Narrabri Mine Modification 5

Environmental Assessment

APPENDIX E

Air Quality and Greenhouse Gas Assessment

Resource Strategies

WHITEHAVEN COAL

Intended for
Narrabri Coal Operations Pty Ltd

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AIR QUALITY AND GREENHOUSE GAS ASSESSMENT
NARRABRI MINE MODIFICATION 5

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1. INTRODUCTION

The Narrabri Mine (NM) is an underground coal mining operation located approximately 28 kilometres (km) south-east of Narrabri and approximately 65 km north-west of Gunnedah in the Gunnedah Basin, New South Wales (NSW) (**Figure 1-1**).

The NM is operated by Narrabri Coal Operations Pty Ltd (NCOPL) on behalf of the Narrabri Joint Venture, which consists of Whitehaven Coal Limited's subsidiary Narrabri Coal Pty Ltd (70%), Upper Horn Investments (Australia) Pty Ltd (7.5%), J-Power Australia Pty Limited (7.5%), EDF Trading Australia Pty Limited (7.5%), and Daewoo International Narrabri Investment Pty Limited and Kores Narrabri Pty Limited (7.5%).

Stage 1 of the NM was originally approved under Part 3A of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) in 2007 and involved initial site establishment activities and continuous miner mining operations.

Project Approval (08_0144) for Stage 2 of the NM was issued in 2010 and allowed the mine to convert to a longwall mining operation.

Project Approval (08_0144) allows for the production and processing of up to 8 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal for a period of 21 years. ROM coal is processed at the NM to produce thermal and PCI product coal. Product coal is transported from the NM by rail to Newcastle.

In 2011, NCOPL submitted two minor applications to modify Project Approval (08_0144) under Section 75W of the EP&A Act to update subsidence management conditions in Project Approval 08_0144 and to allow for the one-off road transport of coal to the Tarrawonga Coal Mine. A third application to modify Project Approval (08_0144) under Section 75W of the EP&A Act submitted in 2012 was withdrawn.

In April 2015, NCOPL submitted an application to modify Project Approval (08_0144) under Section 75W of the EP&A Act to increase the capacity of the existing ROM and product coal stockpiles (the Stockpile Extension Modification). ENVIRON Australia Pty Limited (ENVIRON) (2015) prepared an Air Quality Assessment for the Stockpile Extension Modification. The Stockpile Extension Modification is currently being assessed by the Department of Planning and Environment. Notwithstanding, the Stockpile Extension Modification has been assumed to have been approved for the purposes of this Air Quality Assessment.

NCOPL is currently seeking a separate modification to Project Approval (08_0144) under Section 75W of the EP&A Act to reconfigure the approved underground mine geometry and to increase the ROM coal production rate (Modification 5 [the Modification]).

NCOPL has commissioned ENVIRON to complete an Air Quality and Greenhouse Gas Assessment for the Modification.

1.1 Study objectives and requirements

The Air Quality and Greenhouse Gas Assessment has been prepared in accordance with the:

- Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales ("the Approved Methods") (NSW Environment Protection Authority [EPA], 2005a).
- National Greenhouse Accounts Factors (NGAF) (Department of the Environment [DoE], 2014a).
- Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia. National Greenhouse and Energy Reporting (Measurement) Determination (DoE, 2014b).

The report presents a quantitative assessment of potential air quality impacts, with a particular focus on dust emissions (including particulate matter less than 10 microns in aerodynamic diameter [PM_{10}] and particulate matter less than 2.5 microns in aerodynamic diameter [$PM_{2.5}$]) from the modified NM. An updated estimate of the greenhouse gas emissions associated with the modified NM is also presented.

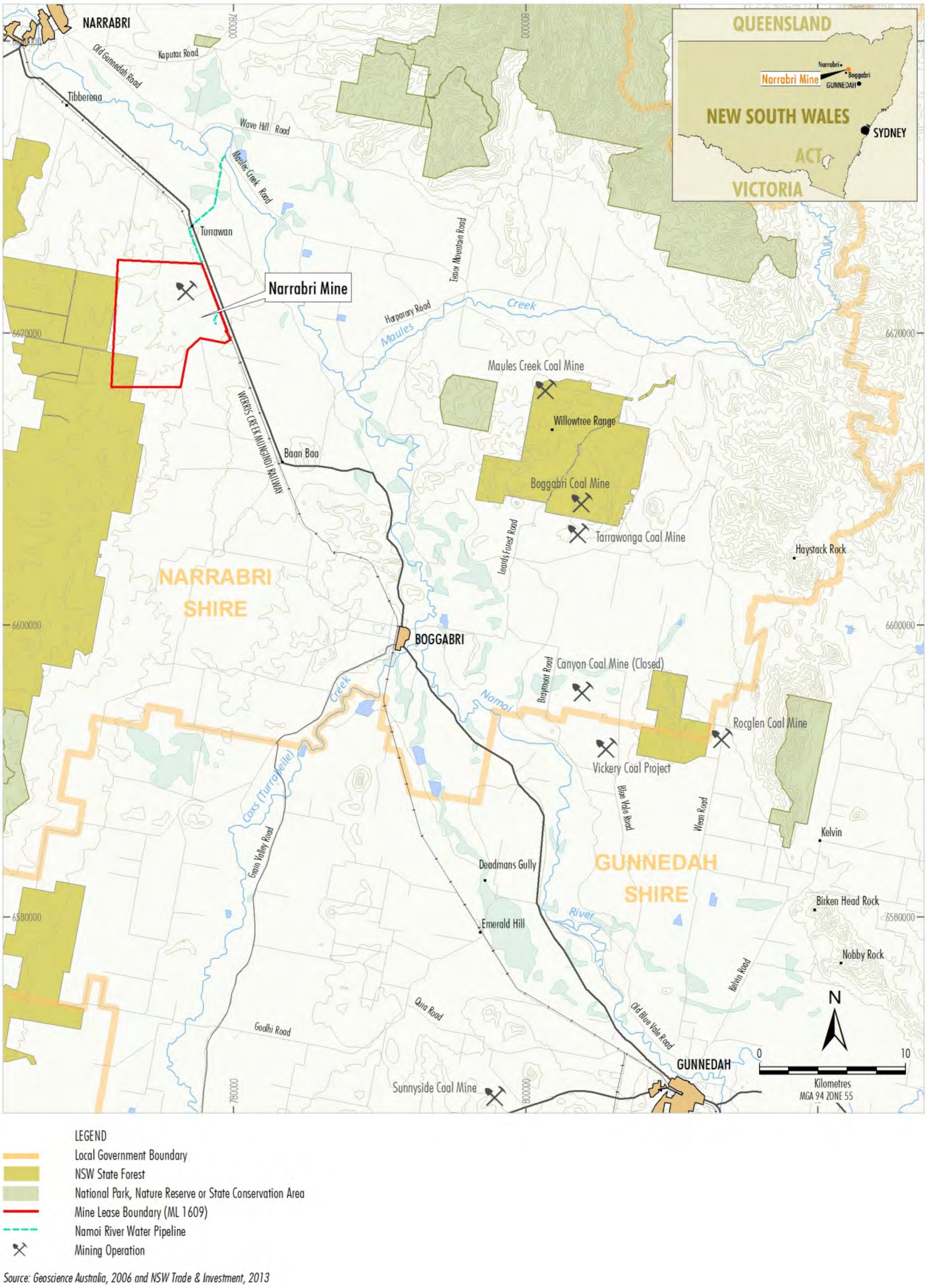

Figure 1-1: Regional setting

2. OVERVIEW OF OPERATIONS

Project Approval (08_0144) allows for the production and processing of up to 8 Mtpa of ROM coal for a period of 21 years. ROM coal is processed at the NM to produce thermal and PCI product coal which is transported from the NM by rail to the Port of Newcastle.

ROM coal from the underground workings is conveyed to a drift conveyor and stacked by means of a reversible tripper onto the ROM coal stockpile. ROM coal is then either fed through reclaim valves to a rotary breaker or fed by dozer push to a hopper which feeds a secondary bypass crusher. Coal from the rotary breaker is conveyed to the coal handling and preparation plant (CHPP) where thermal and PCI products are separated. Coal from the secondary bypass crusher is loaded directly to the thermal product stockpile. Waste from the CHPP is minimal and is blended back into the thermal product within the CHPP building, while waste from the rotary breaker is conveyed to the rejects pile.

2.1 Overview of the Modification

The Modification would involve:

- An increase in longwall panel widths for LW107 to LW120 from 295 metres (m) to 400 m (LW101 to LW106 unchanged) (**Figure 2-1**).
- A reduction in the number of longwall panels from 26 to 20 (**Figure 2-1**).
- A western extension of underground mine footprint relative to the existing/approved underground mine footprint of approximately 60 m within ML 1609 (**Figure 2-1**).
- An increase in the ROM coal production from 8 Mtpa up to approximately 11 Mtpa.
- Continuation of pre-conditioning of the Digby Conglomerate to prevent or minimise the impact of wind blast in the underground workings.
- Minor amendments to the site water management system.
- An increase in the average number of trains from 3 trains/day to 4 trains/day (peak would remain unchanged).

In addition, the Modification would include minor changes to coal processing operations to accommodate the increased ROM coal production, as follows:

- ROM coal would be split approximately 60/40 between the rotary breaker and bypass crusher rather than the existing 67/33 split.
- The rotary breaker yield would be greater than 98% (with less than 2% waste directed to the rejects pile) rather than 96% (with less than 4% waste directed to the rejects pile).
- Product coal from the CHPP would be split approximately 70/30 between the thermal and PCI product stockpiles rather than the existing 73/27 split.

There would be no change to the mine fleet, CHPP or coal handling infrastructure assessed in the Stockpile Extension Modification.

The modified NM general arrangement is shown on **Figure 2-1**[1].

A detailed description of the Modification is provided in the Environmental Assessment.

[1] The general arrangement shown on Figure 2-1 assumes that the Stockpile Extension Modification has been approved (Section 1).

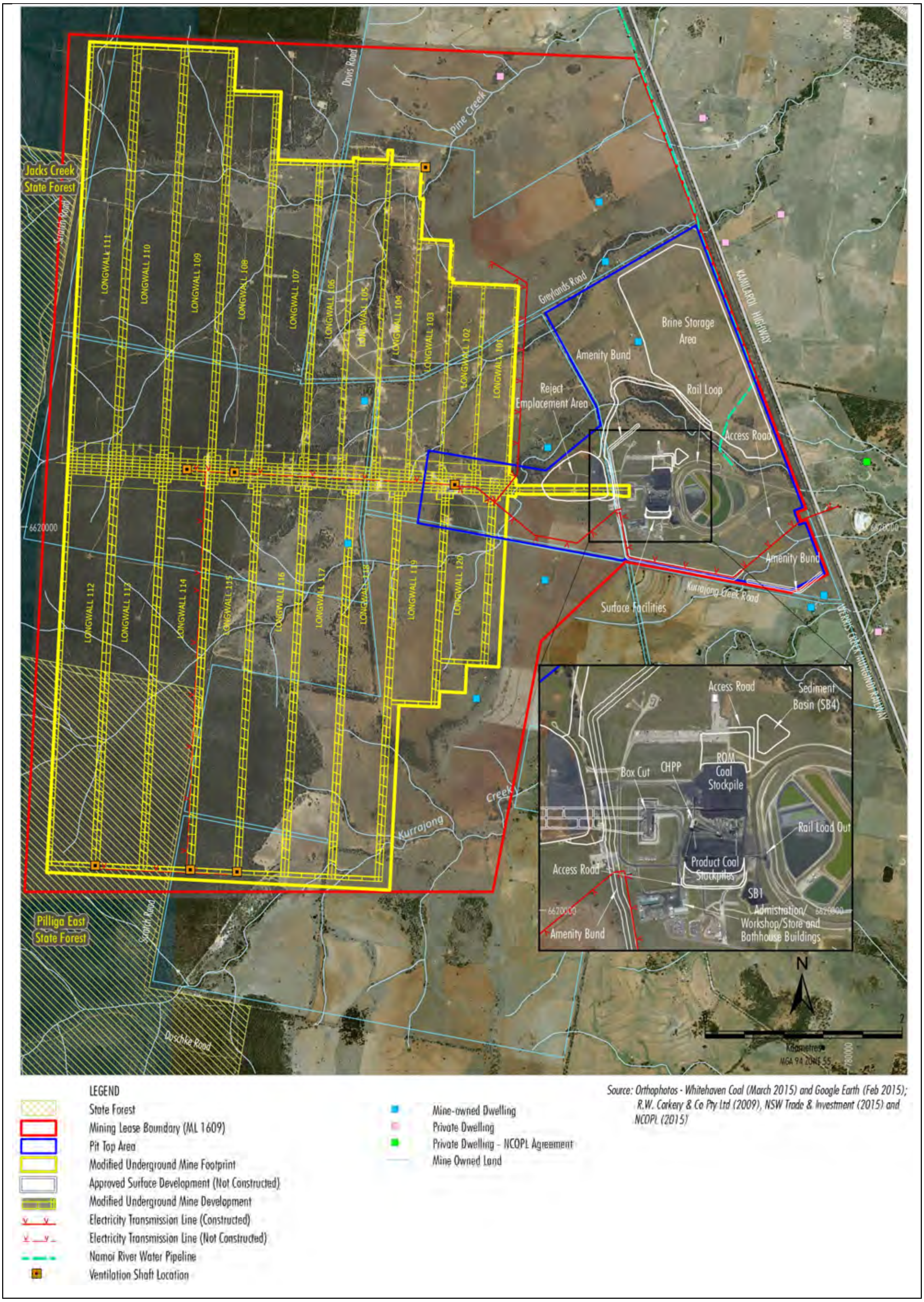

Figure 2-1: Modified Narrabri Mine general arrangement

2.2 Project approval

Project Approval (08_0144) outlines conditions specific to air quality management which include impact assessment criteria, monitoring requirements and statement of commitments.

2.2.1 Impact assessment criteria

Condition 6, Schedule 4 of Project Approval (08_0144) requires that NCOPL ensure no additional exceedances of the impact assessment criteria, at any residence on privately owned land or on more than 25% of any privately owned land. The impact assessment criteria are given in **Table 2-1**, **Table 2-2** and **Table 2-3**.

Table 2-1: Long term impact assessment criteria for particulate matter

Pollutant	Averaging Period	Criterion
Total Suspended Particulates (TSP)	Annual	90 µg/m³
PM_{10}	Annual	30 µg/m³

µg/m³ = micrograms per cubic metre.

Table 2-2: Short term impact assessment criteria for particulate matter

Pollutant	Averaging Period	Criterion
PM_{10}	24 hours	50 µg/m³

µg/m³ = micrograms per cubic metre.

Table 2-3: Long term impact assessment criteria for deposited dust

Pollutant	Averaging Period	Maximum increase	Maximum total
Deposited Dust	Annual	2 g/m²/month	4 g/m²/month

g/m²/month = grams per square metre per month.

2.2.2 Monitoring requirements

Conditions 7 and 8, Schedule 4 of Project Approval (08_0144) outline the requirement for NCOPL to implement dust deposition, PM_{10} and meteorological monitoring, in accordance with the Approved Methods (NSW EPA, 2005b). Further requirements are outlined in the statement of commitments (**Section 2.2.3**).

2.2.3 Statement of commitments

The statement of commitments is included in Appendix 3 of Project Approval (08_0144) and their relevance to this study is outlined below in **Table 2-4**.

Table 2-4: Statement of commitment for air quality

Commitment	Timing	Relevance to this study
Minimise the extent of clearing across the mine site including the campaigns to construct the area for reject emplacement and brine storage ponds.	Ongoing	N/A
Retain cleared trees and branches on the margins of cleared areas for use in stabilising disturbed areas once they are no longer required.		N/A
Undertake soil stripping at times when most appropriate (such as when there is sufficient soil moisture to prevent significant lift off of dust and at times other than periods of high winds.		Controls applied in emissions inventory calculation.
Operate water sprays on all continuous miners, the longwall unit and the breaker feeder to minimise dust creation underground.		N/A
Apply water to the coal at the feed hopper, crusher and at all conveyor transfer and discharge points.		Controls applied in emissions inventory calculation.
Fit all surface conveyors with collection devices to minimise the amount of material falling from the return conveyor belts.	Prior to commencement of coal processing	Included as best practice dust control measure but not included in emission inventory calculation due to lack of published control factors, resulting in a conservative overestimate of emissions.
Enclose the rotary breaker.		Controls applied in emissions inventory calculation.
Partially enclose all surface conveyors to minimise dust lift off.		
Cease construction of the brine storage ponds when the prevailing winds are from the northwest quadrant.	Ongoing	N/A
Apply water onto stockpiles and hardstand areas.	Ongoing	Stockpile controls applied in emissions inventory calculation with consideration also to the findings in SMEC (2014).
Progressively rehabilitate areas of disturbance including gas drainage areas.	Ongoing	Included in emissions inventory calculation based on assumed areas of exposed or active rehabilitation.
Progressively rehabilitate areas no longer required for operational purposes.		
Minimise the length of time coal is held in stockpiles.	Ongoing	Included in emissions inventory calculation based on assumed coal moisture contents.
Monitor coal for signs of spontaneous combustion.		Ongoing air quality controls but not considered relevant to this study.
Immediately report incidents to the appropriate authorities.		
Extinguish fire by removal from stockpile, spreading and saturation with water.	In the event of ignition	
Install underground ventilation system to provide fresh air to employees.	Ongoing	
Optimise and schedule vehicle operations to minimise vehicle movements.		

Commitment	Timing	Relevance to this study
Maintain engines according to manufacturers' guidelines and keep tyres at optimal pressure.		
Minimise vehicle idling time.		
Prepare an updated energy savings plan.	Within 12 months of approval	The Energy Savings Action Plan is considered as part of the mitigation measures for GHG emissions (**Section 11**).
Monitor dust deposition levels at 8 sites (ND1 – ND8).	Monthly	Data reviewed to describe existing environment (**Section 6**).
Monitor PM_{10} levels at 2 sites (ND9 and ND10).	1 in 6 days	
Review and submit dust monitoring results to relevant government agency.	Annually	

2.2.4 Annual Environmental Management Report

In accordance with Project Approval (08_0144), each year NCOPL prepare annual environmental management reports (AEMR)/annual reviews (NCOPL, 2009; 2010; 2011; 2012; 2013; 2014 and 2015). The AEMR provides a review of environmental performance and includes a summary of the air quality monitoring data collected for the period.

A number of complaints are reported relating to the generation of visible dust from the coal handling and processing area. In response, NCOPL developed and implemented a Trigger Action Response Plan (TARP) for dust generation from the coal handling and processing area and is implementing a number of measures to reduce emissions, including:

- Installation of a fully automated water spray system for ROM and product coal stockpiles (**Section 2.3**).
- Better maintenance to remove fine dust from toe of stockpiles and dozer travel routes.
- Converting D10 dozers to D11 dozers to reduce dust emissions.
- Installation of fixed chutes on the product coal skyline gantry to reduce emissions during product loading during unfavourable weather conditions.
- Dust awareness training.

2.3 Pollution Reduction Programs

As a scheduled premises, the NM operates under an Environmental Protection Licence (EPL 12789) which outlines air quality monitoring and reporting requirements. In accordance with previous EPL 12789 requirements, NCOPL has completed the following Pollution Reduction Programs (PRPs) to the satisfaction of the EPA:

- Narrabri Mine: Air Quality Control Protocol (November 2013);
- Implementation of Practical Best Management Practices - Dust Mitigation (December 2013 and February 2014); and
- TARP pit top area dust generation (NCOPL, 2014).

In addition, NCOPL commissioned a dust suppression feasibility study (SMEC, 2014) to:

- *"Determine the optimal, economically viable, solution to mitigate the risk of, and actual release of fugitive dust emissions from site to ensure compliance with statutory requirements and community expectations; and*
- *Recommend a go-forward option supported by a suitably robust capital estimate to be considered for implementation by Whitehaven's management."*

The study concluded that the dust suppression system installed during the construction of the CHPP is ineffective and an alternative water cannon spray system was recommended (SMEC, 2014). The alternate system was commissioned on 30 January 2015. The PRPs are relevant to the existing and future operations of the NM and are considered in this study where appropriate.

3. LOCAL SETTING

The NM is located immediately to the west of the Kamilaroi Highway and the Werris Creek Mungindi Railway, approximately 28 km south-east of Narrabri and approximately 65 km north-west of Gunnedah (**Figure 1-1**). The NM mining lease (Mining Lease 1609) covers an area of 5,298 hectares (ha). The location of the NM in the context of regional topography and land use is shown in **Figure 3-1**. Land use surrounding the site is largely agricultural, primarily cleared grazing land, with areas of native vegetation immediately to the west. The terrain elevation within a radius of 10 km from the site is relatively uniform, varying between approximately 250 m Australian Height Datum (AHD) to 360 m AHD. To the north-east, the terrain raises towards Mt Kaputar, rising elevations of over 1,000 m AHD.

Also shown on **Figure 3-1** are the two regional and the single onsite automatic weather stations (AWS) which are used in the modelling, discussed further in **Section 5**.

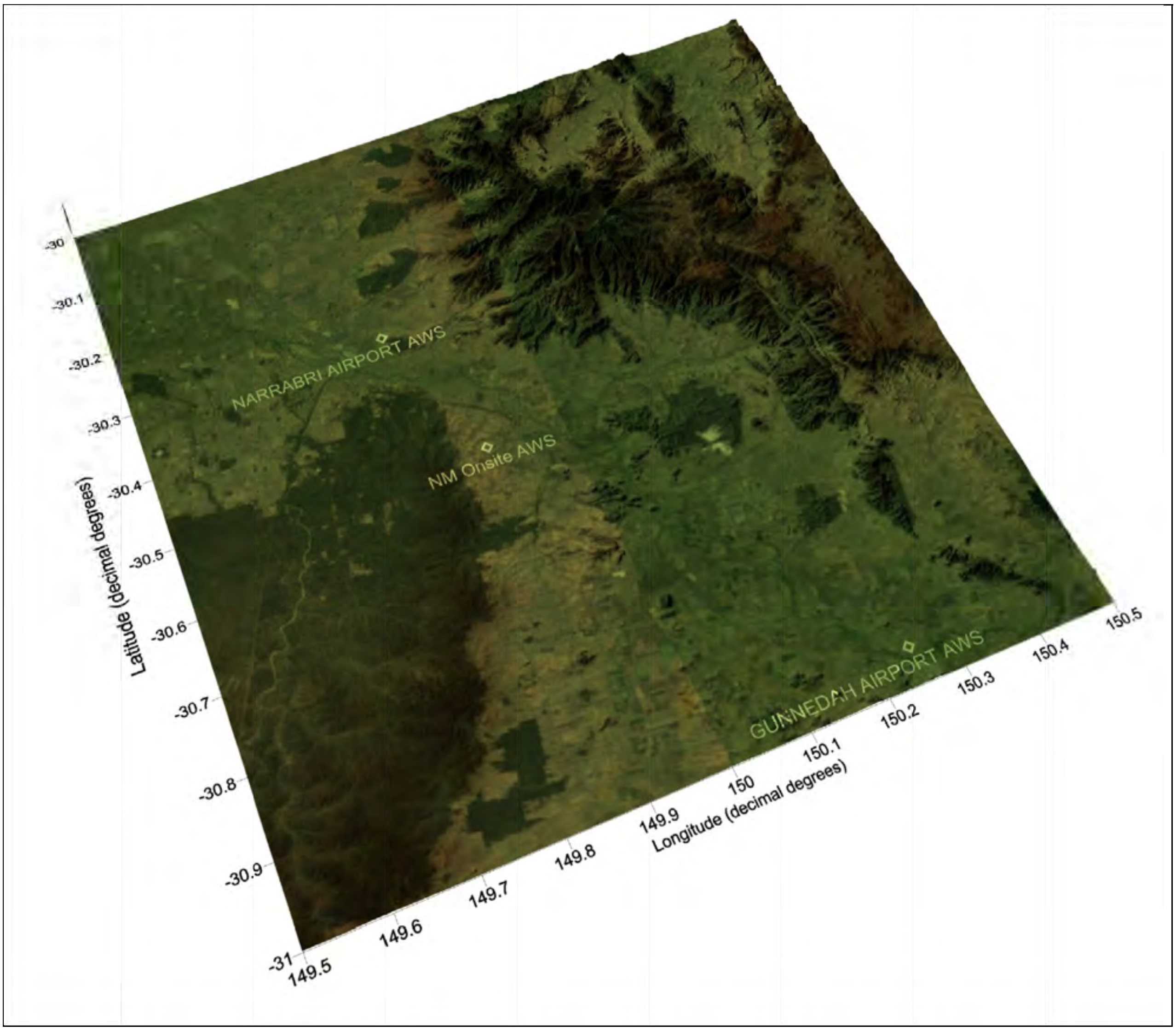

Figure 3-1: Regional topography

3.1 Nearest sensitive receptor locations

The region surrounding the NM site contains a number of rural-residential properties situated at varying distances from the NM site. The locations of the 11 private and 13 mine-owned sensitive receptor locations surrounding the NM site are illustrated in **Figure 3-2** and listed in **Table 3-1**.

NCOPL is currently negotiating the acquisition of Belah Park and Merriman. In addition, NCOPL has entered into a private agreement with the landholder of Bow Hills.

Table 3-1: Locations of sensitive receptors surrounding the site

Property Name	Location (m MGA, Zone 55)		Distance (km) / Direction from CHPP	Elevation (m AHD)
	Easting	Northing		
Private				
Ardmona	780316	6618940	2.6/SE	263
Belah Park[1]	778761	6622882	2.7/NE	258
Bow Hills[2]	780193	6620654	2.1/E	255
Burragurrum	778050	6615757	4.9/S	260
Haylin View	777409	6617326	3.0/S	271
Matilda	777816	6617001	3.3/S	269
Merriman[1]	779320	6623173	3.0/NE	269
Merulana	778531	6624145	3.8/NE	301
Newhaven	776470	6624574	4.6/NW	271
Oakleigh	779632	6617776	2.9/SE	245
Pineview	779361	6617224	3.3/SE	294
Mine Owned				
Barton Hedge	775091	6621282	3.0/W	295
Claremont	776928	6619452	1.5/SW	246
Greylands	777535	6622698	2.4/N	250
Kurrajong	776231	6618257	2.8/SW	247
Matoppo	777880	6621887	1.6/N	322
Mayfield	777268	6616996	3.4/SW	264
Mayfield Cottage	777268	6616808	3.6/SW	272
Merrilong	777053	6616298	4.2/SW	281
Naroo	779628	6619182	1.9/SE	281
Omeo	777474	6623296	3.0/N	278
Turrabaa	779760	6619305	1.8/SE	268
Westhaven	774930	6619835	3.2/W	283
Willarah	776960	6620807	1.7/NW	278

[1] NCOPL is currently negotiating the acquisition of Belah Park and Merriman.

[2] NCOPL has entered into a private agreement with the landholder of Bow Hills.

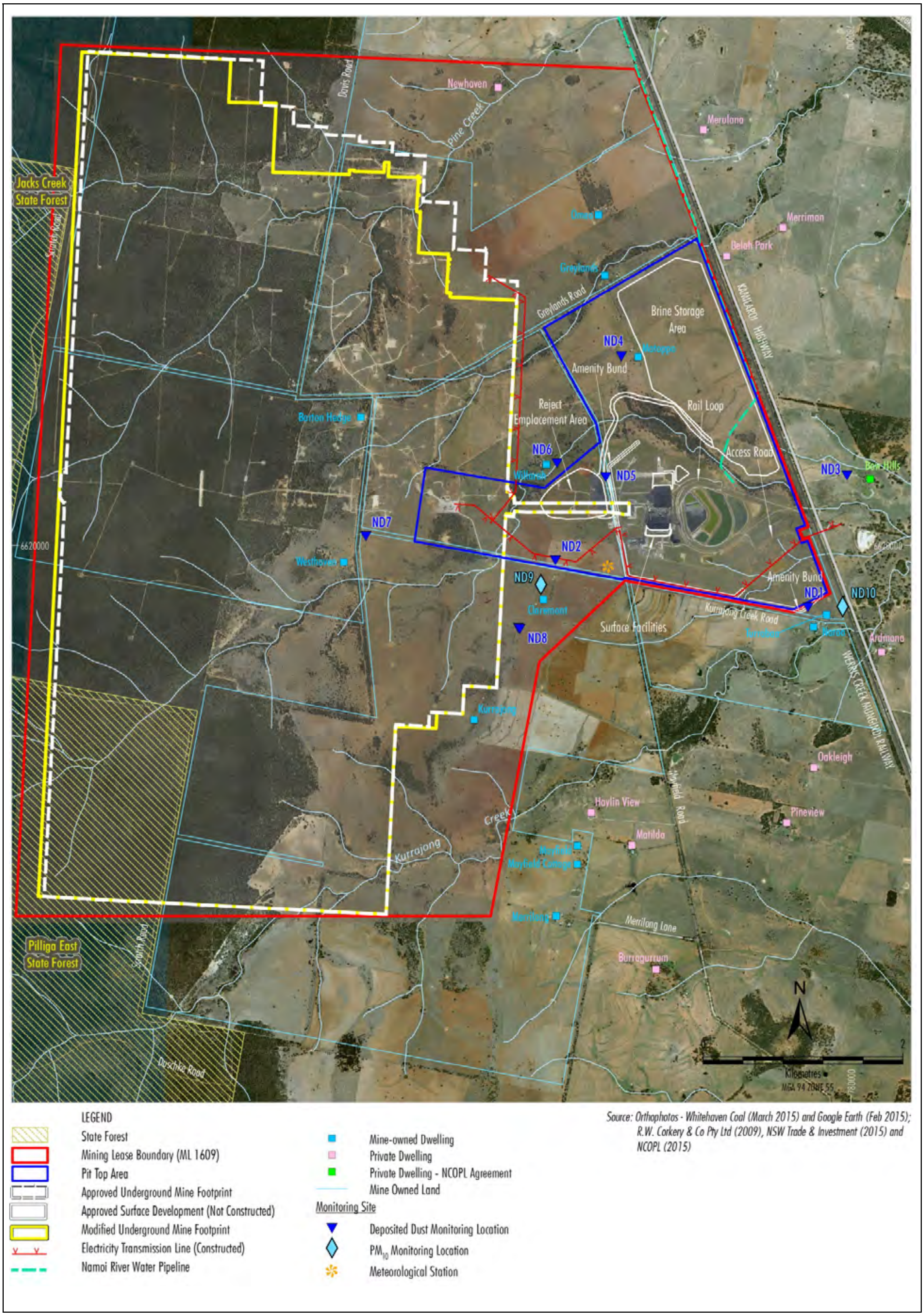

Figure 3-2: Location of sensitive receptors and air quality monitoring sites

4. IMPACT ASSESSMENT CRITERIA

NCOPL is required to demonstrate compliance with the impact assessment criteria outlined in Project Approval (08_0144) and EPL 12789, which are consistent with the criteria outlined in the Approved Methods (NSW EPA, 2005a). The impact assessment criteria are designed to maintain ambient air quality that allows for the adequate protection of human health and well-being. The key emissions to air from the NM occur from coal handling and include TSP, PM_{10}, $PM_{2.5}$ and dust. The Approved Methods specifies that the impact assessment criteria for 'criteria pollutants[2]' are applied at the nearest existing or likely future off-site sensitive receptor and compared against the 100th percentile (i.e. the highest) dispersion modelling prediction. Both the incremental and cumulative impacts need to be considered (consideration of existing ambient background concentration is required).

4.1 Particulate matter

Air quality limits for PM are typically given for particle size metrics including TSP, PM_{10} and $PM_{2.5}$. The impact assessment criteria for TSP and PM_{10} are prescribed in the Approved Methods (and in Project Approval [08_0144] and EPL 12789), however $PM_{2.5}$ is not included. Reference is therefore made to the $PM_{2.5}$ advisory reporting standards issued by the National Environmental Protection Council (NEPC) (NEPC, 2003). The *National Environment Protection (Ambient Air Quality) Measure* (NEPC, 2003) (AAQ NEPM) $PM_{2.5}$ advisory reporting standards were published in 2003 for the purpose of supporting the monitoring and evaluation of ambient $PM_{2.5}$ concentrations ahead of the setting ambient air quality standards for this pollutant.

A review of the AAQ NEPM, completed in 2011, recommended updating the air quality standards (NEPC, 2011). In 2012 the Council of Australian Governments (COAG) identified air quality as an issue of national priority (COAG, 2012), and agreed that its Standing Council on Environment and Water would implement a strategic approach to air quality management in the form of a National Plan for Clean Air. On 29 April 2014, Ministers signalled their intention to vary the AAQ NEPM for particles, to reflect the latest scientific understanding on health risks. An impact statement was published in July 2014 which outlines the options considered in the variation (NEPC, 2014). In summary the variation seeks to formalise the advisory reporting standards for $PM_{2.5}$ and adopt more stringent standards for PM_{10}. The NSW EPA's 24-hour PM_{10} assessment criterion of 50 µg/m^3 is numerically identical to the current AAQ NEPM except that the NEPM standard allows up to five exceedances per year to provide for infrequent bushfire or dust storm incidents. No provision is made by the NSW EPA for allowable exceedances of the 24-hour PM_{10} criterion. The air quality criteria applied for PM in this assessment are presented in **Table 4-1**.

Table 4-1: Impact assessment criteria for PM

PM metric	Averaging period	Concentration (µg/m^3)	Reference
TSP	Annual	90	EPA(1)
PM_{10}	24 hour	50	EPA(1)
	24 hour	50(3)	NEPM(2)
	Annual	30	EPA(1)
$PM_{2.5}$	24 hour	25	NEPM(2)
	Annual	8	NEPM(2)

Note:

1) NSW EPA (2005a) *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales.*
2) NEPC (2003) *National Environment Protection (Ambient Air Quality) Measure*, as amended.
3) Provision made for up to five exceedances of the limit per year.

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[2] 'Criteria pollutants' is used to describe air pollutants that are commonly regulated and typically used as indicators for air quality. In the Approved Methods the criteria pollutants are TSP, PM_{10}, nitrogen oxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), deposited dust, hydrogen fluoride and lead.

4.2 Dust deposition criteria

The NSW EPA impact assessment criteria for dust deposition are summarised in **Table 4-2**, illustrating the maximum increase and total dust deposition rates which would be acceptable so that dust nuisance can be avoided. Cumulative annual average dust deposition rates within residential areas, which are in excess of 4 $g/m^2/month$, are generally considered to indicate that nuisance dust impacts may occur.

Table 4-2: Dust deposition criteria

Pollutant	Maximum Increase in Dust Deposition	Maximum Total Dust Deposition Level
Deposited dust (assessed as insoluble solids)	2 $g/m^2/month$	4 $g/m^2/month$
Source: *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2005a)		

4.3 Products of combustion

The combustion of diesel in mining equipment results in combustion-related emissions including fine PM, NO_2, SO_2, CO and volatile organic compounds, however with the exception of PM, combustion emissions have not been quantitatively assessed. Underground mining operations consume significantly less diesel than open cut mines and combustion related emissions for the NM would not result in significant ground level concentrations. It is noted that emissions of PM from the combustion of diesel fuel in mining equipment are included in the emission factors used to estimate total PM emissions for dozers and trucks.

5. DISPERSION METEOROLOGY

NCOPL operate an on-site meteorological monitoring station at the NM which records 15 minute averages of wind speed and direction, temperature (at 2 and 10 m), rainfall, barometric pressure and solar radiation.

The onsite monitoring data were reviewed by ENVIRON (2015) and the AEMR period April 2013 to March 2014 was selected for modelling, based on the availability and consistency of wind data. This period is retained for the modelling presented in this report.

5.1 Prevailing winds

Annual wind roses for 2012, 2013 and April 2013 to March 2014 are presented in **Figure 5-1** and demonstrate that winds are consistently aligned along the north-west south-east axis. Annual average wind speeds are consistent (3.1 metres per second [m/s] to 3.2 m/s) and the percentage occurrence of calm conditions (less than or equate to 0.5 m/s) varies from 2.5% to 3.4%.

Regional wind patterns, as measured by Bureau of Meteorology (BoM) AWSs located at Narrabri and Gunnedah, were compared to the NM winds (**Figure 5-2**). The wind roses show slightly higher average wind speeds at the BoM sites (4 m/s at Narrabri BoM site and 3.6 m/s at Gunnedah BoM site compared to 3.2 m/s at the NM) with the frequency of calm conditions at the BoM sites also increased (6.3% at Narrabri BoM site and 8.9% at Gunnedah BoM site compared to 3.4% at the NM).

The overall wind patterns are similar, although the Narrabri BoM site displays a strong northerly component that is absent from the NM and Gunnedah BoM site. Variations in regional wind flows are influenced by topographical features, and in particular, the elevated terrain of Mt Kaputar.

The wind roses presented in **Figure 5-2** are representative of longer term wind patterns, shown by an analysis of 5 years of data presented in **Appendix A**.

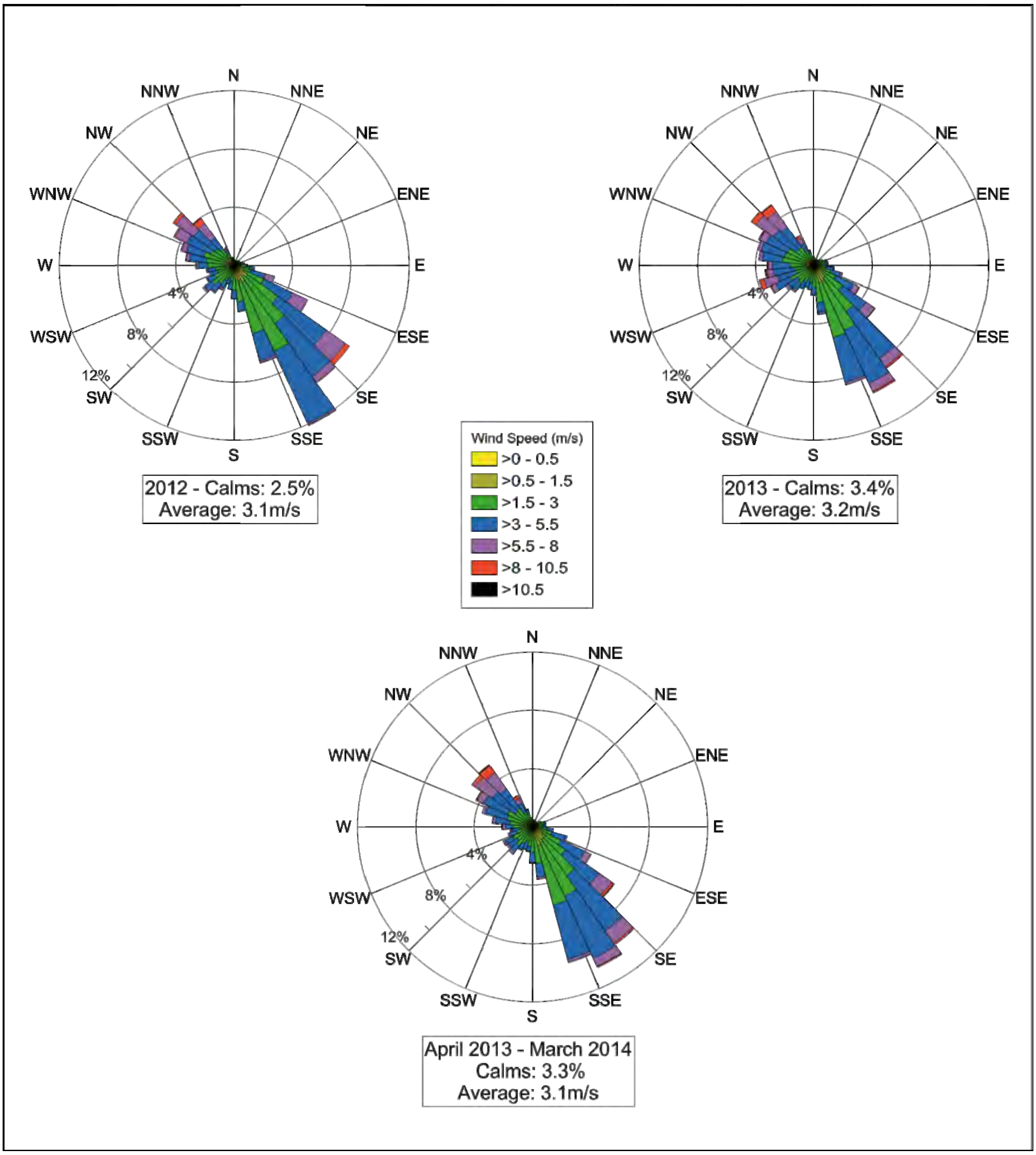
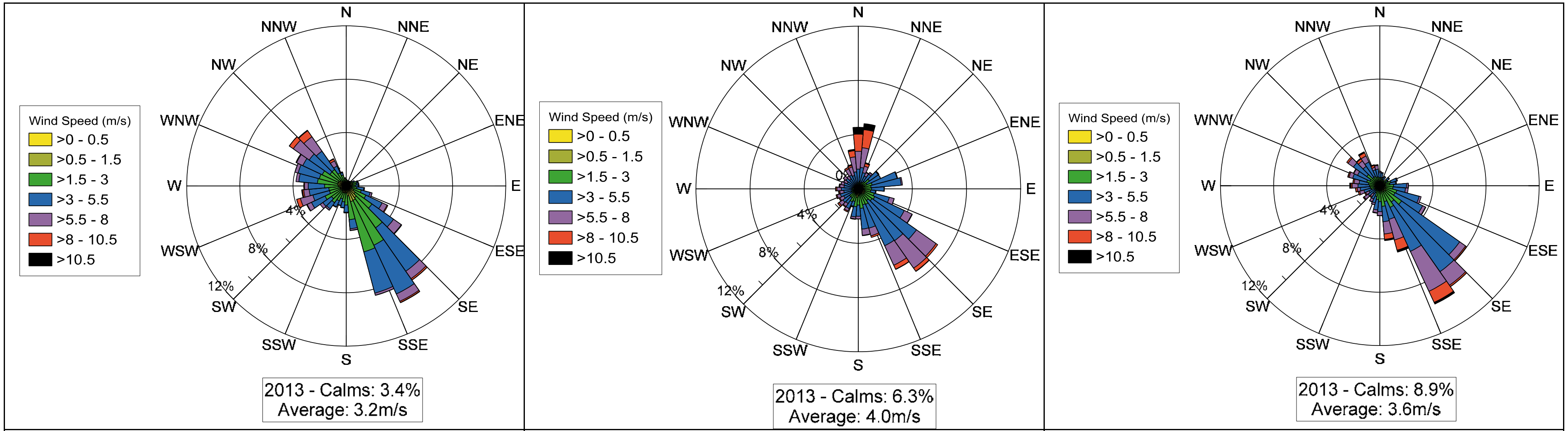


Figure 5-1: Annual wind rose for NM data



NM	Narrabri BoM Site	Gunnedah BoM Site

Figure 5-2: Regional comparison of annual wind roses

5.2 Seasonal wind variation

The AEMR period April 2013 to March 2014 was selected for modelling. It is representative of longer term conditions recorded at the NM and region and there is a high data recovery for the period (>95%). Gaps in the NM data for all parameters were supplemented with data from the Gunnedah BoM site, which was determined to be more suitable than Narrabri BoM site based on the analysis of wind direction and annual average wind speeds. Whitehaven Coal Limited owned meteorological sites at the Tarrawonga and Maules Creek coal mines are influenced by local terrain features and are not suitable for supplementing the NM data.

Seasonal wind roses for the modelling dataset are presented in **Figure 5-3**. Seasonal variation is most evident in autumn when the dominant winds are predominantly from the south-east with little winds from the north-west. In other seasons, the wind patterns are similar to annual patterns and are generally aligned along the north-west to south-east axis.

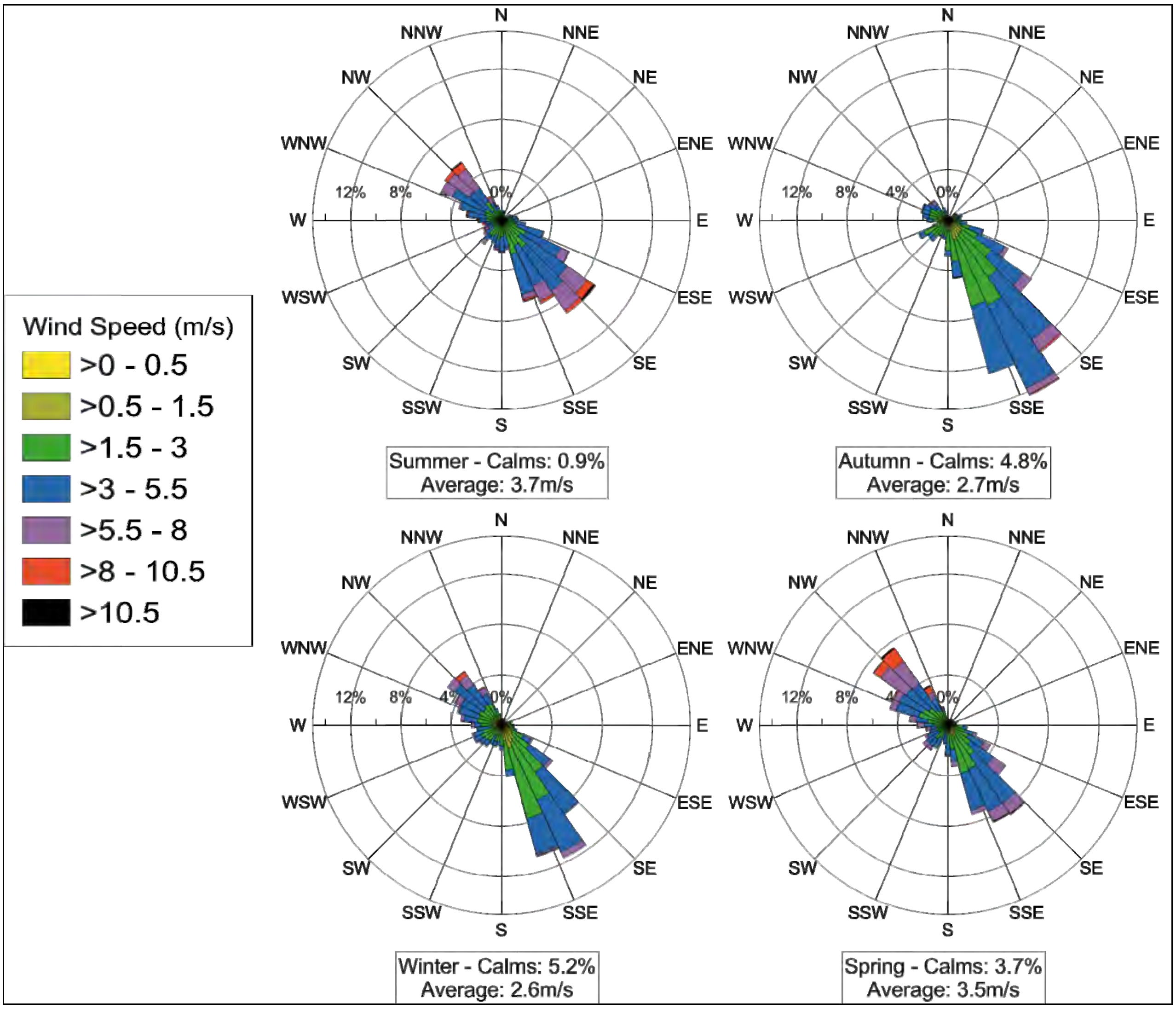


Figure 5-3: Seasonal wind roses for NM data

5.3 Ambient temperature

The monthly minimum, maximum and average temperatures for the modelling dataset are presented in **Figure 5-4** compared with long term mean monthly minimum and maximum temperatures recorded at Narrabri BoM site.

The April 2013 to March 2014 maximum temperatures are higher than the long term mean monthly maximum and the April 2013 to March 2014 minimum temperatures are generally lower than the long term mean monthly minimum. The average temperature falls between the long term maximum and minimum.

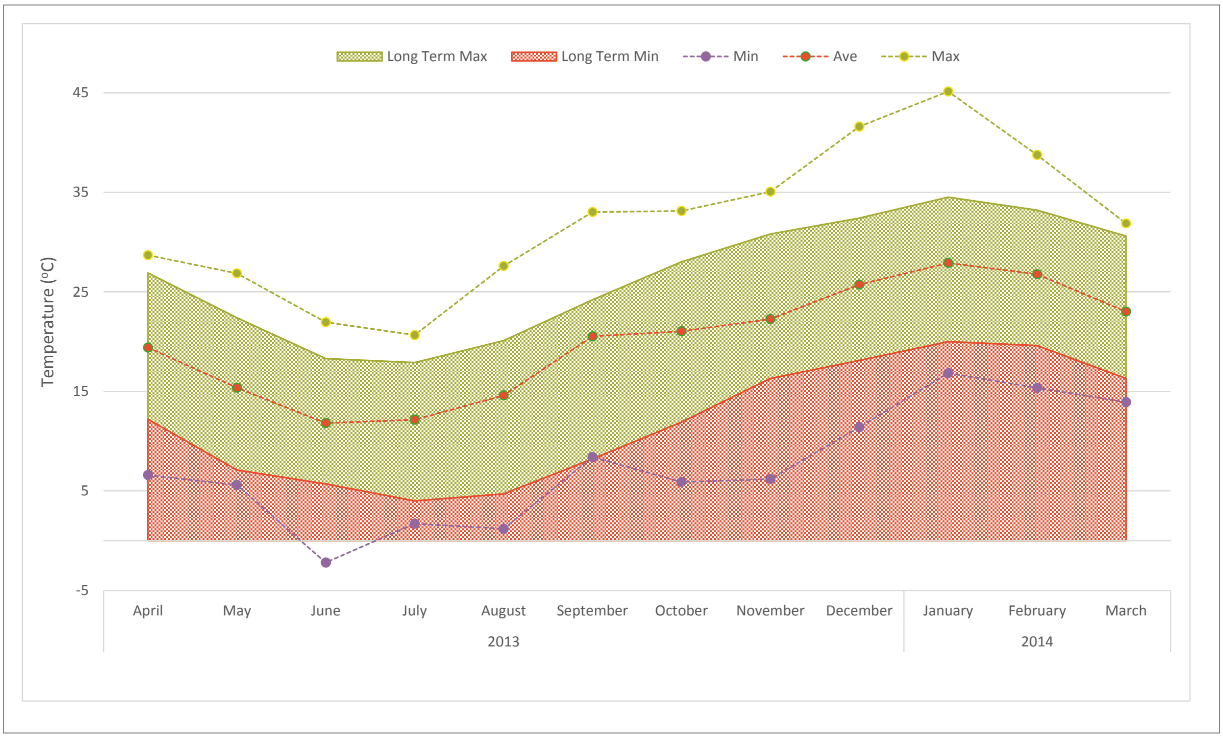


Figure 5-4: NM and Narrabri BoM site (long term) temperature

5.4 Rainfall

Precipitation is important to air pollution studies since it impacts on dust generation potential and represents a removal mechanism for atmospheric pollutants. A comparison between long term average monthly rainfall recorded at Narrabri BoM site[3] and the NM data for the modelling period is presented in **Figure 5-5**. June 2013 recorded rainfall in excess of the long term average and May and October 2013 recorded levels comparable to the long term average. For all other months in the modelling period the recorded rainfall was lower than the average rainfall.

To provide a conservative (upper bound) estimate of the airborne PM concentrations occurring due to the NM, wet deposition (removal of particles from the air by rainfall) was conservatively excluded from the dispersion modelling simulations undertaken in this report.

[3] Data available from Narrabri Airport AWS since 2001

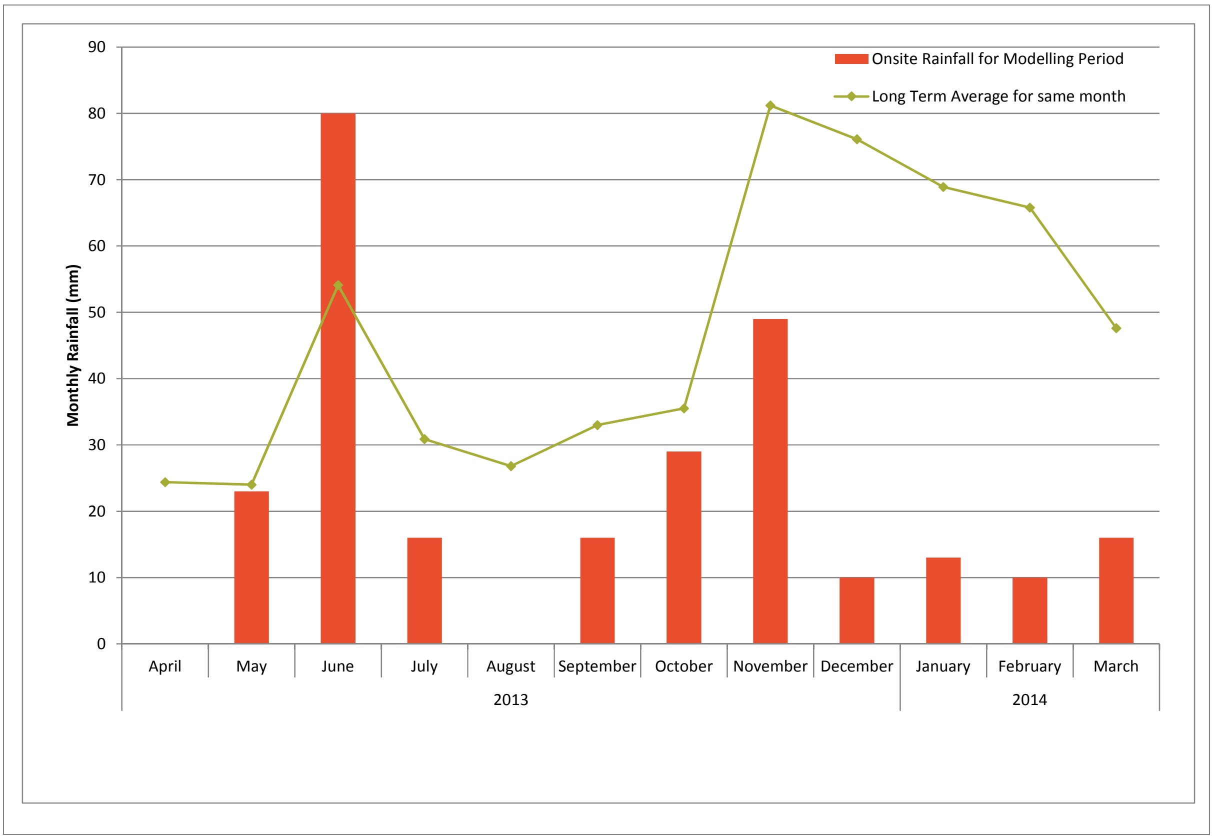


Figure 5-5: Rainfall comparison

5.5 Atmospheric stability and boundary layer depth

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. This layer is directly affected by the earth's surface, either through the retardation of air flow due to the frictional drag of the earth's surface (mechanical mechanisms), or as result of the heat and moisture exchanges that take place at the surface (convective mixing) (Stull, 1997; Oke, 2003).

During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated subsidence inversion. Elevated inversions may occur for a variety of reasons including anticyclonic subsidence and the passage of frontal systems. Due to radiative flux divergence, nights are typically characterised by weak to no vertical mixing and the predominance of stable conditions. These conditions are normally associated with low wind speeds and hence lower dilution potentials.

Hourly-varying atmospheric boundary layer depths were generated for modelling by AERMET, the meteorological processor for the AERMOD dispersion model, using a combination of surface observations from the on-site weather station, sunrise and sunset times and adjusted TAPM-predicted upper air temperature profile. The TAPM-predicted upper air temperature profile is adjusted to the observed 2 m and 10 m temperature recorded at the NM station.

The variation in average boundary layer depth by hour of the day is illustrated in **Figure 5-6**. It can be seen that greater boundary layer depths are experienced during the day time hours, peaking in the mid to late afternoon. Higher day-time wind velocities and the onset of incoming solar radiation increases the amount of mechanical and convective turbulence in the atmosphere. As turbulence increases so too does the depth of the boundary layer, generally contributing to higher mixing depths and greater potential for atmospheric dispersion of pollutants.

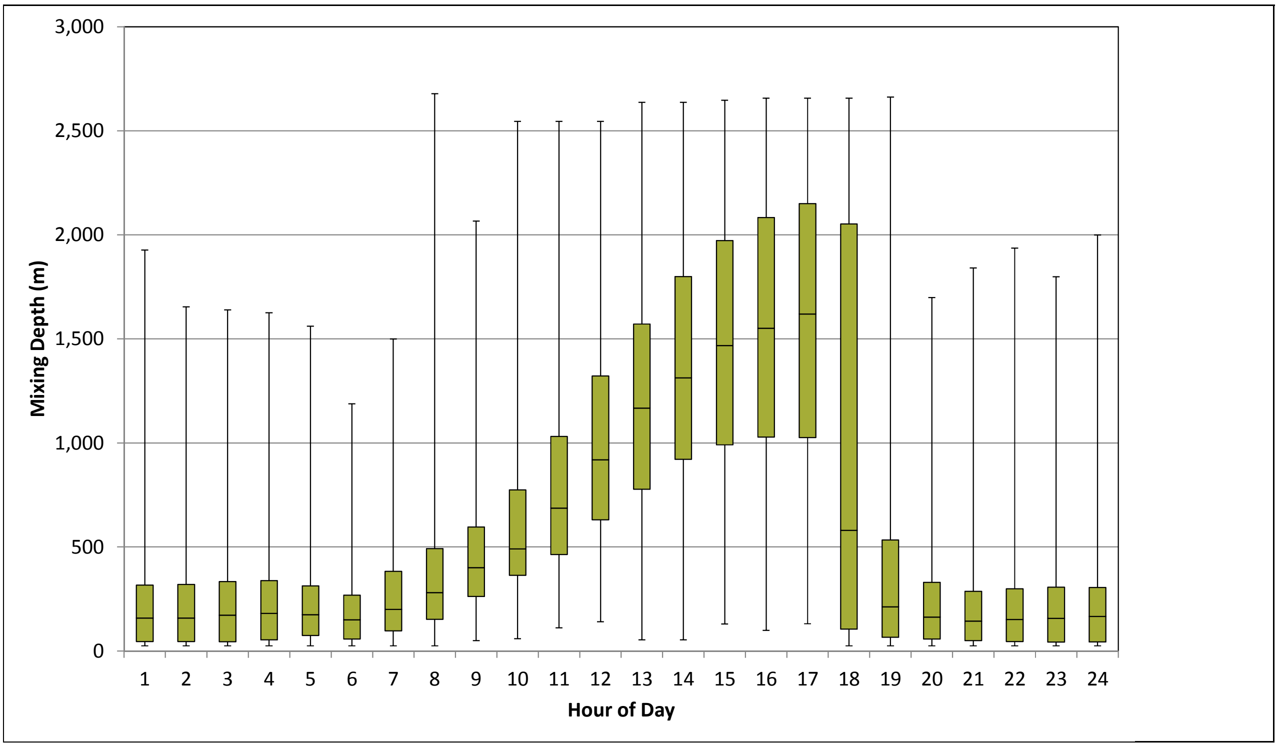


Figure 5-6: AERMET-generated diurnal variations in average boundary layer depth

Note: Lower, middle and upper box markers indicate 25th percentile, median and 75th percentile of AERMET-generated mixing height data respectively, while upper and lower whiskers indicate maximum and minimum values.

The Monin-Obukhov length provides a measure of the stability of the surface layer (i.e. the layer above the ground in which vertical variation of heat and momentum flux is negligible (typically about 10% of the mixing height). Wharton and Lundquist (2010) provide typical value ranges for the Monin-Obukhov length for widely referenced atmospheric stability classes, as listed within **Table 5-1**.

Table 5-1: Monin-Obukhov length with respect to atmospheric stability

Monin-Obukhov length (L) range	Stability class
-50 < L < 0	Very Unstable
-600 < L < -50	Unstable
|L| > 600	Neutral
100 < L < 600	Stable
0 < L < 100	Very Stable

Source: Table 2, Wharton and Lundquist (2010).

Figure 5-7 illustrates the diurnal variation of atmospheric stability derived from the Monin-Obukhov length calculated by AERMET for the NM site. The diurnal profile presented illustrates that atmospheric instability increases during daylight hours as convective energy increases, whereas stable atmospheric conditions prevail during the night-time. This profile indicates that the potential for atmospheric dispersion of emissions would be greatest during day time hours and lowest during evening through to early morning hours.

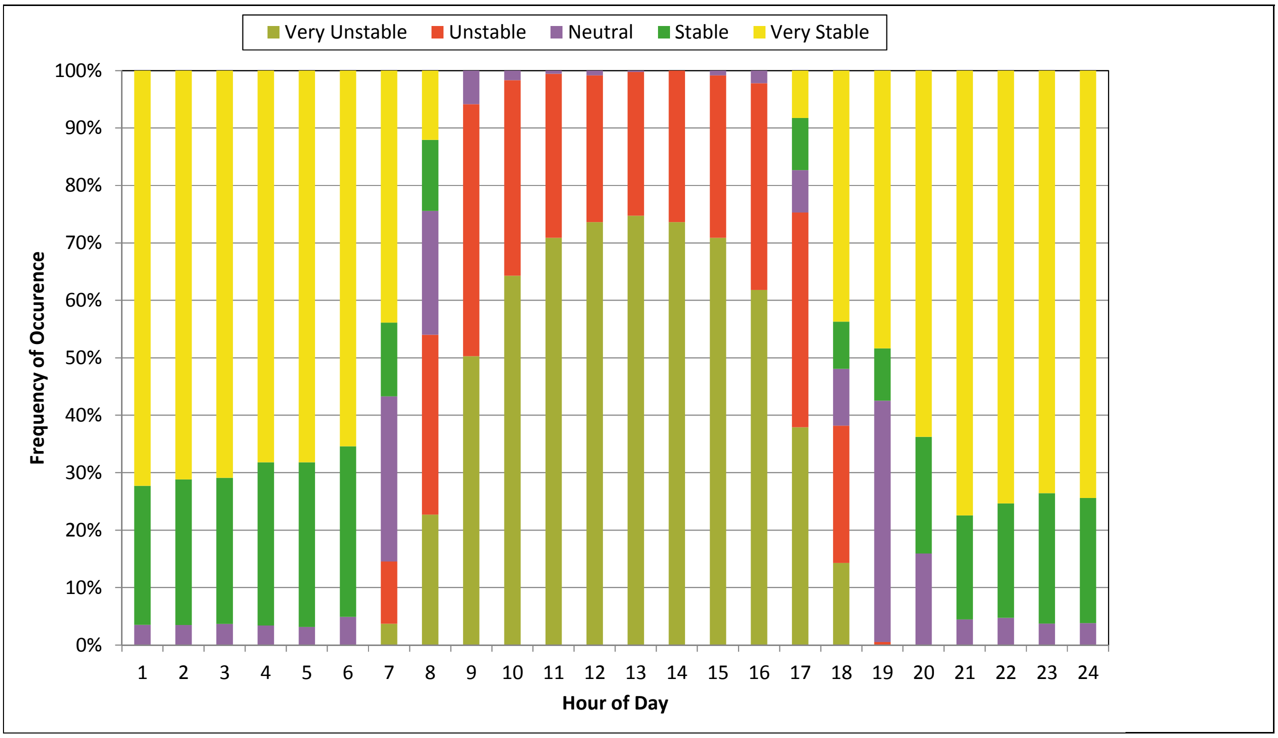


Figure 5-7: Diurnal variations in AERMET-generated atmospheric stability

6. EXISTING AMBIENT AIR QUALITY

NCOPL operate an air quality monitoring network for monitoring compliance. Dust deposition is monitored at the following sites:

- ND1 – Turrabaa
- ND2 – Claremont
- ND3 – Bow Hills
- ND4 –Matoppo
- ND5 – Willarah
- ND6 – Willarah
- ND7 – Claremont
- ND8 – Claremont

In addition, two sites monitor PM_{10} concentrations (ND9 - Claremont and ND10 - Turrabaa).

The air quality monitoring locations are shown in **Figure 3-2**.

6.1 PM_{10} concentration

PM_{10} monitoring commenced in late 2007/early 2008 using high volume air samplers, run every sixth day, to obtain a 24-hour average composite PM_{10} concentration. The 24-hour average PM_{10} concentrations measured at ND9 (Claremont) and ND10 (Turrabaa) are presented in **Figure 6-1**.

ND9 (Claremont) is located approximately 1 km south-west of the coal handling and processing area and ND10 (Turrabaa) is located approximately 1 km to the south-east of the coal handling and processing area (**Figure 3-2**).

With the exception of a period between September and December 2009 (when extensive dust storms occurred across NSW) the 24-hour PM_{10} concentrations remain below the impact assessment criteria. The single exceedance in May 2008 at Turrabaa was attributed to vehicles travelling to the temporary site office at Turrabaa, along an unsealed access track (NCOPL, 2009).

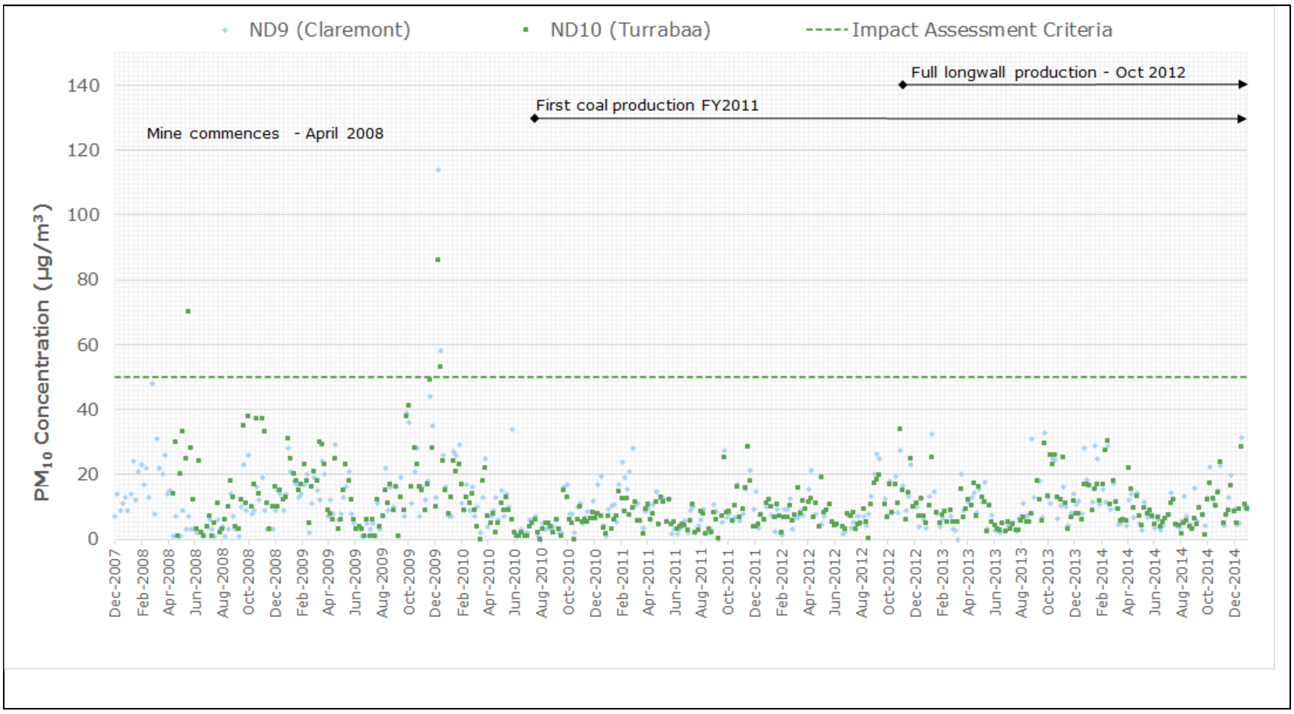


Figure 6-1: 24-hr average PM_{10} concentration - December 2007 to December 2014

Annual average PM_{10} concentrations are presented for each year and for the AEMR period selected for modelling (**Figure 6-2**). In the previous five years, the annual average PM_{10} concentrations at both locations have been less than 50% of the impact assessment criterion of 30 µg/m^3. Annual averages in 2009 were higher, however this was a particularly dry year in NSW, resulting in elevated dust concentrations recorded across much of the state (http://www.bom.gov.au/climate/mwr/).

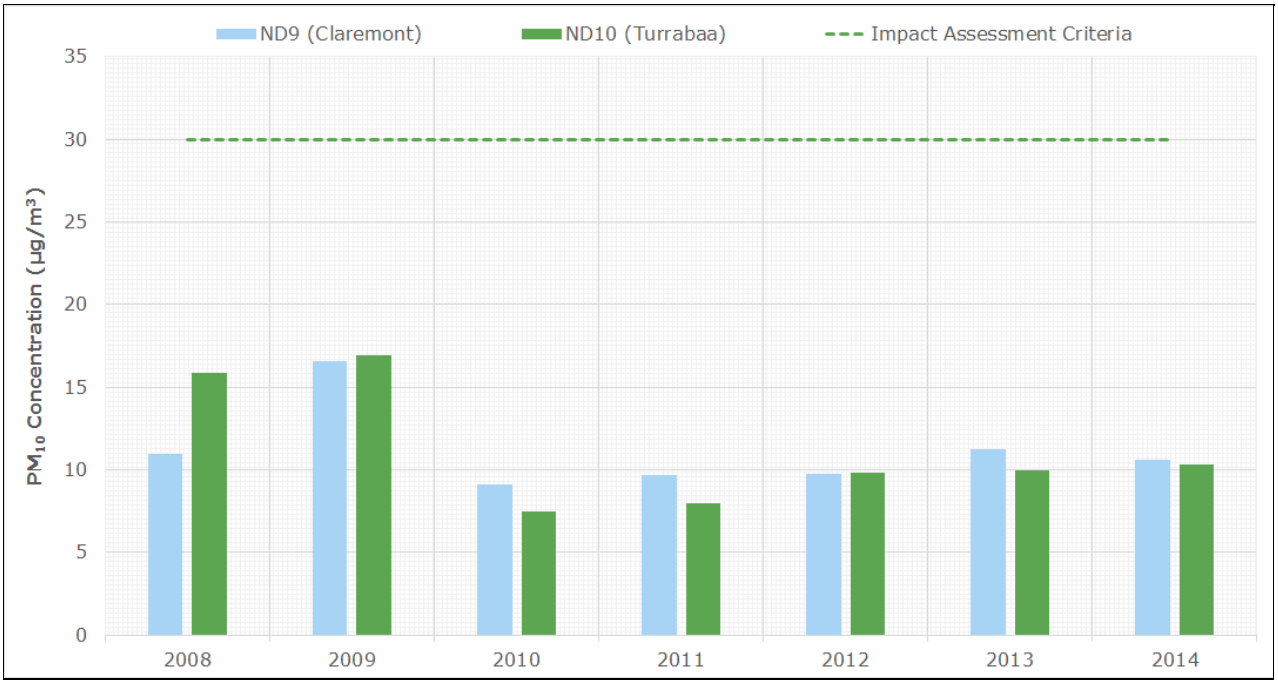


Figure 6-2: Annual average PM_{10} concentration - 2008 to 2014

Based on the northwest-southeast aligned dominant wind directions, ND10 (Turrabaa) is expected to be influenced more by dust emissions from the NM than ND9 (Claremont), however there is little evidence of this in the data and concentrations are similar across the two sites. For example, the maximum 24-hour average PM_{10} concentration during the 2013/2014 AEMR period was 32.7 µg/m^3 at ND9 (Claremont) and 30.1 µg/m^3 at ND10 (Turrabaa). Similarly the annual average was 11.9 µg/m^3 at (ND9) Claremont and 11.2 µg/m^3 at ND10 (Turrabaa). It is possible that another localised source is contributing at the (ND9) Claremont site and not at ND10 (Turrabaa), which may explain why the signal from NM is not evident in the ND10 (Turrabaa) data.

Regardless, existing monitoring data suggests that emissions from NM are not significantly contributing to ambient PM_{10} concentrations at the monitoring locations. This was explored further by modelling existing operations to evaluate model performance and derive suitable background concentrations for cumulative assessment (ENVIRON, 2015). Based on this modelling, the background annual average PM_{10} concentration from sources other than NM was estimated to be in the range of 9 – 11 µg/m³ and a conservative annual average background PM_{10} concentration of 11 µg/m³ has been adopted for this assessment.

6.2 Dust deposition

Annual average dust deposition levels are presented in **Figure 6-3**. In calculating the annual average, obvious outliers in the monthly measurements are removed. With the exception of ND1 and ND5, compliance with the long term impact assessment criteria of 4 g/m^2/month is generally achieved.

ND1 would have been impacted by vehicles travelling to the temporary site office along an unsealed access track in 2008 and 2009 (NCOPL, 2009). As described previously, 2009 was a particularly dry year in NSW, resulting in elevated dust concentrations recorded across much of the state, and reflected in the higher dust deposition readings. The elevated annual average in 2014 is a result of higher than usual levels recorded during the final few months of the year.

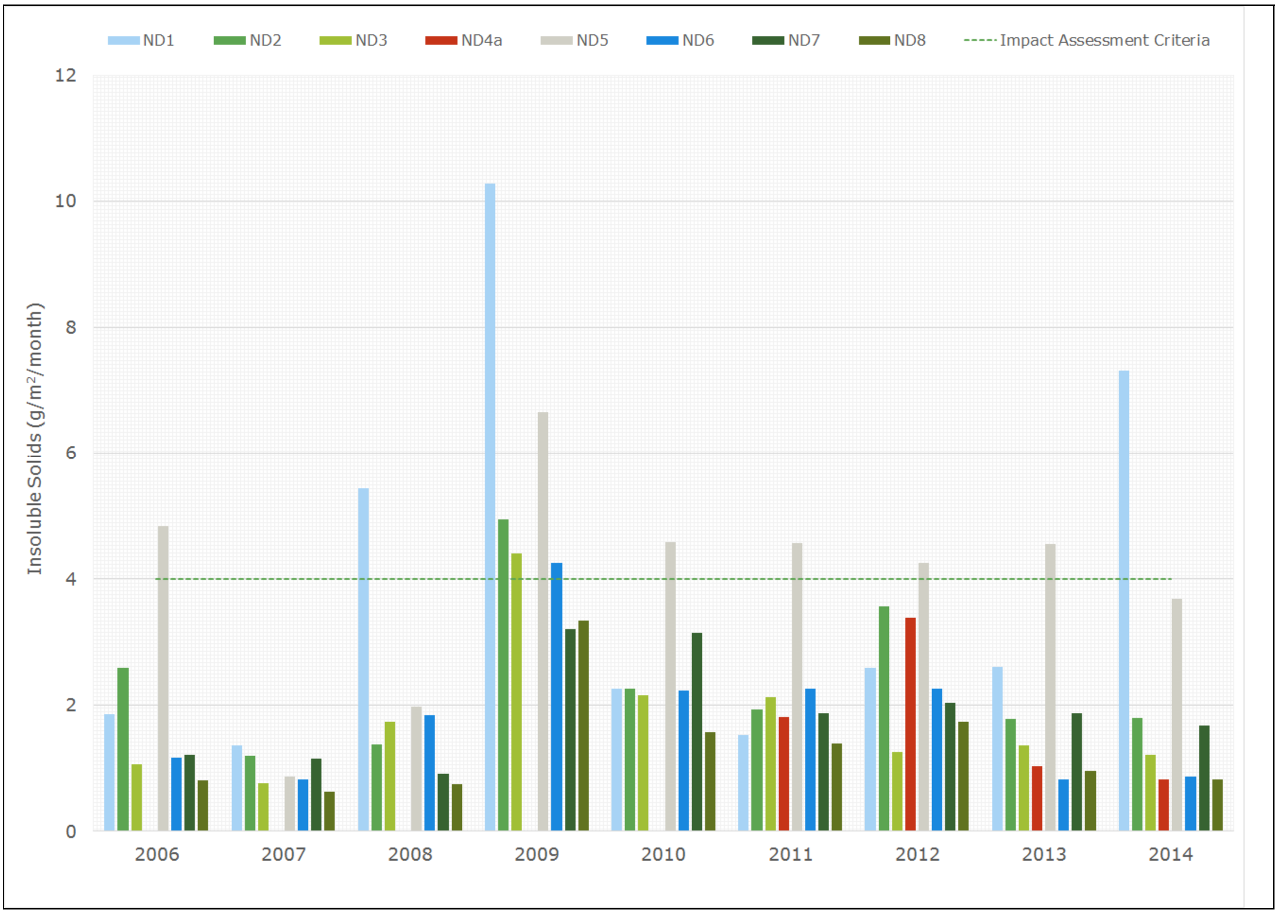


Figure 6-3: Annual average dust deposition - 2006 to 2014

ND5 is the closest monitoring location to NM, located at the boundary of the coal handling and processing area on NCOPL-owned land and in a direct prevailing downwind direction. ND1 was elevated in 2008, 2009 and 2014.

To derive a suitable background dust deposition level, three sites (ND2, ND3 and ND8) that are out of the prevailing wind direction of the NM operations were averaged. These sites are the least influenced by existing NM and the average across all sites and years is 1.9 g/m^2/month. This is a reasonable indicative background for rural locations in NSW.

6.3 TSP concentration

TSP concentrations are not measured in the vicinity of the NM, however annual average TSP concentrations can be derived based on typical ratios of PM_{10}/TSP. To derive TSP concentrations, NCOPL assume that the PM_{10} particle size mass fraction is typically of the order of 50% of the recorded TSP mass. The DPE accepted this relationship in its letter dated 5 August 2011. Applying this PM_{10}/TSP ratio to the adopted background PM_{10} concentration of 11 µg/m^3 results in an annual average TSP concentration of 22 µg/m^3.

6.4 $PM_{2.5}$ concentration

Limited $PM_{2.5}$ monitoring data are available for rural NSW. The NSW Office of Environment and Heritage currently operate 17 stations where simultaneous concentrations of PM_{10} and $PM_{2.5}$ are recorded. The ratio of $PM_{2.5}$ to PM_{10} at these sites varies from 0.29 to 0.45 (with an average of 0.36). The ratio is often determined by the dominant source of PM emissions for that locality. For example, in areas with a lot of wood heaters in winter, $PM_{2.5}$ is expected to make up a larger component of PM_{10} (results in a higher ratio). In contrast, an area where crustal dust is expected to dominate (such as Camberwell in the middle of the Hunter Valley), $PM_{2.5}$ is expected to form a smaller proportion of total PM and the ratio is lower.

The area surrounding the NM is expected to be influenced by PM derived from crustal sources, rather than combustion derived PM, and the $PM_{2.5}/PM_{10}$ ratio would be expected to be in the lower range described above. However, to provide a more conservative estimate of background $PM_{2.5}$, an average $PM_{2.5}/PM_{10}$ ratio of 0.4 is applied to the PM_{10} concentration data, resulting in an annual average concentration of 4.4 µg/m^3.

7. EMISSION INVENTORY

TSP, PM_{10} and $PM_{2.5}$ emissions inventories have been developed for the Modification (**Appendix B**).

The proposed increase in ROM coal production from 8 Mtpa to 10.5 Mtpa would increase emissions from the NM. The additional 2.5 Mtpa of ROM coal would generate additional emissions during its handling and processing on the surface. The increase in ROM coal production would require an approximate 30% in dozer hours for ROM and product coal stockpile maintenance to those assessed in the Stockpile Extension Modification.

The Modification would not result in any significant changes to the surface operations (e.g. increased ROM and product coal stockpile size) beyond those assessed in the Stockpile Extension Modification that would result in additional emissions.

The proposed reconfiguration of the approved underground mine geometry (the increased longwall widths and reduction in number of operating longwalls) would not result in any additional dust generated at the surface. Similarly, there would be no change to ventilation shaft emissions as no changes to the existing ventilation system are proposed. It is noted that the emission estimates for the Modification assumes a maximum air flow rate of 450 cubic metres per second (m^3/s) for the ventilation fans, resulting in a small increase in dust emissions when compared to the previously assumed typical ventilation rate of 435 m^3/s.

Revised PM_{10} emissions estimates for the modified NM are presented in **Table 7-1**. Emission factors developed by the US EPA[4], have been applied to estimate the amount of dust produced by each activity at the NM.

Table 7-1 also includes the PM_{10} emission estimates presented in the Stockpile Extension Modification Air Quality Assessment (ENVIRON, 2015). The PM_{10} emissions estimates show that the proposed increase in ROM coal production results in a 31% increase in PM_{10} emissions. Complete emission inventories for all particle size fractions are provided in **Appendix B**.

Emission reductions were applied to account for controls that are currently in place at NM or outlined in the statement of commitments (**Section 2.2.3**). The levels of emission controls are consistent with best practice emissions control for coal mining (Katestone Environmental, 2011) and as outlined in *Narrabri Mine Particulate Matter Control Best Practice Pollution Reduction Program* (PAEHolmes, 2012):

- ROM and product coal stockpile areas – 50% control applied for all stockpile activity based on the implementation of a fixed water spray suppression system.
- Unpaved roads/surfaces wheel dust – 85% reduction for water application.
- Rotary breaker and secondary crusher – 90% control for enclosure.
- Conveyor transfer – 40% control for wind shielding plus 50% control for water sprays.
- Soil stockpiles – 100% control as assumed to be undisturbed.

[4] United States Environmental Protection Agency (US EPA) AP-42 Compilation of Air Pollutant Emission Factors (US EPA, 1998, US EPA, 2004, US EPA, 2006)

Table 7-1: Calculated annual PM_{10} emissions – existing and proposed operations

Emissions source	Calculated annual emissions (kg/annum)	
	Stockpile Extension Modification (at 8 Mtpa ROM coal)	Modification (at 10.5 Mtpa ROM coal)
TOPSOIL		
Topsoil stripping	1,026	1,026
Topsoil spreading	244	244
ROM COAL		
Loading ROM coal stockpile	2,144	2,814
Dozer on reclaim	36,768	48,251
Rotary breaker	643	756
Screening secondary bypass – screening	1,135	1,806
Secondary bypass – crushing	317	504
Conveyor transfer	1,715	2,251
PRODUCT COAL		
Loading PCI product coal	351	468
Loading thermal (CHPP) product coal	626	720
Loading secondary bypass coal	707	1,126
Conveyor transfer	1,374	1,831
Dozer on reclaim	30,273	39,728
Loading trains	1,718	2,289
CRUSHER WASTE/REJECTS		
Conveyor transfer	100	59
Loading rejects pile	50	29
Hauling rejects	248	146
WIND EROSION		
ROM coal 'Live' stockpile	49	49
ROM coal stockpile – maintenance	37,618	49,367
Product coal 'Live' stockpile	77	77
Product coal stockpile – maintenance	23,149	30,380
Soil stockpiles	0	5,419
Active rehabilitation	876	876
MISCELLANEOUS		
Ventilation shaft	20,435	21,287
Grader	265	265
TOTAL	**161,909**	**211,768**

7.1 Construction activities

As the Modification would not include additional construction activities, no assessment of construction emissions is required.

8. OVERVIEW OF DISPERSION MODELLING

AERMOD is the US EPA's recommended steady-state plume dispersion model for regulatory purposes. AERMOD is designed to handle a variety of pollutant source types, including surface and buoyant elevated sources, in a wide variety of settings such as rural and urban as well as flat and complex terrain[5]. AERMOD is able to predict pollutant concentrations from point, area and volume sources in addition to 'open pit' sources.

AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the US in December 2006 as it provides more realistic results with concentrations that are generally lower and more representatives of actual concentrations compared to the conservative ISC model. Ausplume, a steady state Gaussian plume dispersion model developed by the Victorian EPA and frequently used in Australia for simple near-field applications, is largely based on the ISC model.

Compared to ISC and Ausplume, AERMOD represents an advanced new-generation model, which requires additional meteorological and land use inputs to provide more refined predictions. The most important feature of AERMOD, compared to ISC and Ausplume, is its modification of the basic dispersion model to account more effectively for a variety of meteorological factors and surface characteristics. In particular, it uses the Monin-Obukhov length scale rather than Pasquill-Gifford stability categories to account for the effects of atmospheric stratification. Whereas Ausplume and ISC parameterise dispersion based on semi-empirical fits to field observations and meteorological extrapolations, AERMOD uses surface-layer and boundary layer theory for improved characterisation of the planetary boundary layer turbulence structure.

Verification studies have been undertaken for AERMOD both locally and abroad (Hanna *et al*, 2001; Perry *et al*, 2005; Hurley, 2006). Hanna *et al* (2001) concluded that AERMOD performed better than ISC with predictions generally within a factor of two of actual values. It was noted that AERMOD did tend to under-predict actual concentrations by 20% to 40%, with predictions more accurate for short-term averaging periods. Perry *et al* (2005) summarises the performance of AERMOD across 17 field study databases placing emphasis on statistics that demonstrate the model's abilities to reproduce the upper end of the concentration distribution which are of importance in terms of regulatory modelling. The field studies include flat and complex terrain cases, urban and rural conditions and elevated and surface releases with and without building wake effects. Perry *et al* (2005) concluded that, with few exceptions, AERMOD's performance was superior to that of the other applied models tested.

Hurley (2006) compared the performance of Ausplume, AERMOD and TAPM across several case studies including flat terrain, flat terrain with building downwash, in complex terrain and coastal terrain. AERMOD was determined to perform acceptably for all of the datasets but was found unable to simulate shoreline fumigation in the case of the Kwinana case study. This potential limitation of AERMOD is not of relevance to the NM due to its inland setting.

Input data types required for the AERMOD model include: meteorological data (from AERMET), source data (from the compiled emissions inventory), source and receptor elevations and information on the nature of the receptor grid.

The AERMOD system is composed of two pre-processors that generate the input files required by the AERMOD dispersion model: AERMET (for the preparation of meteorological data) and AERMAP (for the preparation of terrain data). Terrain data for the modelling domain was sourced from NASA's Shuttle Radar Topography Mission data. This data set provided a high-resolution topography at 3 arc-second (~90 m) grid spacing.

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5 Under complex wind conditions and for regional applications, CALPUFF is the US EPA's recommended model for regulatory purposes.

In applying the AERMET meteorological processor to prepare the meteorological data for the AERMOD model, appropriate values for three surface characteristics need to be determined: surface roughness length, albedo, and Bowen ratio. Surface roughness length is related to the height of obstacles in the path of wind flow and is, in principle, the height at which the mean horizontal wind speed is zero based on a logarithmic profile. The surface roughness length influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer. The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

Values for surface roughness length, albedo, and Bowen ratio were selected based on the dominant land use in the vicinity of NM. Surface roughness length is the height at which the mean horizontal wind speed approaches zero and is related to the roughness characteristics of the surrounding area. For example, low flat landscapes are assigned a lower surface roughness length than urban or forest areas. Bowen ratio relates to the amount of moisture at the surface and plays an important role in deriving Monin-Obukhov length and therefore atmospheric stability. Albedo is a measure of how much solar radiation is reflected from the ground when the sun is overhead. Appropriate values for these parameters were selected using the AERSURFACE Utility by assigning appropriate land use types in the vicinity of the NM.

9. DISPERSION MODELLING RESULTS

9.1 PM_{10} concentrations

The modelled modified NM (project-only) and cumulative PM_{10} concentrations are presented in **Table 9-1**. There are no predicted exceedances of the impact assessment criteria for the Modification. Contour plots are presented in **Appendix C**.

Cumulative annual average PM_{10} concentrations are estimated by adding a background concentration of 11 µg/m³ to the predicted modified NM (project-only) concentration. This provides a conservative assessment of impact, particularly at locations close to and in a prevailing downwind direction from the NM operations.

Table 9-1: Modified NM and cumulative PM_{10} concentration (µg/m³)

Criteria	Maximum 24-hour 50 µg/m³		Annual Average 30 µg/m³	
	Modified NM	Cumulative	Modified NM	Cumulative
Private				
Ardmona	32.3	40.2	2.5	13.5
Belah Park[1]	12.0	35.5	1.6	12.6
Bow Hills[2]	12.6	36.4	1.9	12.9
Burragurrum	2.8	32.8	0.2	11.2
Haylin View	4.2	32.9	0.5	11.5
Matilda	3.9	32.8	0.5	11.5
Merriman[1]	7.1	35.5	1.2	12.2
Merulana	9.0	33.7	0.9	11.9
Newhaven	9.8	36.4	2.0	13.0
Oakleigh	12.0	35.8	1.3	12.3
Pineview	5.8	33.1	0.8	11.8
Mine Owned				
Barton Hedge	5.0	32.7	0.5	11.5
Claremont	5.8	32.8	0.5	11.5
Greylands	20.6	38.6	4.1	15.1
Kurrajong	2.0	32.7	0.1	11.1
Matoppo	26.3	38.8	6.4	17.4
Mayfield	3.6	32.8	0.4	11.4
Mayfield Cottage	3.5	32.8	0.4	11.4
Merrilong	2.7	32.8	0.3	11.3
Naroo	35.2	43.1	3.8	14.8
Omeo	14.3	35.6	2.6	13.6
Turrabaa	42.1	50.0	3.8	14.8
Westhaven	4.1	32.7	0.3	11.3
Willarah	49.5	60.4	11.7	22.7

[1] NCOPL is currently negotiating the acquisition of Belah Park and Merriman.

[2] NCOPL has entered into a private agreement with the landholder of Bow Hills.

The potential for cumulative short term impacts (exceedances of the 24-hour average PM_{10} impact assessment criteria) are assessed in two ways. The cumulative predictions presented in **Table 9-1** are estimated by adding the measured daily PM_{10} data at ND9 (Claremont) to the predicted incremental PM_{10} concentration from the NM for the same day. It is noted, that the high volume air sampler data are available every sixth day and the maximum cumulative 24-hour PM_{10} concentration is therefore based on a limited cumulative dataset.

Additional analysis is therefore presented using a statistical approach which presents the likelihood of additional exceedances of the 24-hour average assessment criterion of 50 µg/m^3. A frequency distribution of cumulative impact is presented showing every possible combination of predicted increment and background concentration (i.e. every modelling prediction is added to all available background values from both HVAS sites for multiple years, resulting in over 300,000 combinations).

The frequency distribution is presented in **Figure 9-1** for the two most affected private receptors (note NCOPL has entered into a private agreement with Bow Hills landholder and this has not been include). The analysis shows that the risk of additional exceedances of the 24-hour PM_{10} impact assessment criteria, beyond what is caused by background, would be 0.1% or less than 1 additional exceedance day per year.

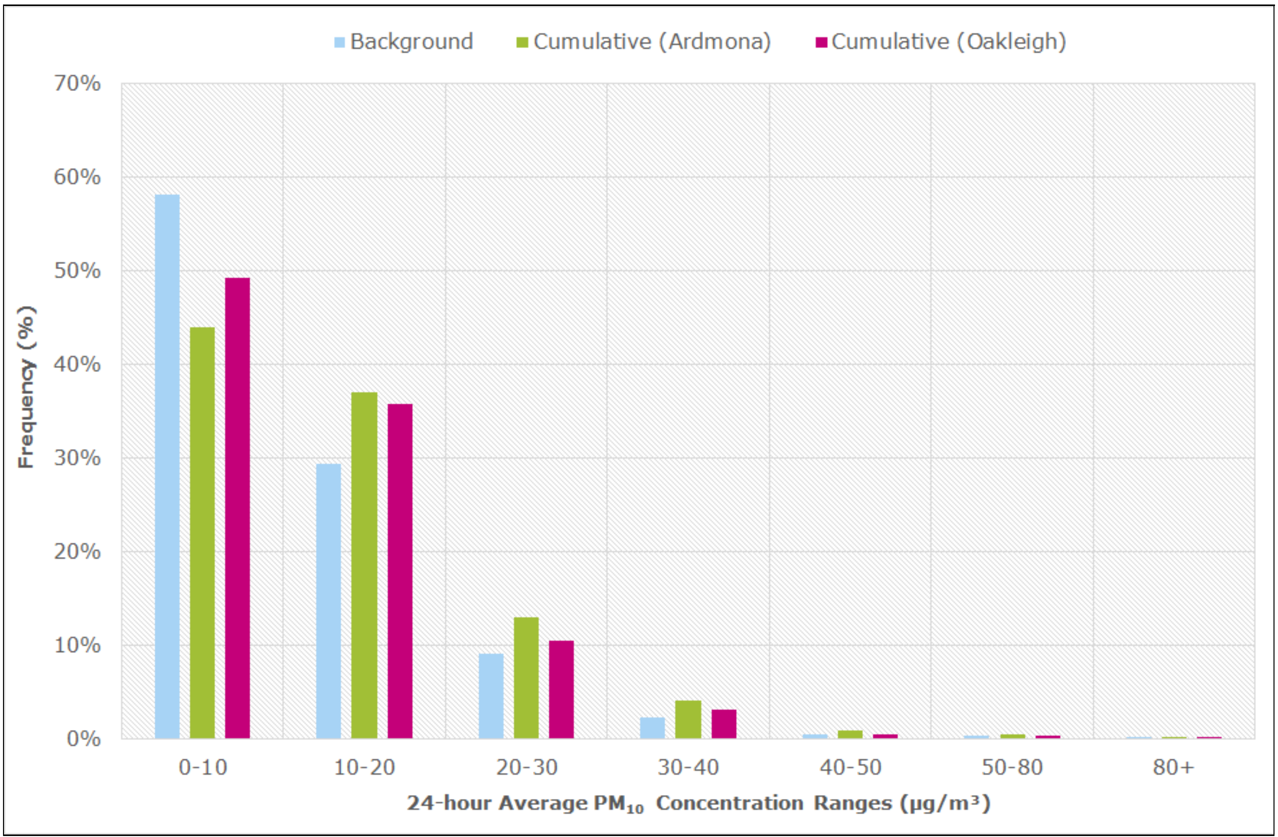

Figure 9-1: Frequency distribution of cumulative 24-hour average PM_{10} concentration

9.2 $PM_{2.5}$ concentrations

The modelled modified NM (project-only) and cumulative $PM_{2.5}$ concentrations are presented in **Table 9-2**. There are no predicted exceedances of the impact assessment criteria for the Modification. Contour plots are presented in **Appendix C**.

Cumulative annual average and 24-hour $PM_{2.5}$ concentrations are estimated by adding a derived background concentration to the predicted increment based on a ratio of $PM_{2.5}/PM_{10}$, as discussed in **Section 6.4**. Similar to PM_{10}, additional analysis is presented using a statistical approach which presents the likelihood of additional exceedances of the 24-hour average advisory reporting standard of 25 µg/m³.

The frequency distribution is presented in **Figure 9-2** for the two most affected private receptors. The analysis shows that the risk of additional exceedances of the 24-hour $PM_{2.5}$ impact assessment criteria is negligible.

Table 9-2: Modified NM and cumulative $PM_{2.5}$ concentration (µg/m³)

Criteria	Maximum 24-hour 25 µg/m³		Annual Average 8 µg/m³	
	Modified NM	Cumulative	Modified NM	Cumulative
Private				
Ardmona	5.0	13.3	0.3	4.7
Belah Park[1]	2.5	13.6	0.2	4.6
Bow Hills[2]	1.3	13.2	0.2	4.6
Burragurrum	0.6	13.1	0.0	4.4
Haylin View	0.4	13.1	0.1	4.5
Matilda	0.7	13.1	0.1	4.5
Merriman[1]	1.3	13.6	0.1	4.5
Merulana	1.7	13.3	0.1	4.5
Newhaven	2.3	13.5	0.4	4.8
Oakleigh	1.7	13.8	0.2	4.6
Pineview	1.2	13.2	0.1	4.5
Mine Owned				
Barton Hedge	1.6	13.1	0.2	4.6
Claremont	2.1	13.1	0.1	4.5
Greylands	2.4	13.6	0.5	4.9
Kurrajong	0.4	13.1	0.1	4.5
Matoppo	2.7	13.7	0.6	5.0
Mayfield	0.4	13.1	0.1	4.5
Mayfield Cottage	0.4	13.1	0.1	4.5
Merrilong	0.4	13.1	0.0	4.4
Naroo	4.5	13.9	0.4	4.8
Omeo	1.9	13.5	0.4	4.8
Turrabaa	5.3	13.5	0.4	4.8
Westhaven	1.1	13.1	0.1	4.5
Willarah	2.7	13.3	0.6	5.0

1 NCOPL is currently negotiating the acquisition of Belah Park and Merriman.

2 NCOPL has entered into a private agreement with the landholder of Bow Hills.

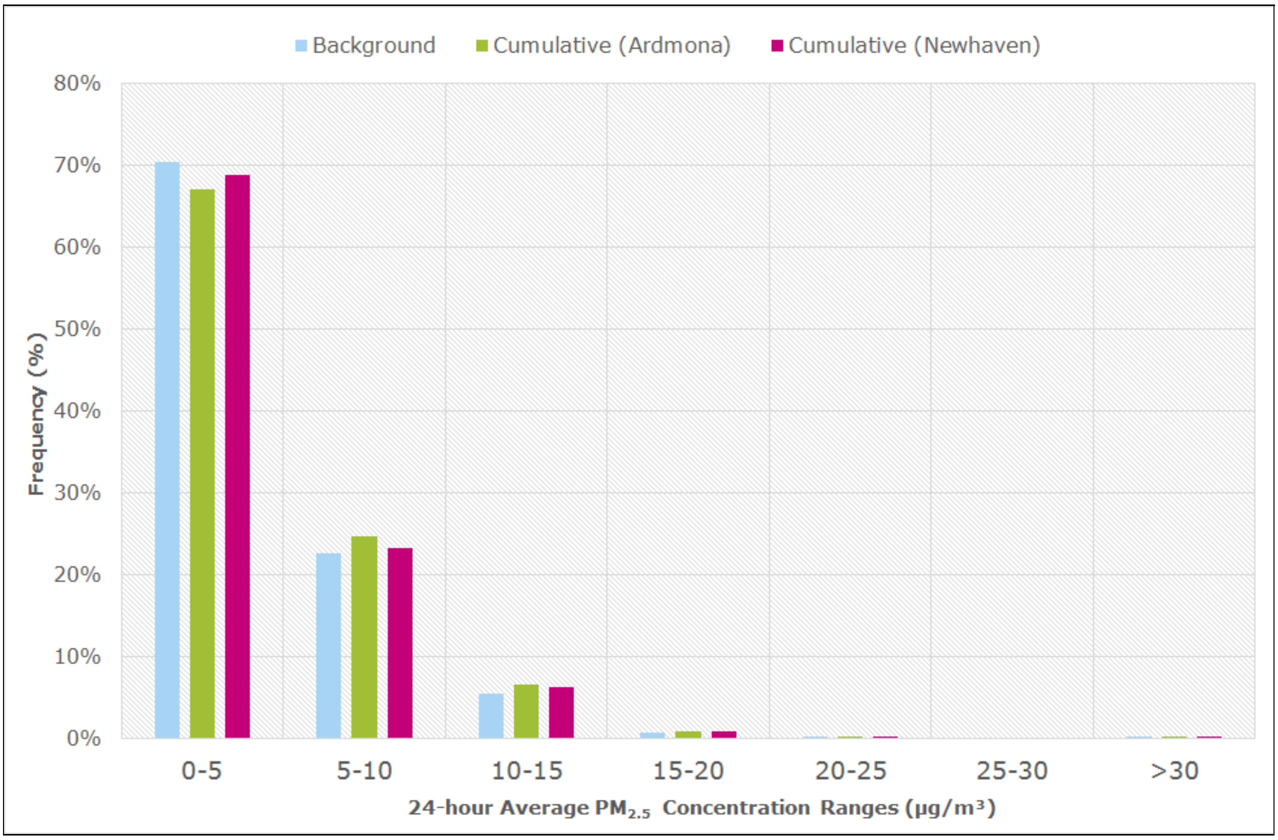

Figure 9-2: Frequency distribution of cumulative 24-hour average $PM_{2.5}$ concentration

9.3 TSP concentration and dust deposition

The modelled modified NM (project-only) and cumulative TSP concentrations and dust deposition are presented in **Table 9-3**. There are no predicted exceedances of the impact assessment criteria. Contour plots are presented in **Appendix C**.

Cumulative annual average TSP concentrations are estimated by adding a background concentration of 22 µg/m³ to the predicted increment. This provides a conservative assessment of impact, particularly at locations close to and in a prevailing downwind direction from NM operations. Cumulative annual average dust deposition is estimated by adding a background of 1.9 g/m^2/month to the predicted increment.

Table 9-3: Modified NM and cumulative TSP concentration (µg/m³) and dust deposition (g/m²/month)

Criteria	Annual average TSP		Annual average dust deposition	
	90 µg/m³		2 g/m²/month	4 g/m²/month
	Modified NM	Cumulative	Modified NM	Cumulative
Private				
Ardmona	4.1	26.1	0.2	2.1
Belah Park[1]	2.5	24.5	0.1	2.0
Bow Hills[2]	3.3	25.3	0.1	2.0
Burragurrum	0.3	22.3	0.0	1.9
Haylin View	0.7	22.7	0.0	1.9
Matilda	0.5	22.5	0.0	1.9
Merriman[1]	1.8	23.8	0.0	1.9
Merulana	1.2	23.2	0.0	1.9
Newhaven	2.9	24.9	0.1	2.0
Oakleigh	2.0	24.0	0.1	2.0
Pineview	1.0	23.0	0.0	1.9
Mine Owned				
Barton Hedge	1.0	23.0	0.0	1.9
Claremont	1.0	23.0	0.0	1.9
Greylands	7.1	29.1	0.2	2.1
Kurrajong	0.2	22.2	0.0	1.9
Matoppo	13.1	35.1	0.4	2.3
Mayfield	0.5	22.5	0.0	1.9
Mayfield Cottage	0.4	22.4	0.0	1.9
Merrilong	0.3	22.3	0.0	1.9
Naroo	7.7	29.7	0.3	2.2
Omeo	3.9	25.9	0.1	2.0
Turrabaa	7.5	29.5	0.3	2.2
Westhaven	0.5	22.5	0.0	1.9
Willarah	26.3	48.3	1.0	2.9

1 NCOPL is currently negotiating the acquisition of Belah Park and Merriman.

2 NCOPL has entered into a private agreement with the landholder of Bow Hills.

10. RAIL TRANSPORT

Heggies (2009a) presented an assessment fugitive dust emissions from coal wagons and found that concentrations of 24-hour average TSP associated with 5 trains per day would be less than 0.5 µg/m³ 100m from the track.

Assuming that 50% of TSP is PM_{10} (as discussed in **Section 6.3**) concentrations of 24-hour average PM_{10} associated with 5 trains per day would be expected to be less than 0.25 µg/m³ beyond 100m from the track. Heggies (2009a) concluded that emissions of PM_{10} from coal wagons would not result in significant air quality impacts.

The modelling presented in Heggies (2009a) assumed an average of 5 trains per day, whereas the approved peak train numbers is 8 trains per day, representing a 60% increase. Furthermore, the emission factor used in Heggies (2009a) is calculated based on an estimated % of the total train load that is lost as fugitive dust, and assumed a train load of 5,400 tonnes. The wagons currently used for NM have a capacity of 97 tonnes, and assuming 82 wagons per train a revised train load of 7,954 tonnes would result in a potential 47% increase from what was assessed in Heggies (2009a).

Therefore, assuming a combined 107% increase in the Heggies (2009a) estimated emissions and a corresponding 107% increase in ground level concentrations, a 24-hour average PM_{10} concentration of approximately 0.5 µg/m³ would be expected 100m from the track. Similar to the conclusion in Heggies (2009a), this is not expected to result in significant rail transport air quality impacts.

The Modification would include an increase in the average number of trains from 3 trains/day to 4 trains/day however the peak number of trains per day (8) would remain unchanged. The Modification would therefore not change the predicted peak 24-hour average PM_{10} concentration (i.e. approximately 0.5 µg/m³) and would not result in significant rail transport air quality impacts.

NCOPL would continue to water product coal as it is loaded onto the conveyor to the rail load-out facility to maintain sufficient moisture content to prevent dust lift-off during loading.

11. GREENHOUSE GAS ASSESSMENT

11.1 Introduction

NM greenhouse gas (GHG) emissions associated with 8 Mtpa ROM coal production were estimated by Heggies (2009b). Estimates were presented for direct (Scope 1) emissions (i.e. fugitive methane, diesel consumption), indirect (Scope 2) (i.e. purchased electricity) and Scope 3 emissions (i.e. employee travel, coal transportation and energy production).

Heggies (2009b) estimated that annual total (Scopes 1 to 3) emissions for the NM to be 19.5 million tonnes of carbon dioxide equivalents (Mt CO_2-e) and annual Scope 1 (direct) emissions to be 0.4 Mt CO_2-e per annum.

NCOPL implements an Energy Savings Action Plan (ESAP) (Advitech, 2014) to minimise GHG emissions at the NM.

11.2 Modification greenhouse gas emissions

Revised emissions estimates are presented for the Modification, based on the latest activity data available for site. The Scope 1, Scope 2 and Scope 3 emission sources are shown in **Table 11-1**, representing the most significant sources associated with the NM. Other minor sources of GHG emissions, such as those generated by employee travel and waste disposal are anticipated to be relatively negligible in comparison and have not been considered further in this assessment.

Table 11-1: Scope 1, 2 and 3 emission sources

Scope 1 (Direct)	Scope 2 (Indirect)	Scope 3 (Indirect)
Fuel combustion on site (diesel fuel) and fugitive emissions of methane from disturbed coal seams.	Consumption of purchased electricity.	Downstream emissions generated from off-site transportation and energy production from coal.

Annual emission estimates are presented for methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2), reported in units of tonnes of carbon dioxide equivalents (t CO_2-e). The relative importance of a GHG is measured in terms of its Global Warming Potential (GWP). The GWP is an index used to convert relevant non-CO_2 gases to a carbon dioxide equivalent (CO_2-e) by multiplying the quantity of the gas by its GWP. The GWP for each type of GHG has been taken from the NGAF (DoE, 2014a), as follows:

- CH_4: GWP of 21 (21 times more effective as a GHG than CO_2).
- N_2O: GWP of 310 (310 times more effective as a GHG than CO_2).

11.3 Operational details

GHG emissions generated by the NM have been estimated for each year of future mining operations (2015 through to 2031). The indicative activity data for each year are presented in **Table 11-2**.

Diesel consumption for future mining years is estimated based on 2014/2015 AEMR data which reports a total of 4,644 kiloLitres (kL) diesel was consumed for a ROM extraction rate of 6.7 Mtpa. A diesel intensity factor of 0.0007 kL per tonne of ROM coal was derived and used to estimate diesel consumption for each future year, based on the proposed mining schedule for the Modification.

Similarly, an electricity intensity factor of 10.7 kiloWatt hours (kWh) per tonne of ROM coal was derived from the AEMR electricity use and used to estimate electricity use for each future year.

Table 11-2: Indicative annual ROM coal production schedule and activity data

Operational year	ROM production (Mt)	Diesel consumption (kL)	Electricity consumed (MWh)
2015	6.4	4,408	68,157
2016	8.0	5,521	85,365
2017	9.6	6,600	102,045
2018	10.0	6,911	106,857
2019	10.5	7,268	112,383
2020	9.5	6,537	101,079
2021	10.4	7,204	111,395
2022	10.1	6,995	108,162
2023	10.2	7,047	108,968
2024	10.2	7,003	108,278
2025	10.1	6,997	108,194
2026	10.1	6,977	107,874
2027	10.2	7,002	108,271
2028	9.8	6,758	104,496
2029	10	6,672	103,169
2030	10	6,663	103,020
2031	2	1,652	25,544

MWh = megawatt hour

11.4 Greenhouse gas emission estimates

11.4.1 Scope 1

Emissions from diesel consumption are estimated based on the activity data presented in **Table 11-2** and the emission factors presented in the NGAF (DoE, 2014a). Table 3 of the NGAF workbook provides an energy content factor (gigaJoules [GJ]/kL) and Scope 1 emission factors (kg CO_2-e/GJ) for liquid fuels used for stationary energy purposes[6].

Fugitive gas emissions are released from the coal seam during pre-drainage, goaf drainage and mine ventilation, while residual gas will desorb from coal stored in stockpiles. The measured gas content at the NM is in the range of 5 to 9 cubic metres per tonne (m^3/t) with peaks of 13.5 m^3/t in the northwest corner of the lease. Emissions are estimated based on an average gas content of 9 m^3/t and assuming 7.5 m^3/t of gas is desorbed with a residual level of 1.5 m^3/t remaining in the coal (Moreby, 2009).

Gas contents of 87% CO_2 and 13% CH_4 are assumed and the quantity of CO_2 and CH_4 in m^3/t is converted to CO_2-e based on the conversion factors for fugitive emissions from extraction of coal (Method 4) in the National Greenhouse and Energy Reporting Technical Guidelines (DoE, 2014b).

11.4.2 Scope 2

Emissions associated with electricity consumption are estimated based on the activity data presented in **Table 11-2** and the latest NGAF workbook Scope 2 emission factor for NSW (0.86 kg CO_2-e/kWh).

11.4.3 Scope 3

Scope 3 emissions associated with energy production from extracted coal are estimated based on the NGAF (DoE, 2014a) energy content factor (GJ/t) and emission factors (kg CO_2-e/GJ) for solid fuels (bituminous coal[7]).

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[6] Defined as non transport

[7] Consistent with the previous GHG assessment (Heggies, 2009b).

Scope 3 emissions for transportation of coal by rail to the Port of Newcastle are estimated based on diesel fuel consumption for a travel distance of approximately 370 km and the NSW average diesel consumption for rail freight of 4.03 Litres/kilotonne-km (NSW EPA, 2012). The annual coal production (10.5 Mt) and the travel distance of 370 km are combined to estimate the gross-tonne-kilometres travelled for loaded trains. For the return trip, an estimate of the gross-tonne-km for empty trains is made based on a wagon weight of 23 t, 82 wagons per train and train capacity of 8,000 t (i.e. 82 x 120 t wagons).

Emissions factors for estimating Scope 3 emissions from diesel (extraction and processing) and electricity (transmission and distribution loses) are also provided in the NGAF (DoE, 2014a).

11.4.4 Summary

A summary of the estimated GHG emissions are presented in **Table 11-3**. The estimated annual average Scope 1 emissions (0.15 Mt CO_2-e/year) represents approximately 0.03% of Australia's commitment under the Kyoto protocol.

Previous GHG estimates presented in Heggies (2009b) were based on different assumptions and input data, and therefore cannot be compared directly. For example, the estimated diesel and electricity consumption for the Modification is higher than that presented in Heggies (2009b), resulting in higher GHG emissions. However, estimates of fugitive emissions (the largest Scope 1 emission) are significantly lower for the Modification, based on using the average gas content of coal.

11.5 Greenhouse gas emission mitigation

Opportunities to minimise energy consumption and GHG emissions at the NM have been a central consideration to the design and engineering of the mine development and wherever practicable energy efficiency measures have been implemented into the mine's infrastructure and operations philosophy (Advitech, 2014).

Specific opportunities for managing GHG emissions are outlined in the ESAP, developed in accordance with the Project Approval's statement of commitments and *Guidelines for Energy Savings Action Plans* (DEUS, 2005).

Table 11-3: Estimated GHG emissions for the Modified NM

Year	ROM (Mt)	GHG emissions (t CO_2-e / year)								
		Scope 1			Scope 2	Scope 3				
		Diesel	Fugitive Methane	Total	Total	Diesel	Electricity	Transportation	Energy Production	Total
2015	6.4	11,825	166,343	178,169	58,615	902	8,860	38,176	15,255,965	15,303,903
2016	8.0	14,811	111,700	126,511	73,414	1,129	11,097	45,112	19,107,705	19,165,044
2017	9.6	17,705	133,526	151,231	87,759	1,350	13,266	51,835	22,841,375	22,907,826
2018	10.0	18,540	139,823	158,363	91,897	1,414	13,891	53,774	23,918,448	23,987,528
2019	10.5	19,499	147,053	166,552	96,649	1,487	14,610	56,002	25,155,344	25,227,442
2020	9.5	17,538	132,262	149,800	86,928	1,337	13,140	51,446	22,625,163	22,691,086
2021	10.4	19,327	145,761	165,088	95,800	1,474	14,481	55,604	24,934,243	25,005,802
2022	10.1	18,767	141,530	160,297	93,020	1,431	14,061	54,301	24,210,567	24,280,360
2023	10.2	18,906	142,584	161,490	93,712	1,442	14,166	54,625	24,390,856	24,461,089
2024	10.2	18,787	141,682	160,469	93,119	1,433	14,076	54,347	24,236,530	24,306,386
2025	10.1	18,772	141,572	160,344	93,047	1,432	14,065	54,313	24,217,680	24,287,490
2026	10.1	18,716	141,153	159,869	92,772	1,427	14,024	54,184	24,146,013	24,215,649
2027	10.2	18,785	141,672	160,457	93,113	1,433	14,075	54,344	24,234,806	24,304,658
2028	9.8	18,130	136,733	154,864	89,867	1,383	13,585	52,823	23,390,002	23,457,792
2029	9.7	17,900	134,997	152,897	88,725	1,365	13,412	52,288	23,092,904	23,159,969
2030	9.7	17,874	134,801	152,675	88,597	1,363	13,393	52,228	23,059,480	23,126,463
2031	2.4	4,432	33,425	37,857	21,968	338	3,321	21,000	5,717,741	5,742,400
Total		**290,316**	**2,266,617**	**2,556,933**	**1,439,002**	**22,139**	**217,524**	**856,402**	**374,534,823**	**375,630,887**

12. CONCLUSION

Dispersion model predictions for the modified NM at the proposed ROM coal production rate of 10.5 Mtpa show that the Modification would not result in any exceedances of the impact assessment criteria for key pollutants, including PM_{10}, $PM_{2.5}$, TSP and dust deposition.

Cumulative annual average PM_{10}, $PM_{2.5}$, TSP and dust deposition predictions are well below the applicable assessment criteria and the risk of additional days over the 24-hour average PM_{10} and $PM_{2.5}$ assessment criteria is minimal.

The dispersion modelling presented in this report assumes dust controls, as outlined in **Section 2**, are implemented and that the stockpile dust suppression system, currently being designed and implemented, is operational.

The estimated annual average Scope 1 emissions (0.15 Mt CO_2-e) from the modified NM is represent approximately 0.03% of Australia's commitment under the Kyoto protocol.

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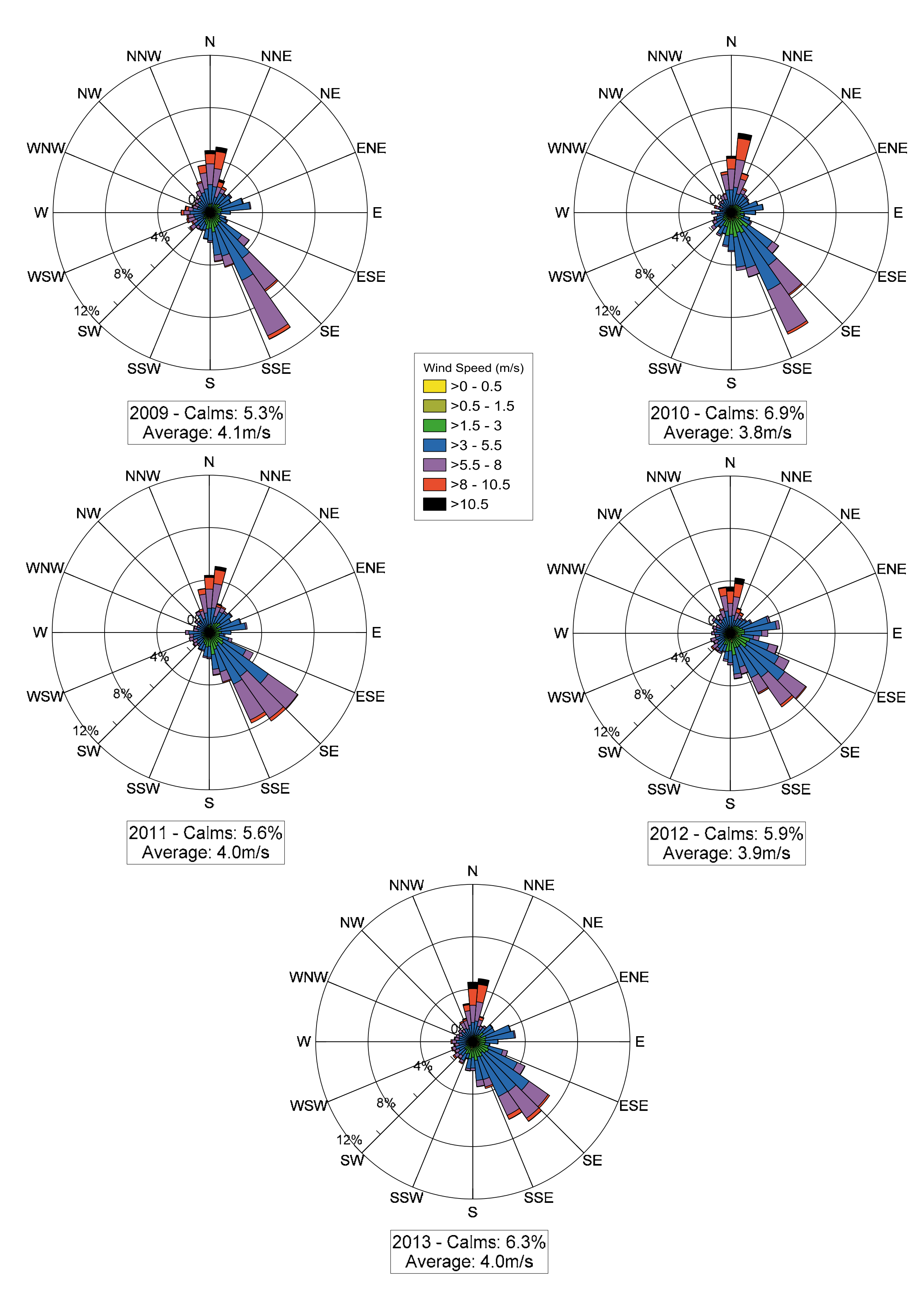
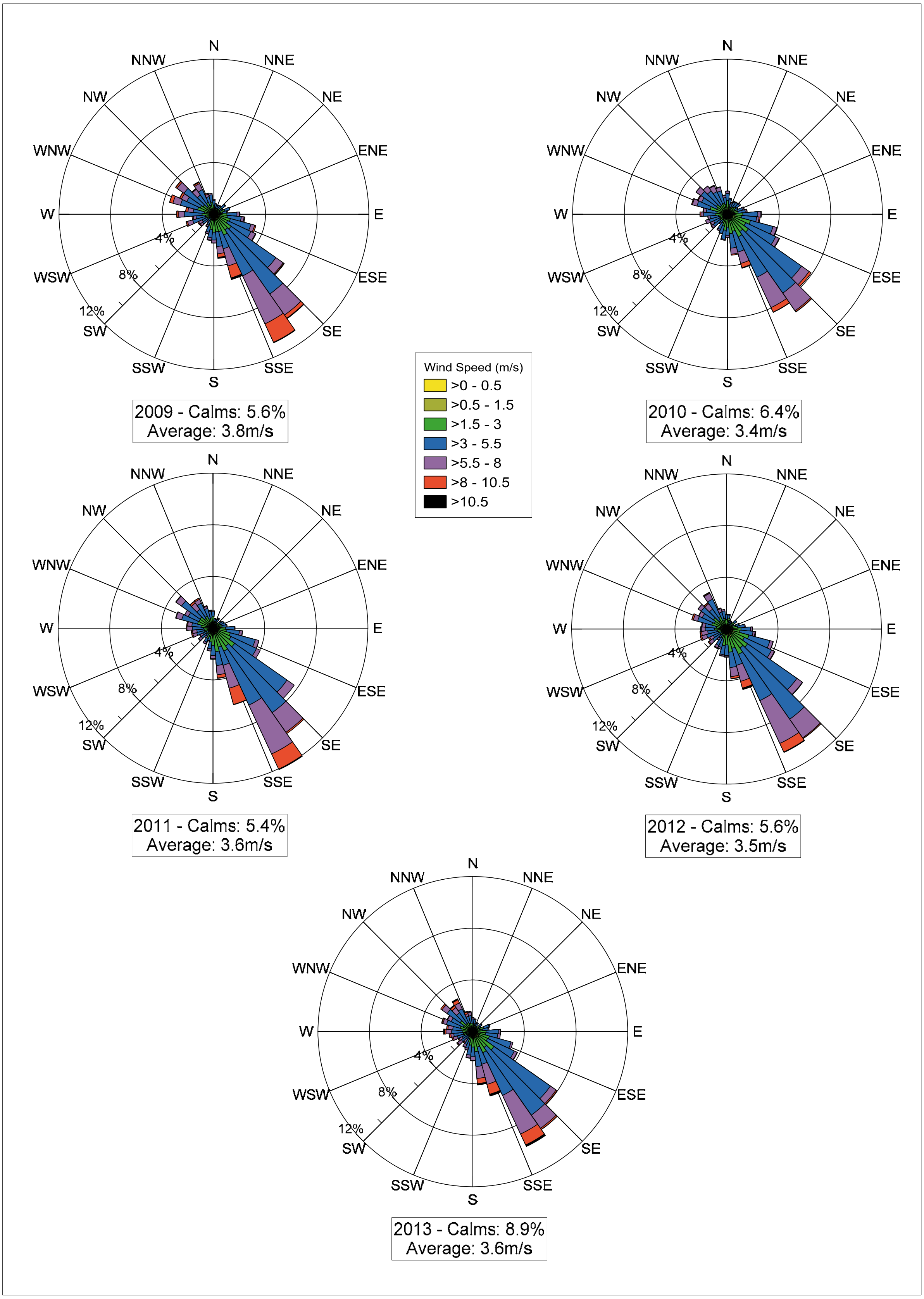
APPENDIX A
ANNUAL WIND ROSES



Annual wind roses Narrabri BoM site



Annual wind roses Gunnedah BoM site

APPENDIX B
EMISSIONS INVENTORY

Emission inventory development

Dust emissions were estimated using United States Environmental Protection Authority (USEPA) AP-42 emission factors and predictive equations listed below, taken from the following chapters:

- Chapter 11.9 Western Surface Coal Mining.
- Chapter 13.2.2 Unpaved Roads.
- Chapter 13.2.4 *13.2.4* Aggregate Handling and Storage Piles
- Chapter 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing.
- Chapter 13.2.5 Industrial Wind Erosion.

Full emission inventories are provided below.

Inventory activity	**Units**	**TSP emission factor / equation**	**PM_{10} emission factor / equation**	**$PM_{2.5}$ emission factor / equation**	**Input variables**		**EF source**
					Parameter	**Value**	
COAL HANDLING							
Loading ROM stockpile	kg/t	$0.74 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	$0.35 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	$0.053 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	U (wind speed) M (moisture content) ROM coal PCI coal CHPP thermal Bypass coal Rejects	3.1 m/s 4.7 % 4.9 % 6.6 % 4.7 % 5.2%	AP42 Chapter 13.2.4
Loading PCI product stockpile							
Loading Thermal (CHPP) product stockpile							
Loading 2ndry bypass coal							
Loading rejects pile							
Loading product coal to trains							
Conveyor transfer - ROM							
Conveyor transfer – product coal							
DOZERS							
Dozers on ROM coal	kg/hr	$35.6 \times \frac{s^{1.2}}{M^{1.3}}$	$6.33 \times \frac{s^{1.5}}{M^{1.4}}$	0.022 x TSP	S (silt content) M (moisture content) ROM coal Product coal	7 % 4.7 % 5.4%	AP42 11.9 Table 11.9-2
Dozers on Product coal							

Inventory activity	Units	TSP emission factor / equation	PM_{10} emission factor / equation	$PM_{2.5}$ emission factor / equation	Input variables		EF source
					Parameter	Value	
WIND EROSION							
'Live' stockpile (hourly varying)	kg/ha/h	$Emission\ Factor = k\sum_{i=1}^{N} Pi$ where: $Pi = 58(u* - ut*)^2 + 25(u* - ut*)$	0.5 * TSP (0.5 from AP42 13.2.5)	0.075 * TSP (0.075 from AP42 13.2.5)	u* (friction velocity (m/s)) ut* (threshold friction velocity (m/s))	hourly varying 1.12 m/s	AP42 13.2.5
Stockpile wind erosion and maintenance	kg/ha/h	1.8 * u	0.5 * TSP (0.5 from AP42 13.2.5)	0.075 * TSP (0.075 from AP42 13.2.5)	u (wind speed)	3.1 m/s	AP42 11.9 Table 11.9-2
UNSEALED HAUL ROADS							
Hauling	kg/VKT	$\left(\frac{0.4536}{1.6093}\right) \times 4.9 * \left(\frac{s}{12}\right)^{0.7} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	$\left(\frac{0.4536}{1.6093}\right) \times 1.5 * \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	$\left(\frac{0.4536}{1.6093}\right) \times 0.15 * \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	Silt content (s) Mean vehicle weight (W)	2% 80 tonnes	AP42 13.2.2
Grading roads	kg/VKT	$0.0034 \times S^{2.5}$	$0.00336 \times S^{2.0}$	$0.0001054 \times S^{2.5}$	S (speed)	4 km/hr	AP42 11.9 Table 11.9-2
COAL PROCESSING							
Rotary breaker / crushing	kg/t	0.0027	0.0012	No data			AP42 11.19.2 Table 11.19.2-2
2ndy bypass screening	kg/t	0.0125	0.0043	No data			AP42 11.19.2 Table 11.19.2-1
TOPSOIL							
Topsoil stripping	kg/t	0.029	TSP x 0.6 [1]	TSP x 0.031 [1]			AP42 11.9 Table 11.9-4 (Scrapers)
Topsoil spreading	kg/t	0.02	TSP x 0.6 [1]	TSP x 0.031 [1]			AP42 11.9 Table 11.9-4 (Scrapers)

Modification 5 - PM10 Emissions

Source	Emission estimate (kg/year)	Intensity	Units	Emission Factor	Units	Variable 1		Variable 2		Variable 3		Variable 4		Variable 5		Control %	Assumptions
TOPSOIL																	
Topsoil Stripping	1,026	58,953	t/yr	0.02	kg/t												Assumptions as per existing scenario in previous Mod
Topsoil Spreading	244	25,791	t/yr	0.01	kg/t												
ROM COAL																	
Loading ROM stockpile	2,814	10,500,000	t/y	0.0003	kg/t	4.7	moisture content in %	1.6	(wind speed/2.2)^1.3								ROM at 11 Mtpa with splits as per previous Mod
Dozer on reclaim	48,251	7,185	h/y	13.43	kg/h	4.7	moisture content in %	7	silt content in %							50	Total 10,950 hours on ROM - 50% on reclaim, 50% on maintenance
Rotary breaker - CHPP	756	6,300,000	t/y	0.0012	kg/t											90	67% to rotary breaker 90% control for rotary breaker enclosed - as per SoC
2ndry bypass - loading ROM hopper	N/A	4,200,000	t/y														Source emissions included in dozer push hours
Screening 2ndry bypass - Screening	1,806	4,200,000	t/y	0.0043	kg/t											90	33% to secondary crusher 90% control for enclosure
2ndry bypass - Crushing	504	4,200,000	t/y	0.0012	kg/t											90	33% to secondary crusher 90% control for enclosure
Conveyor transfer points	2,251	10,500,000	t/y	0.0003	kg/t	4.7	moisture content in %	1.6	(wind speed/2.2)^1.3	8	# transfer points					90	Controls assumed are 40% for wind shielding plus 50% for water sprays
PRODUCT COAL																	
Loading PCI Product Coal	468	1,852,200	t/y	0.0003	kg/t	4.9	moisture content in %	1.6	(wind speed/2.2)^1.3								PCI = 27% of CHPP output which receives 95-97% of rotary breaker throughput (less 3-5% waste). MC = TM minus IM
Loading Thermal (CHPP) Coal	720	4,321,800	t/y	0.0002	kg/t	6.6	moisture content in %	1.6	(wind speed/2.2)^1.3								Thermal CHPP coal = 73% of CHPP output which receives 95-97% of rotary breaker throughput (less 3-5% waste). MC = TM minus IM
Loading 2ndry Bypass Coal	1,126	4,200,000	t/y	0.0003	kg/t	4.7	moisture content in %	1.6	(wind speed/2.2)^1.3								100% of bypass crusher loaded (no waste). MC = TM minus IM
Conveyor transfer	1,831	10,374,000	t/y	0.0002	kg/t	5.4	moisture content in %	1.6	(wind speed/2.2)^1.3	8	# transfer points					90	Total 18 transfer points taken from PRP. Split between ROM, product and rejects conveyors. MC = average of TM minus IM for all coal . Controls assumed are 40% for wind shielding plus 50% for water sprays
Dozer on reclaim	39,728	7,185	h/y	11.06	kg/h	5.4	moisture content in %	7	silt content in %							50	Total 10,950 hours on Product - 50% on reclaim, 50% on maintenance
Loading trains	2,289	10,374,000	t/y	0.0002	kg/t	5.4	moisture content in %	1.6	(wind speed/2.2)^1.3								Waste = 3-5(4)% of rotary breaker
CRUSHER WASTE / REJECTS																	
Conveyor transfer	59	126,000	t/y	0.0002	kg/t	5.2	moisture content in %	1.6	(wind speed/2.2)^1.3	2	# transfer points						Waste = 3-5(4)% of rotary breaker MC = TM minus IM. TM assumed to be same as 2ndry bypass
Loading rejects pile	29	126,000	t/y	0.0002	kg/t	5.2	moisture content in %	1.6	(wind speed/2.2)^1.3								
Hauling rejects	146	126,000	t/y	0.008	kg/t	50	t/load	80	Vehicle gross mass (t)	1	km/return trip	0.39	kg/VKT	2	% silt cont	85	
WIND EROSION	0																
ROM 'Live' stockpile	49	0.3	ha	0.03	kg/ha/Hr	8,760	h/y									50	ROM Live stockpile unchanged from existing scenario 50% control for water sprays
ROM pad - stockpile maintenance	49,367	4.9	ha	2.8	kg/ha/Hr	7,185	h/y	3.1	average wind speed (m/s)							50	ROM pad extended 110m north. 50% control for water sprays Total 10,950 hours on ROM - 50% on reclaim, 50% on maintenance
Product 'Live' stockpile	77	0.5	ha	0.03	kg/ha/Hr	8,760	h/y									50	50% control for water sprays
Product - stockpile maintenance	30,380	3.0	ha	2.8	kg/ha	7,185	h/y	3.1	average wind speed (m/s)							50	Product stockpile area estimated from volume and heights in 'Stockpile Extension 100m Push Out' on Site Plan - Proposed Stockpiling Option. Total 10,950 hours on Product - 50% on reclaim, 50% on maintenance. 50% control for water sprays
Soil stockpiles	5,419	12.4	ha	0.05	kg/ha/h	8,760	h/y										
Active rehab	876	2	ha	0.05	kg/ha/h	8,760	h/y										
MISCELLANEOUS																	
Ventillation Shaft	21,287	450	m3/s	1.5	mg/m3												
Grader	265	4,932	km	0.054	kg/km	4	speed of graders in km/h	1,233	grader hours								
Excavator on rehab																	Source emissions included in topsoil spreading
Total PM10 (kg/yr)	**211,768**																

Modification 5 - PM2.5 Emissions

Source	Emission estimate (kg/year)	Intensity	Units	Emission Factor	Units	Variable 1		Variable 2		Variable 3		Variable 4		Variable 5		Control %
TOPSOIL																
Topsoil Stripping	53	58,953	t/yr	0.001	kg/t											
Topsoil Spreading	16	25,791	t/yr	0.001	kg/t											
ROM COAL																
Loading ROM stockpile	213	10,500,000	t/y	0.00004	kg/t	4.7	moisture content in %	1.6	(wind speed/2.2)^1.3							50
Dozer on reclaim	389	7,185	h/y	0.108	kg/h	4.7	moisture content in %	7	silt content in %							50
Rotary breaker - CHPP	51	6,300,000	t/y	0.0001	kg/t											90
2ndry bypass - loading ROM hopper	N/A	4,200,000														
Screening 2ndry bypass - Screening	158	4,200,000	t/y	0.0004	kg/t											90
2ndry bypass - Crushing	34	4,200,000	t/y	0.0001	kg/t											90
Conveyor transfer points	341	10,500,000	t/y	0.00004	kg/t	4.7	moisture content in %	1.6	(wind speed/2.2)^1.3	8	# transfer points					90
PRODUCT COAL																
Loading PCI Product Coal	35	1,852,200	t/y	0.00004	kg/t	4.9	moisture content in %	1.6	(wind speed/2.2)^1.3							50
Loading Thermal (CHPP) Coal	55	4,321,800	t/y	0.00003	kg/t	6.6	moisture content in %	1.6	(wind speed/2.2)^1.3							50
Loading 2ndry Bypass Coal	85	4,200,000	t/y	0.00004	kg/t	4.7	moisture content in %	1.6	(wind speed/2.2)^1.3							50
Conveyor transfer	277	10,374,000	t/y	0.00003	kg/t	5.4	moisture content in %	1.6	(wind speed/2.2)^1.3	8	# transfer points					90
Dozer on reclaim	3,245	7,185	h/y	0.90	kg/h	5.4	moisture content in %	7	silt content in %							50
Loading trains	347	10,374,000	t/y	0.00003	kg/t	5.4	moisture content in %	1.6	(wind speed/2.2)^1.3							
CRUSHER WASTE / REJECTS																
Conveyor transfer	9	126,000	t/y	0.00004	kg/t	5.2	moisture content in %	1.6	(wind speed/2.2)^1.3	2	# transfer points					
Loading rejects pile	4	126,000	t/y	0.00004	kg/t	5.2	moisture content in %	1.6	(wind speed/2.2)^1.3							
Hauling rejects	15	126,000	t/y	0.001	kg/t	50	t/load	80	Vehicle gross mass (t)	1	km/return trip	0.04	kg/VKT	2	% silt cont	85
WIND EROSION	0															
ROM 'Live' stockpile	7	0.3	ha	0.01	kg/ha/Hr	8,760	h/y									50
ROM pad - stockpile maintenance	7,405	4.9	ha	0.4	kg/ha/Hr	7,185	h/y	3.1	average wind speed (m/s)							50
Product 'Live' stockpile	6	0.5	ha	0.00	kg/ha/Hr	8,760	h/y									50
Product - stockpile maintenance	4,557	3.0	ha	0.4	kg/ha	7,185	h/y	3.1	average wind speed (m/s)							50
Soil stockpiles	0	12.4	ha	0.01	kg/ha/h	8,760	h/y									100
Active rehab	131.4	2	ha	0.008	kg/ha/h	8,760	h/y									
MISCELLANEOUS																
Ventillation Shaft	21,287	450	m3/s	1.5	mg/m3											
Grader	8	4,932	km	0.002	kg/km	4	speed of graders in km/h	1,233	grader hours							
Excavator on rehab																

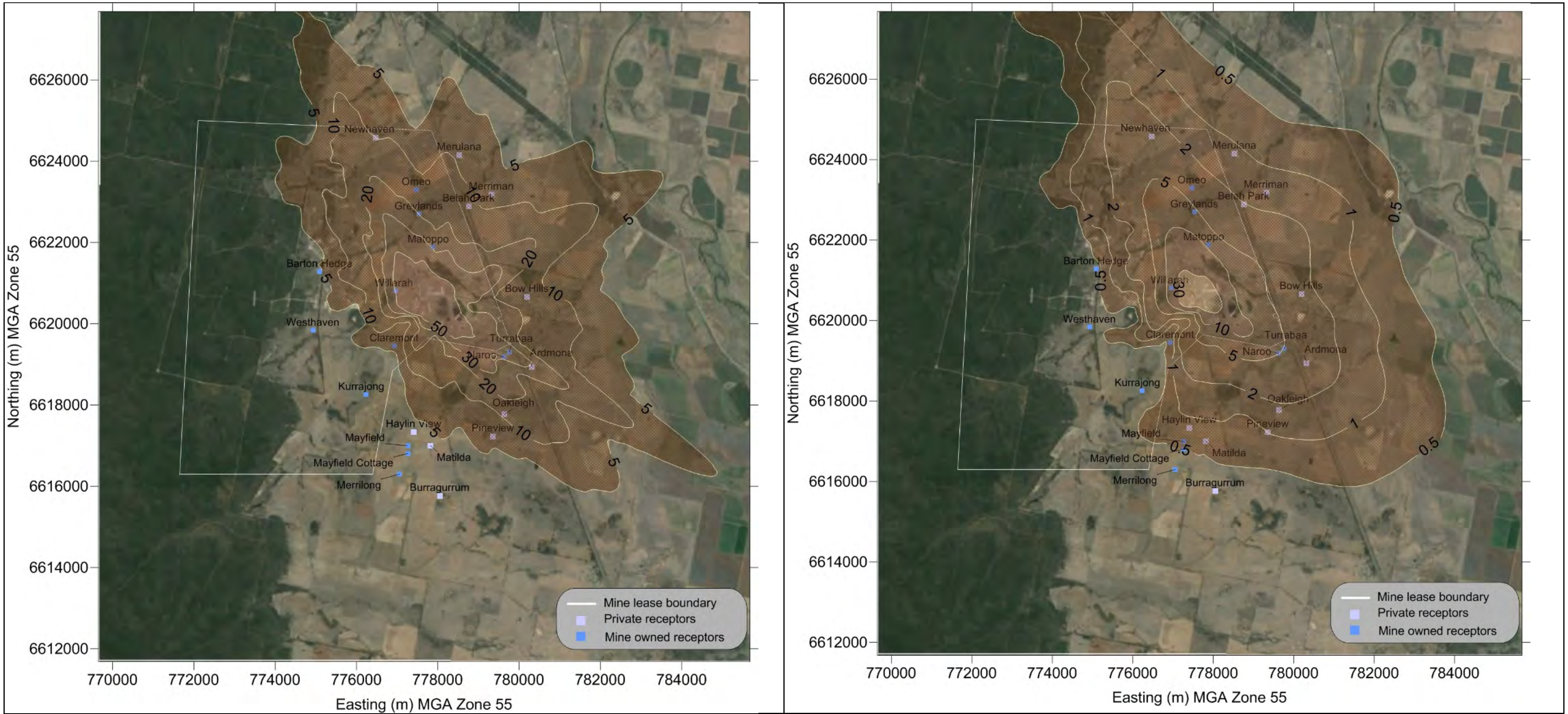
Total PM10 (kg/yr) **38,728**

Modification 5 - TSP Emissions

Source	Emission estimate (kg/year)	Intensity	Units	Emission Factor	Units	Variable 1		Variable 2		Variable 3		Variable 4		Variable 5		Control %
TOPSOIL																
Topsoil Stripping	1,710	58,953	t/yr	0.03	kg/t											
Topsoil Spreading	516	25,791	t/yr	0.02	kg/t											
ROM COAL																
Loading ROM stockpile	2,975	10,500,000	t/y	0.0006	kg/t	4.7	moisture content in %	1.6	(wind speed/2.2)^1.3							50
Dozer on reclaim	176,700	7,185	h/y	49.19	kg/h	4.7	moisture content in %	7	silt content in %							50
Rotary breaker - CHPP	1,701	6,300,000	t/y	0.0027	kg/t											90
2ndry bypass - loading ROM hopper	N/A	4,200,000														
Screening 2ndry bypass - Screening	5,250	4,200,000	t/y	0.0125	kg/t											90
2ndry bypass - Crushing	1,134	4,200,000	t/y	0.0027	kg/t											90
Conveyor transfer points	4,759	10,500,000	t/y	0.0006	kg/t	4.7	moisture content in %	1.6	(wind speed/2.2)^1.3	8	# transfer points					90
PRODUCT COAL																
Loading PCI Product Coal	495	1,852,200	t/y	0.0005	kg/t	4.9	moisture content in %	1.6	(wind speed/2.2)^1.3							50
Loading Thermal (CHPP) Coal	761	4,321,800	t/y	0.0004	kg/t	6.6	moisture content in %	1.6	(wind speed/2.2)^1.3							50
Loading 2ndry Bypass Coal	1,190	4,200,000	t/y	0.0006	kg/t	4.7	moisture content in %	1.6	(wind speed/2.2)^1.3							50
Conveyor transfer	3,872	10,374,000	t/y	0.0005	kg/t	5.4	moisture content in %	1.6	(wind speed/2.2)^1.3	8	# transfer points					90
Dozer on reclaim	147,521	7,185	h/y	41.1	kg/h	5.4	moisture content in %	7	silt content in %							50
Loading trains	4,840	10,374,000	t/y	0.0005	kg/t	5.4	moisture content in %	1.6	(wind speed/2.2)^1.3							
CRUSHER WASTE / REJECTS																
Conveyor transfer	124	126,000	t/y	0.0005	kg/t	5.2	moisture content in %	1.6	(wind speed/2.2)^1.3	2	# transfer points					
Loading rejects pile	62	126,000	t/y	0.0005	kg/t	5.2	moisture content in %	1.583	(wind speed/2.2)^1.3							
Hauling rejects	682	126,000	t/y	0.036	kg/t	50	t/load	80	Vehicle gross mass (t)	1	km/return trip	1.8	kg/VKT	2	% silt cont	85
WIND EROSION	0															
ROM 'Live' stockpile	98	0.3	ha	0.07	kg/ha/Hr	8,760	h/y									50
ROM pad - stockpile maintenance	98,734	4.9	ha	5.6	kg/ha/Hr	7,185	h/y	3.1	average wind speed (m/s)							50
Product 'Live' stockpile	154	0.5	ha	0.07	kg/ha/Hr	8,760	h/y									50
Product - stockpile maintenance	60,759	3.0	ha	5.6	kg/ha	7,185	h/y	3.1	average wind speed (m/s)							50
Soil stockpiles	0	12.4	ha	0.10	kg/ha/h	8,760	h/y									100
Active rehab	1,752	2	ha	0.1	kg/ha/h	8,760	h/y									
MISCELLANEOUS																
Ventillation Shaft	21,287	450	m3/s	1.5	mg/m3											
Grader	268	4,932	km	0.054	kg/km	4	speed of graders in km/h	1,233	grader hours							
Excavator on rehab																

Total PM10 (kg/yr) **537,342**

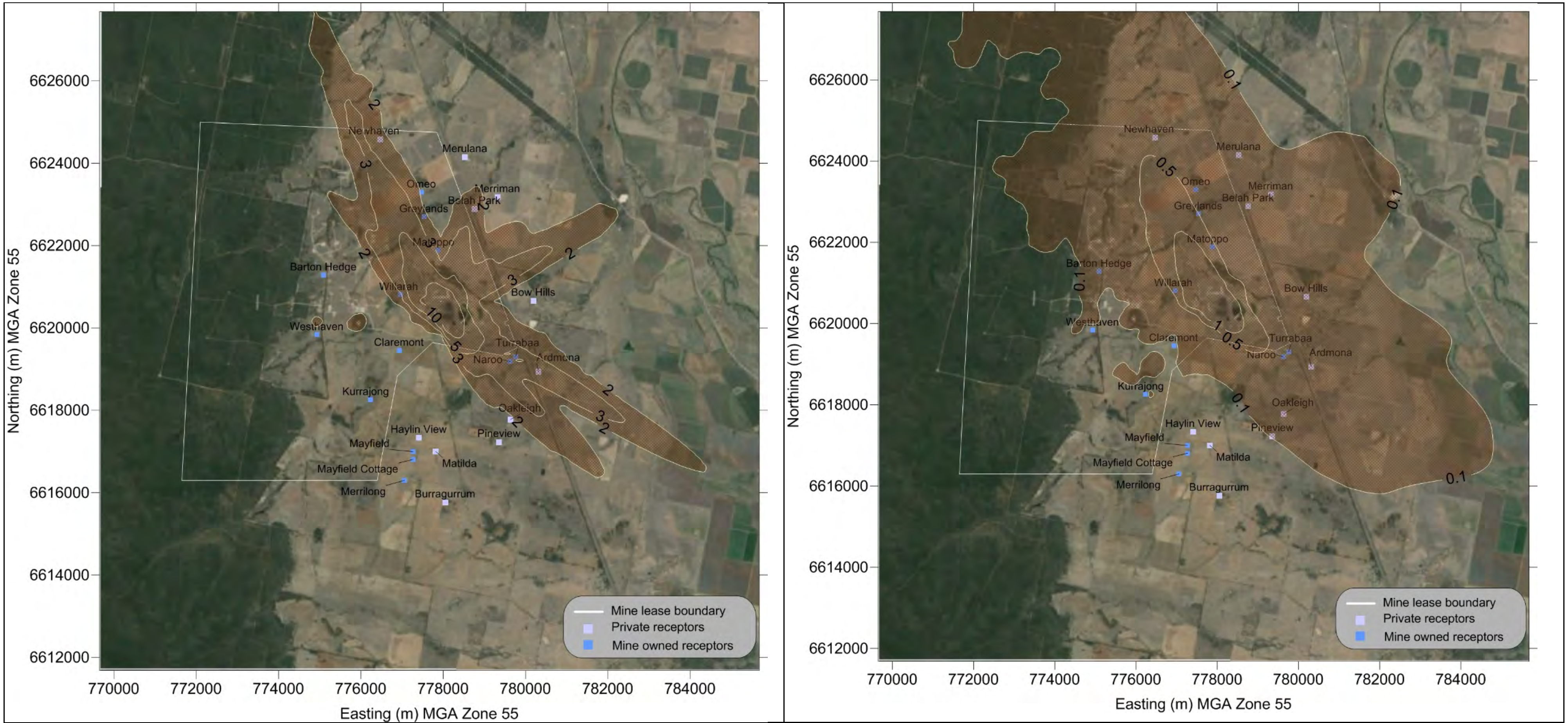
APPENDIX C
CONTOUR PLOTS



Incremental max 24-hour PM_{10} concentration

Incremental annual average PM_{10} concentration

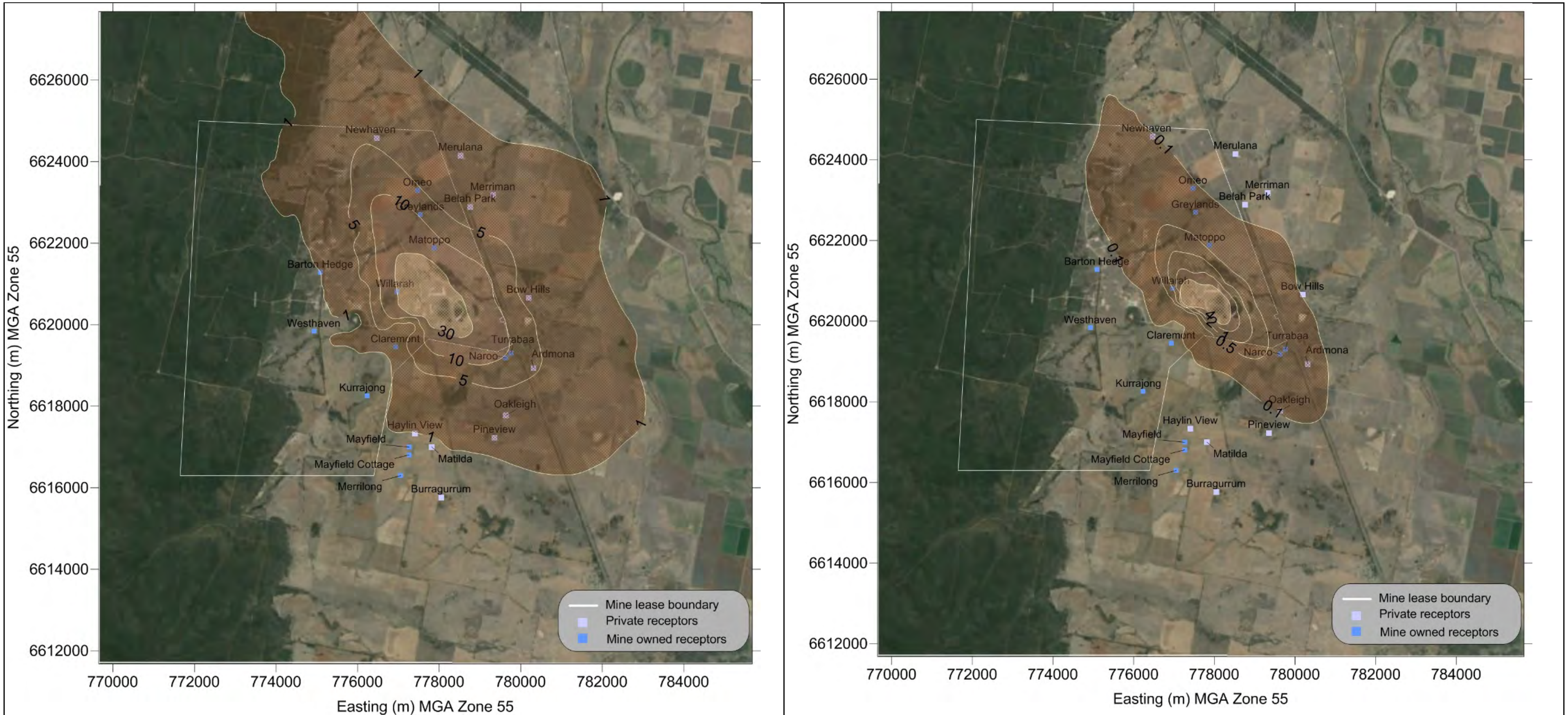
Figure A3-1: Predicted Modified NM PM_{10} concentration



Incremental max 24-hour $PM_{2.5}$ concentration

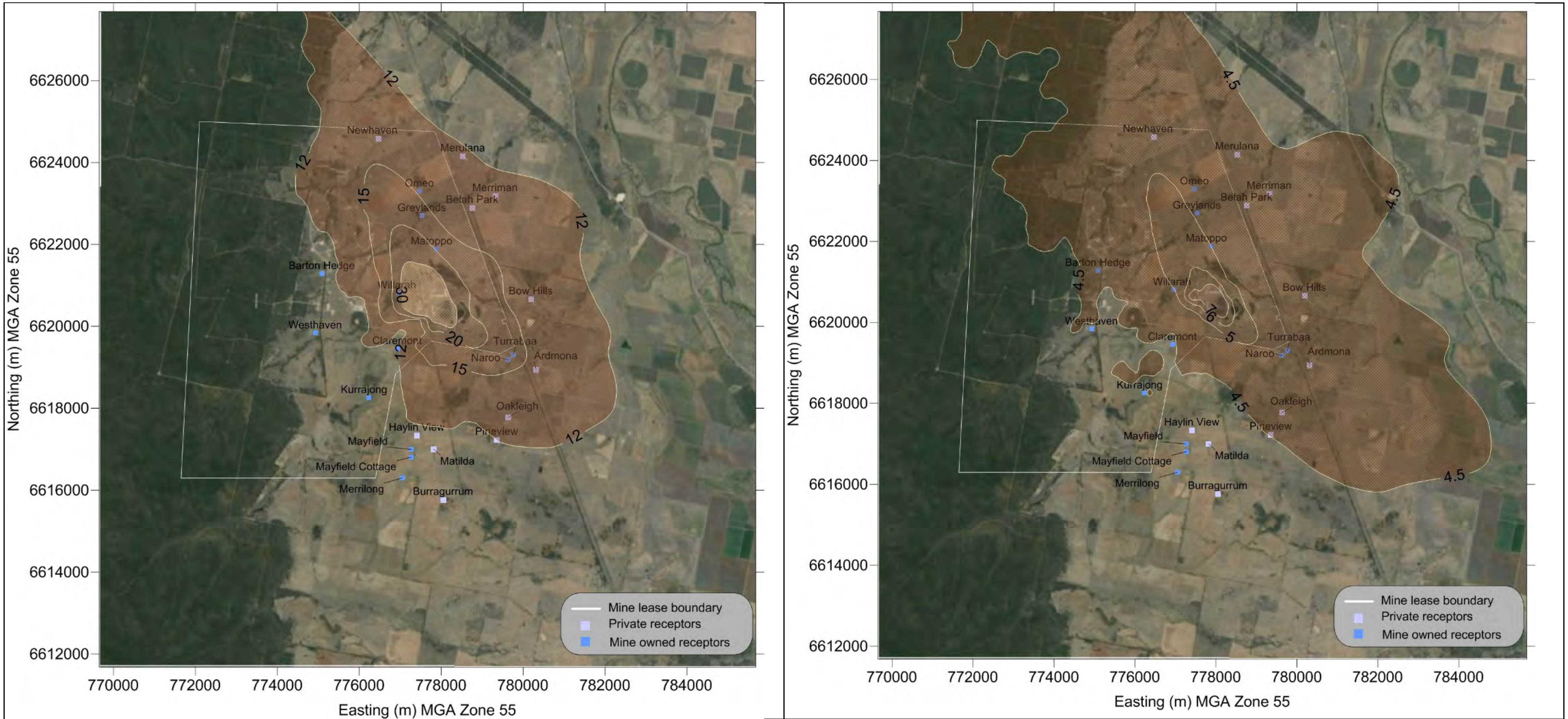
Incremental annual average $PM_{2.5}$ concentration

Figure A3-2: Predicted Modified NM $PM_{2.5}$ concentration



Incremental annual average TSP concentration | Incremental annual average dust deposition

Figure A3-3: Predicted Modified NM TSP concentration and dust deposition



Cumulative annual average PM_{10} concentration | Cumulative annual average $PM_{2.5}$ concentration

Figure A3-4: Predicted cumulative PM_{10} and $PM_{2.5}$ concentration

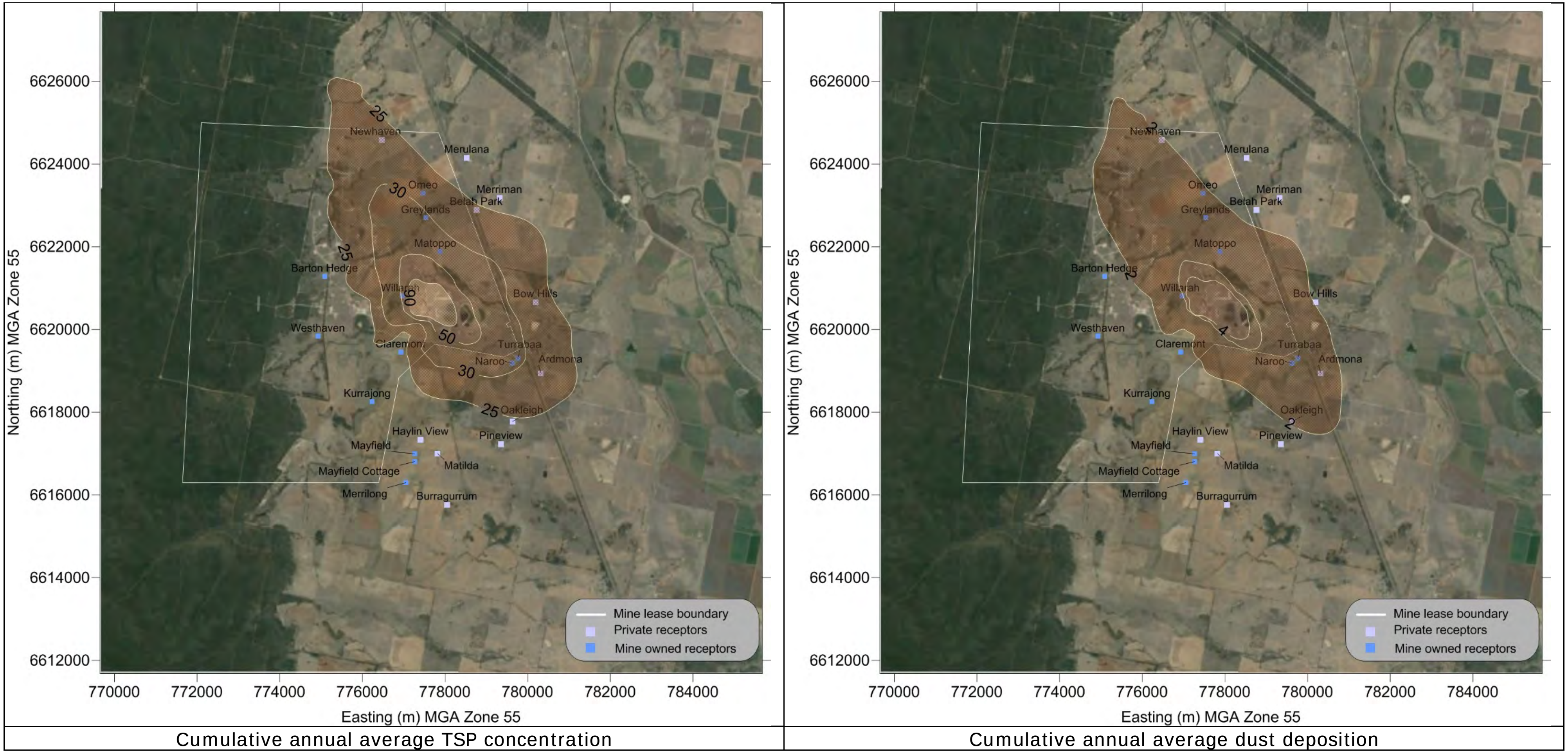


Figure A3-5: Predicted cumulative TSP concentration and dust deposition