts from the project:

- providing cover for dust generating activities, such as rail receiving, conveyor belts and transfer points, and ship loading facility;
- using water spray at coal stockpiles; and
- minimising exposed area to reduce wind erosion.

In addition, the following measures are recommended to further reduce the impact of dust emissions from the CFCT:

- ongoing monitoring of coal moisture contents, which may be used to trigger water sprays;
- installing and maintaining ambient dust monitors near to Receptors 1 and 2, as well as a meteorological monitor to provide a direct measure of weather conditions that are associated with dusty events; and
- working with the existing Abbot Point Coal Terminal to maintain air quality at Abbot Point.

4.6 Conclusions

4.6.1 Assessment Outcomes

In this air quality impact assessment of China First Coal Terminal, a state-of-art combined meteorological and air dispersion modelling approach has been used to predict dust concentrations and dust deposition in the Abbot Point study area. The dust emissions from CFCT are estimated based on NPI or AP-42 data.

To model cumulative impacts, background dust levels without the impacts of existing Abbot Point Coal Terminal have been estimated based on DERM's West Mackay air quality monitoring data; an over estimation of the background levels is expected as West Mackay is situated within an industrial area. In the cumulative impact assessment, impacts from Abbot Point Coal Terminal X110 expansion proposal have been modelled based on published emission data in its EIS document. The emission from this expansion is many times higher than CFCT. The coal handling capacity (40 Mtpa for CFCT and 110 Mtpa for the Abbot Point X110 expansion) partially explains the differences in emissions. It should be noted that the exposed area for CFCT as provided by Waratah Coal is zero as Waratah Coal will handle one type of coal and the need of exposed area other than stockpiles has not been identified.

Based on interpretations of modelling predictions, CFCT impacts alone will not lead to any air quality exceedances of relevant dust related air quality guidelines in Queensland.

However, when combined the impacts from Abbot Point X110 (having much higher dust emissions) and conservatively estimated background levels, the guidelines for PM_{10}, $PM_{2.5}$, TSP and dust deposition have been exceeded. For $PM_{2.5}$, TSP and dust deposition, the exceedances are only limited to the areas within the dust generating facilities such stockyards, jetty, and coal transfer points.

For PM_{10}, with the cumulative impacts, 24-hour *EPP (Air)* guideline of 50 µg/m³ is predicted to be exceeded over a broad area at Abbot Point. This prediction may be exaggerated due to the conservative estimates of background PM_{10} level (26 µg/m³) based on DERM's West Mackay air quality data and other conservative approaches in the assessment.

4.6.2 Commitments

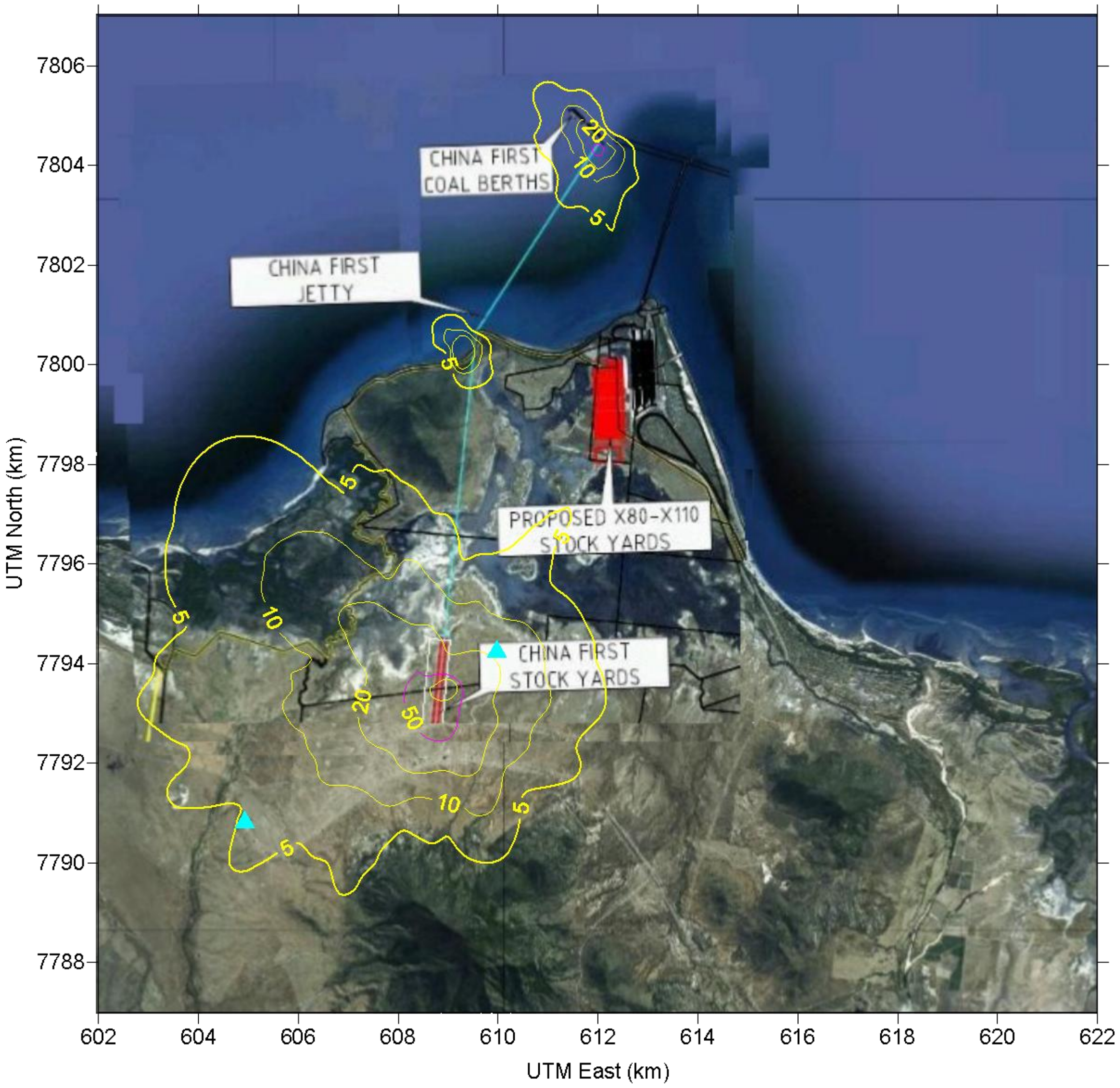
Waratah is committed to apply various control measures to reduce dust emissions during the construction and operation of CFCT.

During the construction phase, dust will be managed through a comprehensive Environmental Management Plan.

During the operation, various dust control measures will be implemented, including but not limited to the following commitments:

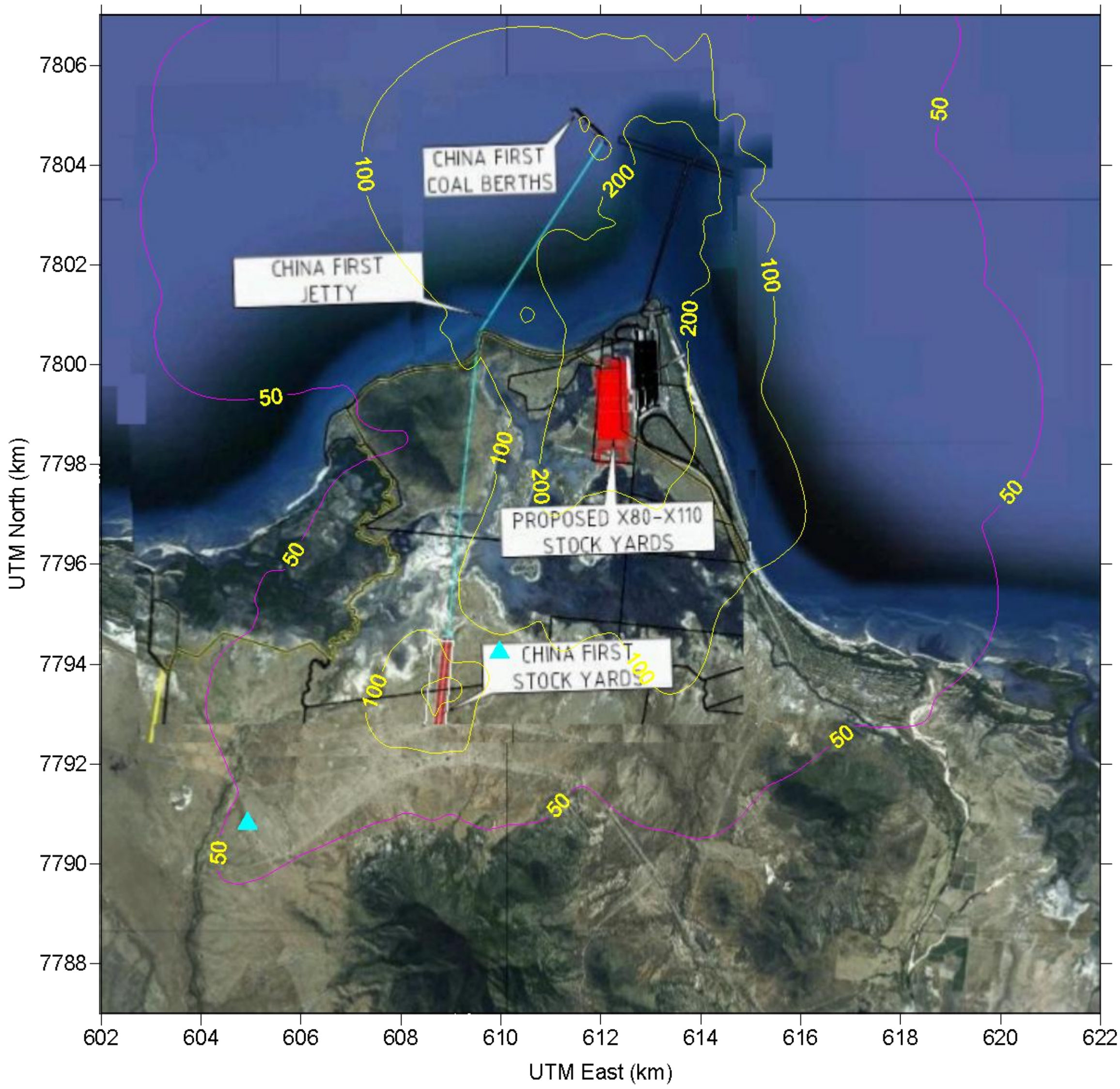
- providing cover for dust generating activities, such as rail receiving, conveyor belts and transfer points, and the ship loading facility;
- using water spray at coal stockpiles;
- minimise exposed areas to reduce wind erosion;
- ongoing monitoring of coal moisture contents, used to trigger the use of water spray to increase moisture of coal when it is below the threshold value;
- installing and maintaining ongoing meteorological and air quality monitors near sensitive receptor locations; and

- collaborating with the existing Abbot Point Coal Terminal to develop further mitigation measures that maintain good air quality at Abbot Point.



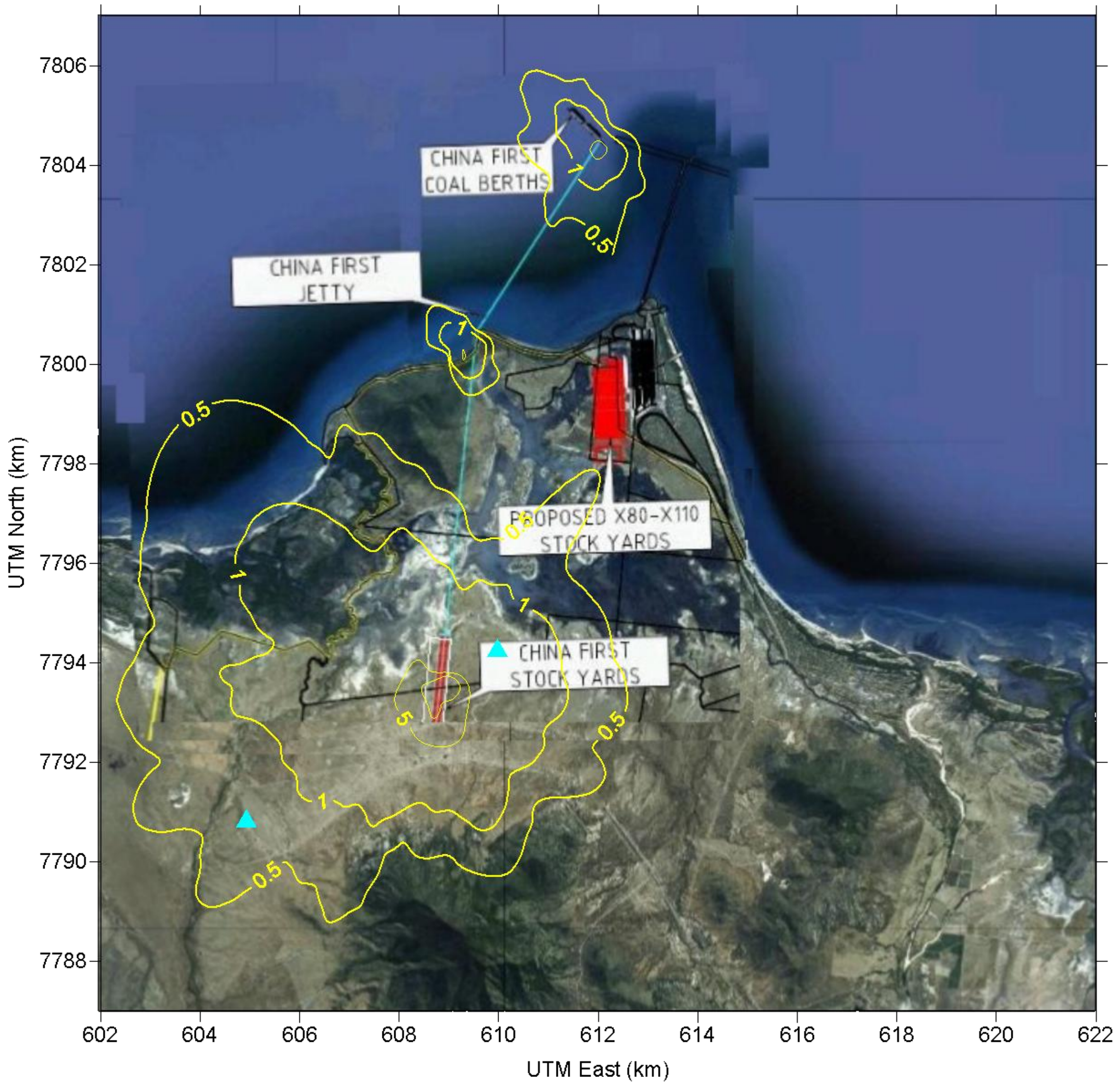
Species: PM$_{10}$	**Location:** Abbot Point	**Scenario:** CFCT only	**Percentile:** Maximum	**Averaging Time:** 24-hour
Model Used: CALPUFF V6	**Units:** µg/m^3	**Guideline:** EPP (Air) = 50 µg/m3	**Met Data:** Combination of TAPM & local observations (2008)	**Plot:** L Fitzmaurice

Figure 4.2: Predicted Maximum 24-hour Ground-level Concentrations of PM$_{10}$ – Impacts from CFCT Only



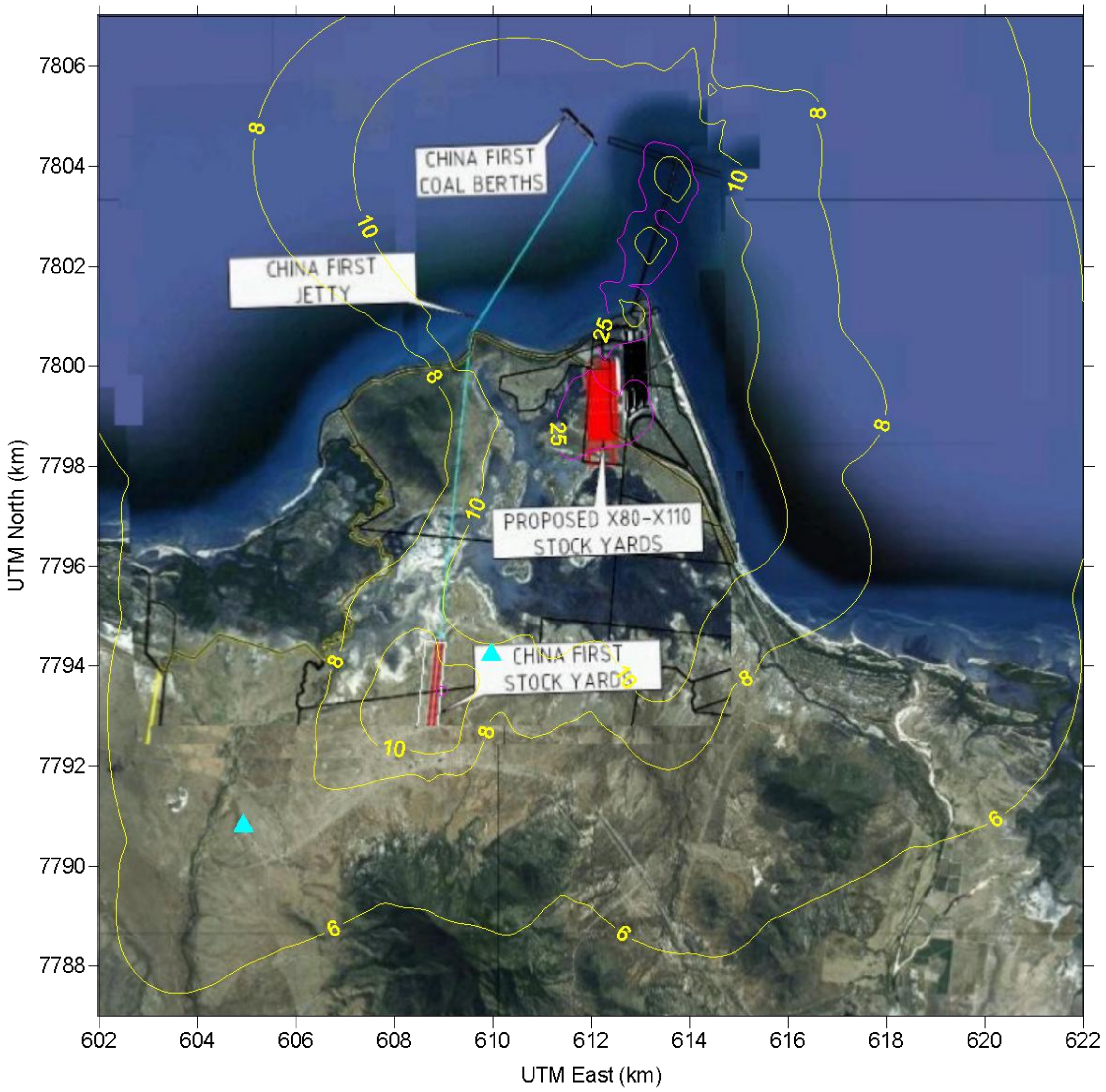
Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Abbot Point	Cumulative	Maximum	24-hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF V6	μg/m^3	EPP (Air) = 50 μg/m3	Combination of TAPM & local observations (2008)	L Fitzmaurice

Figure 4.3: Predicted Maximum 24-hour Ground-level Concentrations of PM_{10} – Cumulative Impacts



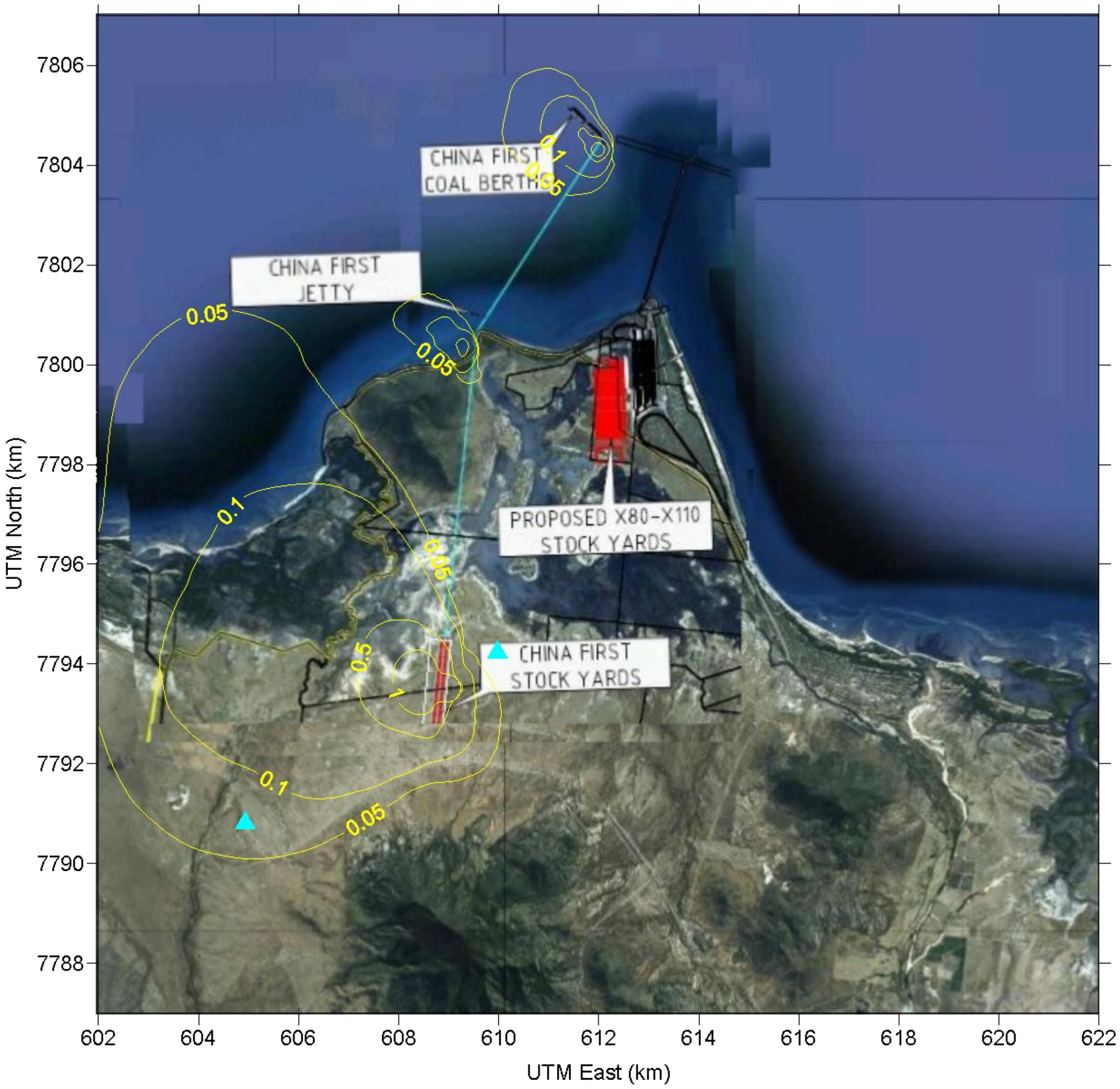
Species: PM2.5	**Location:** Abbot Point	**Scenario:** CFCT only	**Percentile:** Maximum	**Averaging Time:** 24-hour
Model Used: CALPUFF V6	**Units:** µg/m3	**Guideline:** EPP (Air) = 25 µg/m3	**Met Data:** Combination of TAPM & local observations (2008)	**Plot:** L Fitzmaurice

Figure 4.4: Predicted Maximum 24-hour Ground-level Concentrations of $PM_{2.5}$ – Impacts from CFCT Only



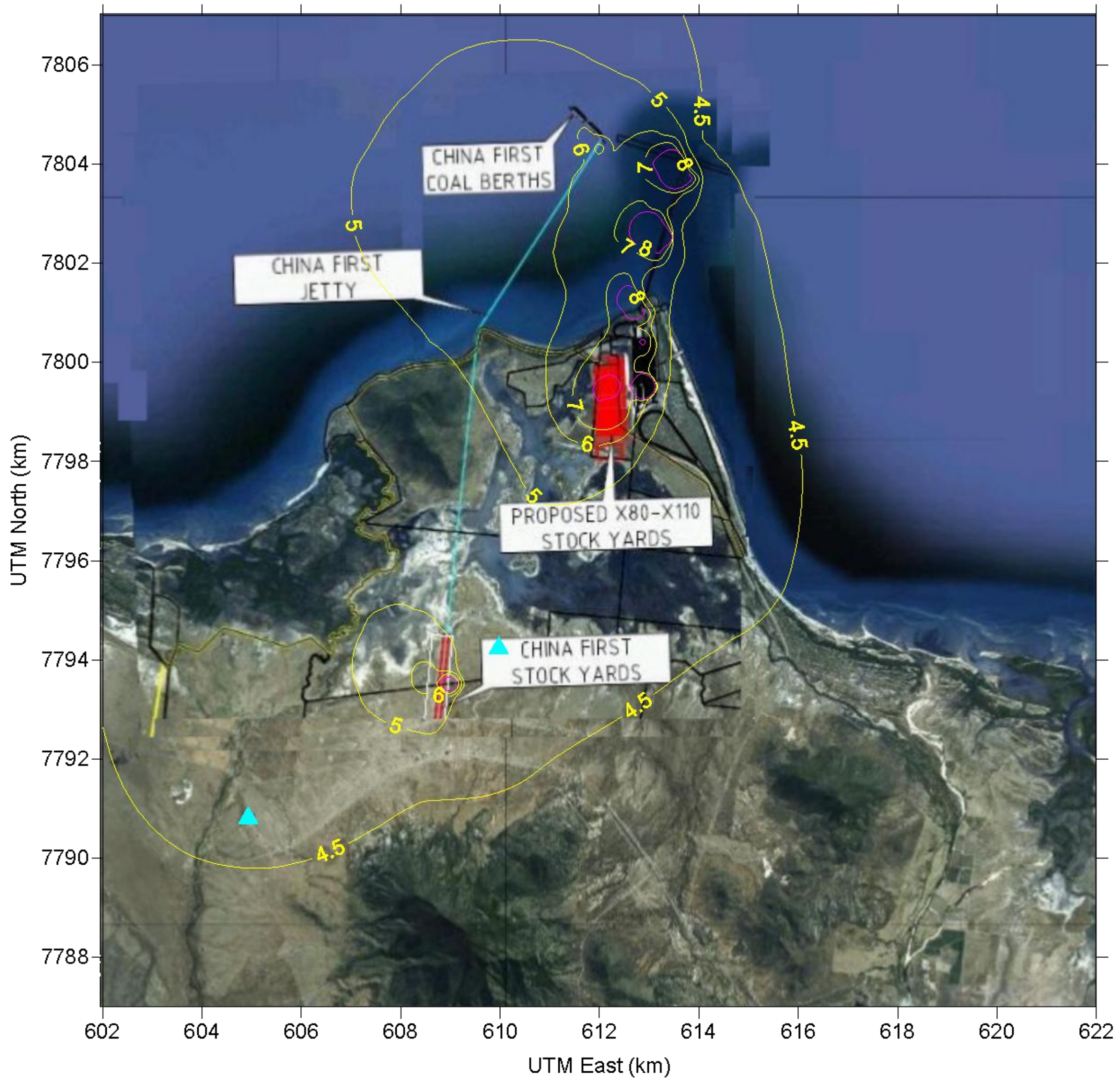
Species: PM$_{2.5}$	Location: Abbot Point	Scenario: Cumulative	Percentile: Maximum	Averaging Time: 24-hour
Model Used: CALPUFF V6	**Units:** µg/m^3	**Guideline:** EPP (Air) = 25 µg/m3	**Met Data:** Combination of TAPM & local observations (2008)	**Plot:** L Fitzmaurice

Figure 4.5: Predicted Maximum 24-hour Ground-level Concentrations of PM$_{2.5}$ – Cumulative Impacts



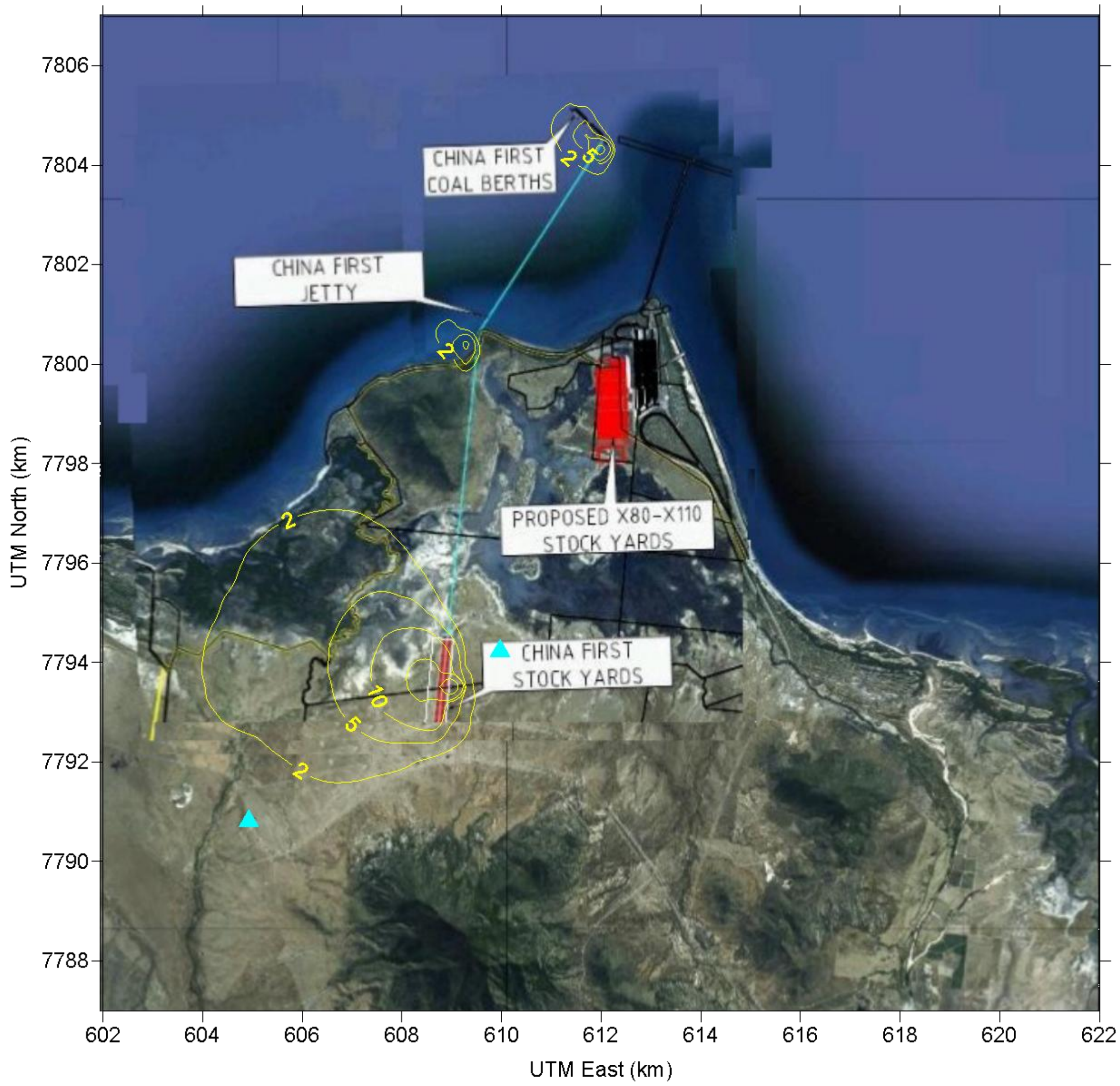
Species: PM$_{2.5}$	**Location:** Abbot Point	**Scenario:** CFCT only	**Percentile:** Not Applicable	**Averaging Time:** Annual
Model Used: CALPUFF V6	**Units:** µg/m^3	**Guideline:** EPP (Air) = 8 µg/m3	**Met Data:** Combination of TAPM & local observations (2008)	**Plot:** L Fitzmaurice

Figure 4.6: Predicted Annual Average Ground-level Concentrations of PM$_{2.5}$ – Impacts from CFCT Only



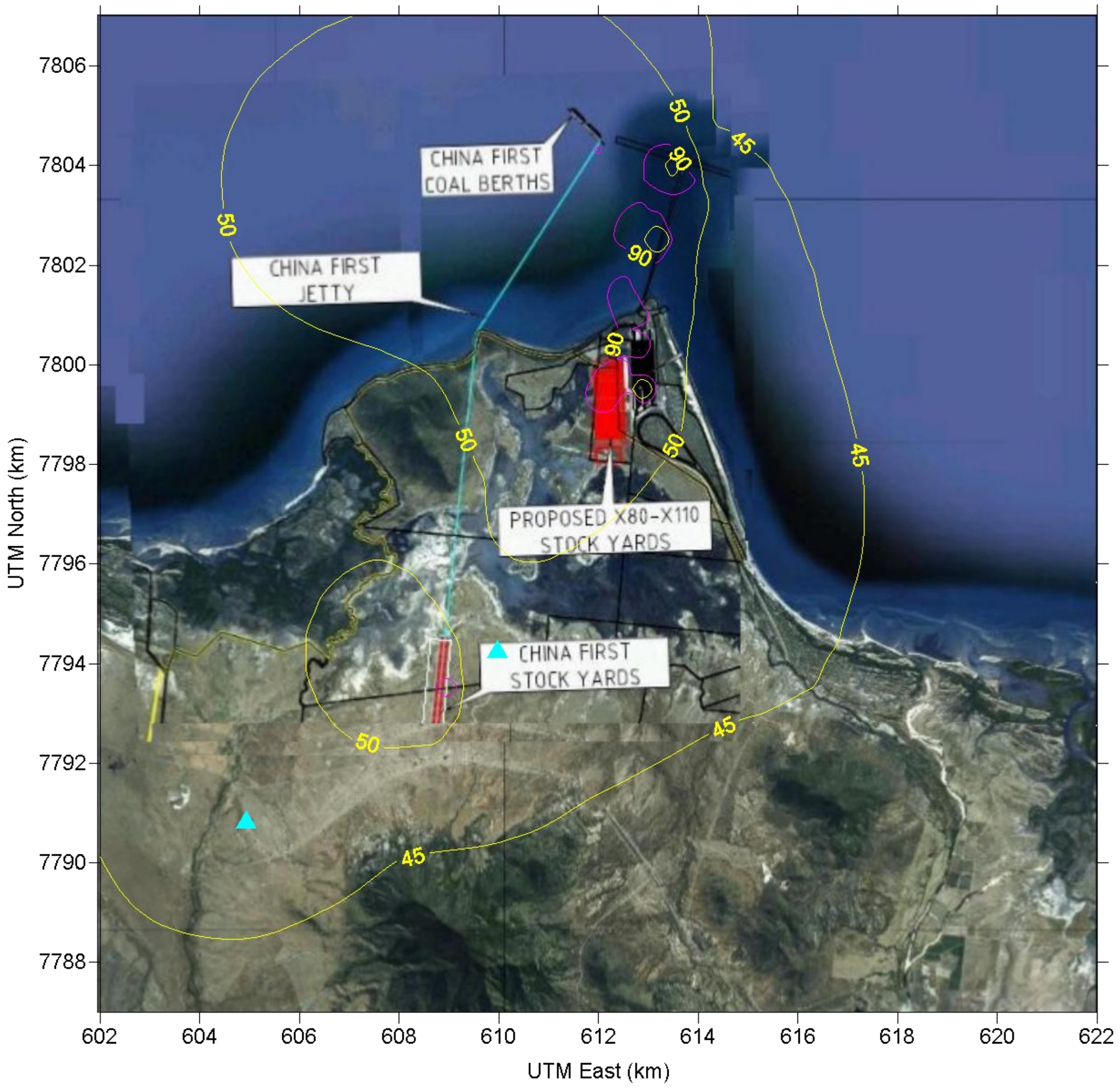
Species:	Location:	Scenario:	Percentile:	Averaging Time:
$PM_{2.5}$	Abbot Point	Cumulative	Not Applicable	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF V6	$\mu g/m^3$	EPP (Air) = 8 µg/m3	Combination of TAPM & local observations (2008)	L Fitzmaurice

Figure 4.7: Predicted Annual Average Ground-level Concentrations of $PM_{2.5}$ – Cumulative Impacts



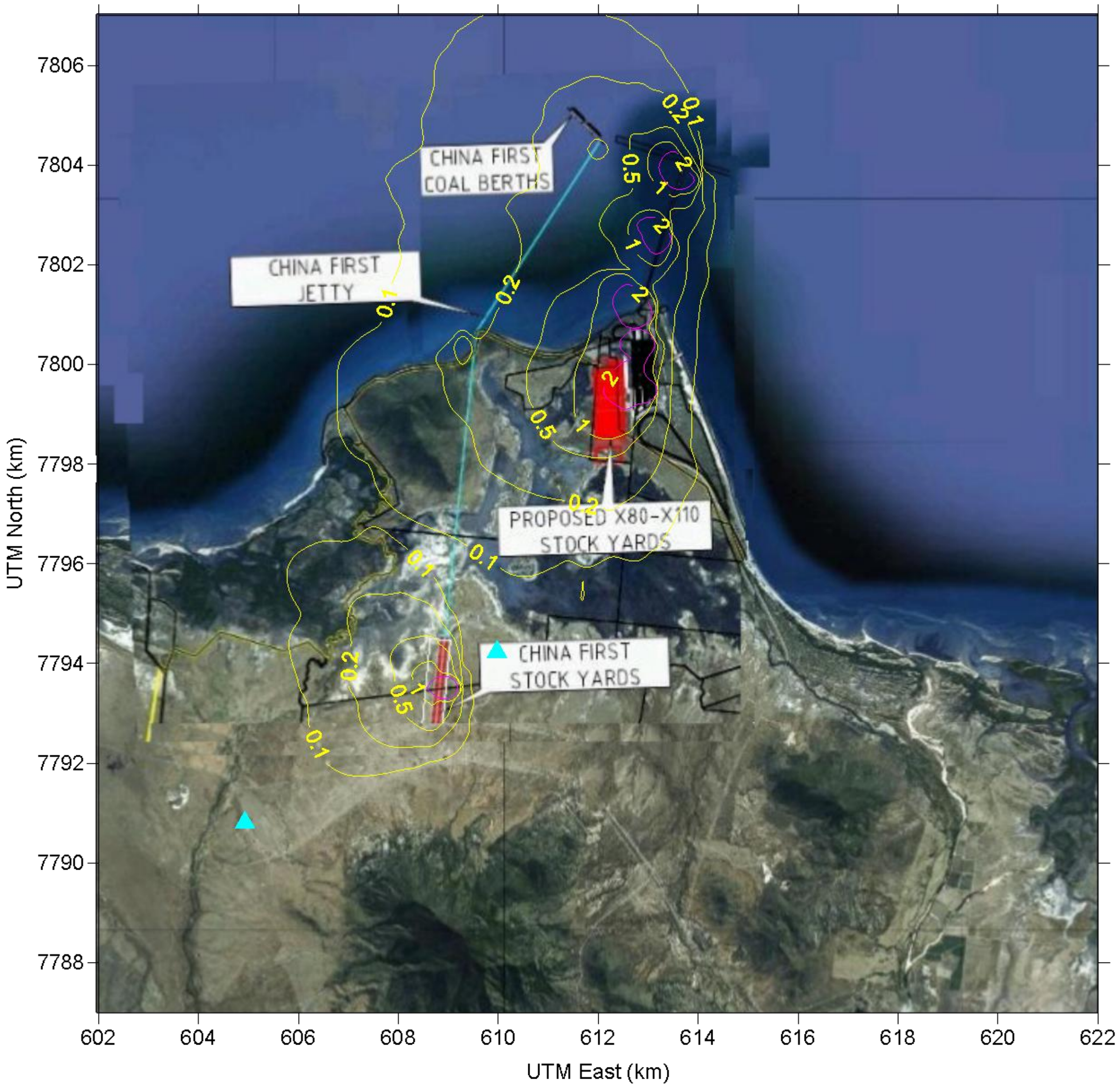
Species: TSP	Location: Abbot Point	Scenario: CFCT only	Percentile: Not Applicable	Averaging Time: Annual
Model Used: CALPUFF V6	**Units:** µg/m^3	**Guideline:** EPP (Air) = 90 µg/m3	**Met Data:** Combination of TAPM & local observations (2008)	**Plot:** L Fitzmaurice

Figure 4.8: Predicted Annual Average Ground-level Concentrations of TSP – Impacts from CFCT Only



Species: TSP	**Location:** Abbot Point	**Scenario:** Cumulative	**Percentile:** Not Applicable	**Averaging Time:** Annual
Model Used: CALPUFF V6	**Units:** μg/m^3	**Guideline:** EPP (Air) = 90 μg/m3	**Met Data:** Combination of TAPM & local observations (2008	**Plot:** L Fitzmaurice

Figure 4.9: Predicted Annual Average Ground-level Concentrations of TSP – Cumulative Impacts



Species: TSP	**Location:** Abbot Point	**Scenario:** Cumulative	**Percentile:** Maximum	**Averaging Time:** Month
Model Used: CALPUFF V6	**Units:** g/m^2/month	**Guideline:** 2 g/m^2/month	**Met Data:** Combination of TAPM & local observations (2008)	**Plot:** L Fitzmaurice

Figure 4.10: Predicted Maximum Monthly Dust Deposition – Cumulative Impacts

5 REFERENCES

BOM (2010) *Climate of Longreach Area*, Bureau of Meteorology. Available at the web site: http://www.bom.gov.au/qld/longreach/climate.shtml

Environment Australia (1998) *Best Practice Environmental Management in Mining: Dust Control*. Environment Australia Department of the Environment.

Connell Hatch (2008) *Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains, Goonyella, Blackwater and Moura Coal Rail Systems.* For Queensland Rail Limited, March 2008.

Geoscience Australia (2009) *Dust Storm: Central to Eastern Australia, September 2009*, Australian Government, September 2009.

Hurley, P. (2008a) *TAPM V4. Part 1: Technical Description*, CSIRO Atmospheric Research Technical Paper No. 25. 59 pp.

Hurley, P. (2008b) *The Air Pollution Model (TAPM) Version 4: User Manual.* Aspendale: CSIRO Atmospheric Research. (CSIRO Marine and Atmospheric Research Internal Report No. 5). 38 pp.

Hurley, P., Edwards, M., and Luhar, A. (2008) *TAPM V4. Part 2: Summary of Some Verification Studies*, CSIRO Atmospheric Research Technical Paper No. 26. 31 pp.

Katestone Environmental Pty Ltd (2009), *Revised Air Quality Assessment of the Abbot Point Coal Terminal X110 Expansion.* Prepared for GHD KE0809644.

Midwest Research Institute (2006) *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors.* (Chatten Cowherd, MRI Project Leader)

National Environmental Protection Council (1998) Ambient Air Quality and Air Toxic National Environmental Protection Measures and subsequent variations http://www.ephc.gov.au

NSW (2005) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. DECCW, NSW. http://www.environment.nsw.gov.au/resources/air/ammodelling05361.pdf

PAEHolmes (2010) *Railway Emissions Inventory,* Developed as part of PAEHolmes Job 3267.

QEPA, (2008), Queensland 2007 air monitoring report, State of Queensland, Environmental Protection Agency, PO Box 15155 City East, Qld 4002

QLD Air EPP, (2008). Environmental Protection (Air) Policy 2008. http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProtAirPo08.pdf

QLD EP Act, (1994). Environmental Protection Act 1994. http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProtA94.pdf

Scire, J.S. Robe, F.R, Fernau, M.E. and Yamartino, R.J. (2000a) *A user's guide for the CALMET Meteorological Model (Version 5)*, Earth Tech, Inc., Concord, MA.

Scire, J.S., Strimaitis, D.G, and Yamartino, R.J. (2000b) *A User's Guide for the CALPUFF Dispersion Model (Version 5)*, Earth Tech, Inc., Concord, MA.

Shao, Y (2000) *Physics and Modelling of Wind Erosion*, University of New South Wales, Sydney.

URS (2009) *Ellensfield Coal Mine Project Environmental Impact Statement: Air Quality Assessment.* Prepared for Vale Australia Pty Ltd, March 2009.

USEPA *AP-42 - Compilation of Air Pollutant Emission Factors, Fifth Edition, Volume 1* (Chapter 13 for Miscellaneous Sources).

Victoria Environmental Protection Agency (1996) *Environmental Guidelines for Major Construction Sites*, February 1996.

Victoria EPA (2004) *Ausplume Gaussian Plume Dispersion Model, Technical User Manual*. 103pp.

APPENDIX A EMISSION ESTIMATION

A.1 MINE

A.1.1 Operation

A.1.1.1 Scrapers

Emissions from scrapers were estimated for each of the dragline systems using the following equation:

$$E_i = VKT \times EF_i$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
VKT	=	Total vehicle kilometres travelled	(VKT/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/VKT)

The total VKT travelled for each scraper was estimated as follows:

$$VKT = OpHrs \times VehicleSpeed \times 8760$$

where:

VKT	=	Total vehicle kilometres travelled	(km/a)
OpHrs	=	Operation hours per day	(h/d)
VehicleSpeed	=	Average vehicle speed	(kg/activity)

The following parameters were used in the equation to calculated VKT:

- assumed operating hours of 24 hours per day per draglines system; and
- an assumed average vehicle speed of 8 km per hour.

The emissions factors used to estimated emissions from scrapers were sourced from Table 1 of the NPI EET Manual for Mining v2.3, 2004.

A summary of the activity data, emission factors and emissions estimated for scrapers is provided in Table A.1

Table A.1: Summary of Emissions from Scrapers

Location	Activity data		Emission factors			Emissions (kg/annum)	
	Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
Dragline 1	70,080	VKT/a	1.64	0.53	kg/VKT	114,931	37,142
Dragline 2	70,080	VKT/a	1.64	0.53	kg/VKT	114,931	37,142
Dragline 3	70,080	VKT/a	1.64	0.53	kg/VKT	114,931	37,142
Dragline 4	70,080	VKT/a	1.64	0.53	kg/VKT	114,931	37,142

A.1.1.2 Blasting

Emissions from blasting were estimated using the following equation:

$$E_i = A \times EF_i$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
A	=	Number of blasts per annum	(blasts/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/blast)

The number of blasts was taken as the number of drill holes, which was estimated as follows:

$$A = MaterialBlasted \times \frac{1}{BlastEfficiency} \times \frac{1}{DrillDepth}$$

where:

MaterialBlasted	=	Annual amount of material blasted	(bcm/a)
BlastEfficiency	=	The blast efficiency per drill hole	(m^3/m/drillhole)
DrillDepth	=	Depth of drill hole	(m)

The following parameters were used to estimate the number of drill holes per annum, as provided by Waratah Coal:

- an annual amount of material blasted of 119,600,000 bcm per annum, for dragline systems 1-4;
- a blast efficiency of 76.3 m^3/m; and
- a drill hole depth of 5 m.

The emission factor for TSP was calculated as follows:

$$EF_{TSP} = 0.00022 \times Area^{1.5}$$

where:

Area	=	Area per blast	(m^2)

The area per blast used in the equation was taken as 77 m^2, as provided by Waratah Coal.

The emission factor for PM_{10} was calculated as 52% of the TSP emission factor, based on the PM_{10}/TSP ratio for blasted provided in Table 1 of the NPI EET Manual for Mining v2.3, 2004.

A summary of the activity data, emission factors and emissions estimated for blasting is provided Table A.2. Total emissions from blasting were equally disturbed among the four dragline systems.

Table A.2: Summary of Emissions from Blasting

Location	Activity data		Emission factors			Emissions (kg/annum)	
	Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
Total for mine	313,335	blasts/a	0.15	0.08	kg/blast	46,577	24,220

A.1.1.3 Drilling

Emissions from drilling holes for blasting were estimated using the following equation:

$$E_i = A \times EF_i$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
A	=	Number of drill holes per annum	(drill holes/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/drill hole)

The number of drill holes per annum as taken as 313,335, as can be seen in Table A.2. The emission factors for TSP and PM_{10} were sourced from Table 1 of the NPI EET Manual for Mining v2.3, 2004.

A summary of the activity data, emission factors and emissions estimated for drilling is provided in Table A.3. Total emissions from drilling were equally disturbed among the four dragline systems.

Table A.3: Summary of Emissions from Drilling

Location	Activity data		Emission factors			Emissions (kg/annum)	
	Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
Total for mine	313,335	drill holes/a	0.59	0.31	kg/hole	184,868	97,134

A.1.1.4 Draglines

Emissions from draglines handling waste were estimated for each of the draglines using the following equation:

$$E_i = bcm \times EF_i$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
Bcm	=	Bank cubic metres handled	(bcm/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/bcm)

Each dragline was assumed to handle 28 million bcm per annum, as this is the capacity of the draglines, as provided by Waratah Coal.

The PM_{10} emission factor for draglines was calculated as follows:

$$EF_{PM10} = 0.0022 \times d^{0.7} \times M_C{}^{-0.3}$$

where:

d	=	Dragline drop height	(m)
M_C	=	Moisture content	(%)

The dragline drop height was taken to be 33 m, as provided by Waratah Coal. The moisture content of waste material was taken to be 2%, which has been conservatively taken from the moisture contents provided by Waratah Coal.

The emission factor for TSP was scaled from the PM_{10} emission factor, based on a PM_{10} ratio of TSP of 43% for draglines, sourced from Appendix A1.1.1 of the NPI EET Manual for Mining v2.3, 2004.

A summary of the activity data, emission factors and emissions estimated for draglines is provided in Table A.4.

Table A.4: Summary of Emissions from Draglines

Location	Activity data		Emission factors			Emissions (kg/annum)	
	Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
Dragline 1	28,000,000	bcm/a	0.05	0.02	kg/bcm	1,345,126	578,404
Dragline 2	28,000,000	bcm/a	0.05	0.02	kg/bcm	1,345,126	578,404
Dragline 3	28,000,000	bcm/a	0.05	0.02	kg/bcm	1,345,126	578,404
Dragline 4	28,000,000	bcm/a	0.05	0.02	kg/bcm	1,345,126	578,404

A.1.1.5 Loading and Unloading Trucks Handling Waste

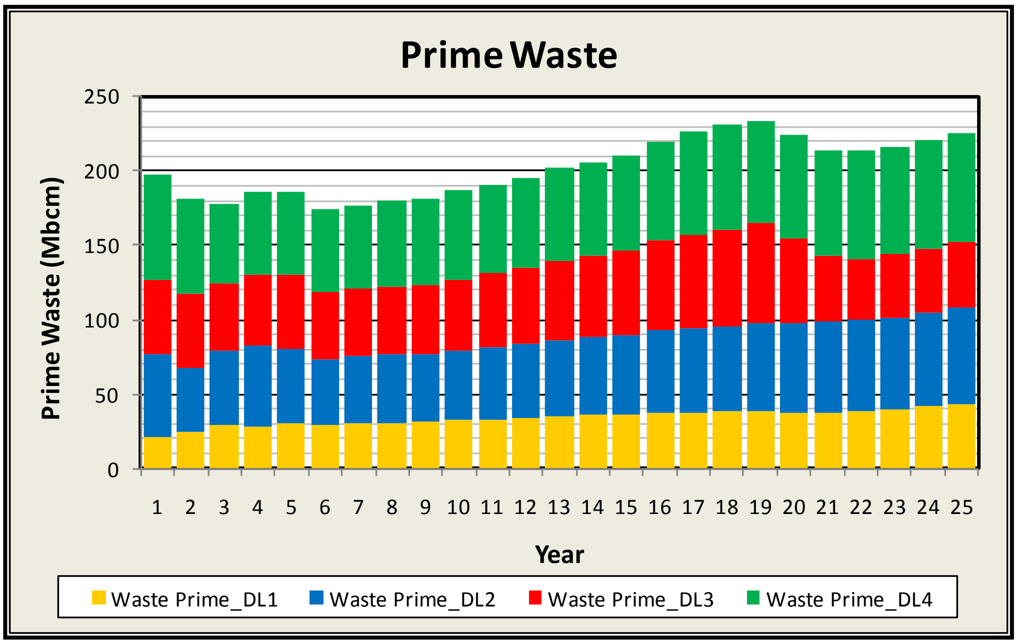
Emissions from shovels and excavators loading waste to trucks, and trucks dumping waste were estimated for each of the dragline systems using the following equation:

$$E_i = A \times EF_i$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
A	=	Amount of material loaded/dumped	(tonnes/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/tonne)

The amount of material handled by loaded/dumped by the shovels and excavators was taken to be the difference between the total prime waste moved and the amount of waste moved by the draglines. The total waste moved per dragline was taken for year 19 (the peak year) from Figure A.1, as provided by Waratah Coal. The amount of waste moved (bcm) was multiplied by an assumed overburden density of 2.6 tonnes per m^3, to give the required units of tonnes per annum.



Source: Waratah Coal, refer to Volume 2, Chapter 2 of the EIS

Figure A.1: Total Prime Waste

Emission factors for loading and unloading trucks with waste were calculated as follows:

$$EF_{PM10} = 0.74 \times 0.0016 \times \frac{U}{2.2}^{1.3} \times M_C{}^{-1.4}$$

$$EF_{PM10} = 0.35 \times 0.0016 \times \frac{U}{2.2}^{1.3} \times M_C{}^{-1.4}$$

where:

M_c	=	Moisture content of material being loaded	(%)
U	=	Mean wind speed	(m/s)

The moisture content of waste material was taken to be 2%, which has been conservatively taken from the moisture contents provided by Waratah Coal. Mean wind speed was calculated using hourly BOM wind speed data from a location close to the mine, for the year 2008.

A summary of the activity data, emission factors and emissions estimated for truck shovels and truck excavators is provided in Table A. 5.

Table A. 5: Summary of Emissions from Loading/Unloading Trucks with Waste from Shovels and Excavators

Location		Activity data		Emission factors			Emissions (kg/annum)	
		Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
Loading	Dragline 1	28,600,000	tonnes/a	0.0016	0.0008	kg/t	45,879	21,699
	Dragline 2	72,800,000	tonnes/a	0.0016	0.0008	kg/t	116,782	55,235
	Dragline 3	109,200,000	tonnes/a	0.0016	0.0008	kg/t	175,173	82,852
	Dragline 4	104,000,000	tonnes/a	0.0016	0.0008	kg/t	166,832	78,907
Unloading	Dragline 1	28,600,000	tonnes/a	0.0016	0.0008	kg/t	45,879	21,699
	Dragline 2	72,800,000	tonnes/a	0.0016	0.0008	kg/t	116,782	55,235
	Dragline 3	109,200,000	tonnes/a	0.0016	0.0008	kg/t	175,173	82,852
	Dragline 4	104,000,000	tonnes/a	0.0016	0.0008	kg/t	166,832	78,907

A.1.1.6 Excavators Mining Coal

Emissions from excavators mining coal were estimated as follows:

$$E_i = A \times EF_i$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
A	=	Amount of coal mined	(tonnes/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/tonne)

The amount of coal mined per dragline system was taken as 5 mtpa, as provided by Waratah Coal.

Emissions factors for excavators loading coal to trucks were estimated as follows, based on the methodologies presented in Table 11.9-2 of the USEPA AP-42 - Compilation of Air Pollutant Emission Factors:

$$EF_{TSP} = 0.58 \times M_C{}^{-1.2}$$

$$EF_{PM10} = 0.75 \times 0.0596 \times M_C{}^{-0.9}$$

where:

M_C	=	Moisture content	(%)

An average moisture content for coal of 11.6% was used in the equation, as provided by Waratah Coal.

A summary of emissions from excavators mining coal is provided in Table A.6.

Table A.6: Summary of Emissions from Excavators Mining Coal

Location	Activity data		Emission factors			Emissions (kg/annum)	
	Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
Dragline 1	5,000,000	tonnes/a	0.0306	0.0049	kg/tonne	153,126	24,619
Dragline 2	5,000,000	tonnes/a	0.0306	0.0049	kg/tonne	153,126	24,619
Dragline 3	5,000,000	tonnes/a	0.0306	0.0049	kg/tonne	153,126	24,619
Dragline 4	5,000,000	tonnes/a	0.0306	0.0049	kg/tonne	153,126	24,619

A.1.1.7 Hauling Coal and Waste

Unpaved road emissions from hauling coal and waste from the OCM pits to the sizing stations and out of pit waste dumps respectively, were estimated using the following equation:

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

where:

E_i	=	Emission rate of pollutant i	(kg/a)
VKT	=	Total vehicle kilometres travelled	(VKT/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/VKT)
CE	=	Emission control efficiency	(%)

Total VKT for hauling was estimated as follows:

$$VKT = \frac{MaterialHandled}{HaulTruckCapacity} \times TripDistance$$

where:

VKT	=	Total vehicle kilometres travelled	(VKT/a)
MaterialHandled	=	Total material handled by truck shovel or truck excavator fleets	(tonnes/a)
HaulTruckCapacity	=	Payload of the haul trucks	(tonnes)
TripDistance	=	Return distance of hauling	(km/trip)

The following parameters were used to estimate VKT from trucks transporting waste from the OCMs to the out of pit spoil dumps:

- the waste handled by the truck shovels or truck excavators per dragline system, as provided in Table A. 5;
- payload of 250 tonnes, as sourced from haul truck design specification sheets; and
- trip distance of 2 km, estimated based on the approximately location of the draglines in year 19 and the location of the out of pit spoil dumps.

The following parameters were used to estimate VKT from trucks hauling coal from the OCMs to the OCM sizing stations:

- the waste handled by the truck shovels or truck excavators per dragline system, as provided in Table A.6;
- payload of 250 tonnes, as sourced from haul truck design specification sheets; and
- the following trip distances, estimated based on the approximately location of the draglines in year 19 and the location of the OCM sizing stations
  - 8.5 km from dragline system 1 to the sizing station for OCM 1
  - 6 km from dragline system 2 to the sizing station for OCM 1
  - 10.5 km from dragline system 3 to the sizing station for OCM 1

- 7.5 km from dragline system 4 to the sizing station for OCM 2.

Emission factors for unpaved roads were used to estimate emissions, sourced from Table 1 of the NPI EET Manual for Mining v2.3, 2004.

Road watering is to occur at the mine site. Therefore a control efficiency of 75% was used, based on level 2 road watering (>2L/m²/h), sourced from Table 3 of the NPI EET Manual for Mining v2.3, 2004, and information provided by Waratah Coal.

A summary of the activity data, emission factors and emissions estimated for hauling coal and waste are provided in Table A.7 and Table A.8 .

Table A.7: Summary of Emissions from Hauling Coal

Location	Activity data		Emission factors			Control efficiency	Emissions (kg/annum)	
	Value	Units	TSP	PM_{10}	Units		TSP	PM_{10}
Dragline 1	340,000	VKT/a	3.88	0.96	kg/VKT	75%	329,800	81,600
Dragline 2	240,000	VKT/a	3.88	0.96	kg/VKT	75%	232,800	57,600
Dragline 3	420,000	VKT/a	3.88	0.96	kg/VKT	75%	407,400	100,800
Dragline 4	300,000	VKT/a	3.88	0.96	kg/VKT	75%	291,000	72,000

Table A.8: Summary of Emissions from Hauling Waste

Location	Activity data		Emission factors			Control efficiency	Emissions (kg/annum)	
	Value	Units	TSP	PM_{10}	Units		TSP	PM_{10}
Dragline 1	228,800	VKT/a	3.88	0.96	kg/VKT	75%	221,936	54,912
Dragline 2	582,400	VKT/a	3.88	0.96	kg/VKT	75%	564,928	139,776
Dragline 3	873,600	VKT/a	3.88	0.96	kg/VKT	75%	847,392	209,664
Dragline 4	832,000	VKT/a	3.88	0.96	kg/VKT	75%	807,040	199,680

A.1.1.8 Trucks Dumping Coal

Emissions from trucks dumping ROM coal at the OCM ROM bins, and reject coal from the CHPP were estimated using the following equation:

$$E_i = A \times EF_i$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
A	=	Amount of coal dumped	(tonnes/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/tonne)

The amount of ROM coal dumped was taken as 15 mtpa for OCM 1 and 5 mtpa for OCM 2, based on the location of draglines and the material flow diagram provided by Waratah Coal. The amount of reject coal dumped was taken as 16 mtpa, which is the difference between the total ROM coal from all OCMs and UGMs (56 mtpa), and the total product coal (40 mtpa).

Emissions factors for TSP and PM_{10} were sourced from Table 1 of the NPI EET Manual for Mining v2.3, 2004.

A summary of the activity data, emission factors and emissions estimated for dumping ROM and reject coal is provided in Table A.9.

Table A.9: Summary of Emissions from Dumping Coal

Location	Activity data		Emission factors			Emissions (kg/annum)	
	Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
OCM 1 ROM bin	15,000,000	tonnes/a	0.01	0.0042	kg/tonne	150,000	63,000
OCM 2 ROM bin	5,000,000	tonnes/a	0.01	0.0042	kg/tonne	50,000	21,000
Rejects	16,000,000	tonnes/a	0.01	0.0042	kg/tonne	160,000	67,200

A.1.1.9 Bulldozers

Emissions from bulldozers were estimated using the following equation:

$$E_i = No. \times OpHrs \times EF_i \times 8760$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
No.	=	Number of bulldozers	(-)
OpHrs	=	Amount of material handled	(h/d)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/h)

The following parameters were used in the equation, as provided by Waratah Coal:

- 2 bulldozers per dragline system operating 24 hours per day;
- 1 bulldozer per UGM operating 2 days per week (7 hours per day); and
- 2 bulldozers operating at the CHPP 24 hours per day.

Emissions factors for bulldozing on overburden were used for the bulldozers operating at the OCM pits. For the bulldozers at the UGMs and CHPP the emissions factors for bulldozers operating on coal were calculated as follows:

$$EF_{TSP} = 35.6 \times sc^{1.2} \times {M_C}^{-1.4}$$

$$EF_{PM10} = 6.33 \times sc^{1.5} \times {M_C}^{-1.4}$$

where:

M_C	=	Moisture content	(%)
Sc	=	Silt content	(%)

An average moisture content of 11.6% was used in the equation, as provided by Waratah Coal. The default silt content of 7% was used, sourced from A1.1.4 of the NPI EET Manual for Mining v2.3, 2004.

A summary of the activity data, emission factors and emissions estimated for bulldozers is provided in Table A.10.

Table A.10: Summary of Emissions from Bulldozers

Location	Activity data		Emission factors			Emissions (kg/annum)	
	Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
Dragline 1	28,600,000	tonnes/a	0.025	0.012	kg/t	715,000	343,200
Dragline 2	72,800,000	tonnes/a	0.025	0.012	kg/t	1,820,000	873,600
Dragline 3	109,200,000	tonnes/a	0.025	0.012	kg/t	2,730,000	1,310,400
Dragline 4	104,000,000	tonnes/a	0.025	0.012	kg/t	2,600,000	1,248,000

A.1.1.10 Miscellaneous Transfer

Emissions from miscellaneous transfer were estimated for the following activities:

- Loading and unloading conveyors at the UGM drift stockpiles and OCM and UGM sizing stations;
- primary, secondary and tertiary sizing stations; and
- loading coal to stockpiles and reclaiming from stockpiles, for the raw, product and reject coal stockpiles.

Emissions were estimated using the following equation:

$$E_i = A \times EF_i$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
A	=	Amount of coal handled	(tonnes/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/tonne)

The emission factor for miscellaneous transfer was calculated as follows:

$$EF_{PM10} = 0.74 \times 0.0016 \times \frac{U}{2.2}^{1.3} \times M_C^{-1.4}$$

$$EF_{PM10} = 0.35 \times 0.0016 \times \frac{U}{2.2}^{1.3} \times M_C^{-1.4}$$

where:

M_c	=	Moisture content of coal	(%)
U	=	Mean wind speed	(m/s)

A summary of the activity data, emission factors and emissions from miscellaneous transfer points is provided in Table A.11.

Table A.11: Summary of Emissions from Miscellaneous Transfer Points

Location	Activity	Activity data		Emission factors			Emissions (kg/annum)	
		Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
OCM sizing station	Loading - belt conveyor	20,000,000	tonnes/a	0.00014	0.00006	kg/tonne	2,738	1,295
	Unloading - belt conveyor	20,000,000	tonnes/a	0.00014	0.00006	kg/tonne	2,738	1,295
	Primary crushing	20,000,000	tonnes/a	0.00014	0.00006	kg/tonne	2,738	1,295
	Secondary sizing	20,000,000	tonnes/a	0.00014	0.00006	kg/tonne	2,738	1,295
	Tertiary sizing	20,000,000	tonnes/a	0.00014	0.00006	kg/tonne	2,738	1,295
UGM sizing station	Unloading conveyor to drift stockpile	36,000,000	tonnes/a	0.00014	0.00006	kg/tonne	4,929	2,331
	Unloading to feeder	36,000,000	tonnes/a	0.00014	0.00006	kg/tonne	4,929	2,331
	Secondary crushing	36,000,000	tonnes/a	0.00014	0.00006	kg/tonne	4,929	2,331
	Tertiary crusing	36,000,000	tonnes/a	0.00014	0.00006	kg/tonne	4,929	2,331
	Loading - belt conveyor	36,000,000	tonnes/a	0.00014	0.00006	kg/tonne	4,929	2,331
Raw coal stockpile	Loading stockpile	56,000,000	tonnes/a	0.00014	0.00006	kg/tonne	7,667	3,626
	Reclaiming	56,000,000	tonnes/a	0.00014	0.00006	kg/tonne	7,667	3,626
Product coal stockpile	Loading stockpile	40,000,000	tonnes/a	0.00014	0.00006	kg/tonne	5,477	2,590
	Reclaiming	40,000,000	tonnes/a	0.00014	0.00006	kg/tonne	5,477	2,590
Reject coal stockpile	Loading stockpile	16,000,000	tonnes/a	0.00014	0.00006	kg/tonne	2,191	1,036
	Reclaiming	16,000,000	tonnes/a	0.00014	0.00006	kg/tonne	2,191	1,036
	Loading trucks	16,000,000	tonnes/a	0.00014	0.00006	kg/tonne	2,191	1,036

A.1.1.11 Wind Erosion of Active Coal Stockpiles

Wind erosion emissions from active coal stockpiles were estimated using the following equation:

$$E_i = A \times EF_i \times 8760$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
A	=	Area of stockpile	(ha)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/ha/h)

Areas of stockpiles were estimated based on the mine plans and information provided by Waratah Coal. Emission factors for wind erosion were sourced from Table 1 of the NPI EET Manual for Mining v2.3, 2004.

A summary of the stockpile areas, emissions factors and emissions from wind erosion is provided in Table A.12.

Table A.12: Summary of Emissions from Wind Erosion of Active Coal Stockpiles

Location	Activity data		Emission factors			Emissions (kg/annum)	
	Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
UGM Drift stockpile 1	2.0	ha	0.4	0.2	kg/ha/h	6,868	3,434
UGM Drift stockpile 2	2.0	ha	0.4	0.2	kg/ha/h	6,868	3,434
UGM Drift stockpile 3	2.0	ha	0.4	0.2	kg/ha/h	6,868	3,434
UGM Drift stockpile 4	2.0	ha	0.4	0.2	kg/ha/h	6,868	3,434
Raw coal stockpile A	4.2	ha	0.4	0.2	kg/ha/h	14,717	7,358
Raw coal stockpile B	2.7	ha	0.4	0.2	kg/ha/h	9,461	4,730
Raw coal stockpile C	4.2	ha	0.4	0.2	kg/ha/h	14,717	7,358
Product coal stockpile A	4.2	ha	0.4	0.2	kg/ha/h	14,717	7,358
Product coal stockpile B	4.2	ha	0.4	0.2	kg/ha/h	14,717	7,358
Reject coal stockpile A	2.7	ha	0.4	0.2	kg/ha/h	9,461	4,730
Reject coal stockpile B	2.7	ha	0.4	0.2	kg/ha/h	9,461	4,730

A.1.1.12 Wind Erosion of Exposed Areas

Emissions from wind erosion of exposed areas were estimated as follows:

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

where:

E_i	=	Emission rate of pollutant i	(kg/a)
A	=	Exposed area	(VKT/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/VKT)
CE	=	Emission control efficiency	(%)

Wind erosion of exposed areas was estimated for the out of pit spoil dumps and the OCM pits. The exposed areas for the out of pit spoil dumps were estimated based on the mine plan provided by Waratah Coal.

Total exposed areas in each of the OCM pits was provided by Waratah Coal, and were 2000 ha and 1500 ha for OCM 1 and OCM 2 respectively. As the open cut mines progress west, rehabilitation of the mined areas is expected to occur at approximately the same rate as the clearing of new areas of mining. The areas of exposed surfaces - 2000 ha and 1500 ha – have been conservatively estimated by Waratah Coal to account for any lag in the rate of rehabilitation.

Total exposed areas per OCM have been split into two areas – *recently disturbed areas*, and *not recently disturbed areas*. The size of the *recently disturbed area* per OCM was estimated based on the approximately size of the area mined per annum, as provided by Waratah Coal. The size of the *not recently disturbed areas* is the remainder of the total exposed areas. A control factor of 50% was assumed for the *not recently disturbed areas* to account for silt depletion, which cannot be considered to be unlimited.

Emission factors for TSP and PM_{10} were sourced from Table 11.9-4 of USEPA AP-42. The emission factor presented is designed for 'seeded land, stripped overburden, and graded overburden' at a dry (rainfall 280 to 420 mm/y), windy (average 4.8 to 6 m/s) coal mine. This was considered to give a more accurate representation of wind erosion in the China First OCM pits than the default NPI emission factor, which does not specify the type of material that is exposed. A comparison with the meteorological conditions at the China First Mine site indicates that the mine site has slightly higher average rainfall and lower average wind speeds than the conditions for the USEPA emission factor, meaning that the emission factor is expected to be conservative.

A summary of the exposed areas, emission factors and emissions for wind erosion of exposed areas is provided in Table A.13.

Table A.13: Summary of Emissions from Wind Erosion of Exposed Areas

Location		Activity data		Emission factors			Control efficiency (%)	Emissions (kg/annum)	
		Value	Units	TSP	PM_{10}	Units		TSP	PM_{10}
OCM 1	Recently disturbed	450	ha	850	425	kg/ha/y		382,500	191,250
	Not recently disturbed	1,550	ha	850	425	kg/ha/y	50%	658,750	329,375
OCM 2	Recently disturbed	150	ha	850	425	kg/ha/y		127,500	63,750
	Not recently disturbed	1,350	ha	850	425	kg/ha/y	50%	573,750	286,875
Out of pit spoil dumps (total)		993	ha	850	425	kg/ha/y		844,066	422,033

A.1.1.13 Underground Mine Vents

Emissions from UGM vents have been estimated using the following equation:

$$E_i = \frac{N \times Q \times C_i}{1000}$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
N	=	Number of vents	(-)
Q	=	Volumetric flowrate of air vented per vent	(m^3/a)
C_i	=	Concentration of pollutant i in the vented air	(g/m^3)

The following parameters were used in the equation:

- 3 vent per underground mine, based on a range of 2-3 vents per mine, as provided by Waratah Coal;
- a volumetric flowrate of 150 m^3/s per vent, as provided by Waratah Coal, which equates to 4,730,400,000 m^3/annum per vent; and
- concentrations of 0.0016 g/m^3 and 0.0012 g/m^3 for TSP and PM_{10} respectively in the vented air, based on monitoring undertaken at an existing underground coal mine (Holmes Air Sciences, 2005).

A summary of the activity data, dust concentrations and emissions estimated for the UGM vents is provided in Table A.14.

Table A.14: Summary of Emissions from UGM Vents

Location	Activity data		Emission factors			Emissions (kg/annum)	
	Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
UGM 1	14,191,200,000	m3/annum	0.0016	0.0011	g/m3	22,706	15,610
UGM 2	14,191,200,000	m3/annum	0.0016	0.0011	g/m3	22,706	15,610
UGM 3	14,191,200,000	m3/annum	0.0016	0.0011	g/m3	22,706	15,610
UGM 4	14,191,200,000	m3/annum	0.0016	0.0011	g/m3	22,706	15,610

A.1.2 **Construction – Cut and Cover**

Emissions from the cut and cover operations for the development of the underground mines were estimated for the following activities:

- Loading trucks with excavated material;
- hauling excavated material;
- unloading trucks;
- bulldozing; and
- grading.

A.1.2.1 Loading and Unloading Trucks

Emissions from loading and unloading trucks were estimated using the methodology presented in Appendix A.1.1.5 - *Loading and Unloading Trucks Handling Waste*. The amount of material loaded and unloaded was assumed to be 2,600,000 tonnes per UGM. This was conservatively estimated based on 1,000,000 m³ being excavated (which is the upper end of the range provided by Waratah Coal), and a overburden density of 2.6 tonnes per m³.

A.1.2.2 Hauling Trucks

Emissions from trucks hauling excavated material were estimated using the methodology presented in Appendix A.1.1.7 - *Hauling Coal and Waste*. The distance travelled per trip was assumed to be 1 km. This is likely to be a conservative estimated, as the material is to be moved to a location near the UGMs, as it is to be used as part of the development of the entrance to the UGMs.

A.1.2.3 Bulldozers

Emissions from bulldozers were estimated using the methodology presented in Appendix A.1.1.9 - *Bulldozers*. Total hours of operation was calculated, based on 1 bulldozer per UGM operating 24 hours per day for 4 months, as provided by Waratah Coal.

A.1.2.4 Grading

Emissions from grading were estimated using the following equation:

$$E_i = VKT \times EF_i$$

where:

E_i	=	Emission rate of pollutant i	(kg/a)
VKT	=	Total vehicle kilometres travelled	(VKT/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/VKT)

The total VKT travelled for graders was estimated as follows:

$$VKT = OpHrs \times VehicleSpeed \times \frac{8760}{3}$$

where:

VKT	=	Total vehicle kilometres travelled	(km/a)
OpHrs	=	Operation hours per day	(h/d)

VehicleSpeed = Average vehicle speed (kg/activity)

The following parameters were used in the equation to calculated VKT:

- assumed operating hours of 24 hours per day per UGM, for 4 months; and
- an assumed average vehicle speed of 8 km per hour.

The emissions factors for graders were calculated as follows:

$$EF_{TSP} = 0.0034 \times S^{2.5}$$

$$EF_{TSP} = 0.0034 \times S^{2.0}$$

where:

S = Average vehicle speed (km/h)

As stated above, average vehicle speed was assumed to be 8 km/h.

A.1.2.5 Summary of Emissions for Cut and Cover Operations

A summary of the activity data, emission factors and emissions for the cut and cover operations is provided in Table A.15.

Table A.15: Summary of Emissions from Cut and Cover Operations

Location	Activity data		Emission factors			Emissions (kg)	
	Value	Units	TSP	PM_{10}	Units	TSP	PM_{10}
Excavating	2,600,000	tonnes	0.0016	0.0008	kg/t	4,171	1,973
Bulldozing	2,920	hours	17	4	kg/h	49,640	11,680
Hauling	10,400	VKT	3.88	0.96	kg/VKT	40,352	9,984
Unloading	2,600,000	tonnes	0.0016	0.0008	kg/t	4,171	1,973
Grading	23,360	VKT	0.6155	0.2176	kg/VKT	14,377	5,083
					Total per UGM	**112,711**	**30,693**
					TOTAL ALL UGMs	**450,844**	**122,772**

A.2 COAL TERMINAL

In this section, the emission estimate methods for uncontrolled dust emission from the China First Coal Terminal (CFCT) are described.

A.2.1 Wind emissions from exposed area

This is used for estimating wind erosion from stationary coal wagons and from coal stockpiles at CFCT.

Uncontrolled wind erosion emissions were estimated using the following equation:

$$E_i = A \times EF_i$$

where:

E_i	=	Emission rate of pollutant i	(kg/hour)
A	=	Area of stockpile	(ha)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/ha/hour)

Areas of stockpiles were estimated based on the coal terminal plans and information provided by Waratah Coal. The default emission factors for wind erosion from Table 1 of the NPI EET Manual for Mining v2.3, 2004 were used: 0.4 kg/ha/hour for TSP, and 0.2 kg/ha/hour for PM_{10}. For CFCT, the area of stockpiles is 40 ha, and the area of train surface modelled is 0.99 ha.

A.2.2 Dust emissions from miscellaneous transfer points

This is used for estimating dust emissions from the following activities at CFCT: coal unloading at rail receiving points, wharf loading, and stacking and reclaiming coal at coal stockpiles.

Uncontrolled emissions were estimated using the following equation:

$$E_i = A \times EF_i$$

where:

E_i	=	Emission rate of pollutant i	(kg/annum)
A	=	Amount of coal handled	(tonnes/annum)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/tonne)

The emission factor for miscellaneous transfer points was calculated as follows (from Table 1 of the NPI EET Manual for Mining v2.3, 2004):

$$EF_{PM10} = 0.74 \times 0.0016 \times \frac{U}{2.2}^{1.3} \times M_C{}^{-1.4}$$

$$EF_{PM10} = 0.35 \times 0.0016 \times \frac{U}{2.2}^{1.3} \times M_C{}^{-1.4}$$

where:

M_c	=	Moisture content of coal	(%)
U	=	Mean wind speed	(m/s)

For CFCT, the mean wind speed of 3.86 m/s based on modelling run and moisture content of coal of 6.9% were used.

APPENDIX B DISPERSION MODELLING METHODOLOGY

B.1 OVERVIEW OF AIR QUALITY MODELLING

B.1.1 Dispersion Models

Air quality modelling via plume dispersion models has undergone significant refinement in recent years. Steady state Gaussian plume air dispersion models such as AUSPLUME and AERMOD have formed the basis of air dispersion assessment for many years and are now being replaced by a generation of more sophisticated non steady-state models, such as CALPUFF (endorsed by the USEPA).

The key assumptions inherent in the steady-state Gaussian plume dispersion models may be summarised as follows:

- Meteorological parameters remain constant for the period of one hour.
- Meteorological parameters remain fixed over the entire modelling domain, which often includes all regions within 10 km or more of the source.
- In the vertical, most meteorological parameters either remain constant (e.g., wind direction) or vary according to generic formulae (e.g., wind speed, temperature) that are seldom, if ever, validated for the site.
- The height of the mixing layer remains constant for the entire region.

In situations where terrain is complex, for example, these assumptions are invalid so these models do not make useful predictions of plume behaviour.

The main sets of conditions under which AUSPLUME, ISC3, AERMOD and similar steady-state models tend to be outperformed by more sophisticated models such as CALPUFF are:

- very light winds;
- stable conditions, associated with surface temperature inversions and often drainage flows along valleys and gullies;
- coastal sites; and
- complex terrain situations.

B.1.2 Meteorological Dispersion Models

To successfully model air dispersion, it is import to provide dispersion models with high-quality meteorological conditions, including wind speed, wind direction, vertical temperature profiles, mixing layer heights and atmospheric stabilities.

Meteorological data can be obtained from nearby meteorological monitoring station data, if they are high quality and with sufficient time resolution. Hourly data are generally required for dispersion models.

In remote area where there are no meteorological stations nearby, CSIRO's The Air Pollution Model (TAPM) modelling has been widely used in Australia to generate meteorological data based on a network of meteorological monitoring stations across the Australian continent. In 1999 PAE (now PAEHolmes) devised this suit of dispersion modelling methodology, which has since been used widely throughout Australia and elsewhere.

B.2 SELECTED METEOROLOGICAL AND DISPERSION MODELS

B.2.1 TAPM

The Air Pollution Model, or TAPM, is a coupled three dimensional meteorological and air pollution model produced by the CSIRO Division of Atmospheric Research. It was released in late 1999. The latest version is version 4. Refer to Hurley (2008a) and Hurley (2008b) for technical details and the user manual, and Hurley et al. (2008) for some verification studies.

The meteorological component of TAPM is an incompressible, non-hydrostatic, primitive equation model. The model solves the momentum equations for horizontal wind components, the incompressible continuity equation for vertical velocity, and scalar equations for potential virtual temperature and specific humidity of water vapour, cloud water/ice, rain water and snow. Cloud microphysical processes, turbulence kinetic energy, eddy dissipation and radiation fluxes are also included (Hurley, 2008a). The model solution for winds, potential virtual temperature and specific humidity, are weakly nudged with synoptic-scale input values of these variables generated from meso-scale modelling.

TAPM may be used to generate meteorology for areas where there are no observations (NSW DECC, 2005). Given no meteorological monitoring stations in the modelling area TAPM was used to generate surface meteorological data for areas where little or no data existed and to generate meteorology for the upper layers of the atmosphere (10 m to 3000 m) as an input into CALMET (described below).

TAPM also has a dispersion modelling component, which is not used for this project.

B.2.2 CALMET

CALMET (Scire et al., 2000a) is a meteorological pre-processor for CALPUFF. It includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are utilised in the CALPUFF dispersion model.

The hourly TAPM-generated upper air data and observed surface data from the Bureau of Meteorology stations for the period of analysis were used as input to the CALMET pre-processor to create a coarse resolution, three-dimensional meteorological field. This grid was used as an input into the dispersion model. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict gridded meteorological fields for the region.

B.2.3 CALPUFF

CALPUFF (Scire *et al*. 2000b) is a multi-layer, multi-species, non-steady state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation and removal. The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer-range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across the puff and takes into account the complex arrangement of emissions from point, area, volume, and line sources.

CALPUFF is a *Guideline Model* recommended for regulatory use by the USEPA and other international regulatory agencies. CALPUFF is used in a wide variety of applications by registered users in over 105 countries throughout the world.

B.2.4 AUSPLUME

AUSPLUME (Victoria EPA, 2004) is a steady-state Gaussian plume air dispersion model. It uses historic hourly meteorological data to calculate plume rise and dispersion. AUSPLUME is a Victoria EPA approved air dispersion model.

As a steady-state Gaussian plume model, it employs a relatively simple methodology. It assumes that for each hour all meteorological conditions, most notably wind speed and direction, are fixed for that hour. It also assumes that meteorological conditions do not vary from location to location, i.e., the wind field is assumed to be constant across the area modelled. During any particular hour under consideration, the plume from the source is assumed to travel in the direction of the wind, and disperse at a rate determined by the current meteorological conditions. In the next modelled hour, the model assumes that the plume instantly changes direction to align itself with the new wind direction and the plume from the previous hour ceases to exist. In other words, all information about the previous hour of modelling is discarded.

AUSPLUME is widely used in Australia as a screening tool for evaluating industrial air emissions. It is much easier to set up and requires significantly less computer time to run.

B.3 MODELLING SUITE OF TAPM, CALMET AND CALPUFF

In 1999 PAE (now PAEHolmes) devised a suit of dispersion modelling methodology using the combination of TAPM, CALMET and CALPUFF. This has since been used widely throughout Australia and elsewhere. Figure B.1 contains a flow diagram showing how these three models interact. First, TAPM was used to generate three-dimensional meteorological fields for a representative year. This is especially useful in remote areas where nearby meteorological monitoring station data are unavailable. The meteorological output from TAPM are then extracted and put in CALMET as upper air and/or surface data input. CALMET will adjust these input data, add local terrain induced flow changes, and make the flow as mass-consistent as possible so that it is suitable for three dimensional dispersion modelling. At last, CALPUFF takes CALMET meteorological output and use it simulate the atmospheric transport, dilution and deposition of emissions from the sources.

This modelling suit is commonly used in areas where limited meteorological observational data are available, where local terrain impacts could be significant, and where cumulative impacts from many different industrial sources need to be assessed. For this project, it has been used for assessment of both the mine and coal terminal.

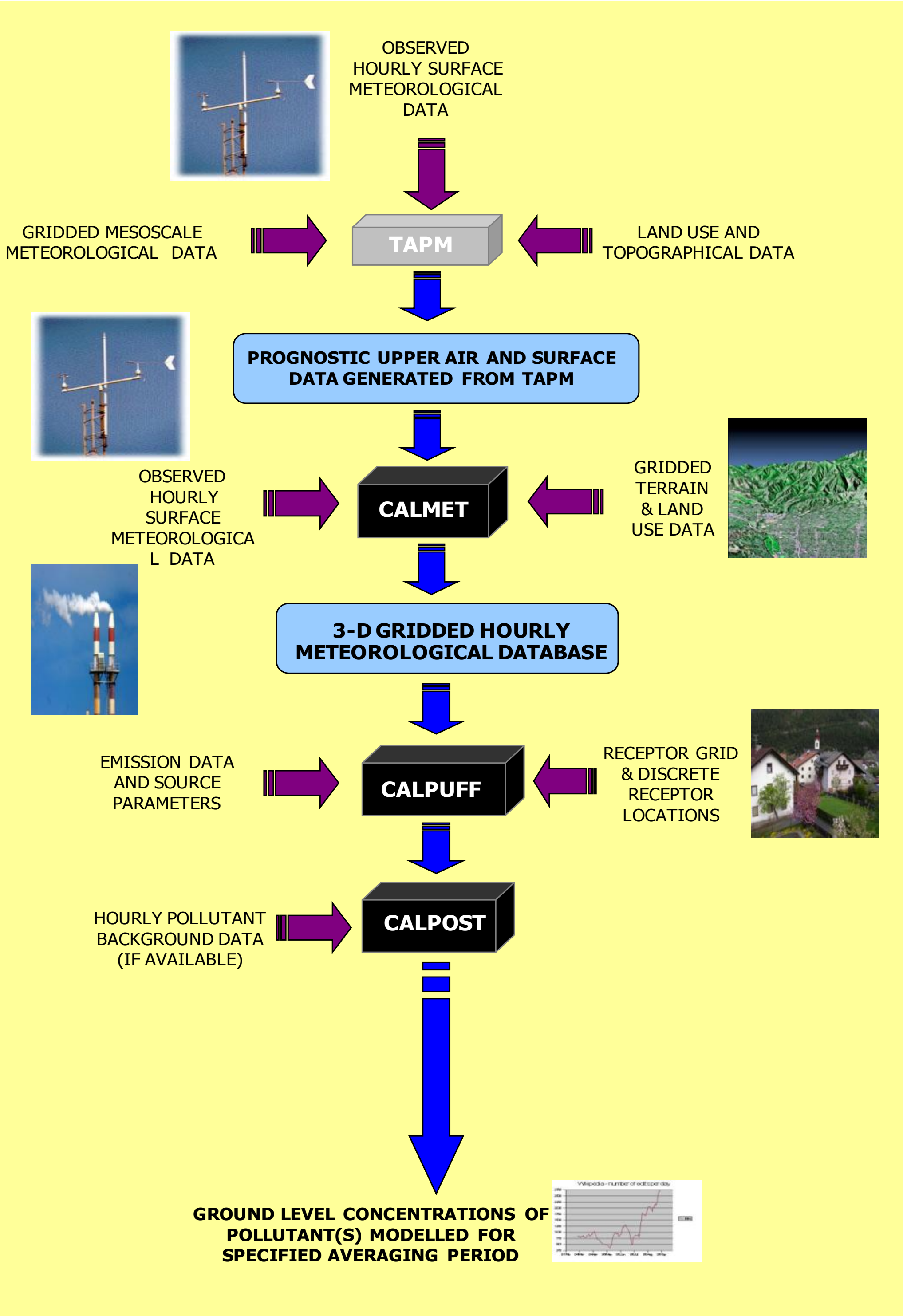


Figure B.1: Flow Diagram for the Modelling Suit of Using TAPM, CALMET and CALPUFF for Assessing Air Quality Impacts

B.4 LIMITATIONS AND ACCURACY OF MODELLING

Atmospheric dispersion models represent a simplification of the many complex processes involved in determining ground-level concentrations of pollutants. One of the crucial issues in obtaining good quality results is the data quality used for modelling and the correct application of an appropriate model for the site conditions.

Model uncertainties are composed of model chemistry/physics uncertainties, data uncertainties, and stochastic uncertainties. In addition, there is inherent uncertainty in the behaviour of the atmosphere, especially on shorter time scales due to the effects of random turbulence. Refer to USEPA (2005) for an overview of model uncertainties.

The main specific sources of uncertainty in dispersion models and their potential effects are summarised in Table B..

Table B.1: Model Uncertainties

Source of uncertainty	Potential Effects
Oversimplification of physics in model code (varies with type of model)	A variety of effects that can lead to both under prediction and over prediction. However, errors are greater in Gaussian plume models, which do not include the effects of non-steady-state meteorology (i.e., spatially- and temporally-varying meteorology).
Oversimplification of chemistry in model code (varies with type of model)	Air pollutants may go through chemical reaction after discharge into the air. Atmospheric chemical processes are often complicated, and oversimplification may lead over- or under-predictions.
Errors in emissions data	Ground level concentrations are proportional to emission rate. Plume rise is affected by source dimensions, temperature and exit velocity. Errors in emission rates and initial emission characteristics such height, initial spread, temperature and velocity will lead errors in predicted concentrations and deposition. The errors can be significant for mining activities as emissions are mostly not measured, rather being calculated based activity data (such as the amount material transported, moisture and silt contents of the material).
Errors in wind data	Wind direction affects direction of plume travel. Wind speed affects plume rise and dilution of plume, resulting in potential errors in distance of plume impact from source, and magnitude of impact.
Errors in stability estimates	Gaussian plume models use estimates of stability class, and 3-dimensional puff models use explicit vertical profiles of temperature and wind (which are used directly or indirectly to estimate stability class for Gaussian models). In either case, errors in these parameters can cause either under prediction or over prediction of ground-level concentrations.
Errors in temperature	Usually the effects are small, but temperature affects plume buoyancy, with potential errors in distance of plume impact from source, and magnitude of impact.
Inherent uncertainty	Models predict 'ensemble mean' concentrations for any specific set of input data (say on a one hour basis), i.e. they predict the mean concentrations that would result from a large set of observations under the specific conditions being modelled. However, for any specific hour with those exact mean hourly conditions, the predicted ground-level concentrations will never exactly match the actual pattern of ground-level concentrations, due to the effects of random turbulent motions and random fluctuations in other factors such as temperature. The inherent uncertainty in concentrations downwind of an emission source has a typical range of variation as much as ±50% (USEPA, 2005).

Among these uncertainties,

- Model chemistry/physics uncertainties are associated with specific air quality models that are chosen, and they will vary with different models and model parameters;
- Meteorological data uncertainties are associated with whether there are locally measured data available and the quality of monitoring data. In the case of without local data, it relies on models such as TAPM and CALMET to generate those data. In the later situation, the data uncertainties are generally larger, especially for locations with complex terrains;
- The uncertainties in emissions for some applications can be quite large. For example, for mining impacts, emissions are generally estimated based on published manuals and not based on site specific emission testings. Even some stack testing data can be quite unreliable due to the difficulties to measure accurately;
- The inherent uncertainties due to random turbulence are mostly outside of the scope of traditional models.

It is very important but quite difficult to quantify these uncertainties and provide a rule of thumb for regulators as well as for modellers. The overall uncertainties could be much smaller than the sum of all the individual uncertainties from the statistical point of view. Generally, models are more reliable for estimating longer time-averaged concentrations such as annual averages than for estimating the peak concentrations for shorter durations (such as 1-hour or 24-hour). USEPA (2005) mentions that the factor-of-two accuracy has been often and long quoted for highest estimated concentrations occurring sometime, somewhere within an area. The accuracy could be even lower for applications that may have large errors in emissions and meteorological data.

B.5 REFERENCES

Hurley, P. (2008a) *TAPM V4. Part 1: Technical Description*, CSIRO Atmospheric Research Technical Paper No. 25. 59 pp.

Hurley, P. (2008b) *The Air Pollution Model (TAPM) Version 4: User Manual.* Aspendale: CSIRO Atmospheric Research. (CSIRO Marine and Atmospheric Research Internal Report No. 5). 38 pp.

Hurley, P., Edwards, M., and Luhar, A. (2008) *TAPM V4. Part 2: Summary of Some Verification Studies*, CSIRO Atmospheric Research Technical Paper No. 26. 31 pp.

Scire, J.S. Robe, F.R, Fernau, M.E. and Yamartino, R.J. (2000a) *A user's guide for the CALMET Meteorological Model (Version 5)*, Earth Tech, Inc., Concord, MA.

Scire, J.S., Strimaitis, D.G, and Yamartino, R.J. (2000b) *A User's Guide for the CALPUFF Dispersion Model (Version 5)*, Earth Tech, Inc., Concord, MA.

USEPA (2005) *Appendix W (*40 CFR Part 51) - *Guideline on Air Quality Models*, Environmental Protection Agency, 45pp (originally published in 1978, and most recently updated in 2005). http://www.epa.gov/scram001/guidance_permit.htm, for Permit Modelling Guidance.

Victoria EPA (2004) *Ausplume Gaussian Plume Dispersion Model, Technical User Manual*. 103pp.

APPENDIX C CLIMATE SUMMARIES

C.1 MINE

C.1.1 Climate and Meteorology

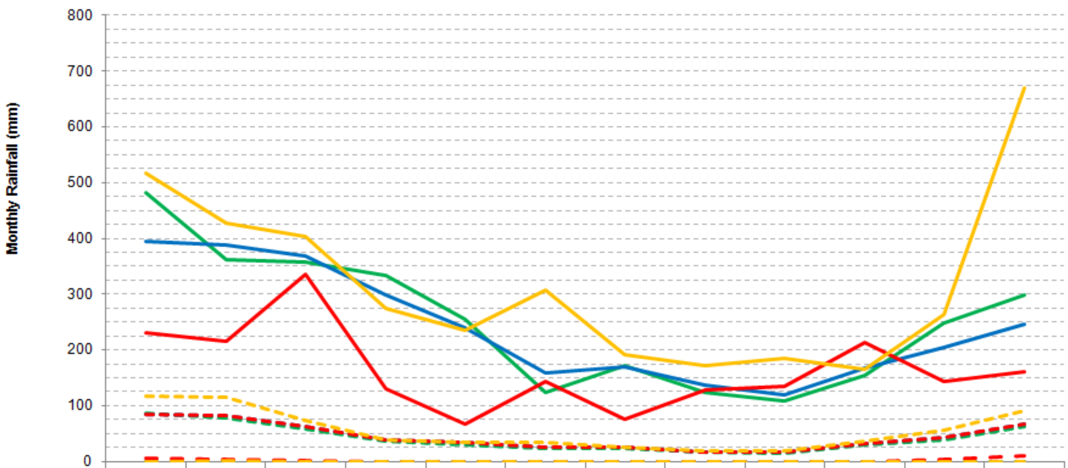
The climate of the study area has a sub-tropical continental climate and in general winter days are warm and sunny and nights are cold. Summer days, as with most Australian locations tend to be hot and nights warm. Summer weather is influenced by a semi-permanent trough that lies roughly north-south through the interior of the state. The trough is normally the boundary between relatively moist air to the east and dry air to the west. It is best developed and generates most weather during spring and summer months. The position of the trough fluctuates diurnally due to vertical mixing and from day to day due to interaction with broadscale synoptic influences. The trough often triggers convection with showers and thunderstorms on its eastern side.

C.1.1.1 Meteorological Stations

Meteorological data has been taken from multiple *Bureau of Meteorology* (BOM) weather stations to provide an indication of regional climate trends. Where possible, data has been taken from the Barcaldine, Emerald, Claremont and Blackall stations, as these are the closest to the location of the China First Project mine site. For some parameters, for example evaporation, data was not available from the preferred stations, so data was taken from the next nearest station.

C.1.1.2 Rainfall

A summary of the long term monthly average rainfall at monitoring locations in the study region is presented in Figure C.1. This summary shows a consistent pattern across the study region of 80-120 mm of rain per month, on average, during the summer months, dropping to average lows of 15-20 mm during winter.

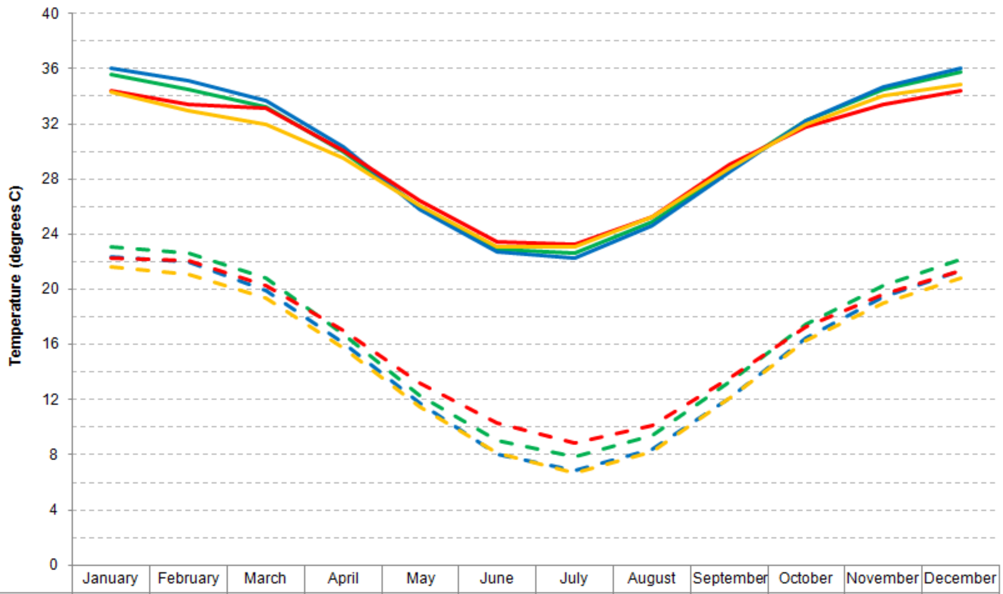


	January	February	March	April	May	June	July	August	September	October	November	December
Barcaldine - Maximum	481.2	362.6	357.1	333.6	255	124.2	171.6	123.4	107.5	154.2	247.9	298.3
Barcaldine - Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Barcaldine - Average	86.1	78.3	59.1	36.7	30.8	24.3	22.9	15.8	15.1	29.1	38.1	63.1
Blackall - Maximum	395.2	389.1	368.5	299.2	240.2	159.9	170.3	136.7	119.4	167.3	203.6	246.8
Blackall - Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Blackall - Average	85.2	81.8	62.8	37.6	33.6	26.2	25.1	16.5	17.4	33.1	42.2	67
Emerald - Maximum	231.6	216.2	335.2	130.1	66.6	143.4	76.4	128.2	135.2	213.4	143.6	162
Emerald - Minimum	6.2	3.7	1.4	0	0	0	0	0	0	0.2	2.8	10.2
Emerald - Average	85.2	81.8	62.8	37.6	33.6	26.2	25.1	16.5	17.4	33.1	42.2	67
Clermont - Maximum	516	428	403.4	274.2	234.4	307.2	192.5	171.2	184.9	165.2	263.9	670.7
Clermont - Minimum	0	1	0	0	0	0	0	0	0	0	0	0
Clermont - Average	117.6	115.7	73.9	38.8	35	34.3	24.9	19	19.3	35.4	57.1	91.8

Figure C.1: Long term average rainfall summary

C.1.1.3 Temperature

The long term monthly average temperatures within the study area display typical ranges for subtropical regions, as shown in Figure C.2. Longreach, being further inland, is generally hotter than the other monitoring stations in the region although it can be cooler during mid winter. Mean monthly minimum temperatures can be as high as 19°C to 22°C in the summer and drop as low as 7°C in the winter. The mean maximum temperatures can range between 33 to 36°C in the hottest months and drop to between 22 and 25°C during the coldest part of the year.



	January	February	March	April	May	June	July	August	September	October	November	December
Barcaldine - Mean Max	35.6	34.5	33.2	30	26	22.9	22.6	24.9	28.7	32.2	34.5	35.8
Barcaldine - Mean Min	23.1	22.6	20.8	16.7	12.3	9	7.9	9.4	13.3	17.5	20.3	22.2
Blackall - Mean Max	36	35.1	33.7	30.3	25.8	22.7	22.3	24.6	28.5	32.2	34.7	36
Blackall - Mean Min	22.4	22	19.9	16.1	11.8	8	6.9	8.4	12.1	16.5	19.5	21.4
Emerald - Mean Max	34.4	33.4	33.1	30.1	26.4	23.4	23.3	25.3	29.1	31.8	33.4	34.4
Emerald - Mean Min	22.3	22.1	20.3	17	13.2	10.3	8.9	10.1	13.6	17.3	19.6	21.4
Clermont - Mean Max	34.3	33	32	29.5	26.1	23.1	23.1	25.3	28.8	32	34	34.9
Clermont - Mean Min	21.6	21.1	19.4	15.7	11.5	8.1	6.7	8.2	12.1	16.3	19	20.8

Figure C.2: Long term average temperature summaries

C.1.1.4 Wind Speed and Direction

Wind roses show the frequency of wind occurrence by direction and strength. The bars correspond to the 16 compass points (N, NNE, NE, etc.). The bar at each wind direction in the wind rose diagram represents winds blowing from that direction. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds. With the resulting figure it is possible to visualise how often winds of a certain direction and strength occur over a long period, either for all hours of the day, or for particular periods during the day.

Long term wind roses from two representative locations in the study area (one from the east and one from the west of the study area) show very different wind strengths although similar wind directions across the study area. Emerald, shown in Figure C.3, is located east of the study area and has winds that are frequently from the east with more moderate winds. Barcaldine, shown in Figure C.4, to the west of the study area, also shows more winds from the east but has a higher frequency of low wind speeds. Calms form between 3% and 7% of monitored 9 AM and 3 PM.

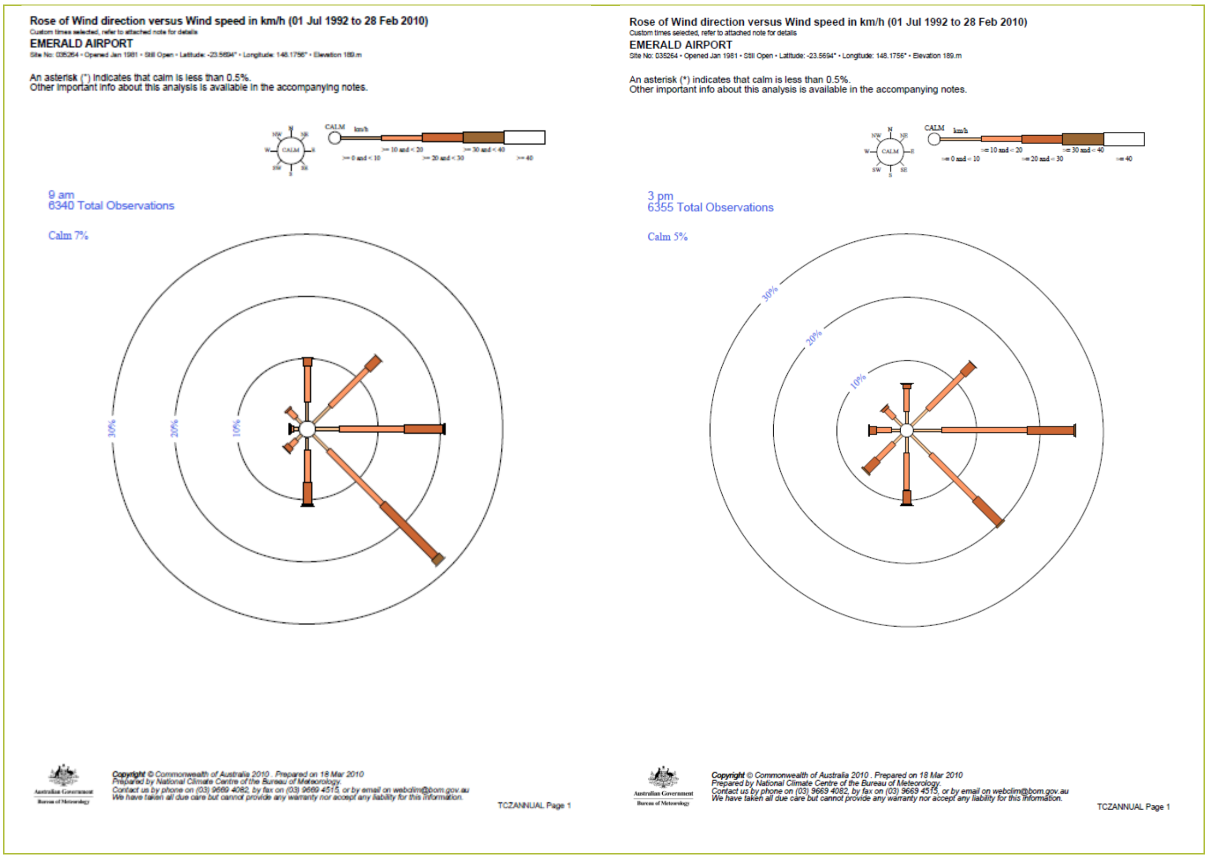


Figure C.3: Long term average 9 AM (left) and 3 PM (right) wind roses from Emerald Airport

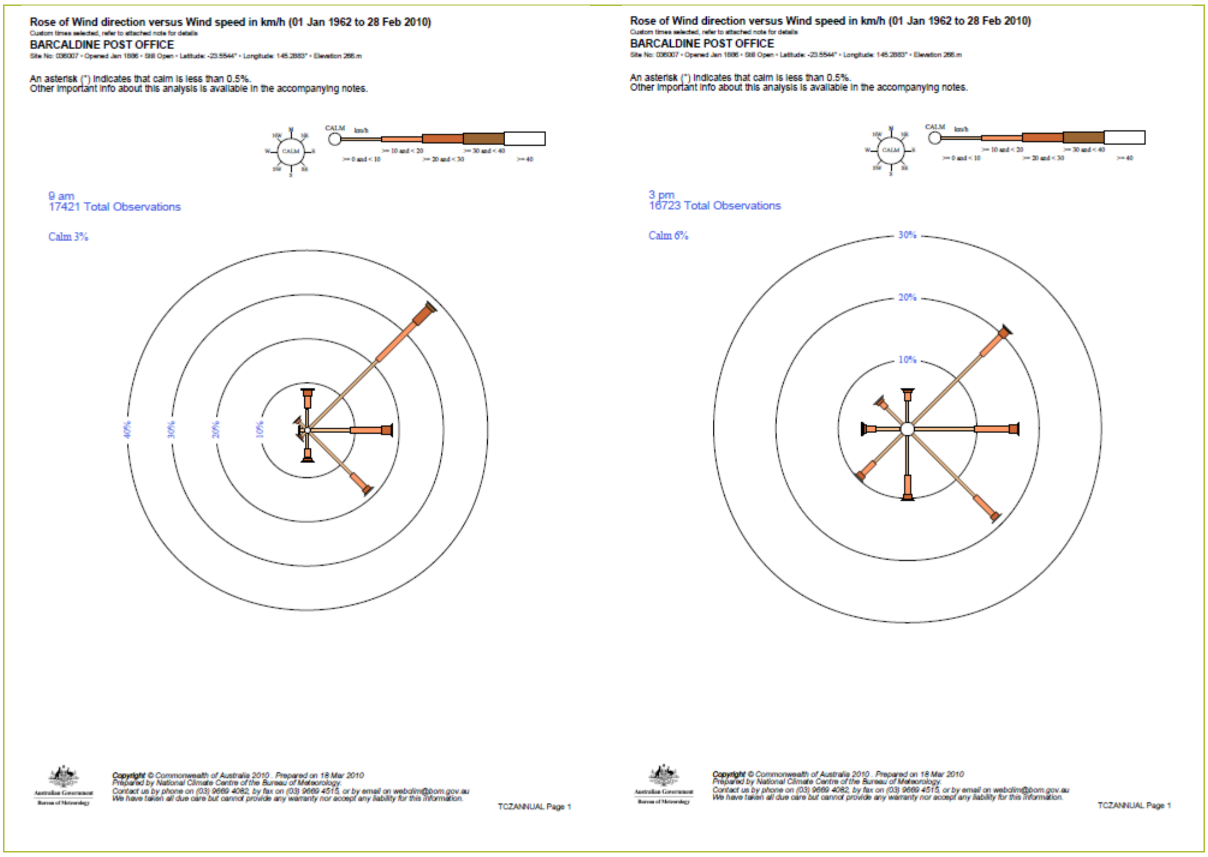
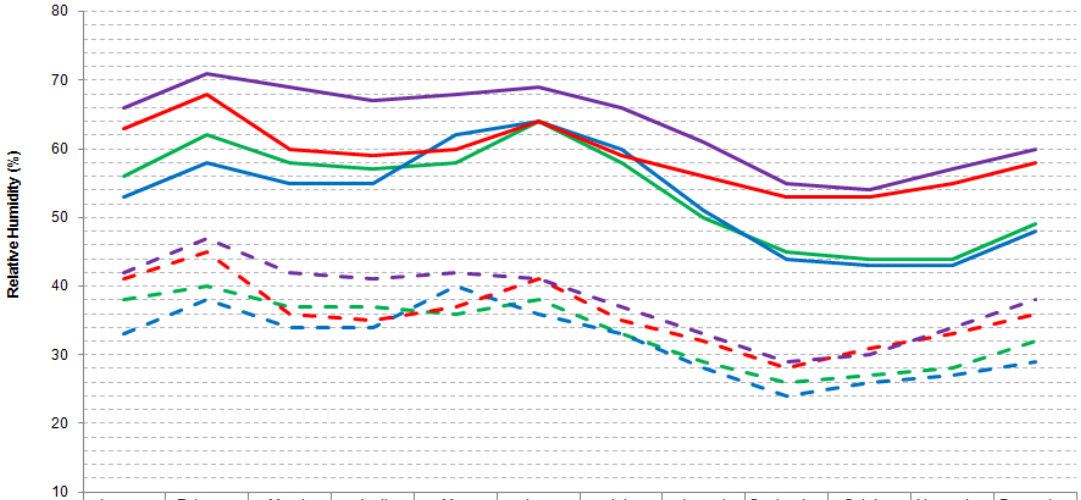


Figure C.4: Long term average 9 AM (left) and 3 PM (right) wind roses from Barcaldine Airport

C.1.1.5 Relative Humidity

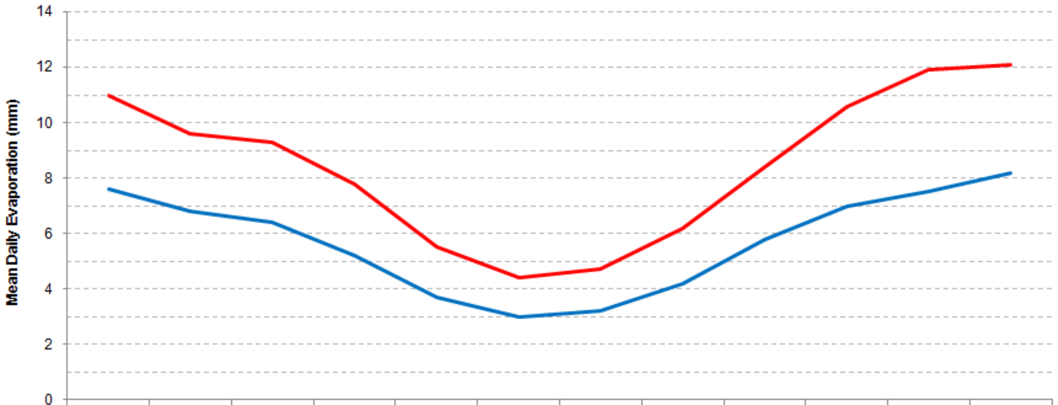
Relative humidity in the study area is typically higher during the summer and autumn months and lower during the spring months. During the summer months the higher temperatures allow greater saturated vapour pressures resulting in lower relative humidities. Finally the relative humidity is also affected by the distance from the sea with stations further from the ocean having less water vapour available and hence lower relative humidity's (Barcaldine is generally lower than Clermont and Emerald).



	January	February	March	April	May	June	July	August	September	October	November	December
Barcaldine - 9AM	56	62	58	57	58	64	58	50	45	44	44	49
Barcaldine - 3PM	38	40	37	37	36	38	33	29	26	27	28	32
Blackall - 9AM	53	58	55	55	62	64	60	51	44	43	43	48
Blackall - 3PM	33	38	34	34	40	36	33	28	24	26	27	29
Emerald - 9AM	63	68	60	59	60	64	59	56	53	53	55	58
Emerald - 3PM	41	45	36	35	37	41	35	32	28	31	33	36
Clermont - 9AM	66	71	69	67	68	69	66	61	55	54	57	60
Clermont - 3PM	42	47	42	41	42	41	37	33	29	30	34	38

C.1.1.6 Evaporation

During the summer months, longer hours of daylight, hotter temperatures and higher solar radiation results in evaporation rates that are 2 to 3 times higher than those experienced during the June to August cooler months. As can be seen in Figure C.5, evaporation is generally lower at Clermont than at Longreach.



	January	February	March	April	May	June	July	August	September	October	November	December
Longreach	11	9.6	9.3	7.8	5.5	4.4	4.7	6.2	8.4	10.6	11.9	12.1
Clermont	7.6	6.8	6.4	5.2	3.7	3	3.2	4.2	5.8	7	7.5	8.2

Figure C.5: Mean daily evaporation

C.1.1.7 Pressure

Hourly mean and monthly mean minimum, 5th and 95th percentile, median and maximum pressures are presented from Figure C.**6** to Figure C.**7** respectively. The hourly graphs shows that the median pressure is generally around 1014 hPa and that the pressure generally remains between 1002 and 1025 hPa. There appears to be a diurnal cycle in pressure, with maximums in the mid morning (7 to 10 am) and minimums during the late afternoon (3 to 5 pm). This is due to a feature often referred to as atmospheric tides. This is where atmospheric solar heating, combined with upward eddy conduction of heat from the ground, generates internal gravity waves in the atmosphere at periods of the integral fractions of a solar day (primarily at the diurnal and semidiurnal periods).

An annual cycle is clearly visible in Figure C.7 which reflects the fact that the sub tropic anticyclone belt migrates north during winter resulting in higher pressures.

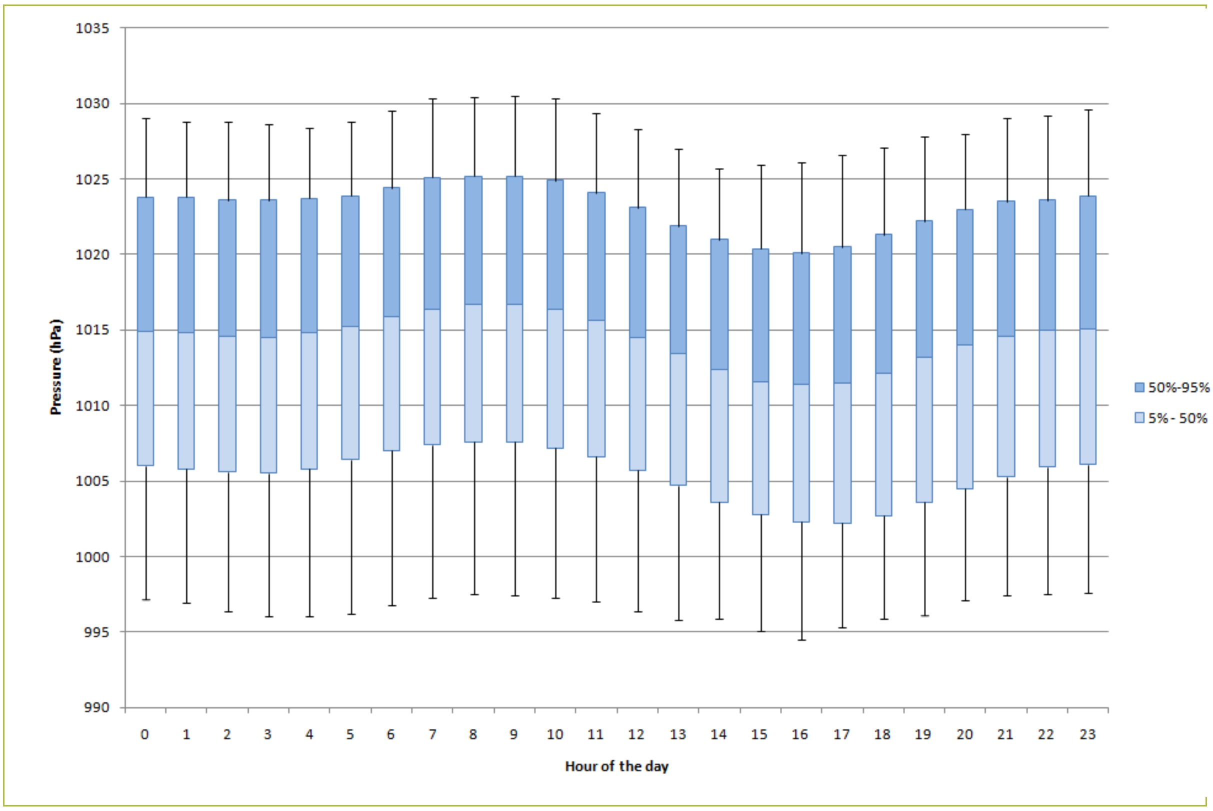


Figure C.6: Hourly average mean sea level pressure from 2001 to 2010

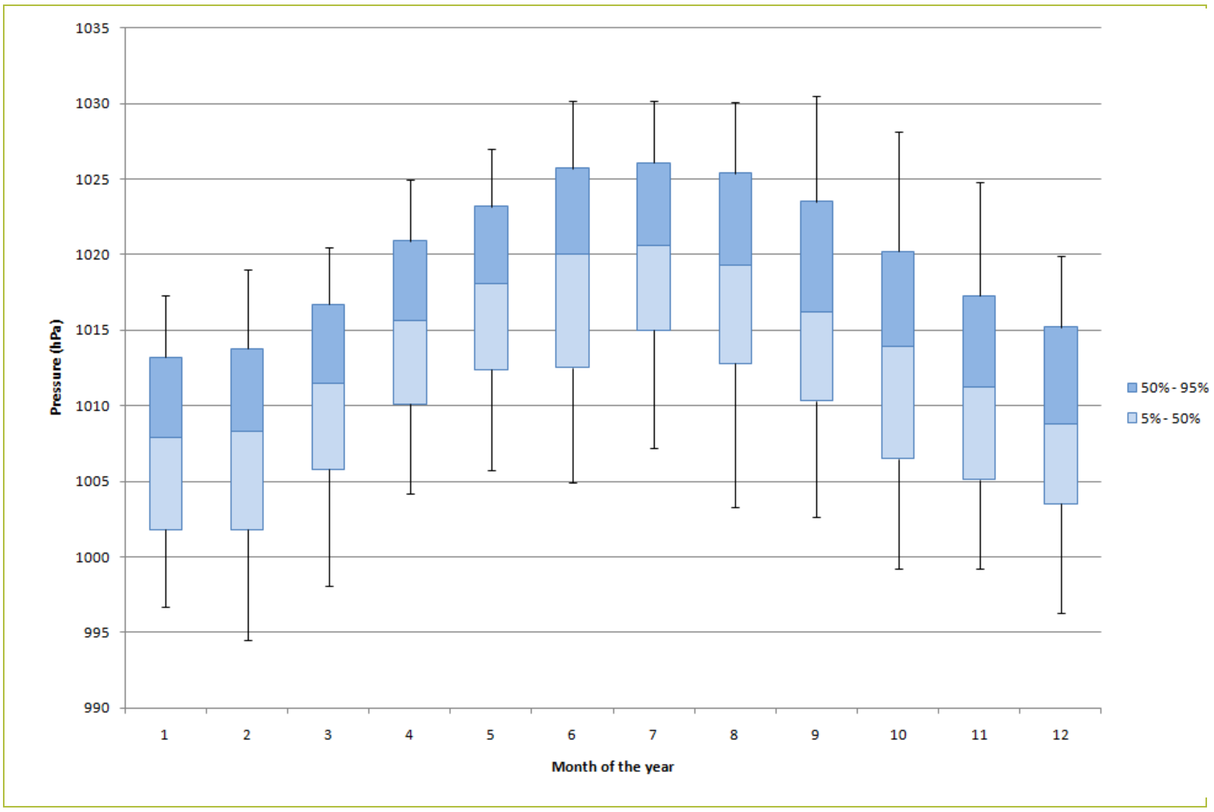


Figure C.7: Monthly average mean sea level pressure from 2001 to 2010

C.1.1.8 Temperature Inversions

A temperature inversion refers to a layer of air in the atmosphere in which the temperature increases with height (instead of general profile of decreasing with height). During the night time the ground is cooled by radiating heat into space. Air in contact with the ground then becomes cooler than the air above it, forming a typical night-time near-ground inversion layer. Inversions can form from other mechanisms, such as when warm air moves over a cool surface, and can also form at high altitudes in the atmosphere.

The lack of convective mixing within the lower-level inversion layer means that lower-level pollution can be trapped within the inversion layer, resulting in high pollution levels. This phenomenon is much more pronounced over land than it is over water, as water holds its heat for longer than land does.

The temperature inversion strength and frequency have been estimated based on TAPM meteorological modelling output (for the year 2008) from a central location within the project area. Analysis of the inversions (see Table C.) show that strong inversions occur in 13% of occasions.

Table C.1: Temperature Inversion at Night Time – Mine Site (2008)

Night Time Inversion Strength	Percentage of occurrence (%)	Number of hours
>3ºC per 100 m	13	1169
>2ºC per 100 m	20	1750
>1ºC per 100 m	30	2595
>0ºC per 100 m	50	4410

C.1.2 **Climate Extremes**

C.1.2.1 Thunder and Lightning

The Bureau of Meteorology (BOM) has estimated that the study area experiences 15 to 25 thunder days per year (see Figure C.8), some of which can result in destructive winds, intense rainfall and flash flooding. Since 1995 BOM has also been monitoring lightning flashes as both total lightning flash density (including intracloud flashes) and cloud to ground flash density per square kilometre per year. Figure C.9 and Figure C.10 present long term (1995 – 2002) averages of expected annual lightning counts. These show that on average the study area might expect between 5 and 10 total flashes/km²/year and 1 to 3 ground flashes/km²/year.

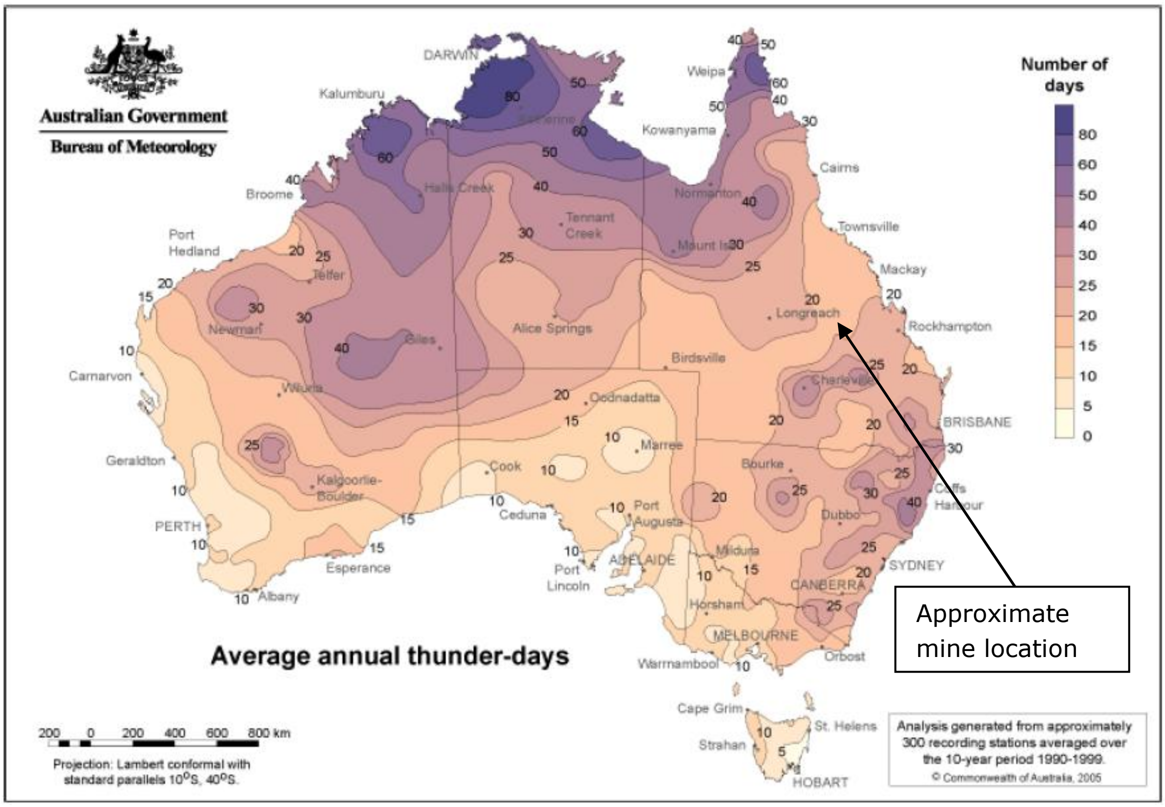


Figure C.8: Average Annual Thunder Days between 1990 – 1999 (BOM, 2010 accessed 23 Apr 10)

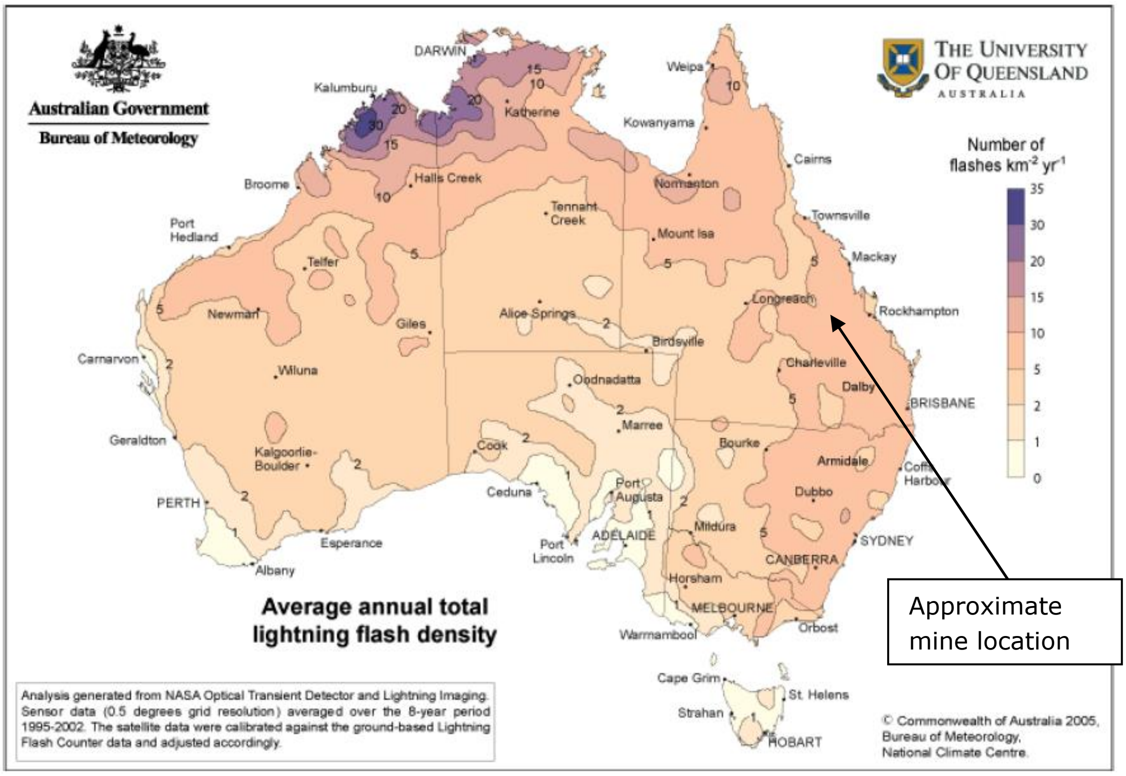


Figure C.9: Average Annual Total Lightning Flash Density between 1906 – 2006 (BOM, 2010 accessed 23 Apr 10)

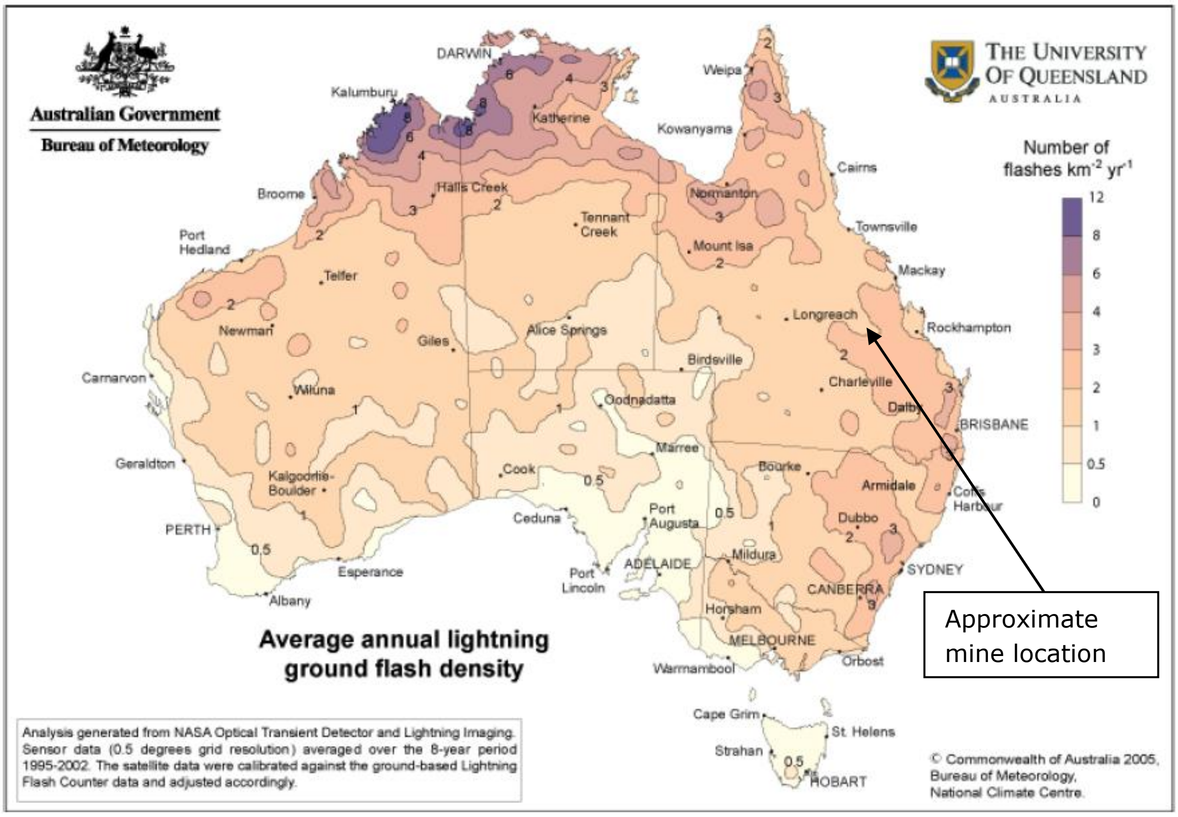


Figure C.10: Average Annual Lightning Ground Flash Density between 1995 – 2002 (BOM, 2010 accessed 23 Apr 10)

C.1.2.2 Tropical Cyclones

Tropical cyclones in the Queensland region mostly form from lows within the monsoon trough, between November and April. The considerable majority of cyclones are formed in coastal north Queensland, however occasionally a cyclone tracks to inland and southern parts of the state, where they generally reduce in intensity. In some cases tropical lows do re-intensify and re-establish as a tropical cyclone, particularly where they interact with warmer coastal airflows associated with tropical waters.

Figure C.11 shows that from 1906-2006 15 tropical cyclones have passed within 200 km of the mine site, which is approximately 350 km from the Queensland coast. Within a radius a 50 km, the number of tropical cyclones track passing the mine site reduces to 2 (refer to Figure C.12).

The average number of tropical cyclones at the mine site is <0.1 per year, based on data from the 1975/76 to 2005/06 cyclone seasons. This period includes El Niño, La Niña and neutral years, however, tropical cyclones impacts in eastern Australia have been shown to occur almost twice more often during La Niña years than during El Niño years.

Trends in tropical cyclone activity in the Australian region have shown that the number of cyclones has decreased in recent decades, although the number of stronger cyclones (with minimum central pressure <970 hPa) has not declined. These trends may be associated with an observed increase in the frequency of El Niño events. It is difficult to determine if trends in tropical cyclone activity are the result of natural variations in large-scale environment in which tropical cyclones form and evolve, or if they are influenced by anthropologic climate change.

The latest predictions indicate that the number of cyclones in eastern Australia is not expected to increase, however projections show more long-lived tropical cyclones in eastern Australian.

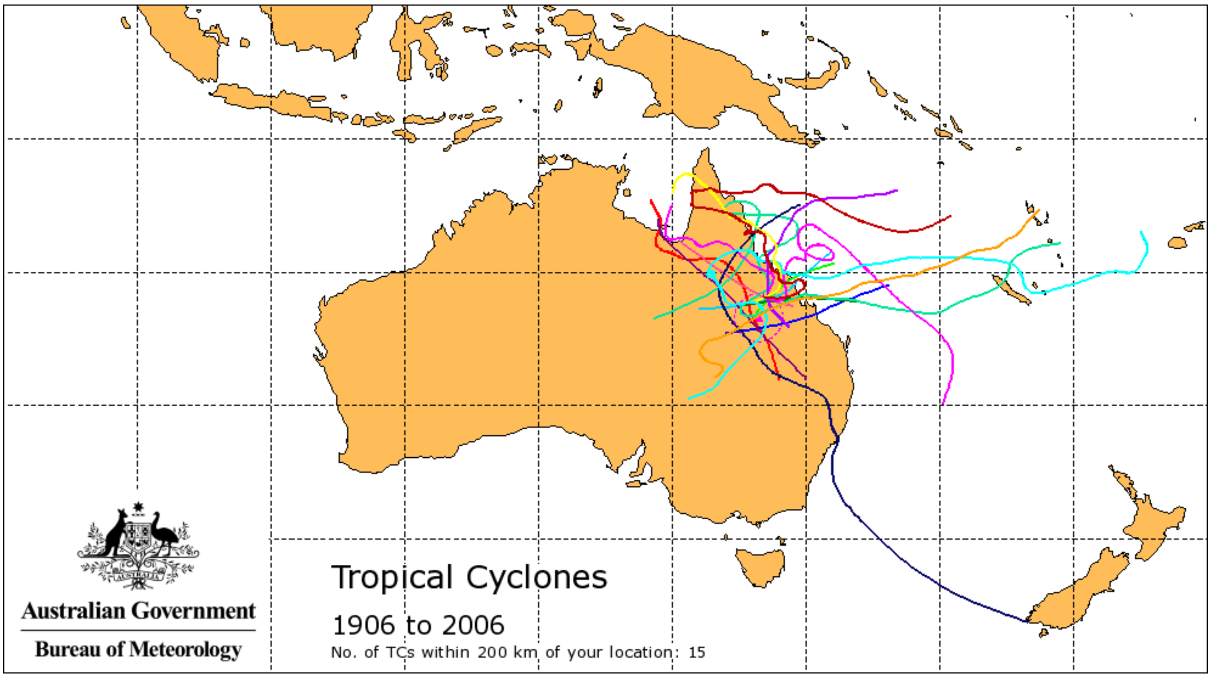


Figure C.11: Number of Tropical Cyclones within 200 km of the Mine Site between 1906 and 2006 (BOM, 2010 accessed 10 May 2010)

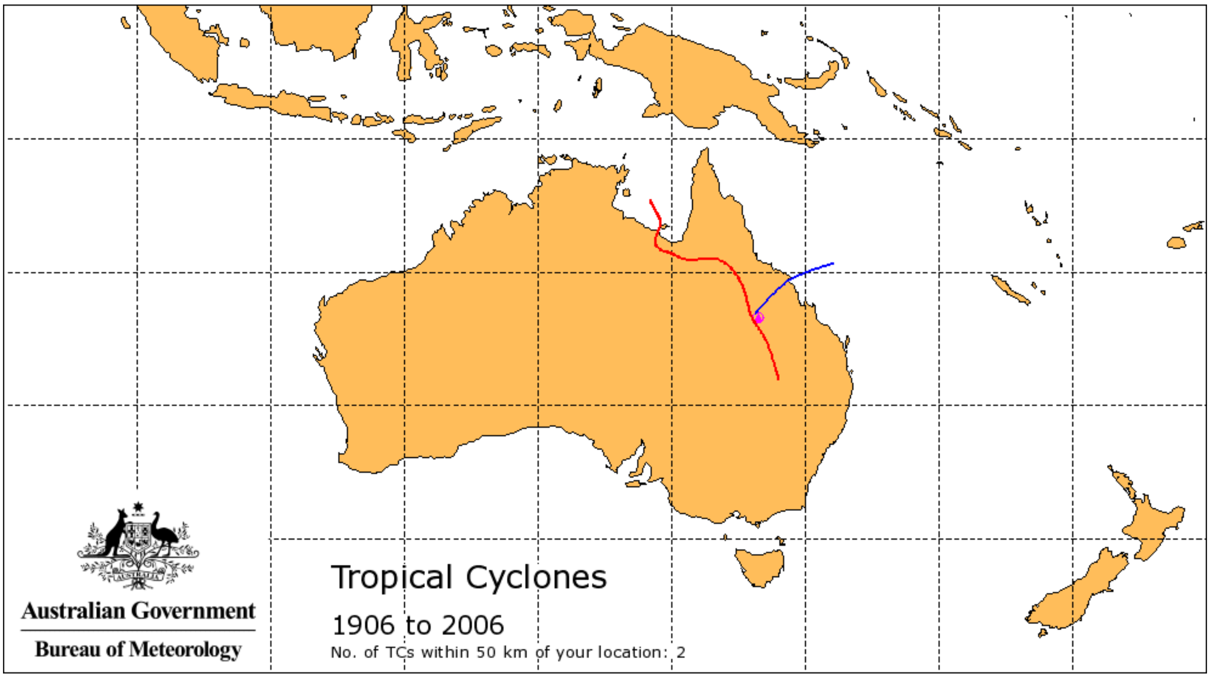


Figure C.12: Number of Tropical Cyclones within 50 km of the Mine Site between 1906 and 2006 (BOM, 2010 accessed 10 May 2010)

C.2 RAILWAY

C.2.1 Climate and Meteorology

The climate of the study area has a tropical climate, with hot and wet summers, and cool and dry winters. Summer has a monsoonal weather, frequently influenced by tropical cyclones and lows, which cause a lot of rainfall in the coastal areas. The wind direction is predominant from the east, south east and north east, influenced by the trade wind.

C.2.1.1 Meteorological Stations

Climate conditions for the China First Project railway have been assessed for three project locations:

- Abbott Point (the coal terminal) – the start of the railway
- central region of the railway; and
- China First Project mine site (the mine) – the end of the railway.

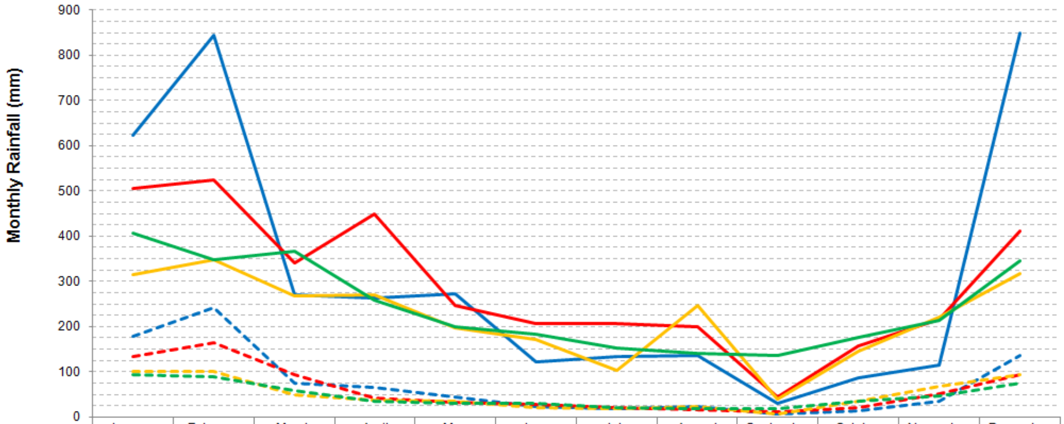
For the coal terminal, meteorological data were taken from the *Bureau of Meteorology* (BOM) weather station at Bowen Airport, except for evaporation data. Evaporation data was not available for Bowen Airport, and has been taken from the closest BOM weather stations: Ayr, Townsville and Te Kowai, which are approximately 115 km north-west, 200 km north-west and 200 km south-east from Bowen respectively.

To provide an indication of regional climate trends for the central region of the railway meteorological data has been taken from BOM weather stations at Collinsville and Moranbah.

Meteorological data from the BOM weather stations at Barcaldine, Emerald, Claremont and Blackall are used to represent the mine, as these are the closest stations to the mine site. For some weather parameters data was not available from these, so data was taken from the next nearest station.

C.2.1.2 Rainfall

A summary of the long term monthly average rainfall for the project locations are presented in Figure C.13. It shows that rainfall is high in summer and low in winter, and coastal sites have more rainfall than inland sites.



	January	February	March	April	May	June	July	August	September	October	November	December
Port - Maximum	623.1	843.4	269.3	264.2	273	123	135	135.3	29.6	87	114.5	848.5
Port - Average	178.3	242.9	75.7	64.6	44.4	23.9	19.3	22.4	7.2	13.4	35.4	135.1
Collinsville - Maximum	505.8	524.6	341.8	448.6	246.6	207.6	207.4	200	45.4	158.3	216.2	410.4
Collinsville - Average	134	164.7	93.2	41.9	32.4	27.3	20.2	17.1	11	21.5	50.5	95
Moranbah - Maximum	315	347.4	268	271	196.6	170.3	103.6	247.3	39.4	146.6	220.3	318.2
Moranbah - Average	102	100.6	48.1	37.4	35.9	22.1	18.5	22.5	7.9	36.1	67.1	94.7
Mine - Maximum	406.0	349.0	366.1	259.3	199.1	183.7	152.7	139.9	136.8	175.0	214.8	344.5
Mine - Average	94.7	90.0	59.3	35.5	29.6	29.5	21.3	18.6	19.1	35.0	47.7	75.8

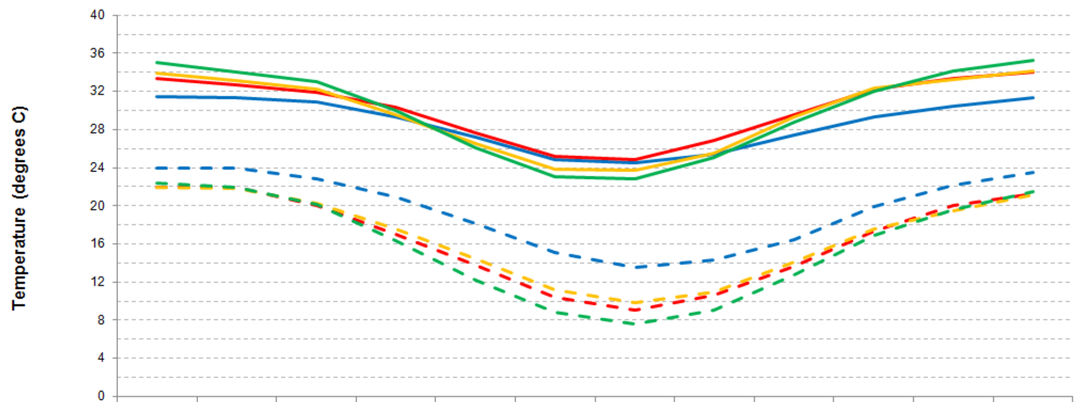
Coal Terminal values taken from the Bowen Airport BOM weather station

Mine values are the average of data from the Barcaldine, Blackall, Claremont and Emerald BOM weather stations

Figure C.13: Long Term Average Rainfall Summary

C.2.1.3 Temperature

Figure C.14 presents the long term average of daily maximum and minimum temperature by the month of the year. In the hot summer months, the mean daily maximum temperature reaches over 31°C at the coal terminal, over 35°C at the mine site, and in-between for other locations. The daily temperature ranges are less for the coal terminal (about 7 – 8 °C) and are more near the mine (about 13 – 15°C), with other sites in between. In the cooler winter months, the mean daily maximum temperature drops to 23 – 25 °C at these locations, and mean daily minimum temperature drop to 13.5°C at the coal terminal and as low as 7.6°C at the mine site, and in-between for other locations



	January	February	March	April	May	June	July	August	September	October	November	December
Port - Mean Max	31.5	31.3	30.9	29.3	27.2	24.9	24.5	25.4	27.4	29.3	30.5	31.4
Port - Mean Min	23.9	23.9	22.8	20.9	18.1	15.1	13.5	14.3	16.4	19.9	22.2	23.5
Collinsville - Mean Max	33.4	32.7	31.9	30.3	27.6	25.2	24.9	26.9	29.6	32.2	33.4	34
Collinsville - Mean Min	21.9	21.9	20	17	13.8	10.4	9	10.6	13.6	17.3	20	21.3
Moranbah - Mean Max	33.9	33.1	32.2	29.6	26.5	23.8	23.7	25.5	29.3	32.4	33.3	34.1
Moranbah - Mean Min	21.9	21.8	20.2	17.6	14.4	11.2	9.8	11	14.1	17.6	19.5	21.1
Mine - Mean Max	35.1	34.0	33.0	30.0	26.1	23.0	22.8	25.0	28.8	32.1	34.2	35.3
Mine - Mean Min	22.4	22.0	20.1	16.4	12.2	8.9	7.6	9.0	12.8	16.9	19.6	21.5

Figure C.14: Long Term Average Daily Temperature Summaries

C.2.1.4 Wind Speed and Direction

Wind roses show the frequency of wind occurrence by direction and strength. The bars correspond to the 8 compass points (N, NE, E, etc.). The bar at each wind direction in the wind rose diagram represents winds blowing from that direction. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds. With the resulting figure it is possible to visualise how often winds of a certain direction and strength occur over a long period, either for all hours of the day, or for particular periods during the day.

Coal Terminal – Start of Rail

Long term 9 AM wind roses for the coal terminal in Figure C.15, produced using wind measurement at Bowen, show that winds are predominately moderate to strong winds from the south-east, with calm conditions occurring for 7% of the monitored period. The 3 PM wind is stronger, predominately from the east, and wind from the north, north-east and south-east is also common. Calm conditions form 0.5% of 3 PM winds.

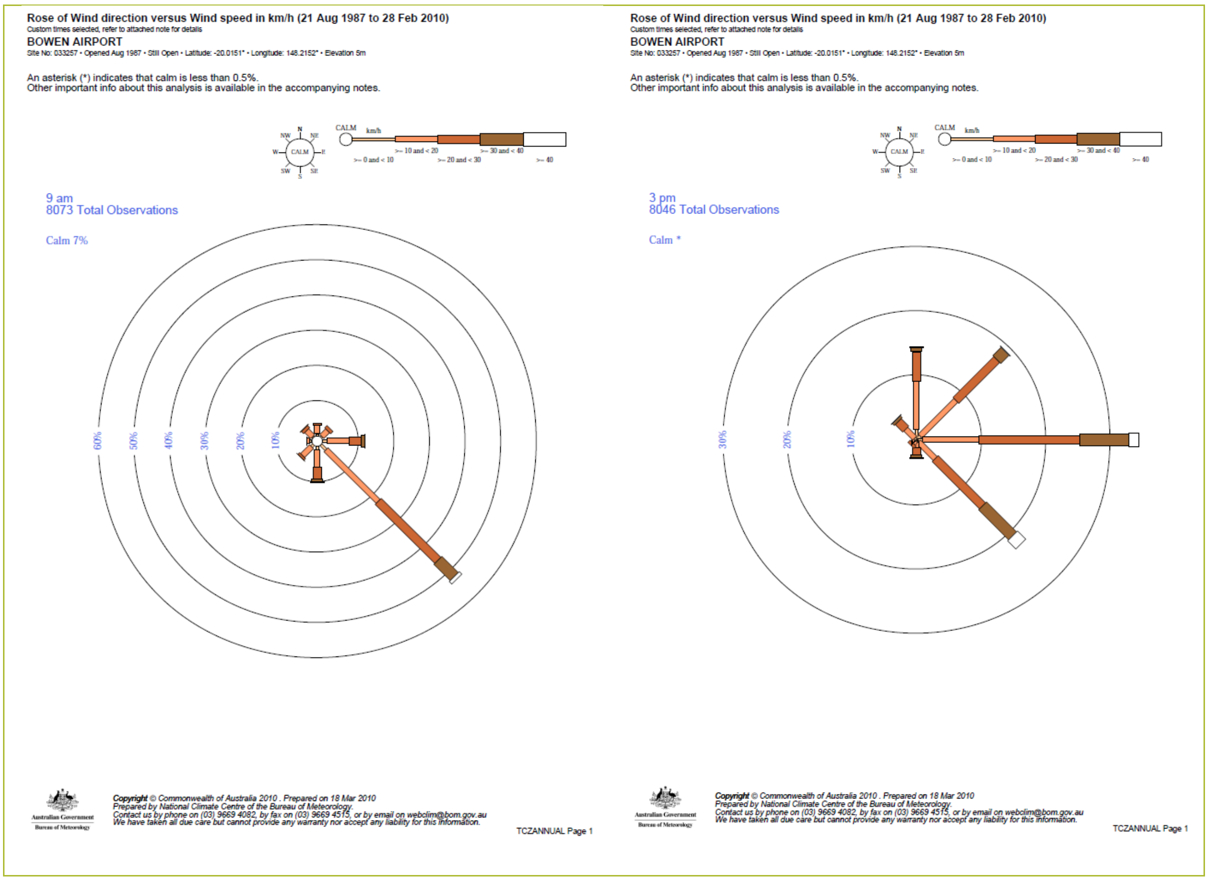


Figure C.15: Long Term Average 9 AM (left) and 3 PM (right) Wind Roses for Bowen

Central Section of Rail

Wind roses from the BOM stations at Proserpine and Moranbah were used to represent the central section of the railway, presented in Figure C.16 and Figure C.17. Here the Proserpine station rather than the Collinsville station data were used because the wind data from the Collinsville BOM station appear to be erroneous (showing long term average winds were almost evenly distributed for all directions – not likely for this location).

Based on wind roses from Proserpine and Moranbah, long term average 9 AM winds for the central section of the railway are predominately from the south-east to east, with calms between 7-24% of the monitored period. Long term average 3 PM winds are generally stronger than for 9 AM, and from the south-east to east. Calms form 0.5-15% of 3 PM winds.

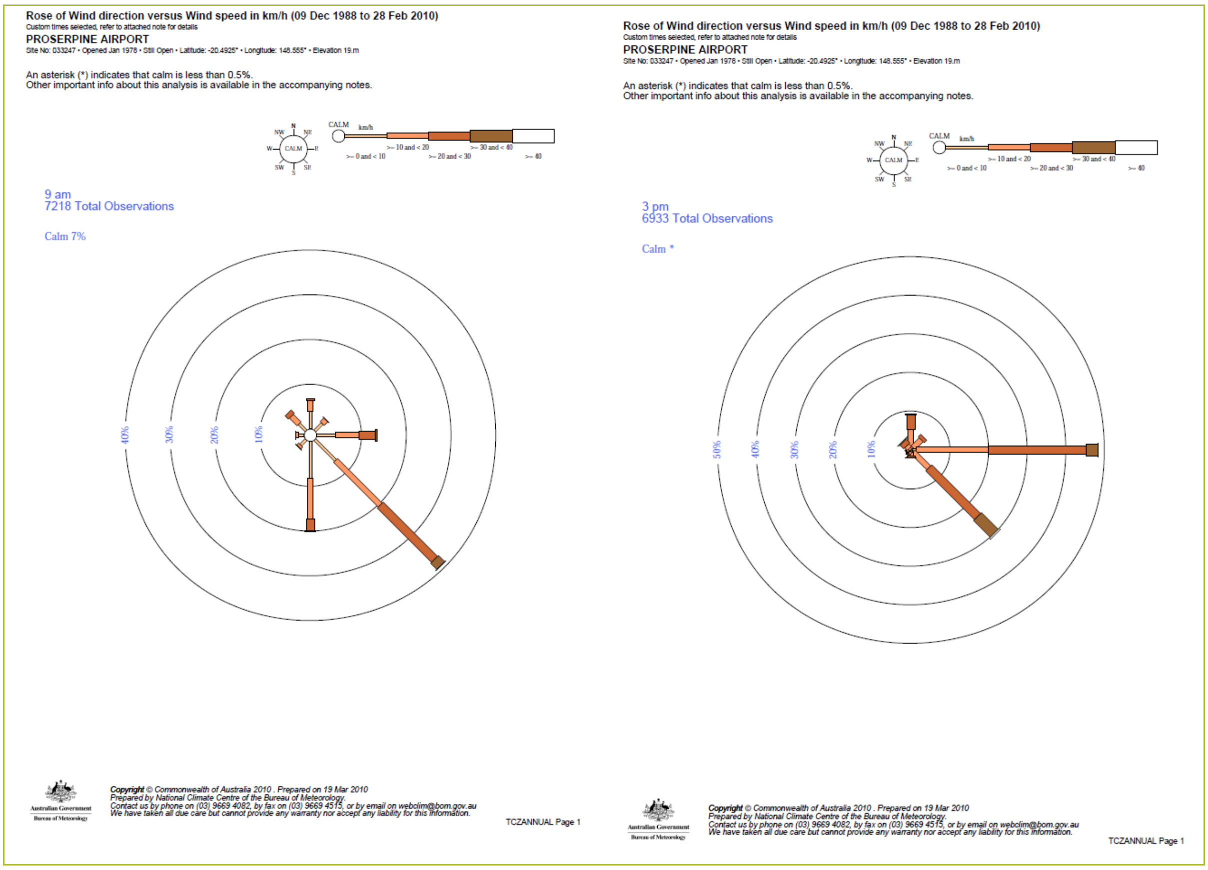


Figure C.16: Long Term Average 9 AM (left) and 3 PM (right) Wind Roses for Proserpine

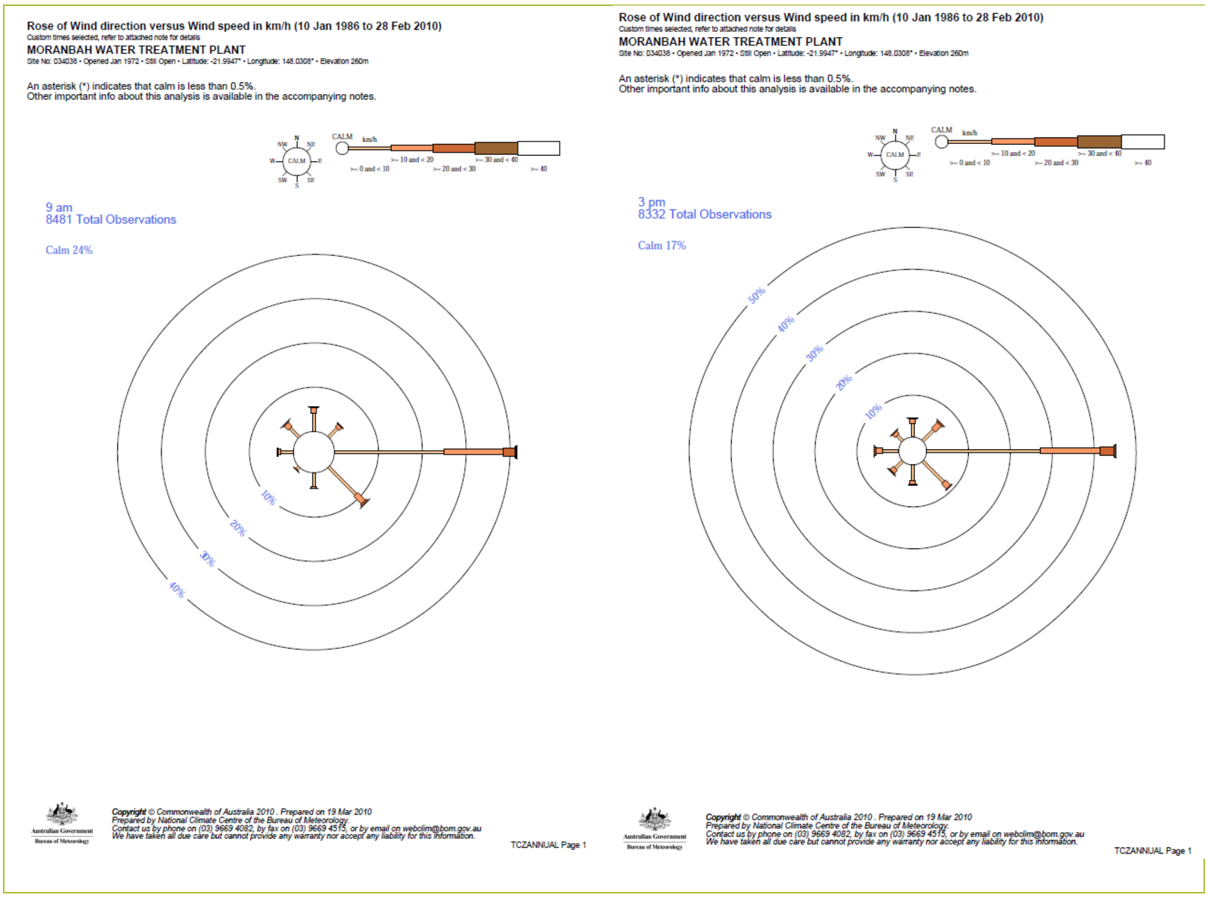


Figure C.17: : Long Term Average 9 AM (left) and 3 PM (right) Wind Roses for Moranbah

Mine – End of Rail

Long term wind roses from two representative locations in the study area (one from the east and one from the west of the study area) show very different wind strengths although similar wind directions across the study area. Emerald, shown in Figure C.18, is located east of the study area and has winds that are frequently from the east with more moderate winds. Barcaldine, shown in Figure C.19, to the west of the study area, also shows more winds from the east but has a higher frequency of low wind speeds. Calms form between 3% and 7% of monitored 9 AM and 3 PM data.

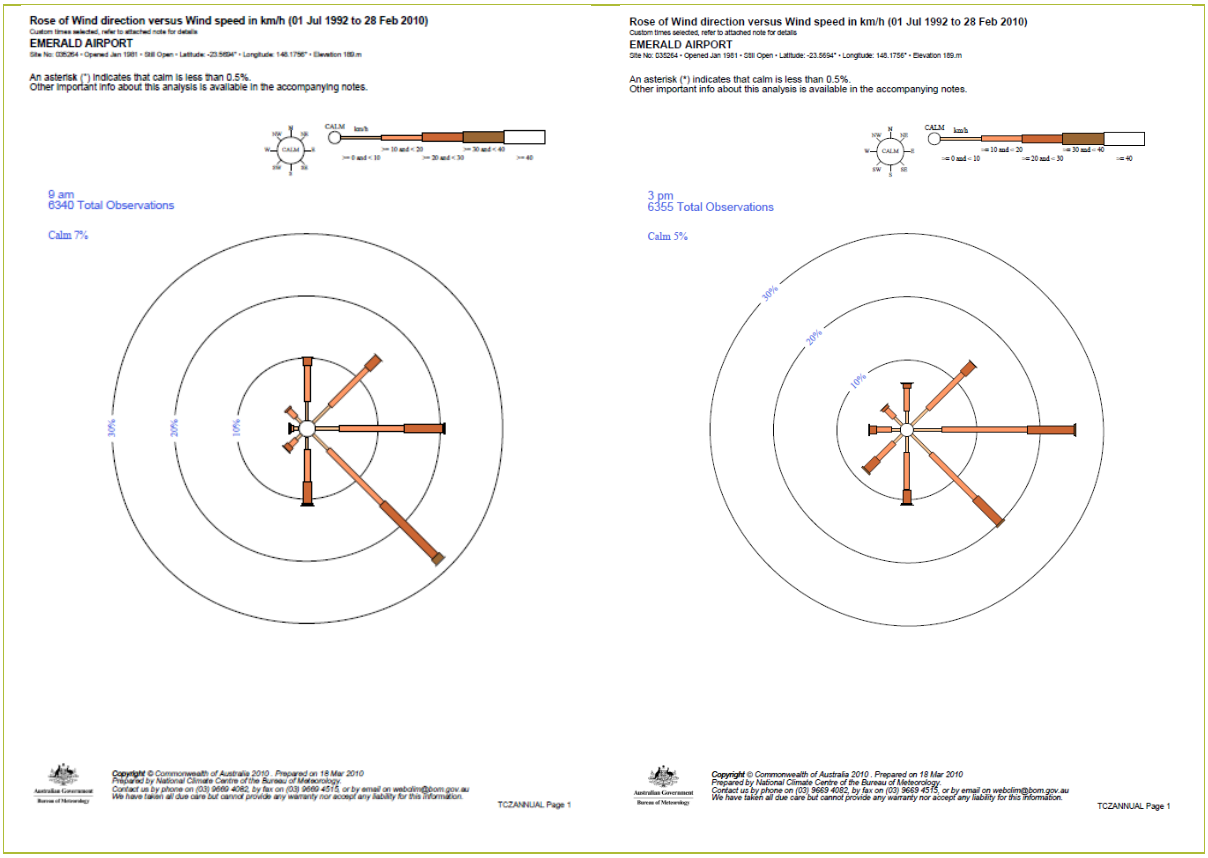


Figure C.18: Long Term Average 9 AM (left) and 3 PM (right) Wind Roses from Emerald Airport

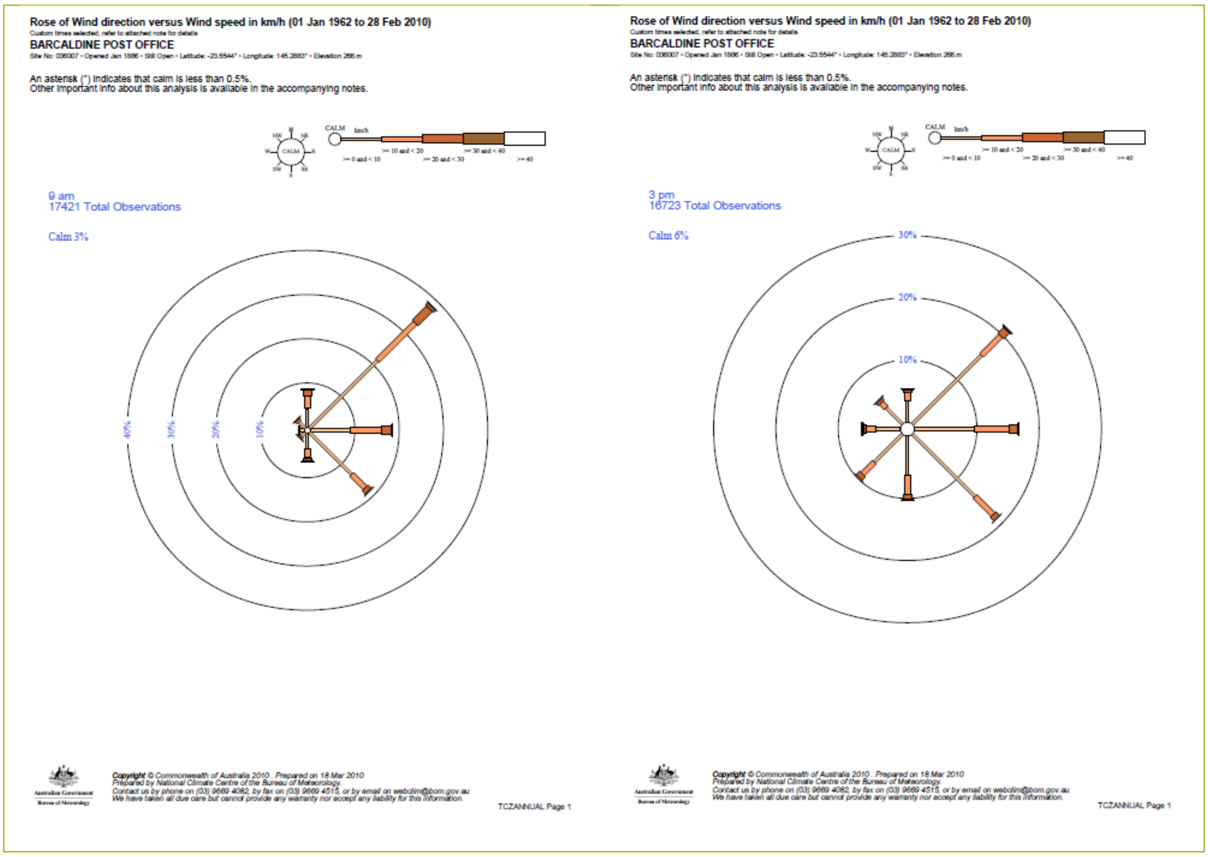
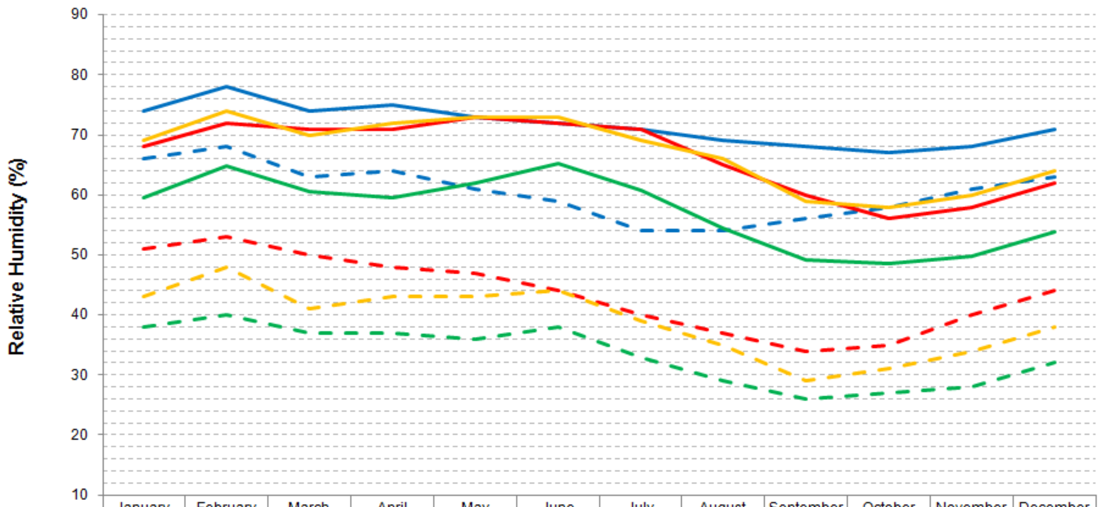


Figure C.19: Long Term Average 9 AM (left) and 3 PM (right) Wind Roses from Barcaldine Airport

C.2.1.5 Relative Humidity

Relative humidity in the study area, presented in Figure C.20, is typically the highest at the coal terminaland the lowest at the mine site. Relative humidity is affected by the distance from the sea with stations further from the ocean having less water vapour available and hence lower relative humidity. Relative humidity for all sections of the railway is highest during the summer, autumn and winter months, and lowest during the spring months.



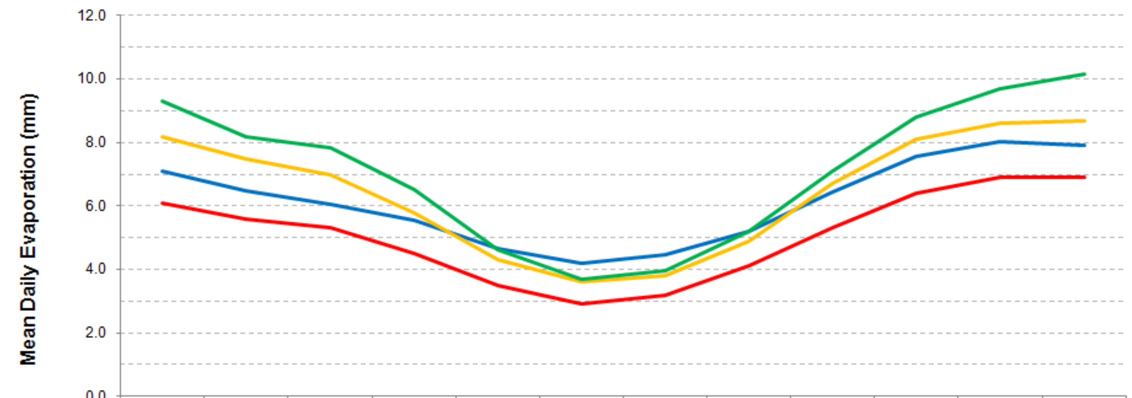
	January	February	March	April	May	June	July	August	September	October	November	December
Port - 9AM	74	78	74	75	73	72	71	69	68	67	68	71
Port - 3PM	66	68	63	64	61	59	54	54	56	58	61	63
Collinsville - 9AM	68	72	71	71	73	72	71	65	60	56	58	62
Collinsville - 3PM	51	53	50	48	47	44	40	37	34	35	40	44
Moranbah - 9AM	69	74	70	72	73	73	69	66	59	58	60	64
Moranbah - 3PM	43	48	41	43	43	44	39	35	29	31	34	38
Mine - 9AM	59.5	64.8	60.5	59.5	62.0	65.3	60.8	54.5	49.3	48.5	49.8	53.8
Mine - 3PM	38	40	37	37	36	38	33	29	26	27	28	32

Figure C.20: Long Term Mean 9 AM and 3 PM Relative Humidity

C.2.1.6 Evaporation

Mean daily evaporation at each of the railway sections, presented in Figure C.21, follow a similar trend, with evaporation during the summer months approximately twice as great as during winter months. This is predominantly due to higher solar radiation and longer hours of daylight during summer. Evaporation rates are also impacted by relative humidity: the drier the air, the higher evaporation would occur.

There is no clear trend of mean daily evaporation increasing or decreasing as the railway moves inland. During the summer months the greatest evaporation occurs at the mine site (8-10 mm), and the least is at Collinsville (6-7 mm). During the winter months, the highest evaporation occurs at the coal terminal(4-5 mm) and the least is at Collinsville (3-4 mm).



	January	February	March	April	May	June	July	August	September	October	November	December
Port	7.1	6.5	6.1	5.6	4.7	4.2	4.5	5.2	6.4	7.6	8.0	7.9
Collinsville	6.1	5.6	5.3	4.5	3.5	2.9	3.2	4.1	5.3	6.4	6.9	6.9
Moranbah	8.2	7.5	7	5.8	4.3	3.6	3.8	4.9	6.7	8.1	8.6	8.7
Mine	9.3	8.2	7.9	6.5	4.6	3.7	4.0	5.2	7.1	8.8	9.7	10.2

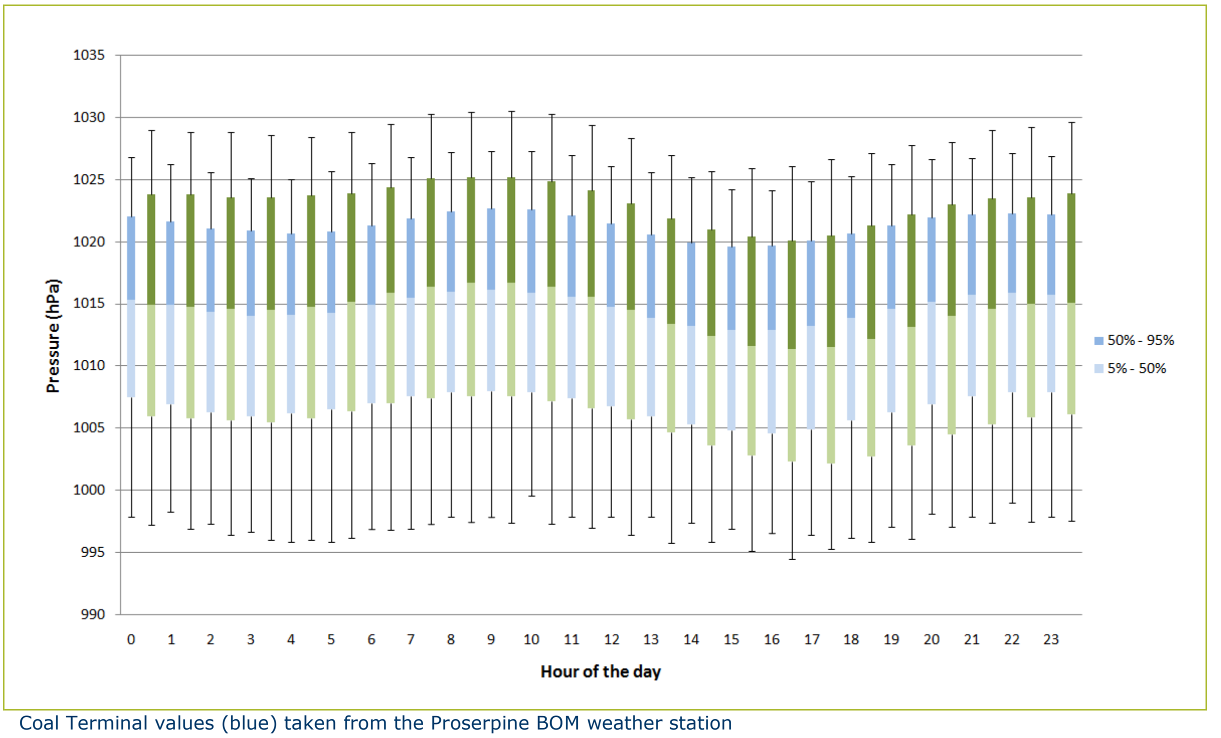
Figure C.21: Mean Daily Evaporation

C.2.1.7 Pressure

Hourly mean and monthly mean sea level pressures for the coal terminal and mine site are presented in Figure C.22 and Figure C.23 respectively. Bars represent (top to bottom) 95th, 50th and 5th percentile values, with error bars representing maximum and minimum values. Data has been taken from the closest available BOM weather stations: Proserpine for the coal terminal and Blackall for the mine. Data was not available for the central railway region.

The hourly graph shows that the median pressure at the mine site and the coal terminal are similar (within 1 hpa), with the range of pressures from minimum to maximum greater at the mine site than at the coal terminal. Both locations follow similar diurnal cycle in pressure, with maximums in the mid morning (7 to 10 am) and minimums during the late afternoon (3 to 5 pm). This is due to a feature often referred to as atmospheric tides. This is where atmospheric solar heating, combined with upward eddy conduction of heat from the ground, generates internal gravity waves in the atmosphere at periods of the integral fractions of a solar day (primarily at the diurnal and semidiurnal periods).

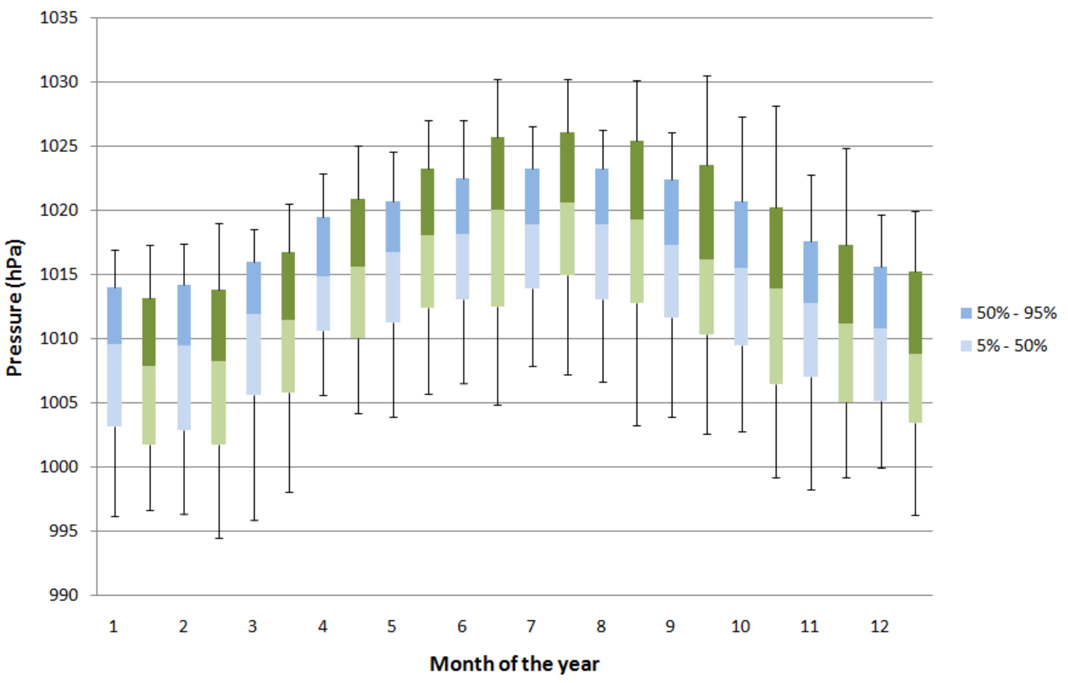
An annual cycle is clearly visible in Figure C.23 for both the coal terminal and the mine site. This reflects the fact that the summer temperature is high and hence pressure is low, opposite to winter.



Coal Terminal values (blue) taken from the Proserpine BOM weather station

Mine values (green) taken from the Blackall BOM weather stations

Figure C.22: Hourly Average Mean Sea Level Pressure for the Coal Terminal (blue) and Mine Site (green)



Coal Terminal values (blue) taken from the Proserpine BOM weather station
Mine values (green)) taken from the Blackall BOM weather stations

Figure C.23: Monthly Average Mean Sea Level Pressure for the Coal Terminal (blue) and Mine Site (green)

C.2.1.8 Temperature Inversions

A temperature inversion refers to a layer of air in the atmosphere in which the temperature increases with height (instead of general profile of decreasing with height). During the night time the ground is cooled by radiating heat into space. Air in contact with the ground then becomes cooler than the air above it, forming a typical night-time near-ground inversion layer. Inversions can form from other mechanisms, such as when warm air moves over a cool surface, and can also form at high altitudes in the atmosphere.

The lack of convective mixing within the lower-level inversion layer means that lower-level pollution can be trapped within the inversion layer, resulting in high pollution levels.

The lower-level temperature inversion strength and frequency have been estimated based on TAPM meteorological modelling output (for the year 2008) for the mine site and the coal terminal. Table C.2 shows that inversion occurs for a greater percentage of the time at the mine site than at the coal terminal. This is because temperature inversions are more pronounced over land than near water, as water holds its heat for longer than land does. From this, it can be expected that the frequency of inversions will increase as the railway moves inland from the coal terminal to the mine site.

Table C.2: Temperature Inversion at Night Time – Mine Site and Coal Terminal (2008)

Night Time Inversion Strength	Mine Site		Coal Terminal	
	Percentage of occurrence (%)	Number of hours	Percentage of occurrence (%)	Number of hours
>3ºC per 100 m	13	1169	1	63
>2ºC per 100 m	20	1750	2	210
>1ºC per 100 m	30	2595	12	1056
>0ºC per 100 m	50	4410	34	2974

C.2.2 **Climate Extremes**

C.2.2.1 Thunder and Lightning

BOM has estimated that the study area experiences 15 to 25 thunder days 9 (BOM, 2010) per year, some of which can result in destructive winds, intense rainfall and flash flooding.

Since 1995 BOM has also been monitoring lightning flashes. Their data (available at www.bom.gov.au) show that on average the study area might expect between 5 and 10 total flashes/km²/year and 1 to 3 ground flashes/km²/year.

C.2.2.2 Tropical Cyclones

Tropical cyclones in the Queensland region mostly form from lows within the monsoon trough, between November and April. The considerable majority of cyclones are formed over tropical waters off north Queensland, and occasionally track to inland and southern parts of the state, where they generally reduce in intensity and become known as ex-tropical cyclones or tropical lows. In some cases tropical lows do re-intensify and re-establish as a tropical cyclone, particularly where they interact with warmer coastal airflows associated with tropical waters.

The number of tropical cyclones in railway region decreases as the railway moves inland from the coal terminal. Between 1906-2006:

- 57 tropical cyclones passed within 200 km of the coal terminal (Figure C.24);
- 27 tropical cyclones passed within 200 km of the centre of the railway (Figure C.25); and
- 15 tropical cyclones passed within 200 km of the mine site (Figure C.26).

The average number of tropical cyclones at the coal terminal site is 0.2-0.4 per year and less than 0.1 per year, based on data from the 1975/76 to 2005/06 cyclone seasons. This period includes El Niño, La Niña and neutral years, however, tropical cyclones impacts in eastern Australia have been shown to occur almost twice more often during La Niña years than during El Niño years.

Trends in tropical cyclone activity in the Australian region have shown that the number of cyclones has decreased in recent decades, although the number of stronger cyclones (with minimum central pressure <970 hPa) has not declined. These trends may be associated with an observed increase in the frequency of El Niño events. It is difficult to determine if trends in tropical cyclone activity are the result of natural variations in large-scale environment in which tropical cyclones form and evolve, or if they are influenced by anthropologic climate change.

The latest predictions indicate that the number of cyclones in eastern Australia is not expected to increase, however projections show more long-lived tropical cyclones in eastern Australian.

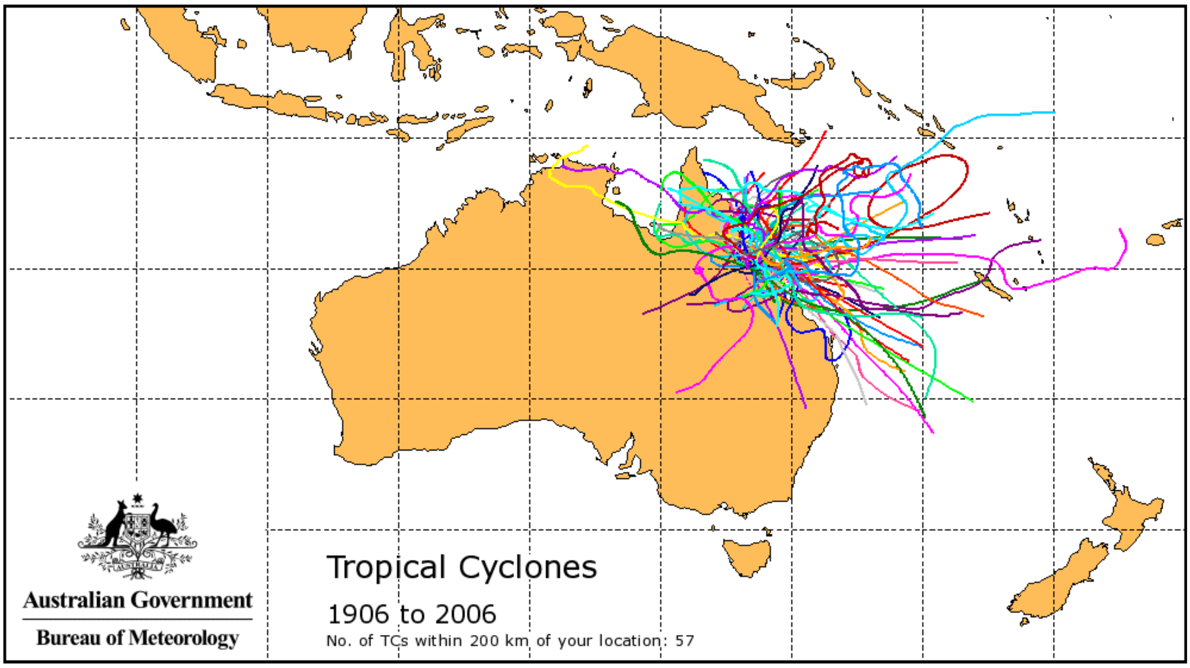


Figure C.24: Number of Tropical Cyclones within 200 km of the Coal Terminal (Bowen) between 1906 and 2006 (BOM, 2010 accessed 10 May 2010)

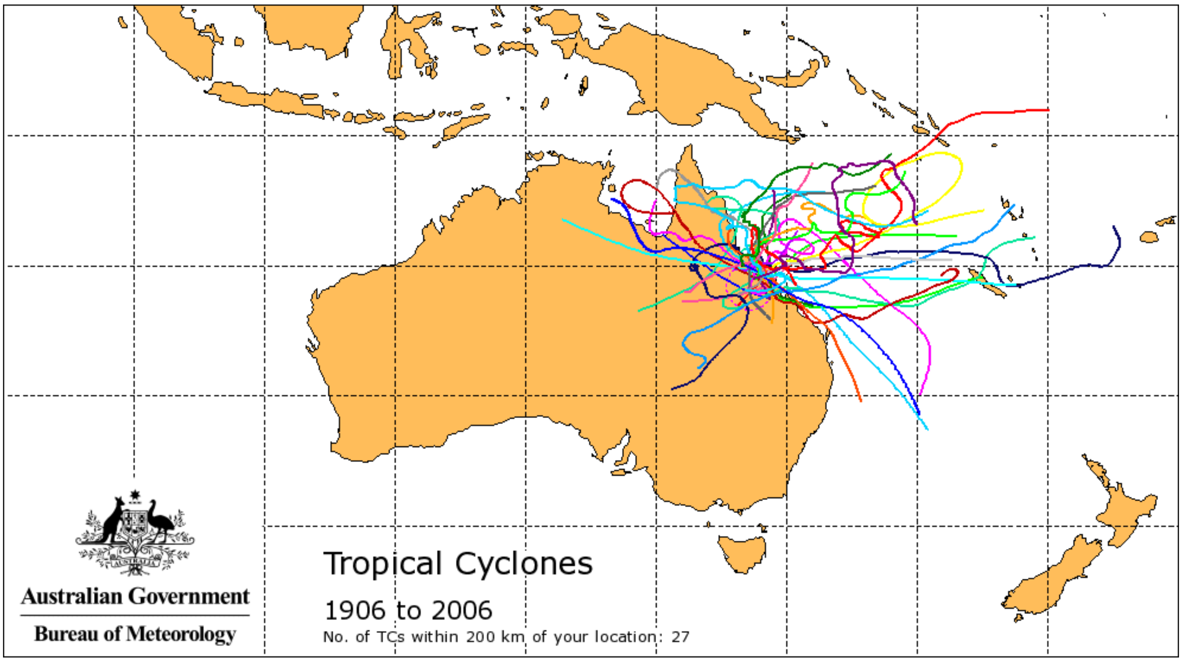


Figure C.25: Number of Tropical Cyclones within 200 km of the Centre of the Railway between 1906 and 2006 (BOM, 2010 accessed 10 May 2010)

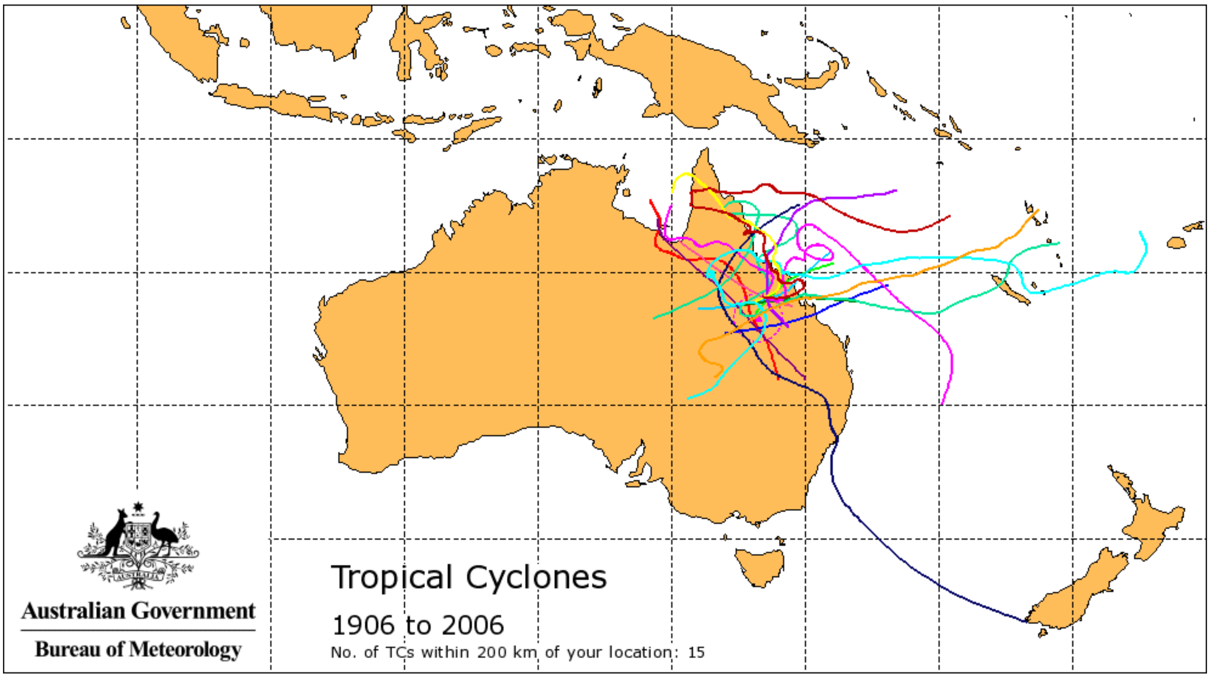


Figure C.26: Number of Tropical Cyclones within 200 km of the Mine Site between 1906 and 2006 (BOM, 2010 accessed 10 May 2010)

C.3 COAL TERMINAL

C.3.1 Climate and Meteorology

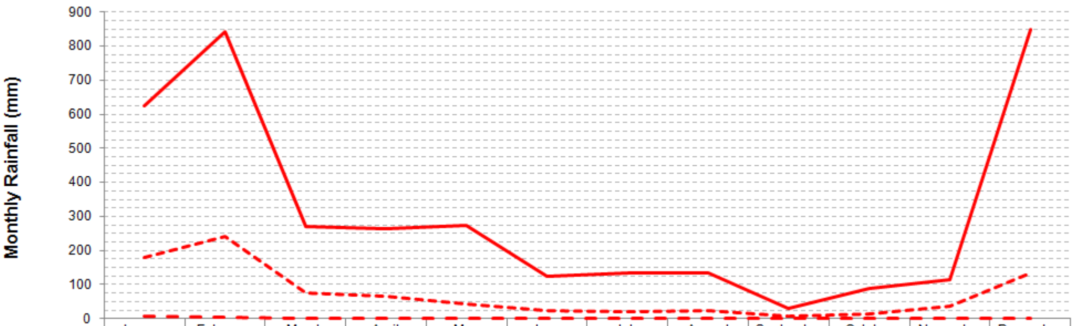
The climate of the study area has a tropical climate, with hot and wet summers, and cool and dry winters. Summer has a monsoonal weather, frequently influenced by tropical cyclones and lows, which cause a lot of rainfall in the coastal areas. The wind direction is predominant from the east, south east and north east, influenced by the trade wind.

C.3.1.1 Meteorological Stations

Climatic conditions for the coal terminal have been assessed using meteorological data from the Bowen Airport, a Bureau of Meteorology (BOM) weather station, except for evaporation. Evaporation data was not available for Bowen Airport, and has been taken from the closest available weather stations: Ayr, Townsville and Te Kowai, which are approximately 115 km north-west, 200 km north-west and 200 km south-east from Bowen respectively. Pressure data was not available from Bowen Airport and was taken from Proserpine, which is approximately 55 km south-east from Bowen.

C.3.1.2 Rainfall

A summary of the long term monthly average rainfall at monitoring locations in the study region is presented in Figure C.1. It shows that rainfall is higher during summer and lower during winter.

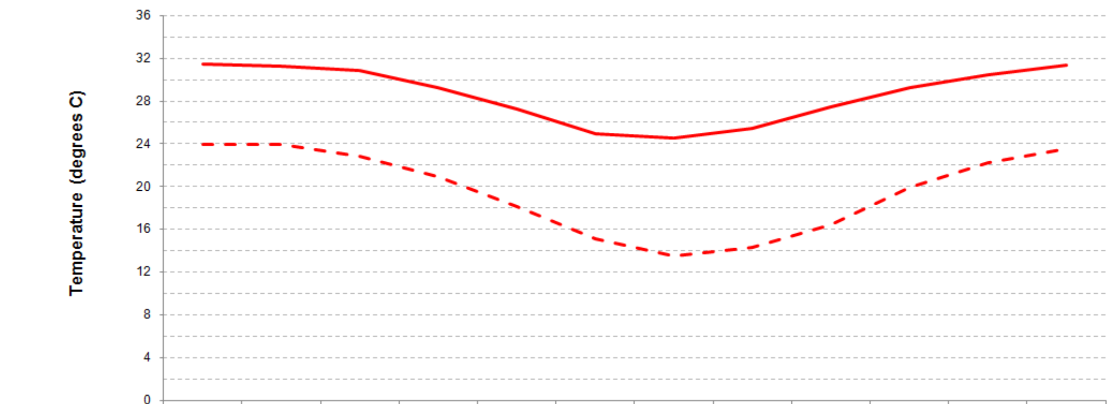


	January	February	March	April	May	June	July	August	September	October	November	December
Bowen - Max	623.1	843.4	269.3	264.2	273	123	135	135.3	29.6	87	114.5	848.5
Bowen - Min	5.8	5.2	0.4	0	0	0	0	0	0	0	0	0.6
Bowen - Average	178.3	242.9	75.7	64.6	44.4	23.9	19.3	22.4	7.2	13.4	35.4	135.1

Figure C.27: Long term average rainfall summary

C.3.1.3 Temperature

Long term average daily temperatures at the coal terminal are presented in Figure C.2. Average maximum temperatures are warm year-round, ranging from 32°C during summer to 25°C during winter. Minimum temperatures range from 24°C during summer to 14°C during winter.



	January	February	March	April	May	June	July	August	September	October	November	December
Bowen - Mean Max	31.5	31.3	30.9	29.3	27.2	24.9	24.5	25.4	27.4	29.3	30.5	31.4
Bowen - Mean Min	23.9	23.9	22.8	20.9	18.1	15.1	13.5	14.3	16.4	19.9	22.2	23.5

Figure C.28: Long term average temperature summaries

C.3.1.4 Wind Speed and Direction

Long term 9 AM and 3 PM wind roses for the coal terminal are presented in Figure C.29. The 9 AM wind roses show that winds are predominately moderate to strong winds from the south-east, with calm conditions occurring for 7% of the monitored period. The 3 PM wind is stronger, predominately from the east, and wind from the north, north-east and south-east is also common. Calm conditions form 0.5% of the 3 PM winds.

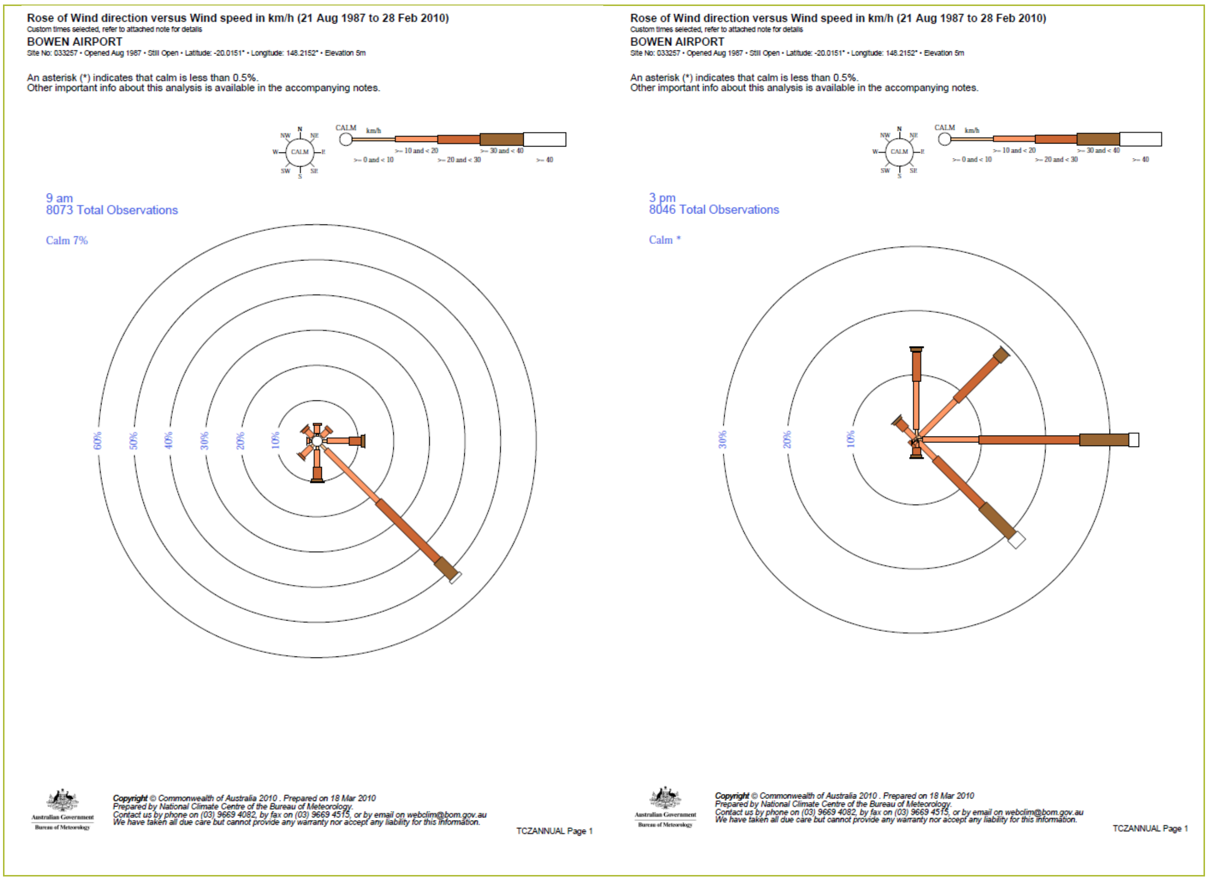
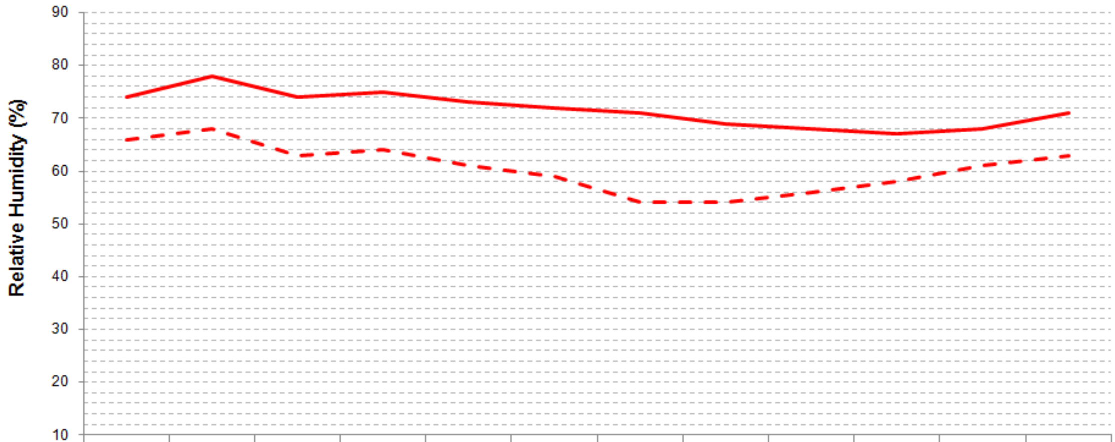


Figure C.29: Long term average 9 AM (left) and 3 PM (right) wind roses for Bowen

C.3.1.5 Relative Humidity

Relative humidity in the study area is typically higher during the summer and autumn months and lower during the winter and spring months, as shown in Figure C.30. The change in 9 AM and 3 PM relative humidity throughout the year is small, due to the coal terminal's proximity to the ocean, which is the major driving force of moisture in the atmosphere.

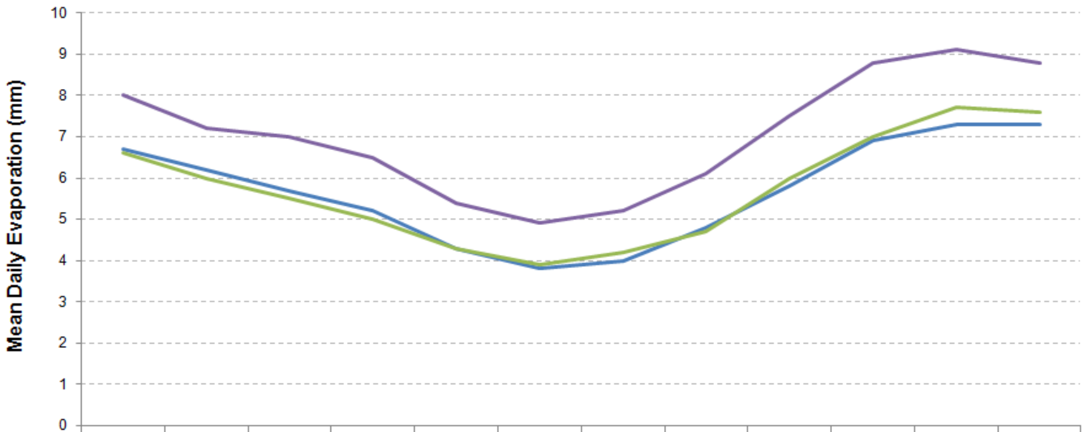


	January	February	March	April	May	June	July	August	September	October	November	December
Bowen - 9AM	74	78	74	75	73	72	71	69	68	67	68	71
Bowen - 3PM	66	68	63	64	61	59	54	54	56	58	61	63

Figure C.30: Long term mean 9 AM and 3 PM relative humidity

C.3.1.6 Evaporation

Mean daily evaporation at the coal terminal is presented in Figure C.31, based on data from Townsville, Ayr and Te Kowai. All sites follow a similar trend, with evaporation during the summer months approximately twice as great as during winter months. This is predominantly due to higher solar radiation and longer hours of daylight during summer. Evaporation rates are also impacted by relative humidity: the drier the air, the higher evaporation would occur.



	January	February	March	April	May	June	July	August	September	October	November	December
Townsville	8	7.2	7	6.5	5.4	4.9	5.2	6.1	7.5	8.8	9.1	8.8
Ayr	6.7	6.2	5.7	5.2	4.3	3.8	4	4.8	5.8	6.9	7.3	7.3
Te Kowai	6.6	6	5.5	5	4.3	3.9	4.2	4.7	6	7	7.7	7.6

Figure C.31: Mean daily evaporation

C.3.1.7 Pressure

Hourly mean and monthly mean minimum, 5th and 95th percentile, median and maximum pressures are presented from Figure C.6 to Figure C.7 respectively. The hourly graph shows that pressure follows a diurnal, with a maximum in the mid morning (7 to 10 am) and a minimum during the late afternoon (3 to 5 pm). This is due to a feature often referred to as atmospheric tides. This is where atmospheric solar heating, combined with upward eddy conduction of heat from the ground, generates internal gravity waves in the atmosphere at periods of the integral fractions of a solar day (primarily at the diurnal and semidiurnal periods).

An annual cycle is clearly visible in Figure C.7 which reflects the fact that the sub tropic anticyclone belt migrates north during winter resulting in higher pressures.

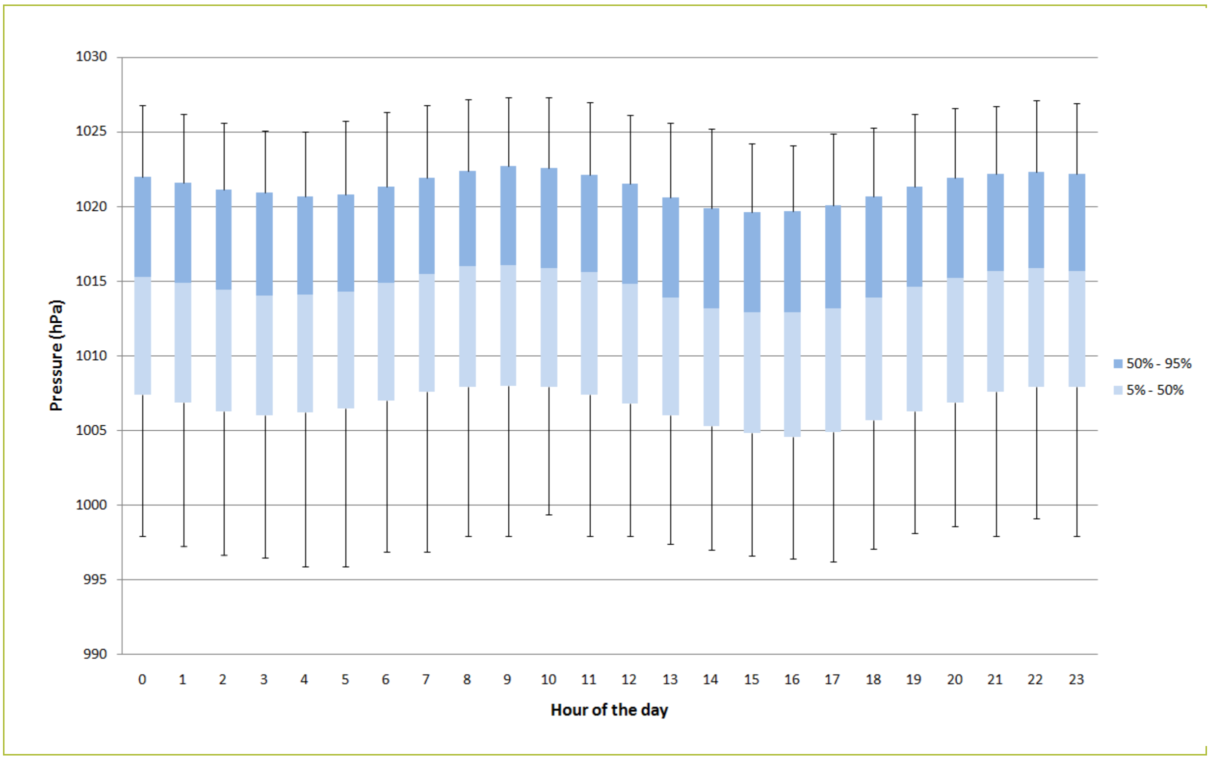


Figure C.32: Hourly average mean sea level pressure from 2001 to 2010

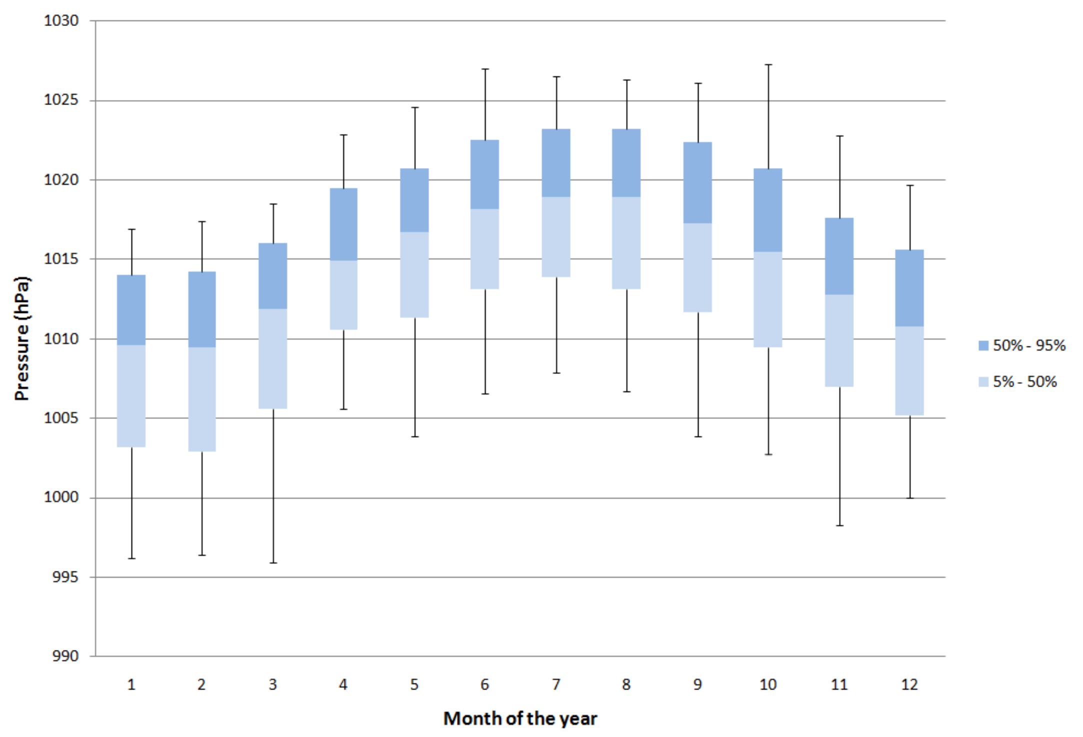


Figure C.33: Monthly average mean sea level pressure from 2001 to 2010

C.3.1.8 Temperature Inversions

A temperature inversion refers to a layer of air in the atmosphere in which the temperature increases with height (instead of general profile of decreasing with height). During the night time the ground is cooled by radiating heat into space. Air in contact with the ground then becomes cooler than the air above it, forming a typical night-time near-ground inversion layer. Inversions can form from other mechanisms, such as when warm air moves over a cool surface, and can also form at high altitudes in the atmosphere.

The lack of convective mixing within the lower-level inversion layer means that lower-level pollution can be trapped within the inversion layer, resulting in high pollution levels. This phenomenon is much more pronounced over land than it is over water, as water holds its heat for longer than land does.

The temperature inversion strength and frequency have been estimated based on TAPM meteorological modelling output (for the year 2008) for the coal terminal area. Analysis of the inversions (see Table C.) show that strong inversions occur in 1% of occasions.

Table C.3: Temperature Inversion at Night Time - Coal Terminal (2008)

Night Time Inversion Strength	Percentage of occurrence (%)	Number of hours
>3ºC per 100 m	1	63
>2ºC per 100 m	2	210
>1ºC per 100 m	12	1056
>0ºC per 100 m	34	2974

C.3.2 **Climate Extremes**

C.3.2.1 Thunder and Lightning

BOM has estimated that the study area experiences 15 to 25 thunder days (BOM, 2010) per year, some of which can result in destructive winds, intense rainfall and flash flooding.

Since 1995 BOM has also been monitoring lightning flashes. Their data (available at www.bom.gov.au) show that on average the study area might expect between 5 and 10 total flashes/km²/year and 1 to 3 ground flashes/km²/year.

C.3.2.2 Tropical Cyclones

Tropical cyclones in the Queensland region mostly form from lows within the monsoon trough, between November and April. The considerable majority of cyclones are formed over tropical waters off north Queensland, and occasionally track to inland and southern parts of the state, where they generally reduce in intensity and become known as ex-tropical cyclones or tropical lows. In some cases tropical lows do re-intensify and re-establish as a tropical cyclone, particularly where they interact with warmer coastal airflows associated with tropical waters.

Between 1906-2006, 57 tropical cyclones passed within 200 km of the coal terminal (Figure C.25) and 10 tropical cyclones passed within 50 km of the coal terminal (Figure C.35). The average number of tropical cyclones at the coal terminal site is 0.2-0.4 per year, based on data from the 1975/76 to 2005/06 cyclone seasons. This period includes El Niño, La Niña and neutral years, however, tropical cyclones impacts in eastern Australia have been shown to occur almost twice more often during La Niña years than during El Niño years.

Trends in tropical cyclone activity in the Australian region have shown that the number of cyclones has decreased in recent decades, although the number of stronger cyclones (with minimum central pressure <970 hPa) has not declined. These trends may be associated with an observed increase in the frequency of El Niño events. It is difficult to determine if trends in tropical cyclone activity are the result of natural variations in large-scale environment in which tropical cyclones form and evolve, or if they are influenced by anthropologic climate change.

The latest predictions indicate that the number of cyclones in eastern Australia is not expected to increase, however projections show more long-lived tropical cyclones in eastern Australian.

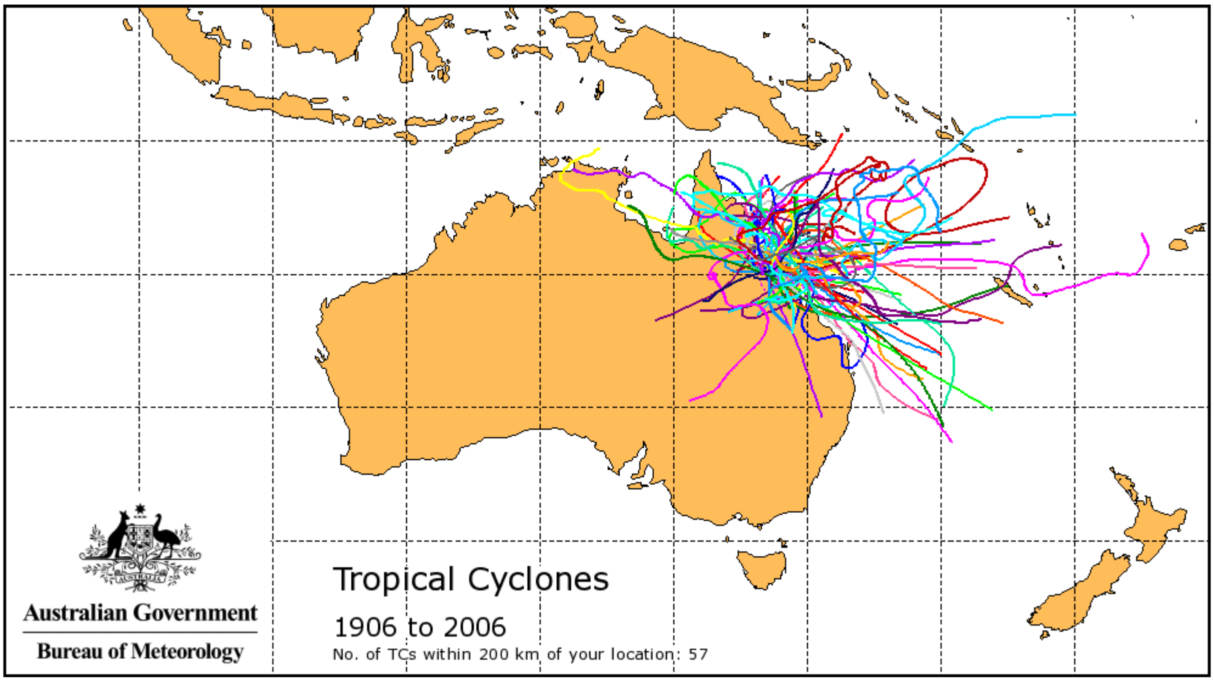


Figure C.34: Number of Tropical Cyclones within 200 km of the Coal Terminal(Bowen) between 1906 and 2006 (BOM, 2010 accessed 10 May 2010)

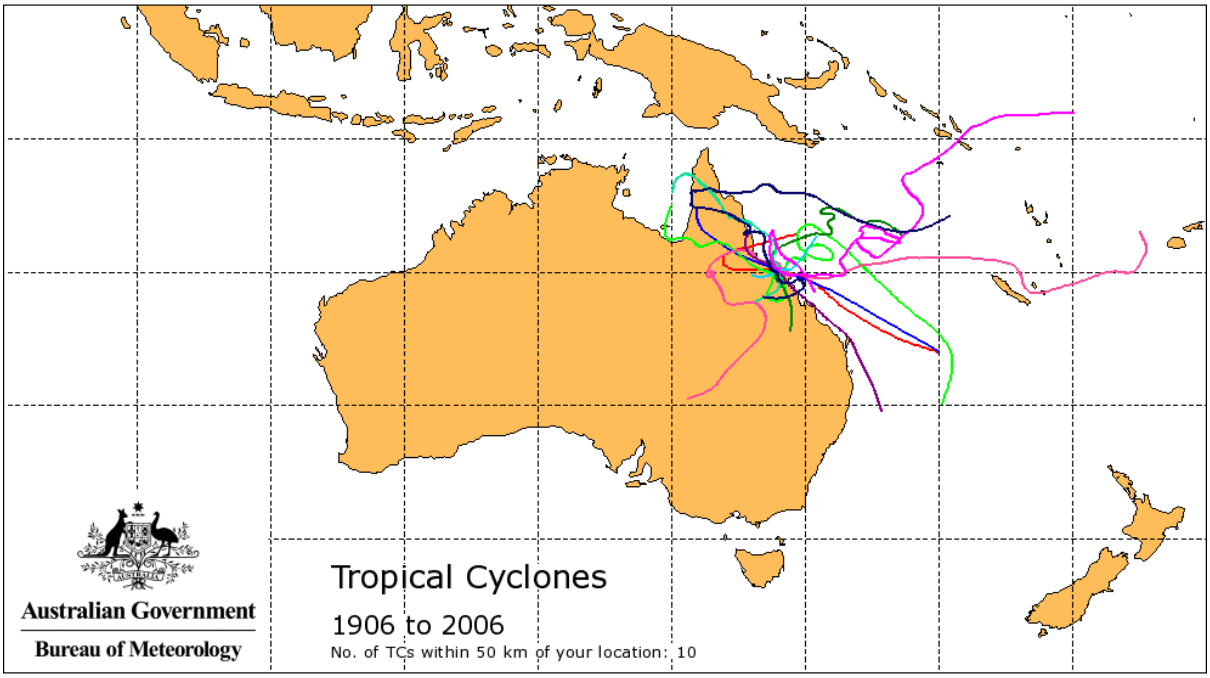


Figure C.35: Number of Tropical Cyclones within 50 km of the Coal Terminal(Bowen) between 1906 and 2006 (BOM, 2010 accessed 10 May 2010)