APPENDIX I

Air Quality and Greenhouse Gas Assessment

Intended for
Illawarra Coal Holdings Pty (Illawarra Metallurgical Coal [IMC])

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DENDROBIUM MINE EXTENSION PROJECT

AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

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EXECUTIVE SUMMARY

Illawarra Coal Holdings Pty Ltd (Illawarra Metallurgical Coal [IMC]), a wholly owned subsidiary of South32 Limited (South32), is the owner and operator of the Dendrobium Mine. The Dendrobium Mine, Appin Mine and supporting operations are managed by Illawarra Metallurgical Coal (IMC). IMC is seeking approval[1] for the Dendrobium Mine Extension Project (the Project), which would support the extraction of approximately 31 million tonnes (Mt) of ROM coal from Area 5, within CCL 768. The life of the Project includes longwall mining in Area 5 up to approximately 31 December 2034, and ongoing use of existing surface facilities for handling of Area 3C ROM coal until 2041.

Ramboll was commissioned to complete an AQA for the Project. The Project seeks to gain access to one new underground mining area, Area 5, and to extend the life of approved surface operations to approximately 2041. The Project also includes the continued use of existing surface infrastructure (for the extended mine life) as well as additional ventilation and gas management infrastructure.

Air quality impacts are assessed using a Level 2 assessment approach in accordance with the NSW Approved Modelling Methods. Emissions inventories have been developed based on a maximum production rate of 5.2 Mtpa. Dispersion modelling was used to predict ground level concentrations for key pollutants from key Project components, at surrounding private and other sensitive receptors. Cumulative impacts were assessed by taking into account the existing ambient baseline air quality.

The predicted Project-only and cumulative annual average PM_{10}, $PM_{2.5}$ and TSP concentrations and dust deposition levels indicate that no sensitive receptor, in the vicinity of the Dendrobium Pit Top and KVCLF, would experience additional exceedances of the NSW EPA's impact assessment criteria. The predicted cumulative 24-hour average PM_{10} and $PM_{2.5}$ concentrations demonstrated that no additional exceedances of the impact assessment criteria are expected at sensitive receptors in the vicinity of the Mine.

The impact of dust emissions from the ventilation shaft are negligible at the closest receptor, and odour would be undetectable (all modelling predictions are less than 1 OU). Emissions from flaring at the ventilation shaft sites are modelled based on a maximum gas flow rate emitted from both Area 3 and Area 5 simultaneously. As flaring is unlikely to occur at these sites simultaneously, the modelled predictions are considered to be highly conservative.

The incremental 1-hour average NO_2 concentration from flaring at the closest receptors is less than 2.6 µg/m³, compared to the impact assessment criterion of 246 µg/m³, while the incremental annual average NO_2 concentration at the closest receptor is 0.035 µg/m³, compared to the impact assessment criterion of 62 µg/m³. Background concentrations in the area are expected to be low to negligible and therefore cumulative impacts are not expected.

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[1] IMC is seeking approval for a State Significant Infrastructure Application the Project under Part 5 of the *Environmental Planning and Assessment Act 197*9 (EP&A Act).

The potential impacts from coal trains were also assessed, in terms of fugitive emissions from coal wagons and diesel exhaust emissions from locomotives. It is noted that material property testing has shown that the measured moisture content for ROM coal arriving at the CPP (6.5%) is higher than the measured DEM level (4.6%) and therefore fugitive emissions are not expected. The emission estimates conservatively do not take this into account and even with fugitive emissions included, the impact from coal transportation is negligible (and well below the NSW EPA's impact assessment criteria).

Modelling results are presented for the CPP, although it is noted that the existing approved operations would not materially change as a result of the Project. The predicted Project-only annual average PM_{10}, $PM_{2.5}$ and TSP concentrations and dust deposition levels at residential areas in the vicinity of the CPP are below the NSW EPA's impact assessment criteria. The maximum predicted Project-only 24-hour average concentrations across residential areas in the vicinity of the CPP are predicted to be in the range of 10 – 20 µg/m³ for PM_{10} and 2.5 – 5 µg/m³ for $PM_{2.5}$. Cumulative analysis predicted a very low risk of additional exceedances for 24-hour PM_{10} (less than 1 day) and no additional exceedances for $PM_{2.5}$. The coal fines dryer at the CPP is not currently operational, but may become operational in the future. The operation of the dryer would result in insignificant increases in emissions in comparison to other emission sources and, as such, increases in emissions in the local airshed would be negligible.

A greenhouse gas assessment was undertaken based on a combination of data provided by South32 and relevant emissions factors. In order to estimate fugitive emissions from pre and post gas drainage, a series of gas emission models were run based on a pore pressure model, established using borehole lithology and density logs from boreholes spread across the mine plan area.

Fugitive gas emissions are compared for venting and flaring of pre- and post-gas drainage. The comparison shows that the adoption of flaring as an abatement option would reduce total fugitive emissions by 31 %.

Based on the average scope 1 emissions (assuming flaring) of 789,551 tonnes CO_2-e, the Project represents approximately 0.58% of total GHG emissions for NSW and 0.15% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2019, which was the most recent at the time of reporting.

Based on the average scope 1 and 2 emissions (assuming flaring) of 854,834 tonnes CO_2-e, the Project represents approximately 0.63% of total GHG emissions for NSW and 0.16% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2019.

A review of best-practice greenhouse gas emission reduction measures relevant to the Project was undertaken by South32, and peer reviewed by Palaris (2022). Details of the proposed management and mitigation of GHG emissions from Project operations can be found in Appendix 6.

Palaris (2022) has stated the proposed mitigation measures, in addition to the optimisation opportunities (the feasibility of which needs to be determined via further studies during the operation of the Project) would minimise GHG emissions where practicable.

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1. INTRODUCTION

The Dendrobium Mine is an existing underground coal mine situated in the Southern Coalfield of New South Wales (NSW), approximately 8 kilometres west of Wollongong (**Figure 1-1**). Illawarra Coal Holdings Pty Ltd (Illawarra Metallurgical Coal [IMC]), a wholly owned subsidiary of South32 Limited (South32), is the owner and operator of the Dendrobium Mine.

IMC is seeking a new Infrastructure Approval to gain access to proposed Area 5 within Consolidated Coal Lease (CCL) 768 and for the use of supporting infrastructure, referred to as *Dendrobium Mine Extension Project* (hereafter referred to as the Project).

Ramboll was commissioned to complete an Air Quality and Greenhouse Gas Assessment (AQA) for the Project.

1.1 Existing operations

The Dendrobium Mine was approved by the NSW Minister for Urban Affairs and Planning on 20 November 2001 under the NSW Environmental Planning and Assessment Act, 1979 (EP&A Act). The Dendrobium Mine was approved under the Commonwealth Environment Protection and Biodiversity Conservation Act, 1999 (EPBC Act) on 20 December 2001.

The existing mining operations are undertaken in accordance with Development Consent DA 60-03-2001 (as modified), as well as the Approval Decision (EPBC 2001/214) under the EPBC Act. Construction for the Dendrobium Mine commenced in January 2002, with longwall mining commencing in April 2005. The general arrangement of the approved Dendrobium Mine is shown in **Figure 1-2**.

The Dendrobium Mine extracts coal from the Wongawilli Seam within CCL 768 using underground longwall mining methods. The Dendrobium Mine primarily produces hard coking coal and has an approved operational capacity of up to 5.2 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal until 31 December 2030.

The Dendrobium Mine includes five approved underground mining areas, named Areas 1, 2, 3A, 3B and 3C (see **Figure 1-2**). Longwall mining is currently being undertaken in Area 3B, with extraction largely complete in Areas 1, 2 and 3A. Key surface facilities at the Dendrobium Mine include the:

- Dendrobium Pit Top.
- Cordeaux Pit Top.
- Kemira Valley Coal Loading Facility (KVCLF).
- Kemira Valley Rail Line.
- Dendrobium Coal Preparation Plant (CPP).
- Dendrobium No 1, 2 and 3 Shafts.
- West Cliff Coal Wash Emplacement.

1.2 Project overview

The Project seeks to gain access to additional coal within CCL 768 in a proposed future underground mining area, namely Area 5 (**Figure 1-3**). This extension would be supported by the development of supporting infrastructure and an extension to the life of approved surface operations to 2041.

The Project would include the following activities:

- Longwall mining of the Bulli Seam in a new underground mining area (Area 5).
- Development of underground roadways from existing Dendrobium Mine underground areas (namely Area 3) to Area 5.
- Use of existing Dendrobium Mine roadways and drifts for personnel and materials access, ventilation, dewatering and other ancillary activities related to Area 5.

- Development of new surface infrastructure associated with mine ventilation and gas management and abatement, water management and other ancillary infrastructure.
- Handling and processing of up to 5.2 Mtpa of ROM coal.
- Extension of underground mining operations within Area 5 until approximately 31 December 2034.
- Use of the existing Dendrobium Pit Top, KVCLF, Dendrobium CPP and Dendrobium Shafts with minor upgrades and extensions until approximately 2041.
- Transport of ROM coal from the KVCLF to the Dendrobium CPP via the Kemira Valley Rail Line.
- Handling and processing of coal from the Dendrobium Mine (including the Project), and IMC's Appin Mine (if required) to the Dendrobium CPP to 2041.
- Delivery of coal from the Dendrobium CPP to Port Kembla for domestic use at the Port Kembla Steelworks and Liberty Primary Steel Whyalla Steelworks or export through the Port Kembla Coal Terminal.
- Transport of coal wash by road to customers for engineering purposes (e.g. civil construction fill) for other beneficial uses and/or for emplacement at the West Cliff Stage 3 and Stage 4 Coal Wash Emplacement.
- Development and rehabilitation of the West Cliff Stage 3 Coal Wash Emplacement (noting that opportunities for beneficial use of coal wash would be maximised).
- Continued use of the Cordeaux Pit Top for mining support activities such as exploration, environmental monitoring, survey, rehabilitation, administration and other ancillary activities.
- Progressive development of sumps, pumps, pipelines, water storages and other water management infrastructure.
- Controlled release of excess water in accordance with the conditions of Environment Protection Licence (EPL) 3241 and/or beneficial use.
- Monitoring, rehabilitation and remediation of subsidence and other mining effects.
- Other associated minor infrastructure, plant, equipment and activities.

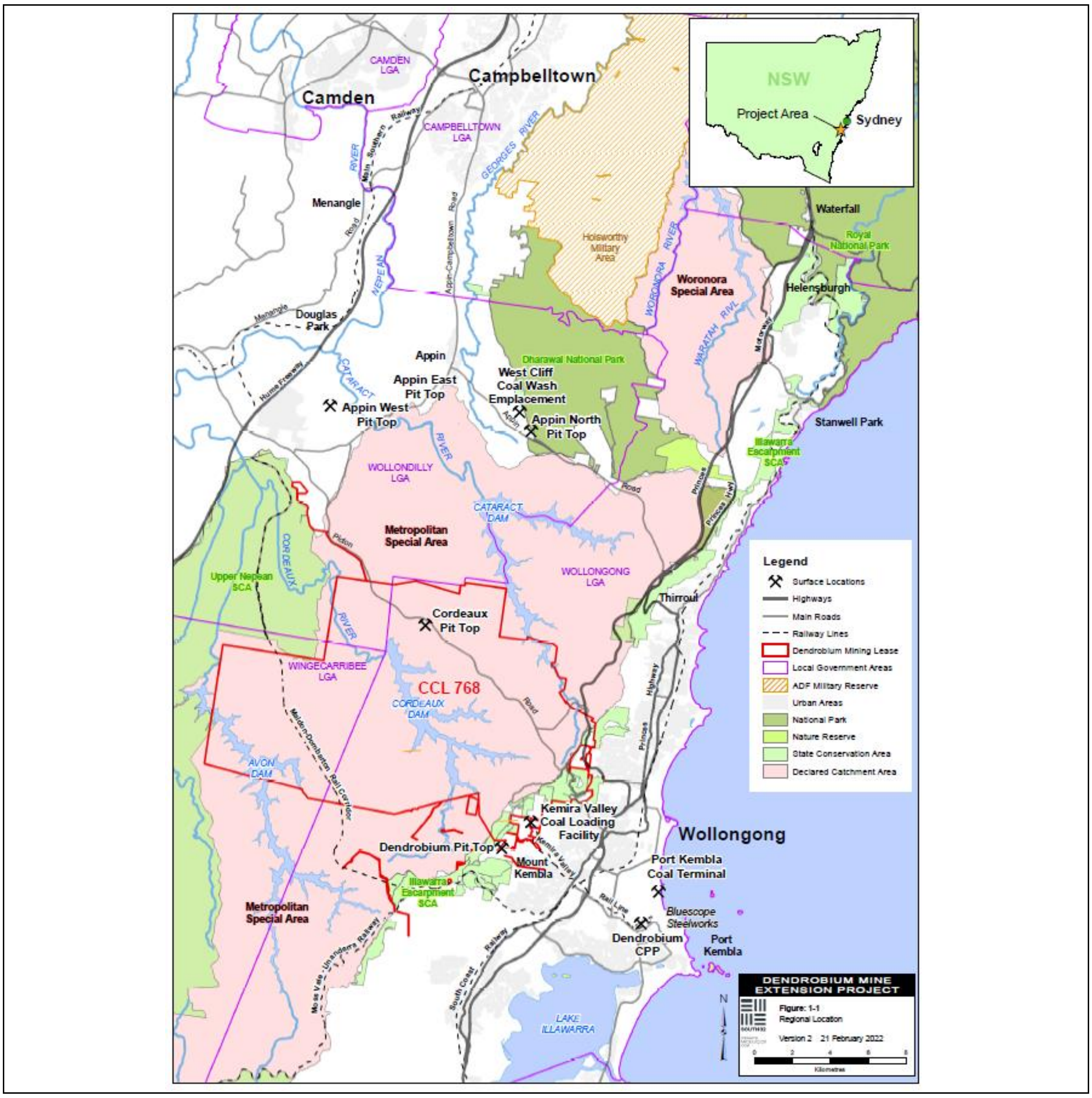


Figure 1-1: Regional location

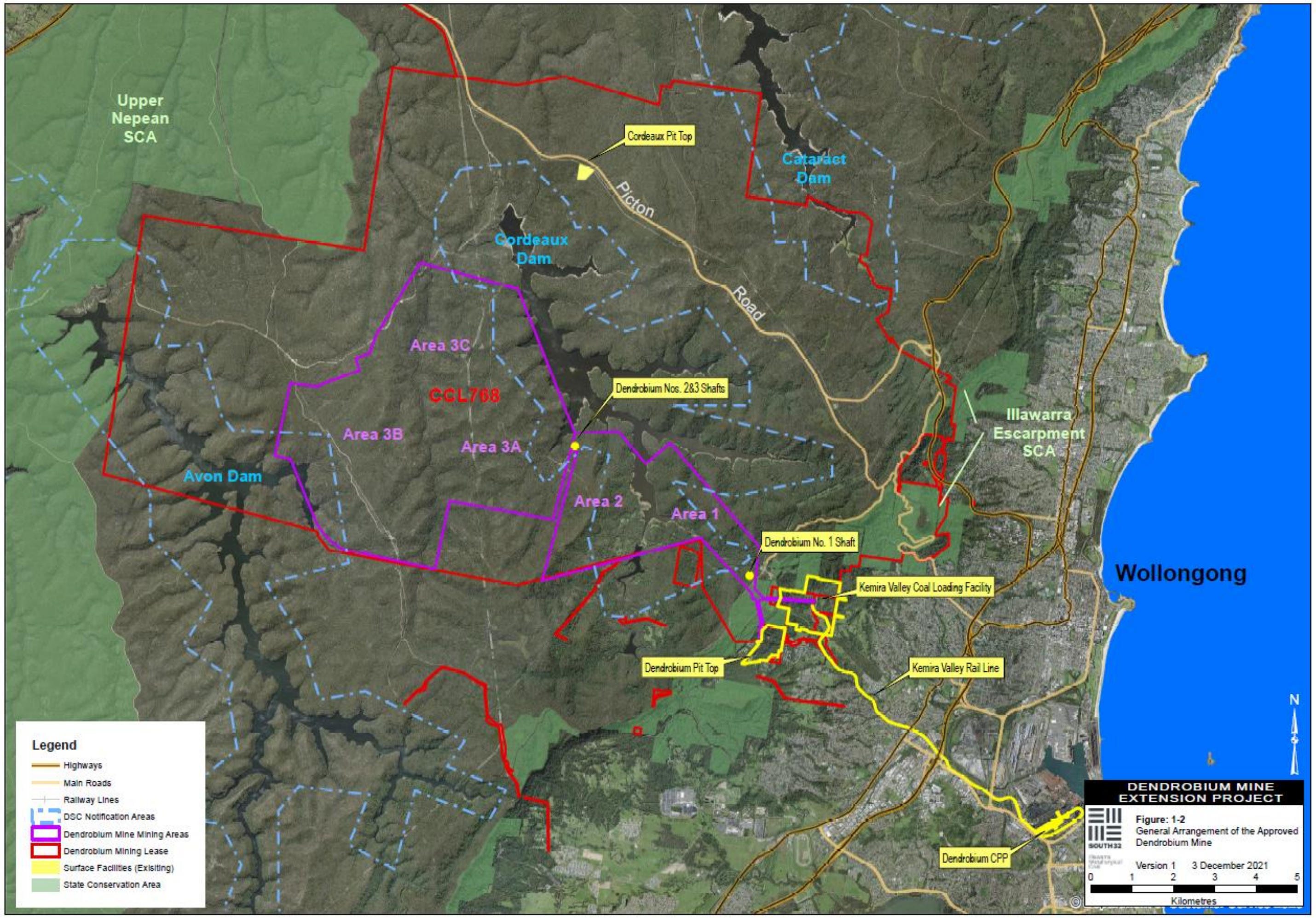


Figure 1-2: General arrangement of the Approved Dendrobium Mine

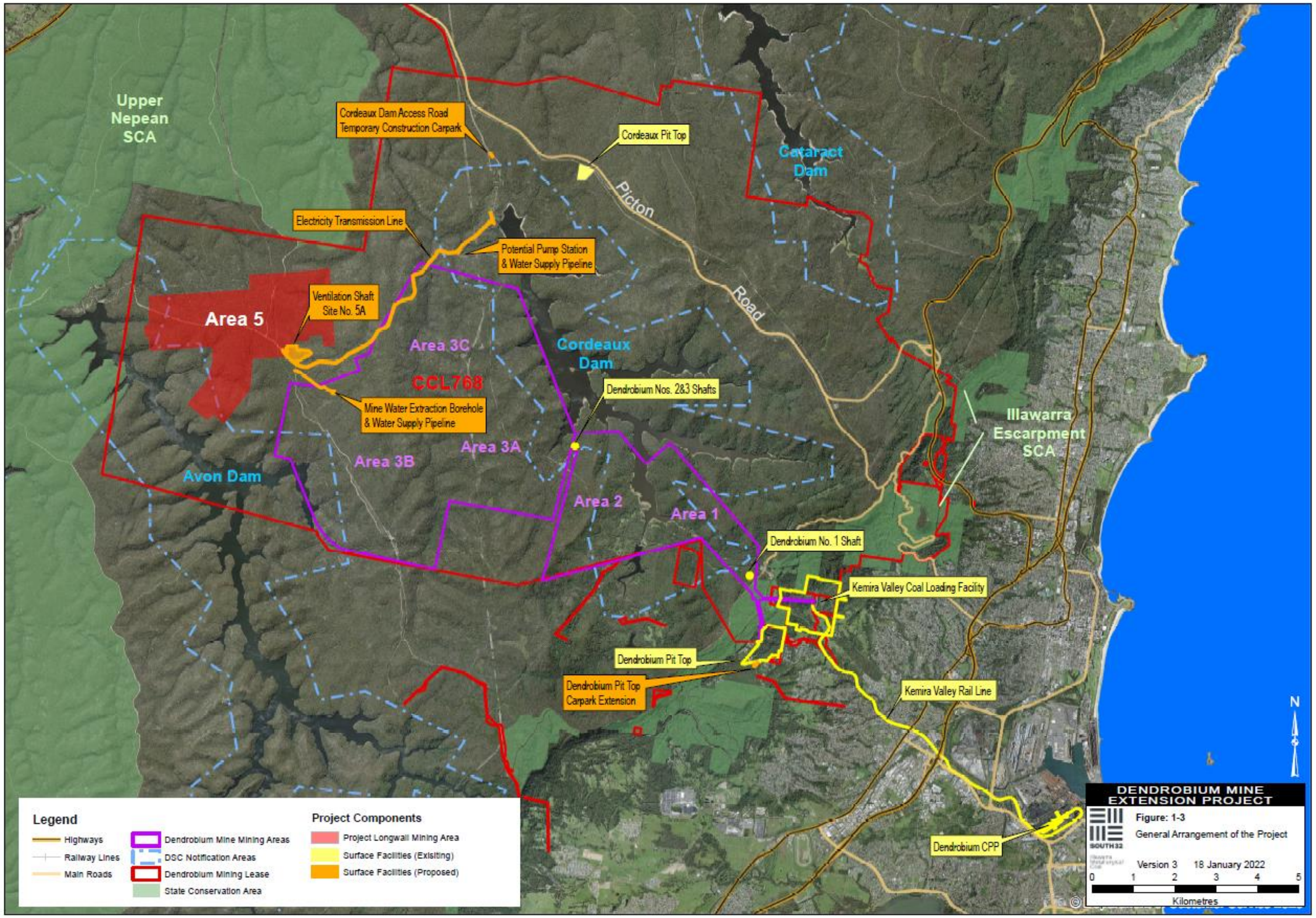


Figure 1-3: Project general arrangement

1.3 Study objectives and requirements

This AQA forms part of an Environmental Impact Statement (EIS), prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs). **Table 1-1** provides a summary of the SEARs for air quality and where the requirement has been addressed in this report, while specific comments from the NSW Environment Protection Authority (EPA) are summarised in Table 1-1.

Table 1-1: Summary of SEARs for air quality and GHG

Requirement	How requirement is addressed
An assessment of the likely air quality impacts of the development in accordance with the Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW.	Report prepared in accordance with the Approved Methods (refer **Section 2**).
An assessment of the likely greenhouse gas impacts of the development;	**Section 8**
An analysis of how the development's greenhouse gas emissions would affect State and national greenhouse gas emission reduction targets;	**Section 8**
A review of available best practice greenhouse gas emissions reduction measures available to the development;	**Section 9 and Appendix 6**
Details of proposed greenhouse gas emissions avoidance, mitigation and/or offset measures;	**Section 9 and Appendix 6**

2. ASSESSMENT APPROACH

This AQA presents a quantitative assessment of potential air quality impacts, using a Level 2 assessment approach in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW ("the Approved Methods") (NSW EPA, 2016).

An overview of the approach to the assessment is as follows:

- The Project was reviewed for potential emission sources.
- Emissions were estimated for all significant sources, using suitable emission factors and activity data.
- Dispersion modelling using a regulatory dispersion model was used to predict ground level concentrations for key pollutants from the Project, at surrounding sensitive receivers.
- Cumulative impacts were assessed, taking into account the combined effect of existing baseline air quality and / or other local sources of emissions.
- Estimates of the greenhouse gas emissions are presented and benchmarked against Greenhouse Gas accounts for NSW and Australia.

2.1 Project components and pollutants considered for assessment

Air quality impacts were modelled in this AQA for the following key Project components:

- KVCLF – fugitive dust from handling and stockpiling of coal, including conveying, sizing, loading the stockpile, maintaining the stockpile and loading trains.
- Dendrobium Pit Top – fugitive dust from vehicle movements associated with personnel and materials access to the underground workings via the Dendrobium Tunnel.
- Kemira Valley Rail Line – fugitive emissions from coal wagons and diesel emissions from locomotives.
- Dendrobium CPP – fugitive dust from handling and stockpiling of coal, including unloading trains, conveying, loading stockpiles, maintaining stockpiles, loading trucks and wind erosion.
- Gas drainage and management, including a new upcast ventilation shaft (at Site No 5A) in Area 5. Drainage and management of gas associated with Area 5 may occur at Shaft Site No. 2/3 at Area 3 or at Shaft Site No. 5A. Shaft Site No. 2/3 was approved as part of the existing Dendrobium Mine and the gas drainage infrastructure proposed to be located at this location is not part of the Project. However, a gas drainage plant including flaring was conservatively modelled simultaneously at both Area 3 and Area 5 to assess potential impacts from both locations. As gas management is not expected to occur at both sites simultaneously, if at all at Shaft Site No. 5A, the modelled predictions are considered to be highly conservative.

Some components of the Project did not require modelling for the reasons summarised below with further discussion provided in subsequent sections:

- Although part of the Project, there is no change to the transport and emplacement of coal wash from the CPP to the West Cliff Coal Wash Emplacement. Local air quality impacts from this Project component have already been assessed and described in the Bulli Seam Operations EIS (PAEHolmes, 2009) and the conclusions remain the same (**Section 0**).
- In addition to the Dendrobium Pit Top, the Cordeaux Pit Top would be used to support mining activities (e.g. exploration and mining activities). However, unlike the Dendrobium Pit Top, the Cordeaux Pit Top is remote from residential areas (the closest receptor is located over 2 km away) and is a minor source of emissions (**Section 7.4**).
- The coal fines dryer at the CPP is not currently operational and there is no change proposed as part of the Project. If it were to become operational, the dryer was assessed in an air quality assessment which accompanied the EIS for the original approval (HAS, 2000) and the conclusions remain the same (refer **Section 7.5.3**).

A summary of the potential emissions to air for each Project component are identified and summarised in **Table 2-1**.

Table 2-1: Emissions sources and air quality indicators for assessment

Project Component	Emission source	Air quality indicator	Included in this assessment	Section in this AQA
Surface infrastructure facilities (KVCLF and Dendrobium Pit Top)	Fugitive dust from coal handling and vehicle movements	Total suspended particulate matter (TSP), particulate matter smaller than 10 micrometres (µm) in diameter (PM_{10}), particulate matter smaller than 2.5 µm in diameter ($PM_{2.5}$) and dust deposition	Emissions assessed and modelled.	**Section 7.1**
	Diesel combustion	PM_{10} and $PM_{2.5}$	Emissions assessed and modelled.	
		Oxides of nitrogen (NO_x)	Other gaseous emissions from diesel combustion have not been modelled. Based on the quantities of diesel consumed, there would be negligible impact on local air quality.	
		Sulphur dioxide (SO_2)		
		Carbon monoxide (CO)		
		Volatile organic compounds (VOCs)		
Kemira Valley Rail Line	Fugitive dust from coal wagons	TSP, PM_{10}, $PM_{2.5}$ and dust deposition	Emissions assessed and modelled.	**Section 7.2**
	Diesel combustion in locomotives	PM_{10} and $PM_{2.5}$	Emissions assessed and modelled.	
		NO_x	Other gaseous emissions from diesel combustion have not been modelled. Based on the quantities of diesel consumed, there would be a negligible impact on local air quality.	
		SO_2		
		CO		
		VOCs		
Ventilation Shaft Site (including Gas Management at Area 3 and Area 5)	Fugitive emissions from upcast Ventilation shafts	TSP, PM_{10}, $PM_{2.5}$ and dust deposition	Emissions assessed and modelled.	**Section 7.3**
		Odour		
	Flaring	NO_x	Emissions assessed and modelled, as the key pollutants from flaring. Emissions of other pollutants from flaring are negligible and are not modelled.	
Cordeaux Pit Top	Fugitive dust from vehicle movements	TSP, PM_{10}, $PM_{2.5}$ and dust deposition	Potential emissions at the Cordeaux Pit Top would be minor and given the separation distance of >2 km from the closest receptor, there would be a negligible impact on local air quality.	**Section 7.4**
	Diesel combustion	PM_{10} and $PM_{2.5}$		
		NO_x		
		SO_2		
		CO		
		VOCs		

Project Component	Emission source	Air quality indicator	Included in this assessment	Section in this AQA
CPP	Fugitive dust from coal handling	TSP, PM_{10}, $PM_{2.5}$ and dust deposition	Emissions assessed and modelled.	**Section 7.5**
	Diesel combustion	PM_{10} and $PM_{2.5}$	Emissions assessed and modelled.	
		NO_x	Other gaseous emissions from diesel combustion have not been modelled. Based on the relatively minor quantities of diesel consumed, there would be a negligible impact on local air quality.	
		SO_2		
		CO		
		VOCs		
	Coal Dryer	PM_{10} and $PM_{2.5}$	Potential emissions reviewed and found to result in negligible potential impacts, consistent with HAS (2000) assessment.	**Section 7.5.3**
		NO_x		
		SO_2		
		CO		
		VOCs		
Coal wash transport and emplacement	Fugitive dust from coal handling	TSP, PM_{10}, $PM_{2.5}$ and dust deposition	There is no material change to the transport and emplacement of coal wash from the CPP to the West Cliff Coal Wash Emplacement and local air quality impacts have already been assessed in the Bulli Seam Operations EIS. Therefore, no further assessment is required as impacts would be minor, as assessed in PAEHolmes (2009).	**Section 0**
	Diesel combustion	PM_{10} and $PM_{2.5}$		
		NO_x		
		SO_2		
		CO		
		VOCs		
Construction	N/A	N/A	Most of the construction activities for the Project would either be minor upgrades or occur at locations separated from sensitive receptors (e.g. the Central Gas Management Sites). All construction activities would be short-term and potential emissions could be controlled using standard mitigation and management practices. Therefore, construction phase emissions are not modelled in this report.	**Section 7.7**
All components	All major sources	Greenhouse gases (GHG)	Emissions quantified.	**Section 8**

2.2 Assessment criteria

2.2.1 Particulate matter

When first regulated, airborne particulate matter (PM) was assessed based on concentrations of TSP. In practice, this typically referred to PM smaller than 30-50 µm in diameter. As air sampling technology improved and the importance of particle size and chemical composition become more apparent, ambient air quality standards have been revised to focus on the smaller particle sizes, thought to be most harmful to human health. Contemporary air quality assessment typically focuses on "fine" and "coarse" inhalable PM, based on health-based ambient air quality standards set for PM_{10} and $PM_{2.5}$.

Air quality criteria for PM in Australia are given for particle size metrics including TSP, PM_{10} and $PM_{2.5}$. The 2016 update to the 'Approved Methods', gazetted on 20 January 2017, includes particle assessment criteria that are consistent with revised National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) national reporting standards (National Environment Protection Council [NEPC], 1998; NEPC, 2015; NEPC, 2021). For this report, predicted ground level concentrations (GLCs) are assessed against the NSW EPA's impact assessment criteria presented in **Table 2-2**.

Table 2-2: Impact assessment criteria for PM

PM metric	Averaging period	Concentration (µg/m³)
TSP	Annual	90
PM_{10}	24-hour	50
	Annual	25
$PM_{2.5}$	24-hour	25
	Annual	8

Note: µg/m³ = micrograms per cubic metre.

The Approved Methods also prescribes nuisance based goals for dust deposition, which relate to amenity type impacts such as soiling of exposed surfaces. The NSW EPA impact assessment criterion for dust deposition is summarised in **Table 2-3**, illustrating the maximum increase and total dust deposition rates which would be acceptable so that dust nuisance can be avoided.

Table 2-3: Dust deposition criteria

Pollutant	Maximum Increase in Dust Deposition	Maximum Total Dust Deposition Level
Deposited dust (assessed as insoluble solids)	2 g/m²/month	4 g/m²/month

Note: g/m² = grams per square metre.

2.2.2 Gaseous pollutants

The impact assessment criteria for gaseous products of combustion are prescribed in the Approved Methods and summarised in **Table 2-4**. The impact assessment criteria for 'criteria pollutants[2]' are applied at the nearest existing or likely future off-site sensitive receptor and compared against the 100th percentile (i.e. the highest) dispersion modelling prediction. Both the incremental and cumulative impacts need to be considered (i.e. consideration of background is required for criteria pollutants).

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

The impact assessment criteria for 'air toxics' are applied at, and beyond, the site boundary and reported as the 99.9th percentile of the dispersion modelling predictions. Only incremental impacts for these pollutants need be reported. Air toxics include the various VOC components of combustion exhaust emissions.

Table 2-4: Impact assessment criteria for gaseous products of combustion

Pollutant	**Averaging period**	**Concentration**	
		µg/m³ 1	**pphm 2**
NO_2	1-hour	246	12
	Annual	62	3
SO_2	10-minute	712	25
	1-hour	570	20
	24-hour	228	8
	Annual	60	2
CO	15-minute	100,000	8,700
	1-hour	30,000	2,500
	8-hour	10,000	900
VOCs			
1,3-butadiene	1-hour 3	40	1.8
Benzene	1-hour 3	29	0.9
Polycyclic aromatic hydrocarbons (as benzo[a]pyrene)	1-hour 3	0.4	-
Note 1: Gas volumes for criteria pollutants expressed at 0°C and 1 atmosphere, and principal toxics at 25°C Note 2: pphm – parts per hundred million Note 3: Expressed as the 99.9th percentile			

In April 2021 the AAQ NEPM was varied, with updates of relevance to this AQA being revised reporting standards for NO_2 and SO_2, as summarised in **Table 2-5** below. The revisions do not supersede the criteria in the Approved Methods, however there is a possibility the revised reporting standards may be adopted as impact assessment criteria for NSW in the future. The AQA will therefore draw comparisons to the revised reporting standards in addition to the current impact assessment criteria.

Table 2-5 AAQ NEPM reporting standards, 2021 revision

Pollutant	**Averaging period**	**Concentration**	
		µg/m³ 1	**pphm 2**
NO_2	1-hour	164	8
	Annual	31	1.5
SO_2	1-hour	286	10
	24-hour	57	2
Note 1: Gas volumes for criteria pollutants expressed at 0°C and 1 atmosphere, and principal toxics at 25°C Note 2: pphm – parts per hundred million			

2.2.3 Odour

Dynamic olfactometry is the accepted method of odour measurement and involves a sample of odorous air being presented to a panel of people with decreasing quantities of clean odour-free air. The panellists note when the smell becomes detectable and the correlation between the known dilution ratios and the panellists' responses are used to calculate the number of dilutions required to achieve the odour detection threshold. The units for odour measurement are "odour units" (OU), which, according to the method described above, are effectively "dilutions to threshold".

The odour nuisance level can be as low as 2 OU and as high as 10 OU (for less offensive odours), whereas an odour assessment criterion of 7 OU is likely to represent the level below which 'offensive' odours should not occur. The NSW EPA's Technical framework - Assessment and management of odour from stationary sources in NSW (NSW EPA, 2006a) recommends that, as a design criterion, no individual should be exposed to ambient odour levels of greater than 7 OU.

The Approved Methods prescribe odour goals which take into account the population density for a particular area. The most stringent odour goal of 2 OU is considered to be acceptable for the whole population and therefore appropriate for urban areas (NSW EPA, 2016).

The 2 OU odour goal should be compared against the 99^{th} percentile of the dispersion modelling predictions. The 1-hour average dispersion modelling prediction is converted to a peak (i.e. 1-second 'nose response average') based on a peak to mean ratio of 2.3, in accordance with the Approved Methods.

2.3 Modelling approach

Dispersion modelling for this assessment uses the CALPUFF modelling system, which is commonly used in NSW for applications where non-steady state conditions may occur (i.e. complex terrain or coastal locations).

The Approved Methods provides recommendations for the selection of dispersion models and includes CALPUFF and The Air Pollution Model (TAPM) as alternative models.

The modelling for this assessment uses a combination of TAPM and CALMET/CALPUFF, as follows:

- TAPM was used to generate gridded three-dimensional upper air data for each hour of the model run period for input into CALMET.
- CALMET, the meteorological pre-processor for the dispersion model CALPUFF, calculates fine resolution three-dimensional meteorological data using a combination of surface observations and the prognostic TAPM upper air data.
- CALPUFF then calculates the dispersion of plumes within this three-dimensional meteorological field.

2.4 Cumulative impacts

Cumulative impacts are assessed by combining the contribution from the Project with the existing ambient air quality environment, described based on baseline monitoring data for the region (described in **Section 5**).

3. LOCAL SETTING AND ASSESSMENT LOCATIONS

3.1 Local setting

The KVCLF and Dendrobium Pit Top are located in Mount Kembla, approximately 8 km west of Wollongong on the Illawarra Escarpment. The Kemira Valley Rail Line runs from the KVCLF to the Dendrobium CPP, located within Port Kembla Steelworks Precinct.

The regional setting and the key Project components considered in this report are shown in **Figure 3-1**. The KVCLF sits on the edge of the Illawarra escarpment, at an elevation of approximately 70 m Australian Height Datum (AHD). The terrain rises sharply into the escarpment, to an elevation greater than 400 m AHD. The regional and local topography and coastal setting have a strong influence on the prevailing meteorology, described further in **Section 4**.

3.2 Assessment locations

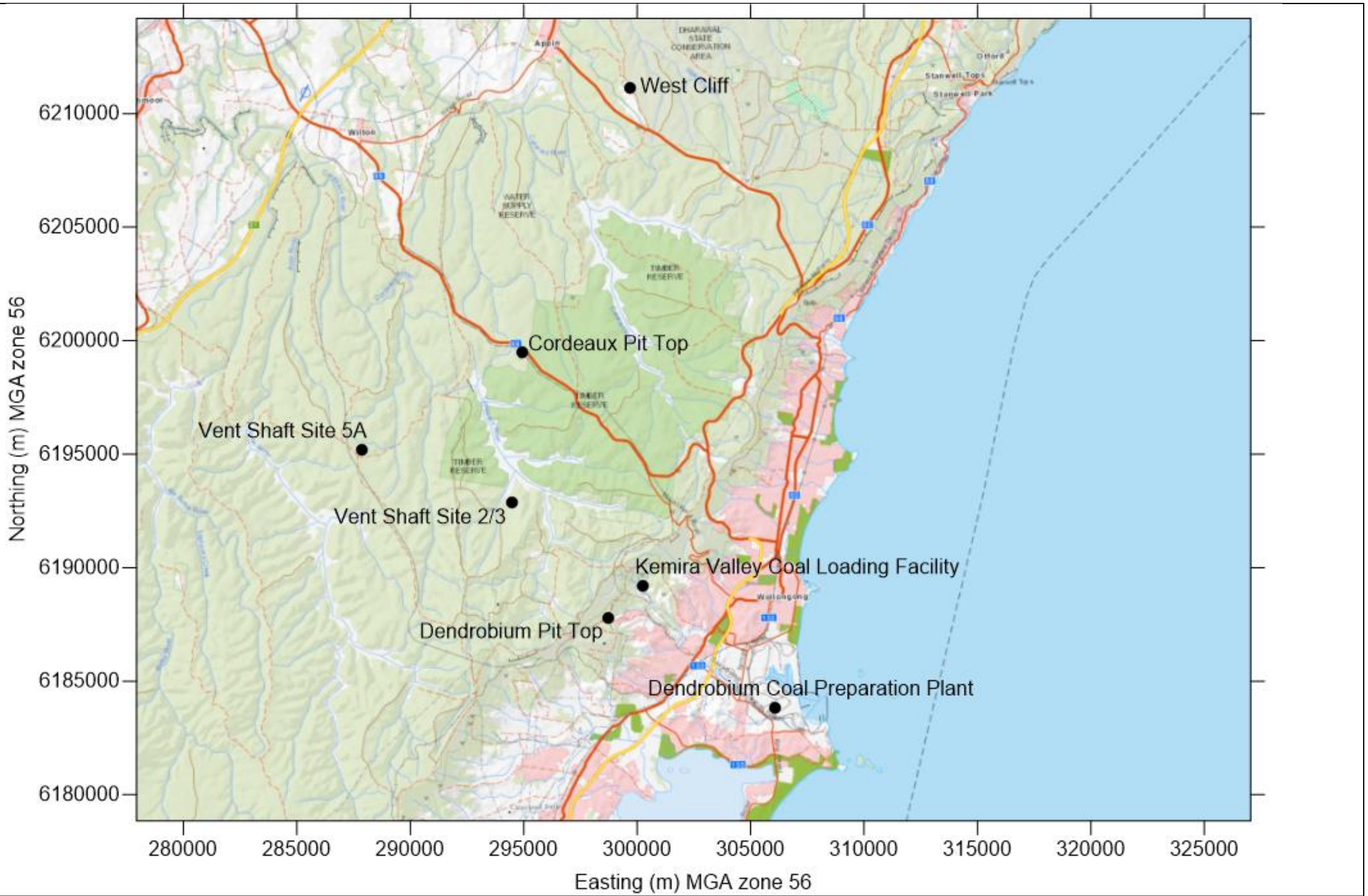
There are a number of residential areas around the KVCLF and Dendrobium Pit Top, including Mount Kembla / Kembla Heights, Cordeaux Heights and Figtree, while the Kemira Valley Rail Line passes through residential areas of Unanderra and Cringila.

Locations representative of these residential areas have also been identified and selected as discrete sensitive receptors, shown in **Figure 3-2**. Additional receptor locations, selected to assess impacts from the rail line, are shown in **Figure 3-3**. Non-residential sensitive receptors are also shown, including schools, places of worship and recreational areas. It is noted that there are a small number of commercial and mine-owned receptors in the vicinity of the KVCLF and Dendrobium Pit Top that are not shown in the figures but listed in **Appendix 1**. These commercial premises are mostly associated with the Mine.

The ventilation shaft sites (also used for central gas management) are remote from any residential areas. Ventilation Shafts No 2 & 3, are located approximately 2.8 km from the nearest receptor (the southern Cordeaux Dam facilities) and 5 km from the Wollongong motorcycle club. Ventilation Shaft Site No 5A is located approximately 5 km from the Avon Dam picnic area and 6.5 km from the Cordeaux Dam picnic area and caretakers' facilities.

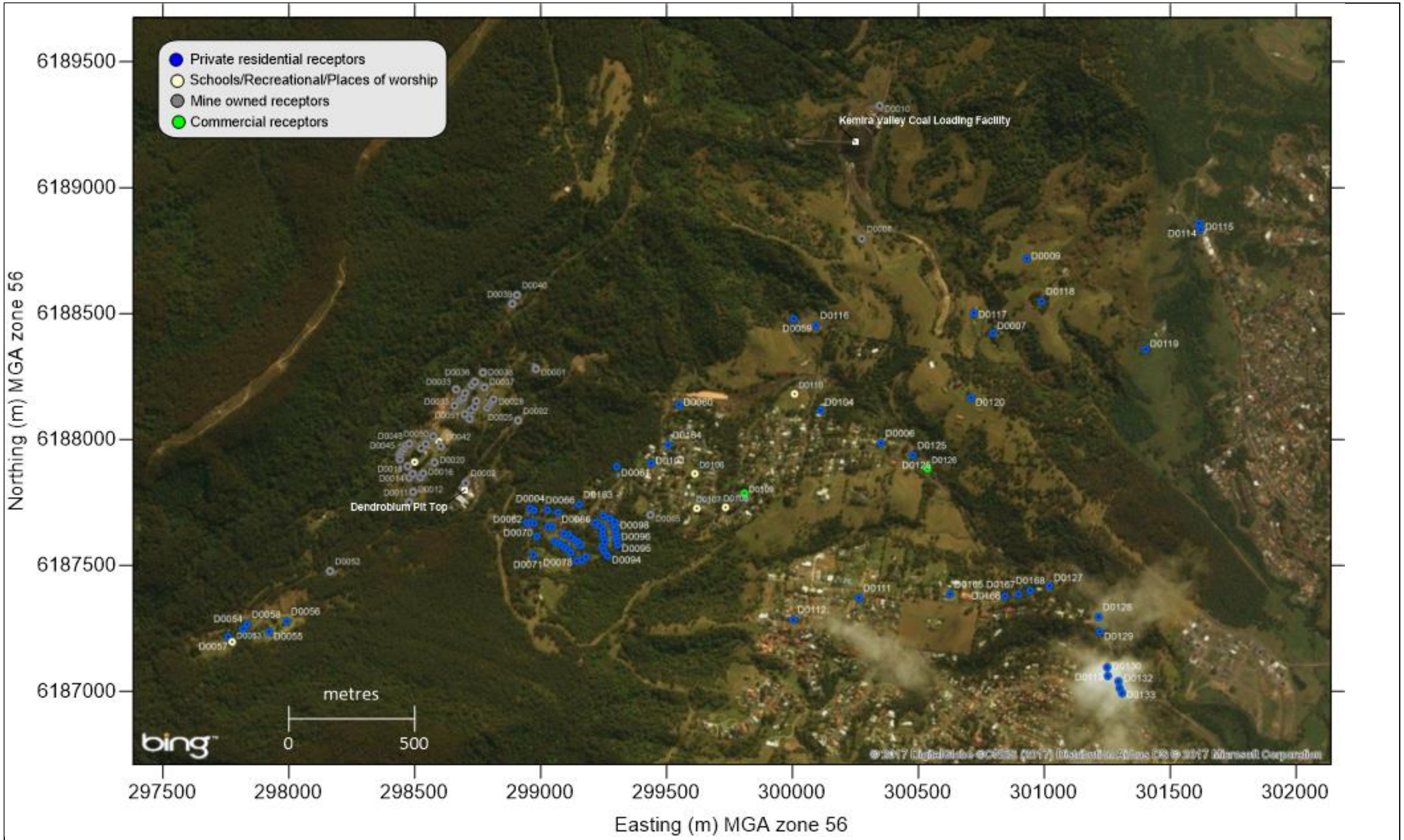
The Cordeaux Pit Top is located approximately 2 km from the Cordeaux Dam picnic area and caretakers' facilities.

The Dendrobium CPP is located close to the residential areas of Cringila, Port Kembla and Warrawong, as shown in **Figure 3-5**. Specific discrete sensitive receptors have not been identified in this report but these residential areas are assessed with reference to the contour plots, which show predicted ground level concentrations of key pollutants across all areas in the vicinity of the CPP.



Note: One ventilation shaft site is proposed for the Project that would have both a downcast (intake) and upcast (exhaust) shaft.

Figure 3-1: Regional topography and key Project surface facilities



Note: not all receptors are labeled due to limited space.

Figure 3-2: Sensitive receptor locations in the vicinity of the KVCLF and Dendrobium Pit Top

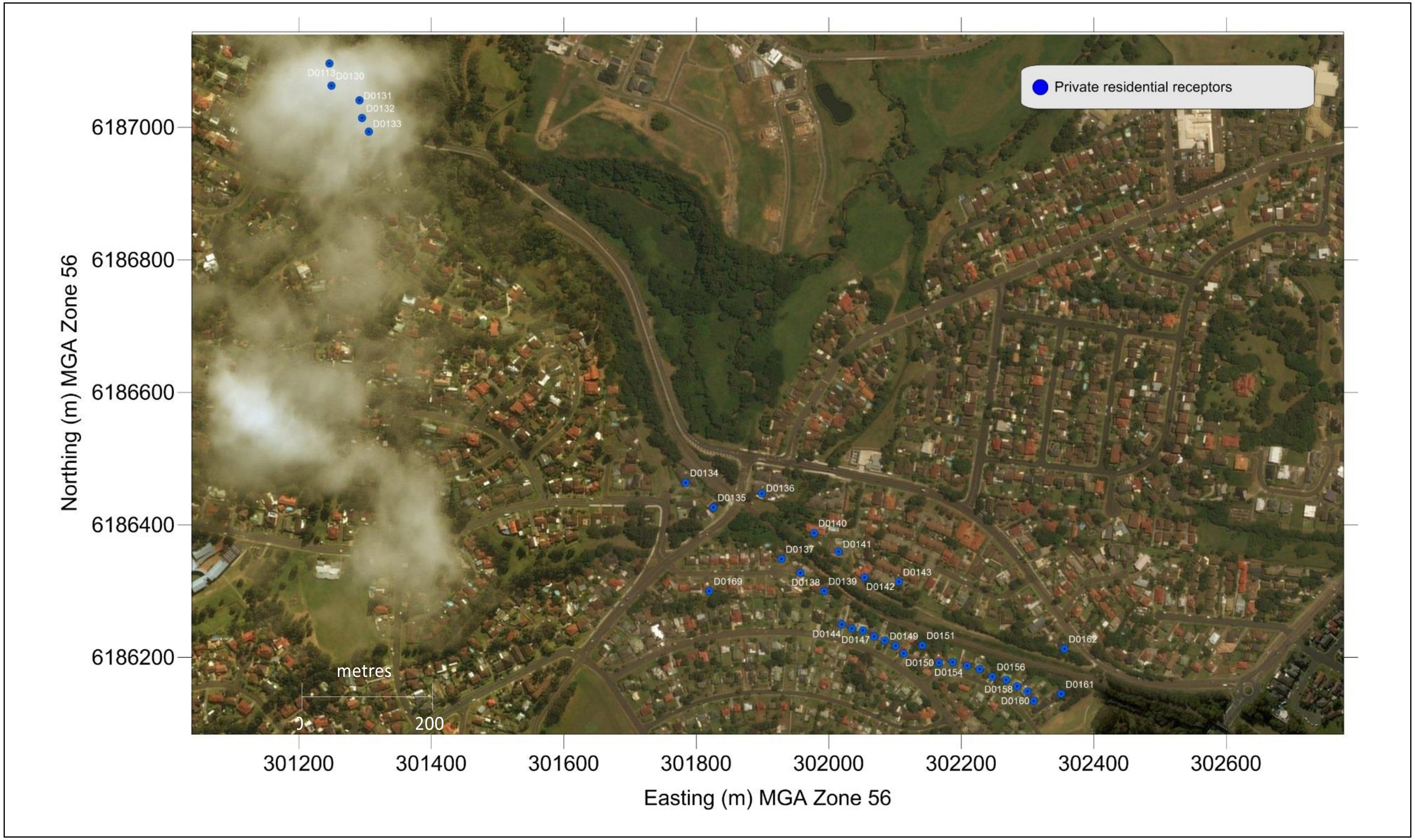


Figure 3-3: Additional sensitive receptor locations for assessment of the Kemira Valley Rail Line

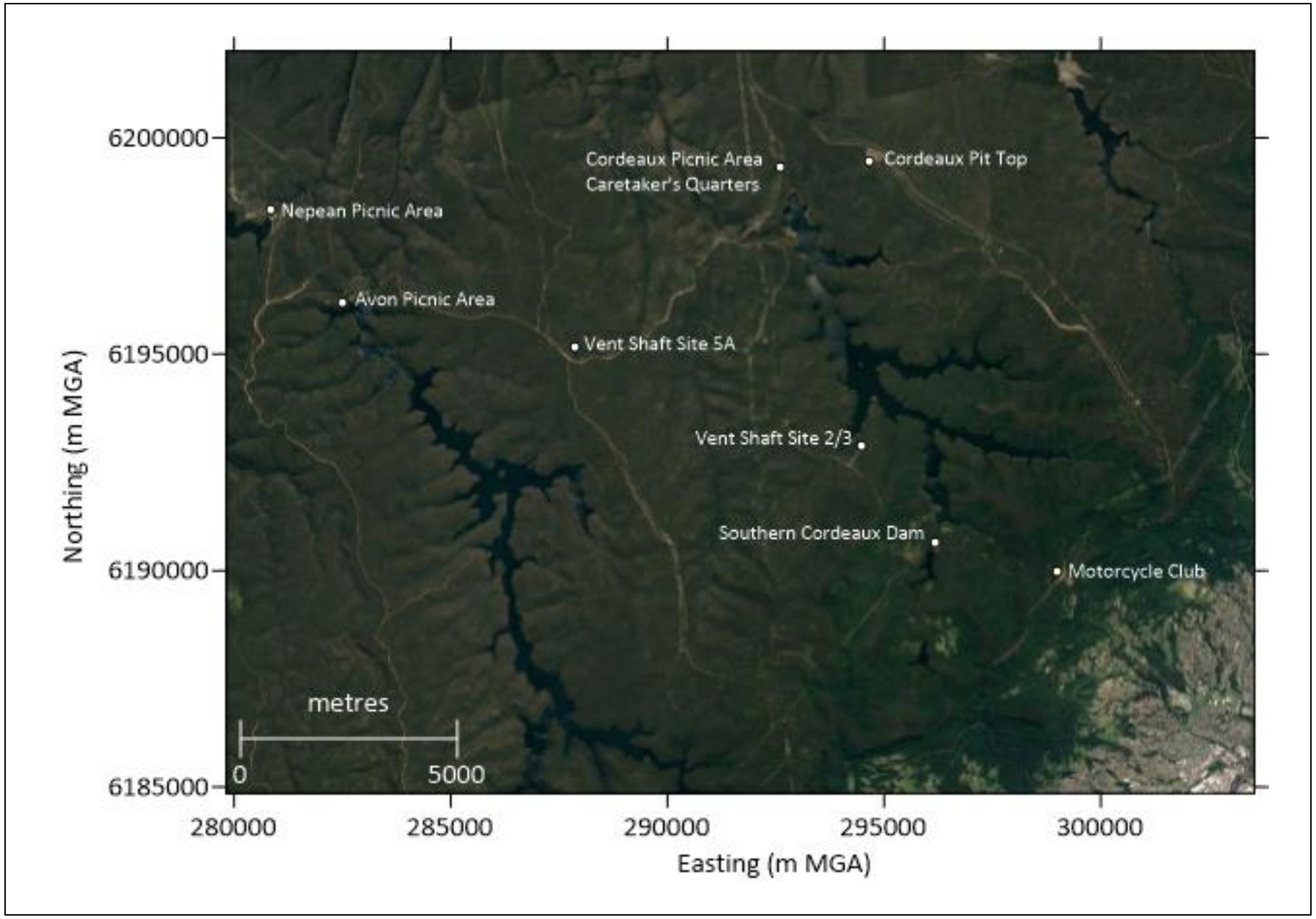


Figure 3-4: Sensitive receptor locations in the vicinity of the ventilation shaft and central gas management sites

Figure 3-5: Residential areas in the vicinity of the CPP

4. OVERVIEW OF LOCAL AND REGIONAL METEOROLOGY

4.1 Introduction

Meteorological mechanisms govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. To adequately characterise the dispersion meteorology of a region, information is needed on the prevailing wind regime, ambient temperature, rainfall, relative humidity, mixing depth and atmospheric stability.

Analysis of meteorology for the region is presented based on the closest Bureau of Meteorology (BoM) automatic weather station (AWS) and NSW Department of Planning, Industry and Environment (DPIE) monitoring sites, as follows:

- Kembla Grange DPIE site – located approximately 6 km south of the KVCLF.
- Wollongong DPIE site – located approximately 5.5 km east of the KVCLF.
- Wollongong Airport BoM AWS – located approximately 16 km south of the KVCLF.
- Bellambi BoM AWS – located approximately 11 km northeast of the KVCLF.

The locations of the surface observation sites in relation to the KVCLF are shown in **Figure 4-1**.

These monitoring locations are also used as surface observation sites in the meteorological monitoring for the assessment (described in **Section 4.5**).

IMC operates an on-site meteorological monitoring station at the Dendrobium Pit Top and KVCLF and these data are also included in the modelling to refine the performance of the meteorological model in predicting local winds for the area around the KVCLF.

Figure 4-1: Surface observation sites for the region

4.2 Prevailing winds and Southern Oscillation Index

Nine years, 2012 to 2020, of hourly meteorological data were reviewed for Wollongong Airport and the annual wind roses are presented in **Figure A3-1** (**Appendix 2**). The annual wind roses show consistency in wind direction, average wind speeds and the percentage occurrence of calm winds (≤0.5 metres per second [m/s]) for each year. The prevailing wind is primarily from the west, with a secondary northeast component. The average windspeed ranges from 3.6 - 3.9 m/s, with calms ranging from 5 – 8%.

Wind roses for the onsite meteorological station for 2014 to 2017 and 2019 to 2020 are presented in **Figure 4-2** and **Figure 4-3**, respectively. Annual wind roses for 2015, 2016, 2017 and 2019 show consistency in wind direction and average wind speeds, with a high degree of variability in the occurrence of calm winds (4.5 – 30%), assumed due to siting or limitations of the monitoring equipment. The 2016 year has the most similar frequency of calms to the BoM Wollongong Airport data. Site meteorological data for 2018 was unavailable at the time of this report.

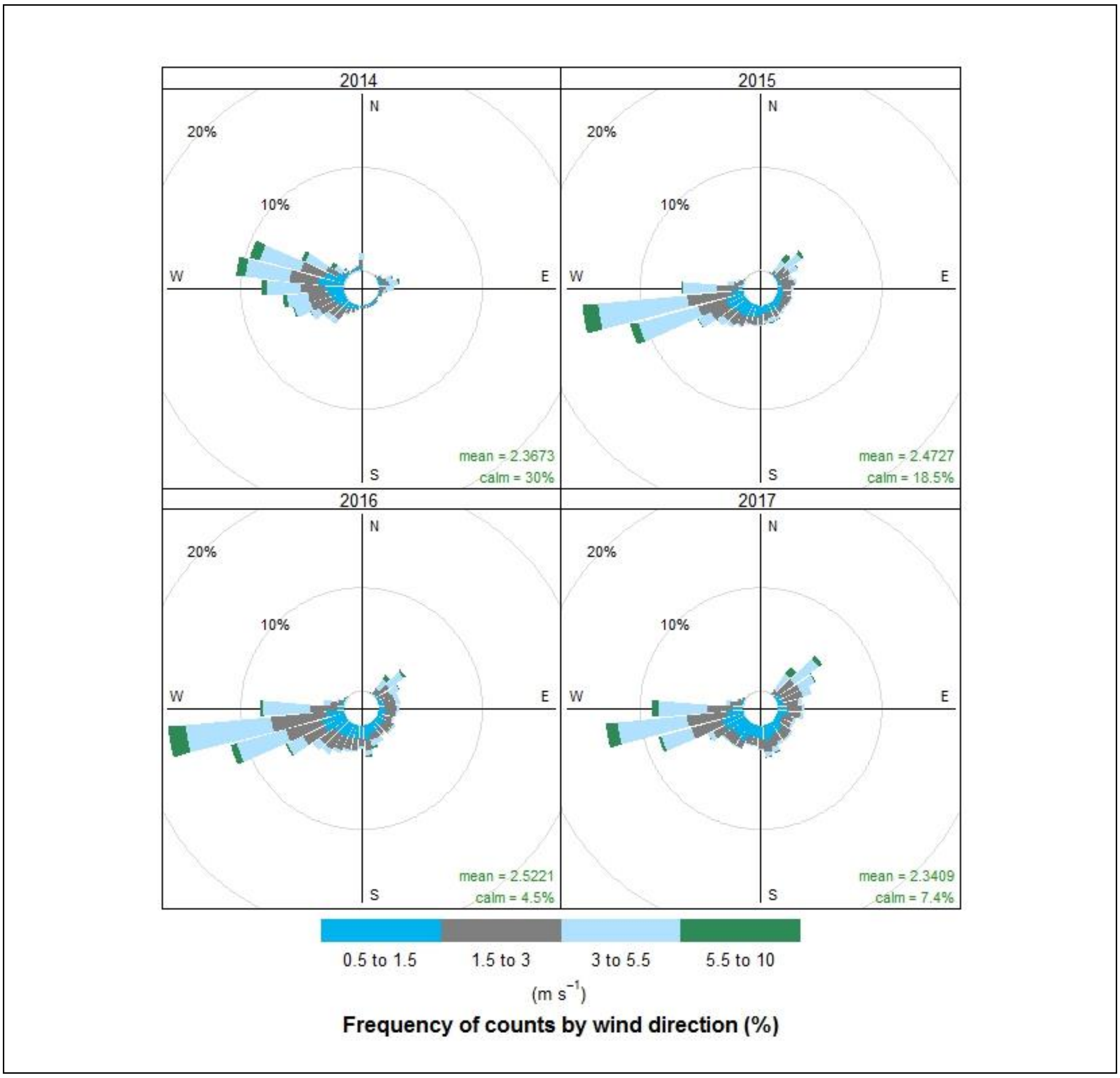


Figure 4-2: Wind roses for the onsite station, 2014 - 2017

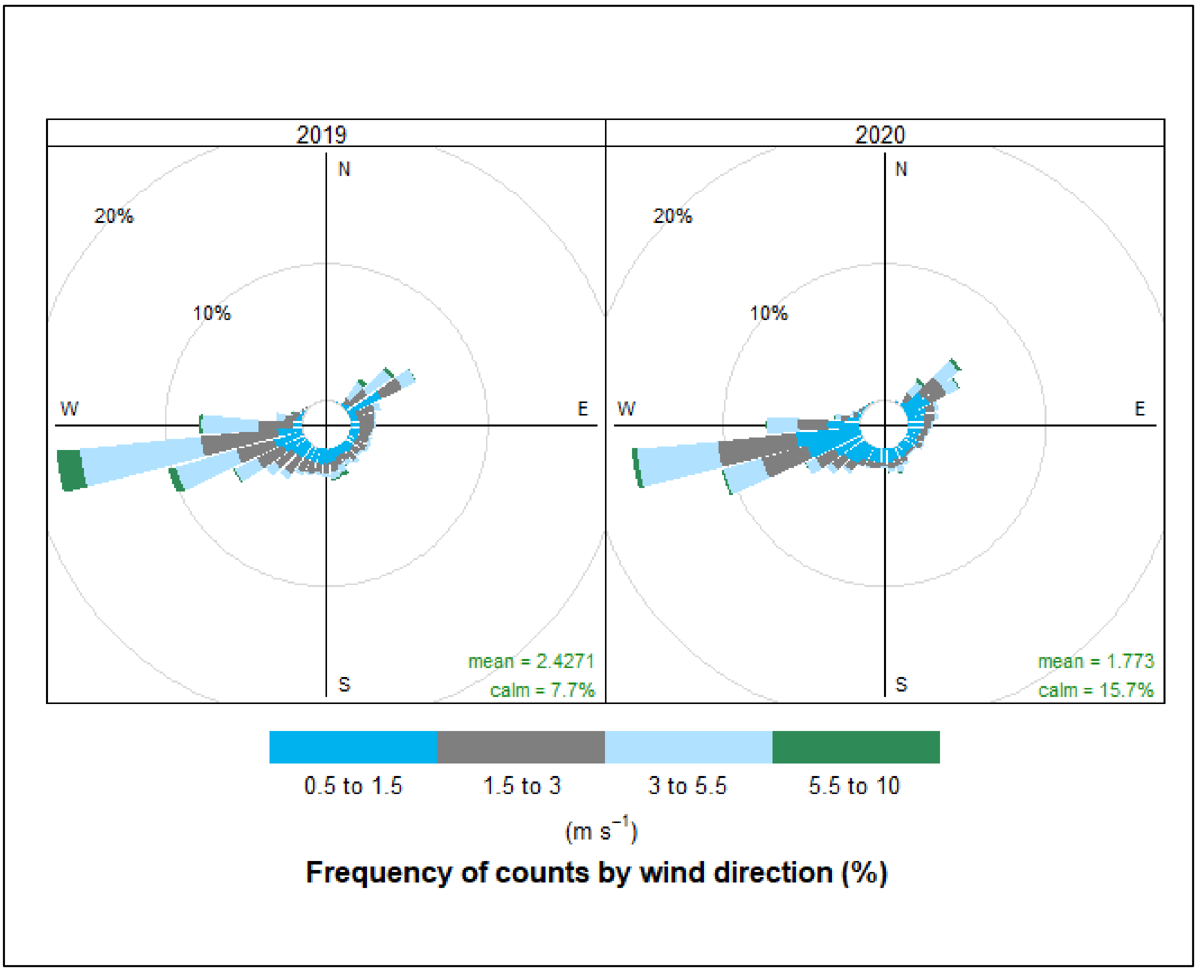


Figure 4-3 Wind roses for the onsite station, 2019 - 2020

In addition to the above meteorological analysis, the southern oscillation index (SOI) was analysed to determine if there were any significant El Nino or La Nina effects for the year of meteorological data used in the modelling. A sustained negative value for SOI of less than -7 indicates an El Nino event, whereas a sustained positive value of greater than +7 indicates a La Nina event. Ideally the year selected for modelling would have an SOI of greater than -7 and less than +7 to reduce the influence of any El Nino or La Nina effects on meteorological patterns. The calculated SOI is presented below in **Figure 4-4** at a monthly resolution and **Figure 4-5** at an annual resolution for the years 2016 to 2020. The SOI can fluctuate significantly over a short averaging period, however this is not necessarily an indication of a El Nino or La Nina event. A longer averaging period can be a better representation of an El Nino or La Nina event. When analysing the SOI at a monthly resolution for the modelling year selected, 2016, it began with an SOI indicating El Nino effects, however this trend was not sustained and generally fluctuated in the neutral range for the remainder of 2016. Additionally, the annual SOI average for 2016 is approximately -3, well outside of the ranges which indicate meteorology influenced by El Nino or La Nina events (<-7 or >+7). Therefore 2016 is considered suitable as a representative meteorological year for the purposes of modelling.

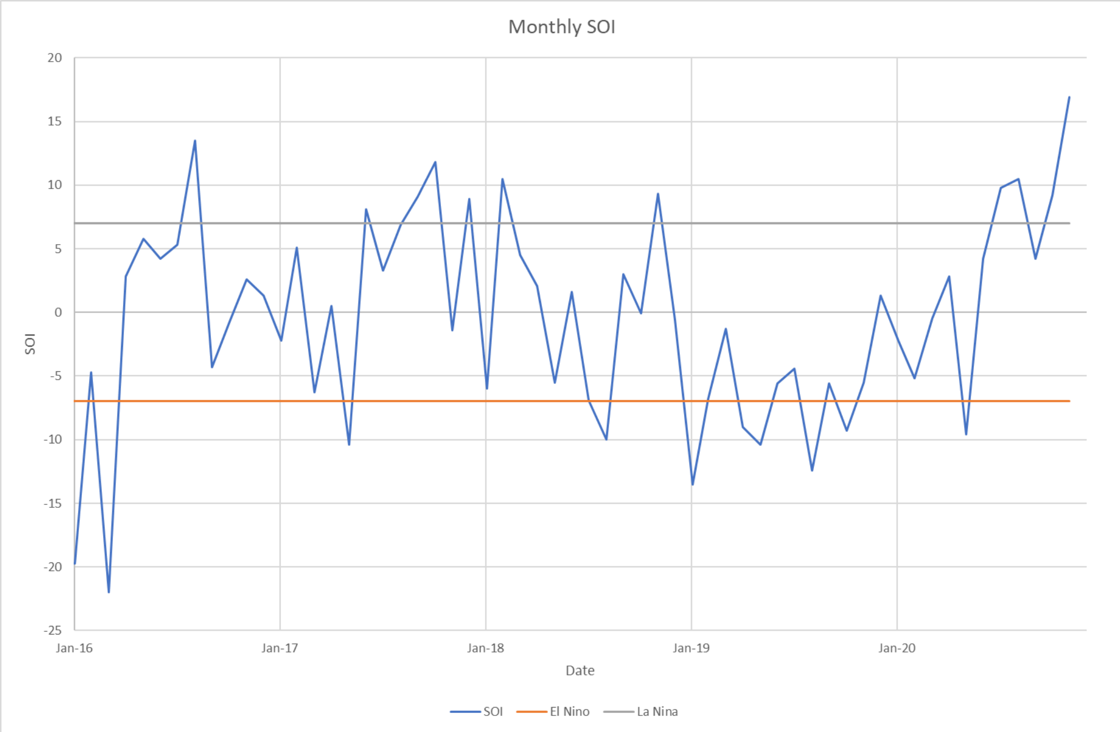


Figure 4-4 Monthly southern oscillation index

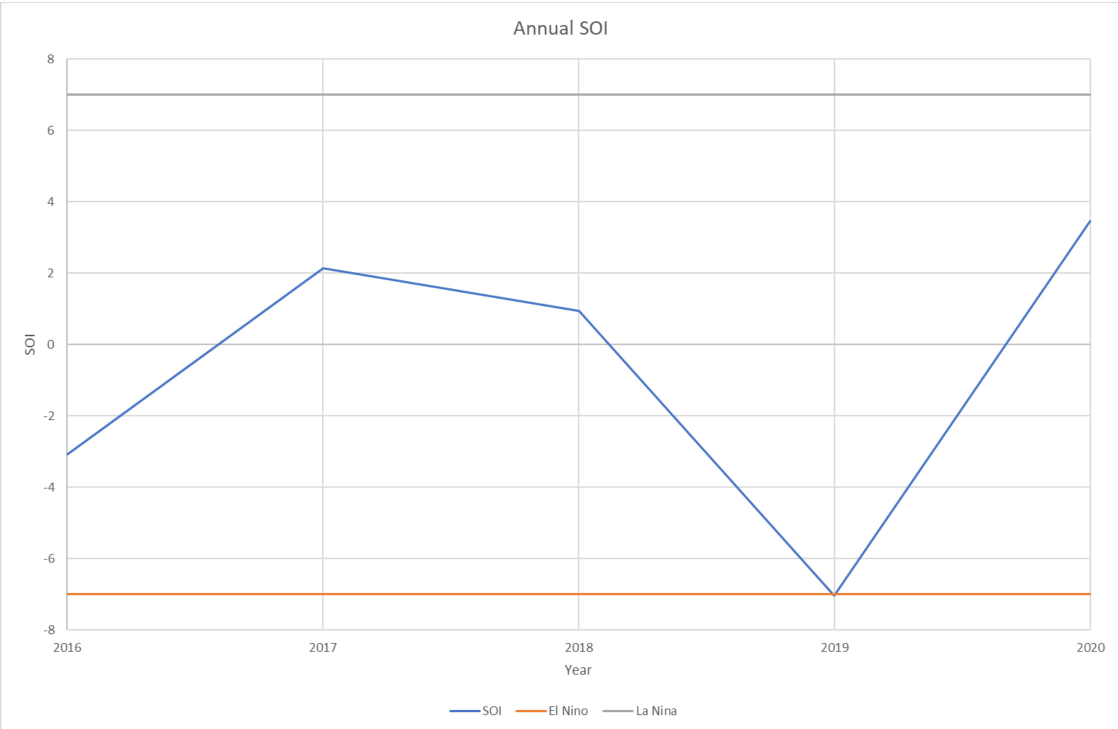


Figure 4-5 Annual southern oscillation index

The 2016 annual wind rose for the regional surface observation sites is presented in **Figure A3-2** (**Appendix 2**). Most sites display a dominant westerly component, the exception being the Wollongong DPIE site, which displays a southwest component. Each site also displays a secondary northeast component. Average winds speeds are approximately 3 m/s at Kembla Grange, 4 m/s at Wollongong Airport and Belambi AWS and 2 m/s at Wollongong. The percentage occurrence of calm winds (<0.5 m/s) is consistent across all sites and slightly higher at Wollongong.

Seasonal and diurnal wind roses for the onsite station in **Figure 4-6** and **Figure 4-7** during 2016 demonstrate consistent wind speeds and directions across all seasons and day and night periods. Seasonal and diurnal wind roses for Kembla Grange (**Figure A3-3** in **Appendix** 2) demonstrate higher wind speeds during the day and dominant onshore winds particularly during summer. Night-time winds are dominated by westerly drainage flow from elevated terrain in all seasons.

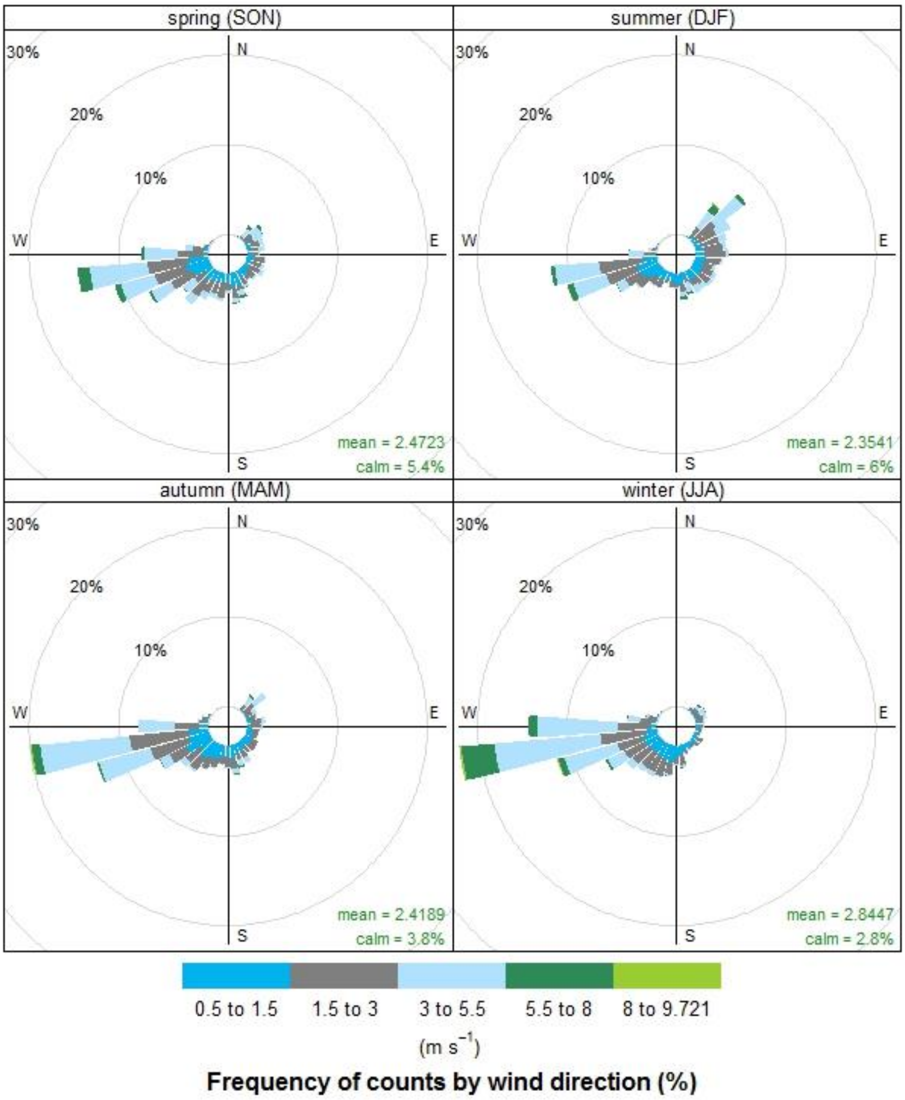


Figure 4-6: Seasonal wind roses for the onsite station - 2016

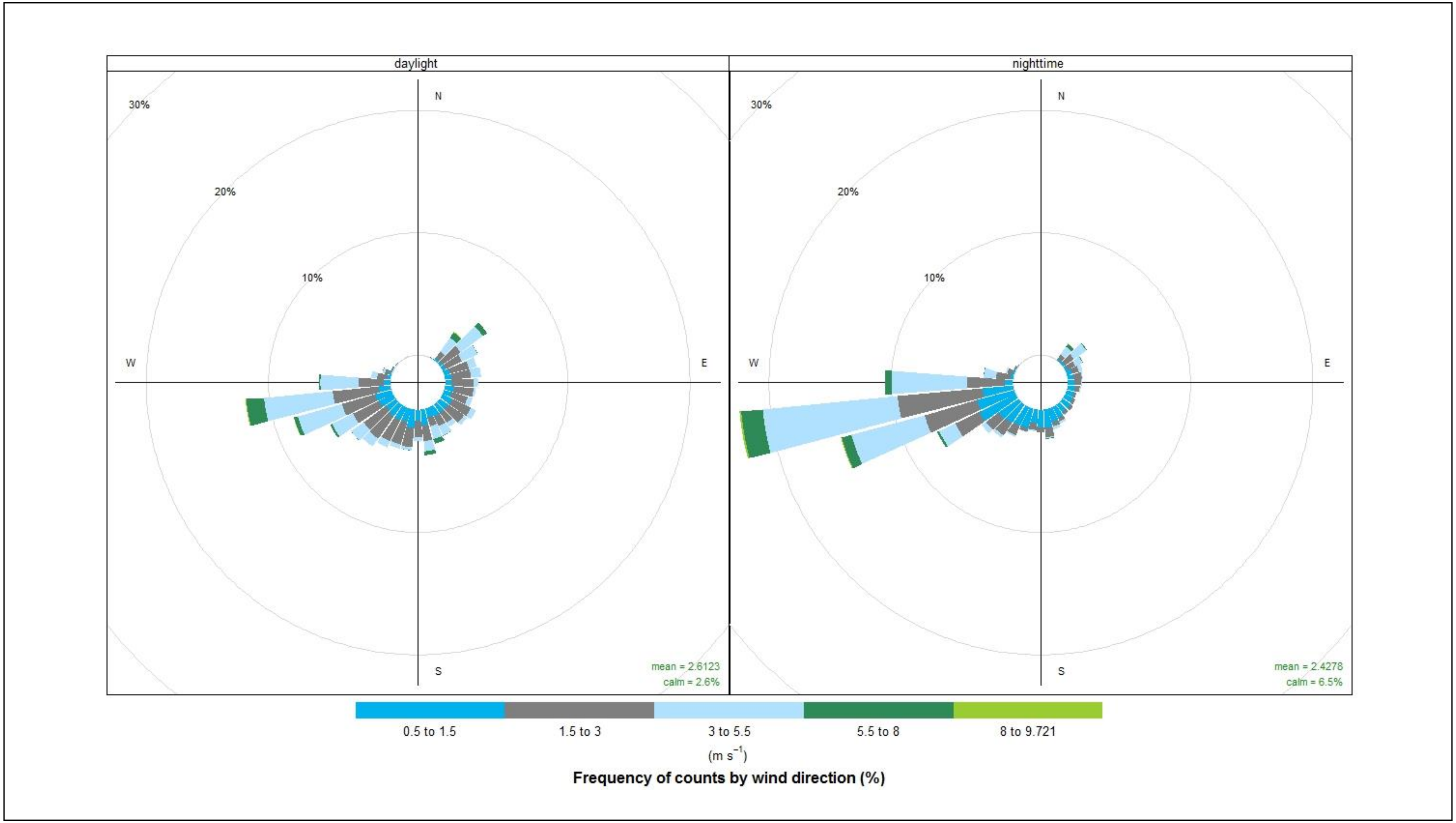
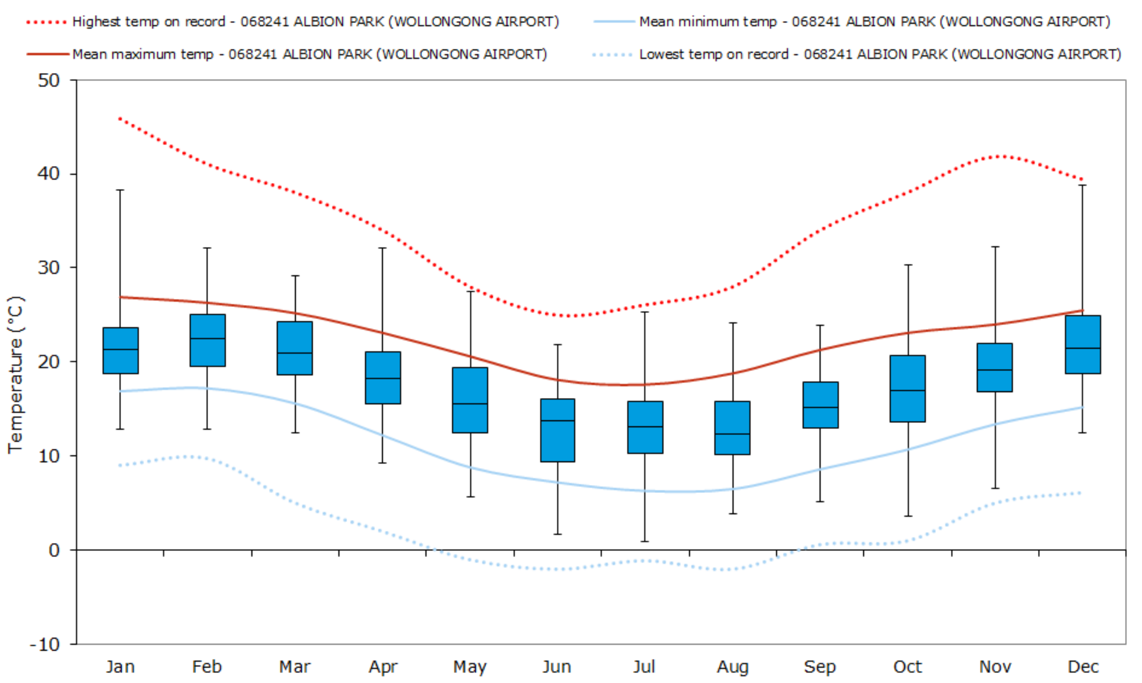


Figure 4-7: Diurnal wind roses for the onsite station - 2016

4.3 Ambient temperature

The minimum, maximum, mean and upper and lower quartile temperatures for each month of the modelling year (2016) are presented as a box and whisker plot shown in **Figure 4-8**, based on data from Wollongong Airport. The modelling year is compared with long-term records at the Wollongong Airport and shown to correlate well with the long-term trends. The upper and lower quartile and mean temperatures for 2016 fall within the long-term mean monthly maximum and minimum temperatures.

The highest temperature for 2016 occurred in December, which was also the highest temperature on record. The lowest temperature for 2016 occurred in July and all minimum temperatures for 2016 are above the long-term minimum.



2016 data are illustrated by the 'box and whisker' plot. Boxes indicate 25th, median and 75th percentile temperature values while upper and lower whiskers indicate maximum and minimum values.

Figure 4-8: Comparison of long-term temperature records with modelling period

4.4 Rainfall

Precipitation is important to air pollution since it impacts on dust generation potential and represents a removal mechanism for atmospheric pollutants. Fugitive emissions may be harder to control during low rainfall periods, while drier periods may also result in more frequent dust storms and bushfire activity, resulting in higher regional background dust levels. Rainfall also acts as a removal mechanism for dust, lowering pollutant concentrations by removing them more efficiently than during dry periods.

To provide a conservative (upper bound) estimate of the pollutant concentrations, wet deposition (removal of particles from the air by rainfall) was not included in the dispersion modelling for this report. Nevertheless, long term rainfall records for Wollongong Airport are presented in **Figure 4-9**. On average, the highest monthly rainfall occurs in February and March and the highest number of rain days occur in November and March.

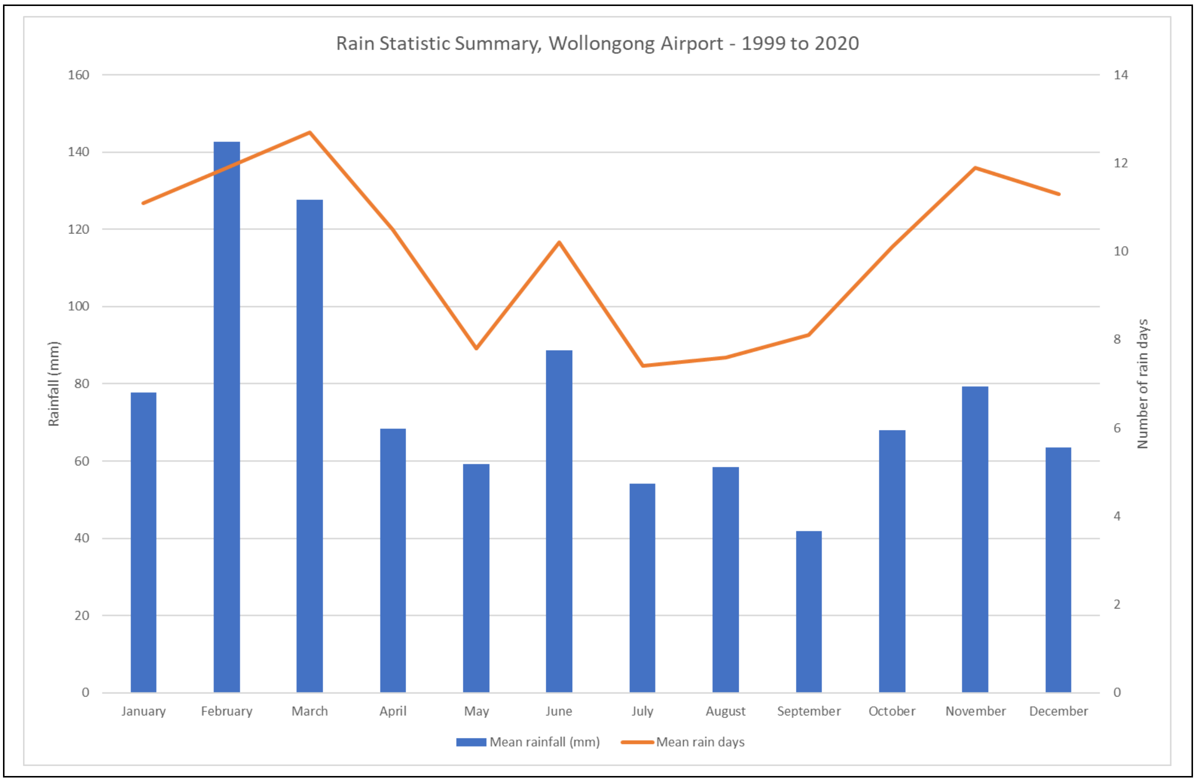


Figure 4-9: Long-term rainfall records for Wollongong Airport AWS

4.5 Meteorological modelling

Where no upper air measurements are available, CALMET can be run using prognostic upper air data (as a three-dimensional '3D.dat' file) and used to drive an 'initial guess' wind field. The model then incorporates mesoscale and local scale effects, including surface observations, to adjust the final wind field. This modelling approach is known as the "hybrid" approach (TRC Environmental Corporation, 2011) and is adopted for this assessment. TAPM was used to generate gridded upper air data for each hour of the model run period, for input into CALMET.

TAPM and CALMET model settings are described in **Appendix 3**, selected in accordance with recommendations in the Approved Methods and in TRC Environmental Corporation (2011).

Surface observations are included in the modelling (referred to as data assimilation) to provide real-world observations and improve the accuracy of the wind field. The surface observations are incorporated into both TAPM and CALMET modelling, for each of the sites shown in **Figure 4-1**.

4.5.1 CALMET predicted winds

CALMET predicted winds speeds are compared with observations at Kembla Grange DPIE site and the onsite meteorological station and shown in **Figure 4-10**. Both the Kembla Grange DPIE site and the onsite station were included as a surface observation site in the modelling, therefore the CALMET winds are expected to match closely to the observation. The dominant wind directions, mean wind speeds and frequency of calms are all similar.

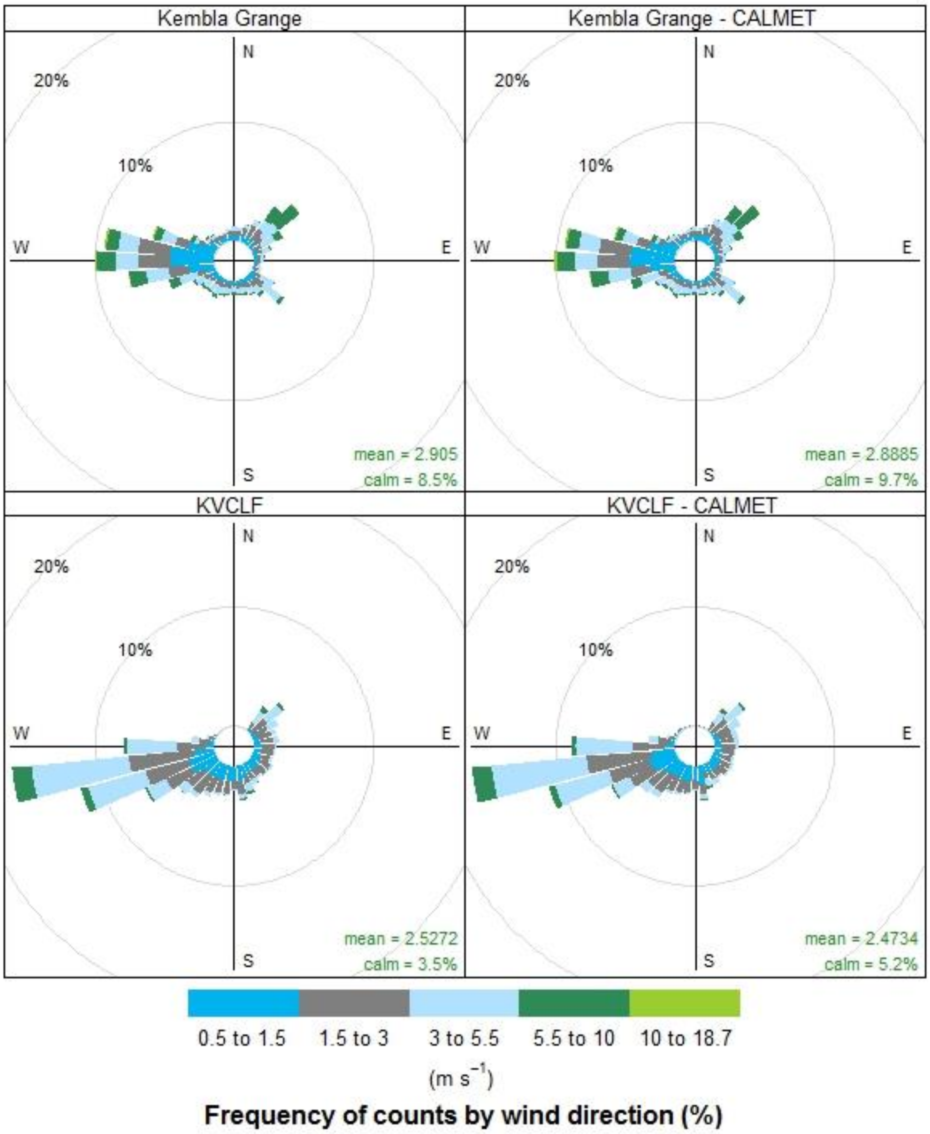


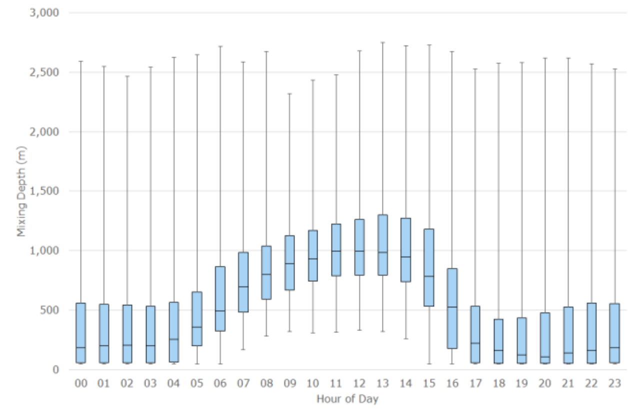
Figure 4-10: Comparison of CALMET winds with observations

4.5.2 Atmospheric stability and boundary layer heights

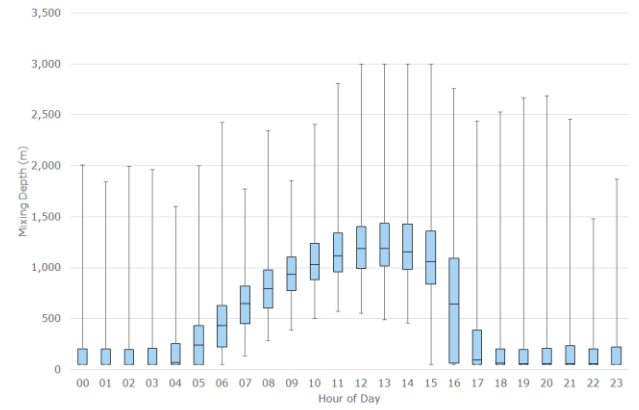
The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. This layer is directly affected by the earth's surface, either through the retardation of air flow due to the frictional drag of the earth's surface (mechanical mechanisms), or as result of the heat and moisture exchanges that take place at the surface (convective mixing) (Stull, 1997; Oke, 2003). During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated subsidence inversion. Due to radiative flux divergence, nights are typically characterised by weak to no vertical mixing and the predominance of stable conditions. These conditions are normally associated with low wind speeds and hence lower dilution potentials.

CALMET-generated mixing heights are extracted at three locations - Port Kembla, Kembla Grange and the KVCLF - to provide an indication of the spatial variation in CALMET-predicted atmospheric boundary layer heights and the average boundary layer heights by hour of the day is shown in **Figure 4-11**. As seen in median and upper and lower quartiles, the highest boundary layer heights are experienced during the day-time hours, peaking in the mid to late afternoon. Higher day-time wind velocities and the onset of incoming solar radiation increases the amount of mechanical and convective turbulence in the atmosphere. As turbulence increases, so too does the depth of the boundary layer, generally contributing to higher mixing depths and greater potential for atmospheric dispersion of pollutants. It is noted that the maximum mixing heights in the modelling data for night time hours reflect the increased mechanical mixing from higher wind speeds near the coast.

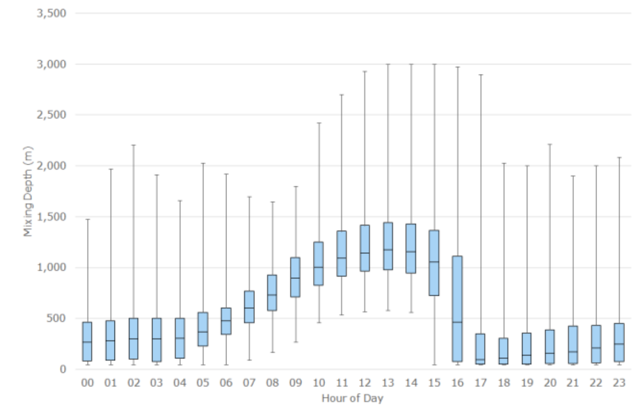
Atmospheric stability refers to the degree of turbulence or mixing that occurs in the atmosphere and is a controlling factor in the rate of atmospheric dispersion of pollutants. The Monin-Obukhov length (L) provides a measure of the stability of the surface layer (i.e. the layer above the ground in which vertical variation of heat and momentum flux is negligible - typically about 10% of the mixing height). 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 4-11** illustrates the diurnal variation of atmospheric stability derived from the Monin-Obukhov length calculated by AERMET for modelling. The diurnal profile at all locations illustrates that atmospheric instability increases during daylight hours as convective energy increases, while stable atmospheric conditions prevail during the night-time. The potential for atmospheric dispersion of emissions is therefore greatest during day-time hours and lowest during evening through to early morning hours.



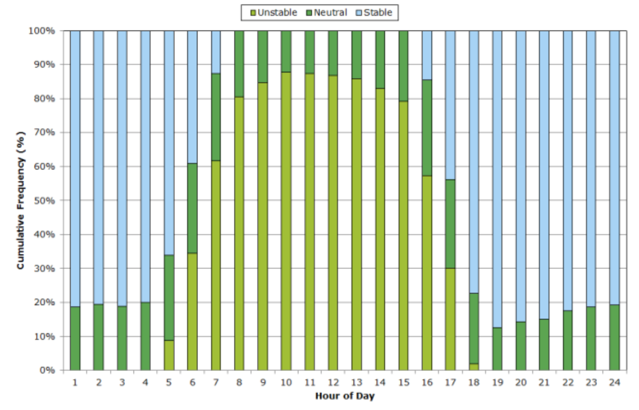
Port Kembla



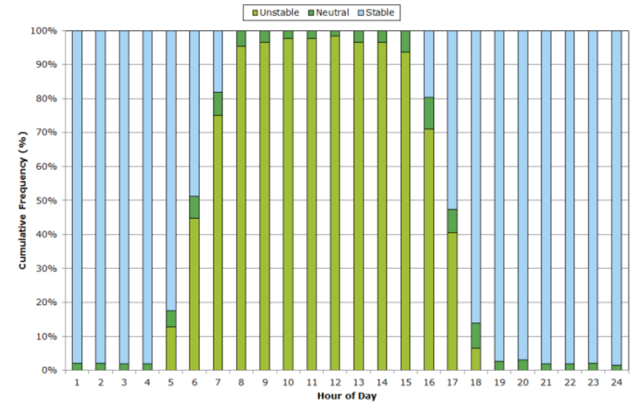
Kembla Grange



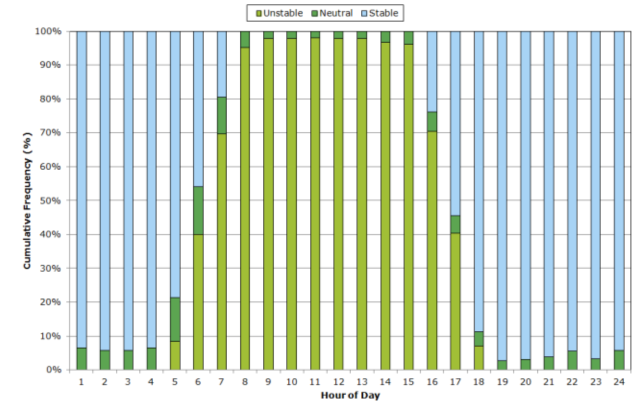
KVCLF



Port Kembla



Kembla Grange



KVCLF

Figure 4-11: Diurnal variations in CALMET-generated mixing heights and atmospheric stability

5. BASELINE AMBIENT AIR QUALITY

IMC has implemented and operates an air quality monitoring program for the Dendrobium Mine, shown in **Figure 5-1**, which historically included:

- Five dust deposition gauge locations, measuring monthly dust deposition and conducting additional laboratory analysis.
- Two high volume air sampler (HVAS) locations, measuring TSP and PM_{10} concentrations on a monthly basis.

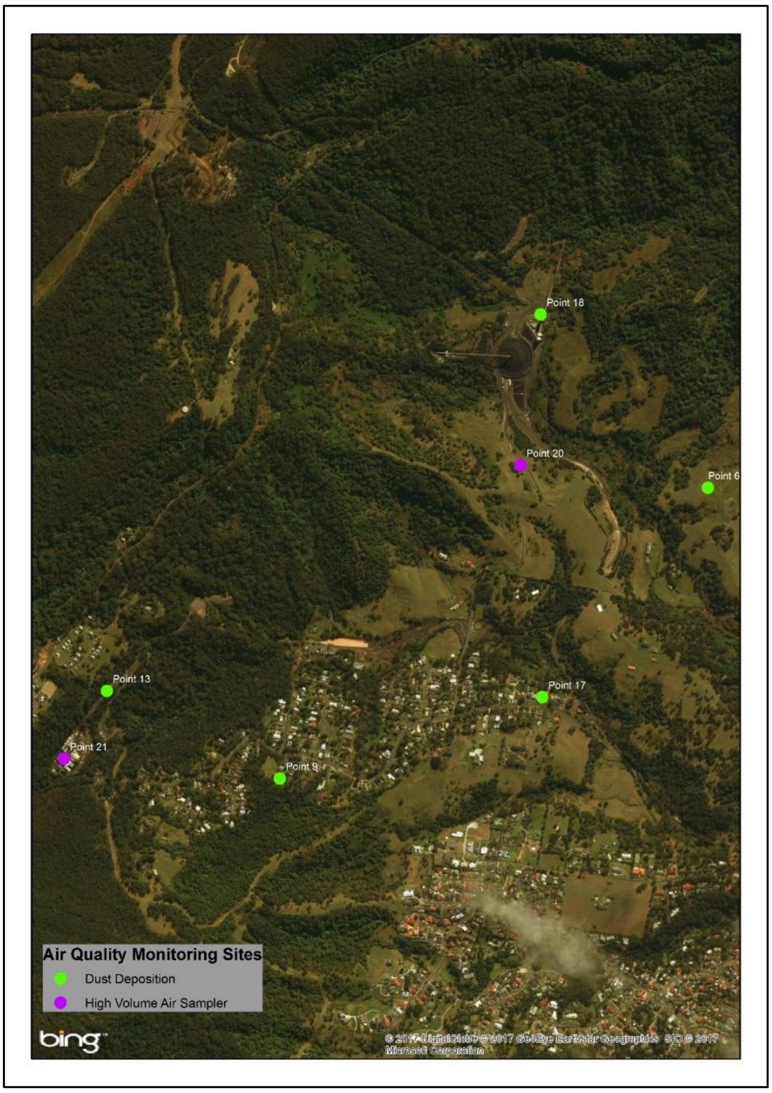


Figure 5-1 Onsite dust monitoring locations

A review of the onsite monitoring data and other regional sources of data are provided in the following sections. The locations used for the baseline review are shown in **Figure 5-2**.

Dust deposition sampling was discontinued in 2021. High volume air samplers were replaced by two real time photometers (at Points 20 and 21) measuring PM_{10} have been operational from July 2021, however this monitoring data has not been used in this AQA.

5.1 PM_{10} and $PM_{2.5}$ concentrations

The average PM_{10} concentrations for the onsite data are summarised in **Table 5-1** for each year. It is noted that these are not true annual averages, as the HVAS are only run once a month. For the same reason, it is not possible to determine the maximum 24-hour PM_{10} concentrations or the number of days over the impact assessment criteria.

Nevertheless, the data are useful to provide an indication of background conditions in the vicinity of the Dendrobium Pit Top and the KVCLF. Concentrations are consistently higher at Point 21, located on the roof of the bathhouse building at the Dendrobium Pit Top, compared with Point 20, located at the entrance to the KVCLF. The average background PM_{10} concentration across both sites and all years is approximately 70% of the impact assessment criteria.

The onsite monitoring data alone is not suitable to derive background datasets for cumulative assessment. For the assessment of cumulative 24-hour impacts, continuous measurements of PM_{10} and $PM_{2.5}$ are needed.

Reference is therefore made to the NSW DPIE sites at Kembla Grange and Wollongong, which both measure PM_{10} and $PM_{2.5}$ on a continuous basis. Summary statistics for the past nine years are presented in **Table 5-1**. $PM_{2.5}$ was added at Kembla Grange in February 2015, however measurements of fine particles by nephelometry[3] are available for 2012 to 2015 and can be used to fill in gaps in the $PM_{2.5}$ data record. A linear relationship between the two variables is derived based on the available data and used to 'predict' $PM_{2.5}$ concentrations where direct measurement is not available.

At Kembla Grange, annual average background PM_{10} concentrations are 75% of the impact assessment criteria (based on the previous nine years). At Wollongong, annual average background PM_{10} concentrations are 70% of the impact assessment criteria (based on the previous nine years). At both sites, annual average background $PM_{2.5}$ concentrations are greater than 80% of the impact assessment criteria (based on the previous nine years).

Exceedances of the 24-hour average impact assessment criteria for PM_{10} occurred in each of the previous nine years at Kembla Grange and in 2013 and 2016 to 2020 at Wollongong. Exceedances of the 24-hour average impact assessment criteria for $PM_{2.5}$ occurred in 2013, 2016, 2019 and 2020 at Kembla Grange and in 2013, 2015, 2018 to 2020 at Wollongong. Long term (2012 – 2020) timeseries plots of 24-hour average concentrations for the DPIE Kembla Grange and Wollongong locations are presented below in **Figure 5-3** and **Figure 5-4**. Timeseries plots of the 24-hour average concentrations at Kembla Grange and Wollongong for 2016 are presented in **Figure 5-5** to **Figure 5-8**.

[3] Monitoring method for fine particles using light scattering sensors. Used as a measure of visibility (or coefficient of light scattering).

Table 5-1: PM_{10} and $PM_{2.5}$ monitoring statistics across all monitoring sites

Site	Parameter	Statistic	2012	2013	2014	2015	2016	2017	2018	2019	2020
EPL Point 20	PM_{10}	Mean	16.5	12.8	14.4	13.4	14.2	15.1	11.3	14.3	11.2
		Max daily	-	-	-	-	-	-	-	-	-
		Days over 50 µg/m³	-	-	-	-	-	-	-	-	-
EPL Point 21	PM_{10}	Mean	16.8	24.2	25.9	19.9	19.3	16.1	14.2	21.3	25.1
		Max daily	-	-	-	-	-	-	-	-	-
		Days over 50 µg/m³	-	-	-	-	-	-	-	-	-
Kembla Grange - DPIE	PM_{10}	Mean	18.3	18.5	17.3	17.8	20.0	20.7	22.8	25.5	21.6
		Max daily	57.2	102.2	99.2	62.8	56.3	67.7	71.8	115.8	187.7
		Days over 50 µg/m³	3	4	1	1	4	5	10	22	19
	$PM_{2.5}$	Mean	6.3	6.9	6.3	6.5	6.6	6.9	7.1	8.7	7.2
		Max daily	18.5	98.5	16.4	23.8	32.0	21.3	21.9	70.1	100.4
		Days over 25 µg/m³	0	5	0	0	2	0	0	12	12
Wollongong - DPIE	PM_{10}	Mean	18.0	17.6	17.7	16.9	17.3	18.1	19.9	22.3	18.8
		Max daily	47.5	93.8	45.3	45.8	52.9	55.3	59.7	117.6	121.6
		Days over 50 µg/m³	0	3	0	0	2	1	5	17	11
	$PM_{2.5}$	Mean	4.6	7.7	7.0	7.6	7.4	7.0	7.3	8.9	7.8
		Max daily	15.6	88.4	17.3	31.6	33.7	24.7	47.6	81.5	100.9
		Days over 25 µg/m³	0	4	0	1	3	0	3	14	10
BlueScope Steel – Old Scout Hall, Warrawong	PM_{10}	Mean	-	-	-	-	17.9	-	-	-	-
		Max daily	-	-	-	-	62.9	-	-	-	-
		Days over 50 µg/m³	-	-	-	-	7	-	-	-	-
BlueScope Steel – North Gate	PM_{10}	Mean	-	-	-	-	21.1	-	-	-	-
		Max daily	-	-	-	-	64.1	-	-	-	-
		Days over 50 µg/m³	-	-	-	-	7	-	-	-	-

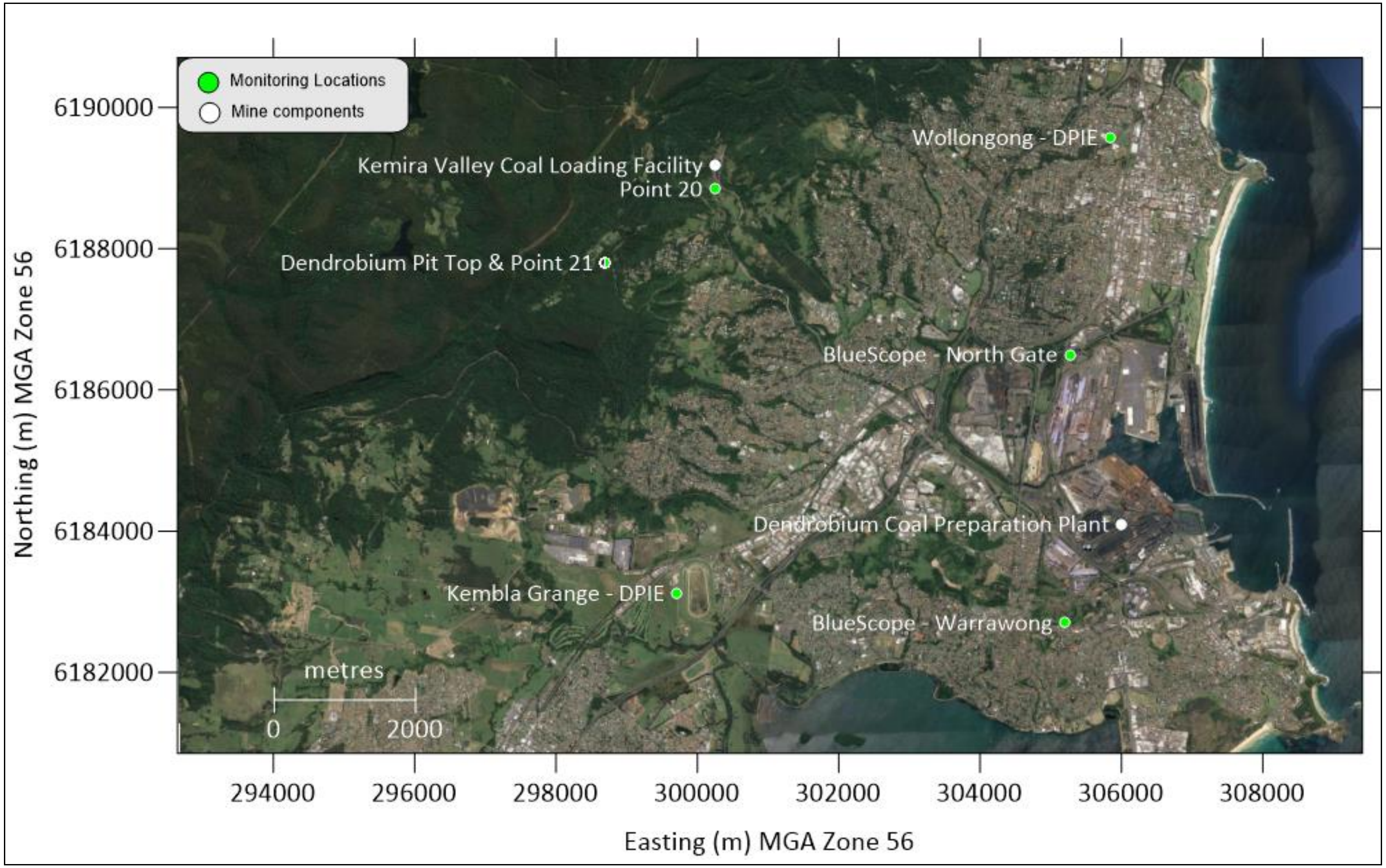


Figure 5-2: Location of $PM_{2.5}$ and PM_{10} monitoring sites used for baseline analysis

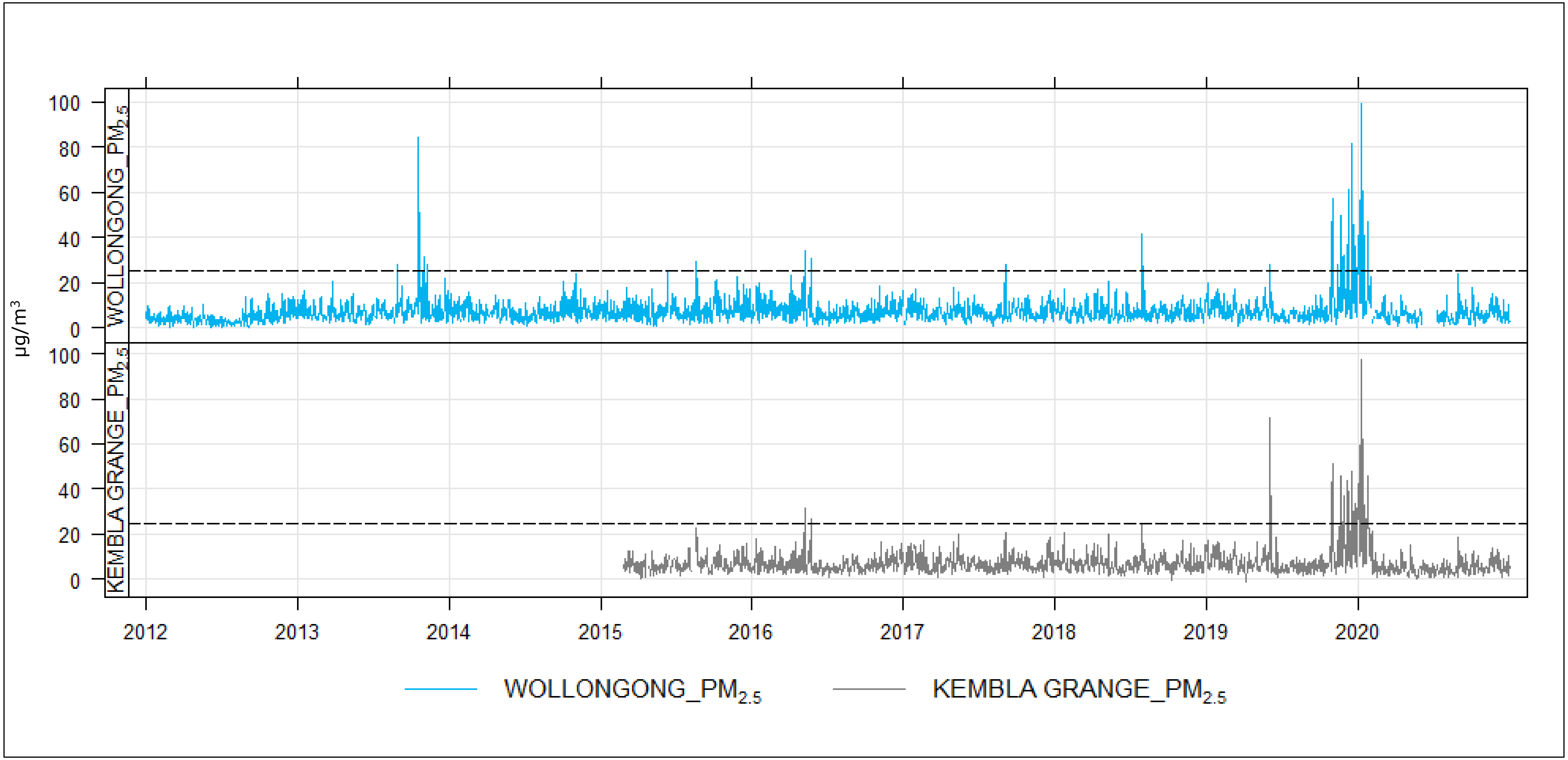


Figure 5-3: 24-hour average $PM_{2.5}$ (µg/m³) concentration, 2012 - 2020

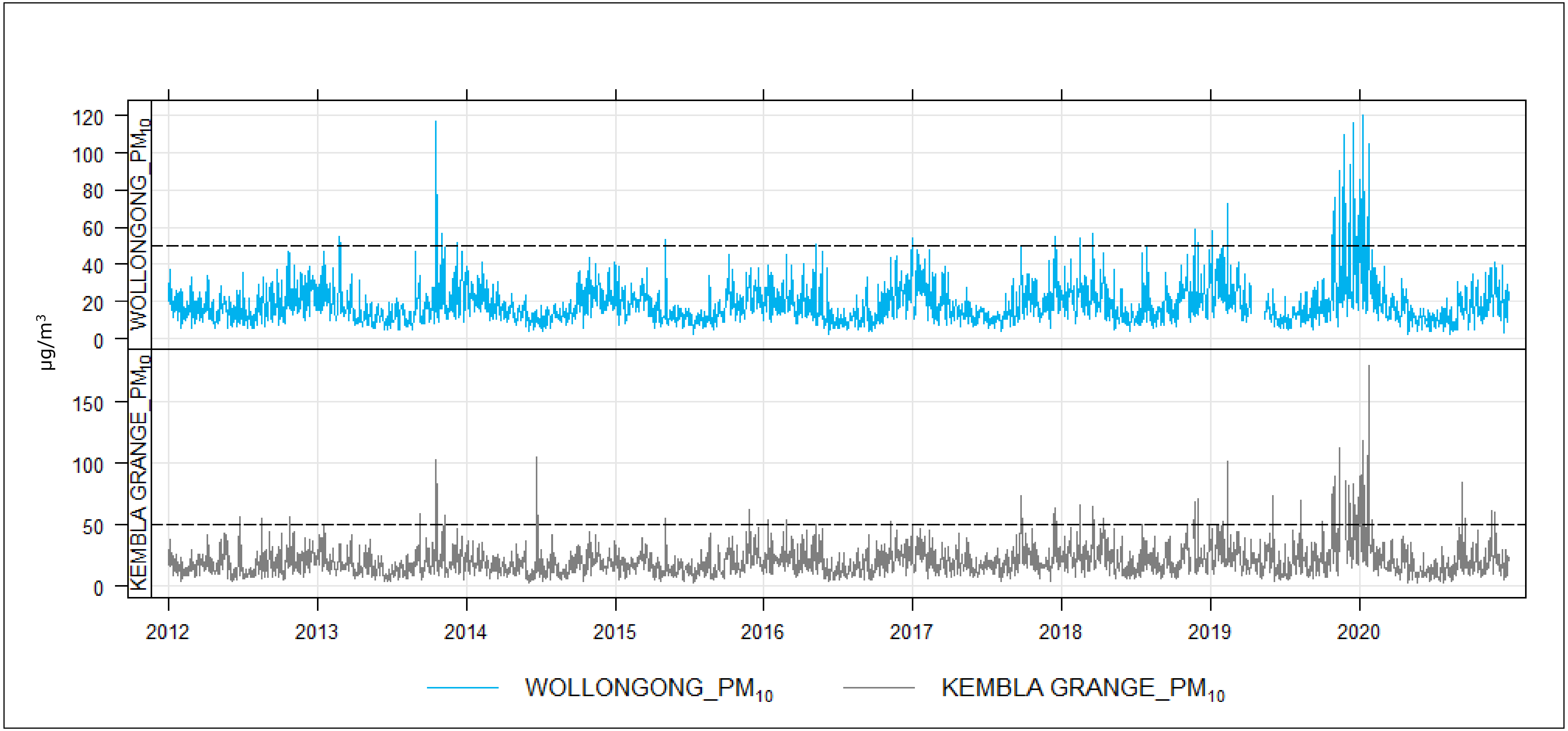


Figure 5-4 24-hour average PM_{10} (μg/m³) concentration, 2012 - 2020

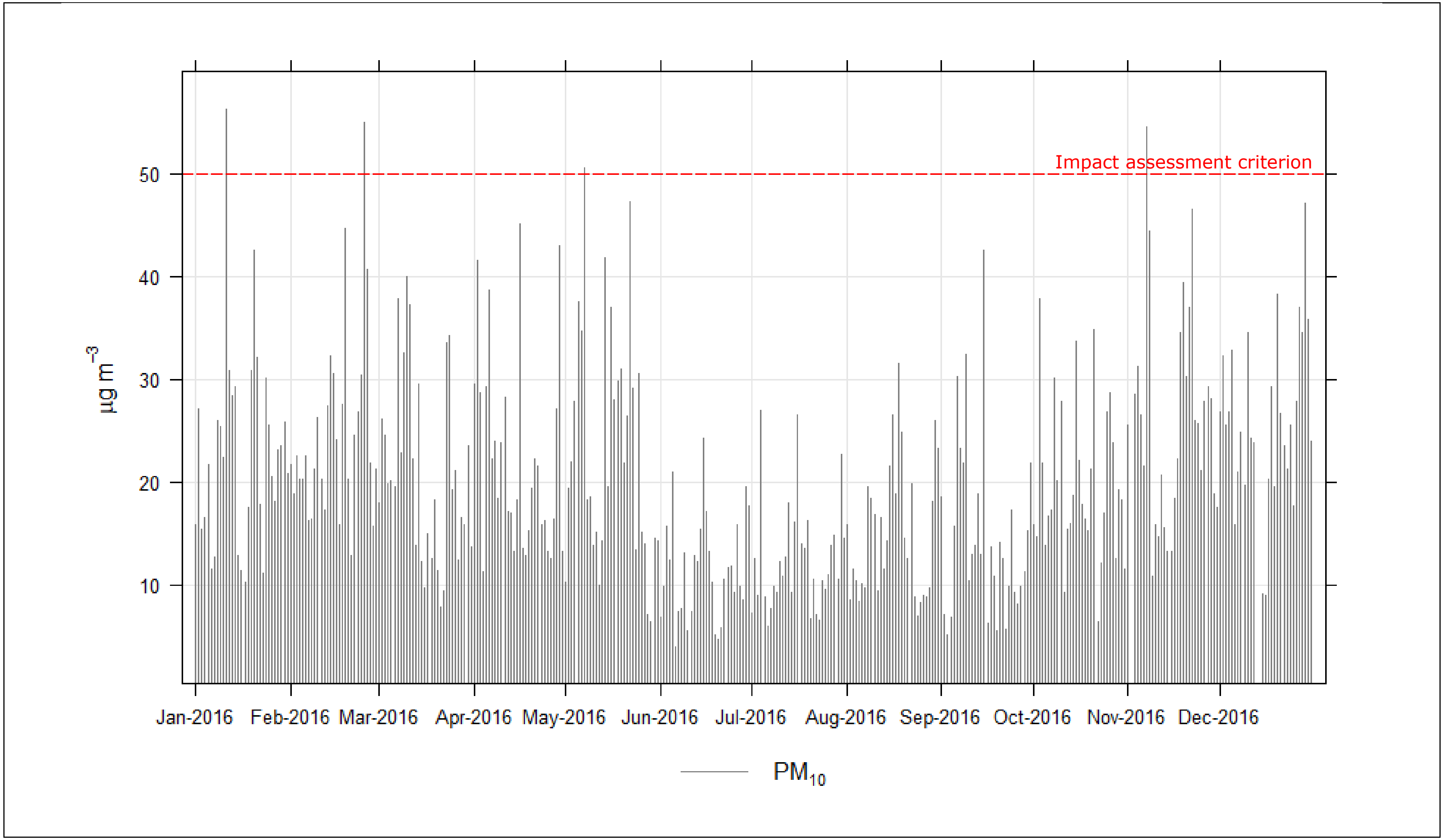


Figure 5-5: Time series of 24-hour PM_{10} concentrations at Kembla Grange - 2016

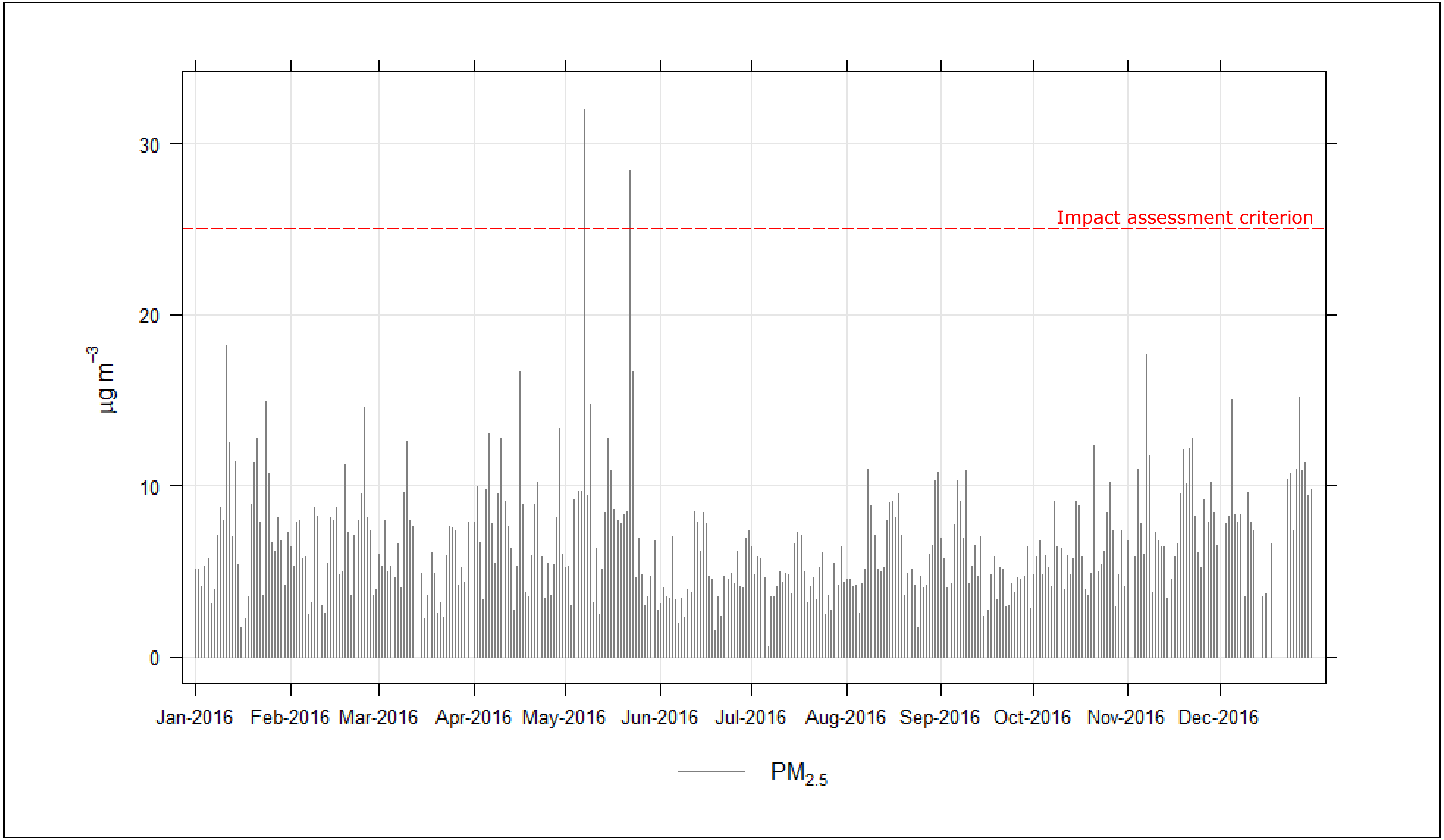


Figure 5-6: Time series of 24-hour $PM_{2.5}$ concentrations at Kembla Grange - 2016

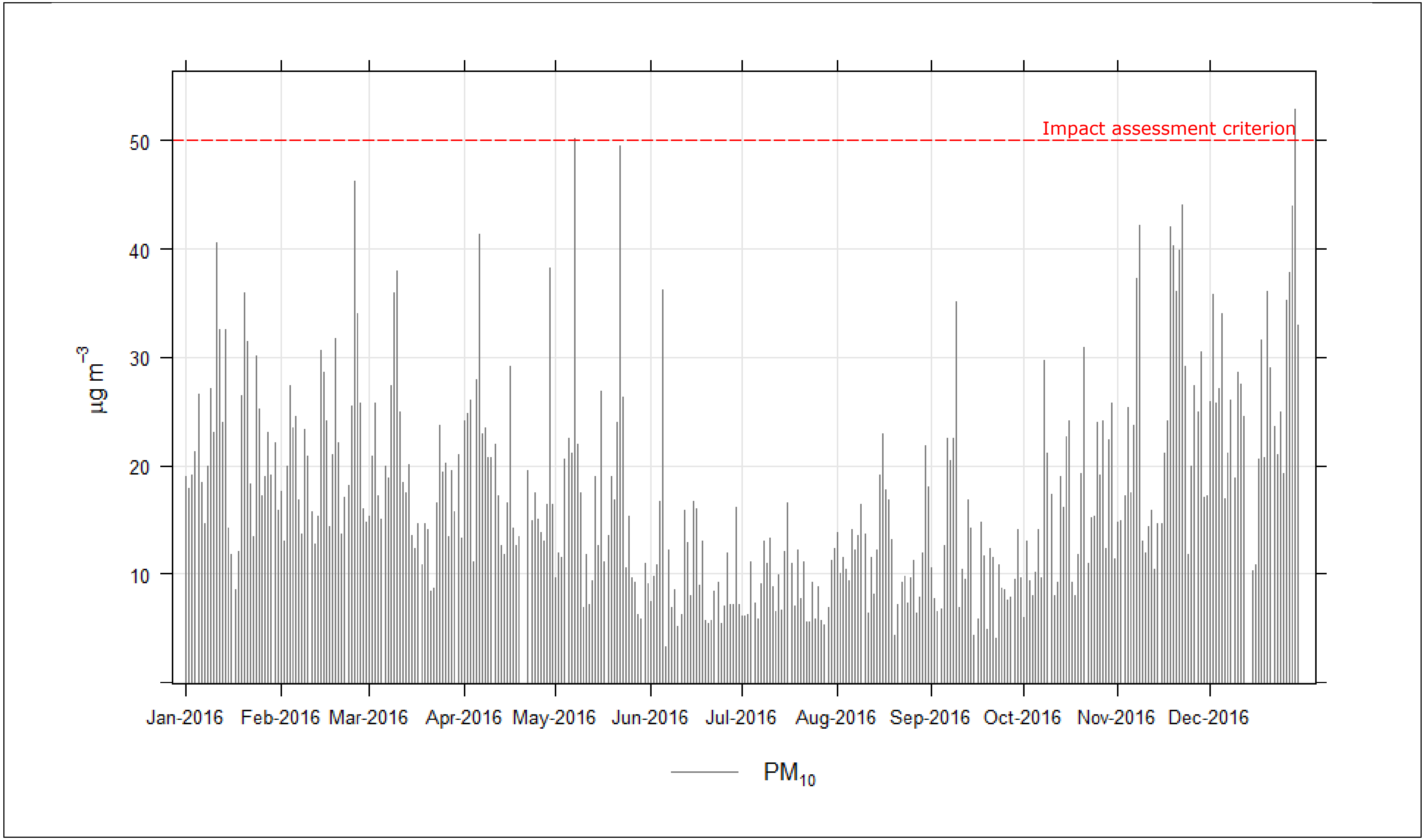


Figure 5-7: Time series of 24-hour PM_{10} concentrations at Wollongong - 2016

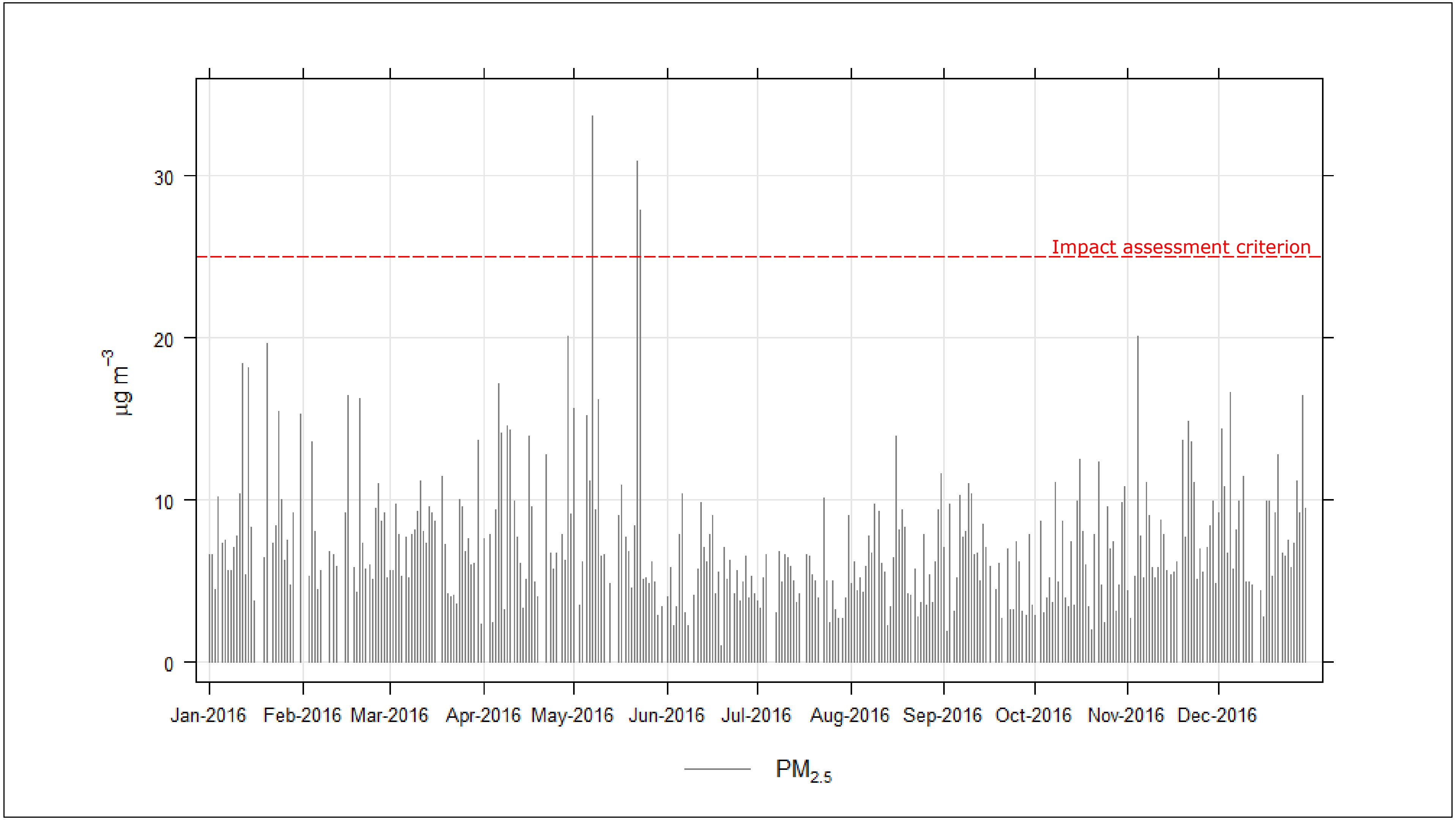


Figure 5-8: Time series of 24-hour $PM_{2.5}$ concentrations at Wollongong - 2016

The number of exceedances of PM_{10} in 2018 were higher than the longer-term average, largely due to wide spread dust storms in much of NSW. The BOM (2019) summary described 2018 as the warmest year on record and very dry, which resulted in a dusty year. NSW DPIE DustWatch reported significant dust storms in:

- February, several dust storms, more dust than previous years.
- April, highest dust activity with the largest dust storm since the 'red dawn' 2009 event.
- August, dustiest August since 2005, large dust storms due to very strong storm frontal winds.
- November, two separate dust events with higher winds than expected for the time of year.

The increase in exceedances was not seen for $PM_{2.5}$ in 2018, as generally dust storms contain larger particles (greater than 2.5 µm). 2019 and 2020 saw higher recorded concentrations than historical averages and more exceedances of the criteria for both PM_{10} and $PM_{2.5}$ due to the extreme firestorms on the east coast. On this basis, it was deemed that 2018 to 2020 were not considered representative of typical background concentrations of $PM_{2.5}$ and PM_{10}.

Data are also presented for the Port Kembla area, based on monitoring sites operated by BlueScope Steel. Under its Environment Protection Licence (EPL), BlueScope Steel is required to report online real-time hourly PM_{10} concentration data for two monitoring sites, one located in Warrawong (Old Scout Hall) and one located north of the steelworks (near the North Gate visitors centre). Summary statistics for 2016 are presented in **Table 5-1**. At the time of reporting a validated dataset covering 2017 – 2020 was not available, however the data would be assumed to follow the same general trends as Wollongong and Kembla Grange. The absent data are not considered to be a limitation of the background air quality characterisation.

The annual mean for Warrawong for 2016 (the site closest to the CPP) is similar in magnitude to the other monitoring locations (72% of the impact assessment criterion), although the number of days above 50 µg/m³ is higher than Kembla Grange. The annual mean for North Gate is higher than all other sites (84% of the impact assessment criterion) and the number of days above 50 µg/m³ is the same as Warrawong.

5.2 TSP and Dust deposition

The average TSP concentrations for the onsite data are summarised in **Table 5-2** for each year. Point 20 is located south of the stockpile at Kemira Valley and Point 21 is located at the roof of the bathhouse building at Dendrobium Pit Top. Similar to PM_{10}, TSP concentrations are consistently higher at Point 21 compared with Point 20 and the average background TSP concentration across both sites and all years is 37% of the impact assessment criterion. 2018 to 2020 TSP data were not removed due to the reasons discussed above for PM_{10} and $PM_{2.5}$, as measured concentrations were of a similar magnitude to historical concentrations.

Table 5-2: Mean TSP concentrations (µg/m³) for onsite data

Site	Parameter	2012	2013	2014	2015	2016	2017	2018	2019	2020
Point 20	TSP	32.4	30.1	22.0	21.7	19.0	22.8	22.2	26.0	32.5
Point 21	TSP	49.3	53.1	50.1	42.0	27.6	27.6	25.3	53.5	49.8

The annual average dust deposition monitoring results for EPL monitoring points is presented in **Table 5-3**. Dust deposition rates averaged over the previous nine years ranges from 0.7 g/m²/month at Point 6 to 3.8 g/m²/month at Point 18, with an overall average across all sites and years of 1.8 g/m²/month. This is typical of background dust deposition across much of NSW, which is typically measured in the range of 1 g/m²/month to 2 g/m²/month.

Table 5-3: Annual average dust deposition for EPL points (g/m^2/month as insoluble solids)

Site	2012	2013	2014	2015	2016	2017	2018	2019	2020
Point 6	1.1	1.3	1.0	0.7	1.1	0.7	1.0	1.3	2.0
Point 9	2.9	3.1	3.6	2.1	0.7	1.2	1.3	1.1	1.4
Point 13	2.8	3.5	3.0	1.2	0.7	2.6	2.4	2.3	2.9
Point 17	1.0	0.8	0.9	0.9	0.6	0.8	0.9	1.3	1.4
Point 18	3.8	1.9	3.6	1.8	2.4	2.6	3.7	2.6	2.9

Additional visual analysis of the dust deposition monitoring data for all offsite monitoring locations shows that, on average, approximately 10% of the total deposition is comprised of coal dust. The remaining deposited dust is comprised of dirt, vegetation, insects and other fibrous material. At the monitoring sites located onsite at the Dendrobium Pit Top and KVCLF (Point 13 and Point 18), coal dust comprises approximately 20% and 30%, respectively.

5.3 Summary and adopted background for cumulative assessment

Cumulative assessment for annual average PM_{10} and $PM_{2.5}$ is based on a background derived average from 2012 to 2017 data from all sites presented in **Table 5-1**. It should be noted that background concentrations of particulates would include existing operations from the mine. Data from 2018 to 2020 were considered to be not representative due to the extraordinary dust and fire events in that period. This approach accounts for temporal and spatial variation in background PM that might occur for the Project in future years. Similarly, the annual average background TSP concentration and dust deposition rate is taken as the period average of all available data from all sites, presented in **Table 5-2** and **Table 5-3**.

For the assessment of short-term impacts for PM_{10} and $PM_{2.5}$, daily varying concentrations for 2016 from the Kembla Grange monitoring site are paired with modelling predictions for assessment of cumulative impacts. The background values adopted for cumulative assessment are summarised in **Table 5-4**.

Table 5-4: Adopted background for cumulative assessment

Pollutant	Averaging period	Adopted background value	Source
PM_{10}	24-hour average	Daily varying	Kembla Grange daily monitoring data for 2016.
	Annual average	18.4 µg/m³	Period average across all sites for 2012-2017.
$PM_{2.5}$	24-hour average	Daily varying	Kembla Grange daily monitoring data for 2016.
	Annual average	6.7 µg/m³	Period average across all sites for 2012-2017.
TSP	Annual average	33.7 µg/m³	Period average across all sites for 2012-2020.
Dust deposition	Annual average	1.8 g/m^2/month	Period average across all sites for 2012-2020.

6. EMISSIONS INVENTORY

Relevant emissions are estimated for each component of the Project, as outlined in **Table 2-1,** and summarised as follows:

- KVCLF – fugitive dust from handling and stockpiling of coal, including conveying, sizing, loading the stockpile, maintaining the stockpile and loading trains.
- Dendrobium Pit Top – fugitive dust from vehicle movements associated with personnel and materials access to the underground workings via the Dendrobium Tunnel and surface activities.
- Kemira Valley Rail Line – fugitive emissions from coal wagons and diesel particulate emissions from locomotives.
- Dendrobium CPP – fugitive dust from handling and stockpiling of coal and coal wash, including unloading trains, conveying, loading stockpiles, maintaining stockpiles, loading trucks, wind erosion.
- Gas drainage and management – including dust and odour emissions associated with upcast ventilation shafts (at Shaft No. 5A) and combustion emissions associated with flaring (pre and post drainage). Drainage and management of gas associated with Area 5 may occur at Shaft Site No. 2/3 in Area 3 and/or at Shaft Site No 5A. The No. 2/3 Shaft Site at Area 3 was approved as a part of the existing mine and the proposed gas management infrastructure at the site is not a part of the Project. However, a gas drainage plant including flaring was conservatively modelled simultaneously at both Area 3 and Area 5 to assess potential impacts from both locations. As gas management is not expected to occur at both sites simultaneously, the modelled predictions are considered to be highly conservative.
- CPP Coal dryer – combustion emissions associated with the coal dryer at the CPP.

6.1 Overview of existing dust controls

Existing dust control measures are outlined in the Dendrobium Mine Air Quality and Greenhouse Gas Management Plan (AQGHGMP). A review of these existing controls against best management practices (BMP) was completed in 2012, as part of the Particulate Matter Control Best Practice Pollution Reduction Program (PAEHolmes, 2012). This review found that existing measures were in accordance with best practice. An updated BMP determination for the Project is summarised in **Appendix 4**.

The existing dust controls are as follows:

- Wind shielding for conveyors and scrapers to clean the return conveyor.
- Reduced drop height (rill tower) and water sprays in the rill tower, for loading the KVCLF stockpile and for train loading.
- Enclosure of the coal sizer with mechanical extraction and control.
- Automated dust suppression system on the KVCLF stockpile.
- Sealed travel routes at the Dendrobium Pit Top and KVCLF and regular operation of a road sweeper. Hosing down of sealed areas is also undertaken if required at the Pit Top.
- Automated fixed water spray system on the mine portal access road.
- Enclosed train loading and profiling of the load.
- Maintaining moisture content of ROM coal in rail wagons above the Dust Extinction Moisture (DEM) level[4].
- Restricted train speeds to minimise fugitive emissions.
- Wind shielding for conveyors and water sprays on transfer points at the CPP.
- Water trucks and water sprays operating at the CPP stockpile areas.
- Water truck operating on internal travel routes at the CPP.
- Covered loads for coal wash trucks.

[4] Measured moisture content for ROM coal arriving at the CPP (6.5%) is higher than the measured DEM level (4.6%). See **Appendix 5**.

The majority of these dust controls are incorporated into the emissions inventory, where appropriate control efficiencies are reported in the literature.

6.2 Modelling scenarios

A single modelling scenario is presented for the KVCLF, Dendrobium Pit Top, Kemira Valley, Rail Line and CPP, based on the maximum production rate of 5.2 Mtpa.

As a part of the existing mine, it is proposed to install a gas drainage plant at Shaft Site No 2/3 that would service Area 5 mine gas via an underground pipeline. The gas drainage plant would be comprised of a single gas vent stack and two enclosed flares. The gas drainage plant layout is proposed to leave space for an additional flare if required in the future, and therefore three flares were modelled to account for worst case emissions.

Area 5 is proposed to be serviced by an upcast and downcast ventilation shaft located at Shaft Site 5A.

As a worst-case scenario the assessment includes a gas drainage plant of equivalent specification (i.e. one vent stack and three flares) at Shaft Site 5A for Area 5 operating concurrently to allow for gas drainage if required at this location.

6.3 Dust emission estimates

Fugitive dust emissions are estimated using emission factors developed by the United States Environmental Protection Agency (US EPA)[5] and the estimated annual emissions for each Project component are presented in **Table 6-1**. Further information on emission inventory development is provided in **Appendix 4**, including the assumptions, input data and emission factors.

The relative contribution of each Project component to annual PM_{10} emissions is presented in **Figure 6-1**.

The largest source of annual PM_{10} emissions is the CPP, followed by the two upcast ventilation shafts. It is noted that the throughput at the CPP is not proposed to change due to this Project, and therefore the potential impacts of dust surrounding the CPP would also be expected not to change from current levels. Also, as mentioned above, the ventilation shaft at Area 3 was approved as a part of the existing mine and therefore was not a part of the expansion project. The ventilation shafts are located in remote areas and the ranking of this source in terms of annual emissions is not indicative of the potential impact on receptor locations (**Section 7**).

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[5] US EPA AP-42 Compilation of Air Pollutant Emissions Factors (US EPA, 1998b; US EPA, 2004; US EPA, 2011; US EPA, 2006a; US EPA, 2006b).

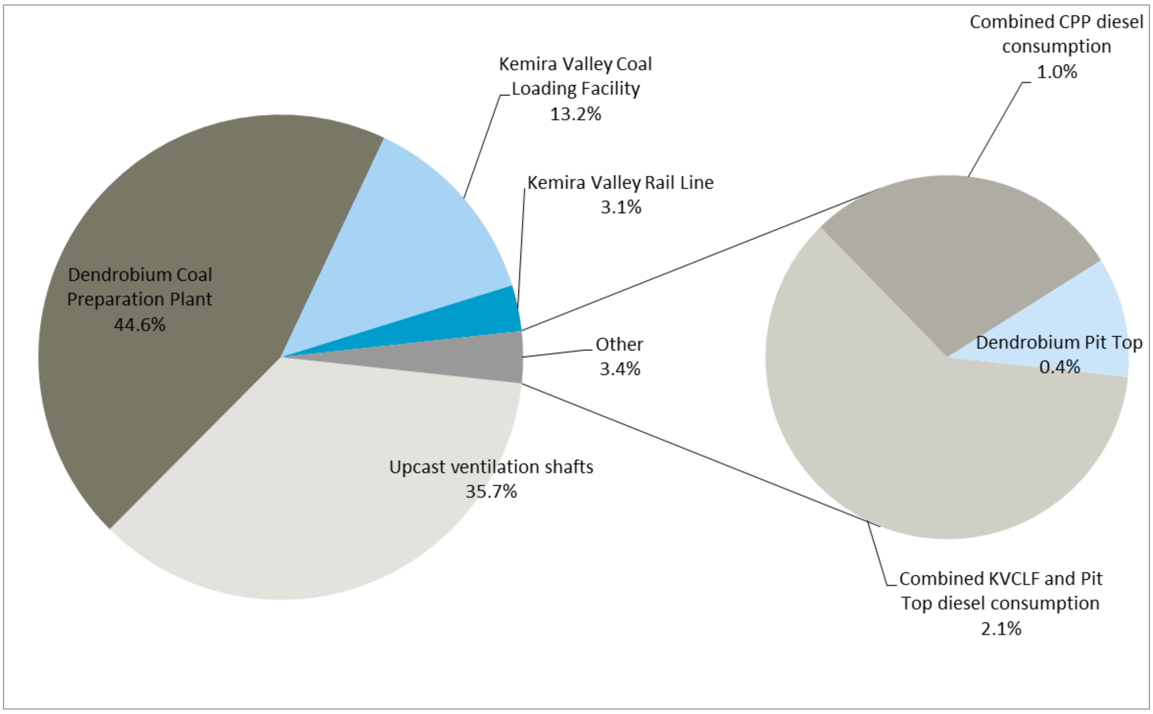

Figure 6-1: Summary of annual PM_{10} emissions (kg/annum)

Table 6-1: Estimated dust emissions for each Project component (kg/annum)

Activity	TSP	PM_{10}	$PM_{2.5}$
KVCLF			
Above ground conveying (wind erosion)	34	17	3
Coal sizer/crusher	9,750	3,354	227
Loading ROM stockpile	388	184	28
Dozer on ROM stockpile	22,866	5,352	503
Excavator on ROM stockpile	311	147	22
Loading trains	466	220	33
Wind erosion of ROM stockpile	60	30	4
Dendrobium Pit Top			
Light vehicle movements into portal - wheel dust	663	127	31
Heavy vehicle movements into portal - wheel dust	687	132	32
Upcast ventilation shafts[1]			
Area 3 – Upcast Ventilation Shaft No 3	22,075	11,038	2,208
Area 5 – Upcast Ventilation Shaft No 5A	28,382	14,191	2,838
Kemira Valley Rail Line			
Fugitive dust from coal wagons	3,216	1,608	241
Diesel emissions from locomotives	557	557	540
Dendrobium Coal Preparation Plant			
ROM coal - unloading at dump station	574	272	41
ROM coal - 10% transfer to raw coal stockpile - conveyor wind erosion	17	8	1
ROM coal - 10% transfer to raw coal stockpile - conveyor transfer points	230	109	16
ROM coal - 10% transfer to raw coal stockpile - loading stockpiles	191	91	14
Front end loaders/dozers on stockpile maintenance (raw coal)	53,354	12,488	1,174
ROM coal - 90% transfer to wash plant - conveyor transfer points	1,034	489	74
Washed coal (83% yield[2]) - 20% transfer to blended beds - conveyor wind erosion	107	54	8
Washed coal - 20% transfer to blended beds - conveyor transfer points	97	46	7
Washed coal - 20% transfer to blended beds - loading stockpiles	162	77	12
Washed coal - loading trucks (80%)	648	307	46
Washed coal - hauling to clean coal stockpile (15%)	12,841	2,465	596
Washed coal - direct hauling to Port Kembla Coal Terminal (65%)	13,911	2,670	646
Washed coal - unload to clean coal stockpiles (15%)	97	46	7
Washed coal - rehandle at clean coal stockpile (15%)	97	46	7
Washed coal - hauling from clean coal stockpile to Port Kembla Coal Terminal (15%)	12,841	2,465	596
Front end loaders/dozers on stockpile maintenance (clean coal)	15,122	3,540	333
Wind erosion (combined stockpiles areas)	10,423	5,212	782
Coal wash (17%) - loading trucks	47	22	3
Coal wash (17%) - transport off-site	5,479	1,052	254

Activity	TSP	PM_{10}	$PM_{2.5}$
Diesel consumption			
Combined KVCLF and Dendrobium Pit Top diesel consumption	1,481	1,481	1,437
Combined CPP diesel consumption	689	689	669

[1] Ventilation shaft flows will vary considerably over the life of the Project. The data presented above is based on predicted maximum shaft flows.

[2] Over the life of the Project, product yields range from 66% to 88%, with an average of 78%. A yield of 83% has been assumed for the modelling scenario. Sensitivity analysis has also been conducted to quantify the change in emissions from 83% to 88%. The change in emissions estimates (0.1%) is not sufficient to result in any change in outcomes for this assessment and therefore the previously assumed 83% yield is retained for all washed coal.

The extent to which emission factors account for the diesel exhaust component of each activity varies according to the emission factor and/or monitoring method that was used in deriving the emission factor. For example, for hauling on paved surfaces, the exhaust component is not included, whereas for material processing/handling, the emission factors may include some of the diesel exhaust component. To be conservative for this assessment, it has been assumed that all emission factors do not include the exhaust component and emissions from diesel combustion are included as a separate emissions source for the KVCLF, the Dendrobium Pit Top and the CPP.

It is noted that the emissions from the rail line include both fugitive dust from coal wagons and diesel exhaust from locomotives. However, material property testing has shown that the measured moisture content for ROM coal arriving at the CPP (6.5%) is higher than the measured DEM level (4.6%). The emission estimates do not take this into account and therefore even though fugitive emissions are not expected, emissions have been included to be conservative.

6.4 Odour emissions from ventilation shafts

There are no receptors within 1 km of the proposed upcast ventilation shaft and there is very little potential for odour impacts from the Project. Notwithstanding, odour impacts are assessed using odour emission rates (OERs) derived from previous odour monitoring for existing mine ventilation shafts in the region (see **Table 6-2**).

To derive OERs for modelling, odour measurements from the Appin Mine Ventilation Shaft No 3 (approved as part of the Bulli Seam Operations) are used. At the time of measurement, Appin Ventilation Shaft No 3 exhausted mine ventilation air (MVA) from Appin Mine Area 7 and the measured odour concentration (in OU) was higher than previous data from the Dendrobium and Metropolitan Mines. OERs are derived using the maximum air flow rate for Ventilation Shaft Site No 5A (**Table 6-3**).

Table 6-2: Odour monitoring data for existing ventilation shafts

Site	Measured odour concentration (OU)	Reference
Dendrobium Mine Ventilation Shaft No 1	54	EML (2005)
Metropolitan Colliery	175	HAS (2008)
Appin Ventilation Shaft No 3	337	TOU (2010)

Table 6-3: Odour emission rates for modelling

Site	Flow rate (m^3/s)	Odour Emission Rate ($OU/m^3/s$)
Upcast Ventilation Shaft No 3	350	117,950
Upcast Ventilation Shaft No 5A	450	151,650

Note: m^3/s = metres per second; $OU/m^3/s$ = odour units per cubic metre per second.

6.5 Estimated emissions from flaring of gas

Enclosed flares would operate at the central gas management site/s located at the existing Shaft Site No 2/3 in Area 3, and potentially at the proposed Shaft Site 5A in Area 5. To provide a conservative assessment of the potential air quality impacts from flaring, emissions are estimated based on a maximum gas flow of 3.0 m^3/s (before any conditioning for flaring purposes), as estimated by IMC. Flaring at the maximum gas flow rate was modelled at the Area 3 central gas management site, located closest to the receptors and also at the proposed Area 5 site for future contingency purposes, which is at least a doubling of maximum emission rates, resulting in a highly conservative assessment of impacts.

As the flares are enclosed, it is appropriate to model using actual source parameters as per point source modelling recommendations. US EPA (1995) prescribes emissions factors for NO_x, CO and VOCs. Properly operated flares achieve at least 98% destruction efficiency, therefore emissions of hydrocarbons (i.e. VOCs) and CO are less than 2% of the hydrocarbons present in the gas. Also, the combustion of methane does not generally produce smoke, therefore particles are not a concern. The primary pollutant of concern is therefore considered to be NO_x.

Emission rates and modelling parameters for flaring are provided in **Table 6-4**.

Table 6-4: Emission rates and modelling parameters for flaring

Parameter	**Value**	
Number of flares	3	
Assumed worst case gas flow rate (m^3/s)	3.0	
Assumed exit velocity of release (m/s)	3.6	
Release height (m)	9.05 m at Area 3 11.2 m at Area 5	
Temperature (K)	1073	
	Emission Factor (lb/MMBtu)	**Emissions Rates (g/s)**
NO_x emission rate	0.068	0.9 per flare

Note: m/s = metres per second; m = metre; K = Kelvin; MMBtu = Metric Million British Thermal Units. 1 MMBtu = 28.32 m^3 methane; g/s = grams per second.

6.6 Estimated emissions from coal dryer

The coal fines dryer is not currently operational but may become operational for the Project in the future. The dryer would run on natural gas. Emissions are estimated based on a gas requirement of 900 kilojoules per kilogram of coal and emission factors for natural gas fired boilers (DEWHA, 2010). The emission estimates are summarised in **Table 6-5**.

Table 6-5: Estimated emissions from the coal fines dryer stack

Stack	**NO_x**	**CO**	**SO_2**	**PM**	**VOCs**
Annual emission (tonnes/annum)	45.5	38.4	0.2	3.4	2.5
Emission rate (grams/second)	1.4	1.2	0.008	0.11	0.08

7. IMPACT ASSESSMENT

7.1 Surface Infrastructure Facilities (Dendrobium Pit Top and KVCLF)

7.1.1 Annual average modelling predictions

The predicted annual average PM_{10}, $PM_{2.5}$, TSP and dust deposition for the KVCLF (including the first 1 km of rail) and Dendrobium Pit Top are presented as contour plots in **Figure 7-1** to **Figure 7-4**. Predictions at private residential receptors are tabulated in **Table 7-1**.

For the majority of private receptors in the vicinity of the KVCLF and Dendrobium Pit Top, the annual average PM_{10} concentration is less than 0.5 µg/m³ (see **Figure 7-1**). To assess against the cumulative impact assessment criterion for annual average PM_{10}, a background of 18.4 µg/m³ was derived (refer **Section 5.3**). When added to each modelling prediction, this would result in a maximum cumulative annual average PM_{10} concentration of 19.5 µg/m³, which complies with the impact assessment criterion of 25 µg/m³.

For the majority of private receptors in the vicinity of the KVCLF and Dendrobium Pit Top, the annual average $PM_{2.5}$ concentration is less than 0.25 µg/m³ (see **Figure 7-2**). To assess against the cumulative impact assessment criterion for annual average $PM_{2.5}$, a background of 6.7 µg/m³ was derived (refer **Section 5.3**). When added to each modelling prediction, this would result in a maximum cumulative annual average $PM_{2.5}$ concentration of 7.1 µg/m³, which complies with the impact assessment criterion of 8 µg/m³.

For the majority of private receptors in the vicinity of the KVCLF and Dendrobium Pit Top, the annual average TSP concentration is less than 1.0 µg/m³ (see **Figure 7-3**). To assess against the cumulative impact assessment criterion for annual average TSP, a background of 34.7 µg/m³ was derived (refer **Section 5.3**). When added to each modelling prediction, this would result in a maximum cumulative annual average TSP concentration of 36.3 µg/m³, which complies with the impact assessment criterion of 90 µg/m³.

For the majority of private receptors in the vicinity of the KVCLF and Dendrobium Pit Top, the annual average dust deposition is less than 0.1 g/m²/month (see **Figure 7-4**). To assess against the cumulative impact assessment criterion for annual average dust deposition, a background of 1.8 g/m²/month was derived (refer **Section 5.3**). When added to each modelling prediction, this would result in a maximum cumulative annual average dust deposition of 2.0 g/m²/month. There are therefore no exceedances of the impact assessment criteria for incremental or cumulative dust deposition at any of the private receptors in the vicinity of surface operations.

It is noted that model runs used to generate contour plots also include the first 1 km of rail line only (and associated fugitive emission estimates from this section of rail). The tabulated predictions in **Table 7-1** include the full length of rail line. This was necessary to avoid excessively long run times for CALPUFF sampling grids (required for contouring). As a result, the tabulated results may not exactly match the contour plots at all receptors.

Results for additional receptor locations adjacent to the rail line are presented in **Section 7.2**.

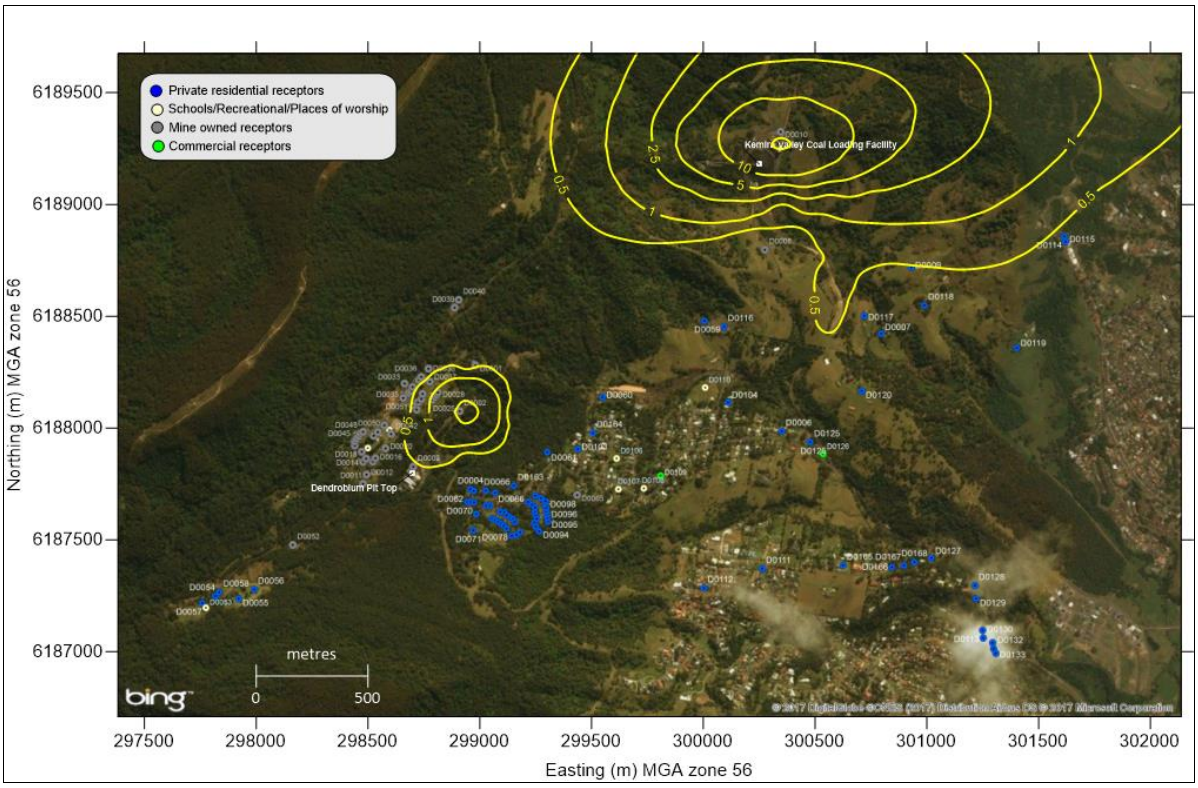

Figure 7-1: Predicted annual average PM_{10} concentration (µg/m^3) for the KVCLF and Dendrobium Pit Top (Project-only)

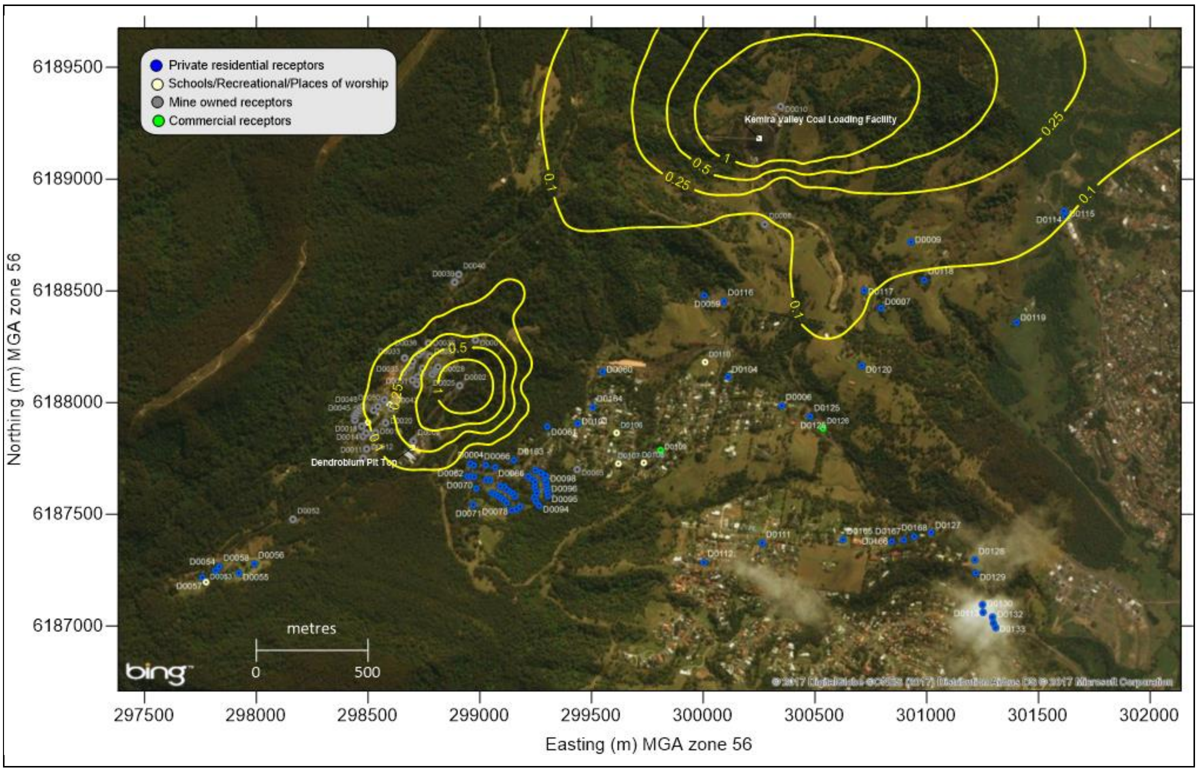

Figure 7-2: Predicted annual average $PM_{2.5}$ concentration (µg/m^3) for the KVCLF and Dendrobium Pit Top (Project-only)

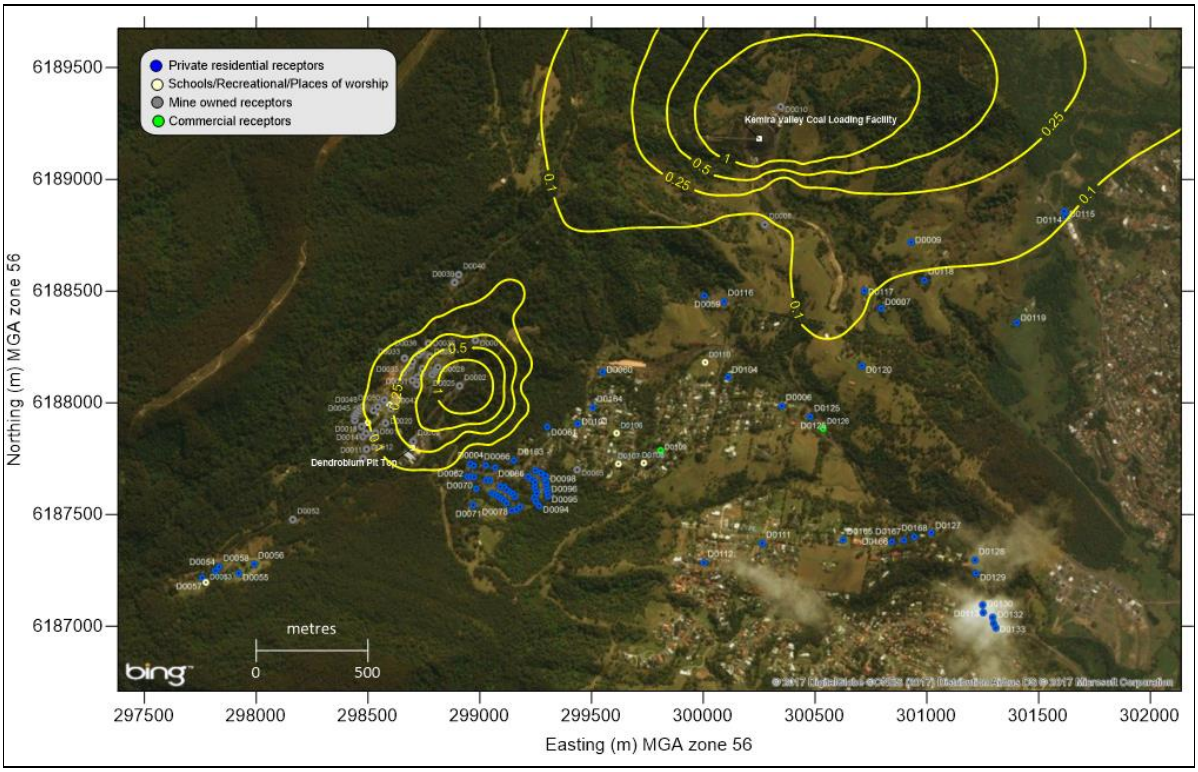

Figure 7-3: Predicted annual average TSP concentration (µg/m³) for the KVCLF and Dendrobium Pit Top (Project-only)

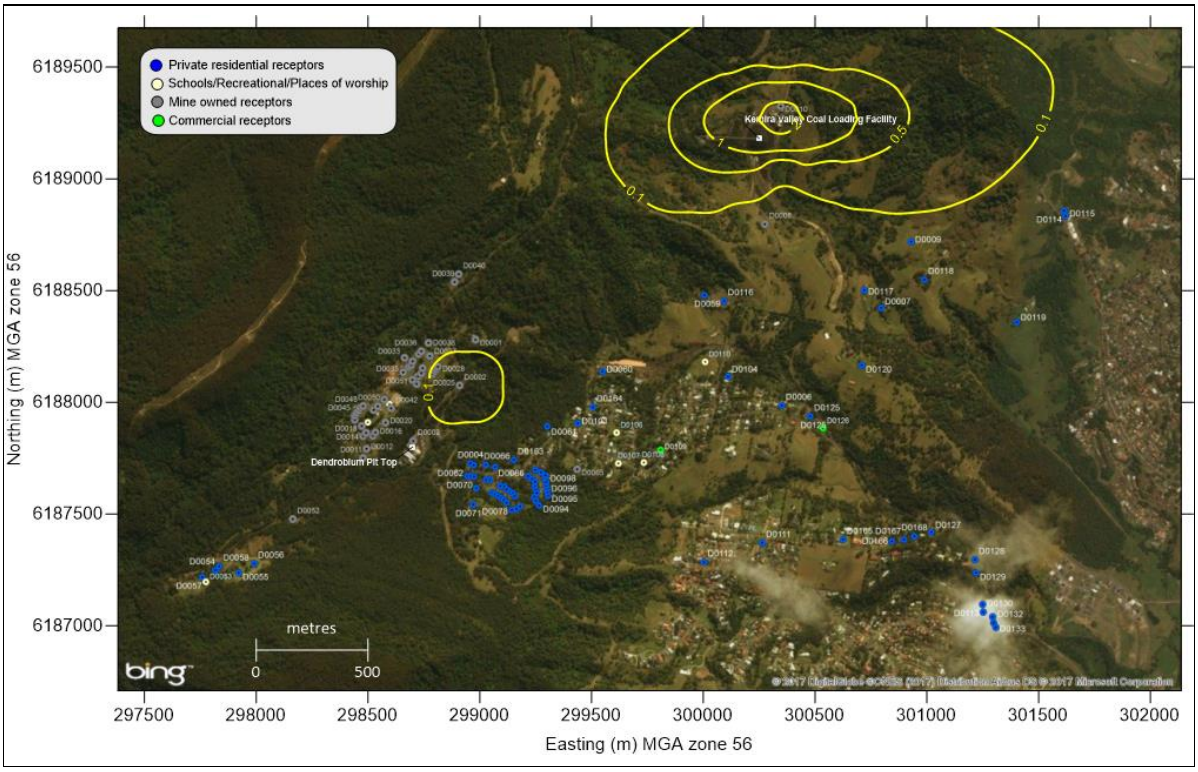

Figure 7-4: Predicted annual average dust deposition rate (g/m²/month) for the KVCLF and Dendrobium Pit Top (Project-only)

Table 7-1: Predicted Project-only annual average PM_{10}, $PM_{2.5}$ and TSP concentration ($\mu g/m^3$) and dust deposition rate ($g/m^2/month$) for the KVCLF and Dendrobium Pit Top

ID	Address	PM_{10}	$PM_{2.5}$	TSP	DDep
D0004	374 Cordeaux Rd Mount Kembla	0.1	0.1	0.2	<0.1
D0005	323-327 Cordeaux Rd Mount Kembla	0.1	<0.1	0.2	<0.1
D0006	214 Cordeaux Rd Mount Kembla	0.2	0.1	0.5	<0.1
D0007	27 Stones Rd Mount Kembla	0.3	0.1	0.7	<0.1
D0009	27 Stones Rd Mount Kembla	0.5	0.1	1.1	0.1
D0054	147 Cordeaux Rd Kembla Heights	<0.1	<0.1	<0.1	<0.1
D0055	145 Cordeaux Rd Kembla Heights	<0.1	<0.1	<0.1	<0.1
D0056	145 Cordeaux Rd Kembla Heights	<0.1	<0.1	<0.1	<0.1
D0057	617 Cordeaux Rd Kembla Heights	<0.1	<0.1	<0.1	<0.1
D0058	145 Cordeaux Rd Kembla Heights	<0.1	<0.1	<0.1	<0.1
D0059	26 Stones Rd Mount Kembla	0.1	0.1	0.3	<0.1
D0060	4-6 Kirkwood Pl Mount Kembla	0.1	0.1	0.3	<0.1
D0061	336 Cordeaux Rd Mount Kembla	0.1	0.1	0.3	<0.1
D0062	381 Cordeaux Rd Mount Kembla	0.1	0.1	0.2	<0.1
D0063	379 Cordeaux Rd Mount Kembla	0.1	0.1	0.2	<0.1
D0064	377 Cordeaux Rd Mount Kembla	0.1	0.1	0.2	<0.1
D0065	372 Cordeaux Rd Mt Kembla	0.1	0.1	0.2	<0.1
D0066	364 Cordeaux Rd Mount Kembla	0.1	0.1	0.2	<0.1
D0067	358 Cordeaux Rd Mount Kembla	0.1	<0.1	0.2	<0.1
D0068	369 Cordeaux Rd Mount Kembla	0.1	0.1	0.2	<0.1
D0069	367 Cordeaux Rd Mount Kembla	0.1	<0.1	0.2	<0.1
D0070	2 Araluen Ave Mount Kembla	0.1	<0.1	0.2	<0.1
D0071	Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0072	4 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0073	6 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0074	8 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0075	10 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0076	12 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0077	14 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0078	18 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0079	20 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0080	17 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0081	11-13 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0081	9 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0082	7 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0083	5 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0084	3 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0085	1 Araluen Ave Mount Kembla	0.1	<0.1	0.1	<0.1
D0086	2 Cudgee Cres Mount Kembla	0.1	<0.1	0.2	<0.1

ID	Address	PM_{10}	$PM_{2.5}$	TSP	DDep
D0087	4 Cudgee Cres Mount Kembla	0.1	<0.1	0.2	<0.1
D0088	6 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0089	8 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0090	10 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0091	12 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0092	14 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0093	16 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0094	18 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0095	17 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0096	15 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0096	13 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0097	11 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0098	9 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0099	7 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0100	5 Cudgee Cres Mount Kembla	0.1	<0.1	0.1	<0.1
D0101	3 Cudgee Cres Mount Kembla	0.1	<0.1	0.2	<0.1
D0102	1 Cudgee Cres Mount Kembla	0.1	<0.1	0.2	<0.1
D0103	14 Benjamin Rd Mount Kembla	0.1	0.1	0.3	<0.1
D0104	39 Stones Rd Mount Kembla	0.1	0.1	0.3	<0.1
D0111	69 William James Dr Cordeaux Heights	0.1	<0.1	0.2	<0.1
D0112	18 Ridgecrest Cordeaux Heights	0.1	<0.1	0.1	<0.1
D0114	246 O'Briens Rd Figtree	0.5	0.1	1.0	<0.1
D0115	244 O'Briens Rd Figtree	0.4	0.1	0.9	<0.1
D0116	20 Stones Rd Mount Kembla	0.2	0.1	0.3	<0.1
D0117	Stones Rd Mount Kembla	0.4	0.1	0.9	<0.1
D0118	121 O'Briens Rd Figtree	0.4	0.1	0.8	<0.1
D0119	117 O'Briens Rd Figtree	0.2	0.1	0.5	<0.1
D0120	Cordeaux Rd Mount Kembla	0.3	0.1	0.6	<0.1
D0122	Cordeaux Dam Rd Cataract	<0.1	<0.1	0.1	<0.1
D0124	Upper Cordeaux Lake No.2	<0.1	<0.1	0.1	<0.1
D0125	200 Cordeaux Rd Mount Kembla	0.8	0.3	2.1	0.1
D0127	2 William James Dr Mount Kembla	0.8	0.3	2.2	0.1
D0128	7 William James Dr Mount Kembla	0.8	0.3	2.1	0.1
D0129	9 William James Dr Mount Kembla	0.5	0.2	1.3	0.1
D0163	354 Cordeaux Rd Mount Kembla	0.1	<0.1	0.2	<0.1
D0164	15 Benjamin Rd Mount Kembla	0.1	0.1	0.3	<0.1
D0165	23 William James Dr Mount Kembla	0.1	<0.1	0.2	<0.1
D0166	10 William James Dr Mount Kembla	0.2	0.1	0.4	<0.1
D0167	8 William James Dr Mount Kembla	0.2	0.1	0.5	<0.1

ID	Address	PM_{10}	$PM_{2.5}$	TSP	DDep
D0168	6 William James Dr Mount Kembla	0.4	0.1	0.9	<0.1

Note: DDep = dust deposition.

7.1.2 Short term (24-hour average) modelling predictions

The predicted Project-only 24-hour average PM_{10} and $PM_{2.5}$ concentrations for the KVCLF and Dendrobium Pit Top are presented as contour plots in **Figure 7-5** and **Figure 7-6**. The Project increment and cumulative predictions at private residential receptors are tabulated in **Table 7-2**.

For the majority of private receptors in the vicinity of the KVCLF, the maximum incremental 24-hour average PM_{10} concentration is less than 5 µg/m³ (see **Figure 7-5**). At the closest private receptor to the KVCLF (approximately 800 m south on Stones Road), the maximum potential incremental increase in 24-hour average PM_{10} concentration is 16.9 µg/m³.

For the assessment of cumulative impacts, a daily varying background concentration from Kembla Grange is paired with each modelling prediction. The background dataset contains four existing exceedances of the impact assessment criterion and therefore cumulative 24-hour average PM_{10} is therefore presented as the 5th highest cumulative concentration. Based on this cumulative analysis, there would be no additional exceedances of the impact assessment criterion for PM_{10}.

For the majority of private receptors in the vicinity of the KVCLF, the maximum incremental 24-hour average $PM_{2.5}$ concentration is less than 1 µg/m³ (see **Figure 7-6**). At the closest private receptor to the KVCLF, the maximum potential incremental increase in 24-hour average $PM_{2.5}$ concentration is 3.8 µg/m³.

For the assessment of cumulative impacts, a daily varying background concentration from Kembla Grange is paired with each modelling prediction. The background dataset contains two existing exceedances of the impact assessment criterion and therefore cumulative 24-hour average $PM_{2.5}$ is therefore presented as the 3rd highest cumulative concentration. Based on this cumulative analysis, there would be no additional exceedances of the impact assessment criterion for $PM_{2.5}$.

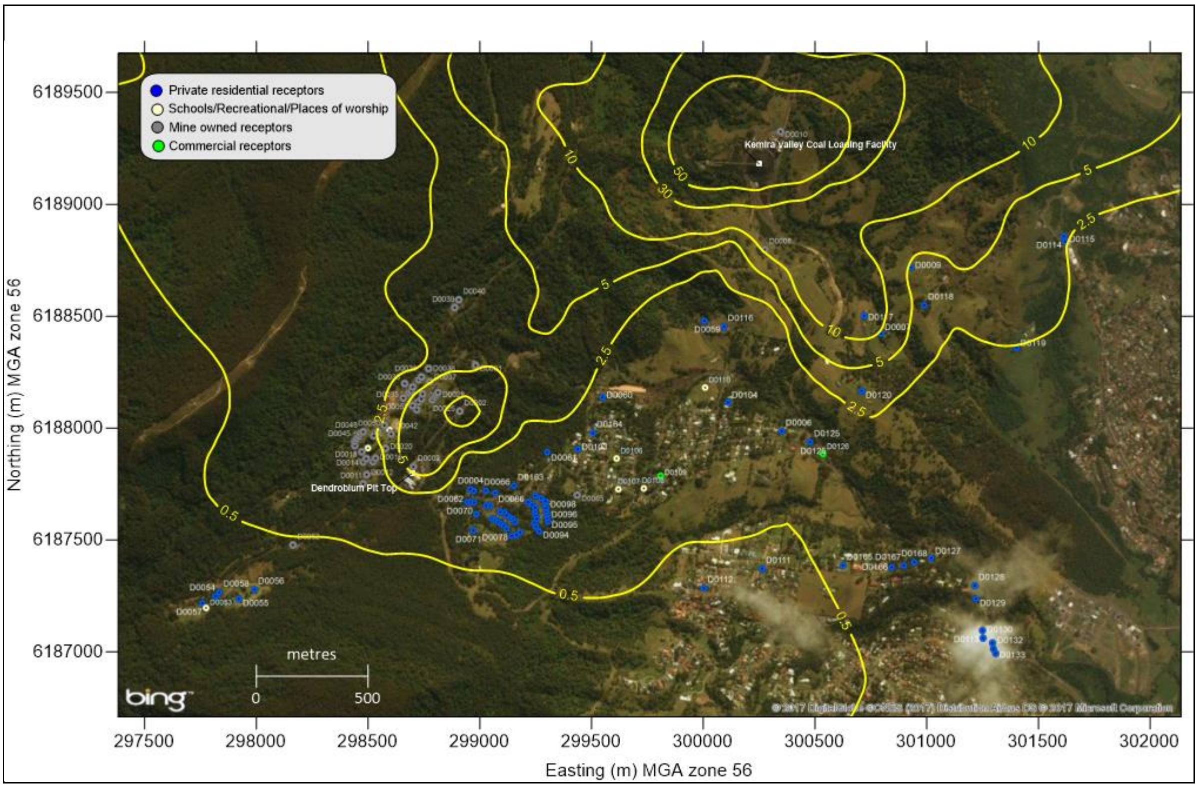

Figure 7-5: Predicted maximum Project-only 24-hour average PM_{10} concentration ($\mu g/m^3$) for the KVCLF and Dendrobium Pit Top

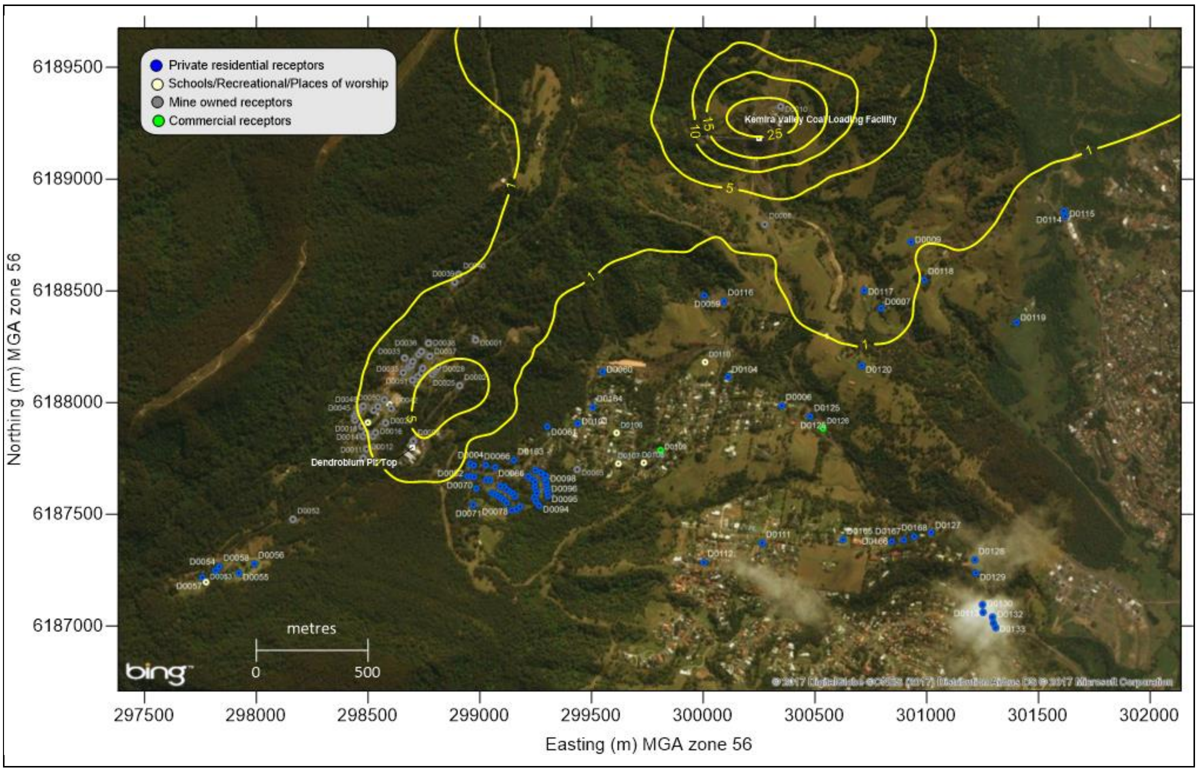

Figure 7-6: Predicted maximum Project-only 24-hour average $PM_{2.5}$ concentration ($\mu g/m^3$) for the KVCLF and Dendrobium Pit Top

Table 7-2: Predicted Project-only and cumulative 24-hour average PM_{10} and $PM_{2.5}$ concentration (µg/m³) for the KVCLF and Dendrobium Pit Top

ID	Address	PM_{10}	$PM_{2.5}$	PM_{10}(1)	$PM_{2.5}$(2)
		Project increment		Cumulative	
D0004	374 Cordeaux Rd Mount Kembla	1.2	0.8	47.4	18.2
D0005	323-327 Cordeaux Rd Mount Kembla	1.4	0.3	47.4	18.2
D0006	214 Cordeaux Rd Mount Kembla	1.7	0.8	47.5	18.2
D0007	27 Stones Rd Mount Kembla	9.8	2.3	47.9	18.2
D0009	27 Stones Rd Mount Kembla	4.1	1.2	48.6	18.2
D0054	147 Cordeaux Rd Kembla Heights	0.3	0.1	47.3	18.2
D0055	145 Cordeaux Rd Kembla Heights	0.2	0.1	47.3	18.2
D0056	145 Cordeaux Rd Kembla Heights	0.3	0.1	47.3	18.2
D0057	617 Cordeaux Rd Kembla Heights	0.3	0.1	47.3	18.2
D0058	145 Cordeaux Rd Kembla Heights	0.3	0.1	47.3	18.2
D0059	26 Stones Rd Mount Kembla	1.5	1.0	47.6	18.2
D0060	4-6 Kirkwood Pl Mount Kembla	1.9	0.8	47.4	18.2
D0061	336 Cordeaux Rd Mount Kembla	1.6	0.7	47.4	18.2
D0062	381 Cordeaux Rd Mount Kembla	1.0	0.7	47.4	18.2
D0063	379 Cordeaux Rd Mount Kembla	1.0	0.7	47.4	18.2
D0064	377 Cordeaux Rd Mount Kembla	1.0	0.7	47.4	18.2
D0065	372 Cordeaux Rd Mt Kembla	1.1	0.8	47.4	18.2
D0066	364 Cordeaux Rd Mount Kembla	0.9	0.6	47.4	18.2
D0067	358 Cordeaux Rd Mount Kembla	0.8	0.5	47.4	18.2
D0068	369 Cordeaux Rd Mount Kembla	0.8	0.5	47.4	18.2
D0069	367 Cordeaux Rd Mount Kembla	0.8	0.5	47.4	18.2
D0070	2 Araluen Ave Mount Kembla	0.9	0.6	47.4	18.2
D0071	Araluen Ave Mount Kembla	1.0	0.7	47.3	18.2
D0072	4 Araluen Ave Mount Kembla	0.7	0.4	47.4	18.2
D0073	6 Araluen Ave Mount Kembla	0.7	0.4	47.4	18.2
D0074	8 Araluen Ave Mount Kembla	0.7	0.4	47.3	18.2
D0075	10 Araluen Ave Mount Kembla	0.7	0.4	47.3	18.2
D0076	12 Araluen Ave Mount Kembla	0.7	0.4	47.3	18.2
D0077	14 Araluen Ave Mount Kembla	0.7	0.4	47.3	18.2
D0078	18 Araluen Ave Mount Kembla	0.7	0.4	47.3	18.2
D0079	20 Araluen Ave Mount Kembla	0.7	0.3	47.3	18.2
D0080	17 Araluen Ave Mount Kembla	0.7	0.3	47.3	18.2
D0081	11-13 Araluen Ave Mount Kembla	0.8	0.3	47.4	18.2
D0081	9 Araluen Ave Mount Kembla	0.8	0.3	47.4	18.2
D0082	7 Araluen Ave Mount Kembla	0.8	0.3	47.4	18.2
D0083	5 Araluen Ave Mount Kembla	0.8	0.3	47.4	18.2
D0084	3 Araluen Ave Mount Kembla	0.8	0.3	47.4	18.2
D0085	1 Araluen Ave Mount Kembla	0.7	0.3	47.4	18.2

ID	Address	PM_{10}	$PM_{2.5}$	PM_{10}(1)	$PM_{2.5}$(2)
		Project increment		**Cumulative**	
D0086	2 Cudgee Cres Mount Kembla	1.0	0.3	47.4	18.2
D0087	4 Cudgee Cres Mount Kembla	1.0	0.3	47.4	18.2
D0088	6 Cudgee Cres Mount Kembla	1.0	0.3	47.4	18.2
D0089	8 Cudgee Cres Mount Kembla	1.0	0.3	47.4	18.2
D0090	10 Cudgee Cres Mount Kembla	1.0	0.3	47.4	18.2
D0091	12 Cudgee Cres Mount Kembla	0.9	0.3	47.4	18.2
D0092	14 Cudgee Cres Mount Kembla	0.9	0.3	47.4	18.2
D0093	16 Cudgee Cres Mount Kembla	0.9	0.3	47.4	18.2
D0094	18 Cudgee Cres Mount Kembla	0.8	0.3	47.4	18.2
D0095	17 Cudgee Cres Mount Kembla	1.0	0.2	47.4	18.2
D0096	15 Cudgee Cres Mount Kembla	1.0	0.2	47.4	18.2
D0096	13 Cudgee Cres Mount Kembla	1.1	0.2	47.4	18.2
D0097	11 Cudgee Cres Mount Kembla	1.1	0.3	47.4	18.2
D0098	9 Cudgee Cres Mount Kembla	1.1	0.3	47.4	18.2
D0099	7 Cudgee Cres Mount Kembla	1.2	0.3	47.4	18.2
D0100	5 Cudgee Cres Mount Kembla	1.2	0.3	47.4	18.2
D0101	3 Cudgee Cres Mount Kembla	1.2	0.3	47.4	18.2
D0102	1 Cudgee Cres Mount Kembla	1.1	0.3	47.4	18.2
D0103	14 Benjamin Rd Mount Kembla	1.6	0.6	47.4	18.2
D0104	39 Stones Rd Mount Kembla	1.5	0.7	47.5	18.2
D0111	69 William James Dr Cordeaux Heights	0.6	0.2	47.4	18.2
D0112	18 Ridgecrest Cordeaux Heights	0.5	0.2	47.4	18.2
D0114	246 O'Briens Rd Figtree	2.5	0.6	47.7	18.2
D0115	244 O'Briens Rd Figtree	2.6	0.6	47.7	18.2
D0116	20 Stones Rd Mount Kembla	1.8	1.0	47.5	18.2
D0117	Stones Rd Mount Kembla	16.9	3.8	47.9	18.2
D0118	121 O'Briens Rd Figtree	3.5	0.9	48.0	18.2
D0119	117 O'Briens Rd Figtree	2.8	0.7	47.8	18.2
D0120	Cordeaux Rd Mount Kembla	4.1	0.9	47.7	18.2
D0122	Cordeaux Dam Rd Cataract	0.9	0.9	47.3	18.2
D0124	Upper Cordeaux Lake No.2	0.3	0.1	47.3	18.2
D0125	200 Cordeaux Rd Mount Kembla	2.6	1.1	48.0	18.4
D0127	2 William James Dr Mount Kembla	2.5	1.0	48.2	18.4
D0128	7 William James Dr Mount Kembla	2.7	1.0	48.1	18.4
D0129	9 William James Dr Mount Kembla	2.5	1.0	47.8	18.3
D0163	354 Cordeaux Rd Mount Kembla	1.0	0.4	47.4	18.2
D0164	15 Benjamin Rd Mount Kembla	1.7	0.7	47.5	18.2
D0165	23 William James Dr Mount Kembla	0.9	0.4	47.5	18.2

ID	Address	PM_{10}	$PM_{2.5}$	PM_{10}(1)	$PM_{2.5}$(2)
		Project increment		Cumulative	
D0166	10 William James Dr Mount Kembla	1.4	0.6	47.5	18.2
D0167	8 William James Dr Mount Kembla	1.6	0.6	47.7	18.3
D0168	6 William James Dr Mount Kembla	1.9	0.7	47.6	18.3

Note: [1] Based on 5th highest 24-hour average PM_{10} level recorded for 2016 at Kembla Grange.

Note: [2] Based on 3rd highest 24-hour average $PM_{2.5}$ level recorded for 2016 at Kembla Grange.

7.2 Kemira Valley Rail Line

The impacts from ROM coal transportation are assessed for selected receptors immediately adjacent to the rail line (as shown in **Figure 3-3**). The receptors represent those closest to the rail line and subject to the greatest potential impact. If compliance with air quality goals is demonstrated for these receptors, it can be inferred that all other receptors in the vicinity of the rail line would also comply.

The predicted annual average PM_{10}, $PM_{2.5}$, TSP and dust deposition for receptors close to the rail line are tabulated in **Table 7-3**. The predicted Project-only and cumulative 24-hour average PM_{10} and $PM_{2.5}$ concentrations are tabulated in **Table 7-4**.

For the residences closest to the rail line, the highest incremental annual average PM_{10} concentration is 1.0 µg/m³ and the highest incremental annual average $PM_{2.5}$ concentration is 0.4 µg/m³. The highest incremental annual average TSP concentration is 2.6 µg/m³ and the highest incremental annual average dust deposition is 0.2 g/m²/month. Adding the background values described in **Section 7.1** would not result in any exceedance of the impact assessment criteria, at receptors close to the rail line.

The maximum incremental 24-hour average PM_{10} concentration is less than 5.0 µg/m³ and the maximum incremental 24-hour average $PM_{2.5}$ concentration is 1.6 µg/m³. When the incremental increases are added to the existing background (**Section 7.1.2**), there would be no additional exceedances of the impact assessment criteria.

It is noted that the modelling includes fugitive dust from coal wagons, in addition to diesel emissions from locomotives. It is noted, however, that fugitive emissions from the coal wagons would be minimal, if present at all, as the measured moisture content for ROM coal arriving at the CPP (6.5%) is higher than the measured DEM level (4.6%) (refer to coal properties testing report in **Appendix 5**).

Table 7-3: Predicted Project-only annual average PM_{10}, $PM_{2.5}$ and TSP concentration (µg/m³) and dust deposition rate (g/m²/month) adjacent to the rail line

ID	Address	PM_{10}	$PM_{2.5}$	TSP	DDep
D0113	46 Natan Pl Cordeaux Heights	0.5	0.2	1.2	0.1
D0130	48 Natan Pl Cordeaux Heights	0.5	0.2	1.2	0.1
D0131	112 Booreea Blvd Cordeaux Heights	0.8	0.3	2.1	0.1
D0132	110 Booreea Blvd Cordeaux Heights	0.6	0.2	1.5	0.1
D0133	108 Booreea Blvd Cordeaux Heights	0.5	0.2	1.3	0.1
D0134	5 Alukea Rd Cordeaux Heights	0.9	0.3	2.3	0.2
D0135	2 Central Ave Cordeaux Heights	0.7	0.3	2.0	0.1
D0136	49-55 Cordeaux Rd Figtree	0.8	0.3	2.1	0.1
D0137	4 Leigh Cres Unanderra	0.9	0.3	2.5	0.2
D0138	2 Leigh Cres Unanderra	0.9	0.3	2.3	0.1

ID	Address	PM_{10}	$PM_{2.5}$	TSP	DDep
D0139	1A Leigh Cres Unanderra	0.8	0.3	2.0	0.1
D0140	41A Cordeaux Rd Figtree	0.8	0.3	2.1	0.1
D0141	39 Cordeaux Rd Figtree	0.8	0.3	2.1	0.1
D0142	37 Cordeaux Rd Figtree	1.0	0.4	2.6	0.2
D0143	31/21 Cordeaux Rd Figtree	0.8	0.3	2.2	0.1
D0144	72 Albert St Unanderra	0.6	0.2	1.4	0.1
D0145	70 Albert St Unanderra	0.5	0.2	1.4	0.1
D0146	68 Albert St Unanderra	0.6	0.2	1.4	0.1
D0147	66 Albert St Unanderra	0.5	0.2	1.4	0.1
D0148	64 Albert St Unanderra	0.6	0.2	1.5	0.1
D0149	62 Albert St Unanderra	0.6	0.2	1.5	0.1
D0150	60 Albert St Unanderra	0.5	0.2	1.4	0.1
D0151	58A Albert St Unanderra	0.7	0.3	1.8	0.1
D0152	58 Hurt Pde Unanderra	0.6	0.2	1.4	0.1
D0153	56 Hurt Pde Unanderra	0.7	0.3	1.8	0.1
D0154	54 Hurt Pde Unanderra	0.8	0.3	1.9	0.1
D0155	52 Hurt Pde Unanderra	0.7	0.3	1.8	0.1
D0156	50 Hurt Pde Unanderra	0.6	0.2	1.6	0.1
D0157	48 Hurt Pde Unanderra	0.7	0.3	1.8	0.1
D0158	46 Hurt Pde Unanderra	0.7	0.3	1.8	0.1
D0159	44 Hurt Pde Unanderra	0.7	0.3	1.8	0.1
D0160	42 Hurt Pde Unanderra	0.6	0.2	1.4	0.1
D0161	40 Hurt Pde Unanderra	0.7	0.3	1.9	0.1
D0162	1 Cordeaux Rd Figtree	0.8	0.3	2.1	0.1
D0169	15 Leigh Cres Unanderra	0.2	0.1	0.4	<0.1

Note: DDep = dust deposition.

Table 7-4: Predicted Project-only and cumulative 24-hour average PM_{10} and $PM_{2.5}$ concentration ($\mu g/m^3$) adjacent to the rail line

ID	Address	PM_{10}	$PM_{2.5}$	$PM_{10}^{(1)}$	$PM_{2.5}^{(2)}$
		Project increment		Cumulative	
D0113	46 Natan Pl Cordeaux Heights	2.8	1.1	47.8	18.4
D0130	48 Natan Pl Cordeaux Heights	2.7	1.0	47.8	18.3
D0131	112 Booreea Blvd Cordeaux Heights	3.2	1.2	48.1	18.4
D0132	110 Booreea Blvd Cordeaux Heights	2.9	1.1	47.9	18.3
D0133	108 Booreea Blvd Cordeaux Heights	2.7	1.1	47.8	18.3
D0134	5 Alukea Rd Cordeaux Heights	4.3	1.6	48.1	18.4
D0135	2 Central Ave Cordeaux Heights	4.1	1.5	48.1	18.4
D0136	49-55 Cordeaux Rd Figtree	4.3	1.5	48.2	18.5
D0137	4 Leigh Cres Unanderra	4.1	1.5	48.3	18.5
D0138	2 Leigh Cres Unanderra	4.3	1.5	48.1	18.4

ID	Address	PM_{10}	$PM_{2.5}$	PM_{10} (1)	$PM_{2.5}$ (2)
		Project increment		Cumulative	
D0139	1A Leigh Cres Unanderra	4.0	1.4	48.1	18.5
D0140	41A Cordeaux Rd Figtree	4.1	1.4	48.2	18.6
D0141	39 Cordeaux Rd Figtree	3.8	1.3	48.3	18.5
D0142	37 Cordeaux Rd Figtree	4.4	1.5	48.5	18.7
D0143	31/21 Cordeaux Rd Figtree	4.2	1.4	48.4	18.6
D0144	72 Albert St Unanderra	4.0	1.4	47.9	18.4
D0145	70 Albert St Unanderra	4.0	1.4	47.9	18.4
D0146	68 Albert St Unanderra	4.0	1.4	47.9	18.4
D0147	66 Albert St Unanderra	4.0	1.4	47.9	18.4
D0148	64 Albert St Unanderra	4.0	1.4	48.0	18.4
D0149	62 Albert St Unanderra	4.2	1.4	48.0	18.4
D0150	60 Albert St Unanderra	4.2	1.4	47.9	18.4
D0151	58A Albert St Unanderra	4.4	1.5	48.0	18.4
D0152	58 Hurt Pde Unanderra	4.1	1.4	48.0	18.4
D0153	56 Hurt Pde Unanderra	4.3	1.4	48.1	18.5
D0154	54 Hurt Pde Unanderra	4.7	1.5	48.1	18.4
D0155	52 Hurt Pde Unanderra	4.6	1.5	48.0	18.4
D0156	50 Hurt Pde Unanderra	4.4	1.4	48.0	18.5
D0157	48 Hurt Pde Unanderra	4.5	1.5	48.2	18.5
D0158	46 Hurt Pde Unanderra	4.6	1.5	48.2	18.4
D0159	44 Hurt Pde Unanderra	4.8	1.6	48.1	18.4
D0160	42 Hurt Pde Unanderra	4.6	1.5	47.9	18.4
D0161	40 Hurt Pde Unanderra	4.8	1.6	48.2	18.5
D0162	1 Cordeaux Rd Figtree	4.8	1.6	48.3	18.6
D0169	15 Leigh Cres Unanderra	2.8	1.0	47.4	18.2

Note: 1 Based on 5th highest 24-hour average PM_{10} level recorded for 2016 at Kembla Grange.

Note: 2 Based on 3rd highest 24-hour average $PM_{2.5}$ level recorded for 2016 at Kembla Grange.

7.3 Ventilation shaft locations and flares

The predicted incremental ground level concentrations for dust and odour from ventilation shafts and NO_x from flaring is presented in **Table 7-5**.

As expected, the impacts from dust emissions at the closest receptors are minimal, despite this being the largest single source in terms of annual emissions. Adding the background values described in **Section 7.1** would not result in any exceedance of the impact assessment criteria.

Modelling of odour emissions, based on the OERS derived in **Section 6.4**, shows that odour at the closest receptor would be undetectable (all modelling predictions are less than 1 OU) (refer **Table 7-5**).

Emissions from flaring are conservatively estimated based on a maximum gas flow rate emitted from the gas management site at both Area 3 and Area 5 simultaneously. As gas management is not expected to occur at both sites simultaneously, the modelled predictions are considered to be highly conservative.

The incremental 1-hour average NO_2 concentration at the closest receptor is 2.6 µg/m³, representing only 1% of the NSW EPA impact assessment criterion of 246 µg/m³, or 1.6% of the AAQ NEPM limit of 164 µg/m³. The incremental annual average NO_2 concentration at the closest receptor is 0.035 µg/m³, which is less than 1% of both the NSW EPA impact assessment criterion of 62 µg/m³, or AAQ NEPM limit of 31 µg/m³. Modelling results are presented based on 100% conversion of NO_x to NO_2 for both 1-hour and annual averages (i.e. all NO emitted is oxidised to NO_2). Background concentrations of NO_2 in the area are expected to be low and therefore cumulative impacts would not occur.

Table 7-5: Predicted Project-only NO_x, PM_{10}, $PM_{2.5}$ and TSP concentration (µg/m³), dust deposition rate (g/m²/month) and odour (OU) in the vicinity of the ventilation shafts

ID	Address	$PM_{2.5}$		PM_{10}		TSP	Dep	NO_x		Odour
		Ann Avg	24-h Avg	Ann Avg	24-h Avg	Ann Avg	Ann Avg	Ann Avg	1-h Avg	1-s Avg[1]
D0121	Cordeaux Dam offices	0.0043	0.097	0.021	0.49	0.030	0.0065	0.029	1.8	0.4
D0122	Caretaker's Quarters	0.0042	0.084	0.021	0.43	0.031	0.0066	0.027	2.0	0.4
D0123	Recreation Facility	0.0043	0.088	0.021	0.45	0.031	0.0066	0.028	2.0	0.4
D0124	Southern Cordeaux Dam Facilities	0.0050	0.047	0.024	0.23	0.033	0.0079	0.035	2.6	0.4
D0170	Avon Picnic Area	0.0014	0.049	0.0061	0.13	0.0052	0.0010	0.017	2.4	0.1
D0171	Nepean Picnic Area	0.0010	0.029	0.0043	0.12	0.0034	0.00067	0.011	1.2	0.1
D0105	Wollongong MCC Club	0.0014	0.016	0.0064	0.076	0.0073	0.0023	0.018	1.1	0.1
Max of Sensitive Receptors		0.0050	0.097	0.024	0.49	0.033	0.0079	0.035	2.6	0.4
Note: [1] 1-second average calculated from 1 hour peak prediction ratio for wake affected point sources, as per recommendations in Table 6.1 of the Approved Methods.										

The predicted 1-hour average and annual average NO_2 concentrations are also presented as contour plots in **Figure 7-7** and **Figure 7-8**.

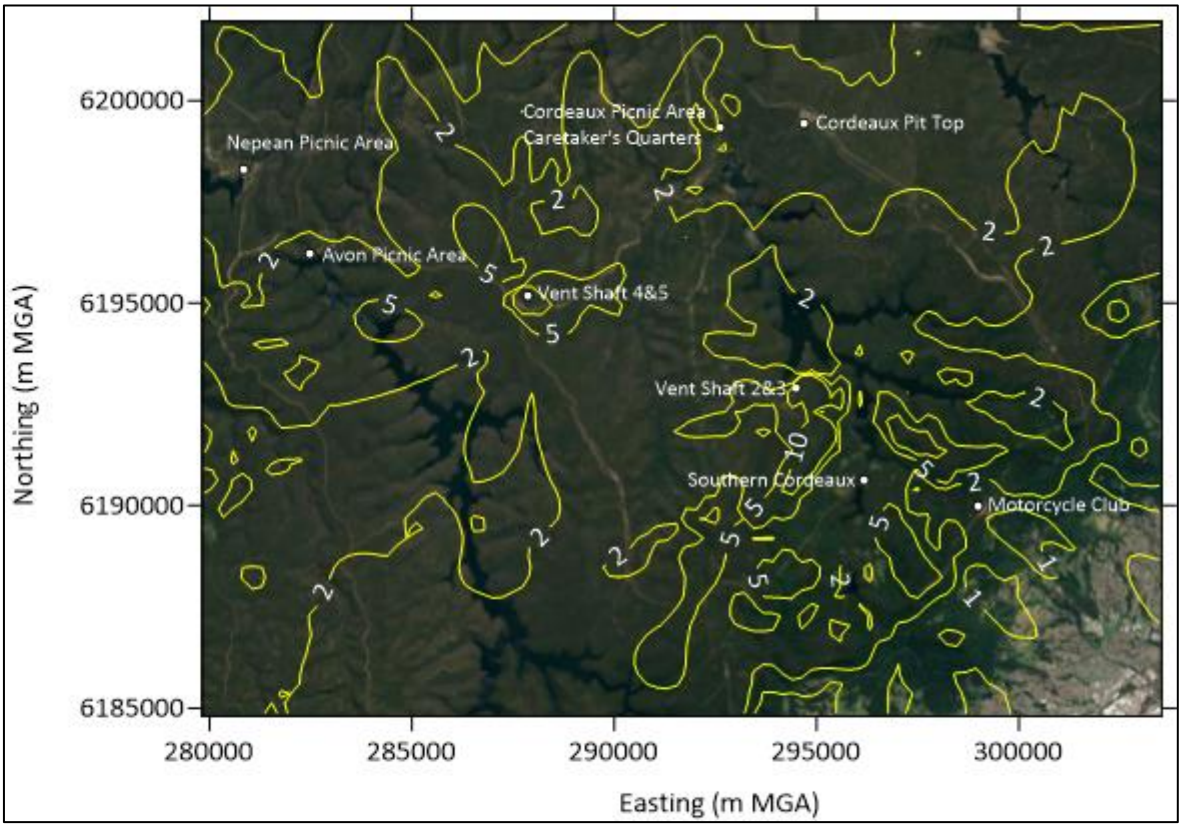

Figure 7-7: Predicted maximum 1-hour average NO_2 concentration (µg/m^3) from flaring at Area 3 and Area 5

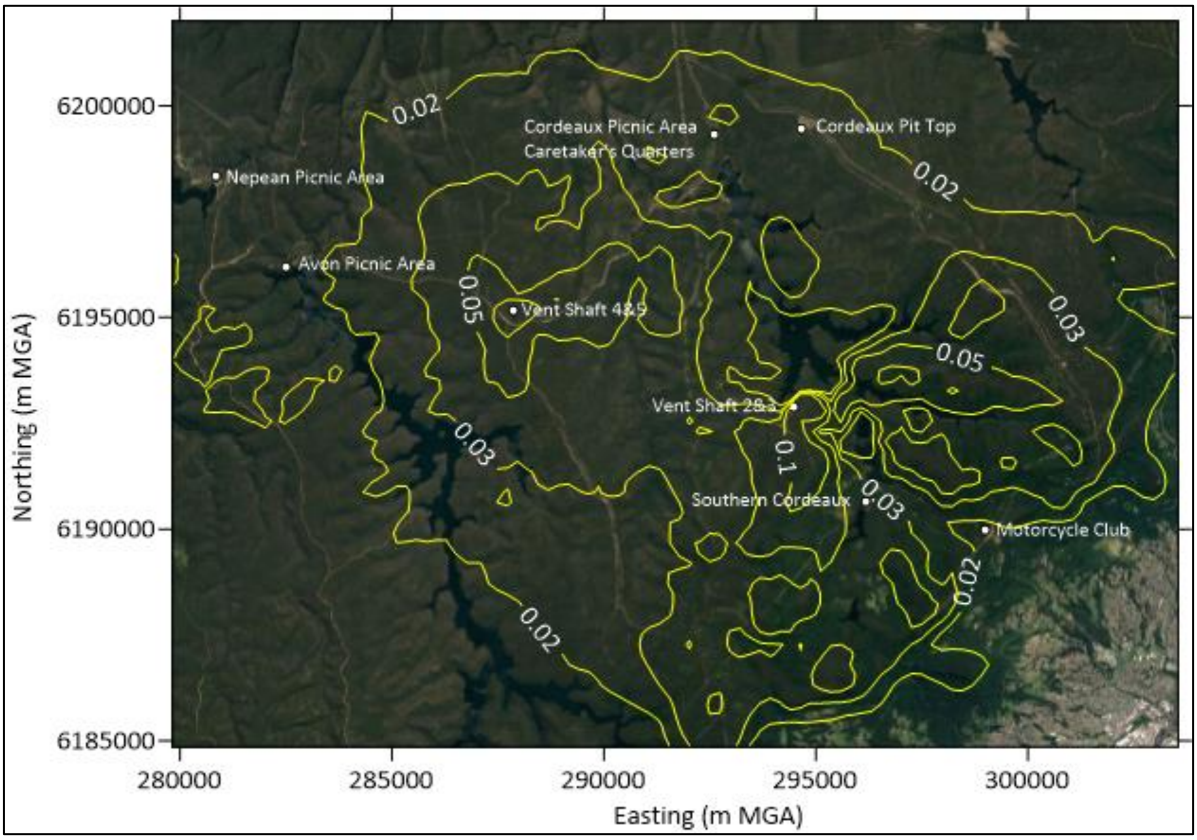

Figure 7-8: Predicted annual average NO_2 concentration (µg/m^3) from flaring at Area 3 and Area 5

7.4 Cordeaux Pit Top

As described previously, emissions associated with the Cordeaux Pit Top have not been modelled, based on the relatively minor dust emissions expected from mine support activities at this location (e.g. exploration and monitoring activities) and the separation distance of 2 km to the closest receptors. The impacts from the Cordeaux Pit Top would be lower in scale to the Dendrobium Pit Top as the facility is not used for mine access. Negligible Project-only ground level concentrations in the vicinity of the Dendrobium Pit Top are presented above (**Section 7.1**) out to a distance of approximately 500 m. It can be inferred from this that impacts at 2 km (distance from the Cordeaux Pit Top to receptors) would be negligible.

7.5 Coal Preparation Plant

7.5.1 Annual average modelling predictions

The Project-only annual average modelling predictions for the CPP are presented as contour plots only (**Figure 7-9** to **Figure 7-12**). The contour plots can be used to assess compliance at the nearby residential suburbs of Port Kembla, Cringila and Warrawong.

The contour plots show that the incremental annual average PM_{10} concentration across the residential areas is generally less than 1.0 µg/m³ (see **Figure 7-9**). If a background of 18.4 µg/m³ is added to this modelling prediction, there would be no exceedances of the annual average impact assessment criterion at residential areas adjacent to the CPP.

It is noted that the monitoring location operated by BlueScope Steel in the vicinity of the CPP recorded annual average PM_{10} concentrations for 2016 that were marginally higher than the derived background. However, these measurements include the existing operations of the CPP, and therefore if used for background would represent a double counting of these emissions sources. It is noted that there is no proposed change to existing operations at the CPP as a result of the Project and therefore the cumulative impacts from the Project should not significantly change compared to what is currently measured at this location.

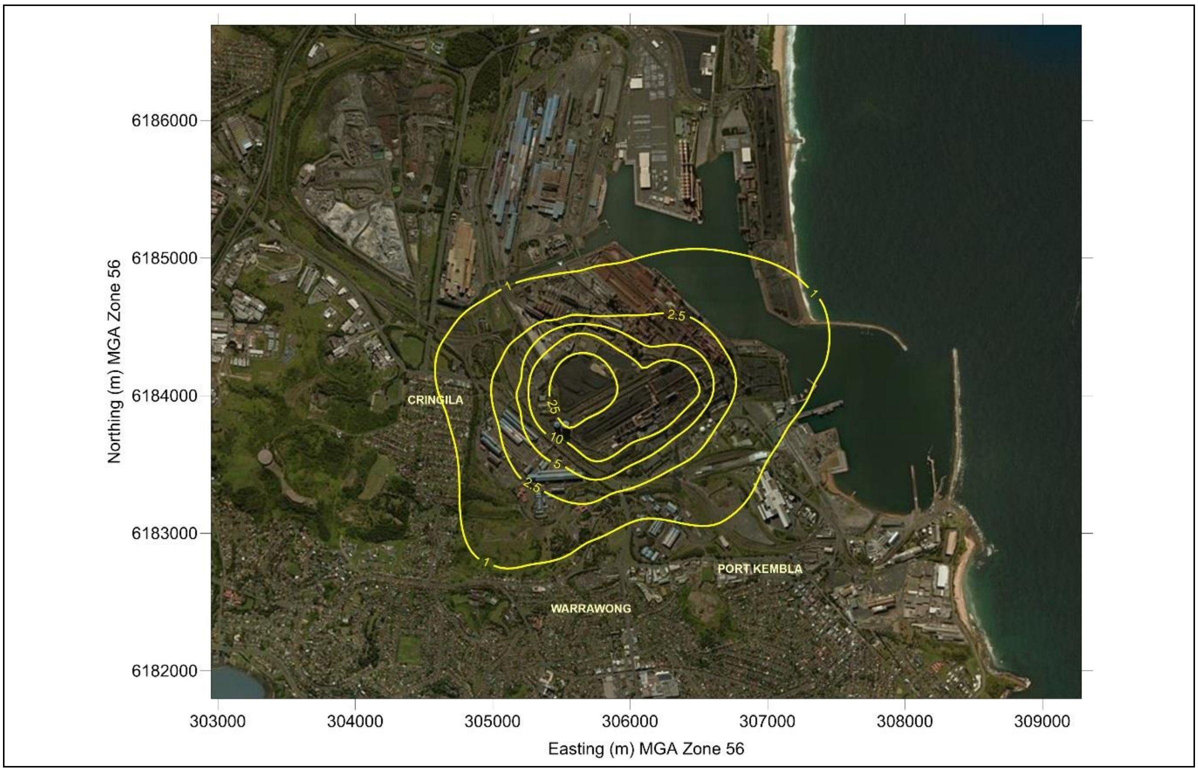

Figure 7-9: Predicted annual average PM_{10} concentration (µg/m³) from the CPP (Project-only)

Figure 7-10 shows that the incremental annual average $PM_{2.5}$ concentration across the residential areas is less than 0.25 µg/m³. If a background of 6.7 µg/m³ is added to this modelling prediction, there would be no exceedances of the annual average impact assessment criterion at residential areas adjacent to the CPP.

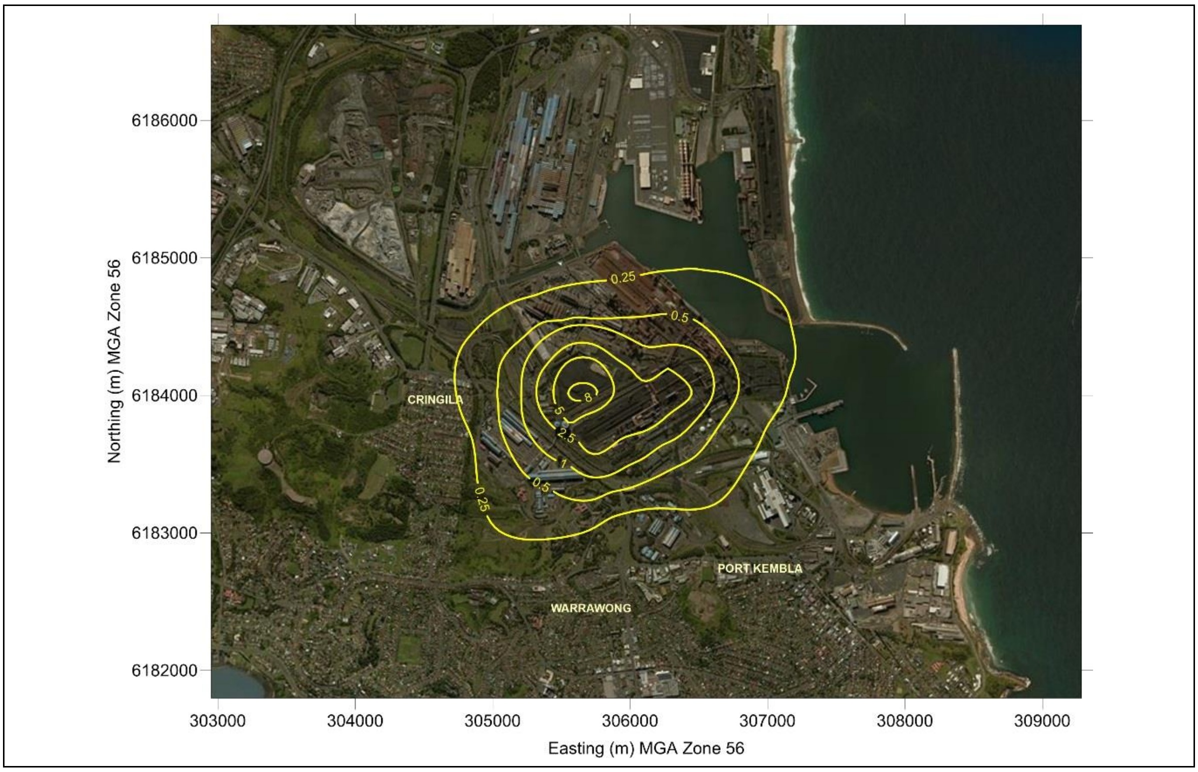

Figure 7-10: Predicted annual average $PM_{2.5}$ concentration (µg/m³) from the CPP (Project-only)

Figure 7-11 shows that the incremental annual average TSP concentration across the residential areas is generally less than 2.5 µg/m³. If a background of 33.7 µg/m³ is added to this modelling prediction, there would be no exceedances of this impact assessment criterion at residential areas adjacent to the CPP.

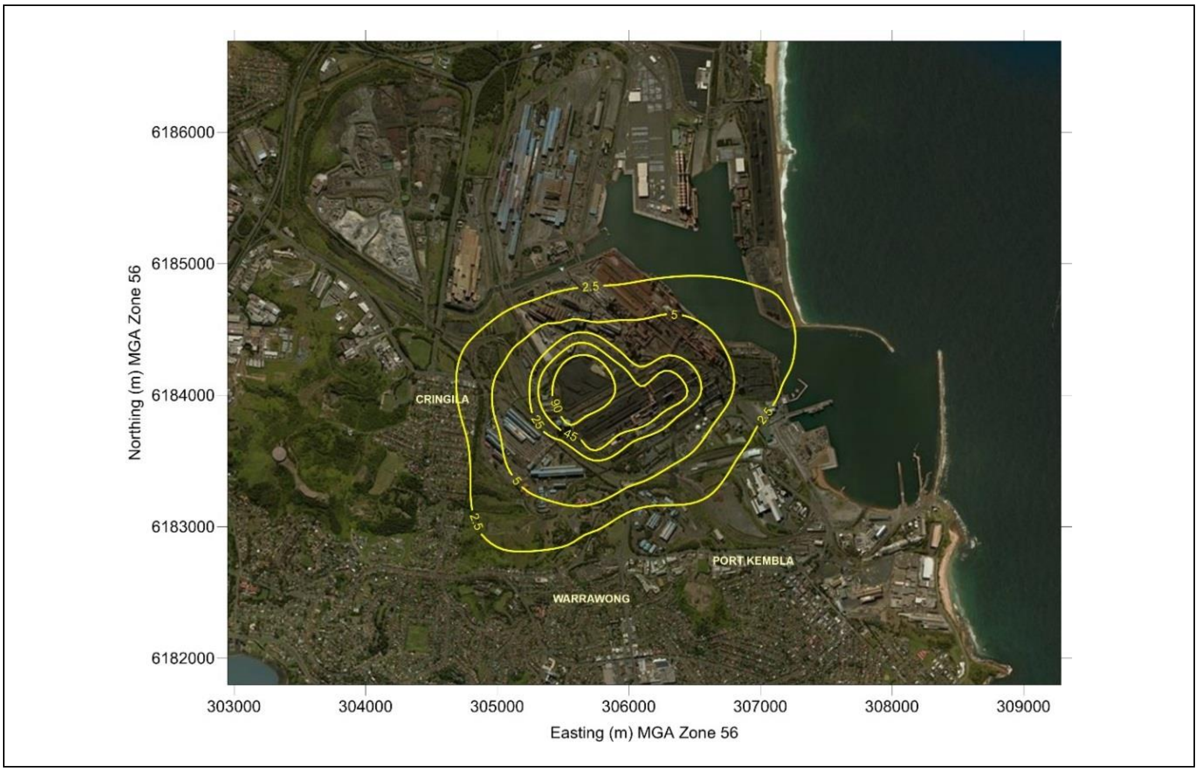

Figure 7-11: Predicted annual average TSP concentration (µg/m³) from the CPP (Project-only)

Figure 7-12 shows that the incremental annual average dust deposition across the residential areas is less than 0.1 g/m²/month, which complies with the impact assessment criterion of 2 g/m²/month. If a background of 1.8 g/m²/month is added to this modelling prediction, there would be no exceedances of the cumulative impact assessment criterion at residential areas adjacent to the CPP.

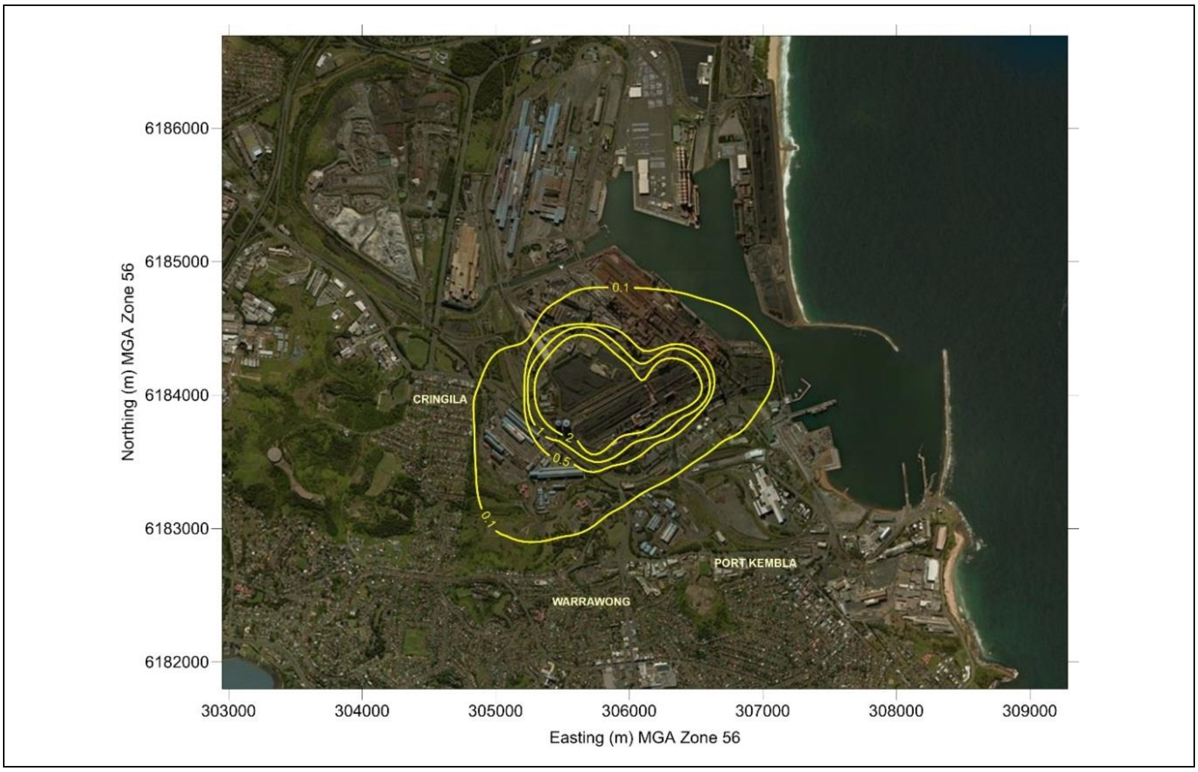

Figure 7-12: Predicted annual average dust deposition rate (g/m²/month) from the CPP (Project-only)

7.5.2 Short term (24-hour average) modelling predictions

The incremental 24-hour average PM_{10} concentrations across residential areas in the vicinity of the CPP are presented in **Figure 7-13**. To the south, across the residential suburb of Warrawong, the maximum incremental 24-hour average PM_{10} concentrations would be less than 10 µg/m³. To the west, across the residential suburb of Cringila, the maximum incremental 24-hour average PM_{10} concentrations would range from 10 – 20 µg/m³.

Figure 7-13: Predicted maximum 24-hour average PM_{10} concentration (µg/m³) from the CPP (Project-only)

As described in **Section 5**, BlueScope Steel operates a PM_{10} monitoring station in the suburb of Warrawong. During 2016, there were seven occasions when the 24-hour average PM_{10} concentration exceeded the impact assessment criterion of 50 µg/m³.

To provide an indication of the likelihood of additional exceedances from the Project, predicted 24-hour average concentrations for the suburbs of Warrawong and Cringila are paired with measured 24-hour average concentrations from the Kembla Grange monitoring site during 2016. The Kembla Grange site is selected as background to avoid double counting the influence of existing CPP operations in the BlueScope Warrawong data.

For the cumulative analysis, each combination of model prediction and recorded concentration is combined, assuming that any background value from the data set could coincide with any given model prediction. The analysis for Warrawong shows a very small risk of additional exceedances, with less than one additional day above 50 µg/m³ when compared to the Kembla Grange background data. For Cringila the risk is also small, with one additional day above 50 µg/m³, when compared to the Kembla Grange data. The predicted cumulative exceedances are less than the number of existing exceedances for 2016 at the BlueScope Warrawong site.

The Project-only 24-hour average $PM_{2.5}$ concentrations across residential areas in the vicinity of the CPP are predicted to be in the range of 2.5 – 5 µg/m³ (see **Figure 7-14**). Similar cumulative analysis was completed for $PM_{2.5}$, by combining each modelling prediction to the measured 24-hour average $PM_{2.5}$ concentrations from the Kembla Grange monitoring site during 2016. For $PM_{2.5}$, the analysis for both suburbs (Warrawong and Cringila) predicts no additional days above 25 µg/m³, when compared to the Kembla Grange background data.

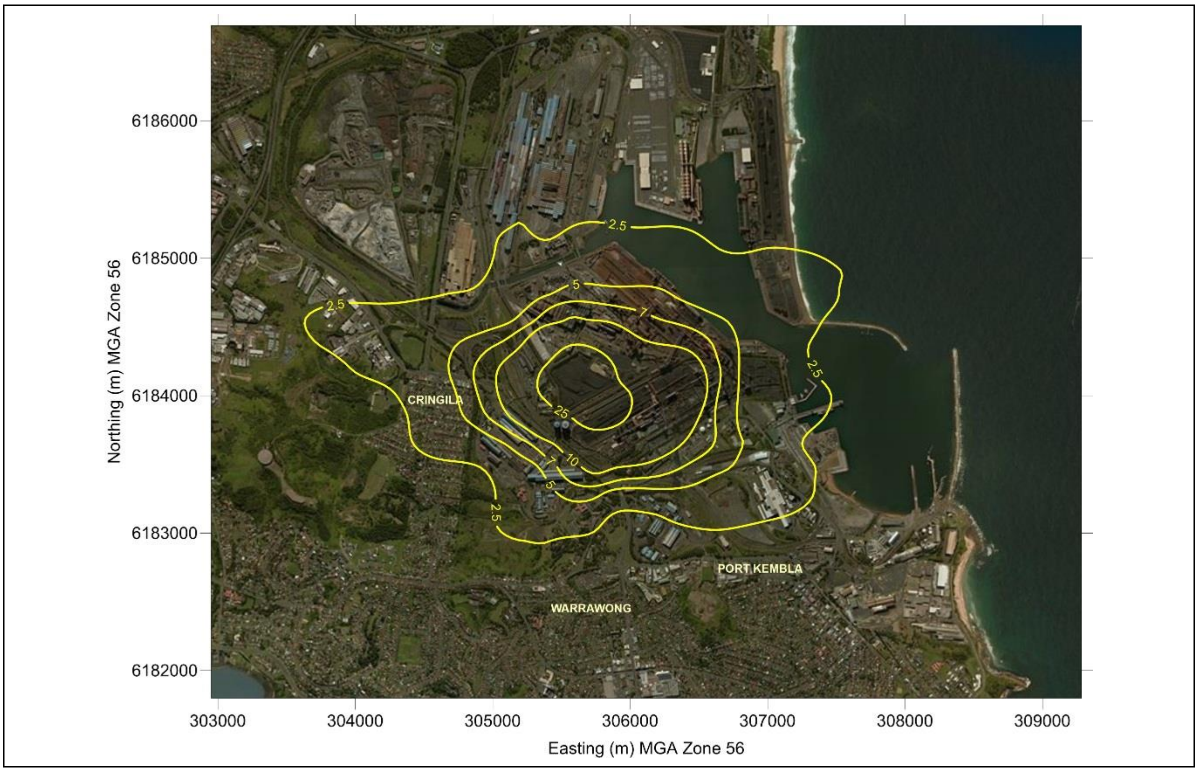

Figure 7-14: Predicted maximum 24-hour average $PM_{2.5}$ concentration (µg/m^3) from the CPP (Project-only)

7.5.3 Coal dryer

The coal fines dryer is not currently operational but may become operational in the future. The coal fines dryer was assessed in an air quality assessment which accompanied the EIS for the original approval (HAS, 2000). The air quality assessment considered emissions for various fuel types and found that emissions would be relatively insignificant when compared to the reported emissions for the Port Kembla Steelworks. For example, using natural gas as a fuel, the operation of the dryer was estimated to increase emissions of NO_x by approximately 0.4%.

The comparative analysis is updated for 2019 to 2020 National Pollutant Inventory (NPI) emission data for the Steelworks[6], comparing natural gas as the proposed fuel for the dryer (**Table 7-6**). The conclusions of the original air quality assessment remain valid; that is, the operation of the dryer results in a marginal increase in emissions in the local airshed. As there is no proposed change to the operation of the coal fines dryer for the Project, no further assessment is required as emissions from the coal dryer would be negligible.

Table 7-6: Emissions comparison for the coal fines dryer

Stack	NO_x	CO	SO_2	PM	VOCs
Annual emission – coal dryer (tpa)	45.5	38.4	0.2	3.4	2.5
Annual emissions – Steelworks (tpa)	6,400	100,000	6,200	1,200	130
Coal dryer as % of Steelworks	0.7%	0.04%	0.003%	0.28%	1.9%

Note: tpa = tonnes per annum.

[6] http://www.npi.gov.au/npidata/action/load/emission-by-individual-facility-result/criteria/state/NSW/year/2020/jurisdiction-facility/360

7.6 Coal wash transport and emplacement at West Cliff Coal Wash Emplacement Area

While the Project involves transport of coal wash from the CPP to the West Cliff Coal Wash Emplacement Area, this transport would occur by backfilling trucks transporting product coal from the West Cliff Coal Preparation Plant. These truck movements, and the associated backfilling with coal wash and emplacement, were assessed as part of the Bulli Seam Operations EIS.

The air quality assessment prepared for the Bulli Seam Operations EIS (PAEHolmes, 2009) concluded that Project-specific and cumulative dust concentrations and deposition levels would be in compliance with all impact assessment criteria at sensitive receptor locations in the vicinity of West Cliff Colliery (now referred to as Appin North). Furthermore, all trucks carrying coal wash are covered and therefore the impacts of trucks travelling on public roads would be minimal.

As there is no proposed change to the practice of coal wash emplacement for the Project, these conclusions remain and no further assessment is required.

7.7 Construction

Most of the construction activities for the Project would either be minor upgrades or occur at locations separated from sensitive receptors (e.g. Shaft Site 5A). All construction activities would be short-term and potential emissions could be controlled using standard mitigation and management practices. Therefore, construction phase emissions are not required to be assessed further in this report.

8. GREENHOUSE GAS ASSESSMENT

8.1 Emissions Estimation Methodology

Estimation of GHG emissions is based on a combination of data provided by South32 and the Australian Government Department of Industry, Science, Energy and Resources (DISER) National Greenhouse Accounts Factors (NGAF) workbook (DISER, 2021). The methodologies in the NGAF workbook follow a simplified approach, equivalent to the "Method 1" approach from the National Greenhouse and Energy Reporting (Measurement) Determination 2008 incorporating the National Greenhouse and Energy Reporting (Measurement) Amendment (2021 Update) Determination 2021.

Emissions estimated from emissions factors were estimated using the fuel energy contents and Scope 1, 2 and 3 emission factors (EF) in the NGAF workbook, along with project specific intensity factors from July 2020 to June 2021 site data.

In order to estimate fugitive emissions from pre and post gas drainage, a series of gas emission models were run based on a pore pressure model, established using borehole lithology and density logs from boreholes spread across the mine plan area to account for:

- Changes in stratigraphy in particular the proximity, thickness and ash content of seams located above and below the seam targeted for mining
- Variations in gas content, gas desorption pressure and gas in place
- Silling

Pore pressure data and mid-burden fracturing interpretations were derived from FLAC caving modelling. Gas content was applied to adjacent seams according to the gas content / depth relationship, adjusted for the average depth of the working seam in that particular zone, cognisant of the measured gas content data in the area. Gas composition assignment was according to the gas composition measurements of the seam.

An estimate of fugitive emissions from the Project on completion of mining has been made based on the area remaining open and ventilated, with estimated unabated fugitive emissions of 0.25 Mt CO_2-e per annum. This is considered conservative as it is likely that much of the project area will be sealed off shortly after extraction.

Additional details regarding the methodology for determining fugitive emissions from pre and post gas drainage can be found in Appendix 7.

8.2 Emission sources

The GHG emissions sources included in this assessment are listed in **Table 8-1**, representing the most significant sources associated with the Project.

Table 8-1 Scope 1, 2 and 3 emission sources

Scope	Source	Site/Location
Scope 1	Direct emissions from fuel combustion (diesel) by onsite plant and equipment	KVCLF, Pit Top and CPP
	Direct emissions from the flaring of gas for pre- and post-drainage	Ventilation shaft sites
	Direct emissions from the venting of gas (via MVA)	Ventilation shaft sites
	Residual (post mining) fugitive emissions from stockpiled coal	KVCLF and CPP
	Direct emissions from the combustion of gas in the coal dryer	CPP
	ROM coal transportation – rail transport from KVCLF to CPP	Kemira Valley Rail Line
	Product coal transportation – road transport from CPP to export terminal [1]	CPP
	Coal wash transportation – road transport from CPP to West Cliff Coal Wash Emplacement Area [2]	CPP
Scope 2	Indirect emissions from the use of electricity purchased from the grid	KVCLF, Pit Top [3] and CPP
Scope 3	Downstream emissions generated from the end use of product coal	Port Kembla Steelworks and export markets
	Balance of fuel cycle for grid electricity, diesel and natural gas	All

Notes:
[1] GHG emissions associated with this activity are estimated based on a return travel distance of 14 km on internal sealed roads. Fugitive dust emissions associated with this source are also assessed, but for a shorter travel distance (i.e. distance to exit point of the CPP only). This is conservative as some product coal would be transported a shorter distance to the Steelworks.
[2] GHG emissions associated with this activity are also considered in the Bulli Seam Operations EIS as Scope 3.

Other minor sources of GHG emissions not included in the assessment are presented in **Table 8-2.** These sources are considered to be negligible in comparison to the sources detailed above and below the materiality threshold.

Table 8-2 Minor emission sources not included

Source	Justification
Employee travel	Similar numbers of operational personnel proposed due to project
Waste disposal	Additional waste is not expected as a part of the project
Vegetation clearing	Existing infrastructure proposed to be suitable for the majority of the project works. Some minor clearing may be necessary for Project surface infrastructure during the expansion phase.

8.3 Activity data

The coal seam gas content would vary as longwall development progresses through the mining area. Likewise, gas flow rates for pre-drainage, post-drainage and MVA would have significant variability over the life of the Project. Estimates of CH_4 and CO_2 emissions from the coal seam have been provided by IMC, extracted from the production development and gas modelling for the Project.

To derive emissions from flaring, the total estimated volume of mine waste gas is calculated by Project year and used in the calculations as per the NGAF handbook. It is assumed that 67% of the coal seam gas is emitted via MVA and 33% via pre and post drainage. Total coal seam gas emissions have been presented separately considering venting or flaring.

Additional activity data for GHG emission estimates is summarised in **Table 8-3**, along with the assumptions/inputs used to derive the values.

Table 8-3: Activity data and assumptions

Activity	Unit	Value at Maximum Production (5.2 Mt)	Source of information / assumptions
Diesel - Pit Top	kL/annum	1,728	A diesel intensity factor (kL/tonne) is derived from 2021 diesel consumption and corresponding ROM coal production. This is then multiplied by the forecast ROM coal production to estimate diesel consumption for each year.
Diesel - Cordeaux	kL/annum	468	
Diesel - CPP	kL/annum	952	
Diesel - Kemira Valley	kL/annum	197	
Diesel - ROM coal transportation by rail	kL/annum	334	A diesel intensity factor (kL/tonne) is derived based on a fuel consumption rate for locomotives of 4.03 l/kt-km. The kt-km per annum is estimated based on a travel distance of 10 km multiplied by the forecast ROM coal production for each year. A return trip kt-km is also calculated for empty wagons.
Diesel - Product coal transport for export by truck	kL/annum	996	Based on reported diesel fuel consumption for articulated trucks given in l/km. The annual VKT is estimated based on a return travel distance of 80 km and the number of trips required to transport coal wash (based on production schedule for each year) using trucks with an average payload of 32.4 tonnes.
Diesel - Coal wash transport to Westcliff coal wash emplacement area by truck	kL/annum	1014	
Electricity use - KVCLF and Pit Top	Mwh/annum	84,609	An electricity intensity factor (kWh/tonne) is derived from 2021 electricity use and corresponding ROM coal production. This is then multiplied by the forecast ROM coal production to estimate electricity consumption for each year.
Electricity use - CPP	Mwh/annum	33,738	
Note: Mt = Megatonne, kL = kilolitre, MWh = megawatt hour			

8.4 NGAF 2021 Emission calculation factors

The greenhouse gases of significance for underground coal mining are CO_2 and CH_4, as they are released from the target coal seam during mining activities. CO_2 and CH_4 have different global warming potentials (GWP), and therefore CH_4 is assigned a factor to convert to CO_2 equivalent. Multiplying the mass of CH_4 by its GWP gives the mass of carbon dioxide emissions that would produce the same warming effect over a 100-year period. The GWP's used for this assessment are presented below in **Table 8-4** and are of particular significance to the predicted mine gas drainage quantities.

Table 8-4 Global warming potentials

Greenhouse Gas	Global warming potential (kg/CO_2-e)
CO_2	1
CH_4	28

Greenhouse gas emissions were calculated using emission factors and energy content factors applied to the mining activities detailed in **Section 8.2**, and are presented below in **Table 8-5**.

Table 8-5 Energy content and emission factors by activity and scope

<table>
<tr><th colspan="6">Scope 1</th></tr>
<tr><th rowspan="2">Source</th><th rowspan="2">Energy content factor</th><th colspan="4">Emission Factor</th></tr>
<tr><th>CO_2</th><th>CH_4</th><th>N_2O</th><th>Unit</th></tr>
<tr><td colspan="6">Gaseous fuel combusted</td></tr>
<tr><td>Natural gas distributed in a pipeline</td><td>39.3 × 10-3 GJ/m3</td><td>51.4</td><td>0.1</td><td>0.03</td><td>kg CO2-e/GJ</td></tr>
<tr><td>Coal mine waste gas that is captured for combustion</td><td>37.7 × 10-3 GJ/m3</td><td>51.9</td><td>4.6</td><td>0.3</td><td>kg CO2-e/GJ</td></tr>
<tr><td colspan="6">Diesel combustion</td></tr>
<tr><td>Diesel oil - Stationary</td><td>38.6 GJ/kL</td><td>69.9</td><td>0.1</td><td>0.2</td><td>kg CO2-e/GJ</td></tr>
<tr><td>Diesel Oil - Transport</td><td>38.6 GJ/kL</td><td>69.9</td><td>0.1</td><td>0.4</td><td>kg CO2-e/GJ</td></tr>
<tr><td colspan="6">Fugitive methane gas emissions post mining</td></tr>
<tr><td>Post mining activities associated with gassy underground mines</td><td>na</td><td colspan="3">0.019</td><td>t CO2-e/t raw coal</td></tr>
<tr><th colspan="6">Scope 2</th></tr>
<tr><td colspan="6">Electricity supplied by the grid</td></tr>
<tr><td>New South Wales and Australian Capital Territory</td><td>na</td><td colspan="3">0.79</td><td>kg CO2-e/kWh</td></tr>
<tr><th colspan="6">Scope 3</th></tr>
<tr><td colspan="6">Diesel, balance of fuel cycle</td></tr>
<tr><td>Diesel Oil</td><td>na</td><td colspan="3">3.6</td><td>kg CO2-e/GJ</td></tr>
<tr><td colspan="6">Natural gas, balance of fuel cycle</td></tr>
<tr><td>NSW - Metro (east of dividing range)</td><td>na</td><td colspan="3">13.1</td><td>kg CO2-e/GJ</td></tr>
<tr><td colspan="6">Electricity, balance of fuel cycle</td></tr>
<tr><td>NSW and ACT</td><td>na</td><td colspan="3">0.08</td><td>kg CO2-e/kWh</td></tr>
<tr><td colspan="6">Product end use</td></tr>
<tr><td>Coking Coal</td><td>6.4 GJ/t</td><td>91.8</td><td>0.03</td><td>0.2</td><td>kg CO2-e/GJ</td></tr>
<tr><td colspan="6">Note: GJ/m3 = Gigajoules per cubic metre, GJ/kL = Gigajoules per kilolitre,
kg CO2-e – kilograms of carbon dioxide equivalent</td></tr>
</table>

8.5 Summary of GHG emission estimates

Annual GHG emissions are directly related to the production schedule and therefore emissions are calculated for each year based on the production schedule prepared for the EIS. The estimated annual GHG emissions are presented in **Table 8-6** and **Table 8-7** for all Project sources plus processing and transport of coal for the Approved Mine. A summary of total GHG emissions by scope is presented in **Table 8-8**.

Fugitive gas emissions are compared for venting and flaring of pre- and post-gas drainage. The comparison shows that the adoption of flaring as an abatement option would reduce total fugitive emissions by 31%.

Based on the average scope 1 emissions (assuming flaring) of 789,551 tonnes CO_2-e, the Project represents approximately 0.58% of total GHG emissions for NSW and 0.15% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2019, which was the most recent at the time of reporting[7].

Based on the average scope 1 and 2 emissions (assuming flaring) of 854,834 tonnes CO_2-e, the Project represents approximately 0.63% of total GHG emissions for NSW and 0.16% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2019.

[7] http://ageis.climatechange.gov.au/

Table 8-6: Estimated Scope 1 GHG emissions (tonnes CO_2-e)

Project Year	Approved Mine Mt	Project (Area 5) ROM Mt	Scope 1											
			Total fugitive emissions (MVA and pre and post gas drainage)		Residual fugitive methane (post mining)	Diesel (Dendrobium)	Diesel (CPP)	Diesel (KV)	Diesel (Cordeaux)	Natural gas (coal dryer)	ROM coal transportation - KVCLF to CPP (train)	Product coal transportation to PKCT (truck)	Coal wash transportation to West Cliff (truck)
			If pre and post gas drainage is vented	If pre and post gas drainage is flared									
1	3.9	0.0	0	0	-	3,503	1,930	399	949	120,104	684	1,854	3,118
2	4.3	0.0	0	0	-	3,902	2,150	445	1,057	132,667	762	2,051	3,557
3	3.6	0.1	154,712	120,120	-	3,248	1,790	370	880	107,252	634	1,666	3,196
4	3.1	0.2	309,423	240,240	-	2,997	1,651	342	812	99,306	585	1,542	2,922
5	2.4	0.4	309,423	240,240	-	2,563	1,412	292	694	85,891	500	1,331	2,429
6	0.0	1.3	539,218	391,270	-	1,186	654	135	321	44,179	232	673	798
7	0.0	3.2	1,171,240	764,741	-	2,888	1,592	329	782	109,799	564	1,668	1,777
8	0.0	4.6	1,454,164	922,176	-	4,167	2,296	475	1,129	159,542	814	2,421	2,478
9	0.0	5.2	1,186,969	957,946	-	4,654	2,564	530	1,261	178,375	909	2,706	2,755
10	0.0	4.7	1,237,935	948,066	-	4,243	2,338	484	1,149	161,798	828	2,457	2,573
11	0.0	4.7	1,520,030	1,009,262	-	4,260	2,347	485	1,154	161,066	832	2,449	2,685
12	0.2	3.4	1,370,721	960,561	-	3,242	1,786	369	878	119,162	633	1,819	2,294
13	0.3	3.5	1,505,590	890,829	-	3,400	1,874	387	921	128,508	664	1,954	2,147
14	3.3	-	0	0	250,000	2,941	1,620	335	797	96,078	574	1,495	2,969
15	3.4	-	0	0	250,000	3,027	1,668	345	820	97,945	591	1,527	3,127
16	3.3	-	0	0	250,000	3,010	1,658	343	815	96,438	588	1,506	3,177
17	3.1	-	0	0	250,000	2,761	1,521	315	748	85,439	539	1,342	3,140
18	2.9	-	0	0	250,000	2,650	1,460	302	718	77,777	518	1,234	3,326
Max annual			**1,520,030**	**1,009,262**	**250,000**	**4,654**	**2,564**	**530**	**1,261**	**178,375**	**909**	**2,706**	**3,557**
Average annual			**597,746**	**413,636**	**250,000**	**3,258**	**1,795**	**371**	**883**	**114,518**	**636**	**1,761**	**2,693**
LOM total			**10,759,425**	**7,445,451**	**1,250,000**	**58,643**	**32,312**	**6,683**	**15,886**	**2,061,324**	**11,450**	**31,696**	**48,467**

Table 8-7 Estimated Scope 2 and 3 GHG emissions (tonnes CO_2-e)

Project Year	Approved Mine Mt	Project (Area 5) ROM Mt	Scope 2			Scope 3								
			Electricity (Dendrobium)	Electricity (Cordeaux)	Electricity (CPP)	End use of coal	Electricity (Dendrobium)	Electricity (Cordeaux)	Electricity (CPP)	Diesel (Dendrobium)	Diesel (CPP)	Diesel (KV)	Diesel (Cordeaux)	Natural gas (coal dryer)
1	3.9	0.0	49,999	256	19,937	0	0	0	0	0	0	0	0	30,533
2	4.3	0.0	55,696	286	22,209	0	0	0	0	0	0	0	0	33,727
3	3.6	0.1	46,363	238	18,487	134,209	73	0	29	3	1	0	1	27,266
4	3.1	0.2	42,775	219	17,057	528,010	287	1	114	10	6	1	3	25,246
5	2.4	0.4	36,586	188	14,589	987,794	537	3	214	19	10	2	5	21,835
6	0.0	1.3	16,935	87	6,753	3,102,913	1,715	9	684	61	34	7	16	11,231
7	0.0	3.2	41,227	211	16,439	7,687,654	4,175	21	1,665	148	82	17	40	27,913
8	0.0	4.6	59,470	305	23,714	11,158,327	6,022	31	2,401	214	118	24	58	40,559
9	0.0	5.2	66,427	341	26,488	12,473,782	6,727	35	2,682	239	132	27	65	45,347
10	0.0	4.7	60,565	311	24,150	11,323,193	6,133	31	2,446	218	120	25	59	41,132
11	0.0	4.7	60,804	312	24,246	11,286,279	6,157	32	2,455	218	120	25	59	40,946
12	0.2	3.4	46,268	237	18,450	8,194,167	4,455	23	1,776	158	87	18	43	30,294
13	0.3	3.5	48,533	249	19,353	8,370,870	4,551	23	1,815	161	89	18	44	32,669
14	3.3	-	41,978	215	16,739	0	0	0	0	0	0	0	0	24,425
15	3.4	-	43,210	222	17,230	0	0	0	0	0	0	0	0	24,900
16	3.3	-	42,956	220	17,129	0	0	0	0	0	0	0	0	24,517
17	3.1	-	39,413	202	15,716	0	0	0	0	0	0	0	0	21,720
18	2.9	-	37,831	194	15,085	0	0	0	0	0	0	0	0	19,772
Max annual			**66,427**	**341**	**26,488**	**12,473,782**	**6,727**	**35**	**2,682**	**239**	**132**	**27**	**65**	**45,347**
Average annual			**46,502**	**239**	**18,543**	**4,180,400**	**2,268**	**12**	**905**	**80**	**44**	**9**	**22**	**29,113**
LOM total			**837,036**	**4,294**	**333,771**	**75,247,199**	**40,832**	**209**	**16,282**	**1,449**	**798**	**165**	**392**	**524,032**

Table 8-8 Summary of GHG emissions (tonnes CO_2-e)

Project Year	Approved Mine Mt	Project Underground Mining - Area 5 (ROM Mt)	Scope 1	Scope 2	Scope 3	Scope 1 & 2
1	3.9	0.0	132,542	70,192	30,533	202,735
2	4.3	0.0	146,590	78,191	33,727	224,781
3	3.6	0.1	239,156	65,088	161,582	304,244
4	3.1	0.2	350,397	60,052	553,679	410,448
5	2.4	0.4	335,353	51,362	1,010,420	386,715
6	0.0	1.3	439,449	23,775	3,116,670	463,224
7	0.0	3.2	884,140	57,878	7,721,715	942,018
8	0.0	4.6	1,095,496	83,490	11,207,754	1,178,985
9	0.0	5.2	1,151,701	93,256	12,529,034	1,244,957
10	0.0	4.7	1,123,937	85,026	11,373,356	1,208,962
11	0.0	4.7	1,184,539	85,361	11,336,292	1,269,901
12	0.2	3.4	1,090,745	64,955	8,231,020	1,155,700
13	0.3	3.5	1,030,684	68,135	8,410,240	1,098,819
14	3.3	-	356,810	58,932	24,425	415,742
15	3.4	-	359,051	60,661	24,900	419,712
16	3.3	-	357,535	60,305	24,517	417,840
17	3.1	-	345,805	55,331	21,720	401,137
18	2.9	-	337,985	53,111	19,772	391,096
Max annual			**1,453,818**	**93,256**	**12,473,782**	**1,547,075**
Average annual			**789,551**	**65,283**	**4,183,740**	**854,834**
LOM total			**10,961,913**	**1,175,101**	**75,307,326**	**12,137,014**

9. MANAGEMENT AND MONITORING

The Dendrobium AQGHGMP outlines the roles, responsibilities, legislative requirements, management measures and monitoring requirements under the Dendrobium Mine's existing approval and EPL.

The existing monitoring data demonstrates compliance with impact assessment criteria at the monitoring locations, which suggests that the existing controls are effective in preventing dust impacts from existing operations. The modelling results presented in this report also suggest that the existing controls would be effective in preventing dust impacts from the Project.

It is noted that due to the historical PM_{10} monitoring frequency (once a month), it is not possible to determine the maximum 24-hour PM_{10} concentration or the number of days over the impact assessment criteria.

In July 2021 two real time monitors were installed on site to continuously measure PM_{10} concentrations which would assist in addressing the shortfalls of the historical once per month PM_{10} monitoring. The initial data has been reviewed at the end of 2021 to confirm the instruments are operating as designed.

The AQGHGMP was revised in early 2021 and would be reviewed and augmented, if required, for the operation of the Project.

9.1 Greenhouse gas emission reduction measures

In regard to greenhouse gas emissions, a review of best-practice greenhouse gas emission reduction measures relevant to the Project was undertaken by South32, and peer reviewed by Palaris (2022). Based on this review, greenhouse gas mitigation measures that are proposed for the Project include:

- implementation of best practice abatement technology for fugitive emissions by maximising the capture of gas via effective inseam drainage of the Bulli Seam prior to longwall extraction (pre-drainage), cross measure drainage of the underlying Wongawilli Seam during longwall extraction (post-drainage) and flaring of methane (thereby converting methane to carbon dioxide and lowering the global warming potential by a factor of 28); and
- investigation of further opportunities to maximise gas capture via pre-drainage of the underlying Wongawilli Seam and management of goaf gas, and implementation of these measures if technically feasible and commercially viable.

Palaris (2022) has stated the proposed mitigation measures, in addition to the optimisation opportunities (the feasibility of which needs to be determined via further studies during the operation of the Project) would minimise GHG emissions where practicable. Further details of the proposed management and mitigation of GHG emissions from operations can be found in Appendix 6.

9.2 Dust complaints

A review of complaints data between July 2020 and June 2021 indicated that four complaints regarding dust were received. Complaint management documentation suggests such complaints are addressed in a timely fashion.

The low frequency of dust complaints is consistent with historical compliance monitoring and modelling predictions presented in this report and provides additional evidence that existing dust controls are effective in protecting receptors.

10. CONCLUSION

Ramboll was commissioned to complete an AQA for the Project. The Project seeks to gain access to one new underground mining area, Area 5, and to extend the life of approved surface operations to approximately 2041. The Project also includes the continued use of existing surface infrastructure (for the extended mine life) as well as additional ventilation and gas management infrastructure.

Air quality impacts are assessed using a Level 2 assessment approach in accordance with the NSW Approved Modelling Methods. Emissions inventories have been developed based on a maximum production rate of 5.2 Mtpa. Dispersion modelling was used to predict ground level concentrations for key pollutants from key Project components, at surrounding private and other sensitive receptors. Cumulative impacts were assessed by taking into account the existing ambient baseline air quality.

The predicted Project-only and cumulative annual average PM_{10}, $PM_{2.5}$ and TSP concentrations and dust deposition levels indicate that no sensitive receptor, in the vicinity of the Dendrobium Pit Top and KVCLF, would experience additional exceedances of the NSW EPA's impact assessment criteria. The predicted cumulative 24-hour average PM_{10} and $PM_{2.5}$ concentrations demonstrated that no additional exceedances of the impact assessment criteria are expected at sensitive receptors in the vicinity of the Mine.

The impact of dust emissions from the ventilation shaft are negligible at the closest receptor, and odour would be undetectable (all modelling predictions are less than 1 OU). Emissions from flaring at the ventilation shaft sites are modelled based on a maximum gas flow rate emitted from both Area 3 and Area 5 simultaneously. As flaring is unlikely to occur at both sites simultaneously, the modelled predictions are considered to be highly conservative.

The incremental 1-hour average NO_2 concentration from flaring at the closest receptors is less than 2.6 µg/m³, compared to the impact assessment criterion of 246 µg/m³, while the incremental annual average NO_2 concentration at the closest receptor is 0.035 µg/m³, compared to the impact assessment criterion of 62 µg/m³. Background concentrations in the area are expected to be low to negligible and therefore cumulative impacts are not expected.

The potential impacts from coal trains were also assessed, in terms of fugitive emissions from coal wagons and diesel exhaust emissions from locomotives. It is noted that material property testing has shown that the measured moisture content for ROM coal arriving at the CPP (6.5%) is higher than the measured DEM level (4.6%) and therefore fugitive emissions are not expected. The emission estimates conservatively do not take this into account and, even with fugitive emissions included, the impact from coal transportation is negligible (and well below the NSW EPA's impact assessment criteria).

Modelling results are presented for the CPP, although it is noted that the existing approved operations would not materially change as a result of the Project. The predicted Project-only annual average PM_{10}, $PM_{2.5}$ and TSP concentrations and dust deposition levels at residential areas in the vicinity of the CPP are below the NSW EPA's impact assessment criteria. The maximum predicted Project-only 24-hour average concentrations across residential areas in the vicinity of the CPP are predicted to be in the range of 10 – 20 µg/m³ for PM_{10} and 2.5 – 5 µg/m³ for $PM_{2.5}$. Cumulative analysis predicted a very low risk of additional exceedances for 24-hour PM_{10} (less than 1 day) and no additional exceedances for $PM_{2.5}$. The coal fines dryer at the CPP is not currently operational, but may become operational in the future. The operation of the dryer would result in insignificant increases in emissions in comparison to other emission sources and, as such, increases in emissions in the local airshed would be negligible.

Estimated annual average Scope 1 emissions represent approximately 0.58% of total GHG emissions for NSW and 0.15% of total GHG emissions for Australia, whilst estimated annual average Scope 1 and 2 emissions represent approximately 0.63% of total GHG emissions for NSW and 0.16% of total GHG emissions for Australia based on the National Greenhouse Gas Inventory for 2019.

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APPENDIX 1
ASSESSMENT LOCATIONS

Table A1-1: Assessment locations

Identifier	Category		Address	Location (m MGA, zone 56)		Elevation (m AHD)
				Easting	Northing	
D0001	Residential	(Mine-owned)	17 High St Kembla Heights	298980	6188279	230.0
D0002	Commercial Premises	(Mine-owned)	Dendrobium Pit Top	298909	6188075	209.9
D0003	Commercial Premises	(Mine-owned)	Dendrobium Pit Top	298702	6187827	213.0
D0004	Residential		374 Cordeaux Rd Mount Kembla	298957	6187726	190.8
D0005	School		323-327 Cordeaux Rd Mount Kembla	299434	6187701	129.0
D0006	Residential		214 Cordeaux Rd Mount Kembla	300349	6187985	64.4
D0007	Residential		27 Stones Rd Mount Kembla	300793	6188421	49.5
D0008	Commercial Premises	(Mine-owned)	Kemira Valley	300273	6188795	88.7
D0009	Residential		27 Stones Rd Mount Kembla	300928	6188716	96.2
D0010	Commercial Premises		Kemira Valley Coal Loader	300344	6189321	70.0
D0011	Residential	(Mine-owned)	13 Harry Graham Dr Kembla Heights	298478	6187751	254.5
D0012	Residential	(Mine-owned)	17 Harry Graham Dr Kembla Heights	298493	6187792	252.5
D0013	Residential	(Mine-owned)	25 View St Kembla Heights	298521	6187849	252.7
D0014	Residential	(Mine-owned)	21 Harry Graham Dr Kembla Heights	298477	6187849	254.1
D0015	Residential	(Mine-owned)	23 Harry Graham Dr Kembla Heights	298491	6187863	254.0
D0016	Residential	(Mine-owned)	26 View St Kembla Heights	298533	6187865	252.9
D0017	Residential	(Mine-owned)	25 Harry Graham Dr Kembla Heights	298471	6187893	254.8
D0018	Residential	(Mine-owned)	28 Harry Graham Dr Kembla Heights	298441	6187921	258.9
D0019	Recreation Facility		29 Harry Graham Dr Kembla Heights	298499	6187909	253.7
D0020	Residential	(Mine-owned)	34 View St Kembla Heights	298578	6187909	250.5
D0021	Residential	(Mine-owned)	47 Harry Graham Dr Kembla Heights	298573	6188012	247.8
D0022	Residential	(Mine-owned)	5 Mount St Kembla Heights	298718	6188081	238.2

Identifier	Category		Address	Location (m MGA, zone 56)		Elevation (m AHD)
				Easting	Northing	
D0023	Residential	(Mine-owned)	2 Central Ave Kembla Heights	298723	6188114	237.6
D0024	Residential	(Mine-owned)	4 Central Ave Kembla Heights	298738	6188129	236.6
D0025	Residential	(Mine-owned)	7 Central Ave Kembla Heights	298787	6188125	232.4
D0026	Residential	(Mine-owned)	11 Central Ave Kembla Heights	298799	6188138	231.8
D0027	Residential	(Mine-owned)	11 Central Ave Kembla Heights	298805	6188147	231.7
D0028	Residential	(Mine-owned)	13 Central Ave Kembla Heights	298812	6188158	231.7
D0029	Residential	(Mine-owned)	6 Central Ave Kembla Heights	298744	6188152	236.4
D0030	Residential	(Mine-owned)	59 Harry Graham Dr Kembla Heights	298682	6188155	240.1
D0031	Residential	(Mine-owned)	61 Harry Graham Dr Kembla Heights	298693	6188165	238.8
D0032	Residential	(Mine-owned)	63 Harry Graham Dr Kembla Heights	298699	6188183	239.9
D0033	Residential	(Mine-owned)	62 Harry Graham Dr Kembla Heights	298663	6188198	247.8
D0034	Residential	(Mine-owned)	5 High St Kembla Heights	298727	6188215	242.0
D0035	Residential	(Mine-owned)	55 Harry Graham Dr Kembla Heights	298657	6188133	244.7
D0036	Residential	(Mine-owned)	7 High St Kembla Heights	298738	6188227	242.2
D0037	Residential	(Mine-owned)	12 Central Ave Kembla Heights	298776	6188206	237.5
D0038	Residential	(Mine-owned)	15 High St Kembla Heights	298770	6188264	242.3
D0039	Residential	(Mine-owned)	82 Harry Graham Dr Kembla Heights	298887	6188536	277.6
D0040	Residential	(Mine-owned)	84 Harry Graham Dr Kembla Heights	298905	6188571	283.7
D0041	Recreation Facility		1 Church Lane Kembla Heights	298595	6187990	246.4
D0042	Residential	(Mine-owned)	6 Church Lane Kembla Heights	298603	6187972	246.7
D0043	Commercial Premises	(Mine-owned)	41 Harry Graham Dr Kembla Heights	298525	6187965	249.3
D0044	Residential	(Mine-owned)	43 Harry Graham Dr Kembla Heights	298544	6187981	247.2
D0045	Residential	(Mine-owned)	30 Harry Graham Dr Kembla Heights	298441	6187940	259.0
D0046	Residential	(Mine-owned)	32 Harry Graham Dr Kembla Heights	298449	6187952	257.1
D0047	Residential	(Mine-owned)	34 Harry Graham Dr Kembla Heights	298458	6187963	254.7

Identifier	Category		Address	Location (m MGA, zone 56)		Elevation (m AHD)
				Easting	Northing	
D0048	Residential	(Mine-owned)	36 Harry Graham Dr Kembla Heights	298466	6187975	253.5
D0050	Residential	(Mine-owned)	38 Harry Graham Dr Kembla Heights	298478	6187983	252.3
D0051	Residential	(Mine-owned)	3 Mount St Kembla Heights	298698	6188099	239.7
D0052	Residential	(Mine-owned)	141 Cordeaux Rd Kembla Heights	298163	6187478	289.5
D0053	Place of Worship		617 Cordeaux Rd Kembla Heights	297775	6187197	301.5
D0054	Residential		147 Cordeaux Rd Kembla Heights	297818	6187249	291.7
D0055	Residential		145 Cordeaux Rd Kembla Heights	297922	6187238	305.9
D0056	Residential		145 Cordeaux Rd Kembla Heights	297992	6187279	309.6
D0057	Residential		617 Cordeaux Rd Kembla Heights	297759	6187218	293.8
D0058	Residential		145 Cordeaux Rd Kembla Heights	297835	6187266	291.4
D0059	Residential		26 Stones Rd Mount Kembla	300003	6188477	79.2
D0060	Residential		4-6 Kirkwood Pl Mount Kembla	299549	6188136	84.8
D0061	Residential		336 Cordeaux Rd Mount Kembla	299301	6187892	139.8
D0062	Residential		381 Cordeaux Rd Mount Kembla	298944	6187670	196.3
D0063	Residential		379 Cordeaux Rd Mount Kembla	298959	6187669	193.8
D0064	Residential		377 Cordeaux Rd Mount Kembla	298973	6187668	191.4
D0065	Residential		372 Cordeaux Rd Mt Kembla	298973	6187718	190.1
D0066	Residential		364 Cordeaux Rd Mount Kembla	299026	6187719	183.3
D0067	Residential		358 Cordeaux Rd Mount Kembla	299067	6187710	177.7
D0068	Residential		369 Cordeaux Rd Mount Kembla	299027	6187653	183.2
D0069	Residential		367 Cordeaux Rd Mount Kembla	299045	6187653	181.0
D0070	Residential		2 Araluen Ave Mount Kembla	298984	6187616	191.1
D0071	Residential		Araluen Ave Mount Kembla	298970	6187542	201.4
D0072	Residential		4 Araluen Ave Mount Kembla	299053	6187595	184.2
D0073	Residential		6 Araluen Ave Mount Kembla	299067	6187589	183.4

Identifier	Category	Address	Location (m MGA, zone 56)		Elevation (m AHD)
			Easting	Northing	
D0074	Residential	8 Araluen Ave Mount Kembla	299081	6187583	182.7
D0075	Residential	10 Araluen Ave Mount Kembla	299094	6187574	182.6
D0076	Residential	12 Araluen Ave Mount Kembla	299106	6187564	182.6
D0077	Residential	14 Araluen Ave Mount Kembla	299120	6187551	182.6
D0078	Residential	18 Araluen Ave Mount Kembla	299142	6187518	184.0
D0079	Residential	20 Araluen Ave Mount Kembla	299163	6187522	180.1
D0080	Residential	17 Araluen Ave Mount Kembla	299180	6187534	175.3
D0081	Residential	11-13 Araluen Ave Mount Kembla	299156	6187580	175.8
D0081	Residential	9 Araluen Ave Mount Kembla	299146	6187595	175.2
D0082	Residential	7 Araluen Ave Mount Kembla	299132	6187603	175.6
D0083	Residential	5 Araluen Ave Mount Kembla	299119	6187610	175.9
D0084	Residential	3 Araluen Ave Mount Kembla	299108	6187623	175.3
D0085	Residential	1 Araluen Ave Mount Kembla	299091	6187626	176.3
D0086	Residential	2 Cudgee Cres Mount Kembla	299215	6187670	158.2
D0087	Residential	4 Cudgee Cres Mount Kembla	299234	6187657	155.3
D0088	Residential	6 Cudgee Cres Mount Kembla	299247	6187645	154.4
D0089	Residential	8 Cudgee Cres Mount Kembla	299245	6187622	155.4
D0090	Residential	10 Cudgee Cres Mount Kembla	299250	6187609	155.7
D0091	Residential	12 Cudgee Cres Mount Kembla	299255	6187594	155.9
D0092	Residential	14 Cudgee Cres Mount Kembla	299244	6187577	158.5
D0093	Residential	16 Cudgee Cres Mount Kembla	299249	6187560	158.8
D0094	Residential	18 Cudgee Cres Mount Kembla	299265	6187539	157.0
D0095	Residential	17 Cudgee Cres Mount Kembla	299304	6187582	149.3
D0096	Residential	15 Cudgee Cres Mount Kembla	299302	6187598	149.6
D0096	Residential	13 Cudgee Cres Mount Kembla	299301	6187614	149.7

Identifier	Category	Address	Location (m MGA, zone 56)		Elevation (m AHD)
			Easting	Northing	
D0097	Residential	11 Cudgee Cres Mount Kembla	299297	6187627	150.1
D0098	Residential	9 Cudgee Cres Mount Kembla	299297	6187643	149.9
D0099	Residential	7 Cudgee Cres Mount Kembla	299291	6187659	150.2
D0100	Residential	5 Cudgee Cres Mount Kembla	299293	6187673	149.8
D0101	Residential	3 Cudgee Cres Mount Kembla	299273	6187686	151.3
D0102	Residential	1 Cudgee Cres Mount Kembla	299249	6187697	153.1
D0103	Residential	14 Benjamin Rd Mount Kembla	299438	6187906	114.0
D0104	Residential	39 Stones Rd Mount Kembla	300109	6188114	72.6
D0105	Recreation Facility (Wollongong Motorcycle Club)	340 Harry Graham Dr Kembla Heights	299164	6189847	310.4
D0106	Recreation Facility	Stafford Rd Mount Kembla	299611	6187863	94.8
D0107	Place of Worship	301 Cordeaux Rd Mount Kembla	299619	6187726	99.1
D0108	Other	Cordeaux Rd Mt Kembla	299733	6187730	98.6
D0109	Commercial Premises	274 Cordeaux Rd Mount Kembla	299807	6187787	98.6
D0110	Recreation Facility	Stones Rd Mount Kembla	300006	6188179	66.2
D0111	Residential	69 William James Dr Cordeaux Heights	300261	6187372	98.1
D0112	Residential	18 Ridgecrest Cordeaux Heights	300001	6187286	103.6
D0113	Residential	46 Natan Pl Cordeaux Heights	301246	6187096	44.1
D0114	Residential	246 O'Briens Rd Figtree	301611	6188854	176.6
D0115	Residential	244 O'Briens Rd Figtree	301618	6188830	172.6
D0116	Residential	20 Stones Rd Mount Kembla	300092	6188451	84.0
D0117	Residential	Stones Rd Mount Kembla	300718	6188499	51.4
D0118	Residential	121 O'Briens Rd Figtree	300987	6188546	95.8
D0119	Residential	117 O'Briens Rd Figtree	301399	6188357	96.2
D0120	Residential	Cordeaux Rd Mount Kembla	300707	6188164	90.3

Identifier	Category	Address	Location (m MGA, zone 56)		Elevation (m AHD)
			Easting	Northing	
D0121	Commercial Premises	Cordeaux Dam Rd Cataract	292632	6199555	358.2
D0122	Caretaker's Quarters	Cordeaux Dam Rd Cataract	292575	6199200	344.4
D0123	Recreation Facility	Cordeaux dam Rd Cataract	292558	6199320	352.0
D0124	Caretaker's Quarters	Upper Cordeaux Lake No.2	296163	6190595	319.4
D0125	Residential	200 Cordeaux Rd Mount Kembla	300476	6187936	52.8
D0126	Commercial Premises	200 Cordeaux Rd Mount Kembla	300533	6187883	51.0
D0127	Residential	2 William James Dr Mount Kembla	301017	6187419	53.2
D0128	Residential	7 William James Dr Mount Kembla	301212	6187296	49.0
D0129	Residential	9 William James Dr Mount Kembla	301218	6187238	43.0
D0130	Residential	48 Natan Pl Cordeaux Heights	301249	6187063	45.6
D0131	Residential	112 Booreea Blvd Cordeaux Heights	301292	6187041	39.0
D0132	Residential	110 Booreea Blvd Cordeaux Heights	301295	6187014	38.0
D0133	Residential	108 Booreea Blvd Cordeaux Heights	301306	6186994	34.8
D0134	Residential	5 Alukea Rd Cordeaux Heights	301784	6186464	26.4
D0135	Residential	2 Central Ave Cordeaux Heights	301826	6186427	23.2
D0136	Residential	49-55 Cordeaux Rd Figtree	301899	6186448	21.5
D0137	Residential	4 Leigh Cres Unanderra	301928	6186349	25.6
D0138	Residential	2 Leigh Cres Unanderra	301957	6186328	27.2
D0139	Residential	1A Leigh Cres Unanderra	301993	6186300	27.4
D0140	Residential	41A Cordeaux Rd Figtree	301978	6186388	22.9
D0141	Residential	39 Cordeaux Rd Figtree	302015	6186360	24.2
D0142	Residential	37 Cordeaux Rd Figtree	302054	6186321	25.2
D0143	Residential	31/21 Cordeaux Rd Figtree	302106	6186315	25.0

Identifier	Category	Address	Location (m MGA, zone 56)		Elevation (m AHD)
			Easting	Northing	
D0144	Residential	72 Albert St Unanderra	302019	6186250	24.4
D0145	Residential	70 Albert St Unanderra	302035	6186244	23.4
D0146	Residential	68 Albert St Unanderra	302051	6186241	22.5
D0147	Residential	66 Albert St Unanderra	302068	6186232	21.2
D0148	Residential	64 Albert St Unanderra	302084	6186226	19.9
D0149	Residential	62 Albert St Unanderra	302101	6186218	18.5
D0150	Residential	60 Albert St Unanderra	302113	6186206	18.0
D0151	Residential	58A Albert St Unanderra	302141	6186219	19.0
D0152	Residential	58 Hurt Pde Unanderra	302166	6186192	17.6
D0153	Residential	56 Hurt Pde Unanderra	302187	6186193	17.3
D0154	Residential	54 Hurt Pde Unanderra	302209	6186188	16.3
D0155	Residential	52 Hurt Pde Unanderra	302228	6186183	15.3
D0156	Residential	50 Hurt Pde Unanderra	302247	6186171	13.8
D0157	Residential	48 Hurt Pde Unanderra	302267	6186166	13.5
D0158	Residential	46 Hurt Pde Unanderra	302284	6186157	13.1
D0159	Residential	44 Hurt Pde Unanderra	302300	6186149	12.8
D0160	Residential	42 Hurt Pde Unanderra	302309	6186135	12.2
D0161	Residential	40 Hurt Pde Unanderra	302351	6186146	14.6
D0162	Residential	1 Cordeaux Rd Figtree	302355	6186213	18.3
D0163	Residential	354 Cordeaux Rd Mount Kembla	299152	6187741	165.2
D0165	Residential	23 William James Dr Mount Kembla	300622	6187387	78.4
D0166	Residential	10 William James Dr Mount Kembla	300841	6187378	70.1
D0167	Residential	8 William James Dr Mount Kembla	300895	6187386	67.2
D0168	Residential	6 William James Dr Mount Kembla	300941	6187401	61.8
D0169	Residential	15 Leigh Cres Unanderra	301820	6186300	30.1

Identifier	Category	Address	Location (m MGA, zone 56)		Elevation (m AHD)
			Easting	Northing	
D0164	Residential	15 Benjamin Rd Mount Kembla	299505	6187978	99.8
D0170	Recreational	Avon Picnic Area	282535	6196212	354.9
D0171	Recreational	Nepean Picnic Area	280872	6198326	325.5

Note: m AHD = metres Australian Height Datum

APPENDIX 2
ANNUAL WIND ROSE PLOTS

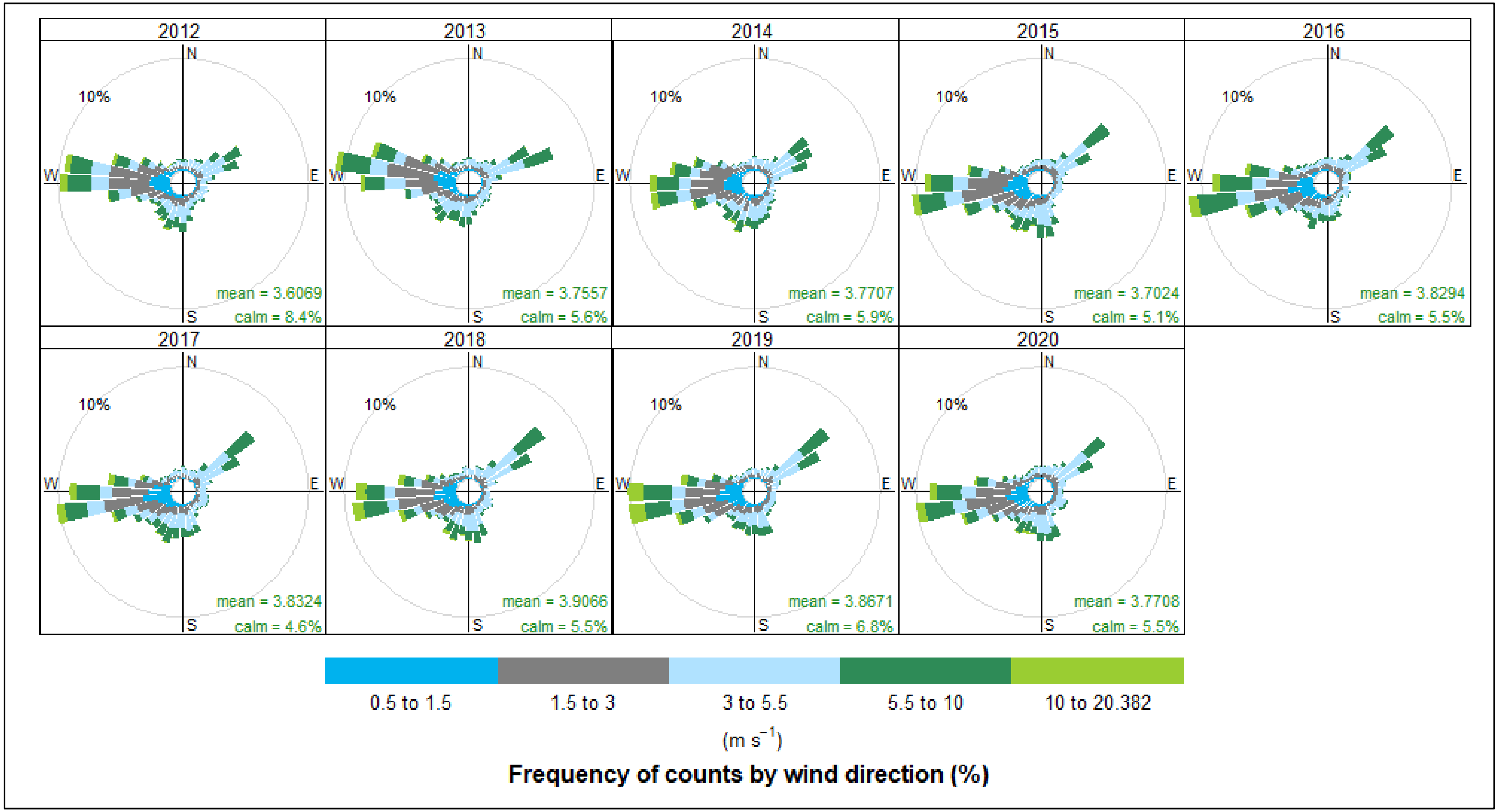

Figure A2-1: Annual wind roses for Wollongong Airport AWS – 2012 to 2020

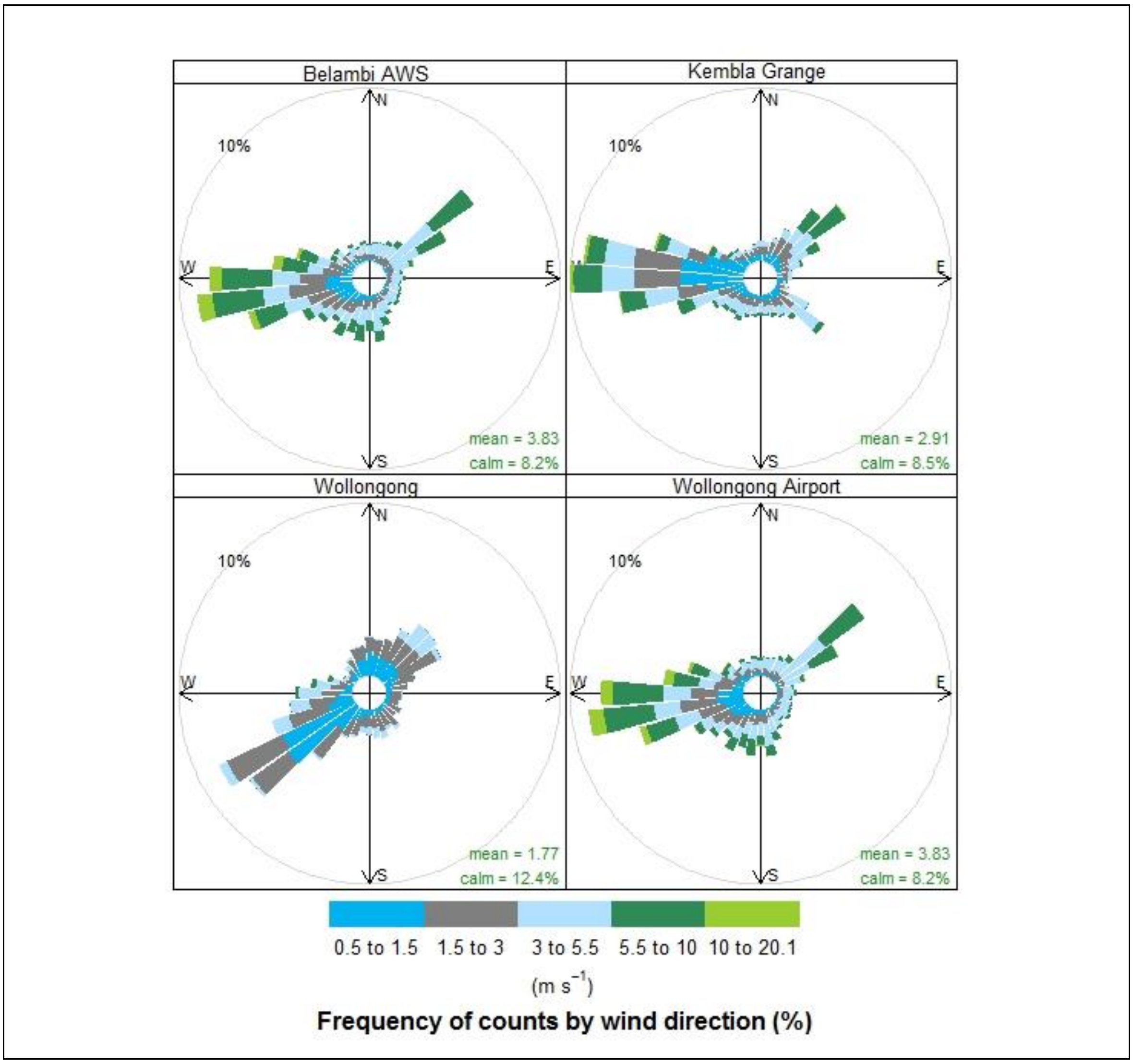

Figure A2-2: Regional wind roses for Project – 2016

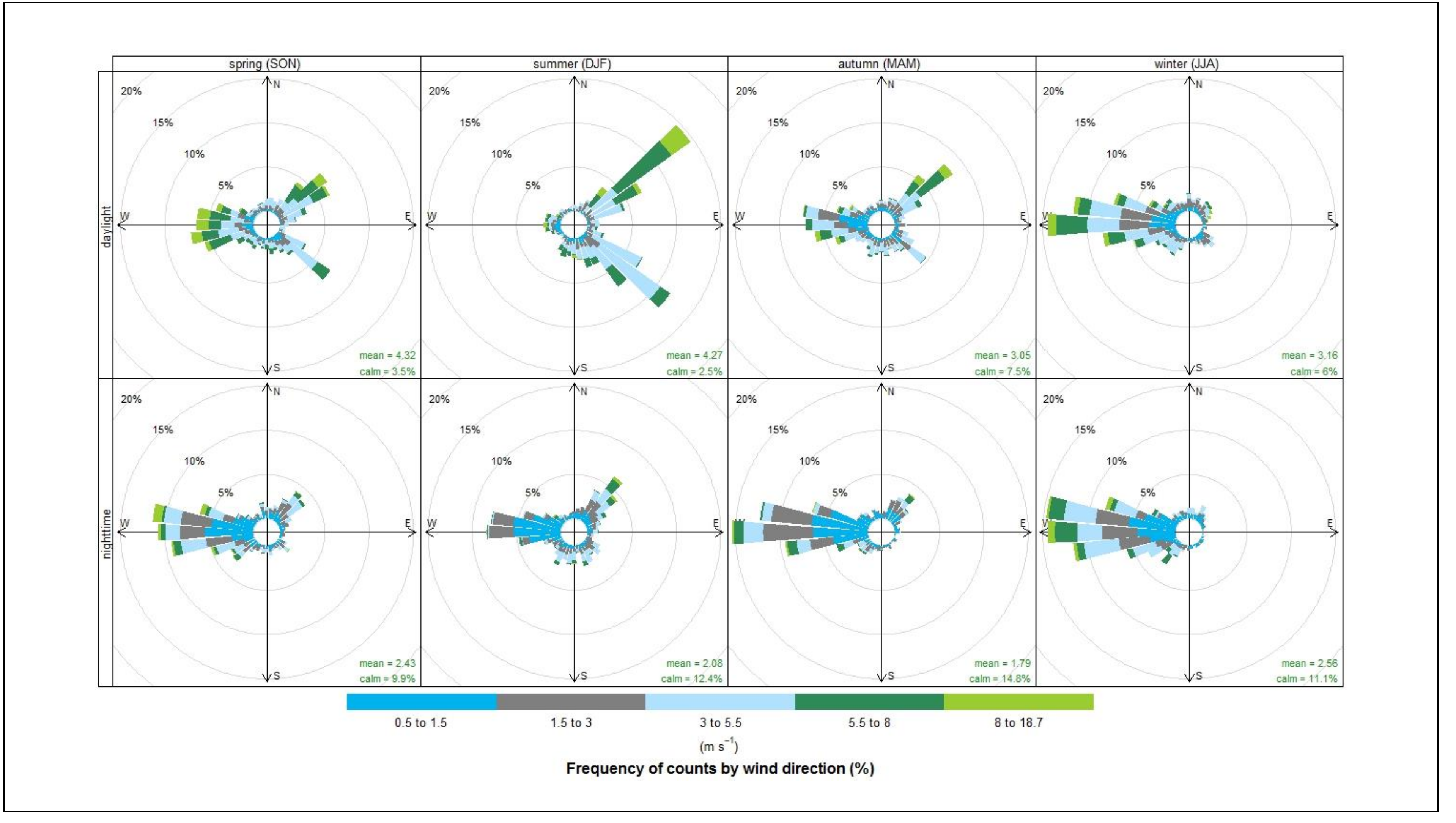

Figure A2-3: Seasonal and diurnal wind roses for Kembla Grange DPIE site

APPENDIX 3
MODEL SET UP AND SETTINGS

A TAPM model was developed for the assessment

Table A3-1: TAPM settings

Parameter	Setting
Model Version	TAPM v.4.0.5
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grid points	25 x 25 & 40 x 35[1]
Vertical grids / vertical extent	30 / 8000 m (~400 mb)
Centre of analysis	Lat 150.8250, long -34.41667 Easting 300246, Northing 6189170 & 294225, 6187000[1]
Year of analysis	2016
Terrain and landuse	Default TAPM values based on land-use and soils data sets from Geoscience Australia and the US Geological Survey, Earth Resources Observation Systems (EROS) Data Center Distributed Active Archive Center (EDC DAAC)
Assimilation sites	Kembla Grange DPIE, Wollongong DPIE, Wollongong Airport AWS

[1] – TAPM settings used for the ventilation shaft and flare modelling

Two CALMET models were developed for the assessment due to the large area covered by the Dendrobium Mine:

Table A3-2: CALMET settings

Parameter	Setting
Grid domain	20 km x 20 km & 35 km x 35 km[1]
Grid resolution	0.2 km
Number of grid points	100 x 100 & 175 x 150[1]
Reference grid coordinate	290.246, 6179.170 & 294.225, 6187.000[1]
Vertical grids / vertical extent	10 cell heights / 4,000 m
Upper air meteorology	Prognostic 3D.dat extracted from TAPM at 1 km grid
Surface observations	Kembla Grange DPIE, Wollongong DPIE, Wollongong Airport AWS, Bellambi AWS

[1] – CALMET settings used for the ventilation shaft and flare modelling

Table A3-3: CALMET model options

Flag	Description	Recommended setting	Value used
NOOBS	Meteorological data options	0,1,2	1 - combination of surface and prognostic data
ICLOUD	Cloud data options – gridded cloud fields	4	4 - gridded cloud cover from Prognostic relative humidity at all levels (MM5toGrads algorithm)
IEXTRP	Extrapolate surface wind observations to upper layers	-4	-4 - similarity theory used

Table A3-3: CALMET model options

Flag	Description	Recommended setting	Value used
IFRADJ	Compute Froude number adjustment effects	1	1 - applied
IKINE	Compute kinematic effects	0	0 - not computed
BIAS (NZ)	Relative weight given to vertically extrapolated surface observations vs. upper air data	NZ * 0	NZ * 0 - layers in lower levels of model will have stronger weighting towards surface, higher levels will have stronger weighting to upper air data
TERRAD	Radius of influence of terrain	No default (typically 5-15 km)	3 km
RMAX1 and RMAX2	Maximum radius of influence over land for observations in layer 1 and aloft	No default	4 km, 10 km
R1 and R2	Distance from observations in layer 1 and aloft at which observations and Step 1 wind fields are weighted equally	No default	R1 - 2 km, R2 – 10 km

Table A3-4: CALPUFF model options

Flag	Description	Value used	Description
MCHEM	Chemical transformation	0	Not modelled
MDRY	Dry deposition	1	Yes
MWET	Wet deposition	0	Not modelled
MTRANS	Transitional plume rise allowed?	1	Yes
MTIP	Stack tip downwash?	1	Yes
MRISE	Method to compute plume rise	1	Briggs plume rise
MSHEAR	Vertical wind shear	0	Vertical wind shear not modelled
MPARTL	Partial plume penetration of elevated inversion?	1	Yes
MSPLIT	Puff splitting	0	No puff splitting
MSLUG	Near field modelled as slugs	0	Not used
MDISP	Dispersion coefficients	2	Based on micrometeorology
MPDF	Probability density function used for dispersion under convective conditions	1	Yes
MROUGH	PG sigma y,z adjusted for z	0	No
MCTADJ	Terrain adjustment method	3	Partial plume adjustment

Table A3-4: CALPUFF model options			
Flag	**Description**	**Value used**	**Description**
MBDW	Method for building downwash	1	ISC method

APPENDIX 4
PARTICULATE MATTER EMISSIONS INVENTORY DEVELOPMENT

Overview

Dust emissions were estimated using US EPA AP-42 emission factors and predictive equations taken from the following chapters:

- Chapter 11.9 Western Surface Coal Mining.
- Chapter 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing.
- Chapter 13.2.1 Paved Roads.
- Chapter 13.2.4 Aggregate Handling and Storage Piles.
- Chapter 13.2.5 Industrial Wind Erosion.

The inputs and assumptions listed in **Table A4-1** are used with the various emission factor equations listed in **Table A4-2** to derive site specific uncontrolled emission factors for each source. Emissions were quantified for each particle size fraction, with the TSP size fraction also used to predict dust deposition rates. Fine particles (PM_{10} and $PM_{2.5}$) were estimated using the fraction specific equations or ratios for the different particle size fractions available within the literature (shown in **Table A4-2**).

Table A4-1: Inputs and assumptions for predictive emission factors

Input parameter	Value	Source of Information
Dendrobium Pit Top		
Silt loading of paved surface	14 g/m^2	Taken from measurements obtained for the Dust Stop PRP (PAEHolmes, 2012)
Average distance travelled for vehicles accessing the mine portal	0.3 km	Consistent with previous AQA (HAS, 2000)
Average vehicle mass for light vehicles entering the mine portal	12 t	Consistent with previous AQA (HAS, 2000)
Average vehicle mass for heavy vehicles entering the mine portal	30 t	Consistent with previous AQA (HAS, 2000)
KVCLF		
Moisture content of ROM coal	6%	Material properties testing (**Appendix 6**)
Silt content of ROM coal	2.5%	Material properties testing (**Appendix 6**)
Dozer hours	2628	Assumed 30% utilisation (twice the actual utilisation for 2016 and assumed a conservative estimate for all years with a max production of 5.2 Mtpa)
Stockpile area for wind erosion	1.4 ha	Consistent with previous AQA (HAS, 2000)
CPP		
Moisture content of ROM coal	6%	Material properties testing (**Appendix 6**)
Moisture content of washed coal	9%	Material properties testing (**Appendix 6**)
Moisture content of coal wash	22%	Client supplied

Input parameter	Value	Source of Information
Silt content of coal	2.5%	Material properties testing (**Appendix 6**)
Silt content of coal	2.5%	Material properties testing (**Appendix 6**)
Average vehicle mass for coal trucks	33 t	Consistent with previous AQA (HAS, 2000)
Average distance travelled for hauling to clean coal stockpile	2.0 km	estimated
Average distance travelled for hauling off-site (to site exit)	0.5 km	estimated
Silt loading of paved surface	9.7 g/m^2	AP42 13.2.2 Table 13.2.1-3 - value for iron and steel production facility

Diesel emission estimates

The emissions factors (kg/kL) used to estimate PM_{10} and $PM_{2.5}$ emissions for the KVCLF and Dendrobium Pit Top assume a NSW mining fleet average emission performance, taken from the NSW EPA's benchmarking study to evaluate a number of options for reducing diesel emissions for coal mines in NSW (NSW EPA, 2014). Estimates of diesel consumption (kL/annum) are derived from current (2021) diesel consumption data scaled according to the increase in production from 2021 ROM to the maximum production scenario presented in this report.

The emissions factors for diesel locomotives operating along the rail line assume an emission performance equivalent to US EPA Tier 0 emission factors. An estimate of diesel consumption for the locomotives is based on a NSW fleet average diesel consumption rate of 4.03 L/kilotonne.km (NSW EPA, 2012) and a travel distance of 10 km. The annual coal production and the travel distance are combined to estimate the gross-tonne-km travelled for loaded trains. For the return trip, an estimate of the gross-tonne-km for empty trains is made based on a wagon weight of 23 t and an average of 20 wagons per train. The number of wagons per train was estimated from the reported trains per annum during financial year 2015 and financial year 16 and the corresponding ROM coal transported (assuming a wagon capacity of 97 t).

Hourly varying emissions for modelling

Fugitive dust emissions sources can be categorised into three emission source types, as follows:

- Wind-insensitive sources (where the emission rate is independent of the wind speed).
- Wind-sensitive sources (where there is a relationship between the emission rate and wind speed).
- Wind erosion sources (where the emission is dependent on the wind speed).

The annual emissions for wind independent sources are evenly apportioned for each hour of the year (no adjustment applied). Emissions for wind-sensitive sources are relatively minor and therefore no adjustment is applied for hourly wind speeds (i.e. evenly apportioned for each hour of the year). Wind dependent emissions (wind erosions from stockpiles) are adjusted according to the cube of the hourly average wind speed (Skidmore, 1998) and normalised so that the total emission over all hours in the year adds up to the estimated annual total emission. Emissions are grouped into wind speed bands and averaged, such that the magnitude of emissions increase with each wind speed band.

Best Management Practice Determination

In June 2011 the NSW EPA published the best practice document 'NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining' (Katestone, 2011).

An overview of the BMP determination for the Project, and the emission reductions applied, is presented in **Table A4-3**.

Emissions Inventory

The emissions inventory for each component of the Project is presented in **Tables A4-4, A4-5** and **A4-6**.

Table A4-2: Equations and emission factors

Inventory activity	Units	TSP emission factor/equation	PM_{10} emission factor/equation	$PM_{2.5}$ emission factor/equation	EF source
Material handling (conveyor transfer loading trains and trucks, unloading trucks, rehandle)	kg/t	$0.74 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	$0.35 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	$0.053 \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$	AP42 13.2.4
Dozers on coal	kg/hr	$35.6 \times \frac{s^{1.2}}{M^{1.3}}$	$6.33 \times \frac{s^{1.5}}{M^{1.4}}$	0.022 x TSP	AP42 11.9
Wind erosion from exposed conveyors	kg/ha/yr	0.85×1000	0.5 * TSP	0.075 * TSP	AP42 11.9
Stockpile wind erosion	kg/ha/hr	$Emission\ Factor = k\sum_{i=1}^{N} Pi$ where: $Pi = 58(u* - ut*)^2 + 25(u* - ut*)$	0.5 * TSP	0.075 * TSP	AP42 13.2.5
Hauling on paved surfaces	g/VKT	$3.23\ x\ sL^{0.91} \times W^{1.02}$	$0.62\ x\ sL^{0.91} \times W^{1.02}$	$0.15\ x\ sL^{0.91} \times W^{1.02}$	AP42 13.2.1
Coal sizer	kg/t	0.0125	0.0043	0.0003	AP42 11.19.2

Note: VKT = vehicle kilometre travelled; U/u = wind speed (m/s); M = moisture content (%); s = silt content (%); W = vehicle weight (t); S = speed (km/hr); ha = hectares, u* (friction velocity (m/s)), ut* (threshold friction velocity (m/s))

Table A4-3: BMP determination and emission controls

Activity	BMP	Applied?	Control %	Comment
Hauling	Speed reduction	Yes	N/A	Speed restrictions would apply, however controls are not applied in the emission inventory.
	Surface improvements	Yes	N/A	All travel surfaces at the Dendrobium Pit Top are paved/sealed.
	Surface treatments	Yes	50%	Water truck operates at the CPP and a road sweeper operates at the Dendrobium Pit Top.
	Use of larger trucks	N/A	N/A	Not applicable to an underground mine.
	Conveyors	Yes	N/A	The majority of coal movement is via conveyors. It is not practical to use conveyors to the clean coal stockpile at the CPP.
Stockpile wind erosion	Water sprays	Yes	50%	Fixed water sprays on KVCLF stockpile. Water trucks operate at the CPP.
Loading stockpiles	Minimising drop heights	Yes	75%	Rill tower used to reduce drop heights and water sprays operate during loading.
	Water application	Yes		
Coal sizing	Wet suppression	Yes	85%	70% for enclosure plus 50% for watering. It is noted that the coal sizer is fully enclosed, with mechanical ventilation and duct collection installed. Therefore, control efficiency would be higher than 85%.
	Wind shielding	Yes		
	Dust extraction	Yes		
Coal conveying	Wind shielding	Yes	40%	
Loading trains	Enclosure	Yes	70%	
Coal wagons	Load profiling	Yes	N/A	
	Moisture content above DEM	Yes	N/A	Measured moisture content for ROM coal arriving at the CPP (6.5%) is higher than the measured DEM level (4.6%).

Table A4-4: Dendrobium Mine - $PM_{2.5}$ emission inventory

Activity	Emission estimate (kg/year)	Intensity	Units	Emission Factor	Units	Variable 1		Variable 2		Variable 3		Variable 4		Variable 5		Control %	Control
KVCLF																	
Above ground conveying (wind erosion)	3	0.07	ha	64	kg/ha/yr	270	length (m)	2.5	width (m)							40	Wind shielding
Coal sizer/crusher	227	5,200,000	t/y	0.0003	kg/t											85	70% for enclosure plus 50% for water sprays
Loading ROM stockpile	28	5,200,000	t/y	0.00002	kg/t	6	moisture content in %	1.2	(wind speed/2.2)^1.3							75	Telescopic chute with water sprays
Dozer on ROM stockpile	503	2,628	h/y	0.2	kg/h	6	moisture content in %	2.5	silt content in %								
Excavator on ROM stockpile	22	5,200,000	t/y	0.00002	kg/t	6	moisture content in %	1.2	(wind speed/2.2)^1.3	0.2	times re-handled						
Loading trains	33	5,200,000	t/y	0.00002	kg/t	6	moisture content in %	1.2	(wind speed/2.2)^1.3							70	Enclosure
Wind erosion of ROM stockpile	4	1.4	ha	6	kg/ha/yr											50	Water sprays
Dendrobium Pit Top																	
Light vehicle movements into portal - wheel dust	31	12,000	RTV/year	5	Vehicle gross mass	0.30	km/trip	0.01	kg/VKT	14.0	road surface silt loading (g/m2)						
Heavy vehicle movements into portal - wheel dust	32	3,000	RTV/year	30	Vehicle gross mass	0.20	km/trip	0.05	kg/VKT	14.0	road surface silt loading (g/m2)						
Upcast ventilation shafts																	
Ventilation Shaft No. 3 - Area 3	2,208	350	m^3/s	0.2	mg/m^3												
Ventilation Shaft No.5A - Area 5	2,838	450	m^3/s	0.2	mg/m^3												
Diesel consumption																	
Combined KVCLF and Pit Top	1,437	1034	kL/y	1.39	kg/kL												
Rail																	
Fugitive dust from coal wagons	241	0.45	g/wagon/km	10	km/trip	893	trains per year	60	wagons per train	97	wagon capacity (t)						
Diesel emissions from locomotives	540	310	kL/y	1.75	kg/kL												
CHPP																	
ROM coal - unloading at dump station	41	5,200,000	t/y	0.00003	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3							70	Partial enclosure
ROM coal - 10% transfer to Raw coal stockpile - conveyor wind erosion	1	0.07	ha	64	kg/ha/yr	260	length (m)	2.5	width (m)							70	Partial enclosure
ROM coal - 10% transfer to Raw coal stockpile - conveyor transfer points	16	520,000	t/y	0.00003	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3	4	tranfer points					70	40% for wind shielding plus 50% for water sprays
ROM coal - 10% transfer to Raw coal stockpile - loading stockpiles	14	520,000	t/y	0.00003	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3								
FEL/dozers on stockpile maintenance (raw coal)	1,174	12,264	h/y	0.2	kg/h	6	moisture content in %	3	silt content in %							50	watering
ROM coal - 90% transfer to wash plant - conveyor transfer points	74	4,680,000	t/y	0.00003	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3	2	tranfer points					70	40% for wind shielding plus 50% for water sprays
Washed coal - 20% transfer to Blended Beds - conveyor wind erosion	8	0.42	ha	64	kg/ha/yr	1,680	length (m)	2.5	width (m)							70	Partial enclosure
Washed coal - 20% transfer to Blended Beds - conveyor transfer points	7	776,880	t/y	0.00001	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3	2.0	tranfer points					70	40% for wind shielding plus 50% for water sprays
Washed coal - 20% transfer to Blended Beds - loading stockpiles	12	776,880	t/y	0.00001	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - loading trucks (83%)	46	3,107,520	t/y	0.00001	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - hauling to Clean coal stockpile (15%)	596	466,128	t/y	0.003	kg/t	32	t/load	33	Vehicle gross mass (t)	2.0	km/return trip	0.04	kg/VKT	9.7	road surface si	50	watering
Washed coal - direct hauling to PKCT (65%)	646	2,019,888	t/y	0.001	kg/t	32	t/load	33	Vehicle gross mass (t)	0.5	km/return trip	0.04	kg/VKT	9.7	road surface si	50	watering
Washed coal - unload to Clean coal stockpiles (15%)	7	466,128	t/y	0.00001	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - rehandle at Clean coal stockpile (15%)	7	466,128	t/y	0.00001	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - hauling from Clean coal stockpile to PKCT (15%)	596	466,128	t/y	0.003	kg/t	32	t/load	33	Vehicle gross mass (t)	2.0	km/return trip	0.04	kg/VKT	9.7	road surface si	50	watering
FEL/dozers on stockpile maintenance (clean coal)	333	6,132	h/y	0.1	kg/h	9	moisture content in %	2.5	silt content in %							50	watering
Wind erosion (combined stockpiles areas)	782	13.7	ha	115	kg/ha/yr											50	watering
Coal wash - loading trucks	3	795,600	t/y	0.00000	kg/t	22	moisture content in %	1.4	(wind speed/2.2)^1.3								
Coal wash - transport off-site	254	795,600	t/y	0.00064	kg/t	32	t/load	33	Vehicle gross mass (t)	0.5	km/return trip	0.04	kg/VKT	9.7	road surface si	50	watering
Diesel consumption																	
Combined CPP diesel consumption	669	481	kL/y	1.39	kg/kL												
West Cliff Waste Emplacement																	
Wheel generated dust	799	12,400	VKT/yr	40	Vehicle gross mass	0.0644	kg/VKT	5.0	% silt content							50	watering
Trucks unloading	4	795,600	t/y	0.00001	kg/t	22	moisture content in %	1.9	(wind speed/2.2)^1.3								
Excavator	4	795,600	t/y	0.00001	kg/t	22	moisture content in %	1.9	(wind speed/2.2)^1.3								
Dozer/FEL	81	2,600	h/y	0.03	kg/h	22	moisture content in %	2.5	silt content in %								
Wind erosion	1,275	20.0	ha	64	kg/ha/yr												
Grader	159	8,320	km	0.019	kg/km	8	speed of graders in km/h	1,040	grader hours								
Total (kg/yr)	**15,758**																

Table A4-5: Dendrobium Mine – PM_{10} emission inventory

Activity	Emission estimate (kg/year)	Intensity	Units	Emission Factor	Units	Variable 1		Variable 2		Variable 3		Variable 4		Variable 5		Control %	Control
Kemira Valley Coal Loading Facility																	
Above ground conveying (wind erosion)	17	0.07	ha	425	kg/ha/yr	270	length (m)	2.5	width (m)							40	Wind shielding
Coal sizer/crusher	3,354	5,200,000	t/y	0.0043	kg/t											85	70% for enclosure plus 50% for water sprays
Loading ROM stockpile	184	5,200,000	t/y	0.0001	kg/t	6	moisture content in %	1.2	(wind speed/2.2)^1.3							75	Telescopic chute with water sprays
Dozer on ROM stockpile	5,352	2,628	h/y	2.0	kg/h	6	moisture content in %	2.5	silt content in %								
Excavator on ROM stockpile	147	5,200,000	t/y	0.0001	kg/t	6	moisture content in %	1.2	(wind speed/2.2)^1.3	0.2	times re-handled						
Loading trains	220	5,200,000	t/y	0.0001	kg/t	6	moisture content in %	1.2	(wind speed/2.2)^1.3							70	Enclosure
Wind erosion of ROM stockpile	30	1.4	ha	43	kg/ha/yr											50	Water sprays
Dendrobium Pit Top																	
Light vehicle movements into portal - wheel dust	127	12,000	RTV/year	5	Vehicle gross mass (t)	0.30	km/trip	0.04	kg/VKT	14.0	road surface silt loading (g/m2)						
Heavy vehicle movements into portal - wheel dust	132	3,000	RTV/year	30	Vehicle gross mass (t)	0.20	km/trip	0.22	kg/VKT	14.0	road surface silt loading (g/m2)						
Upcast ventilation shafts																	
Ventilation Shaft No. 3 - Area 3	11,038	350	m^3/s	1.0	mg/m^3												
Ventilation Shaft No. 5A - Area 5	14,191	450	m^3/s	1.0	mg/m^3												
Diesel consumption																	
Combined KVCLF and Pit Top diesel consumption	1,481	1034	kL/y	1.43	kg/kL												
Kemira Valley Rail Line																	
Fugitive dust from coal wagons	1,608	3	g/wagon/km	10	km/trip	893	trains per year	60	wagons per train	97	wagon capacity (t)						
Diesel emissions from locomotives	557	310	kL/y	1.80	kg/kL												
Dendrobium Coal Preparation Plant																	
ROM coal - unloading at dump station	272	5,200,000	t/y	0.00017	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3							70	Partial enclosure
ROM coal - 10% transfer to Raw coal stockpile - conveyor wind erosion	8	0.07	ha	425	kg/ha/yr	260	length (m)	2.5	width (m)							70	Partial enclosure
ROM coal - 10% transfer to Raw coal stockpile - conveyor transfer points	109	520,000	t/y	0.00017	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3	4	tranfer points					70	40% for wind shielding plus 50% for water sprays
ROM coal - 10% transfer to Raw coal stockpile - loading stockpiles	91	520,000	t/y	0.00017	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3								
FEL/dozers on stockpile maintenance (raw coal)	12,488	12,264	h/y	2.0	kg/h	6	moisture content in %	2.5	silt content in %							50	watering
ROM coal - 90% transfer to wash plant - conveyor transfer points	489	4,680,000	t/y	0.00017	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3	2	tranfer points					70	40% for wind shielding plus 50% for water sprays
Washed coal - 20% transfer to Blended Beds - conveyor wind erosion	54	0.42	ha	425	kg/ha/yr	1,680	length (m)	2.5	width (m)							70	Partial enclosure
Washed coal - 20% transfer to Blended Beds - conveyor transfer points	46	776,880	t/y	0.00010	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3	2.0	tranfer points					70	40% for wind shielding plus 50% for water sprays
Washed coal - 20% transfer to Blended Beds - loading stockpiles	77	776,880	t/y	0.00010	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - loading trucks (83%)	307	3,107,520	t/y	0.00010	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - hauling to Clean coal stockpile (15%)	2,465	466,128	t/y	0.011	kg/t	32	t/load	33	Vehicle gross mass (t)	2.0	km/return trip	0.171	kg/VKT	9.7	road surface si	50	watering
Washed coal - direct hauling to PKCT (65%)	2,670	2,019,888	t/y	0.003	kg/t	32	t/load	33	Vehicle gross mass (t)	0.5	km/return trip	0.171	kg/VKT	9.7	road surface si	50	watering
Washed coal - unload to Clean coal stockpiles (15%)	46	466,128	t/y	0.00010	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - rehandle at Clean coal stockpile (15%)	46	466,128	t/y	0.00010	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - hauling from Clean coal stockpile to PKCT (15%)	2,465	466,128	t/y	0.011	kg/t	32	t/load	33	Vehicle gross mass (t)	2.0	km/return trip	0.171	kg/VKT	9.7	road surface si	50	watering
FEL/dozers on stockpile maintenance (clean coal)	3,540	6,132	h/y	1.2	kg/h	9	moisture content in %	2.5	silt content in %							50	watering
Wind erosion (combined stockpiles areas)	5,212	13.7	ha	763	kg/ha/yr											50	watering
Coal wash - loading trucks	22	795,600	t/y	0.00003	kg/t	22	moisture content in %	1.4	(wind speed/2.2)^1.3								
Coal wash - transport off-site	1,052	795,600	t/y	0.00264	kg/t	32	t/load	33	Vehicle gross mass (t)	0.5	km/return trip	0.17	kg/VKT	9.7	road surface si	50	watering
Diesel consumption																	
Combined CPP diesel consumption	689	481	kL/y	1.43	kg/kL												
West Cliff Waste Emplacement																	
Wheel generated dust	7,991	12,400	VKT/yr	40	Vehicle gross mass (t)	0.6445	kg/VKT	5.0	% silt content							50	watering
Trucks unloading	29	795,600	t/y	0.0000	kg/t	22	moisture content in %	1.9	(wind speed/2.2)^1.3								
Excavator	29	795,600	t/y	0.0000	kg/t	22	moisture content in %	1.9	(wind speed/2.2)^1.3								
Dozer/FEL	859	2,600	h/y	0.3	kg/h	22	moisture content in %	2.5	silt content in %								
Wind erosion	8,500	20.0	ha	425	kg/ha/yr												
Grader	1,789	8,320	km	0.215	kg/km	8	speed of graders in km/h	1,040	grader hours								
Total (kg/yr)	**89,786**																

Table A4-6: Dendrobium Mine – TSP emission inventory

Activity	Emission estimate (kg/year)	Intensity	Units	Emission Factor	Units	Variable 1		Variable 2		Variable 3		Variable 4		Variable 5		Control %	Control
KVCLF																	
Above ground conveying (wind erosion)	34	0.07	ha	850	kg/ha/yr	270	length (m)	2.5	width (m)							40	Wind shielding
Coal sizer/crusher	9,750	5,200,000	t/y	0.0125	kg/t											85	70% for enclosure plus 50% for water sprays
Loading ROM stockpile	388	5,200,000	t/y	0.0003	kg/t	6	moisture content in %	1.2	(wind speed/2.2)^1.3							75	Telescopic chute with water sprays
Dozer on ROM stockpile	22,866	2,628	h/y	8.7	kg/h	6	moisture content in %	2.5	silt content in %								
Excavator on ROM stockpile	311	5,200,000	t/y	0.0003	kg/t	6	moisture content in %	1.2	(wind speed/2.2)^1.3	0.2	times re-handled						
Loading trains	466	5,200,000	t/y	0.0003	kg/t	6	moisture content in %	1.2	(wind speed/2.2)^1.3							70	Enclosure
Wind erosion of ROM stockpile	60	1.4	ha	85	kg/ha/yr											50	Water sprays
Dendrobium Pit Top																	
Light vehicle movements into portal - wheel dust	663	12,000	RTV/year	5	Vehicle gross mass (	0.30	km/trip	0.2	kg/VKT	14.0	road surface silt loading (g/m2)						
Heavy vehicle movements into portal - wheel dust	687	3,000	RTV/year	30	Vehicle gross mass (	0.20	km/trip	1.1	kg/VKT	14.0	road surface silt loading (g/m2)						
Upcast ventilation shafts																	
Ventilation Shaft No. 3 - Area 3	22,075	350	m^3/s	2.0	mg/m^3												
Ventilation Shaft No. 5A - Area 5	28,382	450	m^3/s	2.0	mg/m^3												
Diesel consumption																	
Combined KVCLF and Pit Top	1,481	1034	kL/y	1.43	kg/kL												
Rail																	
Fugitive dust from coal wagons	3,216	6	g/wagon/km	10	km/trip	893	trains per year	60	wagons per train	97	wagon capacity (t)						
Diesel emissions from locomotives	557	310	kL/y	1.80	kg/kL												
CHPP																	
ROM coal - unloading at dump station	574	5,200,000	t/y	0.0004	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3							70	Partial enclosure
ROM coal - 10% transfer to Raw coal stockpile - conveyor wind erosion	17	0.07	ha	850	kg/ha/yr	260	length (m)	2.5	width (m)							70	Partial enclosure
ROM coal - 10% transfer to Raw coal stockpile - conveyor transfer points	230	520,000	t/y	0.0004	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3	4	tranfer points					70	40% for wind shielding plus 50% for water sprays
ROM coal - 10% transfer to Raw coal stockpile - loading stockpiles	191	520,000	t/y	0.0004	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3								
FEL/dozers on stockpile maintenance (raw coal)	53,354	12,264	h/y	8.7	kg/h	6	moisture content in %	3	silt content in %							50	watering
ROM coal - 90% transfer to wash plant - conveyor transfer points	1,034	4,680,000	t/y	0.0004	kg/t	6	moisture content in %	1.4	(wind speed/2.2)^1.3	2	tranfer points					70	40% for wind shielding plus 50% for water sprays
Washed coal - 20% transfer to Blended Beds - conveyor wind erosion	107	0.42	ha	850	kg/ha/yr	1,680	length (m)	2.5	width (m)							70	Partial enclosure
Washed coal - 20% transfer to Blended Beds - conveyor transfer points	97	776,880	t/y	0.0002	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3	2.0	tranfer points					70	40% for wind shielding plus 50% for water sprays
Washed coal - 20% transfer to Blended Beds - loading stockpiles	162	776,880	t/y	0.0002	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - loading trucks (83%)	648	3,107,520	t/y	0.0002	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - hauling to Clean coal stockpile (15%)	12,841	466,128	t/y	0.055	kg/t	32	t/load	33	Vehicle gross mass (t)	2.0	km/return trip	0.9	kg/VKT	9.7	road surface si	50	watering
Washed coal - direct hauling to PKCT (65%)	13,911	2,019,888	t/y	0.014	kg/t	32	t/load	33	Vehicle gross mass (t)	0.5	km/return trip	0.9	kg/VKT	9.7	road surface si	50	watering
Washed coal - unload to Clean coal stockpiles (15%)	97	466,128	t/y	0.0002	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - rehandle at Clean coal stockpile (15%)	97	466,128	t/y	0.0002	kg/t	9	moisture content in %	1.4	(wind speed/2.2)^1.3								
Washed coal - hauling from Clean coal stockpile to PKCT (15%)	12,841	466,128	t/y	0.055	kg/t	32	t/load	33	Vehicle gross mass (t)	2.0	km/return trip	0.9	kg/VKT	9.7	road surface si	50	watering
FEL/dozers on stockpile maintenance (clean coal)	15,122	6,132	h/y	4.9	kg/h	9	moisture content in %	2.5	silt content in %							50	watering
Wind erosion (combined stockpiles areas)	10,423	13.7	ha	1527	kg/ha/yr											50	watering
Coal wash - loading trucks	47	795,600	t/y	0.0001	kg/t	22	moisture content in %	1.4	(wind speed/2.2)^1.3								
Coal wash - transport off-site	5,479	795,600	t/y	0.01377	kg/t	32	t/load	33	Vehicle gross mass (t)	0.5	km/return trip	0.9	kg/VKT	9.7	road surface si	50	watering
Diesel consumption																	
Combined CPP diesel consumption	689	481	kL/y	1.43	kg/kL												
West Cliff Waste Emplacement																	
Wheel generated dust	31,100	12,400	VKT/yr	40	Vehicle gross mass (	2.5	kg/VKT	5.0	% silt content							50	watering
Trucks unloading	62	795,600	t/y	0.0001	kg/t	22	moisture content in %	1.9	(wind speed/2.2)^1.3								
Excavator	62	795,600	t/y	0.0001	kg/t	22	moisture content in %	1.9	(wind speed/2.2)^1.3								
Dozer/FEL	3,669	2,600	h/y	1.4	kg/h	22	moisture content in %	2.5	silt content in %								
Wind erosion	17,000	20.0	ha	850	kg/ha/yr												
Grader	5,121	8,320	km	0.615	kg/km	8	speed of graders in km/h	1,040	grader hours								
Total (kg/yr)	**275,925**																

APPENDIX 5
COAL PROPERTIES TESTING REPORT

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REPORT 9031

Ramboll Environ Australia Pty Ltd

Dust Extinction Moisture and Particle Size Distribution Investigation

To:	Ramboll Environ Australia Pty Ltd	**Date:**	22/08/2017
Attention:	Ronan Kellaghan	**Pages:**	6 (excl Appendices)
Email:	RKellaghan@ramboll.com	**Authored:**	Daniel Ausling
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DISCLAIMER

Users of this report are invited to contact TUNRA Bulk Solids if clarification of any aspect is required. The test results presented are for a client supplied bulk material sample. Should the material handled in practice vary from this test sample then the results in this report may be far from optimal. In addition, any extrapolation of the data and / or recommendations to situations other than those for which they were specifically intended without confirmation by TUNRA Bulk Solids may lead to erroneous conclusions. The contents of this report may not be reproduced without the consent of the client; and then only in full. This investigation was performed using the facilities of the Bulk Solids Handling Laboratories of TUNRA Bulk Solids Handling Research Associates and the Centre for Bulk Solids & Particulate Technologies at The University of Newcastle.

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TABLE OF CONTENTS

1 INTRODUCTION

This report has been commissioned by Ramboll Environ Australia Pty Ltd (herein referred to as Ramboll). The testing conducted determined the Dust Extinction Moisture (DEM) and Particle Size Distribution (PSD) of a sample of Wongawilli Dendrobium ROM Coal supplied in the -6.3mm size fraction. This work is covered by the purchase order number AS122085.

2 TEST RESULTS

2.1 Moisture Content

Total moisture content for the test sample is determined using a method derived from AS 1038 Part 1 Method C and is quoted as a percentage of wet weight (%wb). The Wongawilli ROM sample supplied had a nominal top size of 6.3mm.

Table 1 Moisture Content

Wongawilli ROM Coal -6.3mm	Moisture Content (%)
As Supplied	6.5 %
Saturated	27.4 %

2.2 Particle Size Distribution

The particle size distribution of a coarse bulk solid with a majority of particles larger than 0.1mm is determined using a dry sieving technique. The full results can be seen in Figure 1 with the results summarised in Table 2.

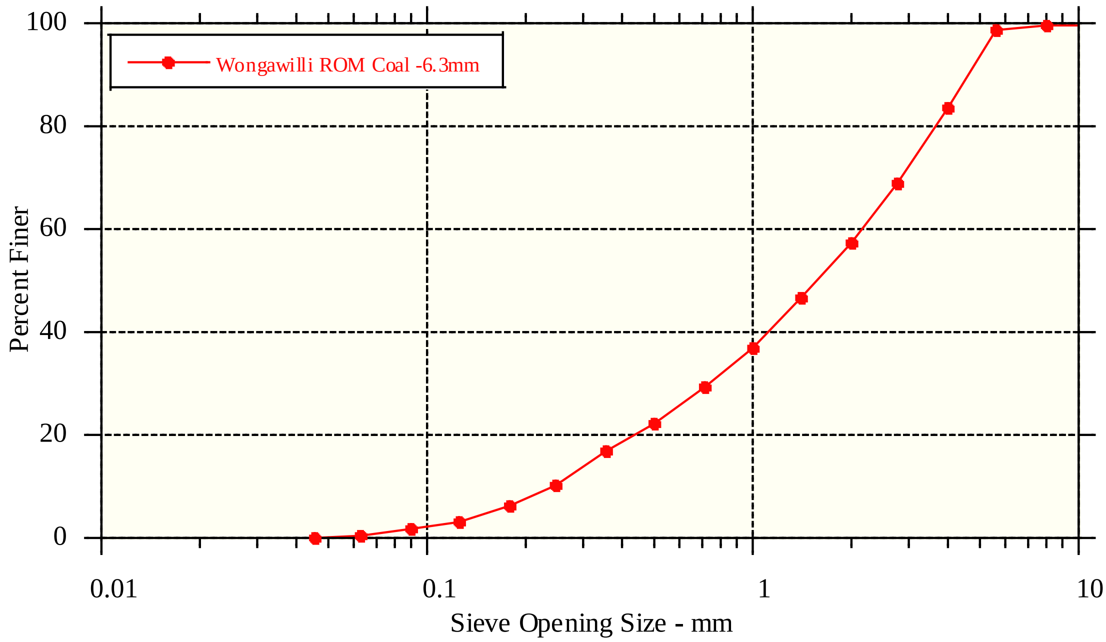

Figure 1 Particle size distribution for Wongawilli ROM Coal -6.3mm.

Table 2 Particle Size Distribution Summary

Sample	d_{10} (mm)	d_{50} (mm)	d_{90} (mm)
Wongawilli ROM Coal -6.3mm	0.25	1.6	4.7

2.3 Dust Extinction Moisture

The dust extinction moisture (DEM) determined for the Wongawilli ROM Coal sample provided is summarised in Table 3 with full results presented in Figure 2.

Table 3 Dust Extinction Moisture

Sample	DEM
Wongawilli ROM Coal	4.6 %

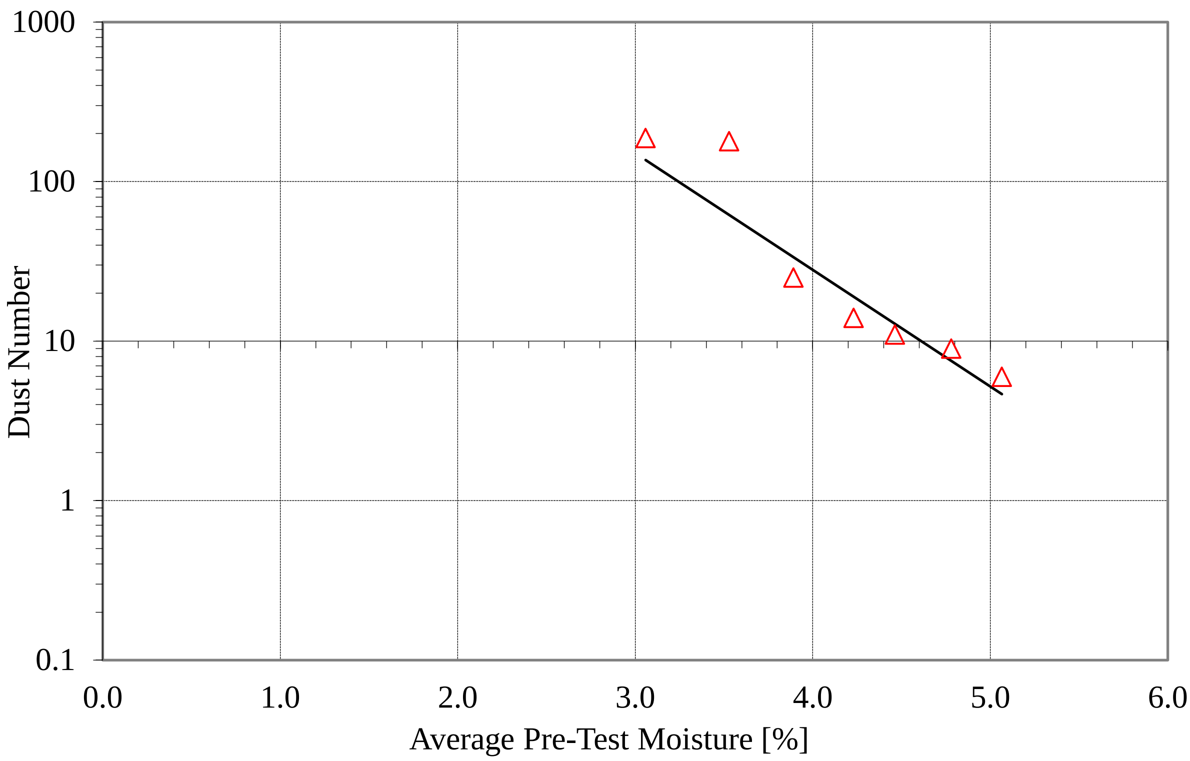

Figure 2 Dust number measurement results for Wongawilli ROM Coal -6.3mm.

3 REFERENCES

[1] Australian Standard AS 4156.6-2000, *Coal Preparation Part 6: Determination of Dust/Moisture Relationship for Coal.*

APPENDICES

APPENDIX: DUST EXTINCTION MOISTURE TEST PROCEDURE

The moisture content at which a material is deemed to emit no dust was determined using a procedure set down in Australian Standard AS-4156.6-2000. This standard was written specifically for coal but has been utilised for other bulk materials by modifying the quantity of sample placed in the test rig; the Standard calls for 1kg of coal in the -6.3mm size fraction. The actual weight of the sample is taken into account when determining the dust number.

AS-4156-2000 should be referred to for a complete explanation of the general test procedure, however, a concise description is as follows. The test rig shown in Figure 1 consists of a rotating drum in which the sample of material to be tested is placed. The drum is rotated at a speed of 30rpm for a period of 10 minutes while an air flow rate of 170L/min is drawn through a hole in the drum lid, through a hollow drive shaft and a paper filter bag which collects the dust generated in the drum. The weight of the filter bag is measured before and after the test to determine the quantity of dust collected. A dust number is then calculated using the formula given in Equation 1.

Figure 1 – Dust Extinction Moisture Test Facility

$$\text{Dust Number} = \frac{M_b - M_a}{M_s} \times 100{,}000 \qquad (1)$$

Where

M_b	=	Mass of filter bag and dust (grams)
M_a	=	Mass of filter bag (grams)
M_s	=	Mass of sample in drum (grams)

The test work is conducted on a number of samples over a range of moistures. The dust numbers obtained are plotted on a log-linear graph where a line of best fit that crosses the dust number of 10 is deemed the Dust Extinction Moisture (DEM). The test is performed within a climate controlled chamber with a regulated humidity of between 61-65%RH and a temperature of 20-22°C.

APPENDIX 6
GREENHOUSE GAS MITIGATION STRATEGY

MEMORANDUM

Greenhouse Gas Mitigation

This Section addresses the SEARs requirements:

- a review of available best practice greenhouse gas emissions reduction measures available to the development;

- details of proposed greenhouse gas emissions avoidance, mitigation and/or offset measures;

South32's Approach to Climate Change

In 2016, South32 committed to supporting the objectives of the Paris Agreement and set a long-term goal of achieving net zero operational greenhouse gas emissions by 2050 across the group. South32's approach to climate change aligns with its purpose and includes decarbonising operations, reshaping its portfolio and supporting the global transition to a low carbon future.

As a diversified mining and metals company operating in a number of jurisdictions, South32's decarbonisation plans include a broad range of options, shaped by different mining and processing methods, energy markets and regulations. At some of our operations we have the opportunity to decarbonise through processing or efficiency improvements, while for our refineries and smelters, the focus is procuring low-carbon energy and evaluating new technologies. Decarbonisation technologies available at IMC are detailed in subsequent sections of this chapter.

There is no definitive 'best pathway' to net zero and some of the innovations required are not fully developed. This is why South32 are investing in research and development (e.g. VAMMIT, see below) and will continue to evaluate new and existing technologies and solutions as they become available.

IMC Decarbonisation Plans

IMC's decarbonisation plan and contribution towards South32's group-wide goal reflects what is reasonable and practicable at IMC given the nature of the operations and Project, and availability of proven, safe and cost effective emissions technologies.

IMC comprises two underground metallurgical coal mines, Appin and Dendrobium, located in the Southern Coalfield of New South Wales. Within IMC, Appin Mine produces approximately 93% of emissions, Dendrobium approximately 6% and combined diesel emissions less than 1% of Scope 1 emissions. The fugitive gas emissions are approximately 2Mt CO_2-e per annum.

Scope 1 carbon emissions are predominantly from the release of gases from the underground coal seams during mining. These gases are known as fugitive emissions. The amount of fugitive emissions can vary greatly between mining areas, based on the surrounding rock strata, depth and seam. The largest proportion of these emissions at IMC is from the Appin underground mine due to its relatively high gas and methane content. At Appin Mine, the methane split is approximately 13% pre-drainage capture, 30% post drainage capture and 57% ventilation air methane (VAM) which is not captured. Dendrobium is currently mining in areas of relatively low gas, however these areas will be exhausted by 2024 at currently approved production rates and the Project is proposing to extract from Area 5 with a higher gas concentration. IMC is proposing gas drainage and flaring to mitigate gas from future mining at Dendrobium, including Area 5 (the Project).

Therefore, IMC's decarbonisation plans are focused on reducing fugitive emissions by increasing the efficiency of gas drainage and assessing technologies for reducing ventilation air methane.

For the Project, which involves longwall mining in the Bulli Seam in Area 5, it is proposed:

- Best practice abatement technology for fugitive emissions would be implemented by maximising the capture of gas via effective Inseam Drainage of the Bulli Seam prior to longwall extraction (Pre-Drainage), Cross Measure Drainage of the underlying Wongawilli Seam during longwall extraction (Post Drainage) and flaring of methane, thereby converting methane to carbon dioxide and lowering the global warming potential by a factor of 28.
- Further opportunities to maximise gas capture via pre-drainage of the underlying Wongawilli Seam and management of goaf gas would be investigated, and implemented if technically feasible and commercially viable.

This is predicted to reduce fugitive GHG emissions by approximately 3.4 Mt CO_2-e or 31% over the life of the Project which is a significant and material reduction.

Additional abatement measures for fugitive emissions have been considered, but are not considered reasonable or feasible for inclusion in the Project. This includes:

- Combustion of gas to generate electricity: While this technology is used at the Appin Mine, it requires a relatively homogenous gas resource at 75-95% methane, and notwithstanding, requires periodic gas enrichment from the state gas network to feed the electricity generation plant. By comparison, the Area 5 gas content is lower in methane content and less homogenous, and as such, would require gas enrichment which is not available in the Metropolitan Special Area. Accordingly, this option is not considered viable for the Project.
- Ventilation Air Methane (VAM): In partnership with CSIRO, IMC is supporting the development of VAM abatement technology at the Appin Mine. This project is at the pre-feasibility stage of a full scale demonstration plant, following the trial of pilot plants over the last three years. If the technology is successful at Appin, it may be considered at the Dendrobium Mine, however the associated development of infrastructure required to implement VAM abatement at Dendrobium would be subject to separate assessment and approval. Accordingly, VAM abatement does not form part of the Project.

Current IMC Mitigation Practices

Gas Drainage

The early drainage and capture of gas into a pipeline is much more efficient than later gas emitted through VAM at low concentrations which becomes significantly more difficult to capture and abate. Therefore, gas drainage and capture is recognised as industry best practice and is currently IMC's primary mitigation measure for fugitive emissions.

Gas is drained from coal seams before and after mining activity. The captured gas is piped to the surface and either supplied to a third party provider to generate electricity (as occurs at Appin Mine) or destroyed through flaring which converts the methane into carbon dioxide (proposed for the Project). Global warming potentials (GWPs) are values that allow direct comparison of the impact of different greenhouse gases in the atmosphere by comparing how much energy one tonne of a gas will absorb compared to one tonne of carbon dioxide. Methane has a GWP of 28 compared to carbon dioxide (GWP of 1) so flaring is an effective measure to reduce emissions and global warming potential.

Appin is currently mining in a relatively homogenous gas environment with consistent gas composition and content. The majority of the coal mine waste gas released is collected and removed ahead of and during the progressive longwall mining activities using an underground gas pipeline network. In the case of Appin Mine, these volumes are delivered to the Appin and Tower power stations adjacent to the pit tops, operated by a third party (energy generation company EDL) to provide power to the NSW state grid or destroyed through flaring which converts the methane into carbon dioxide. Gases which are not captured in these pipelines are removed through closely monitored ventilation systems.

Appin are targeting an increase in post drainage capture efficiency from 61 per cent in FY21 to 67 per cent by FY24 through increased in-seam drilling. Studies are underway to evaluate drilling methods to increase post-drainage capture, as well as identify additional pre-drainage targets.

Dendrobium is currently mining in an area with lower fugitive emissions, currently comprising ~ 6% of the total Scope 1 emissions from IMC. The current Dendrobium operations are not drained and flared.

Future IMC GHG Mitigation Strategies

Ventilation Air Methane (VAM)

While IMC's gas drainage is aligned with industry best practice, some residual gases subsequently enter the underground mine ventilation system. The high volume of air in underground coal mine ventilation systems contains very low concentrations of methane (ventilation air methane or VAM) which cannot be effectively abated at scale, necessitating a commercial-scale technology solution.

In partnership with Australia's national science agency CSIRO, IMC are supporting the development of VAM abatement technologies which aim to increase the effectiveness of methane capture at low concentrations in ventilation air in a safe manner. If successful, this would represent a significant advancement for the industry with potential for deployment beyond IMC.

A trial of CSIRO's VAMMIT (Ventilation air methane mitigation) technology has been undertaken over the past three years and is expected to be completed by March 2022, which will inform the future deployment at IMC. IMC are also investigating other VAM abatement technologies alongside the work with CSIRO.

IMC has supported CSIRO through the development of successful pilot plants installed and tested at the West Cliff VAM site. These trials have informed planning to further progress CSIRO's design into a full scale demonstration plant.

South32 and CSIRO are making a joint effort in trialling and demonstrating a full scale VAMMIT unit at Appin Mine. The main objectives are to:

- Design a full scale VAMMIT unit based on the existing pilot plant trials at IMC,
- Assess the viability of a second VAMMIT unit;
- Conduct site construction and modification;
- Commission and function test the full scale VAMMIT unit, and conduct further modifications if required through the commissioning;
- Carry out site trials of the VAMMIT unit with actual VAM to demonstrate its performance;
- Long term operation of the VAMMIT unit to demonstrate its advantages (e.g. avoiding dust deposition, ceramic bed stability); and
- Conduct data analysis to optimise the VAMMIT and determine dust removal efficiency through the VAMMIT unit during the long term operation.

Once the first full scale VAMMIT unit is demonstrated with the design details and optimised operational parameters, a study into the full-scale development solution for IMC can commence.

IMC propose a phased approach to design, construct and operate a commercial scale, CSIRO Thermal VAMMIT unit at Appin Vent Shaft 2. Pre-Feasibility phase is planned to commence in Q2 2022 when the pilot plant trials are finalised.

Other Strategies
IMC is continuing to investigate other emissions reductions measures against a number of criteria, including safety, technical performance, operability, emissions reduction, maturity, scale, economic viability and time required to adapt to changes in process or energy efficiency technologies.

This includes reducing Scope 2 emissions by purchasing energy from renewable sources, acknowledging these are much smaller contributors to IMC's GHG emissions.

Project GHG Mitigation Strategy

The revised mine plan for the Project represents an approximately 60% reduction in longwall mining area (from the previous application) or 46Mt reduction in ROM coal and therefore the revised mine plan mitigates against a commensurate volume of GHG emissions, which is a significant and material reduction.

The Area 5 mining domain is characterised as a variable gas reservoir. It is predicted to produce significantly more gas due to higher insitu methane content throughout the Area 5 mining domain.

The Area 5 mining domain is characterised by the following;

- Bulli Seam gas contents range from $2m^3/t$ to $10m^3/t$. The Bulli seam gas composition is predominantly CH_4 to the East with increasing levels of CO_2 to the west and south-west.
- The Wongawilli seam is identified as a major gas source, at 9-11m thick and ranging between 16-34m below the Bulli Seam with similar gas compositions and content values as the Bulli Seam in this area.
- The underlying Balgownie, Cape Horne, American Creek and Tongarra seams are only seen as minor contributors to the overall gas reservoir.
- Relative to total longwall gas emission rates and the experience across some areas of Appin Mine the volume of gas derived from the overlying sandstones is modelled to be low in Area 5.

The proposed gas drainage infrastructure to support the mine extension into higher insitu gas areas will primarily consist of additional ventilation fans, gas extraction plant and enclosed flares. Studies to date clearly identify that proposed gas drainage activities, including capture and flaring represents a significant reduction in greenhouse gas emissions and is aligned to a best practise mitigation strategy suitable for the Project.

The option to generate electricity from Area 5 captured gas has been considered. It was deemed unviable because of:

- the variable nature of both the volumes and quality of the insitu gas resource in Area 5 (2-10 m^3/t content and 40-90% methane ratio),
- the short overall mining life of the domain (~7.5 years) with higher gas areas occurring later in the domain life.

In contrast, Appin Mine has a relatively homogeneous insitu gas resource of 7-16 m^3/t content at a 75-95% methane ratio and access to the state gas network to enrich supply to regulate the feed to the electricity generation plant when required. At Appin, where gas quality is much better, enrichment of the gas supply to the power engines is periodically required when methane concentrations are below the threshold required by the engines. Based on this experience, any such gas powered electricity generation plant for Area 5 would be expected to require gas enrichment to operate, which is not available in the Metropolitan Special Area.

The option to use VAM abatement was deemed unviable because of the unavailability of proven, safe, cost effective VAM technologies suitable for the Project.

Inseam Drainage (Pre-Drainage)

The mining in Area 5 ranges in virgin gas content from 2 m^3/t to 10m^3/t. Modelling indicates that gate roads would need to be pre-drained to below 3.5 m^3/t to manage rib emissions to acceptable levels to maintain air quality standards to within acceptable requirements. Empirical designs based on similar permeability areas at Appin have been developed as a notional Bulli seam pre-drainage design.

Cross Measure (Post Drainage)

The source of longwall gas in Area 5 is expected to be predominantly from the Wongawilli Seam, with Wongawilli Seam gas typically making up 50-65% of total longwall gas. Pore pressure models developed to estimate Specific Gas Emissions (SGE) indicate that the next most prominent source after the Wongawilli Seam is the Colo Vale Sandstone. Other analysis of geophysical data suggests gas derived from the overlying sandstones is modelled to be low in Area 5. As such, the focus of post-drainage is primarily the Wongawilli Seam.

The mechanism for gas release from the Wongawilli Seam is through horizontal fractures forming on the horizontal bands within the Wongawilli Seam as the longwall in the Bulli seam retreats. This means that a post-drainage philosophy based on sub-vertical holes to intersect these horizontal shears (similar to Appin) is the most appropriate method for post drainage of this seam.

Gas Plant and Flaring

The gas captured in the pre and post drainage processes would be brought to the surface via a gas reticulation piping system that is powered by a surface vacuum gas plant with downstream flaring on the outlet side of the vacuum pumps. Flaring occurs when a mixture of methane and oxygen is ignited for combustion to occur, with enclosed flares, as proposed for the Project, allowing gas under pressure containing methane to be mixed with sufficient oxygen to allow initial combustion to occur. Gas pressure regulation and control of inlet air, via automatically adjusted louvres, allows combustion to be controlled within the flume stack of the enclosed flare.

Typically, operating temperatures between 950 – 1100 degrees Celsius are maintained. Most enclosed flares operating within the Australian mining industry having a thermal capacity of between 40 – 60MW and depending on the gas composition, each flare can be in the order of 2200 – 2800 l/s flow capacity.

Future Project Gas Drainage Optimisation Opportunities

Pre-drainage of additional target seams

Limited horizontal drilling has been completed in the Wongawilli seam, which can present difficult drilling conditions. If successful, a pre-drainage regime targeting the Wongawilli seam could capture a portion of the gas prior to mining, ultimately diverting methane from the mine ventilation system. This concept would need to be studied further to confirm technical feasibility and commercial viability.

Goaf Capture

The Area 5 mining domain has been designed with access to the rear of the longwall blocks after mining has commenced. This creates the opportunity to allow gas capture from the longwall goaf and to be redirected to the gas drainage reticulating system rather than gas leaking into the ventilation stream and being released directly to the atmosphere. Goaf capture operates via a large diameter pipe connected through the final longwall seals to capture gas as barometric pressure changes are favourable. This concept would need to be studied further to confirm technical feasibility and commercial viability.

Conclusions

The early drainage and capture of gas into a pipeline allows for much more efficient abatement than gas emitted through VAM. Therefore, gas drainage and capture is recognised as industry best practice. The Project has analysed the predominant gas sources and proposes to mitigate fugitive emissions by effective Inseam Drainage (Pre-Drainage), Cross Measure (Post Drainage) and flaring of methane which will significantly reduce GHG emissions. This is predicted to reduce fugitive GHG emissions by approximately 3.4 Mt CO_2-e or 31% over the life of the Project which is a significant and material reduction.

The Project will also investigate methods to increase gas drainage efficiencies such as pre-drainage of additional target seams and goaf capture.

The use of VAM abatement by the Project was deemed unviable because of the unavailability of proven, safe and cost effective VAM technologies suitable for the Project, and the low likelihood of such technologies being available within the short mining life of the domain (~7.5 years).

APPENDIX 7
FUGITIVE GREENHOUSE GAS EMISSIONS FORECAST

MEMORANDUM

SOUTH32

Date	15 Feb 2022
To	Chris McEvoy (DNDA - Approvals Lead)
Copy	Gary Brassington (IMC Approvals Manager)
From	Daniel McCarthy (DNDA - Mine Design Lead)
Our Ref	OneDrive - South32\DND ADAPT\1 Project\30 Approvals\01 Stat Approvals\DND Adapt\EIS\Air & GHG\DNDA GHG Emissions Forecast

Dendrobium Mine Extension Project - Greenhouse Gas Emissions Forecast

Gas Modelling

A series of gas emission models were run based on a pore pressure model, established using borehole lithology and density logs from boreholes spread across the mine plan area to account for:

- Changes in stratigraphy in particular the proximity, thickness and ash content of seams located above and below the seam targeted for mining.
- Variations in gas content, gas desorption pressure and gas in place.
- Silling.

Pore pressure data and mid-burden fracturing interpretations were derived from FLAC caving modelling. Gas content was applied to adjacent seams according to the gas content / depth relationship, adjusted for the average depth of the working seam in that particular zone, cognisant of the measured gas content data in the area. Gas composition assignment was according to the gas composition measurements of the seam.

Emission coefficients within the pore pressure model were adjusted aware of measured longwall gas emission characteristics from Areas 7 and 9 at Appin Mine, cognisant of stratigraphic differences, in particular the closer proximity of the underlying seams in Area 5. During model development it was noted that exploration field geologists have had no occurrences of gas being liberated from surface boreholes when drilling through the sandstones.

Gas Drainage Assumptions For Emissions Forecast

Inseam Drainage (Pre-Drainage)
The mining area in Area 5 ranges in virgin gas content from 2m^3/t to 10m^3/t. Modelling indicates that gateroads need to be pre-drained to below 3.5 m^3/t to manage rib emissions to acceptable levels to maintain air quality standards to within acceptable requirements. Empirical designs based on similar permeability areas at Appin Mine have been developed as notional Bulli seam pre-drainage designs.

Cross Measure (Post Drainage)
The source of longwall gas in Area 5 is expected to be predominantly from the Wongawilli Seam, with Wongawilli Seam gas typically making up 50-65% of total longwall gas. Pore pressure models developed to estimate Specific Gas Emissions (SGE) indicate that the next most prominent source after the Wongawilli Seam is the Colo Vale Sandstone. Other analysis of geophysical data suggests a low probability of the sandstones above the Bulli Seam in this area containing gas. As such, the focus of post-drainage is primarily the Wongawilli Seam.

The mechanism for gas release from the Wongawilli Seam is through horizontal fractures forming on the horizontal bands within the Wongawilli Seam as the longwall in the Bulli seam retreats. This means that a post-drainage philosophy based on sub-vertical holes that intersect these horizontal shears (similar to Appin) is the most appropriate method for post drainage of this seam.

Gas Plant and Flaring

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Typically, operating temperatures between 950 – 1100 degrees Celsius are maintained. Most enclosed flares operating within the Australian mining industry having a thermal capacity of between 40 – 60MW and depending on the gas composition, each flare can be in the order of 2200 – 2800 l/s flow capacity.

Greenhouse Gas Emissions Forecast

Production Period

The Greenhouse Gas emission estimate includes emissions associated with longwall production, development rib emissions and sealed goaf gas make. The emissions for each longwall block were applied to the forecast production schedule to produce an annualised GHG emissions forecast as supplied in Table 1 below. The unabated estimated fugitive emissions from the project is 10.8 Mt CO2-e, with the gas drainage and flaring program forecast to reduce the overall emissions output by 3.4 Mt CO_{2-e} , a reduction of 31%.

Post Mining

An estimate of emissions from the Project on completion of mining has been made based on the area remaining open and ventilated, with estimated unabated fugitive emissions of 0.25 Mt CO_2-e per annum. This is considered conservative as it is likely that much of the project area will be sealed off shortly after extraction.

Table 1 - DNDA Green House Gas Emissions Forecast

Project Year	Project (Area 5) ROM Mt	Scope 1 Total fugitive emissions (MVA and pre and post gas drainage)	
		If pre and post gas drainage is vented	If pre and post gas drainage is flared
1	-	-	-
2	-	-	-
3	0.1	154,712	120,120
4	0.2	309,423	240,240
5	0.4	309,423	240,240
6	1.3	539,218	391,270
7	3.2	1,171,240	764,741
8	4.6	1,454,164	922,176
9	5.2	1,186,969	957,946
10	4.7	1,237,935	948,066
11	4.7	1,520,030	1,009,262
12	3.4	1,370,721	960,561
13	3.5	1,505,590	890,829
Max annual (t $CO_{2\text{-}e}$)		**1,520,030**	**1,009,262**
Average annual (t $CO_{2\text{-}e}$)		**978,130**	**676,859**
LOM total (t $CO_{2\text{-}e}$)		**10,759,425**	**7,445,451**

The densities used in the base calculations are 0.678 kg/m3 for CH_4 and 1.861 kg/m3 for CO_2 at 15°C and at standard atmospheric pressure.