

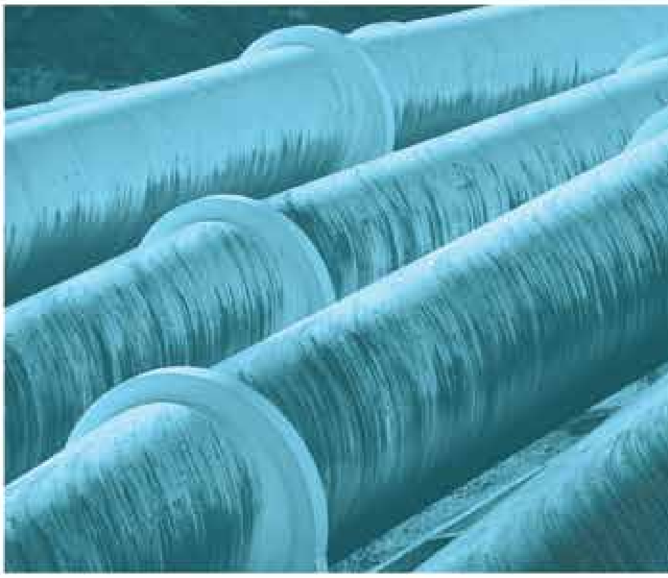

Wongawilli Colliery Modification Report

PA 09_0161 MOD 2 - North West Mains Development

Volume 4 - Appendix F

Prepared for Wollongong Coal Limited

November 2020

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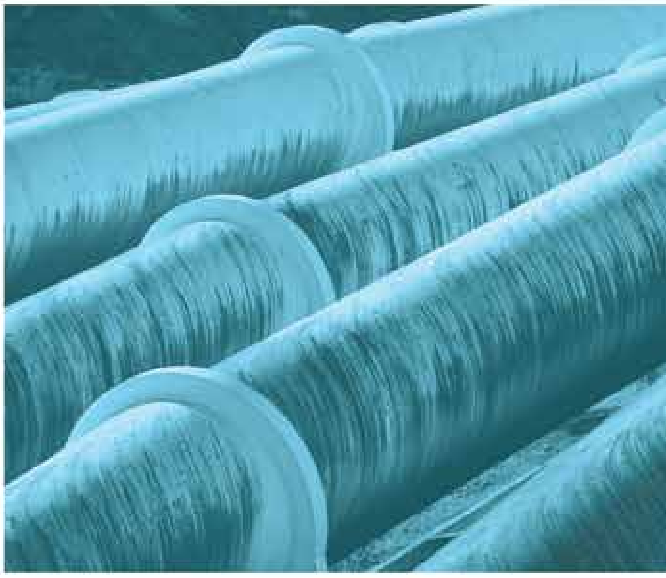
Appendix F

Air quality and greenhouse gas assessment


Wongawilli MOD2 NW Mains

Air Quality and Greenhouse Gas Assessment

Prepared for Wollongong Coal Limited
December 2020

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Wongawilli MOD2 NW Mains

Air Quality and Greenhouse Gas Assessment

Report Number

J200053 RP02

Client

Wollongong Coal Limited

Date

17 November 2020

Version

Final

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17 November 2020

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Executive Summary

Wongawilli Colliery (the Colliery) is an underground coal mine located approximately 15 kilometres (km) south-west of Wollongong within the Wollongong and Wingecarribee local government areas (LGAs). The Colliery is owned and operated by Wollongong Coal Pty Limited (Wollongong Coal). Wollongong Coal is majority owned by Jindal Steel and Power Limited (JSPL), who largely purchase coal produced at the Colliery for steel production purposes.

Wollongong Coal are seeking modification to existing approved operations at the Colliery to extend the life of the mine by 5 years and enable the continued development of the approved North West Mains Development (NWMD).

The proposed modification is seeking to:

- extend the life of the mine by 5 years to 31 December 2025 to enable Wollongong Coal to continue development of the approved NWMD;
- first workings place change mining method using two continuous miners to enable extraction of coal from within the approved NWMD workings;
- additional driveage and underground mains heading of approximately 2.9 km to access the existing Wongawilli Ventilation Shaft 1;
- provide additional access to the NWMD to that currently approved via existing Portals 6 and 7;
- minor alignment changes to the approved NWMD as ventilation infrastructure is no longer proposed at the western end of the approved NWMD alignment; and
- construction of a new section of coal conveyor system, approximately 60 m in length, at the Wongawilli Upper top pit.

This air quality impact assessment (AQIA) has been prepared by EMM Consulting Pty Limited (EMM) on behalf of Wollongong Coal, to assess potential air quality impacts associated with the Colliery on the surrounding environment. The AQIA has been prepared in general accordance with the guidelines specified by the NSW Environment Protection Authority (EPA) in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA 2016).

Existing environmental conditions were quantified primarily using data from the Colliery air quality monitoring network and the nearby NSW Department of Planning, Industry and Environment Kembla Grange air quality monitoring station.

Emissions of total suspended particulates (TSP), particulate matter less than 10 micrometres (µm) in aerodynamic diameter (PM_{10}) and particulate matter less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$) were quantified for all significant emission sources at the Colliery. Emissions were quantified primarily using publicly available emission estimation techniques.

Atmospheric dispersion modelling of air pollutant emissions from the Colliery was completed using the AERMOD model.

The results of the dispersion modelling highlighted the predicted impacts from Colliery operations will not result in exceedance of any applicable criteria at any neighbouring assessment location.

A GHG assessment was also undertaken for the Colliery. Annual scope 1 and 2 GHG emissions generated by the Colliery represent approximately 0.291% of total GHG emissions for NSW and 0.071% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2018.

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1 Introduction

Wongawilli Colliery (the Colliery) is an underground coal mine located approximately 15 kilometres (km) south-west of Wollongong within the Wollongong and Wingecarribee local government areas (LGAs). The regional and local settings of the Colliery are presented in Figure 1.1 and Figure 1.2.

The Colliery is owned and operated by Wollongong Coal Pty Limited (Wollongong Coal). Wollongong Coal is majority owned by Jindal Steel and Power Limited (JSPL), who largely purchase coal produced at the Colliery for steel production purposes.

This environmental assessment (EA) has been prepared to accompany a modification application (MOD2) to the existing Project Approval (PA) for the underground coal mine (PA 09_0161) originally approved in November 2011 and subsequently modified in December 2015 (MOD1).

MOD2 is sought under section 4.55(2) of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

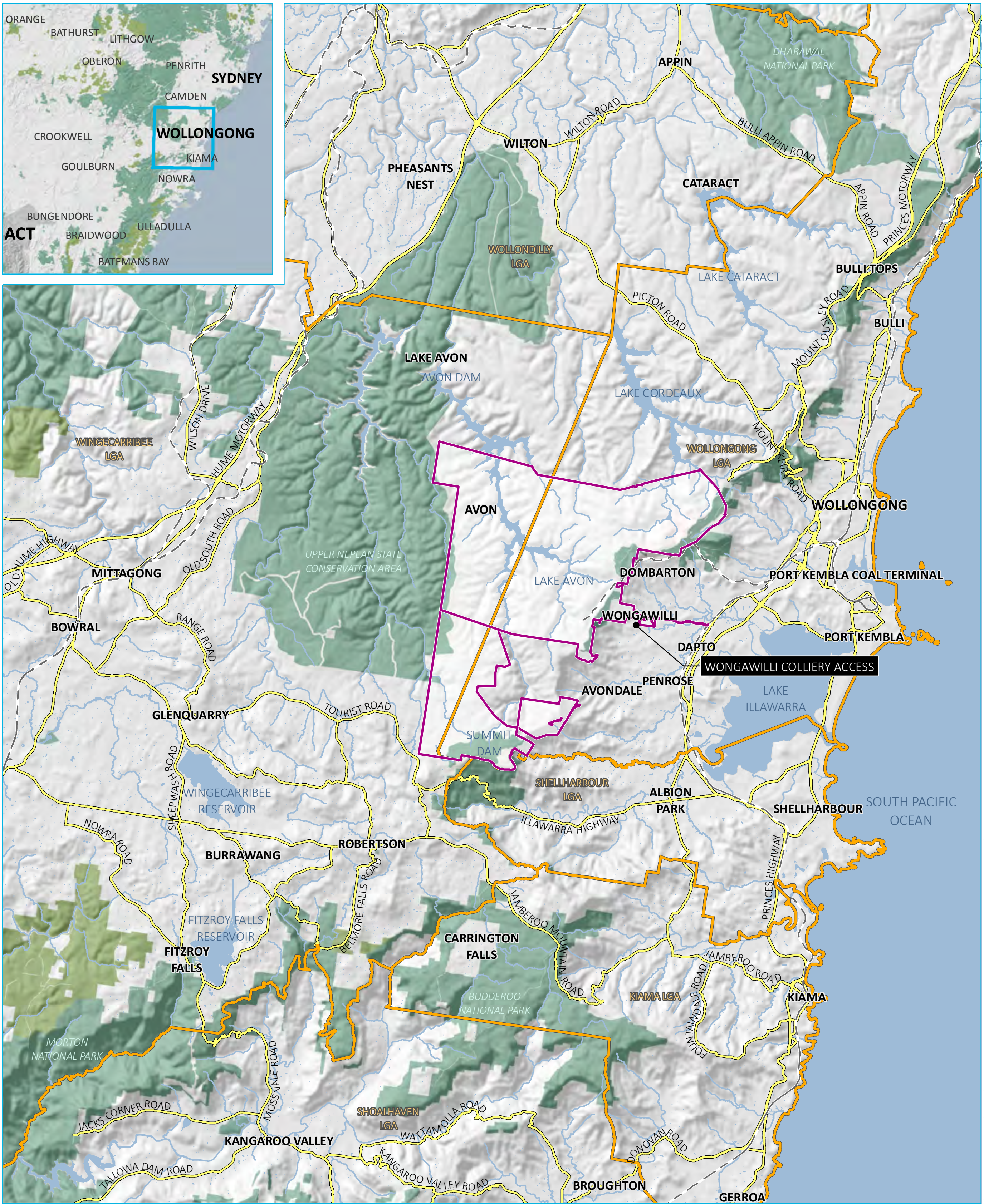
The Colliery is a well-established underground coal mine with mining activities having occurred at the site since 1916, principally producing coking coal for steel production.

The Colliery is located within the Nebo Project Area and was approved under the now repealed Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) by the Planning Assessment Commission (PAC) (now the Independent Planning Commission (IPC)). The PA permitted:

- continued use of the surface infrastructure at the Wongawilli pit top as currently operated;
- run of mine (ROM) coal production of up to 2 million tonnes per annum (Mtpa);
- mining of six longwalls panels (N1 to N6) in the Nebo Project Area;
- continued development and construction of the North West Mains Development (NWMD);
- continued transportation of ROM coal from Wongawilli Colliery to Port Kembla Coal Terminal by rail; and
- rehabilitation of the site.

Under the conditions of its PA, the Colliery is approved to undertake mining operations until 31 December 2020, with the coal extracted transported via rail to Port Kembla for export to JSPL's steel production facilities and other markets.

The proposed modification is seeking to extend the life of the mine by 5 years to enable Wollongong Coal to continue development of the approved NWMD. To date, approximately 500 m of the NWMD has been developed prior to the Colliery going into care and maintenance in July 2019. Furthermore, the modification largely seeks approval to extend the length of NWMD approximately 2.9 km to access the existing Wongawilli Ventilation Shaft 1 and construction of a new section of coal conveyor system, approximately 60 m in length, at the Wongawilli Upper top pit. The NWMD would continue to be extracted via first workings mining method using two continuous miners. Wollongong Coal committed in 2019 to no longer undertake mining via longwall extraction methods. As such, no longwall mining is proposed as part of this modification application.



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Source: EMM (2020); DFSI (2017); GA (2011); ASGC (2006)

0 5 10 km

GDA 1994 MGA Zone 56

N

KEY

- Project application area
- Rail line
- Major road
- Named watercourse
- Waterbody
- Local government area
- NPWS reserve
- State forest

Regional setting

Wollongong Coal Limited
Wongawilli Modification 2 North West Mains
Air quality impact assessment
Figure 1.1

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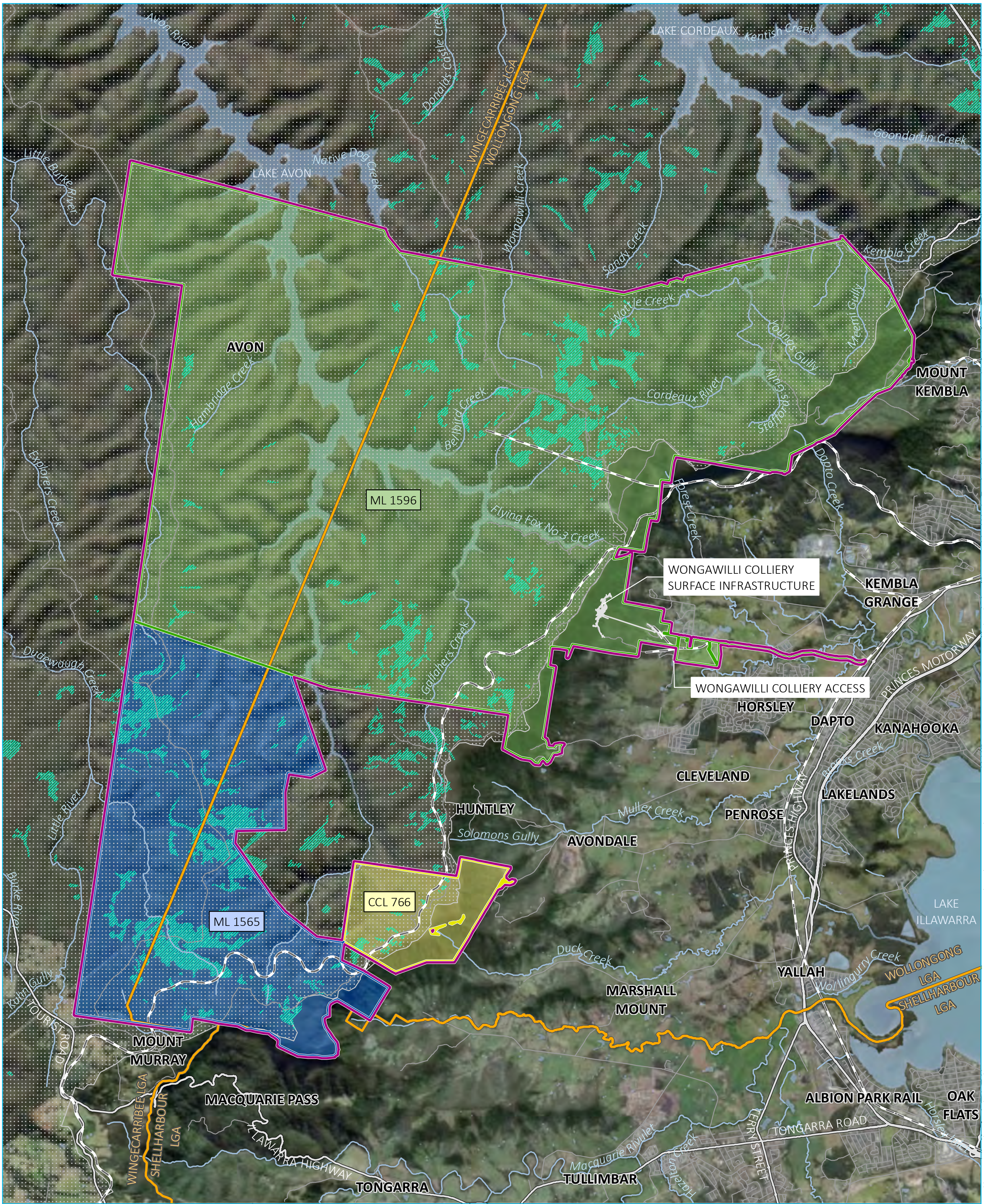

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Source: EMM (2020); Wollongong Coal Limited (2020); DPE (2019); WaterNSW (2019); DFSI (2017); OEH (2015); GA (2011)

0 2.5 5 km
GDA 1994 MGA Zone 56
N

KEY

- Project application area

Mining title

- ML 1565
- ML 1596
- CCL 766
- Wongawilli Colliery surface infrastructure
- Rail line
- Major road
- Minor road
- Named watercourse
- Waterbody
- Upland swamp
- Metropolitan special area
- Local government area

NOTE: Project application area is offset for viewing purposes

Local setting

Wollongong Coal Limited
Wongawilli Modification 2 North West Mains
Air quality impact assessment
Figure 1.2

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1.1 Modification overview

MOD2 is seeking to:

- extend the life of the mine by 5 years to 31 December 2025 to enable Wollongong Coal to continue development of the approved NWMD;
- additional driveage and underground mains heading of approximately 2.9 linear km to access the existing Wongawilli Ventilation Shaft 1;
- provide additional access to the NWMD to that currently approved via existing Portals W10 and W9;
- minor alignment changes to the approved NWMD as ventilation infrastructure is no longer proposed at the western end of the approved NWMD alignment;
- relocation of coal handling infrastructure including the crusher, sizer and screen from the Wongawilli lower pit top to underground; and
- construction of a new section of coal conveyor system, approximately 60 m in length, and coal storage bin at the Wongawilli upper pit top.

Wollongong Coal propose to continue coal production at up to 2 Mtpa, noting restricted production during the MOD2 approval period given stone driveage requirements. Wollongong Coal in addition propose to utilise largely existing surface infrastructure (ie coal handling, water management systems, administration facilities) at the Wongawilli lower and upper pit tops. Product coal will continue to be transported from the Colliery to Port Kembla by rail.

The modification does not seek to change any of the other aspects of the mining operations, including the extraction rate, coal processing and handling activities, offsite coal transportation routes or hours of operation which will remain as currently approved.

MOD2 compared to the current approved project is outlined in Table 1.1.

Table 1.1 Proposed modification

Element	The Colliery (Currently approved Project)	MOD2
Operating hours	24 hours per day, seven days per week Unloading from coal handling / train loading infrastructure occurring during normal operational hours: • 7am to 6pm Monday to Friday • 8am to 4 pm Saturday • no time on Sundays and public holidays	Conveyance of coal from the Wongawilli upper pit top to the lower pit top to be restricted to normal operational hours.
Coal seams	Bulli and Wongawilli Coal Seams	No change
Extraction rate	2 million tonnes per annum	No change
Approval period ending	31 December 2020	31 December 2025
Mine life	9 years consisting of 4 years (original consent), plus 5 years (MOD1)	Coal extraction until 31 December 2025, representing an extension of the approved mine life by 5 years

Table 1.1 Proposed modification

Element	The Colliery (Currently approved Project)	MOD2
Mining method	Longwall and first workings mining methods	First working mining methods only.
Underground workings	Four 5.5 m wide by 3.6 m high roadways Access from existing portals	Minor alignment changes to the western end of the approved NWMD, Additional first workings proposed to enable access to the existing Wongawilli Shaft 1.
Mine infrastructure, coal stockpiles and product transport	Wongawilli lower and upper pit top facilities and coal handling / load out infrastructure to rail	No change to rail transport requirements. No change to Wongawilli pit top administration and workshop facilities. Additional access to the NWMD via existing Portals W9 and W10. Relocation of crusher, sizer, and screen to underground. Improvements to the coal conveyance network including the construction of a new section of coal conveyor, approximately 60 m in length and coal storage bin. Extension of the Wongawilli lower pit top noise wall.
Rail transport requirements	No transport of coal by road. Train movements restrictions: • 8 train movements (calendar year average) a day • 10 train movements (max. weekly rolling average) a day • 3 train movements a night during normal operations • 4 train movements a night during advertised campaigns, with a maximum of 10 such campaigns per year	Maximum of 4 train movements a day. No train movements at night.
Waste management	Waste rock to be stored underground in two of the four Western Driveage roadways. Waste rock which does come to the surface to be utilised for ballast or fill underground or used on the surface for landscaping and rehabilitation	Waste rock to be stored underground within existing and NWMD workings. Maintain approval for waste rock to be utilised on the surface for landscaping and rehabilitation purposes
Mine ventilation	Mine portals and vent shafts including: • two portals for personnel and materials • one portal for coal extraction • two portals into the NWMD • Wongawilli Shaft 1, Nebo Shaft 3 and 4 Existing Nebo area portals (Wonga Belts and Wonga Track) and ventilation shafts (Vent Shaft 3 and 4) are proposed to be closed off and rehabilitated so will no longer be in use	Revised NWMD will reduce future ventilation shaft requirements via relying on the existing Wongawilli 1 ventilation shaft. Four portals into the NWMD.

Table 1.1 Proposed modification

Element	The Colliery (Currently approved Project)	MOD2
Workforce	Approved for up to 300 FTEs and contract personnel	Employment of up to 150 FTEs

1.2 Report overview

This air quality impact assessment (AQIA) has been prepared by EMM Consulting Pty Limited (EMM) on behalf of Wollongong Coal, to assess potential air quality impacts associated with the Colliery on the surrounding environment. The AQIA has been prepared in general accordance with the guidelines specified by the NSW Environment Protection Authority (EPA) in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA 2016), referred to from now on as "the Approved Methods for Modelling". This AQIA supports the EA for MOD2 (EMM 2020).

The AQIA consists of the following sections:

- a description of the local setting and surrounds of the Colliery;
- the pollutants which are relevant to the assessment, and the applicable impact assessment criteria;
- a description of the existing environment, specifically:
  - the meteorology and climate; and
  - the existing air quality environment;
- a detailed air pollutant emissions inventory for the Colliery;
- atmospheric dispersion modelling, including an analysis of Colliery-only and cumulative impacts accounting for baseline air quality;
- an overview of mitigation measures and air quality monitoring for the Colliery; and
- a greenhouse gas assessment.

2 Project overview

2.1 The site and surrounds

The approved NWMD and proposed additional driveage underlies the eastern extent of the Illawarra Plateau within the Upper Nepean State and Illawarra Escarpment Conservation Areas, including the south-western part of Lake Avon, Gallahers Creek and Flying Fox No. 3 Creek, smaller tributary streams and two identified swamps. The existing Upper and Lower Wongawilli Colliery pit top site infrastructure is situated on the eastern escarpment of the Illawarra Plateau, approximately 15 km south-west of Wollongong (Figure 1.1, Figure 1.2).

The existing Colliery mine access point and surface infrastructure facilities are at approximately 260 metres Australian Height Datum (mAHD) (referred to as the 'Upper Wongawilli pit top'), while the coal handling facilities are at the base of the Illawarra Escarpment at approximately 40 m AHD (referred to as the 'Lower Wongawilli pit top'). The Wongawilli Upper and Lower pit tops are connected by an existing coal conveyor and an access road.

Wongawilli Road/West Dapto Road connects the Colliery to the Princess Highway approximately 4.3 km west of the mine. The Collieries private rail line runs east from the Lower Wongawilli pit top to the south of Wongawilli, while the state-owned Unanderra to Moss Vale rail line is west of the Upper Wongawilli pit top and runs in a north south direction.

The nearest major population centres are the Wollongong suburbs of Horsley, approximately 2.7 km south-east, and Dapto, approximately 4 km south-east of the Lower Wongawilli pit top. The residential suburbs of Wongawilli and Dombarton neighbour the Colliery (Figure 1.2).

2.2 Project description

2.2.1 Approved NWMD

The approved NWMD, consists of four separate roadways and interconnecting cut-throughs developed using first workings mining methods, accessed via two portals located at the Wongawilli upper pit top. The approved NWMD is approximately 4,990 m long. To date, approximately 500 m of the NWMD has been developed prior to the Colliery going into care and maintenance in 2019. Since approval of the NWMD, headings have been realigned approximately 35m south west of the approved alignment to improve the functionality of the Colliery and avoid interaction with built infrastructure associated with the Lake Avon reservoir. The realignment of the headings was undertaken in accordance with condition 1 schedule 2 of the PA, as such is not the subject of this modification.

The approved NWMD alignment allows for ventilation infrastructure to be intercepted within the Metropolitan 'Special Areas' at the western end of the approved alignment. The development and construction of ventilation infrastructure was not subject of the PA as modified.

2.2.2 Wongawilli top pit

Wollongong Coal propose to largely utilise existing pit top surface infrastructure at the Wongawilli lower and upper pit top areas. The exception being the construction of a new section of coal conveyor system, approximately 60 m in length, and coal storage bin at the Wongawilli upper pit top and relocation of the coal preparation infrastructure including the crusher, sizer and screen which is to be located underground. Wollongong Coal in addition, propose to utilise two additional existing portals located at the Wongawilli upper pit top, Portals W9 and W10, to provide improved access to the NWMD. Surface infrastructure including the Wongawilli Shaft 1 is displayed in Figure 2.1.

ROM coal has historically been conveyed from the NWMD from the existing conveyor belt portal using the Main North Underground Conveyor via the Transfer House to the Decline ROM Coal Conveyor before being placed within either of the Coal Storage Bins or at the Lower Wongawilli pit top stockpile area. Existing coal preparation infrastructure is located at the Wongawilli lower pit top, in which ROM is subject to crushing and sizing prior to being placed within the coal storage bins or at the stockpile area. ROM coal is directly loaded to trains from the Coal Storage Bins or from stockpiles via a front hand loader.

MOD2 seeks to improve the coal conveyor network by constructing a new conveyor section from North West Mains B Portal to the existing Main North Underground Conveyor. The new conveyor section comprises the construction of a coal storage bin in which ROM coal would be placed before being transported via the new section of conveyor, approximately 60m in length, to the existing Main North Underground Conveyor. The new conveyor section would also require the construction of three drive heads and ancillary support infrastructure.

Minor modifications to the existing Main North Underground Conveyor will also be required to facilitate the upgrade of the conveyor network. All new and upgraded conveyor sections will be enclosed to reduce impacts as is consistent with existing infrastructure.

The proposed changes to the conveyor network will improve the transportation of ROM coal from the NWMD portals to the existing coal handling and train loading infrastructure and will result in the redundancy of approximately 50 m of the existing Main North Underground Conveyor. This section of the existing conveyor will be decommissioned in accordance with the Mining SEPP and does not form part of this modification.

The relocation of coal preparation equipment including the crusher, sizer and screen is proposed to remove noise sources at the Wongawilli lower pit top. The relocation of the equipment to underground will provide improved noise outcomes for residents neighbouring the operation. The relocated coal preparation equipment would be integrated into the existing coal conveyance system located within the NWMD workings. The existing crusher, sizer and screen will be removed from the Wongawilli lower pit top. To further reduce potential noise impacts to local receivers the existing noise barrier located at the Wongawilli lower pit top will be extended. The extension to the noise barrier is proposed to be located within the existing rail corridor disturbance area.

It is noted for the purpose of this AQIA, the coal preparation equipment (ie crusher, sizer and screen) is assumed to occur in the existing location, rather than underground as proposed. Therefore, the emission calculations (Section 6) and associated predicted impacts at neighbouring residences (Section 7) presented in this report should be viewed as conservative.

No further changes are proposed to existing surface infrastructure to that currently approved.

2.2.3 Hours of operation

This modification does not propose to change the existing Wollongong Colliery hours of operation, being 24 hours per day, seven days per week with unloading from coal handling / train loading infrastructure occurring during normal operational hours as follows:

- 7am to 6pm Monday to Friday;
- 8am to 4 pm Saturday; and
- no time on Sundays and public holidays.

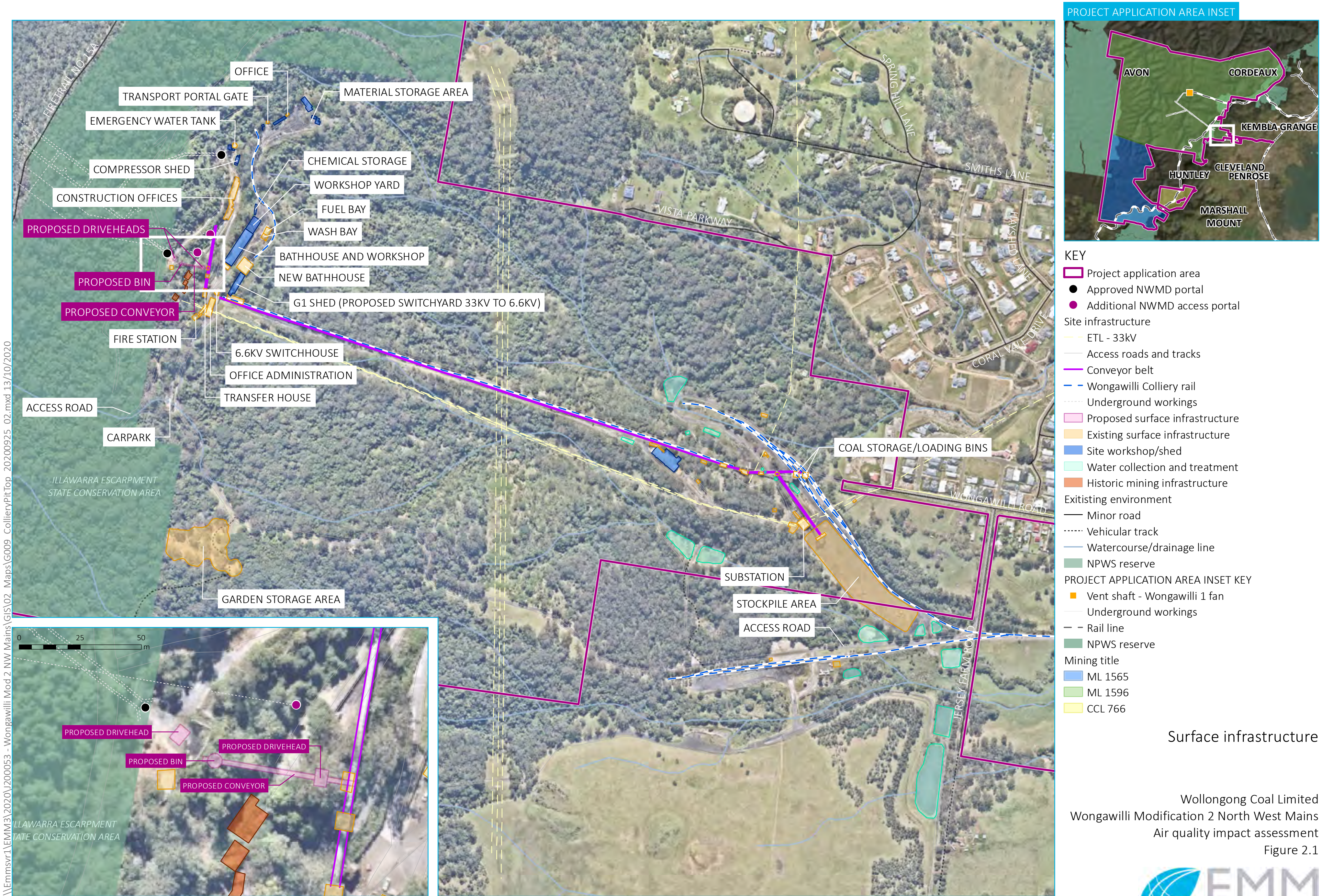
However, to further minimise potential impacts to residents neighbouring the operation Wollongong Coal propose to restrict the conveyance of coal from the Wongawilli upper pit top to the lower pit top to during normal operational hours as defined above. Coal is proposed to be stored within the proposed coal storage bin located at the Wongawilli upper pit top outside of normal operating hours.

2.2.4 Workforce requirements

As result of longwall mining no longer occurring at the Colliery, FTE personnel requirements will reduce to approximately 150 persons.

2.2.5 Mining operations

As previously stated, MOD2 does not seek to change any of the other aspects of the mining operations, including the coal processing and handling activities, offsite coal transportation routes, proposed rehabilitation activities or hours of operation which will remain as currently approved.



Source: EMM (2020); Wollongong Coal Limited (2020); NearMap (2020); DFSI (2017); GA (2011); ASGC (2006)

Surface infrastructure

Wollongong Coal Limited
Wongawilli Modification 2 North West Mains
Air quality impact assessment
Figure 2.1

EMM creating opportunities

2.3 The surrounds

The majority of the Colliery surrounds is zoned for environmental management and conservation under the relevant Local Environmental Plans (LEPs), including E1 National Parks and Nature Reserves, E2 Environmental Conservation and E3 Environmental Management. There are small areas zoned for public recreation (RE1), primary production (RU1) and rural landscapes (RU2), low density (R2) and large lot residential (R5) and infrastructure (SP2) located to the east of the Colliery (Figure 1.2).

As previously noted, the Wongawilli area has a long history of mining spanning from the early 1900s. Historically, the suburb of Wongawilli was approximately 1.5 km east of the Lower pit top, however in recent years, land close to the Colliery has been rezoned and subdivided for residential development. New residential areas have been developed including along Bankbook Drive, McDermid Lane and Coral Vale Drive.

The nearest residence to the Colliery is located on Bankbook Drive, approximately 150 m from the boundary of the Lower Wongawilli pit top. A community hall and Dapto Rural Fire Brigade Station on Wongawilli Road, east of the Lower Wongawilli pit top separate residences and the Wongawilli Coals operations.

The closest school is a preschool, the Little School Preschool Incorporated, located approximately 2 km north-east from the Lower Wongawilli pit top at the base of the Illawarra Escarpment.

Agricultural areas exist to the south, east and north of the Lower Wongawilli pit top.

Land uses surrounding the site include:

- north – the Illawarra Escarpment Conservation Area (IECA) and land which falls within the Sydney drinking water catchment
- east – housing development inclusive of small residential holdings and low density rural holdings
- south – housing development inclusive of small residential holdings and low density rural holdings
- west – the IECA and land which falls within the Sydney drinking water catchment

2.4 Surrounding assessment locations

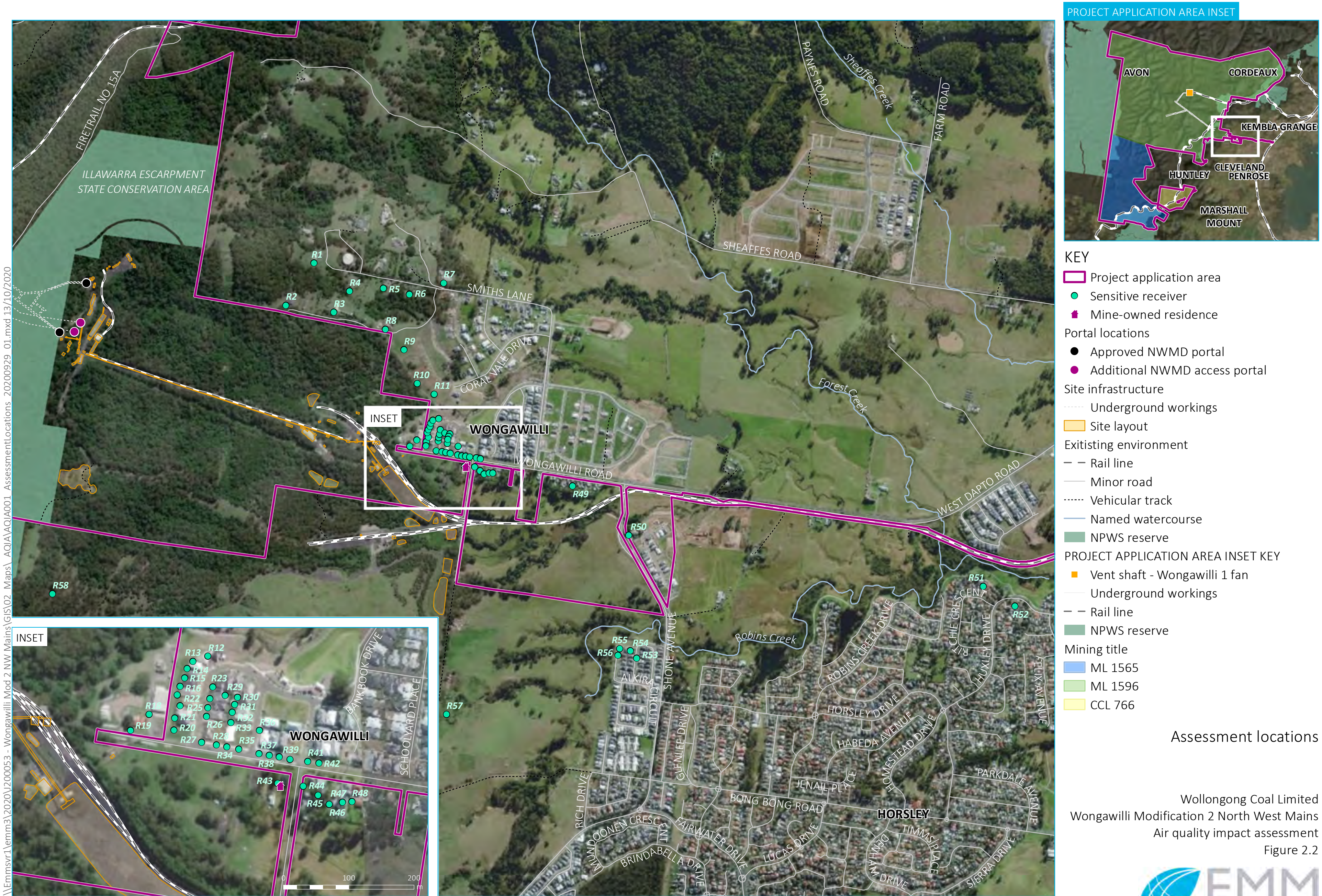
A selection of neighbouring residential receptors, considered to be representative of the surrounding environment, have been adopted as assessment locations for the prediction of air quality impacts from the Colliery. Details are provided in Table 2.1 and their locations are shown in Figure 2.2.

Table 2.1 Representative assessment locations

Assessment location ID	Easting	Northing
R01	293565	6183409
R02	293450	6183236
R03	293646	6183208
R04	293710	6183294
R05	293849	6183307
R06	293955	6183282
R07	294095	6183327
R08	293857	6183138
R09	293932	6183054
R10	293987	6182917
R11	294057	6182873
R12	294075	6182774
R13	294052	6182766
R14	294043	6182755
R15	294039	6182741
R16	294032	6182728
R17	294028	6182715
R18	293985	6182685
R19	293956	6182660
R20	294023	6182661
R21	294024	6182679
R22	294032	6182698
R23	294082	6182727
R24	294078	6182709
R25	294075	6182695
R26	294073	6182682
R27	294065	6182642
R28	294088	6182638
R29	294101	6182714
R30	294120	6182711
R31	294116	6182700
R32	294112	6182688
R33	294110	6182672
R34	294104	6182635

Table 2.1 Representative assessment locations

Assessment location ID	Easting	Northing
R35	294122	6182632
R36	294154	6182660
R37	294153	6182625
R38	294169	6182622
R39	294184	6182620
R40	294201	6182616
R41	294228	6182613
R42	294245	6182610
R43	294182	6182579
R44	294221	6182575
R45	294244	6182561
R46	294261	6182547
R47	294281	6182550
R48	294296	6182551
R49	294622	6182498
R50	294851	6182298
R51	296299	6182088
R52	296430	6182008
R53	294884	6181794
R54	294858	6181824
R55	294814	6181833
R56	294808	6181806
R57	294108	6181565
R58	292496	6182057



Source: EMM (2020); Wollongong Coal Limited (2020); DFSI (2017); GA (2011); ASGC (2006)

Assessment locations

Wollongong Coal Limited
Wongawilli Modification 2 North West Mains
Air quality impact assessment
Figure 2.2

EMM creating opportunities

3 Pollutants and assessment criteria

3.1 Potential air pollutants

Operational emission sources associated with the Colliery include a mixture of the following:

- fugitive sources of particulate matter, such as ROM coal transfers, conveying and processing activities, movement of mobile plant and equipment, and wind erosion of the ROM coal stockpile;
- point sources, specifically the NWMD ventilation outlet for emissions from underground mining operations; and
- combustion sources, such as exhaust emissions from Colliery mobile equipment fleet and locomotive engines.

A detailed description of emission sources associated with the Colliery is presented in Chapter 6.

The primary air pollutants emitted by the Colliery comprise of:

- particulate matter, specifically:
  - total suspended particulate matter (TSP);
  - particulate matter less than 10 micrometres (µm) in aerodynamic diameter (PM_{10}); and
  - particulate matter less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$).
- oxides of nitrogen (NO_x)[1], including nitrogen dioxide (NO_2);
- sulphur dioxide (SO_2);
- carbon monoxide (CO); and
- volatile organic compounds (VOCs).

This assessment focuses on emissions of particulate matter pollutants (TSP, PM_{10}, $PM_{2.5}$ and associated dust deposition). The emissions and associated impacts of fuel combustion pollutants (NO_x, SO_2, CO and VOCs) are expected to be minor and have not been considered further.

The Colliery must demonstrate compliance with the impact assessment criteria for these pollutants, as defined in the Approved Methods for Modelling (NSW EPA 2016). The impact assessment criteria are designed to maintain ambient air quality that allows for the adequate protection of human health and well-being. The applicable criteria are presented in Section 3.2.

[1] By convention, NO_x = Nitrous oxide (NO) + NO_2.

3.2 Impact assessment criteria

3.2.1 Particulate matter

The NSW EPA's impact assessment criteria for particulate matter, as documented in Section 7 of the Approved Methods for Modelling, are presented in Table 3.1. The assessment criteria for PM_{10} and $PM_{2.5}$ are consistent with the national air quality standards that are defined in the *National Environment Protection (Ambient Air Quality) Measure* (AAQ NEPM) (Department of the Environment 2016).

TSP, which relates to airborne particles less than around 50 µm in diameter, is used as a metric for assessing amenity impacts (reduction in visibility, dust deposition and soiling of buildings and surfaces) rather than health impacts (NSW EPA 2013). Particles less than 10 µm in diameter, accounted for in this assessment by PM_{10} and $PM_{2.5}$, are a subset of TSP and are fine enough to enter the human respiratory system and can therefore lead to adverse human health impacts. The NSW EPA impact assessment criteria for PM_{10} and $PM_{2.5}$ are therefore used to assess the potential impacts of airborne particulate matter on human health.

The Approved Methods for Modelling classifies TSP, PM_{10}, $PM_{2.5}$ and dust deposition as 'criteria pollutants'. The impact assessment criteria for criteria pollutants are applied at the nearest existing or likely future off-site sensitive receptors[2], and compared against the 100^{th} percentile (ie the highest) dispersion modelling prediction for the relevant averaging. Both the incremental (Colliery-only) and cumulative (Colliery plus background) impacts need to be presented, with the latter requiring consideration of the existing ambient background concentrations.

For dust deposition, the NSW EPA (2016) specifies criteria for the project-only increment and cumulative dust deposition levels. Dust deposition impacts are derived from TSP emission rates and particle deposition calculations in the dispersion modelling process.

Table 3.1 Impact assessment criteria for particulate matter

PM metric	Averaging period	Impact assessment criterion
TSP	Annual	90 µg/m^3
PM_{10}	24 hour	50 µg/m^3
	Annual	25 µg/m^3
$PM_{2.5}$	24 hour	25 µg/m^3
	Annual	8 µg/m^3
Dust deposition	Annual	2 g/m^2/month (project increment only)
		4 g/m^2/month (cumulative)

Notes: µg/m^3: micrograms per cubic meter; g/m^2/month: grams per square metre per month

2 NSW EPA (2016) defines a sensitive receptor as a location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area.

3.3 POEO (Clean Air) regulation

The statutory framework for managing air emissions in NSW is provided in the *Protection of the Environment Operations Act 1997*[3] (POEO Act). The primary regulations for air quality made under the POEO Act are:

- Protection of the Environment Operations (Clean Air) Regulation 2010[4].
- Protection of the Environment Operations (General) Regulation 2009[5].

The Colliery will comply with the POEO regulations as follows:

- as a scheduled activity under the POEO regulations, the Colliery is required to operate under an Environment Protection Licence (EPL) 1087 issued by the NSW EPA and comply with requirements including emission limits, monitoring and pollution-reduction programmes (PRPs);
- the Colliery does not feature significant odour-generating emission sources and is therefore unlikely to generate odourous emissions; and
- no open burning is performed on-site.

3.4 Voluntary land acquisition and mitigation policy

In September 2018, the Department of Planning, Industry and Environment (DPIE) released the *Voluntary Land Acquisition and Mitigation Policy (VLAMP) for State Significant Mining, Petroleum and Extractive Industry Developments*. The VLAMP describes the voluntary mitigation and land acquisition policy to address dust and noise impacts, and outlines mitigation and acquisition criteria for particulate matter.

Under the VLAMP, if a development cannot comply with the relevant impact assessment criteria, or if the mitigation or acquisition criteria may be exceeded, the applicant should consider a negotiated agreement with the affected landowner or acquire the land. In doing so, the land is then no longer subject to the impact assessment, mitigation or acquisition criteria, although provisions do apply to the "use of the acquired land", primarily related to informing and protecting existing or prospective tenants.

In relation to dust, voluntary mitigation rights apply when a development contributes to exceedances of the criteria set out in Table 3.2. Voluntary acquisition rights apply when a development contributes to exceedances of the criteria set out in Table 3.3. The criteria for voluntary mitigation and acquisition are the same, except for the number of days the short-term impact assessment criteria for PM_{10} and $PM_{2.5}$ can be exceeded, which is zero for mitigation and five for acquisition.

Voluntary mitigation rights apply to any residence on privately-owned land or any workplace on privately-owned land where the consequences of the exceedance, in the opinion of the consent authority, are unreasonably deleterious to worker health or the carrying out of business.

Voluntary acquisition rights also apply to any residence or any workplace on privately-owned land, but also apply when an exceedance occurs across more than 25% of any privately-owned land where there is an existing dwelling or where a dwelling could be built under existing planning controls.

[3] http://www.legislation.nsw.gov.au/maintop/view/inforce/act+156+1997+cd+0+N

[4] http://www.legislation.nsw.gov.au/maintop/view/inforce/subordleg+428+2010+cd+0+N

[5] http://www.legislation.nsw.gov.au/maintop/view/inforce/subordleg+211+2009+cd+0+N

Table 3.2 VLAMP mitigation criteria

Pollutant	Averaging period	Mitigation criterion	Impact type
PM_{10}	24-hour	50 µg/m³**	Human health
	Annual	25 µg/m³*	Human health
$PM_{2.5}$	24-hour	25 µg/m³**	Human health
	Annual	8 µg/m³*	Human health
TSP	Annual	90 µg/m³*	Amenity
Deposited dust	Annual	2 g/m²/month**	Amenity
		4 g/m²/month*	

Note: * - cumulative impact (project + background); ** - incremental impact (project only) with zero allowable exceedances of the criteria over the life of the development

Table 3.3 VLAMP acquisition criteria

Pollutant	Averaging period	Mitigation criterion	Impact type
PM_{10}	24-hour	50 µg/m³**	Human health
	Annual	25 µg/m³*	Human health
$PM_{2.5}$	24-hour	25 µg/m³**	Human health
	Annual	8 µg/m³*	Human health
TSP	Annual	90 µg/m³*	Amenity
Deposited dust	Annual	2 g/m²/month**	Amenity
		4 g/m²/month*	

Note: * - cumulative impact (project + background); ** - incremental impact (project only) with five allowable exceedances of the criteria over the life of the development

4 Meteorology and climate

4.1 Monitoring data resources

Wollongong Coal maintains a meteorological monitoring station as part of the Colliery air quality monitoring network (Wongawilli Colliery meteorological station hereafter referred to as the WCM). Section 5.2 provides further details regarding the Wollongong Coal monitoring network. The WCM is located approximately 250 m east of the Colliery ROM stockpile.

Data from the WCM recorded between October 2015 and December 2019 were collated and processed by EMM. The dataset featured a number of extended periods of missing data due to instrumentation issues or damage. The most complete 12-month period of meteorological data from the WCM occurred between May 2016 and April 2017, with approximately 96% completeness of 1-hour observations.

To verify that this data period is representative of the local area, meteorological monitoring data from the NSW DPIE air quality monitoring station (AQMS) at Kembla Grange for the period between 2015 and 2019 were also collated and processed. The Kembla Grange AQMS is located approximately 5.5 km east-northeast of the WCM at the Kembla Grange Racecourse.

A five-year (2015 to 2019) analysis of meteorological monitoring data from the DPIE Kembla Grange AQMS is presented in Appendix A. The analysis demonstrated a similarity across all years for the most important parameters for pollutant dispersion, such as wind speed and direction, temperature and relative humidity. The recorded winds across all five years were predominately from the west, with a less dominant north-easterly flow observed. Across the five years of data, the annual average recorded wind speed ranged from 2.8 m/s to 3.1 m/s, while the frequency of calm conditions (ie wind speeds less than 0.5 m/s) occurred between 8.1% and 9.4% of the time.

The interannual similarities demonstrated by the five-year analysis of the DPIE Kembla Grange dataset indicate that any 12-month period within this five-year period would be representative at that monitoring location. In the absence of a complete five years of monitoring data, this conclusion is also applied from the WCM to justify the use of the onsite data captured between May 2016 and April 2017.

Wind roses for the period at the WCM and DPIE Kembla Grange AQMS between May 2016 and April 2017 are provided in Figure 4.1. Both wind roses exhibit the dominant westerly air flow, however the WCM wind rose shows a greater distribution of wind from all directions. The mean wind speed is comparable between the two sites (2.9 m/s at WCM and 3.0 m/s at Kembla Grange). The frequency of calms is higher for the DPIE Kembla Grange dataset.

The differences in wind direction between the two sites are likely attributable to topographical influences surrounding the WCM station, in particular the Illawarra Escarpment to the immediate west. By comparison, the DPIE Kembla Grange AQMS is located in a more exposed location (Kembla Grange Racecourse) with no notable influencing terrain features. The WCM site is located in proximity of the primary Colliery emission sources and is therefore representative of the localised dispersion conditions.

The greater distribution of recorded wind direction exhibited in the WCM data relative to the DPIE Kembla Grange AQMS is notable for the atmospheric dispersion modelling component of this report (Chapter 7). The higher proportion of wind direction from the south to southwest in the WCM dataset will result in a higher proportion of the modelling period where the neighbouring assessment locations (Figure 2.2) are downwind of the Colliery emission sources.

From the comparison analysis conducted for the DPIE Kembla Grange and WCM datasets, it is considered that the WCM meteorological monitoring data for the period between May 2016 and April 2017 is appropriate for use as the primary source of meteorological inputs to the dispersion modelling of this assessment. Hereafter, the period between May 2016 and April 2017 is referred to as the 2016-2017 modelling period.

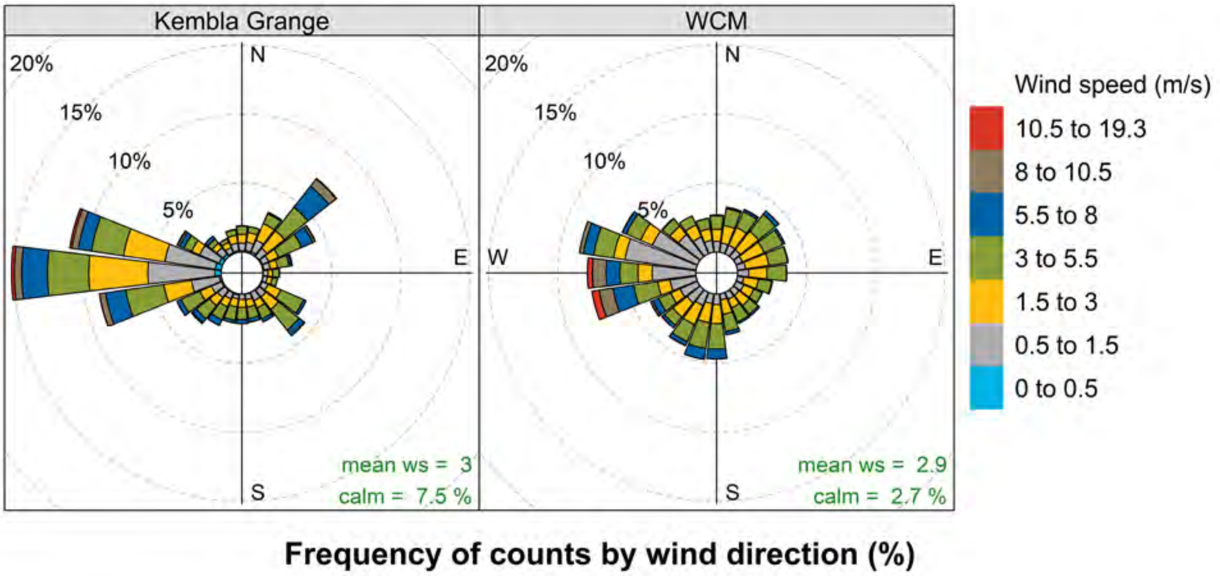


Figure 4.1 Wind speed and direction comparison – May 2016 and April 2017– WCM and DPIE Kembla Grange AQMS

4.2 Meteorological modelling and processing

Atmospheric dispersion modelling for this assessment has been completed using the AMS[6]/USEPA[7] regulatory model AERMOD (model version v19191, further discussion presented in Chapter 7). The meteorological inputs for AERMOD were generated using the AERMET meteorological processor (model version v19191), using local surface observations and upper air profiles generated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) TAPM meteorological modelling module.

Further details of the TAPM meteorological modelling and AERMET data processing completed to prepare the inputs for AERMOD are documented in Appendix A.

4.3 AERMET meteorological dataset

4.3.1 Wind speed and direction

A wind rose showing the wind speed and direction from the WCM AERMET dataset during the 2016-2017 modelling period is presented in Figure 4.2. The WCM AERMET dataset features a combination of station measurements from the 2016-2017 modelling period and data gap substitutions (interpolation and substitution methods, as per Appendix A).

6 AMS - American Meteorological Society

7 USEPA - United States Environmental Protection Agency

As discussed in Section 4.1, the recorded wind pattern for 2016-2017 modelling period was dominated by westerly air flow, with less dominant southerly and north-easterly components. The annual average wind speed for the WCM AERMET dataset for the 2016-2017 modelling period was 2.9 m/s, with a frequency of calm conditions in the order of 2.5%.

Seasonal and diurnal wind roses for the WCM AERMET dataset for the 2016-2017 modelling period are provided in Figure 4.3 and Figure 4.4 respectively. Some seasonal variation in both wind speed and direction is observed, with winds typically lower in winter and autumn than spring and summer. The westerly component is most pronounced in autumn and winter, while the southerly component is observed in all seasons. Summer features a higher occurrence of north-easterly air flow associated with the coastal land-sea breeze.

Wind speed and wind direction varied on a diurnal basis in the WCM 2016-2017 modelling period dataset. The night-time hours feature a higher proportion of westerly winds than daytime hours. The wind speeds at night were slightly lower on average than during the daytime, with average wind speeds of 3.1 m/s during the day and 2.6 m/s during the night. Calm conditions were more prevalent during night hours.

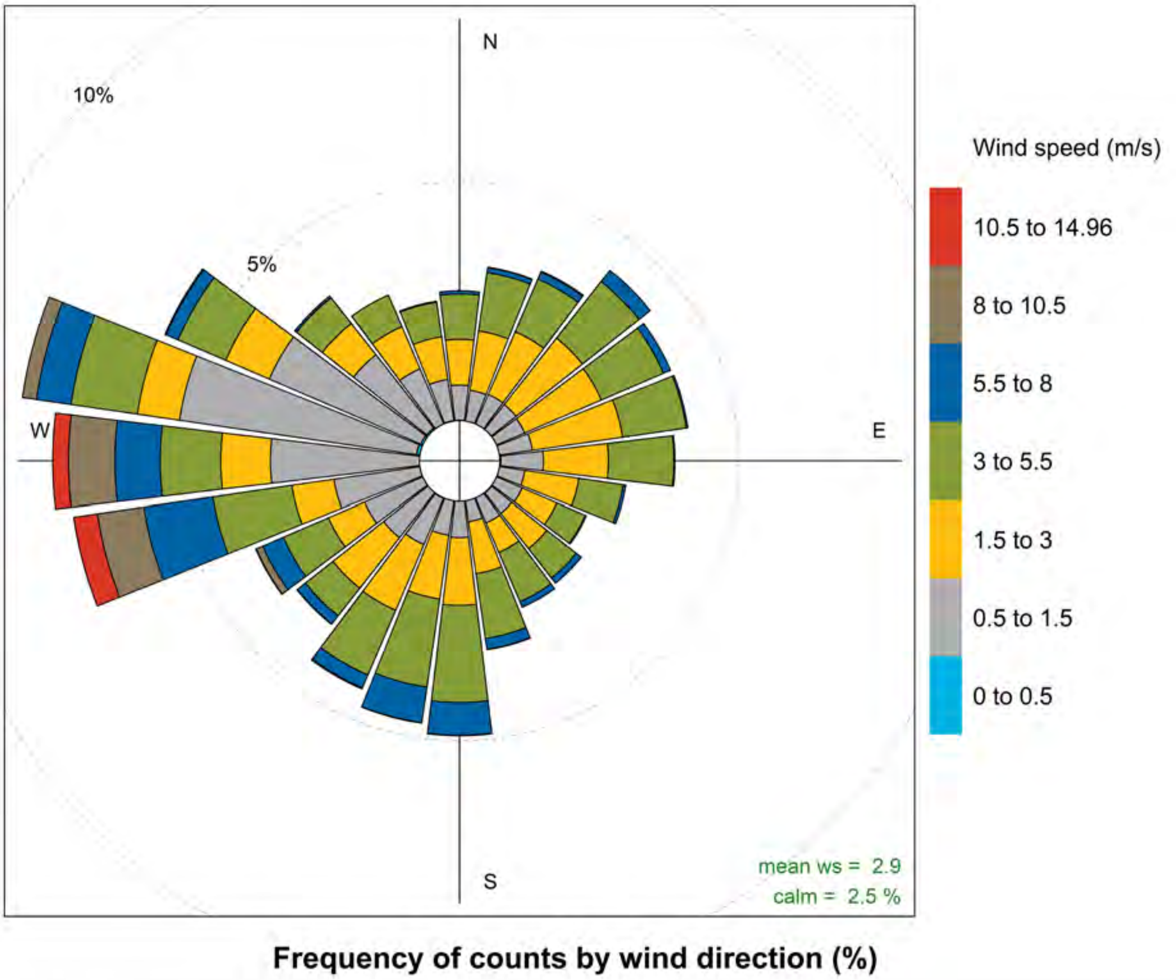


Figure 4.2 Wind speed and direction – WCM AERMET – 2016-2017 modelling period

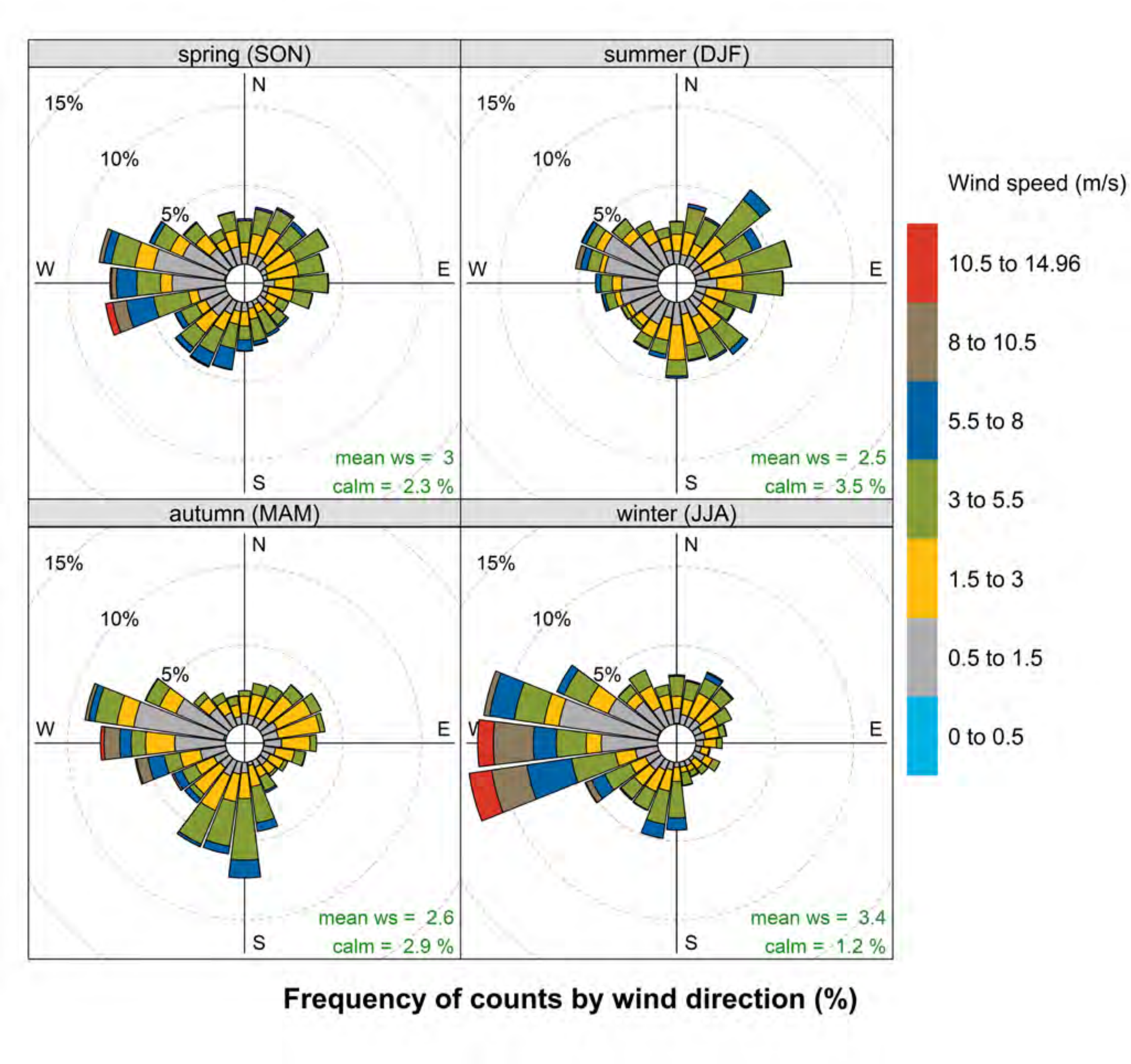


Figure 4.3 Seasonal wind speed and direction – WWC AERMET – 2016-2017 modelling period

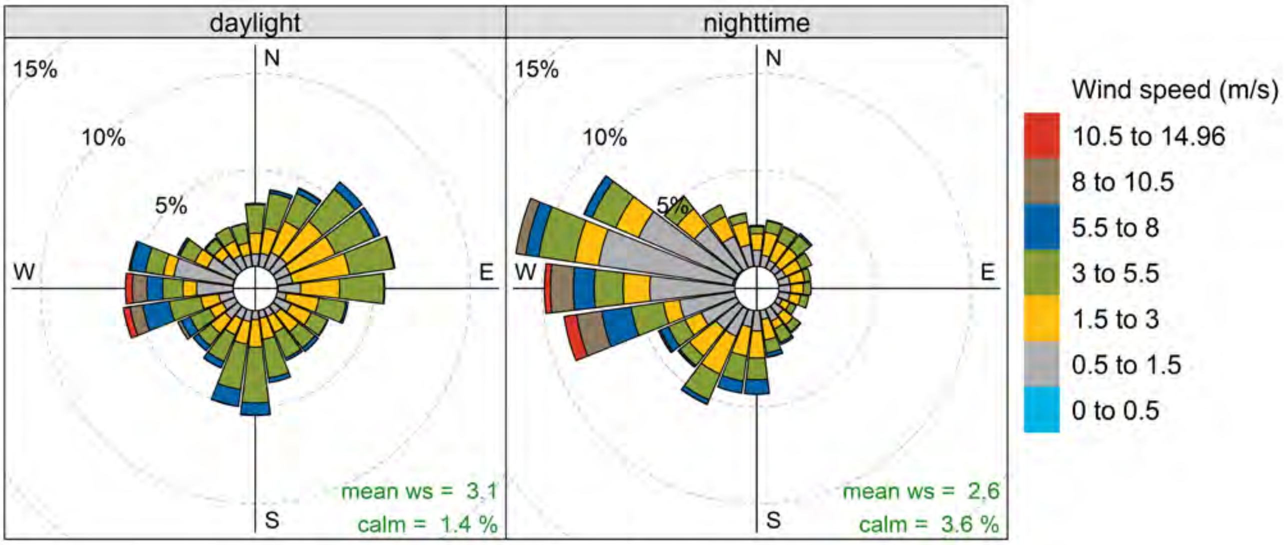


Figure 4.4 Diurnal wind speed and direction – WCM AERMET – 2016-2017 modelling period

4.3.2 Atmospheric stability and mixing depth

Atmospheric stability refers to the degree of turbulence or mixing that occurs within the atmosphere and is a controlling factor in the rate of atmospheric dispersion of pollutants.

The Monin-Obukhov length (L) provides a measure of the stability of the surface layer (ie the layer above the ground in which vertical variation of heat and momentum flux is negligible; typically, about 10% of the mixing height). Negative L values correspond to unstable atmospheric conditions, while positive L values correspond to stable atmospheric conditions. Very large positive or negative L values correspond to neutral atmospheric conditions.

Figure 4.5 illustrates the overall diurnal variation of atmospheric stability derived from the Monin-Obukhov length calculated by AERMET based on the 2016-2017 modelling period dataset. The diurnal profile shows that atmospheric instability increases during the daylight hours as the sun generated convective energy increases, whereas stable atmospheric conditions prevail during the night-time. This profile indicates that the potential for effective atmospheric dispersion of emissions would be greatest during day-time hours and lowest during evening through to early morning hours.

Mixing depth refers to the height of the atmosphere above ground level within which air pollution can be dispersed, otherwise known as the boundary layer. The mixing depth of the atmosphere is influenced by mechanical (associated with wind speed) and thermal (associated with solar radiation) turbulence. Similar to the Monin-Obukhov length analysis above, higher daytime wind speeds 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 the atmospheric dispersion of pollutants.

Hourly-varying atmospheric boundary layer depths were generated by AERMET, the meteorological processor for the AERMOD dispersion model. The variation in AERMET-calculated boundary layer depth by hour of the day is illustrated in Figure 4.6. Greater boundary layer depths occur during the daytime hours, peaking in the mid to late afternoon.

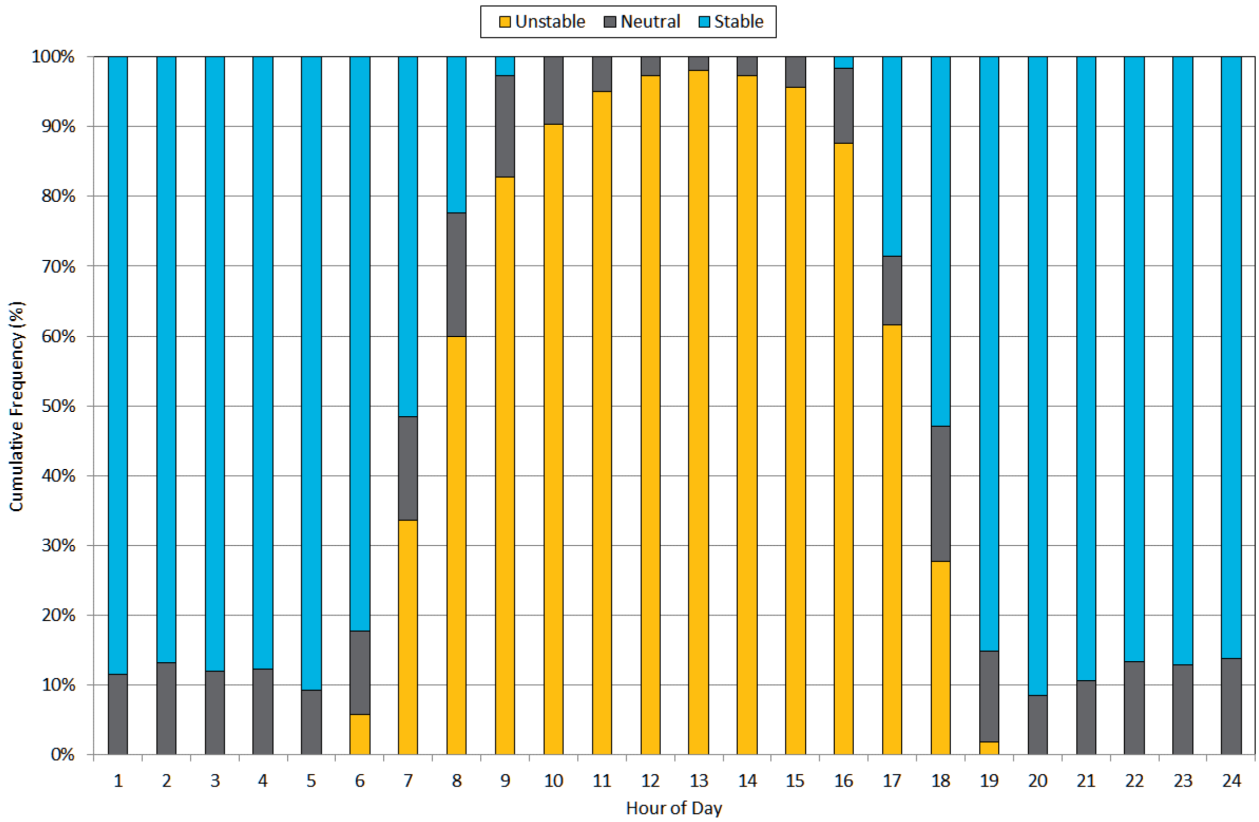


Figure 4.5 **AERMET-calculated diurnal variation in atmospheric stability – WCM AERMET – 2016-2017 modelling period**

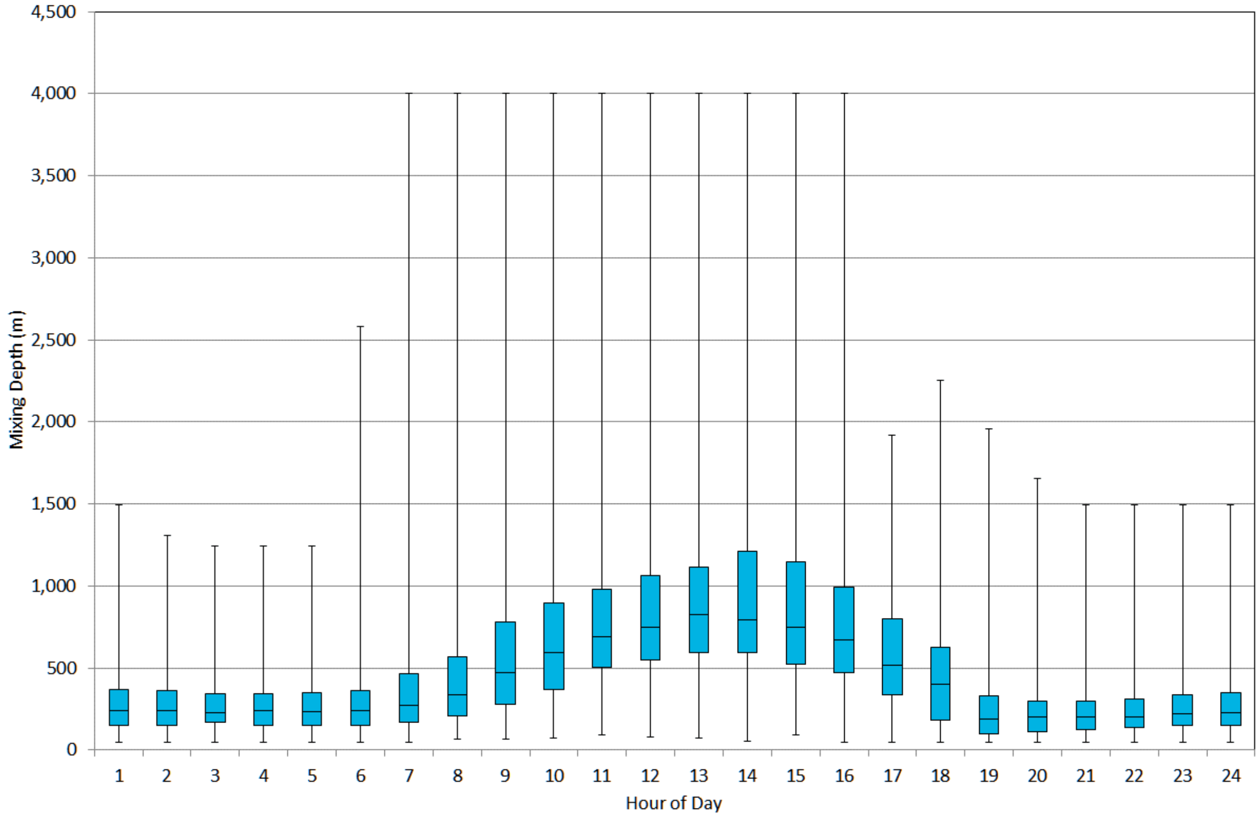


Figure 4.6 **AERMET-calculated diurnal variation in atmospheric mixing depth – WCM AERMET – 2016-2017 modelling period**

5 Baseline air quality

5.1 Existing sources of emissions

The National Pollutant Inventory (NPI) and NSW EPA environment protection licence databases have been reviewed to identify significant existing sources of air pollutants within 5 km of the Colliery. The review identified small scale industrial operations including an asphalt production plant, a sewage filtration plant, materials recycling facility and several natural gas pipeline metering stations.

Further afield in the Unanderra and Port Kembla areas, more than 10 km to the east of the Colliery, are significant existing industrial developments including the Bluescope Steel plant, Port Kembla terminal and other assorted manufacturing facilities. To the south-east is the Energy Australia Tallawarra gas-fired power station.

Other contributing non-Colliery sources of air pollutant emissions to baseline air quality include:

- dust entrainment due to vehicle movements along unsealed and sealed town and rural roads with high silt loadings;
- dust emissions from agricultural activities;
- fuel combustion-related emissions from on-road and non-road engines;
- wind generated dust from exposed areas within the surrounding region;
- seasonal emissions from household wood burning for heating during winter; and
- sea salts contained in sea breezes.

More remote sources which contribute episodically to suspended particulates in the region include dust storms and bushfires. It is considered that all of the above emission sources are accounted for in the monitoring data analysed in the following sections of this report.

5.2 Air quality monitoring data resources

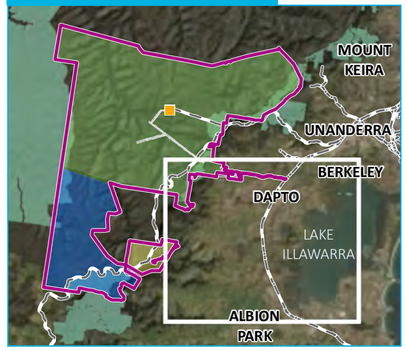
The air quality monitoring network for the Colliery used for annual environmental compliance reporting consists of the following:

- one automatic weather station (AWS);
- one beta attenuation monitor (BAM) unit for the recording PM_{10} concentrations on a continuous basis; and
- five dust deposition gauges.

The locations of the Colliery air quality monitoring network are illustrated in Figure 5.1.

To supplement the data from the Colliery air quality monitoring network, data from the DPIE Kembla Grange AQMS has been referenced.

PROJECT APPLICATION AREA INSET



KEY

- Project application area
- Continuous PM monitor
- Dust deposition guage
- Meteorological station

Site infrastructure

- Underground workings
- Site layout

Exitisting environment

- Rail line
- Major road
- Minor road
- Vehicular track
- Named watercourse
- Named waterbody
- NPWS reserve

PROJECT APPLICATION AREA INSET KEY

- Vent shaft - Wongawilli 1 fan
- Underground workings
- Rail line
- NPWS reserve

Mining title

- ML 1565
- ML 1596
- CCL 766

Monitoring resources

Wollongong Coal Limited
Wongawilli Modification 2 North West Mains
Air quality impact assessment
Figure 5.1

Source: EMM (2020); Wollongong Coal Limited (2020); DFSI (2017); GA (2011); ASGC (2006)

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EMM creating opportunities

5.3 Background air quality environment

5.3.1 PM_{10}

Data from the Colliery BAM unit were collated for the period between January 2016 and August 2020. A summary of key statistics for the almost five years of analysed data is presented in Table 5.1. Exceedances of the NSW EPA 24-hour average criterion of 50 µg/m³ were recorded for all years except 2016. Exceedances are shown in bold, all of which are attributable to regional scale.

The data in Table 5.1 illustrates that PM_{10} concentrations increased notably from 2016 through to 2020, which is linked to intensifying drought conditions across eastern Australia and most notably, extensive bushfire events in late 2019-early 2020.

Table 5.1 Statistics for PM_{10} concentrations – Colliery BAM – 2016 to 2020

Year	Maximum	99th percentile	90th percentile	75th percentile	Median	Average	Days > 50 µg/m³
	24-hour average PM_{10} concentration (µg/m³)						
2016	49.7	36.1	20.9	16.1	9.3	11.1	0
2017	**64.5**	32.7	23.2	15.8	9.8	11.4	**1**
2018	**103.5**	**61.4**	21.4	13.0	5.1	8.4	**7**
2019	**173.2**	**69.8**	25.5	13.7	7.8	11.9	**11**
2020	**121.8**	**91.4**	25.1	12.6	6.9	11.7	**7**

The frequency of recorded PM_{10} concentrations at the Colliery BAM by year for the period 2016 to 2020 is shown in Figure 5.2. The distribution of recorded PM_{10} concentrations for 2018 through to 2020 feature a notably higher occurrence of concentrations greater than 50 µg/m³ than the previous years of data.

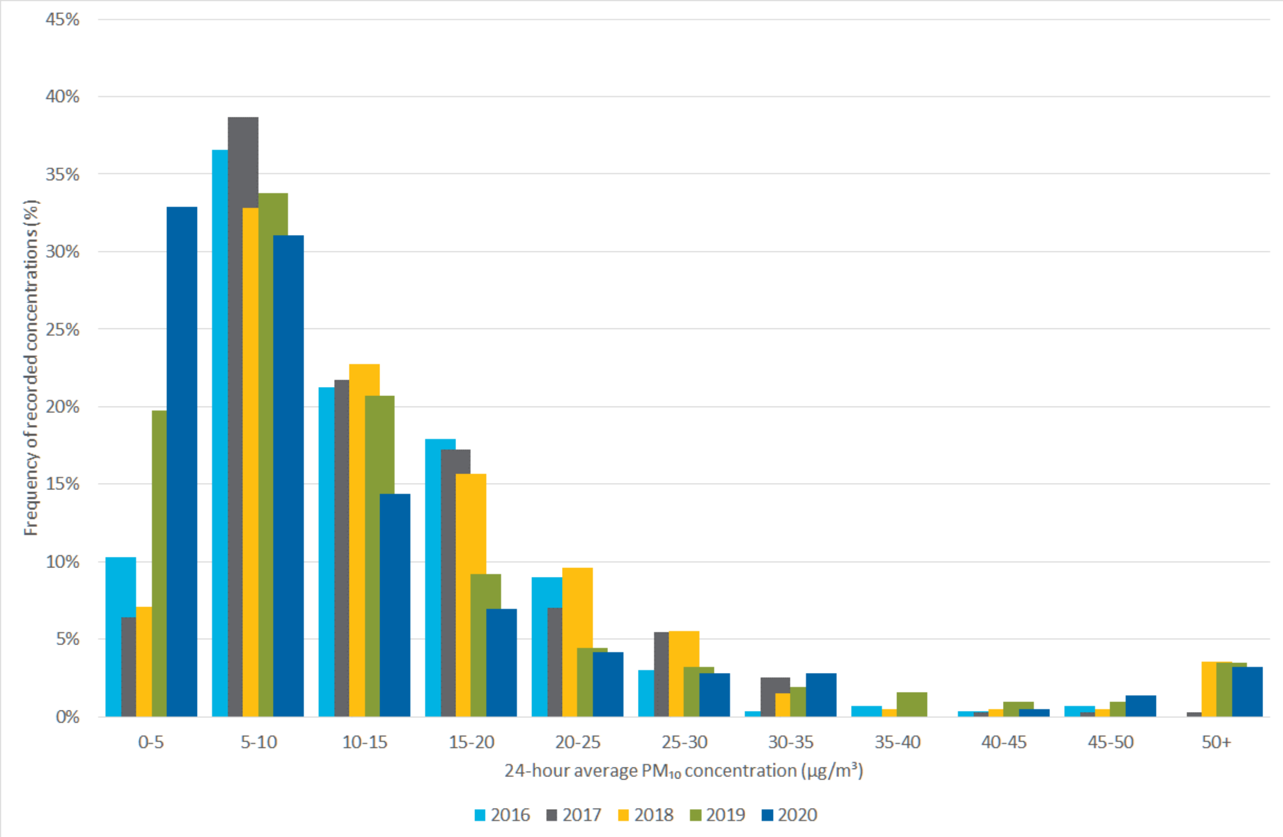

Figure 5.2 Frequency distribution of PM_{10} monitoring data – Colliery BAM - 2016 to 2020

The Colliery BAM PM_{10} dataset features periods of missing concentrations due to equipment downtime. To supplement the Colliery BAM PM_{10} dataset, daily varying PM_{10} concentrations were accessed from the DPIE Kembla Grange AQMS for the period between 2016 and 2020.

A summary of key statistics for the five years of analysed data is presented in Table 5.2. Exceedances of the NSW EPA 24-hour average criterion of 50 µg/m³ were recorded for all years. Exceedances are shown in bold.

The data in Table 5.2 illustrates that PM_{10} concentrations increased notably from 2016 through to 2020, which is linked to intensifying drought conditions across eastern Australia and most notably, extensive bushfire events in late 2019-early 2020.

Table 5.2 Statistics for PM_{10} concentrations – DPIE Kembla Grange AQMS – 2016 to 2020

Year	Maximum	99th percentile	90th percentile	75th percentile	Median	Average	Days > 50 µg/m³
	24-hour average PM_{10} concentration (µg/m³)						
2016	**56.3**	48.5	32.8	26.0	18.1	19.8	**4**
2017	**67.7**	**50.6**	33.0	24.8	18.0	20.2	**4**
2018	**71.8**	**64.5**	38.9	28.8	19.7	22.0	**10**
2019	**115.8**	**88.4**	43.7	31.4	20.4	23.8	**21**
2020	**187.7**	**98.1**	36.0	24.1	15.6	20.3	**12**

Note: Data source NSW DPIE 2020

The frequency of recorded PM_{10} concentrations at the Kembla Grange AQMS by year for the period 2016 to 2020 is shown in Figure 5.3. The distribution of recorded PM_{10} concentrations is similar to that presented in Figure 5.2 for the Colliery BAM, however it is noted that the peak in frequency occurs between 10 µg/m³ and 25 µg/m³ at the DPIE Kembla Grange AQMS compared with 0 µg/m³ to 10 µg/m³ for Colliery BAM. This is reflective of the higher measurements recorded at the DPIE Kembla Grange AQMS.

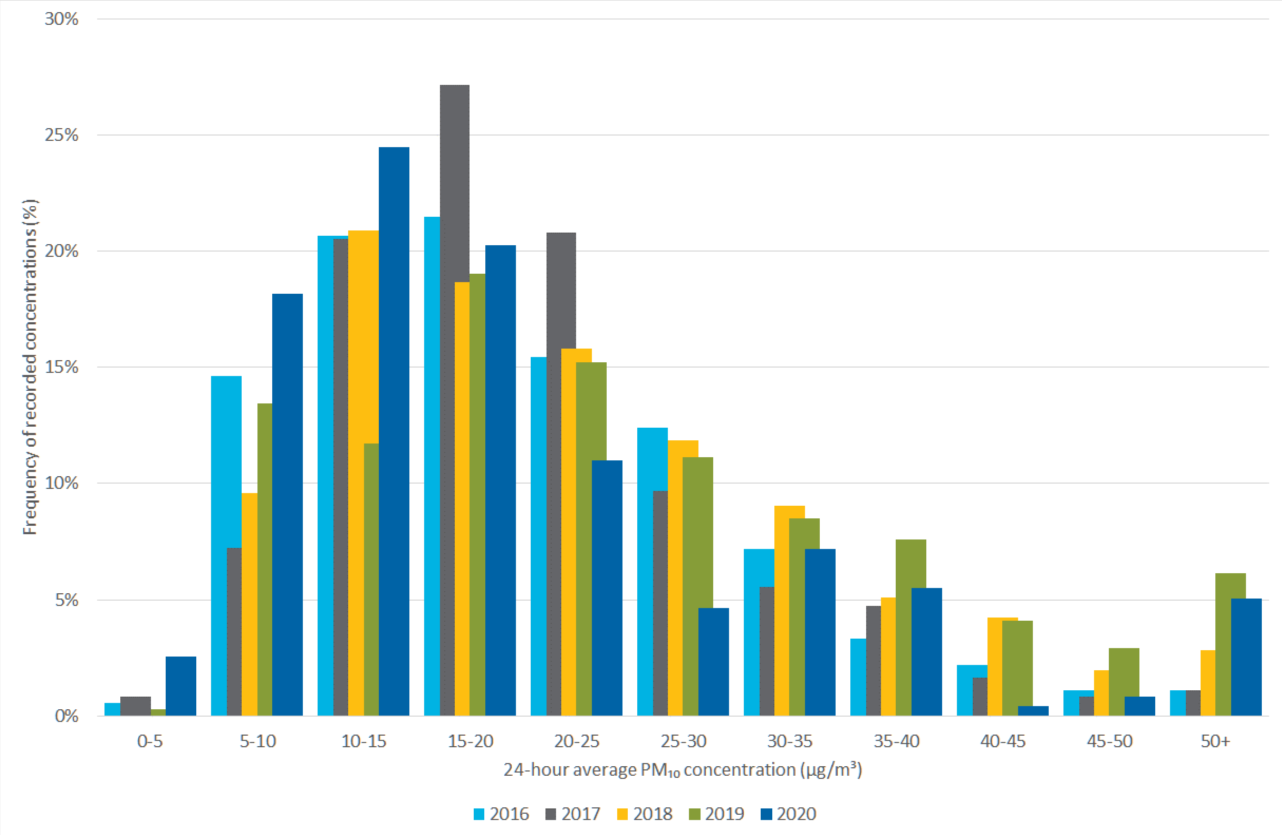

Figure 5.3 Frequency distribution of PM_{10} monitoring data – DPIE Kembla Grange AQMS - 2016 to 2020

A timeseries of recorded 24-hour PM_{10} concentrations recorded at the Colliery BAM and DPIE Kembla Grange AQMS is presented in Figure 5.4. From this timeseries, it can be seen that the two stations track consistently throughout the five years of data, however the Colliery BAM is consistently lower than the data recorded at the DPIE Kembla Grange AQMS. The discussed increasing trend with time in recorded concentrations associated with intensifying drought conditions is evident for both monitoring location datasets.

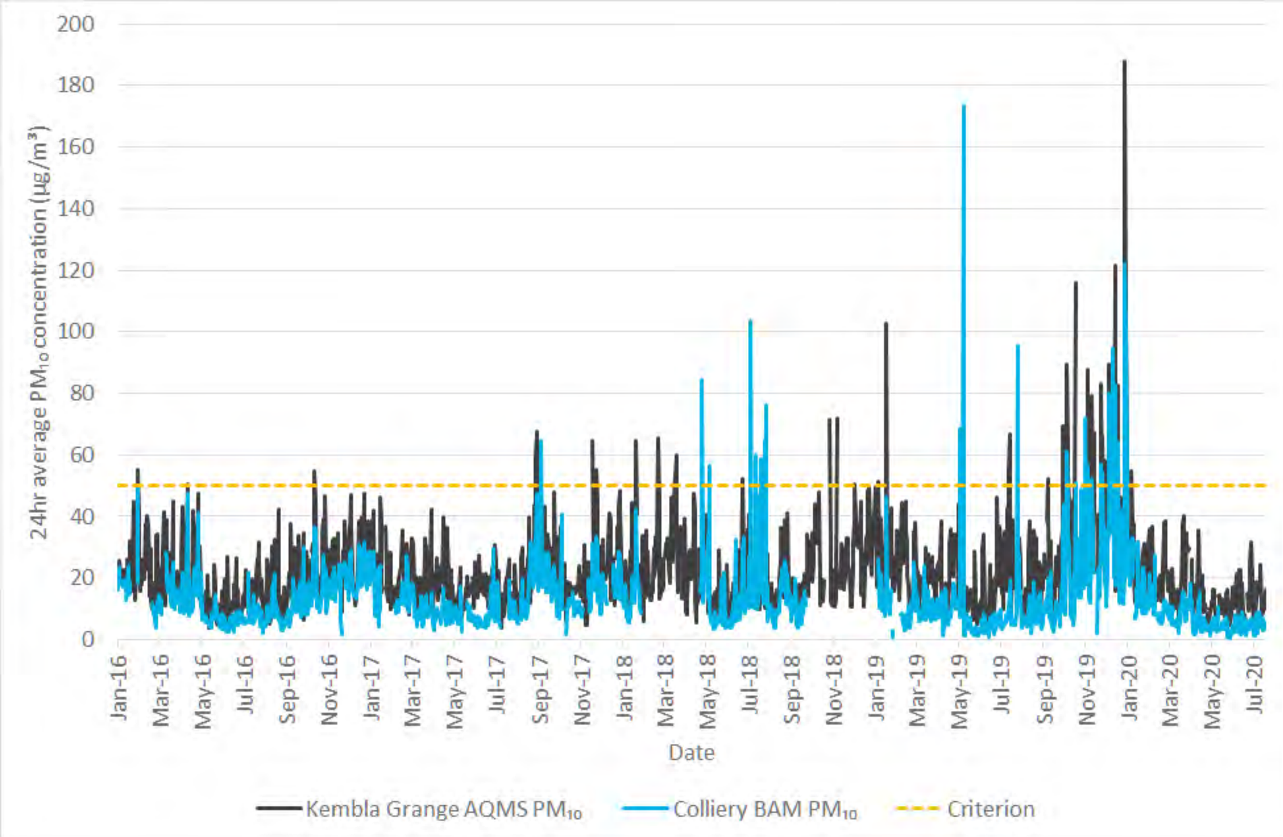

Figure 5.4 Timeseries of 24-hour average PM_{10} concentrations – Colliery BAM and Kembla Grange AQMS – 2016 to 2020

For the purpose of this AQIA, the daily-varying concentrations recorded during the 2016-2017 modelling period by the DPIE Kembla Grange AQMS will be adopted, with the following justification provided:

- relative to the Colliery BAM PM_{10} dataset, the concurrent measurements at the DPIE Kembla Grange AQMS are consistently higher, providing a conservatively high representation of existing background concentrations for cumulative assessment purposes;
- the DPIE Kembla Grange AQMS possesses a higher data capture rate than the Colliery BAM for the 2016-2017 modelling period; and
- the adoption of the DPIE Kembla Grange AQMS dataset provides a consistent $PM_{2.5}$ dataset for use in cumulative impact assessment (no $PM_{2.5}$ monitoring is conducted at the Colliery).

The 2016-2017 modelling period dataset from the DPIE Kembla Grange AQMS featured two exceedances of the NSW EPA 24-hour average criterion of 50 µg/m³, which were highly likely to be associated with regional scale hazard reduction burns or dust storm events. The highest 24-hour average PM_{10} concentration not in exceedance of the NSW EPA criterion (50 µg/m³) was 47.4 µg/m³. A timeseries of the 24-hour average PM_{10} concentrations recorded at the two monitoring locations during the 2016-2017 modelling period are illustrated in Figure 5.5.

The annual average PM_{10} concentration for the DPIE Kembla Grange AQMS PM_{10} dataset for the 2016-2017 modelling period is 19.7 µg/m³.

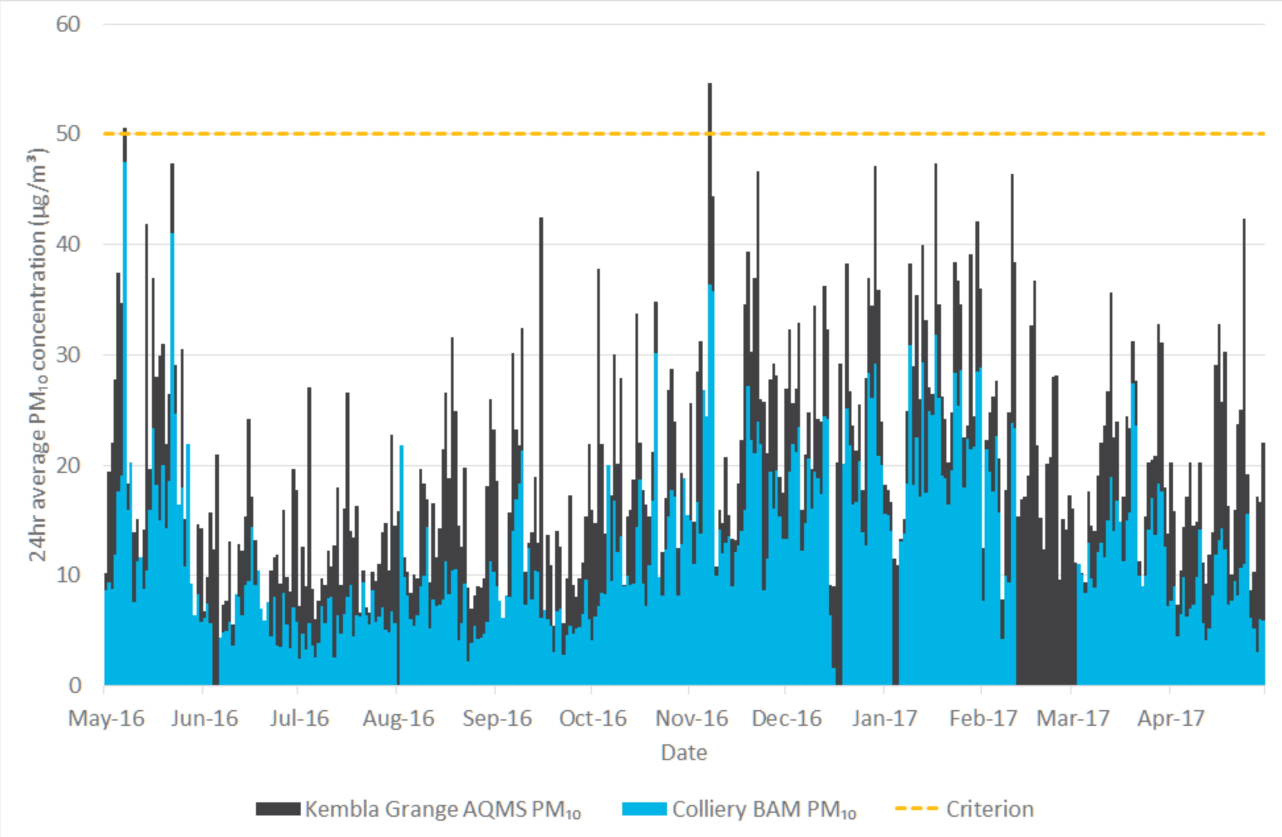

Figure 5.5 Timeseries of 24-hour average PM_{10} concentrations – Colliery BAM and Kembla Grange AQMS – 2016-2017 modelling period

5.3.2 $PM_{2.5}$

No monitoring of $PM_{2.5}$ is conducted by the Colliery air quality monitoring network. For consistency with the background concentrations adopted for PM_{10}, the daily-varying $PM_{2.5}$ concentrations recorded by the DPIE Kembla Grange AQMS during the 2016-2017 modelling period were adopted as background $PM_{2.5}$ for the Colliery.

On the basis that the PM_{10} concentrations recorded by the DPIE Kembla Grange AQMS were demonstrated to be higher than the concurrent measurements at the Colliery BAM, the adoption of DPIE Kembla Grange AQMS $PM_{2.5}$ measurements will conservatively represent background concentrations at the Colliery (ie worst case scenario).

The 2016-2017 modelling period 24-hour average $PM_{2.5}$ concentration dataset from the DPIE Kembla Grange AQMS featured two exceedances of the NSW EPA 24-hour average criterion of 25 µg/m³. The highest 24-hour average $PM_{2.5}$ concentration not in exceedance of the NSW EPA criterion (25 µg/m³) is 17.7 µg/m³. A timeseries of the 24-hour average $PM_{2.5}$ concentrations recorded at the DPIE Kembla Grange AQMS during the 2016-2017 modelling period is illustrated in Figure 5.6.

The annual average $PM_{2.5}$ concentration for the 2016-2017 modelling period DPIE Kembla Grange AQMS $PM_{2.5}$ dataset is 6.8 µg/m³.

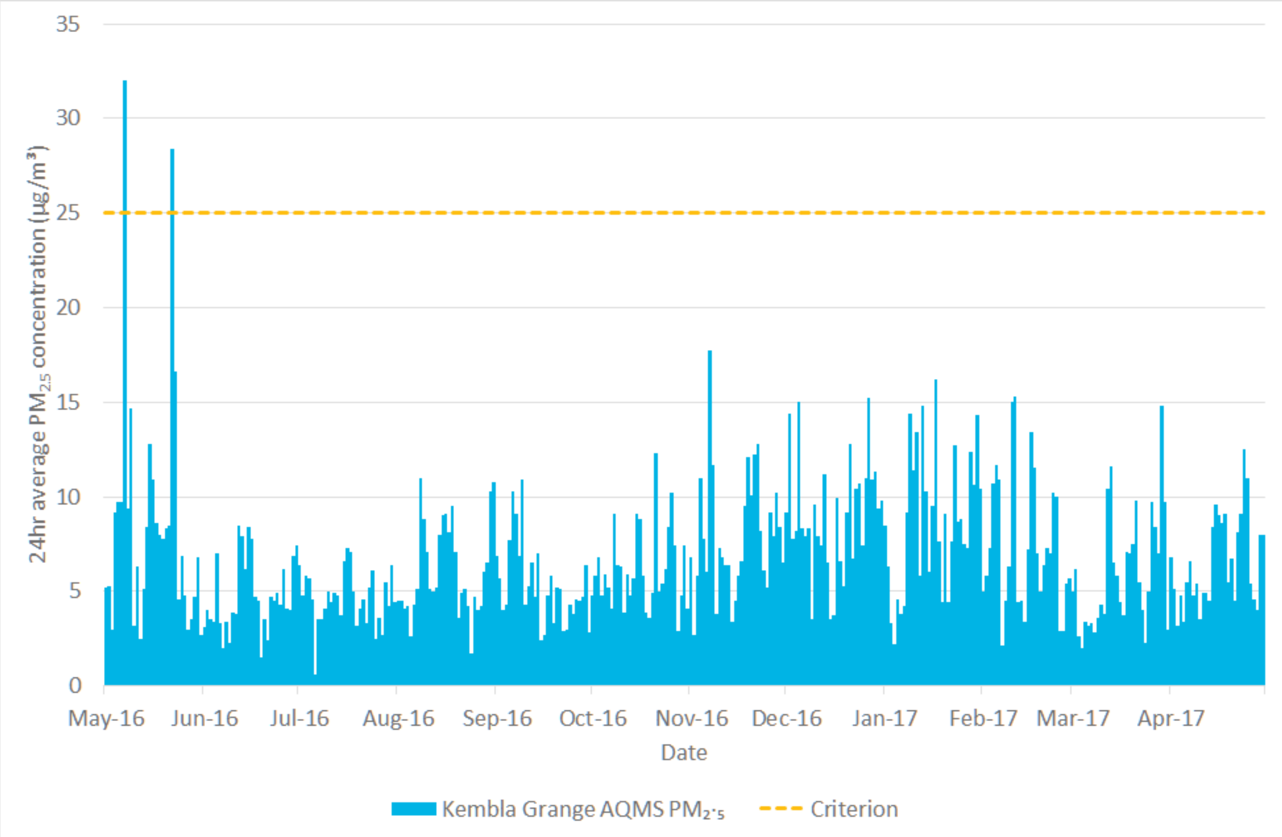

Figure 5.6 **Timeseries of 24-hour average $PM_{2.5}$ concentrations –Kembla Grange AQMS – 2016-2017 modelling period**

5.3.3 TSP

No monitoring of TSP is currently conducted by the Colliery air quality monitoring network. Historically, 24-hour average TSP concentrations were recorded by a high volume air sampler (HVAS) located to the south of the Colliery. The TSP HVAS sampling was discontinued in December 2015.

Analysis of data recorded by the HVAS between 2006 and 2015 returned annual average TSP concentrations of between 16.8 µg/m³ and 28.8 µg/m³. There are no concurrent PM_{10} measurements for the period between 2006 and 2015 at the Colliery to derive a PM_{10}:TSP relationship. Based on EMM's observations of similar sites, the typical ratio of annual average PM_{10} to annual average TSP concentrations is between 0.4 and 0.5.

To derive an annual average TSP concentration consistent with the 2016-2017 modelling period Kembla Grange AQMS PM_{10} background dataset (see Section 5.3.1), a ratio of 0.4 has been applied to the annual average PM_{10} concentration, returning a TSP background concentration of 49.3 µg/m³. This derived TSP concentration is notably higher than the TSP concentrations recorded at the Colliery between 2006 and 2015 and is considered conservative for cumulative assessment purpose (ie worst case scenario).

5.3.4 Dust deposition

As stated in Section 5.3.1, the Colliery air quality monitoring network comprises of five dust deposition gauges that are used for annual reporting purposes. Dust deposition rates recorded between January 2013 and August 2020 were analysed to determine existing dust deposition levels. The annual average dust deposition results from the five monitoring locations are presented in Table 5.3.

Table 5.3 Annual dust deposition results – Colliery monitoring network – 2013 to 2020

Monitoring year	Annual average dust deposition levels (g/m²/month) by monitoring location				
	C	D	F	G	H
2013	0.4	1.8	2.5	1.0	0.8
2014	2.0	0.9	1.6	1.1	1.6
2015	0.7	0.9	5.5	1.2	1.3
2016	0.7	0.8	1.2	0.7	1.4
2017	0.8	0.8	0.9	0.7	0.8
2018	1.8	1.5	1.2	1.5	1.2
2019	0.9	1.3	2.1	0.9	2.4
2020	1.3	2.0	2.5	1.6	2.5
Criterion			**4.0**		

For all years of monitoring, the NSW EPA impact assessment criterion was not exceeded at any monitoring location.

The highest recorded annual average dust deposition level for the 2016-2017 modelling period was 1.0 g/m^2/month at locations F and H. This value has been adopted as background for this assessment.

5.3.5 Adopted background summary

Background values adopted for cumulative assessment, based on the analysis presented in the preceding sections, are as follows:

- annual average TSP – 49.3 µg/m^3, derived from the annual average PM_{10} concentration;
- 24-hour PM_{10} – daily varying concentrations from the DPIE Kembla Grange AQMS during the 2016-2017 modelling period. Concentrations range from 4.0 µg/m^3 to 54.6 µg/m^3;
- annual average PM_{10} – 19.7 µg/m^3, from the DPIE Kembla Grange AQMS during the 2016-2017 modelling period;
- 24-hour $PM_{2.5}$ – daily varying concentrations from the DPIE Kembla Grange AQMS during the 2016-2017 modelling period. Concentrations range from 0.6 µg/m^{3}to 32.0 µg/m^3;
- annual average $PM_{2.5}$ – 6.8 µg/m^3, from the DPIE Kembla Grange AQMS during the 2016-2017 modelling period; and
- annual dust deposition – 1.0 g/m^2/month, from the Colliery air quality monitoring network during the 2016-2017 modelling period.

6 Emissions inventory

6.1 Sources of emissions

Sources of atmospheric emissions associated with the Colliery include:

- conveying and transfer of ROM coal from NWMD portal at pit top area;
- transfer of ROM coal from pit top area to stockpile area via decline conveyor;
- sizing of ROM coal;
- transfer of ROM coal to rail loading bins and rill tower;
- ROM coal loading to rail wagons from rail loading bins;
- unloading of ROM coal from rill tower to the ROM coal stockpile;
- handling and loading of ROM coal to rail wagons by front-end loader (FEL);
- management of the ROM coal stockpile by bulldozer;
- wind erosion of the ROM coal stockpile and exposed pit top area;
- underground emissions from NWMD mining operations released through the Wongawilli Shaft 1; and
- diesel fuel combustion by on-site plant and equipment.

6.2 Emission scenario

A single emission scenario has been prepared for the Colliery, representative of 2 Mtpa ROM coal extraction operations. The scenario features the following operational assumptions:

- 2 Mtpa ROM coal production, transfer and conveying from the NWMD portal to rail loading facility;
- ROM coal conveying, transfers and sizing occurring continuously;
- ROM coal preparation (crusher, sizer and screen) occurs at the existing surface location rather than underground as proposed (see Section 2.2.2) leading to conservatively high emission estimates;
- loading of two trains per day occurring during day-time hours only;
- loading of ROM coal to wagons to be predominately conducted by the rail loading bins, with 10% loaded via FEL from the ROM coal stockpile;
- bulldozer operations at the ROM coal stockpile area occur 5% of day shift hours; and
- underground mining emissions released from the Wongawilli Shaft 1.

6.3 Fugitive particulate matter emissions

Fugitive dust sources associated with the Colliery were quantified through the application of NPI emission estimation techniques and USEPA AP-42 emission factor equations. Particulate matter emissions were quantified for the three size fractions identified in Chapter 3, with the TSP fraction also used to provide an indication of dust deposition rates. Emission rates for coarse particles (PM_{10}) and fine particles ($PM_{2.5}$) were estimated using ratios for the different particle size fractions available in the literature (principally the USEPA AP-42).

Emissions from diesel locomotives at the Colliery during wagon loading operations were estimated using NSW EPA-commissioned locomotive testing emission factors. Further details are presented in Appendix B.

6.3.1 Particulate matter emission reduction factors

A best practice dust management review was completed for the Colliery in 2012 (NRE 2012) in response to Pollution Reduction Program 9 of the EPL for the Colliery (EPL 1087). This review concluded there were several best practice controls in place at the Colliery.

In particular, NRE (2012) identifies that an automated chemical wetting system (Compliance 2000) was installed at the surface screener during 2011. The system applies a 1,000 part water to 1 part wetting agent mix to coal at two stages before it enters the screener. Coal located on the conveyor is dosed with the diluted mixture as it approaches the end of the conveyor system and is then dosed again as it falls from the conveyor belt into the screener. The two stages of application aim to ensure that the chemical wetting agent is mixed through the coal to avoid just the surface crust being treated.

Additionally, there are 13 ground-based water sprays located along the perimeter of the ROM coal stockpile area to apply water to the stockpile surface. The water sprays are triggered automatically based on meteorological triggers or can be operated manually as required.

The particulate matter control measures listed in the best practice dust management review have been retained in this AQIA wherever applicable. The adopted control measures and associated emission reduction factors are presented in Table 6.1. It is noted that these emission reduction factors have been applied to annual emission calculations.

Table 6.1 Particulate matter control measures

Emission sources	Control measures	Emission reduction factors (%)[1, 2]
Conveyor transfer points	Enclosure	70%
	Water sprays	50%
Coal sizing	Enclosure	70%
	Chemical wetting agent	80%
Rail wagon loading from rail bin and ROM coal stockpile loading	Residual wetting agent	50%
FEL handling ROM coal	Residual moisture from stockpile spray system	50%
Bulldozer on ROM coal stockpile	Travel routes kept moist by stockpile spray system	50%
Wind erosion from ROM coal stockpile	Stockpile water spray system	50%

[1] All control reduction factors adopted from the best practice dust management review conducted for the Colliery in 2012 are consistent with *NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Katestone 2011).
[2] Where two emission reduction factors apply, a combined emission reduction factor has been applied consistent with NPI 2012.

6.3.2 Particulate matter emissions

A summary of annual site emissions by source type is presented in Table 6.2. Further, the contribution of source type to total annual emissions by particle size are illustrated in Figure 6.1. Particulate matter control measures, as documented in Section 6.3.1 are accounted for in these emission totals.

Across all particle sizes, the most significant sources of emissions are the FEL and bulldozer operations associated with the ROM coal stockpile. Wind erosion from the ROM coal stockpile is also a notable contributing source of particulate matter on an annual basis. Further details regarding emission estimation factors and assumptions are provided in Appendix B.

Table 6.2 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions – 2 Mtpa operations

Emissions source	Calculated annual emissions (kg/annum) by source		
	TSP	PM_{10}	$PM_{2.5}$
Conveyor transfer point - NW Mains portal to new transfer bin	41.2	19.5	2.9
Conveyor transfer point - new transfer bin to pit top conveyor	41.2	19.5	2.9
Conveyor transfer point - pit top conveyor to transfer house/decline belt	41.2	19.5	2.9
Conveyor transfer point - decline belt to sizing station	41.2	19.5	2.9
Coal sizing	324.0	144.0	26.7
Conveyor transfer point - coal sizer to elevator tower	41.2	19.5	2.9
Conveyor transfer point - elevator tower to rail loading bins	41.2	19.5	2.9
Conveyor transfer point - elevator tower to rill towers	4.1	1.9	0.3
Conveyor transfer point - rail wagon loading	13.7	6.5	1.0
Conveyor transfer point - rill tower to stockpile	13.7	6.5	1.0
FELs loading coal to rail wagons (stockpile handle and wagon loading)	5,880.9	955.2	111.7
Bulldozer on ROM stockpile	2,088.3	1,155.7	91.9
Wind erosion of ROM stockpile	724.4	362.2	54.3
Wind erosion of timber yard/flat top	511.1	255.5	38.3
Wongawilli Shaft 1	109.6	109.6	109.6
Site surface diesel combustion	1.5	1.5	1.4
Diesel locomotive emissions	93.6	93.6	89.9
Total	**10,011.8**	**3,209.0**	**543.7**

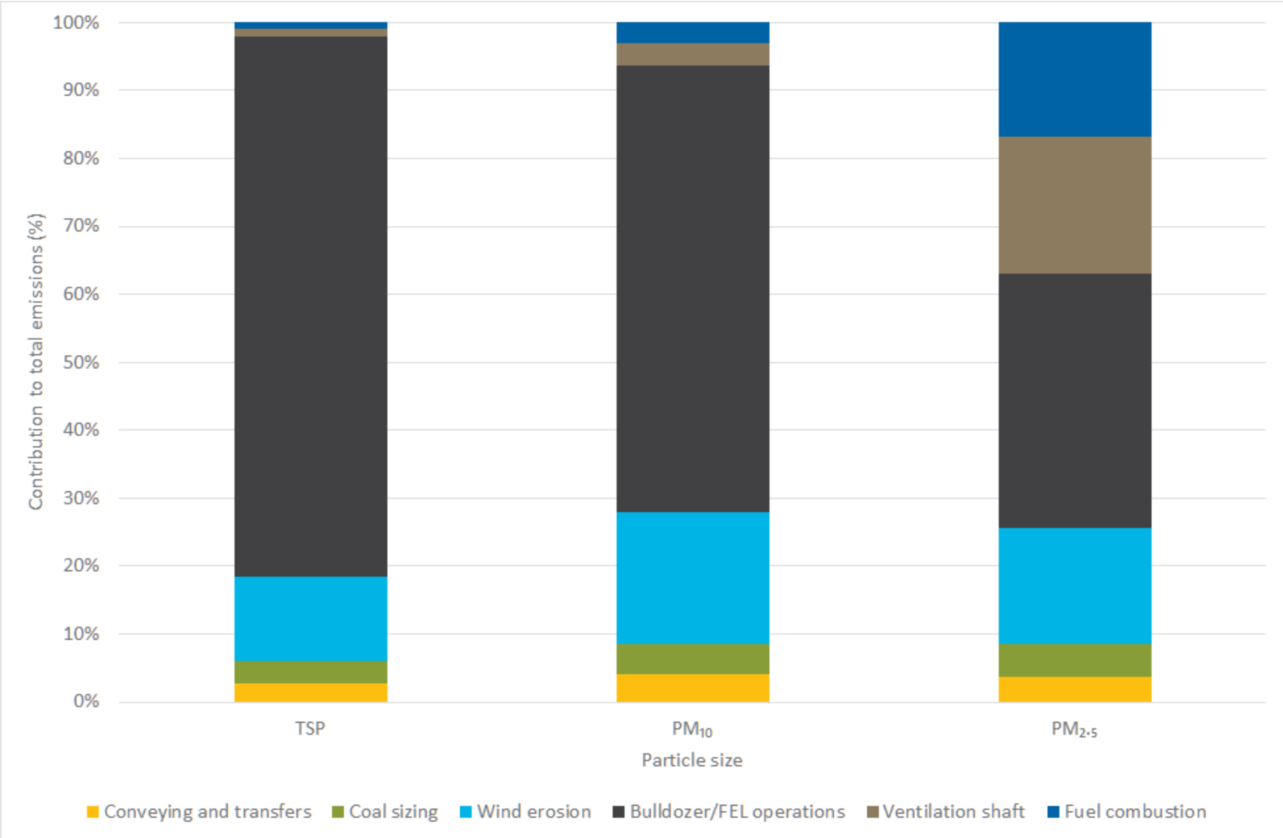

Figure 6.1 Contribution to annual emissions by emissions source type and particle size

7 Air dispersion modelling

7.1 Dispersion model selection and configuration

The atmospheric dispersion modelling completed for this assessment used the AERMOD dispersion model (version v19191). 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.

In addition to the 58 assessment locations (documented in Section 2.4), air pollutant concentrations were predicted over a 8 km by 8 km model domain featuring the following nested grids:

- a 0.6 km by 0.6 km domain with 20 m resolution;
- a 1.2 km by 1.2 km domain with 50 m resolution;
- a 2.2 km by 2.2 km domain with 100 m resolution;
- a 4.2 km by 4.2 km domain with 200 m resolution; and
- a 8 km by 8 km domain with 500 m resolution.

Specific activities (conveyor transfer points, ROM coal stockpiling areas, wind erosion etc) were represented by a series of volume sources and area sources which were located according to the layout the Colliery. The modelled source locations are shown in Appendix B.

Simulations were undertaken for the 12-month 2016-2017 modelling period using the AERMET-generated file based largely on the WCM dataset as input (see Chapter 4 for a description of input meteorology).

7.2 Incremental (Colliery-only) results

As stated previously, emissions were quantified for a single emission scenario representative of 2 Mtpa ROM coal extraction operations at the Colliery. The predicted incremental (Colliery-only) concentrations and deposition rates are presented in Table 7.1. It is reiterated that ROM coal preparation emissions were assumed to occur in the existing location at the surface rather than underground (see Section 2.2.2), therefore the presented model predictions should be viewed as conservative.

The predicted concentrations and deposition rates for all pollutants and averaging periods presented in Table 7.1 are below the applicable NSW EPA assessment criteria. It is noted that, excluding dust deposition, the assessment criteria listed are applicable to cumulative concentrations. Analysis of cumulative impact compliance is presented in Section 7.3.

Contour plots illustrating spatial variations in incremental TSP, PM_{10} and $PM_{2.5}$ concentrations and dust deposition rates from the Colliery are provided in Appendix C. Isopleth plots of the maximum 24-hour average concentrations presented in Appendix C do not represent the dispersion pattern on any individual day, but rather illustrate the maximum daily concentration that was predicted to occur at each model calculation point given the range of meteorological conditions occurring over the 2016-2017 modelling period.

Table 7.1 Incremental (Colliery-only) concentration and deposition results

Assessment location ID	Predicted incremental concentrations (µg/m³) or deposition rates (g/m²/month)					
	TSP	PM_{10}		$PM_{2.5}$		Dust deposition
	Annual	24-hour maximum	Annual	24-hour maximum	Annual	Annual
Criterion	**90**	**50**	**25**	**25**	**8**	**2**
R01	0.1	0.3	<0.1	<0.1	<0.1	<0.1
R02	0.1	0.2	<0.1	<0.1	<0.1	<0.1
R03	0.1	0.5	<0.1	0.1	<0.1	<0.1
R04	0.1	0.5	<0.1	0.1	<0.1	<0.1
R05	0.1	1.0	0.1	0.1	<0.1	<0.1
R06	0.1	1.4	0.1	0.2	<0.1	<0.1
R07	0.1	0.9	0.1	0.1	<0.1	<0.1
R08	0.2	1.7	0.1	0.2	<0.1	<0.1
R09	0.3	2.4	0.2	0.3	<0.1	<0.1
R10	0.6	4.4	0.4	0.6	0.1	0.1
R11	0.6	4.9	0.4	0.6	0.1	0.1
R12	0.8	5.5	0.5	0.7	0.1	0.1
R13	0.9	6.3	0.6	0.8	0.1	0.2
R14	1.0	6.7	0.6	0.8	0.1	0.2
R15	1.1	7.2	0.7	0.9	0.1	0.2
R16	1.2	7.9	0.8	1.0	0.1	0.2
R17	1.4	8.5	0.8	1.1	0.1	0.2
R18	2.1	11.9	1.3	1.5	0.2	0.4
R19	3.1	16.3	1.8	2.1	0.3	0.5
R20	2.0	10.4	1.2	1.3	0.2	0.3
R21	1.8	9.7	1.1	1.2	0.1	0.3
R22	1.5	8.8	0.9	1.1	0.1	0.3
R23	1.0	5.9	0.6	0.7	0.1	0.2
R24	1.1	6.4	0.7	0.8	0.1	0.2
R25	1.2	6.8	0.7	0.9	0.1	0.2
R26	1.3	7.2	0.8	0.9	0.1	0.2
R27	1.7	8.3	1.0	1.0	0.1	0.3
R28	1.4	6.9	0.9	0.9	0.1	0.3
R29	1.0	5.4	0.6	0.7	0.1	0.2
R30	0.9	4.7	0.6	0.6	0.1	0.1
R31	0.9	5.0	0.6	0.6	0.1	0.2
R32	1.0	5.2	0.6	0.7	0.1	0.2
R33	1.1	5.5	0.7	0.7	0.1	0.2

Table 7.1 Incremental (Colliery-only) concentration and deposition results

Assessment location ID	Predicted incremental concentrations (µg/m³) or deposition rates (g/m²/month)					
	TSP	PM_{10}		$PM_{2.5}$		Dust deposition
	Annual	24-hour maximum	Annual	24-hour maximum	Annual	Annual
Criterion	**90**	**50**	**25**	**25**	**8**	**2**
R34	1.3	6.0	0.8	0.7	0.1	0.2
R35	1.2	5.1	0.7	0.6	0.1	0.2
R36	0.9	3.8	0.5	0.5	0.1	0.2
R37	1.0	3.9	0.6	0.5	0.1	0.2
R38	0.9	3.5	0.6	0.4	0.1	0.2
R39	0.8	3.2	0.5	0.4	0.1	0.2
R40	0.7	3.1	0.5	0.4	0.1	0.1
R41	0.6	3.0	0.4	0.4	0.1	0.1
R42	0.6	2.9	0.4	0.3	0.1	0.1
R43	0.9	3.6	0.6	0.4	0.1	0.2
R44	0.7	3.2	0.5	0.4	0.1	0.1
R45	0.6	3.0	0.4	0.3	0.1	0.1
R46	0.6	2.7	0.4	0.3	0.1	0.1
R47	0.5	2.5	0.4	0.3	<0.1	0.1
R48	0.5	2.3	0.3	0.3	<0.1	0.1
R49	0.1	0.7	0.1	0.1	<0.1	<0.1
R50	0.1	0.7	0.1	0.1	<0.1	<0.1
R51	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
R52	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
R53	0.1	0.9	0.1	0.1	<0.1	<0.1
R54	0.1	0.9	0.1	0.1	<0.1	<0.1
R55	0.1	0.9	0.1	0.1	<0.1	<0.1
R56	0.1	0.8	0.1	0.1	<0.1	<0.1
R57	0.1	0.8	0.1	0.1	<0.1	<0.1
R58	<0.1	0.4	<0.1	<0.1	<0.1	<0.1

Notes: Criteria for TSP, PM_{10} and $PM_{2.5}$ is applicable to cumulative (increment + background) and is provided for comparison purposes only.

7.3 Cumulative (Colliery plus background) results

Predicted cumulative TSP, PM_{10} and $PM_{2.5}$ concentrations and dust deposition rates at surrounding assessment locations are presented in Table 7.2.

Cumulative impacts at each assessment location have been quantified in the following way:

- for 24-hour average concentrations, each daily varying model predicted PM_{10} and $PM_{2.5}$ concentrations due to the Colliery has been combined with the corresponding concentration from the 2016-2017 modelling period DPIE Kembla Grange AQMS PM_{10} and $PM_{2.5}$ background datasets; and
- for annual average concentrations, the predicted annual average concentrations have been paired with the corresponding background annual average concentration or deposition rate (Section 5.3.5).

As detailed in Section 5.3, there are two existing exceedances of the applicable criteria for 24-hour average PM_{10} and $PM_{2.5}$ in the adopted background datasets. For cumulative impact assessment purposes, these are therefore classed as existing exceedances.

Section 5.1.3 of the Approved Methods for Modelling states that in the event of existing ambient air pollutant concentrations in exceedance of applicable impact assessment criteria, the assessment must:

> …demonstrate that no additional exceedances of the impact assessment criteria will occur as a result of the proposed activity and that best management practices will be implemented to minimise emissions of air pollutants as far as is practical.

To analyse if emissions from the Colliery will lead to additional exceedances of the applicable criteria, the 3rd highest 24-hour cumulative PM_{10} and $PM_{2.5}$ concentrations at each assessment location are reported in Table 7.2. If the presented 3rd highest cumulative concentration is above the relevant criteria, this is therefore classed as an additional exceedance event. It is stressed that data points have not been removed from the background datasets but simply, the next highest result not affected by background above the criterion is shown in this section.

The predicted cumulative concentrations for all pollutants and averaging periods comply with the applicable NSW EPA assessment criterion for all assessment locations. The modelling results presented therefore indicate that operation of the Colliery consistent with the operational assumptions of the modelled scenario will not adversely impact assessment locations in the surrounding environment.

Table 7.2 Cumulative (Colliery plus background) concentration and deposition results

Assessment location ID	Predicted cumulative concentrations (µg/m³) or deposition rates (g/m²/month)					
	TSP	PM_{10}		$PM_{2.5}$		Dust deposition
	Annual	24-hour maximum	Annual	24-hour maximum	Annual	Annual
Criterion	90	50	25	25	8	4
R01	49.4	47.4	19.8	17.7	6.8	1.0
R02	49.4	47.4	19.8	17.7	6.8	1.0
R03	49.4	47.4	19.8	17.7	6.8	1.0
R04	49.4	47.4	19.8	17.7	6.8	1.0
R05	49.4	47.4	19.8	17.7	6.8	1.0
R06	49.4	47.4	19.8	17.7	6.8	1.0
R07	49.4	47.4	19.8	17.7	6.8	1.0
R08	49.5	47.4	19.8	17.7	6.8	1.0
R09	49.6	47.5	19.9	17.7	6.8	1.0
R10	49.9	47.7	20.1	17.7	6.8	1.1
R11	49.9	47.8	20.1	17.7	6.8	1.1
R12	50.1	48.0	20.3	17.7	6.8	1.1
R13	50.2	48.0	20.3	17.7	6.8	1.2
R14	50.3	48.1	20.4	17.7	6.9	1.2
R15	50.4	48.2	20.4	17.7	6.9	1.2
R16	50.5	48.3	20.5	17.7	6.9	1.2
R17	50.7	48.4	20.6	17.7	6.9	1.2
R18	51.4	48.9	21.0	17.8	6.9	1.4
R19	52.4	49.6	21.6	17.8	7.0	1.5
R20	51.3	48.8	20.9	17.8	6.9	1.3
R21	51.1	48.6	20.8	17.7	6.9	1.3
R22	50.8	48.4	20.6	17.7	6.9	1.3
R23	50.3	48.1	20.3	17.7	6.9	1.2
R24	50.4	48.2	20.4	17.7	6.9	1.2
R25	50.5	48.2	20.5	17.7	6.9	1.2
R26	50.6	48.3	20.5	17.7	6.9	1.2
R27	51.0	48.6	20.7	17.7	6.9	1.3
R28	50.7	48.4	20.6	17.7	6.9	1.3
R29	50.3	48.1	20.3	17.7	6.8	1.2
R30	50.2	48.0	20.3	17.7	6.8	1.1
R31	50.2	48.1	20.3	17.7	6.8	1.2
R32	50.3	48.1	20.4	17.7	6.9	1.2
R33	50.4	48.2	20.4	17.7	6.9	1.2

Table 7.2 Cumulative (Colliery plus background) concentration and deposition results

Assessment location ID	Predicted cumulative concentrations (µg/m³) or deposition rates (g/m²/month)					
	TSP	PM_{10}		$PM_{2.5}$		Dust deposition
	Annual	24-hour maximum	Annual	24-hour maximum	Annual	Annual
Criterion	90	50	25	25	8	4
R34	50.6	48.3	20.5	17.7	6.9	1.2
R35	50.5	48.2	20.4	17.7	6.9	1.2
R36	50.2	48.0	20.3	17.7	6.8	1.2
R37	50.3	48.1	20.3	17.7	6.8	1.2
R38	50.2	48.0	20.3	17.7	6.8	1.2
R39	50.1	48.0	20.2	17.7	6.8	1.2
R40	50.0	47.9	20.2	17.7	6.8	1.1
R41	49.9	47.9	20.1	17.7	6.8	1.1
R42	49.9	47.8	20.1	17.7	6.8	1.1
R43	50.2	48.1	20.3	17.7	6.8	1.2
R44	50.0	47.9	20.2	17.7	6.8	1.1
R45	49.9	47.9	20.1	17.7	6.8	1.1
R46	49.9	47.8	20.1	17.7	6.8	1.1
R47	49.8	47.8	20.1	17.7	6.8	1.1
R48	49.8	47.8	20.1	17.7	6.8	1.1
R49	49.4	47.5	19.8	17.7	6.8	1.0
R50	49.4	47.4	19.8	17.7	6.8	1.0
R51	49.3	47.4	19.7	17.7	6.8	1.0
R52	49.3	47.4	19.7	17.7	6.8	1.0
R53	49.4	47.5	19.8	17.7	6.8	1.0
R54	49.4	47.5	19.8	17.7	6.8	1.0
R55	49.4	47.5	19.8	17.7	6.8	1.0
R56	49.4	47.5	19.8	17.7	6.8	1.0
R57	49.4	47.4	19.8	17.7	6.8	1.0
R58	49.3	47.4	19.7	17.7	6.8	1.0

Note: Due to two existing exceedance events in the 2016-2017 modelling period background dataset (see Section 5.3.1), the third highest cumulative 24-hour average PM_{10} and $PM_{2.5}$ concentrations are presented.

To illustrate the contribution of background concentrations and Colliery emission sources to cumulative concentrations, the following figures have been generated:

- Figure 7.1 – cumulative 24-hour average PM_{10} concentrations at the most impacted assessment location (R19 – Wongawilli Community Hall);
- Figure 7.2 – cumulative 24-hour average $PM_{2.5}$ concentrations at the most impacted assessment location (R19 – Wongawilli Community Hall);

- Figure 7.3 – cumulative annual average PM_{10} concentrations at all assessment locations; and
- Figure 7.4 – cumulative annual average $PM_{2.5}$ concentrations at all assessment locations.

These figures illustrate that the predicted daily-varying cumulative concentrations are below applicable impact assessment criteria at all assessment locations. Further, the figures illustrate that ambient background concentrations are the major contributor to cumulative concentrations.

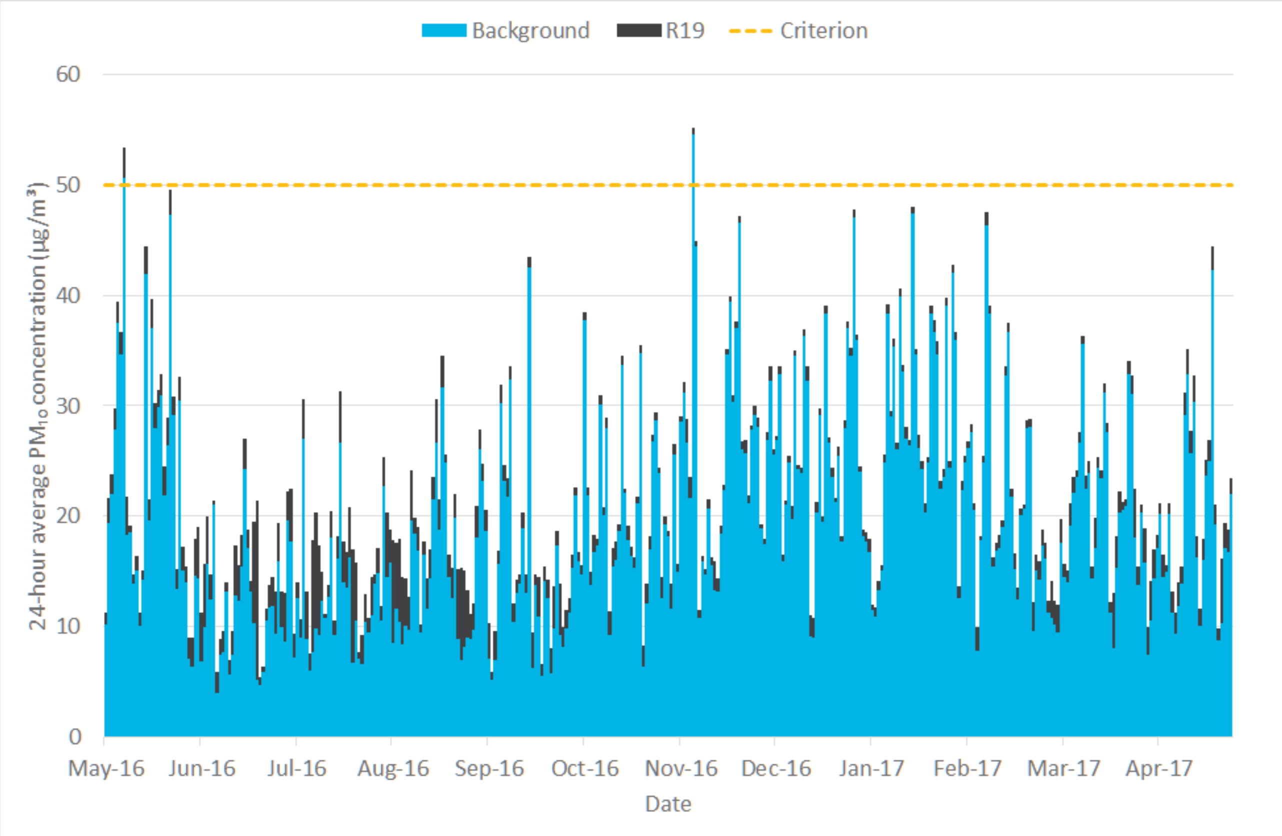

Figure 7.1 Daily-varying cumulative 24-hour average PM_{10} concentrations – assessment location R19

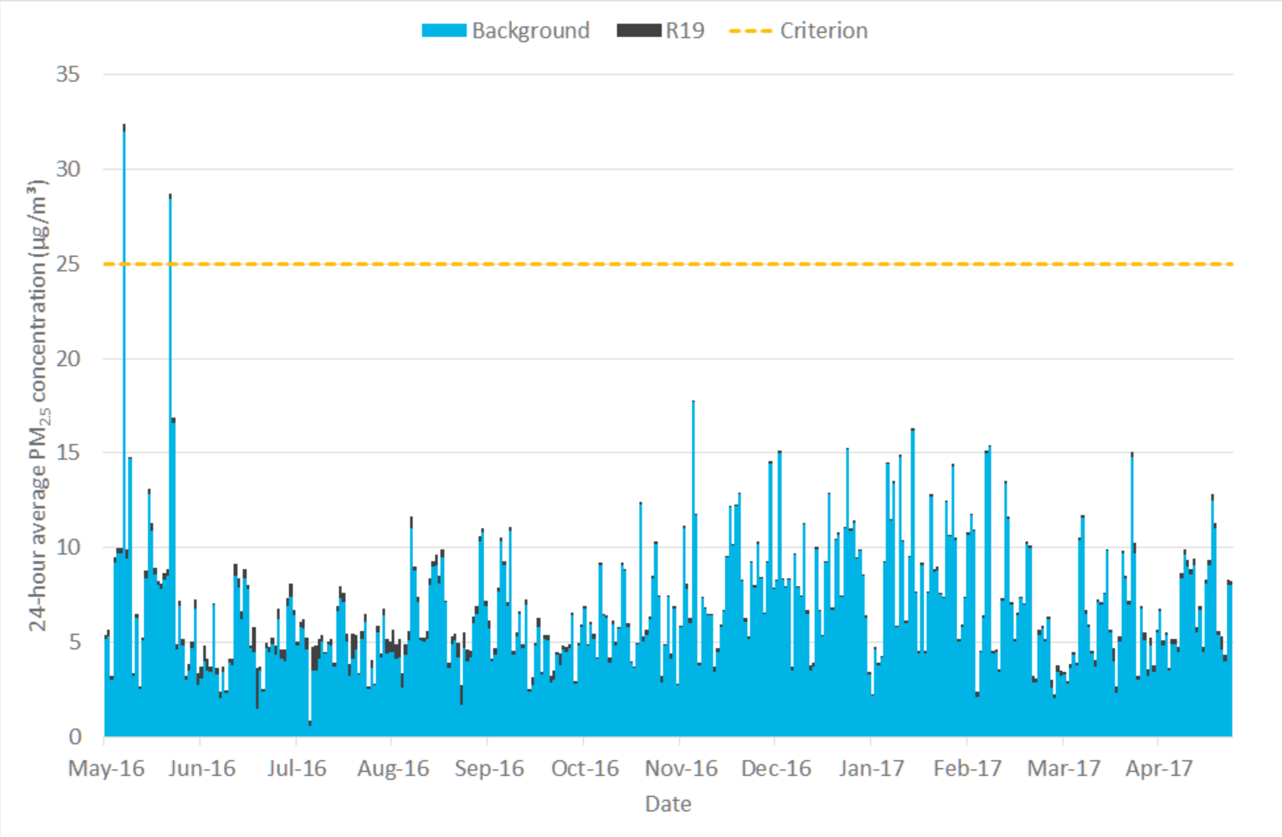

Figure 7.2 Daily-varying cumulative 24-hour average $PM_{2.5}$ concentrations – assessment location R19

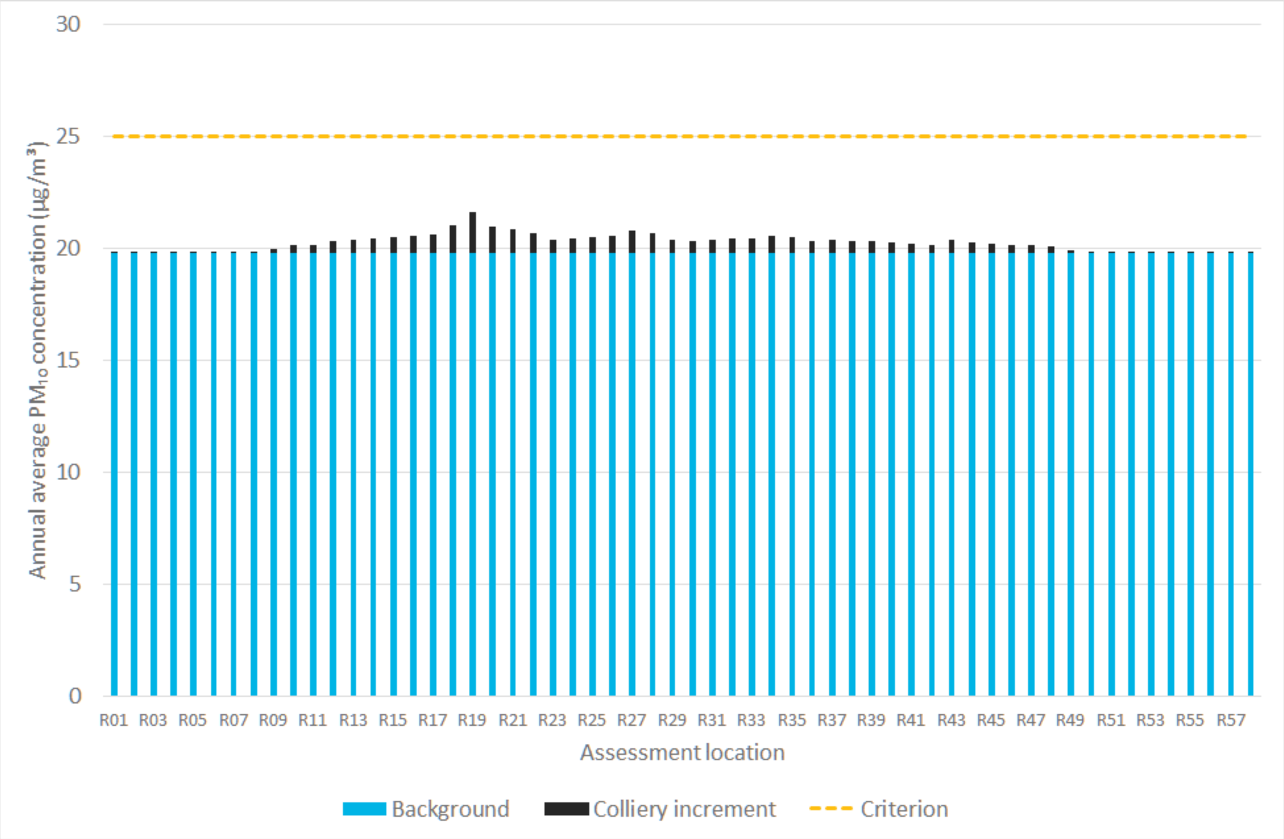

Figure 7.3 Cumulative annual average PM_{10} concentrations – all assessment locations

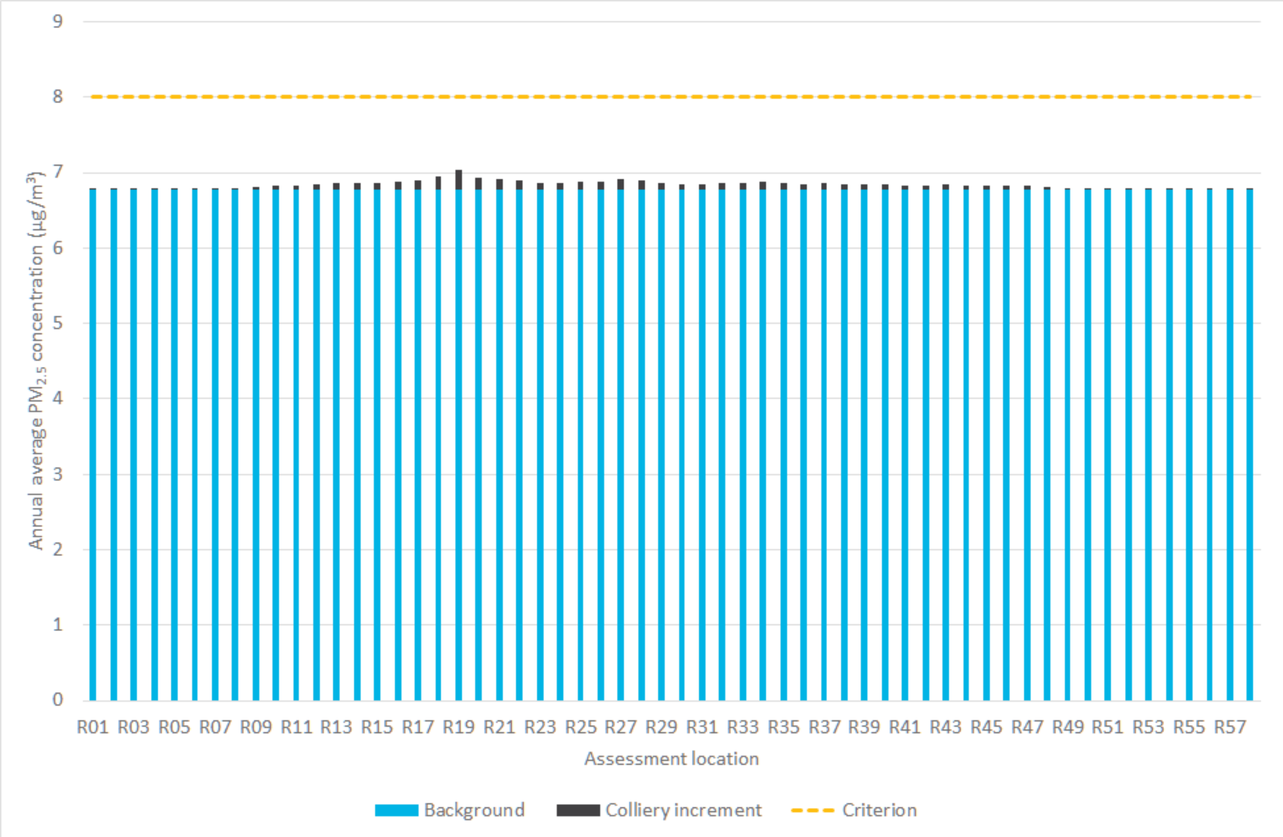

Figure 7.4 Cumulative annual average $PM_{2.5}$ concentrations – all assessment locations

7.4 Voluntary land acquisition criteria

The results presented in Section 7.2 and Section 7.3 demonstrate compliance with the relevant VLAMP criteria for both mitigation and acquisition presented in Section 3.4. As stated, VLAMP criteria also apply if the development contributes to an exceedance on more than 25% of privately-owned land upon which a dwelling could be built under existing planning controls.

Analysis of the contour plots presented in Appendix C indicates that Colliery-only 24-hour PM_{10} and $PM_{2.5}$ concentrations will not exceed 50 µg/m³ or 25 µg/m³ across more than 25% of any privately-owned land.

To assess against voluntary land acquisition criteria for cumulative annual average PM_{10}, $PM_{2.5}$, TSP or dust deposition, the relevant fixed background value from Section 5.3.5 was added to the incremental contour plots presented in Appendix C. This analysis highlighted that no exceedance of relevant VLAMP criteria across more than 25% of any privately-owned land would occur.

8 Air quality monitoring

As documented in Section 5.2, Wollongong Coal maintain an air quality monitoring network at the Colliery for compliance reporting purposes, comprising of one BAM (continuous PM_{10}), five dust deposition gauges (monthly dust deposition gauges) and a meteorological monitoring station (WCM).

This monitoring network will continue to be maintained on an ongoing basis to satisfy Wollongong Coals EPL1087 requirements. The combination of continuous measurements of PM_{10} and meteorology by the installed BAM and the WCM will allow Wollongong Coal to undertake detailed investigations into any potential criteria exceedances (ie identify regional exceedance events through the pairing of PM_{10} and wind speed/direction measurements). Expansion of the monitoring network is not proposed at this point in time and is not considered required on the basis of the modelling presented.

Daily and annual average PM_{10} concentrations and monthly average dust deposition results will continue to be recorded and reported in quarterly and annual environmental management reports.

9 Greenhouse gas assessment

9.1 Introduction

The estimation of greenhouse gas (GHG) emissions for the Colliery was based on the Australian Government Department of the Environment and Energy (DoEE) National Greenhouse Accounts Factors (NGAF) workbook (DoEE 2020). The methodologies in the NGAF workbook follow a simplified approach, equivalent to the 'Method 1' approach outlined in the National Greenhouse and Energy Reporting (Measurement) Technical Guidelines (DoE 2014). The Technical Guidelines are used for the purpose of reporting under the National Greenhouse and Energy Reporting Act 2007 (the NGER Act).

For accounting and reporting purposes, GHG emissions are defined as 'direct' and 'indirect' emissions. Direct emissions (also referred to as scope 1 emissions) occur within the boundary of an organisation and as a result of that organisation's activities. Indirect emissions are generated as a consequence of an organisation's activities but are physically produced by the activities of another organisation (DoEE 2019). Indirect emissions are further defined as scope 2 and scope 3 emissions. Scope 2 emissions occur from the generation of the electricity purchased and consumed by an organisation. Scope 3 emissions occur from all other upstream and downstream activities, for example the downstream extraction and production of raw materials or the upstream use of products and services.

Scope 3 is an optional reporting category (Bhatia et al 2010) and should not be used to make comparisons between organisations, for example in benchmarking GHG intensity of products or services. Typically, only major sources of scope 3 emissions are accounted and reported by organisations. Specific scope 3 emission factors are provided in the NGAF workbook for the consumption of fossil fuels and purchased electricity, making it straightforward for these sources to be included in a GHG inventory, even though they are a relatively minor source.

9.2 Emission sources

The GHG emission sources included in this assessment are listed in Table 9.1, representing the most significant sources associated with the Colliery.

Table 9.1 Scope 1, 2 and 3 emission sources

Scope 1	Scope 2	Scope 3
Direct emissions from fuel combustion (diesel) by onsite plant and equipment.	Indirect emissions associated with the consumption of purchased electricity.	Indirect upstream emissions from the extraction, production and transport of diesel.
Fugitive emissions from underground mining operations.		Indirect upstream emissions from electricity lost in delivery in the transmission and distribution network.
Post mining emissions from extracted coal in the ROM coal stockpiles.		Combustion of extracted coal by end users.
		Transportation of extracted coal to market (rail and shipping).

Emissions of GHGs have been quantified based on the following assumptions:

- annual ROM coal extraction and production of 2 Mtpa;
- annual diesel consumption of 50,000 L per annum;

- annual purchased electricity consumption of 27,196,000 kWh;
- 100% of ROM coal from the Colliery is coking coal for distribution to India;
- return rail transport distance to Port Kembla of 30 km; and
- a return shipping distance from Port Kembla to end user countries of 24,000 km.

Emission calculations are presented in Appendix D.

9.3 Excluded emissions

There are a number of GHG emissions that are considered minor relative to diesel and electricity consumption and have been excluded from this GHG assessment. Excluded sources are:

- Liquid petroleum gas (LPG) and petrol consumption (scope 1);
- fugitive leaks from high voltage switch gear and refrigeration (scope 1);
- explosives detonation in underground operations (scope 1);
- use of paints, solvents, oils and grease (scope 1);
- disposal of solid waste at landfill (scope 3); and
- travel of employees to and from the Colliery (scope 3).

9.4 Emission estimates

The following emission factors have been used to estimate GHG emissions from the Colliery:

- diesel consumption on-site (scope 1) – diesel oil factors from Table 4 of the NGAF workbook (2020);
- post mining activities associated with gassy underground coal mines (scope 1) - factor from Table 7 of the NGAF workbook (2020);
- fugitive emissions from underground coal extraction (scope 1) – factor derived from 2018-2019 NGERs reporting data from the Colliery for mine ventilation emissions;
- electricity consumption (scope 2) – NSW Scope 2 emission factor from Table 5 of the NGAF workbook (2020);
- diesel consumption on-site (scope 3) – diesel oil factor from Table 43 of the NGAF workbook (2020);
- electricity consumption (scope 3) – NSW scope 3 emission factor from Table 44 of the NGAF workbook (2020);
- transportation of product coal to market by rail and shipping (scope 3) – applicable emission factors from AGO 2007; and
- combustion of product coal by end users (scope 3) – scope 1 emission factor for coking coal combustion from Table 1 of the NGAF workbook (2020) applied as scope 3.

The estimated annual GHG emissions for each emission source are presented in Table 9.2.

Table 9.2 Estimated annual GHG emissions – 2 Mtpa operations

Emission sources	Scope 1 (t CO_2-e/year)	Scope 2 (t CO_2-e/year)	Scope 3 (t CO_2-e/year)
Diesel combustion	136	-	7
Fugitive emissions from mining	357,761	-	-
Post-mining emissions	3,800	-	-
Electricity consumption	-	22,029	2,448
End use of product coal	-	-	5,521,800
Transport of product coal via rail	-	-	756
Transport of product coal via ship	-	-	604,800
Total	**361,697**	**22,029**	**6,129,811**

The significance of GHG emissions relative to state and national GHG emissions is made by comparing annual average GHG emissions against the most recent available total GHG emissions inventories (calendar year 2018[8]) for NSW (131,684.9 kt CO_2-e) and Australia (537,446.4 kt CO_2-e).

Annual scope 1 and 2 GHG emissions generated by the Colliery represent approximately 0.291% of total GHG emissions for NSW and 0.071% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2018.

Scope 3 emissions are approximately 6.1 Mtpa, with the majority associated with consumption of product coal by end users. Wollongong Coal commit to only exporting product coal to signatories of the Paris Agreement, with the majority planned for export to India. Any scope 3 emissions associated with the consumption of product coal from the Colliery will therefore be accounted for in the Nationally Determined Contribution commitments for the end user nation.

The calculated annual scope 1 and 2 emissions from the Colliery are greater than the NGER Scheme facility reporting threshold of 25,000 tpa CO_2-e. Wollongong Coal currently calculate and report scope 1 and 2 GHG emissions annually in accordance with the requirements of the NGER Act and will continue to do so as long as scope 1 and 2 GHG emissions are above the reporting threshold.

9.5 Mitigation measures

Wollongong Coal describe key greenhouse gas management practices, reporting requirements and responsibilities in *Wongawilli Colliery Air Quality and Greenhouse Gas Management Plan* (Wollongong Coal 2016). Commitments relating to GHG emissions listed in this plan include:

- monitoring and reporting - mine ventilation gas monitoring methodology and commitment to annual NGERs reporting;
- mine ventilation - continue regular greenhouse gas monitoring at operating ventilation fan locations;

8 https://ageis.climatechange.gov.au/SGGI.aspx

- diesel fuel - ensure the efficiency of all upgraded mobile and fixed equipment has been considered during procurement for fuel-powered equipment;
- diesel fuel - ensure all equipment is well maintained and operated to retain high levels of fuel efficiency; and
- electricity consumption - implement reasonable and feasible outcomes of any energy audits completed for the Colliery.

10 Conclusions

An AQIA focusing on the quantification of emissions and resultant air quality impacts from 2 Mtpa ROM coal extraction operations at the Colliery has been conducted by EMM. Emissions of TSP, PM_{10} and $PM_{2.5}$ were quantified for all significant Colliery emission sources. Emissions were quantified predominately using publicly available emission estimation techniques.

Atmospheric dispersion modelling predictions of air pollution emissions were undertaken using the AERMOD dispersion model.

The results of the dispersion modelling highlighted the predicted impacts from Colliery operations will not result in exceedance of any applicable criteria at any neighbouring assessment location.

A GHG assessment was also undertaken for the Colliery. Annual scope 1 and 2 GHG emissions generated by the Colliery represent approximately 0.291% of total GHG emissions for NSW and 0.071% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2018.

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US-EPA 2006, AP-42 Chapter 13.2.4 – *Aggregate Handling and Storage Piles*

US-EPA 2013, AERSURFACE User's Guide

Wollongong Coal 2016, *Air Quality & Greenhouse Gas Management Plan*

Abbreviations

AERMOD	AMS/US-EPA regulatory model
AHD	Australian height datum
Approved Methods for Modelling *in New South Wales*	*Approved Methods for the Modelling and Assessment of Air Pollutants*
AQMS	Air quality monitoring station
AWS	Automatic weather station
BAM	Beta attenuation monitor
BoM	Bureau of Meteorology
CO_2-e	Carbon dioxide equivalent
CO	Carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DPIE	Department of Planning and Environment
DoEE	Department of the Environment and Energy
EA	Environmental assessment
EPA	Environment Protection Authority
EPL	Environment protection licence
GHG	Greenhouse gas
HVAS	High volume air sampler
IPC	Independent Planning Commission
JSPL	Jindal Steel and Power Limited
LPG	Liquid petroleum gas
NGAF	National Greenhouse Accounts Factors
NO_x	Oxides of nitrogen
NPI	National Pollution Inventory
NWMD	North West Mains Development
PA	Project approval
PM_{10}	Particulate matter less than 10 microns in aerodynamic diameter
$PM_{2.5}$	Particulate matter less than 2.5 microns in aerodynamic diameter
PRP	Pollution reduction program
ROM	Run-of-mine

SO_2	Sulphur dioxide
TAPM	The Air Pollution Model
The Colliery	Wongawilli Colliery
US-EPA	United States Environmental Protection Agency
VLAMP	Voluntary Land Acquisition and Mitigation Policy
VOC	Volatile organic compounds


Appendix A

Meteorological modelling and processing




A.1 Meteorological monitoring datasets

As discussed in Section 4.1, meteorological datasets were collated from the following monitoring stations:

- WCM meteorological monitoring station;
- NSW DPIE Kembla Grange AQMS, located 5.5 km to the east-northeast of the WCM; and
- BoM Albion Park (Wollongong Airport) AWS, located 9.8 km to the south-southeast of the WCM.

The WCM is the primary resource for meteorological data in this assessment. Data from this station was collected for the period between January 2015 and December 2019. Data availability and analysis of inter-annual trends for this five-year period is presented in the following sections.

A.1.1 Data availability

A summary of data availability from the WCM and Kembla Grange AQMS for the period between 2015 and 2019 is provided in Figure A.1 and Figure A.2 respectively.

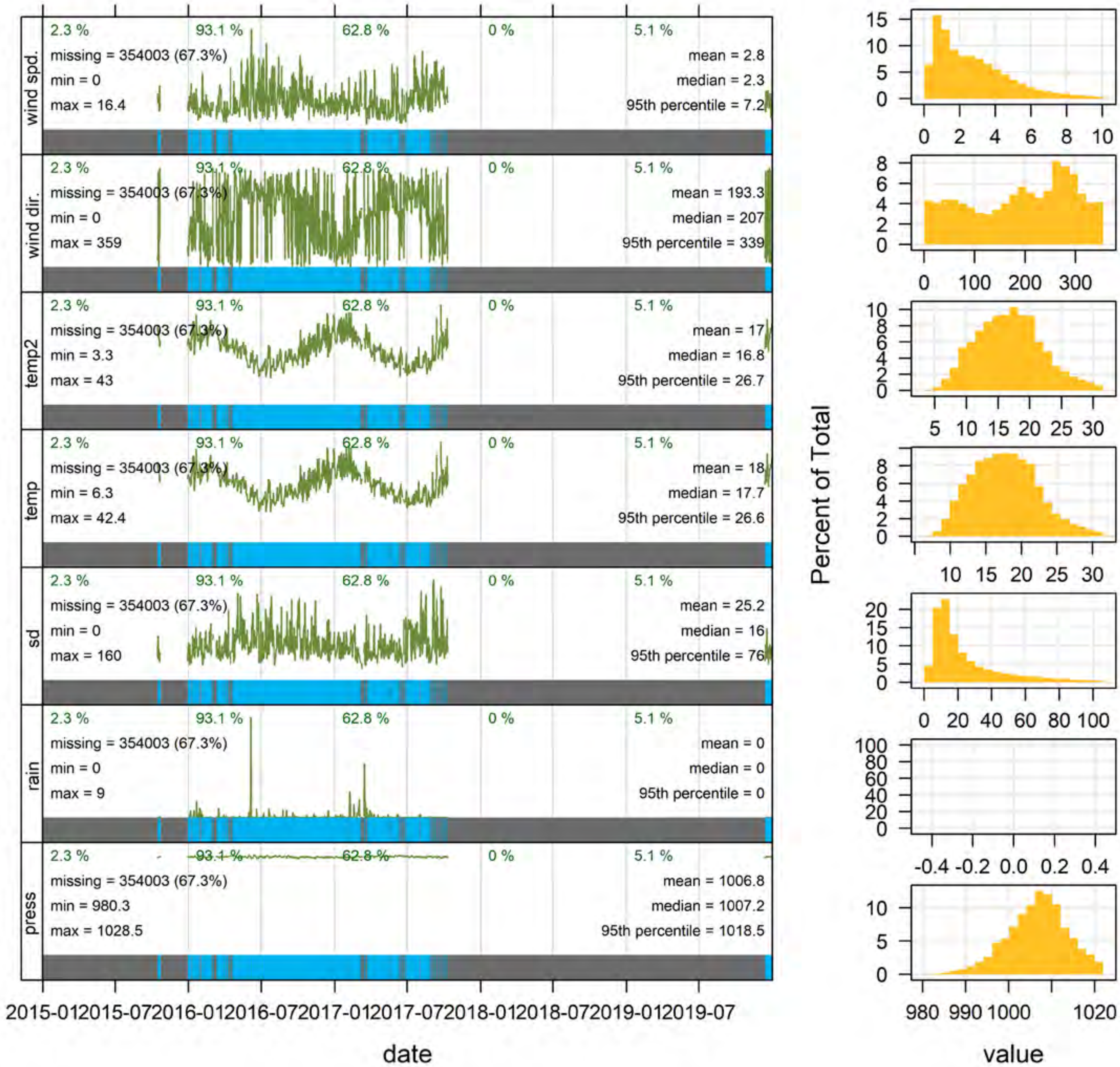


Figure A.1 Five-year data completeness analysis plot – WCM – 2015 to 2019

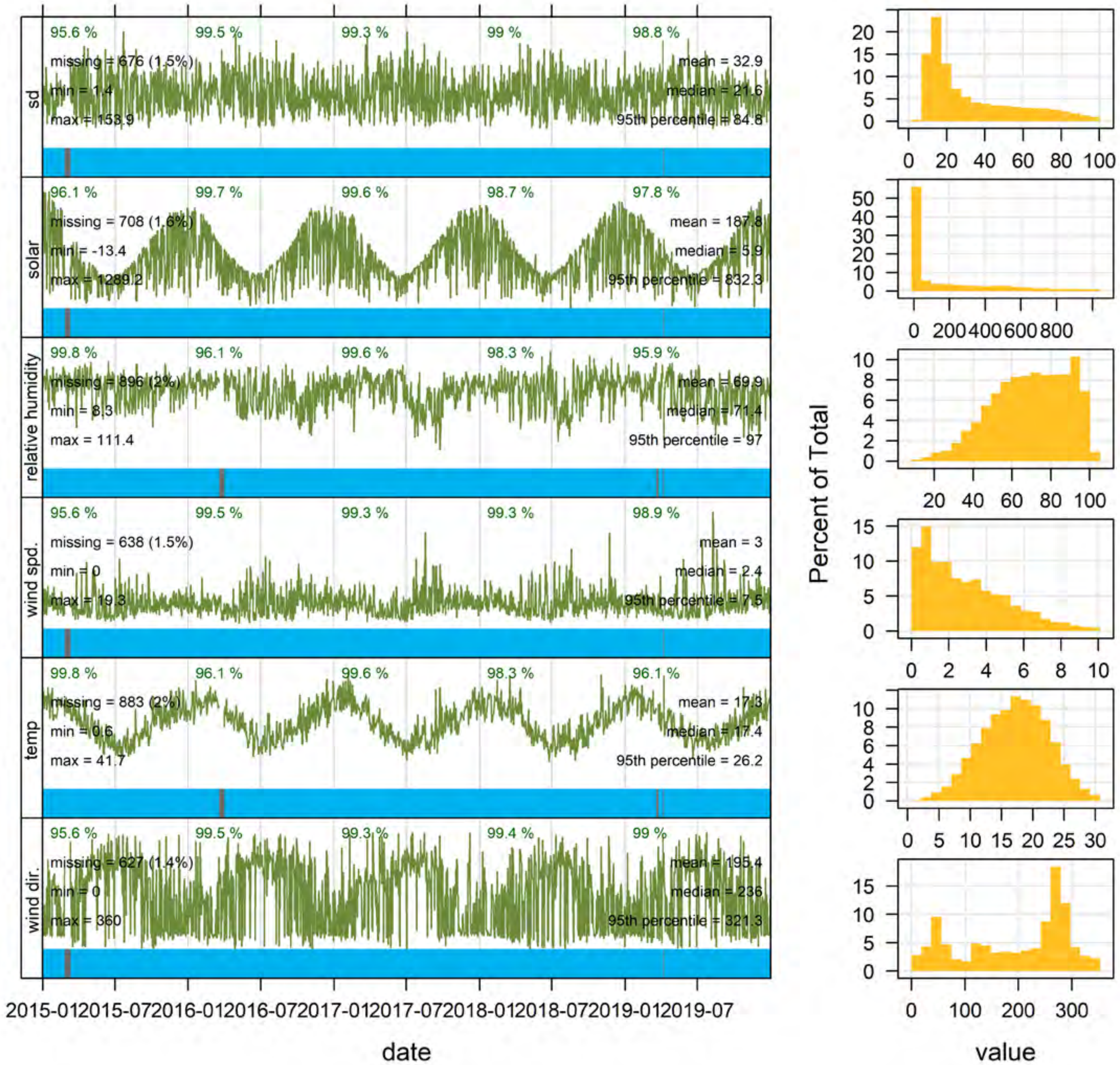


Figure A.2 Five-year data completeness analysis plot – DPIE Kembla Grange AQMS – 2015 to 2019

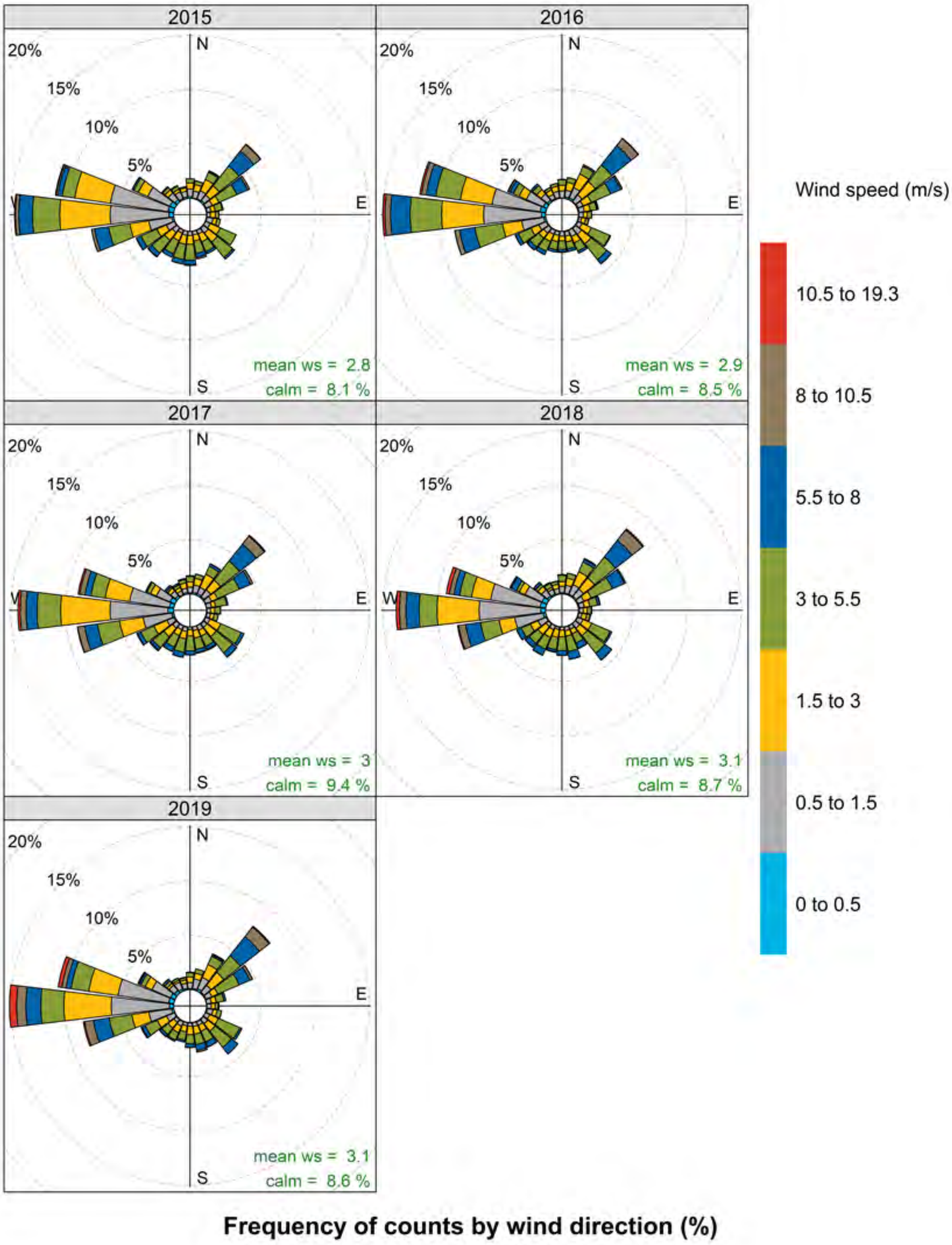


Figure A.3 Inter-annual wind roses – DPIE Kembla Grange AQMS – 2015 to 2019

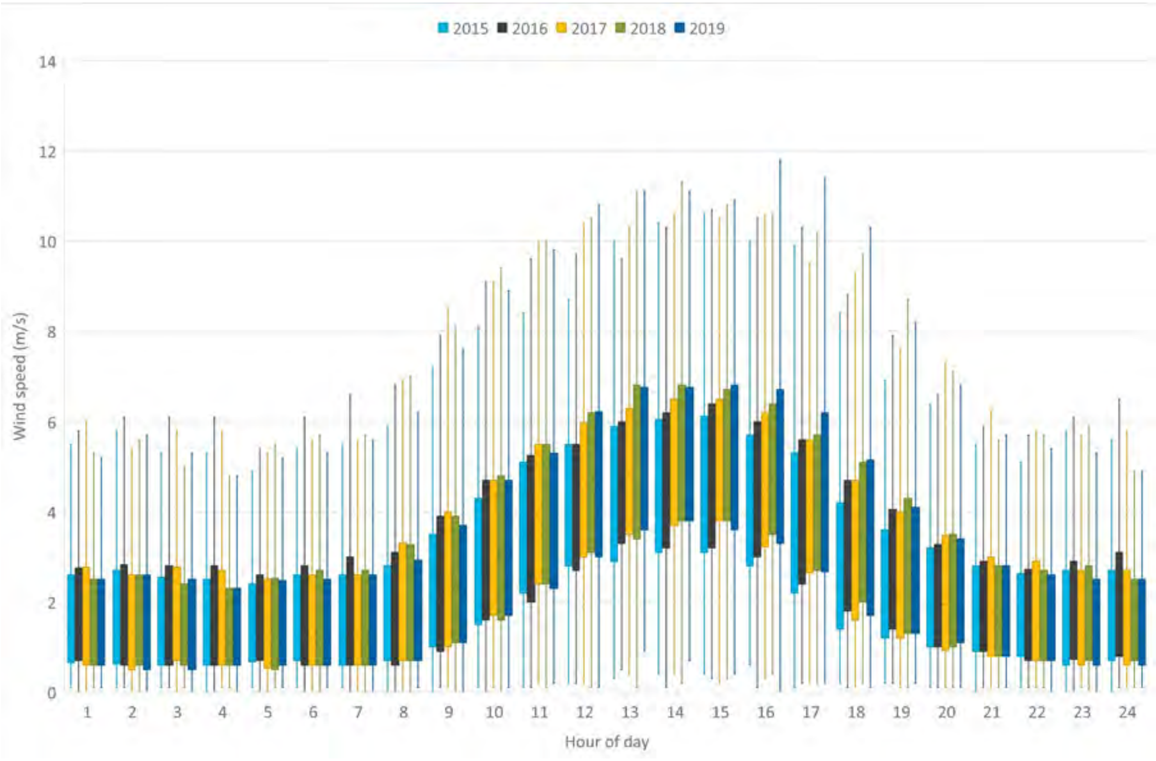


Figure A.4 Inter-annual variability in diurnal wind speed – DPIE Kembla Grange – 2015 to 2019

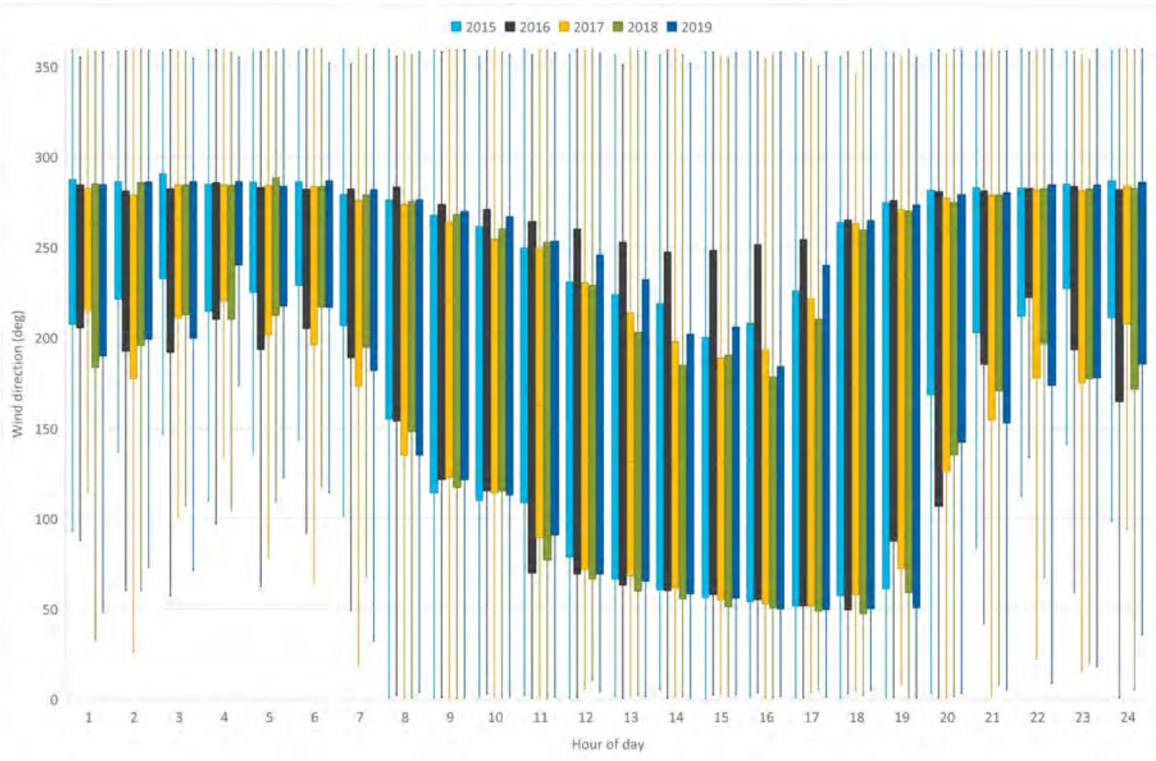


Figure A.5 Inter-annual variability in diurnal wind direction – DPIE Kembla Grange – 2015 to 2019

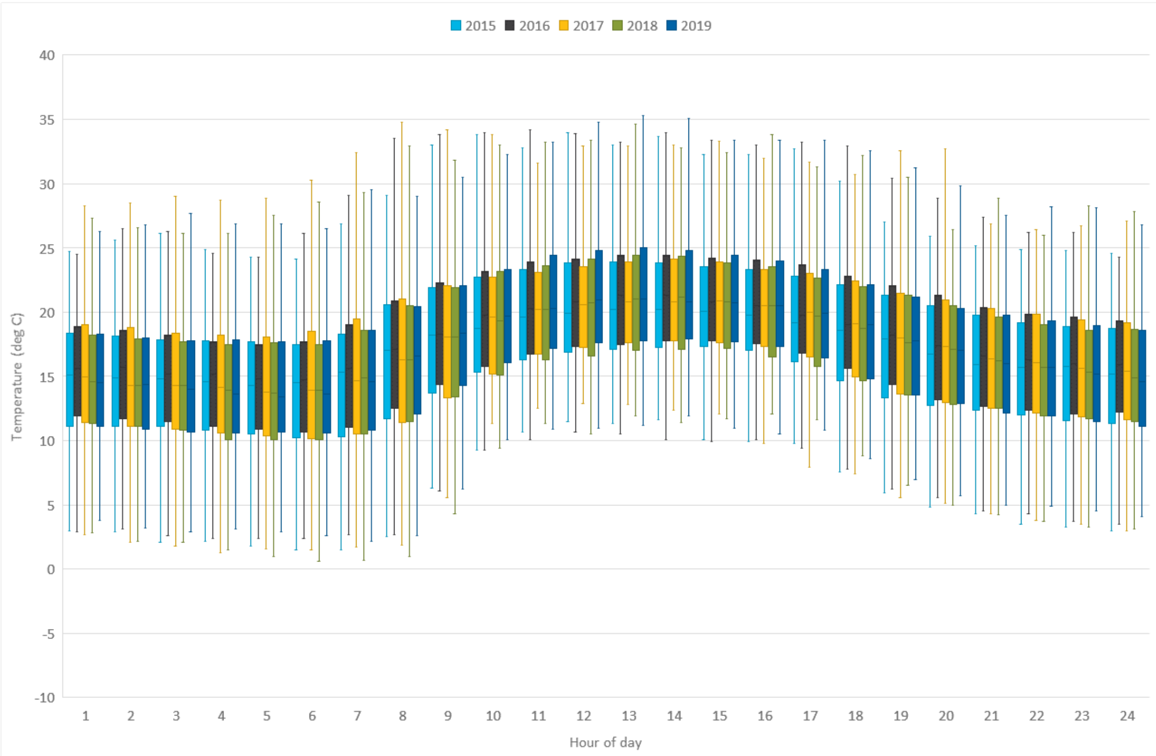


Figure A.6 Inter-annual variability in diurnal air temperature – DPIE Kembla Grange – 2015 to 2019

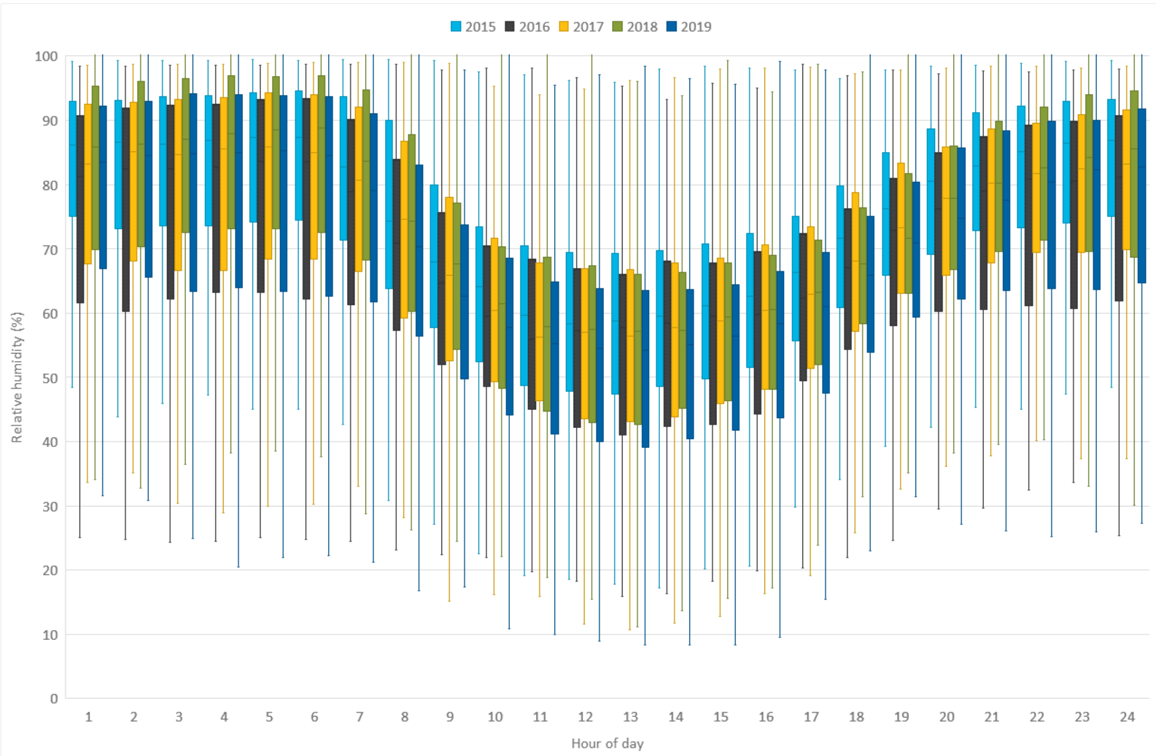


Figure A.7 Inter-annual variability in diurnal relative humidity – DPIE Kembla Grange – 2015 to 2019

A.2 TAPM modelling

To supplement the meteorological monitoring datasets adopted for this assessment, the Commonwealth Scientific and Industry Research Organisation (CSIRO) prognostic meteorological model The Air Pollution Model (TAPM) was used to generate required parameters that are not routinely measured, specifically mixing height and vertical wind/temperature profile.

TAPM was configured and run in accordance with the Section 4.5 of the Approved Methods for Modelling as follows:

- TAPM version 4.0.5;
- inclusion of high resolution (90 m) regional topography (improvement over default 250 m resolution data);
- Grid domains with cell resolutions of 30 km, 10 km, 3 km, 1 km and 0.3 km. Each grid domain features 25 x 25 horizontal grid points and 25 vertical levels;
- TAPM default databases for land use, synoptic analyses and sea surface temperature; and
- TAPM defaults for advanced meteorological inputs.

A.3 AERMET meteorological processing

The meteorological inputs for AERMOD were generated using the AERMET meteorological processor. The following sections provide an overview of meteorological processing completed for this assessment.

A.3.1 Surface characteristics

Prior to processing meteorological data, the surface characteristics of the area surrounding the adopted monitoring station require parameterisation. The following surface parameters are required by AERMET:

- surface roughness length;
- albedo; and
- Bowen ratio.

As detailed by USEPA (2013), the surface roughness length is related to the height of obstacles to the wind flow (eg vegetation, built environment) 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.

The land cover of the 10 km by 10 km area surrounding the on-site meteorological station was mapped (see Figure A.8). Using the AERSURFACE tool and following the associated guidance of USEPA (2013), surface roughness was determined for 12 (30 degree) sectors grouped by similar land use types within a 1 km radius around the on-site meteorological station, while the Bowen ratio and albedo were determined for the total 10 km by 10 km area. Monthly-varying values for surface roughness, Bowen ratio and albedo were allocated to each sector based on the values prescribed by USEPA (2013), as specified in Table A.1 and Table A.2. The following profiles were applied to individual months:

- Midsummer – January, February, December;
- Autumn – March, April, May;
- Late autumn / winter without snow – June, July, August; and
- Transitional spring – September, October, November.

The surface moisture characteristics for the 2016-2017 modelling period was determined by comparing the period rainfall total to the previous 30-year rainfall records from the BoM Berkeley (Northcliffe Drive) long term rainfall station. Annual rainfall for 2016-2017 modelling period was 259 mm, which places the 12-month period in the upper 70^{th}-percentile for the previous 30 years, and therefore a 'wet' surface moisture classification was allocated. It is noted that the rainfall records are not incorporated into dispersion model predictions (ie no wet deposition is modelled).

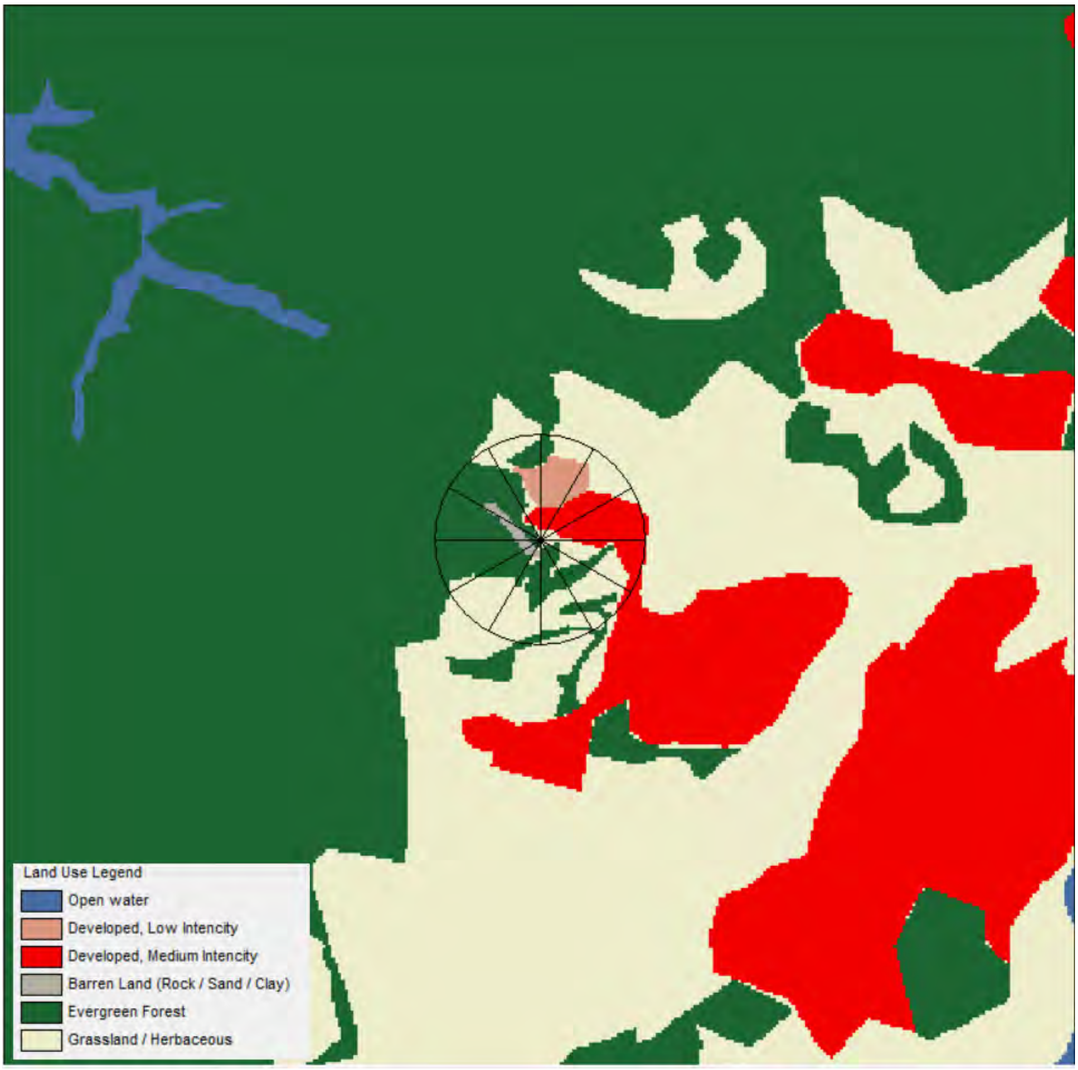


Figure A.8 Land use map for AERSURFACE processing – WCM

Note: Marked in figure are the 1 km radius for surface roughness (12 sectors defined) and 10 km x 10 km for albedo/bowen ratio (total image shown)

Table A.1 Monthly surface roughness length values by sector

Month	Surface roughness length (m) by sector (degrees)											
	0-30	30-60	60-90	90-120	120-150	150-180	180-210	210-240	240-270	270-300	300-330	330-0
Jan	0.147	0.168	0.221	0.202	0.347	0.418	0.254	0.247	0.845	0.725	0.782	0.294
Feb	0.147	0.168	0.221	0.202	0.347	0.418	0.254	0.247	0.845	0.725	0.782	0.294
Mar	0.141	0.165	0.221	0.202	0.347	0.418	0.254	0.247	0.845	0.725	0.782	0.289
Apr	0.141	0.165	0.221	0.202	0.347	0.418	0.254	0.247	0.845	0.725	0.782	0.289
May	0.141	0.165	0.221	0.202	0.347	0.418	0.254	0.247	0.845	0.725	0.782	0.289
Jun	0.038	0.04	0.072	0.032	0.077	0.117	0.045	0.045	0.633	0.544	0.528	0.091
Jul	0.038	0.04	0.072	0.032	0.077	0.117	0.045	0.045	0.633	0.544	0.528	0.091
Aug	0.038	0.04	0.072	0.032	0.077	0.117	0.045	0.045	0.633	0.544	0.528	0.091
Sep	0.112	0.127	0.183	0.135	0.245	0.314	0.175	0.174	0.819	0.725	0.738	0.229
Oct	0.112	0.127	0.183	0.135	0.245	0.314	0.175	0.174	0.819	0.725	0.738	0.229
Nov	0.112	0.127	0.183	0.135	0.245	0.314	0.175	0.174	0.819	0.725	0.738	0.229
Dec	0.147	0.168	0.221	0.202	0.347	0.418	0.254	0.247	0.845	0.725	0.782	0.294

Table A.2 Monthly Bowen ratio and albedo values (all sectors)

Month	Monthly value (all sectors)	
	Bowen ratio	Albedo
January	0.29	0.14
February	0.29	0.14
March	0.39	0.14
April	0.39	0.14
May	0.39	0.14
June	0.49	0.41
July	0.49	0.41
August	0.49	0.41
September	0.34	0.14
October	0.34	0.14
November	0.34	0.14
December	0.29	0.14

A.3.2 Meteorological inputs

Monitoring data from the WCM, DPIE Kembla Grange AQMS and BoM Albion Park (Wollongong Airport) AWS were combined with TAPM meteorological modelling outputs for input to AERMET. Data gaps in the WWC 2016-2017 meteorological were filled through a combination of interpolation and substitution.

The following parameters were input as on-site data to AERMET:

- wind speed and direction – WCM;
- sigma-theta (standard deviation of wind direction) - WCM;
- temperature (heights of 2 m and 10 m) - WCM;
- relative humidity - WCM;
- station level pressure – WCM;
- cloud cover - BoM Albion Park (Wollongong Airport);
- solar radiation – DPIE Kembla Grange; and
- mixing depth – TAPM at WCM.

The period of meteorological data input to AERMET was 1 May 2016 to 31 April 2017.

A.3.3 Upper air profile

Due to the absence of necessary local upper air meteorological measurements, the hourly profile file generated by TAPM at the WCM location was adopted. Using the temperature difference between levels, the TAPM-generated vertical temperature profile for each hour was adjusted relative to the hourly surface (10m) temperature observations from the WCM.


Appendix B

Emissions inventory background




B.1 Introduction

Air emission sources associated with the Colliery were identified and quantified through the application of accepted published emission estimation factors, collated from a combination of US-EPA AP-42 Air Pollutant Emission Factors and NPI emission estimation manuals.

Particulate matter emissions were quantified for various particle size fractions. The dispersion of TSP emissions was simulated to predict dust deposition rates. Coarse and fine particulate matter (PM_{10} and $PM_{2.5}$) were estimated using ratios for the different particle size fractions available within the literature (principally the US-EPA AP-42), as documented in subsequent sections.

B.2 Emissions inventory assumptions

Material parameters adopted within the emissions inventory are presented in Table B.1.

Table B.1 Assumed material parameters

Material	Parameter	Value	Source
ROM coal	Moisture content	12%	Wollongong Coal provided data
	Silt content	10%	

B.3 Locomotive emissions

The following assumptions were applied in the calculation of locomotive engine emissions at the Colliery during rail loading operations:

- two trains per day;
- two locomotive engines per train (5000 class C40aci with maximum power of 3,100 kW);
- four hours of loading time per train, with locomotives assumed to be in idling notch setting for the duration, equating to 16 hours of total locomotive idling per day;
- idling notch setting assumed to be 1% of maximum power rating (Graver and Frey 2012, Kim et al 2020), equating to a power of 31 kW;
- annual locomotive power is therefore 181,040 kWh;
- PM emission factor (0.517 g/kWh) taken from NSW EPA commissioned study, *Diesel Locomotive Emissions Upgrade Kit Demonstration Project - Fuel Efficiency, Emissions & Noise Testing* (ABMARC 2015), with Tier 0+ emission factors for a 90 class locomotive; and
- PM emission factor applied to TSP and PM_{10} emission calculations, with $PM_{2.5}$ emissions derived from the $PM_{2.5}$:PM_{10} relationship (96% of PM_{10}) from Table 7 of NPI 2008.

B.4 Site surface diesel combustion emissions

Annual projections of diesel consumption were sourced from Wollongong Coal, with the following assumptions applied:

- annual diesel consumption for NWMD operations at the Colliery will be in the order of 50,000 L per year;
- 95% of diesel is consumed underground, while the remaining 5% is consumed by the FEL and bulldozer at the surface;
- the corresponding USEPA (USEPA 2016) Tier 2 emission standards for PM of 0.2 g/kWh were selected;
- the g/kWh emission standard was converted to g per litre of diesel by applying a scaling factor of 3, as per the notes for Table 35 in *NPI Emission Estimation Technique Manual for Combustion Engines* (NPI 2008); and
- the PM emission standard is assumed to correspond to PM_{10}, with $PM_{2.5}$ emissions derived from the relationship between PM_{10} and $PM_{2.5}$ emission factors presented in Table 35 in NPI, 2008 (91.7%).

B.5 Ventilation shaft emissions

Site specific emissions monitoring was not available for the Wongawilli Shaft 1 for use in this AQIA. The emission concentration from the nearby Dendrobium Mine (1.6 mg/m^3) published in the recent air quality assessment for that site (Ramboll 2019) was adopted to represent emissions from the Wongawilli Shaft 1. This emission factor was adopted for TSP, PM_{10} and $PM_{2.5}$ emission quantification. Based on ventilation flow measurements at the Colliery, the typical ventilation rate is in the order of 130 m^3/s.

B.6 Emissions inventory table

A summary of the emissions inventory is presented in Table B.2.

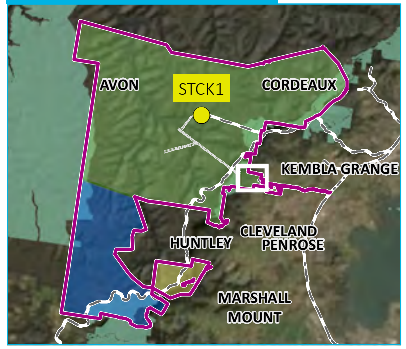
Table B.2 Emissions inventory – Colliery 2 Mtpa operations

Source name	Emission estimate TSP (kg/year)	Emission estimate PM_{10} (kg/year)	Emission estimate $PM_{2.5}$ (kg/year)	Activity rate	Units	TSP emission factor	PM_{10} emission factor	$PM_{2.5}$ emission factor	Unit	Parameter 1	Unit	Parameter 2	Unit	Parameter 3	Unit	Reduction factor	Emission control	Emission factor source
Conveyor transfer point - NW Mains portal to new transfer bin	41.2	19.5	2.9	2,000,000	t/year	0.0001	0.0001	0.00001	kg/t	2.89	Average wind speed (m/s)	12	Moisture content (%)			0.85	Enclosure and water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Conveyor transfer point - new transfer bin to pit top conveyor	41.2	19.5	2.9	2,000,000	t/year	0.0001	0.0001	0.00001	kg/t	2.89	Average wind speed (m/s)	12	Moisture content (%)			0.85	Enclosure and water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Conveyor transfer point - pit top conveyor to transfer house/decline belt	41.2	19.5	2.9	2,000,000	t/year	0.0001	0.0001	0.00001	kg/t	2.89	Average wind speed (m/s)	12	Moisture content (%)			0.85	Enclosure and water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Conveyor transfer point - decline belt to sizing station	41.2	19.5	2.9	2,000,000	t/year	0.0001	0.0001	0.00001	kg/t	2.89	Average wind speed (m/s)	12	Moisture content (%)			0.85	Enclosure and water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Coal sizing	324.0	144.0	26.7	2,000,000	t/year	0.0027	0.00120	0.00022	kg/t							0.94	Enclosure and chemical wetting agent	USEPA AP-42 11.19.2-1 - Tertiary crushing
Conveyor transfer point - coal sizer to elevator tower	41.2	19.5	2.9	2,000,000	t/year	0.0001	0.0001	0.00001	kg/t	2.89	Average wind speed (m/s)	12	Moisture content (%)			0.85	Enclosure and water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Conveyor transfer point - elevator tower to rail loading bins	41.2	19.5	2.9	2,000,000	t/year	0.0001	0.0001	0.00001	kg/t	2.89	Average wind speed (m/s)	12	Moisture content (%)			0.85	Enclosure and water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Conveyor transfer point - elevator tower to rill towers	4.1	1.9	0.3	200,000	t/year	0.0001	0.0001	0.00001	kg/t	2.89	Average wind speed (m/s)	12	Moisture content (%)			0.85	Enclosure and water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Conveyor transfer point - Rail wagon loading	13.7	6.5	1.0	200,000	t/year	0.0001	0.0001	0.00001	kg/t	2.89	Average wind speed (m/s)	12	Moisture content (%)			0.5	Residual chemical dust suppressant and wetting from conveyor system	USEPA AP-42 13.2.4 - Materials handling equation
Conveyor transfer point - rill tower to stockpile	13.7	6.5	1.0	200,000	t/year	0.0001	0.0001	0.00001	kg/t	2.89	Average wind speed (m/s)	12	Moisture content (%)			0.5	Residual chemical dust suppressant and wetting from conveyor system	USEPA AP-42 13.2.4 - Materials handling equation

Table B.2 Emissions inventory – Colliery 2 Mtpa operations

Source name	Emission estimate TSP (kg/year)	Emission estimate PM_{10} (kg/year)	Emission estimate $PM_{2.5}$ (kg/year)	Activity rate	Units	TSP emission factor	PM_{10} emission factor	$PM_{2.5}$ emission factor	Unit	Parameter 1	Unit	Parameter 2	Unit	Parameter 3	Unit	Reduction factor	Emission control	Emission factor source
FELs loading coal to rail wagons (stockpile handle and wagon loading)	5,880.9	955.2	111.7	200,000	t/year	0.0294	0.0048	0.00056	kg/t			12	Moisture content (%)			0.5	Residual chemical dust suppressant and wetting from conveyor system/spray system	USEPA AP-42 13.2.4 - Materials handling equation
Dozer on ROM stockpile	2,088.3	1,155.7	91.9	187	hr/year	22.3	6.2	0.5	kg/h	10	Silt content (%)	12	Moisture content (%)			0.5	Travel routes kept moist	USEPA AP-42 11.9.2 - Dozers on coal
Wind erosion of ROM stockpile	724.4	362.2	54.3	1.72	Area (ha)	4,222	2,111	317	kg/ha/year	10	Silt content (%)	79	Rainfall days	11.3	Winds >5.4m/s	0.9	Water sprays and chemical suppression	NPI Mining Active Stockpile equation
Wind erosion of Timber yard/Flat top	511.1	255.5	38.3	0.60	Area (ha)	850	425	64	kg/ha/year	2.89	Average wind speed (m/s)	12	Moisture content (%)					
Upcast vent shaft	109.6	109.6	109.6							2.89	Average wind speed (m/s)	12	Moisture content (%)					
Site diesel combustion	1.5	1.5	1.4							2.89	Average wind speed (m/s)	12	Moisture content (%)					
Diesel locomotive emissions	93.6	93.6	89.9							2.89	Average wind speed (m/s)	12	Moisture content (%)					

PROJECT APPLICATION AREA INSET



KEY

- Project application area
- Sensitive receiver

Emission sources

- Point - refer to inset
- Volume
- Line volume
- Area

Portal locations

- Approved NWMD portal
- Additional NWMD access portal

Site infrastructure

- Underground workings
- Site layout

Exitisting environment

- Rail line
- Minor road
- Vehicular track
- Watercourse/drainage line
- NPWS reserve
- Underground workings

PROJECT APPLICATION AREA INSET KEY

- Rail line
- NPWS reserve

Mining title

- ML 1565
- ML 1596
- CCL 766

Model source locations

Wollongong Coal Limited
Wongawilli Modification 2 North West Mains
Air quality impact assessment
Figure B.1

Source: EMM (2020); Wollongong Coal Limited (2020); DFSI (2017); GA (2011); ASGC (2006)

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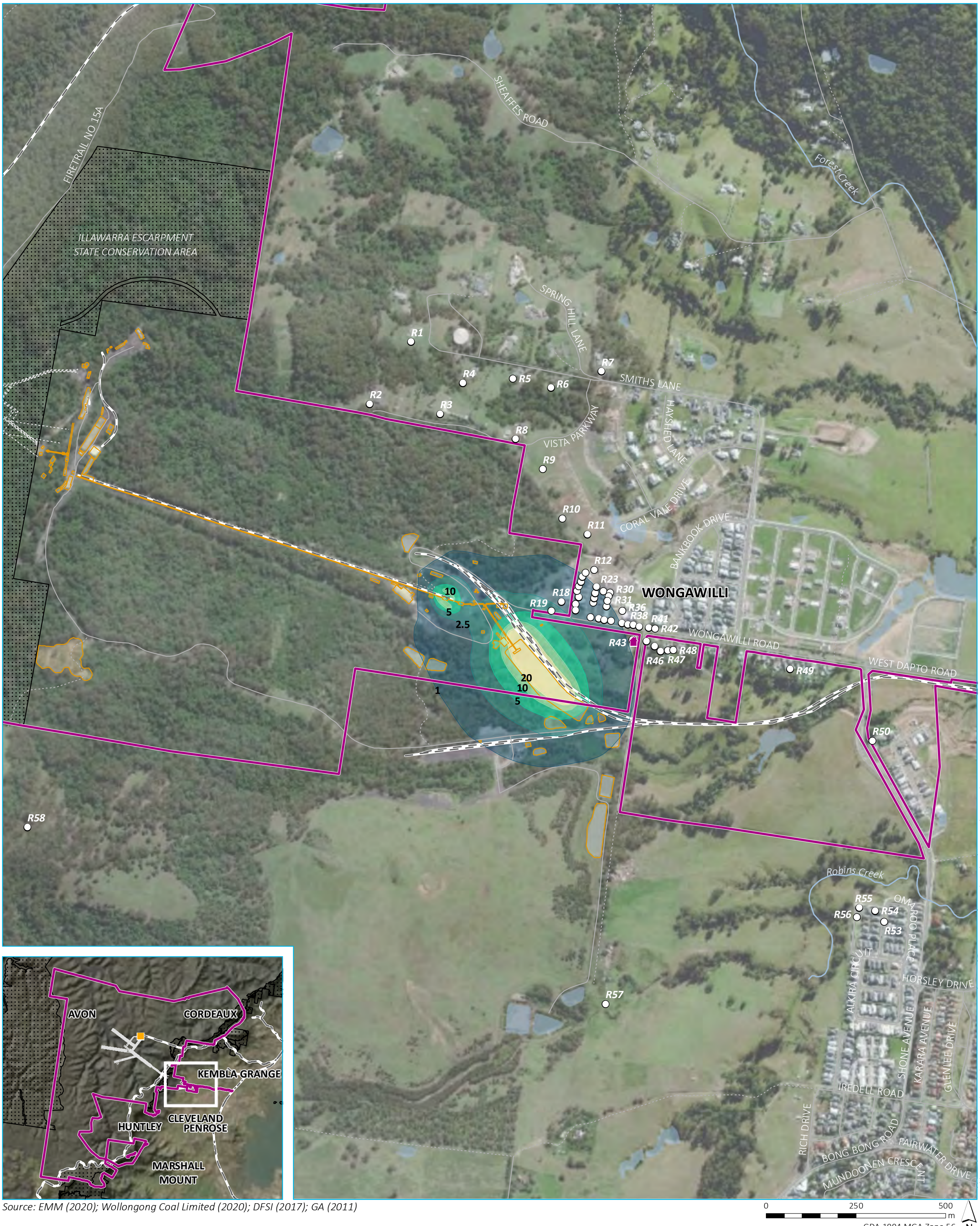
Appendix C

Predicted incremental isopleth plots



Source: EMM (2020); Wollongong Coal Limited (2020); DFSI (2017); GA (2011)

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KEY

Project application area

Sensitive receiver

Mine-owned residence

Site infrastructure

Underground workings

Vent shaft (refer to inset)

Site layout

Existing environment

Rail line

Minor road

Vehicular track

Named watercourse

NPWS reserve

Waterbody

Annual average TSP concentration

1 - 2.5 µg/m³

2.5 - 5 µg/m³

5 - 10 µg/m³

10 - 20 µg/m³

> 20 µg/m³

Predicted annual average TSP concentrations – site only

Wollongong Coal Limited

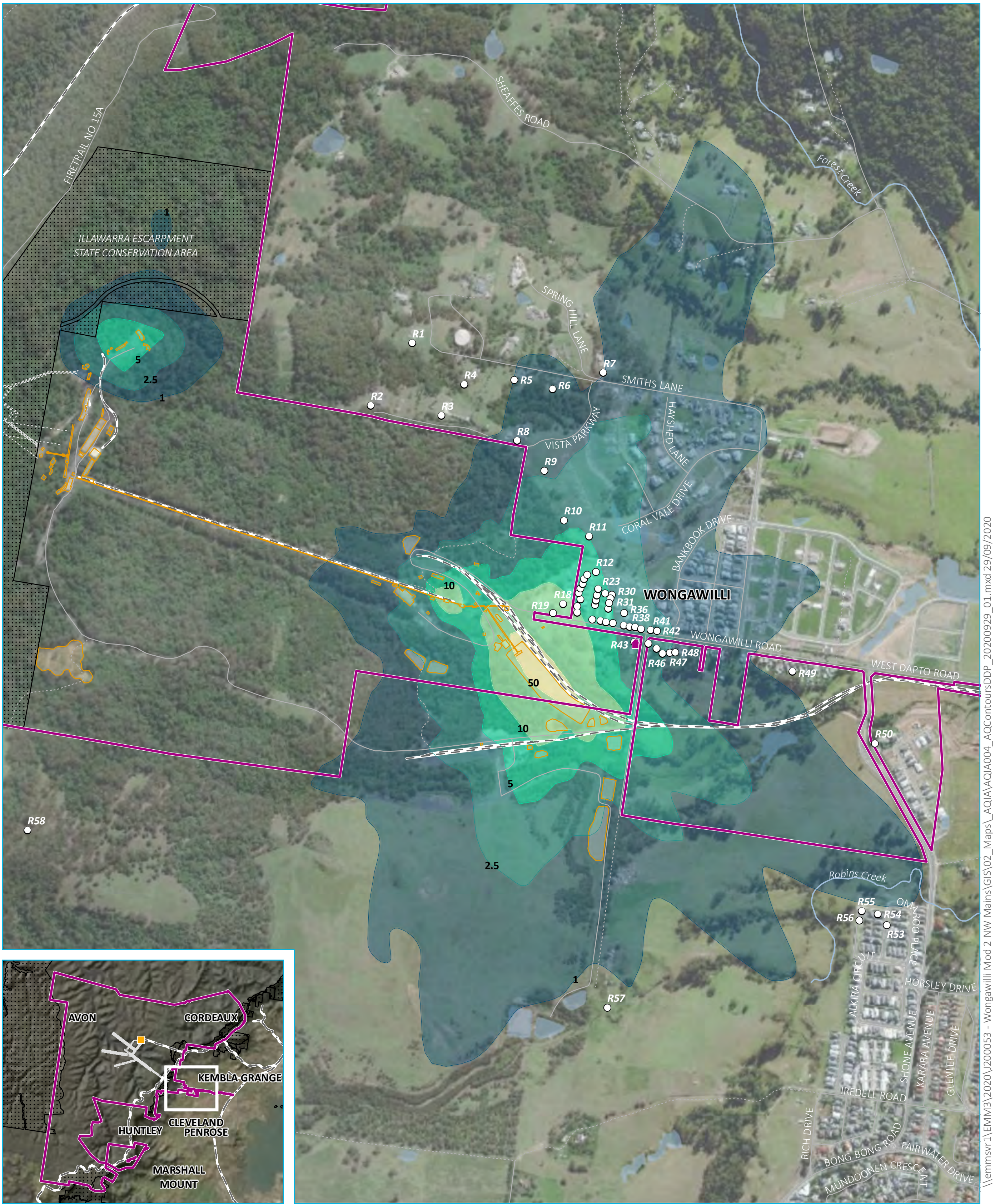
Wongawilli Modification 2 North West Mains

Air quality impact assessment

Figure C.1

EMM

creating opportunities



Source: EMM (2020); Wollongong Coal Limited (2020); DFSI (2017); GA (2011)

KEY

- Project application area
- Sensitive receiver
- Mine-owned residence

Site infrastructure

- Underground workings
- Vent shaft (refer to inset)
- Site layout

Existing environment

- Rail line
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve
- Waterbody

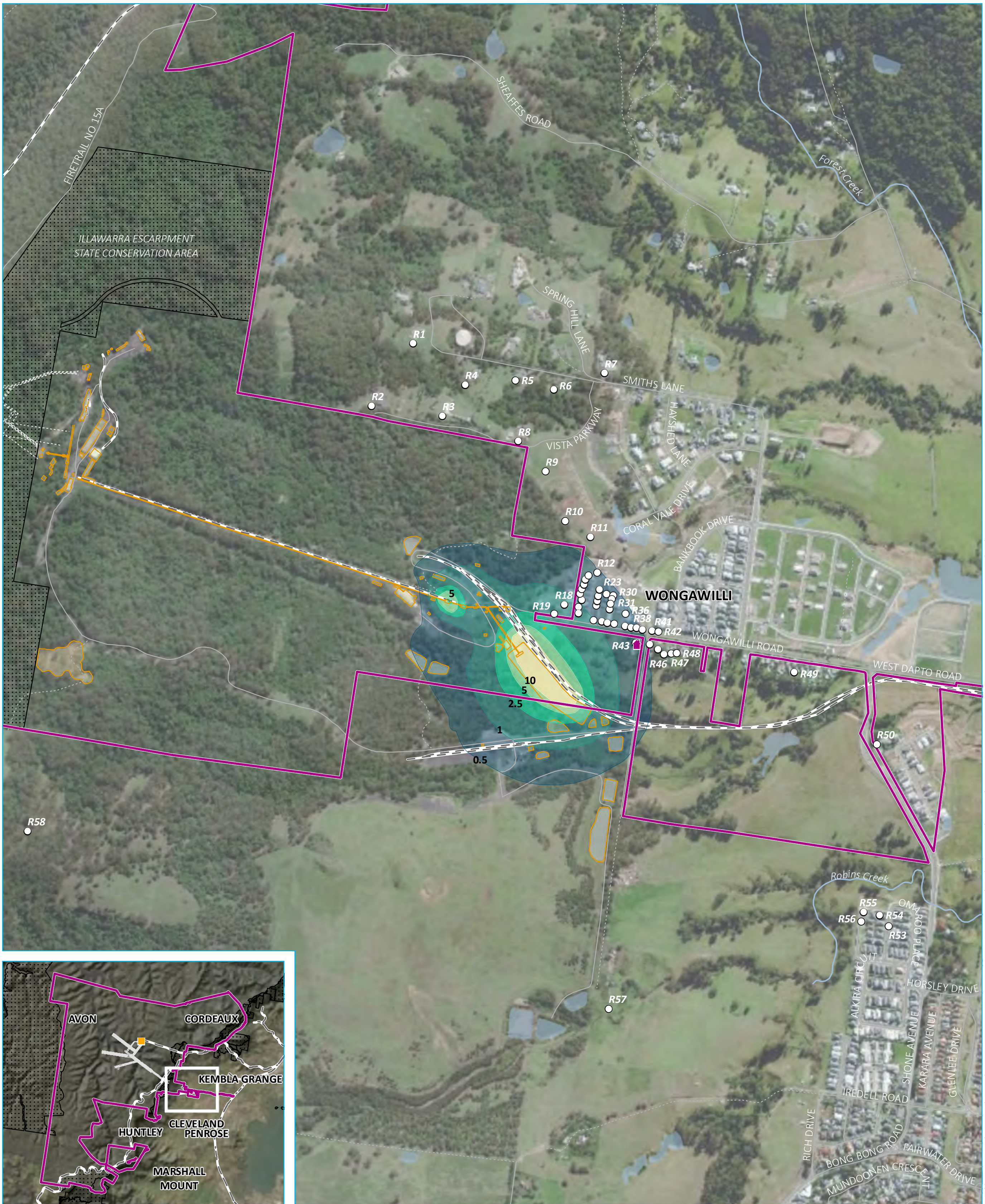
24-hour average PM_{10} concentrations

- 1 - 2.5 µg/m³
- 2.5 - 5 µg/m³
- 5 - 10 µg/m³
- 10 - 50 µg/m³
- > 50 µg/m³

Maximum predicted 24-hour average PM_{10} concentrations – site only

Wollongong Coal Limited
Wongawilli Modification 2 North West Mains
Air quality impact assessment
Figure C.2

EMM creating opportunities



Source: EMM (2020); Wollongong Coal Limited (2020); DFSI (2017); GA (2011)

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KEY

- Project application area
- Sensitive receiver
- Mine-owned residence

Site infrastructure

- Underground workings
- Vent shaft (refer to inset)
- Site layout

Existing environment

- Rail line
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve
- Waterbody

Annual average PM_{10} concentrations

- 0.5 - 1 µg/m³
- 1 - 2.5 µg/m³
- 2.5 - 5 µg/m³
- 5 - 10 µg/m³
- > 10 µg/m³

Predicted annual average PM_{10} concentrations – site only

Wollongong Coal Limited
Wongawilli Modification 2 North West Mains
Air quality impact assessment
Figure C.3

EMM
creating opportunities

Source: EMM (2020); Wollongong Coal Limited (2020); DFSI (2017); GA (2011)

0 250 500 m

GDA 1994 MGA Zone 56

N

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KEY

Project application area

Sensitive receiver

Mine-owned residence

Site infrastructure

Underground workings

Vent shaft (refer to inset)

Site layout

Existing environment

Rail line

Minor road

Vehicular track

Named watercourse

NPWS reserve

Waterbody

24-hour average $PM_{2.5}$ concentrations

0.5 - 1 µg/m³

1 - 2.5 µg/m³

2.5 - 5 µg/m³

5 - 10 µg/m³

> 10 µg/m³

Maximum predicted 24-hour average $PM_{2.5}$ concentrations – site only

Wollongong Coal Limited

Wongawilli Modification 2 North West Mains

Air quality impact assessment

Figure C.4

EMM

creating opportunities

Source: EMM (2020); Wollongong Coal Limited (2020); DFSI (2017); GA (2011)

0 250 500 m
GDA 1994 MGA Zone 56 N

KEY

- Project application area
- Sensitive receiver
- Mine-owned residence

Site infrastructure

- Underground workings
- Vent shaft (refer to inset)
- Site layout

Existing environment

- Rail line
- Minor road
- Vehicular track
- Named watercourse
- NPWS reserve
- Waterbody

Annual average $PM_{2.5}$ concentrations

- 0.5 - 1 µg/m³
- 1 - 2 µg/m³
- > 2 µg/m³

Predicted annual average $PM_{2.5}$ concentrations – site only

Wollongong Coal Limited
Wongawilli Modification 2 North West Mains
Air quality impact assessment
Figure C.5

EMM creating opportunities

Source: EMM (2020); Wollongong Coal Limited (2020); DFSI (2017); GA (2011)

0 250 500 m
GDA 1994 MGA Zone 56

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KEY

Project application area
Sensitive receiver
Mine-owned residence

Site infrastructure
Underground workings
Vent shaft (refer to inset)
Site layout

Existing environment
Rail line
Minor road
Vehicular track
Named watercourse
NPWS reserve
Waterbody

Average dust deposition levels
0.1 - 0.5 g/m²/month
0.5 - 1 g/m²/month
1 - 2 g/m²/month
2 - 4 g/m²/month
> 4 g/m²/month
2 g/m²/month (incremental VLAMP mitigation criteria)

Predicted annual average dust deposition levels – site only

Wollongong Coal Limited
Wongawilli Modification 2 North West Mains
Air quality impact assessment
Figure C.6

EMM
creating opportunities


Appendix D

Greenhouse gas emission calculation data




D.1 Diesel consumption

GHG emissions from diesel consumption were estimated using the following equation:

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

Where:

E_{ij}	=	Emissions of GHG from diesel combustion	(t CO_2-e)
Q_i	=	Quantity of fuel	(kL)
EC_i	=	Energy content of fuel	(GJ/kL)[9]
EF_{ijoxec}	=	Emission factor (scope 1 or 3) for diesel consumption	(kg CO_2-e/GJ)[10]

GHG emission factors and energy content for diesel were sourced from the NGAF (DoEE 2020). These are presented in Table D.1. The quantity of diesel used is listed in Table D.2.

The estimated annual GHG emissions from diesel consumption are presented in Table D.2.

Table D.1 Diesel GHG emission factors

Fuel type	Energy content (GJ/kL)	Scope 1 Emission Factors (kg CO_2-e/GJ)			Scope 3 Emission Factor (kg CO_2-e/GJ)
		CO_2	CH_4	N_2O	CO_2
Transport energy	38.6	69.9	0.1	0.4	3.6

Table D.2 Estimated CO_2-e (tonnes) for diesel consumption per year

Diesel use (L/annum)	Emissions (t CO_2-e)		Total
	Scope 1	Scope 3	
50,000	136	7	143

9 GJ = gigajoules

10 kg CO_2-e/GJ = kilograms of carbon dioxide equivalents per gigajoule

D.2 Post-mining activities

Emissions for scope 1 post-mining activities were calculated using the 'post mining activities associated with gassy underground mines' per the NGAF. The NGAF provides a CH_4 emission factor of 0.019 tonnes CO_2-e/tonne of ROM coal.

Annual ROM coal extraction is 2 Mtpa, while Wollongong Coal estimate that only 10% of extracted material would be stored in the ROM coal stockpile during a 12-month period. The estimated annual GHG emissions from post mining activities are presented in Table D.3.

Table D.3 Estimated CO_2-e (tonnes) for post-mining activities

ROM coal stockpiled (t/annum)	Scope 1 emissions (t CO_2-e)
200,000	3,800

D.3 Fugitive emissions from mine ventilation air

Annual GHG emissions from the *National Greenhouse and Energy Reporting (NGER) Section 19 - Energy And Emissions Report for Wollongong Coal Limited for the reporting year 2018 – 2019* were reviewed. It is understood that this report has been audited and accepted by the Clean Energy Regulator.

From this report, Wollongong Coal reported the following under fugitive emissions from mine ventilation air:

- 250,441 t of ROM coal extracted by the Colliery; and
- 44,799 t of CO_2-e released via mine ventilation air based on ventilation monitoring data.

When combined, these two totals equate to a fugitive emission factor of 0.179 t CO_2-e/t ROM coal. In order to estimate fugitive emissions arising from 2 Mtpa operations, this derived site specific factor based on NGERs reporting data has been adopted in this GHG assessment.

The estimated annual GHG emissions from mine ventilation air are presented in Table D.4.

Table D.4 Estimated CO_2-e (tonnes) for mine ventilation air

Annual ROM coal (t)	Scope 1 emissions (t CO_2-e)
2,000,000	357,761

D.4 Electricity use

GHG emissions associated with electricity consumption were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

Where:

$E_{CO2\text{-}e}$	=	Emissions of GHG from electricity consumption	(t CO_2-e)
Q_i	=	Quantity of electricity	(MWh)[11]
EF	=	Emission factor (scope 2 or 3) for electricity consumption	(kg CO_2-e/kWh)[12]

GHG emission factors for electricity use were sourced from the NGAF (DoEE 2020). These are presented in Table D.5. The estimated GHG emissions from electricity consumption are presented in Table D.6.

Table D.5 Electricity GHG emission factors

Use	Emission Factors (kg CO_2-e/kWh)	
	Scope 2	**Scope 3**
Electricity	0.81	0.09

Table D.6 Estimated CO_2-e (tonnes) for electricity consumption

Electricity use (MWh)	Emissions (t CO_2-e)	
	Scope 2	**Scope 3**
27,196	22,029	2,448

11 kWh = kilowatt hours

12 kg CO_2-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour

D.5 Energy production from product coal (end use)

GHG emissions associated with energy production from product coal were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EC \times EF}{1000}$$

Where:

E_{CO2-e}	=	Emissions of GHG from electricity consumption	(t CO_2-e)
Q	=	Quantity of coal burnt	(t)
EC	=	Energy Content Factor for bituminous coal	(GJ/t)
EF	=	Emission factor for bituminous coal combustion	(kg CO_2-e/GJ)

GHG emission factors for fuel combustion were sourced from the NGAF (DoEE 2020). These are presented in Table D.7. The scope 1 emission factors for coking coal were used to calculate the scope 3 emissions from the burning of ROM coal by end users per Appendix 4 of the NGAF.

The estimated annual GHG emissions from product coal use are presented in Table D.8

Table D.7 Fuel combustion GHG emission factors

Fuel type	Energy content (GJ/t)	Scope 1 Emission Factors (kg CO_2-e/GJ)		
		CO_2	CH_4	N_2O
Coking coal	30	91.8	0.03	0.2

Table D.8 Estimated CO_2-e (tonnes) for energy production from product coal

Product coal (t/annum)	Emissions (t CO_2-e)
	Scope 3
2,000,000	5,521,800

D.6 Transport of product coal

GHG emissions associated with the transport of product coal via rail and ship were estimated using the following equation:

$$E_{CO_2-e} = \frac{D \times Q \times EF}{1000}$$

Where:

$E_{CO2\text{-}e}$	=	Emissions of GHG from rail/shipping transport	(t CO_2-e)
D	=	Average distance travelled by rail/ship	(km)
Q	=	Quantity of coal transported	(t)
EF	=	Emission factor for rail/ship freight movement	(g CO_2/tonne-km)

GHG emission factors for rail and ship transport are not available in the NGAF. Therefore, these emission factors were sourced from various greenhouse gas assessments for coal mines. These assessments adopted the emission factors from AGO 2007 which are presented in Table D.9 below. The quantity of coal transported, and average distances travelled by rail and ship are listed in Table D.10.

The estimated annual GHG emissions from transport of product coal are presented in Table D.10.

Table D.9 Rail and ship GHG emission factors

Use	Emission Factors (kg CO_2-e/tonne-km)
	Scope 3
Rail	0.0054
Ship	0.0126

Table D.10 Estimated CO_2-e (tonnes) for transport of product coal

Transport type	Product coal (t/annum)	Travel distance (return) (km)	Scope 3 emissions (t CO_2-e)
Rail	2,000,000	30	6,426
Ship	2,000,000	24,000	2,016,000