


Appendix E

Air quality impact assessment

EMM creating opportunities

Holcim

Dubbo Quarry Continuation Project

Air Quality Impact Assessment

Report Number

J180313 RP#1

Client

Holcim (Australia) Pty Limited

Date

14 January 2021

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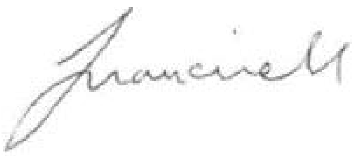
Final

Prepared by



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14 January 2021

Executive Summary

Dubbo Quarry (the quarry) is a basalt quarry owned and operated by Holcim (Australia) Pty Limited (Holcim), located approximately 1.9 kilometres (km) west of the city of Dubbo on Sheraton Road. The quarry falls within the Dubbo Regional Council local government area (Dubbo LGA), which is managed by Dubbo Regional Council (DRC).

Holcim is seeking approval for the Dubbo Quarry Continuation Project (henceforth referred to as 'the project') which involves the continued operation of the quarry through the development of two new resource areas to the south and west of the existing quarry boundary.

The existing quarry produces high quality aggregates for use in the construction industry, such as concrete and asphalt production, and for use as road base. The existing consent for quarry operations places no restriction on production, with the existing infrastructure having the capacity to produce a maximum of 500,000 tonnes per annum (tpa). At a production rate of 500,000 tpa, consistent with the existing operations, the two proposed extension areas provide sufficient resource for quarry operations to continue for up to 25 years.

This Air Quality Impact Assessment (AQIA) documents the existing air quality and meteorological environment, applicable impact assessment criteria, air pollutant emission calculations, dispersion modelling of calculated emissions and provides an assessment of predicted impacts relative to criteria.

The AQIA has been prepared in general accordance with the guidelines specified by the NSW Environment Protection Authority (EPA) in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (EPA 2016).

Local meteorological conditions were quantified primarily using data from the Bureau of Meteorology's (BoM) Dubbo Airport Automatic Weather Station (AWS). Background air quality was characterised using data from the Department of Planning, Industry and Environment's (DPIE) air quality monitoring stations at Tamworth and Bathurst.

Emissions estimation and dispersion modelling was completed for an existing operational scenario and two proposed scenarios with rock extracted in the Western Extension Area (WEA) and the Southern Extension Area (SEA) at a maximum extraction rate of 500,000 tpa (all material).

Emissions of total suspended particulates (TSP), particulate matter less than 10 micrometres (µm) in aerodynamic diameter (PM_{10}), and particulate matter less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$) were estimated and modelled. The atmospheric dispersion of air pollutant emissions was simulated using the AERMOD model.

The results of the modelling show that the predicted concentrations and deposition rates for incremental particulate matter (TSP, PM_{10}, $PM_{2.5}$ and dust deposition) were below the applicable impact assessment criteria at all assessment locations.

Cumulative impacts were assessed by combining modelled existing quarry and project impacts with recorded ambient background levels. The cumulative results showed that compliance with applicable NSW EPA impact assessment criteria is predicted at all assessment locations for all pollutants and averaging periods.

A range of best practice dust mitigation measures are and will continue to be employed at the quarry. These include the use of water carts and sprays, paved roads, watering of conveyor transfer points, watering exposed areas where possible, and progressive rehabilitation of exposed areas. These measures were taken into account in the emissions estimation and modelling of each scenario.

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1 Introduction

1.1 Overview

Holcim (Australia) Pty Limited (Holcim) are the owners and operators of Dubbo Quarry (the quarry) located on Sheraton Road, Dubbo (refer Figure 1.1). The quarry has operated since 1980 under a development consent granted by Dubbo Regional Council (DRC). Accessible basalt resources within the existing quarry boundary (refer Figure 1.2) are close to exhaustion and planning approval is required to allow the quarry to continue operating. Holcim is, therefore, seeking approval for the Dubbo Quarry Continuation Project (henceforth referred to as 'the project'), which involves the continued operation of the quarry through the development of two new resource areas to the south and west of the existing quarry boundary (refer Figure 1.2).

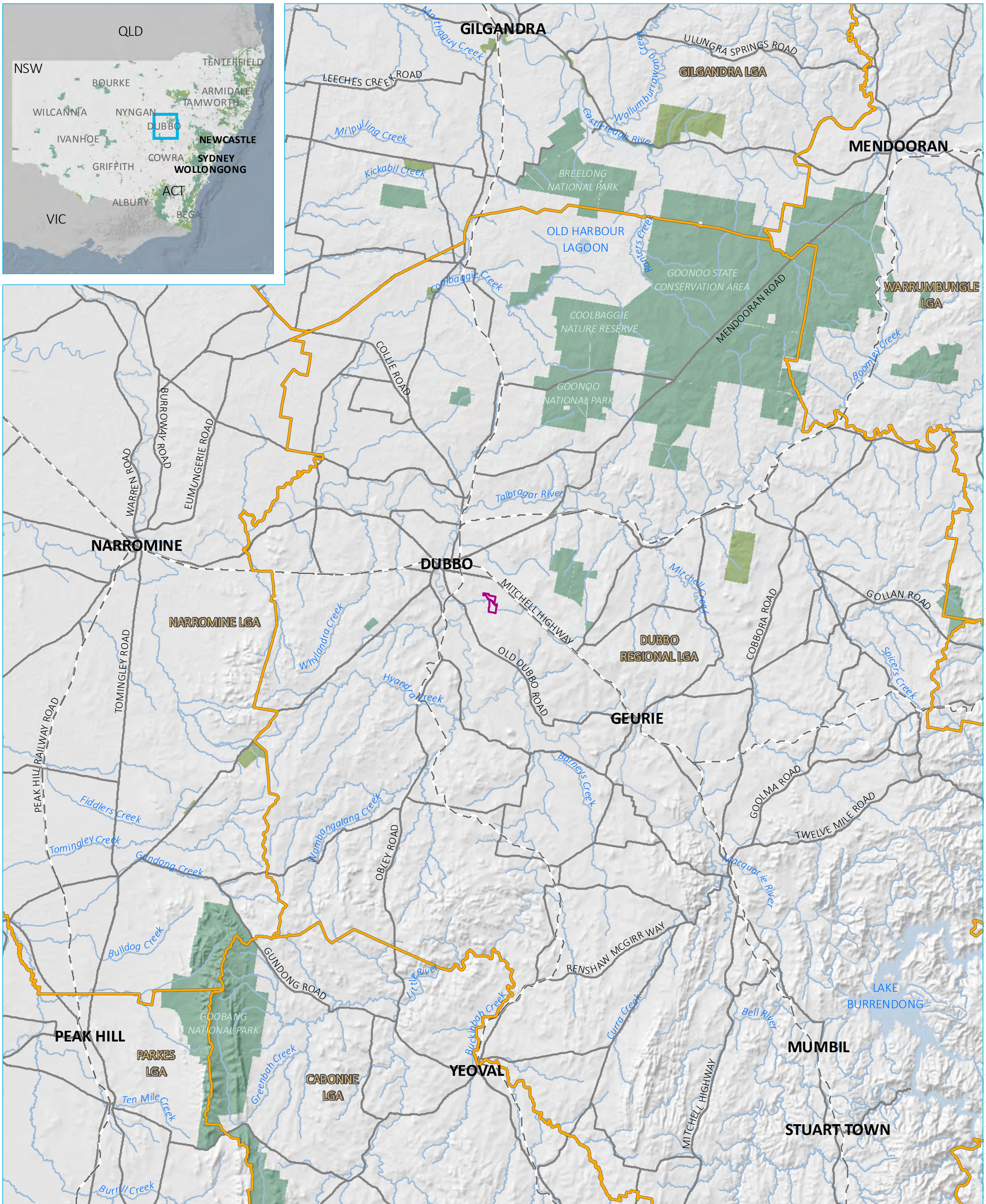
This Air Quality Impact Assessment (AQIA) has been prepared by EMM Consulting Pty Limited (EMM) on behalf of Holcim to assess potential air quality impacts on the surrounding environment as a result of the project. The AQIA has been prepared in general accordance with the guidelines specified by the NSW Environment Protection Authority (EPA) in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (EPA 2016), referred to herein as 'the Approved Methods for Modelling'.

1.2 Purpose of this report

This AQIA documents the existing air quality and meteorological environment, applicable impact assessment criteria, air pollutant emission calculations, dispersion modelling of calculated emissions and assessment of predicted impacts relative to criteria.

This AQIA consists of the following sections:

- a description of the local setting and surrounds of the quarry;
- the pollutants which are relevant to the assessment, and the applicable impact assessment criteria;
- a description of the existing environment, specifically:
  - the meteorology and climate; and
  - the existing air quality environment;
- detailed air pollutant emissions inventories for the quarry;
- atmospheric dispersion modelling for the quantified emissions, including an analysis of project-only and cumulative impacts accounting for baseline air quality; and
- an overview of best practice dust mitigation measures currently and proposed to be employed at the quarry.



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

0 10 20 km

GDA 1994 MGA Zone 55

N

KEY

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

Regional setting

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure 1.1

EMM creating opportunities

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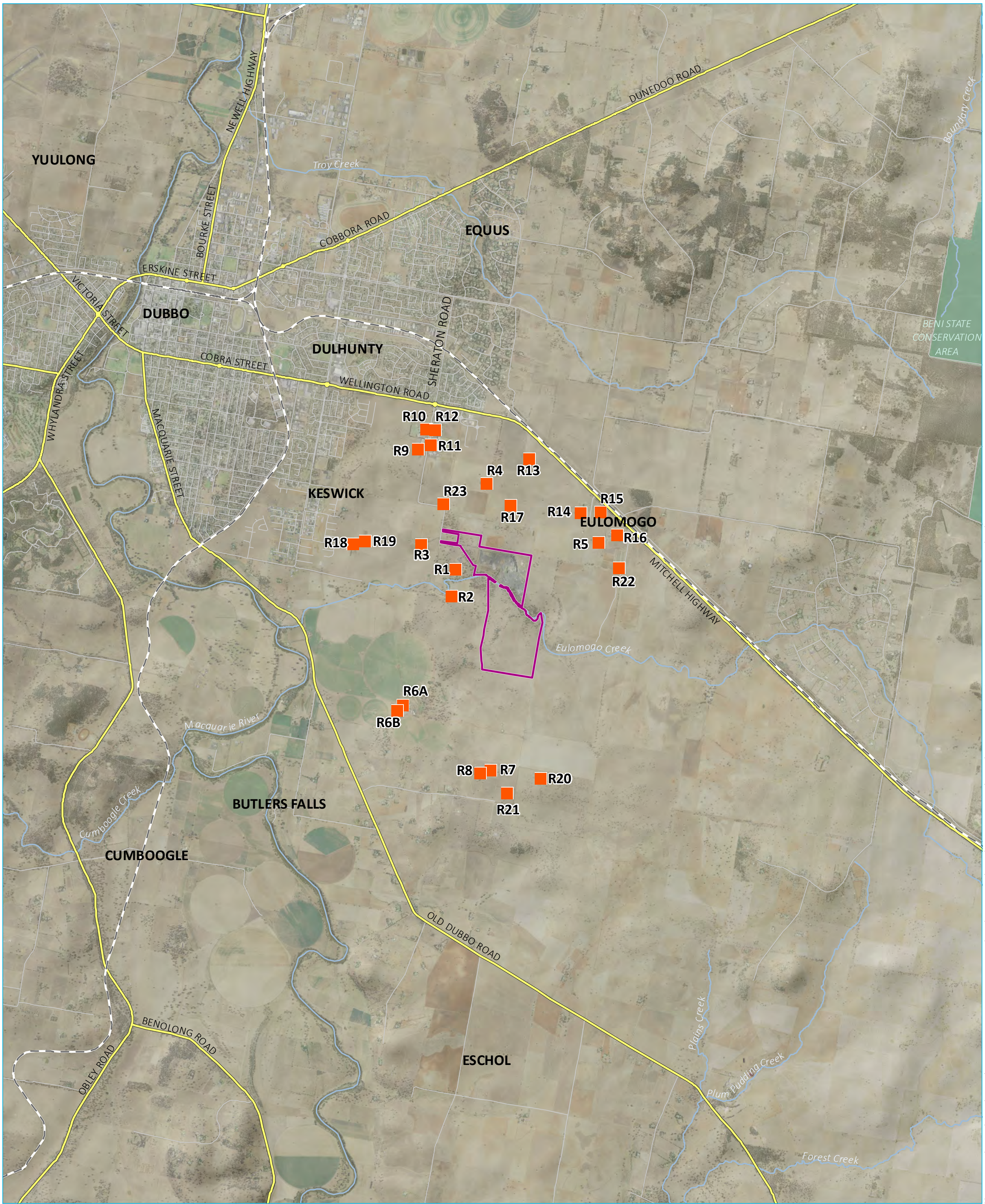

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DFSI (2017); DFSI (2020); EMM (2020)

0 1 2 km

GDA 1994 MGA Zone 55

N

KEY

- Project area
- Assessment location
- Rail line
- Major road
- Minor road
- Named watercourse
- NPWS reserve

Local context

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure 1.2

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1.3 Project overview

Development consent for Dubbo Quarry was originally granted by Talbragar Shire Council on 18 March 1980 under SPR79/22 (the existing consent). This consent related to the establishment of a basalt quarry on former Portions 208 and 211, Parish Dubbo (the existing site) and contains eight conditions with no restrictions on production rates or operating hours. Holcim also holds Environment Protection Licence (EPL) No. 2212 for land-based extraction activities between 100,000 and 500,000 tonnes per annum (tpa).

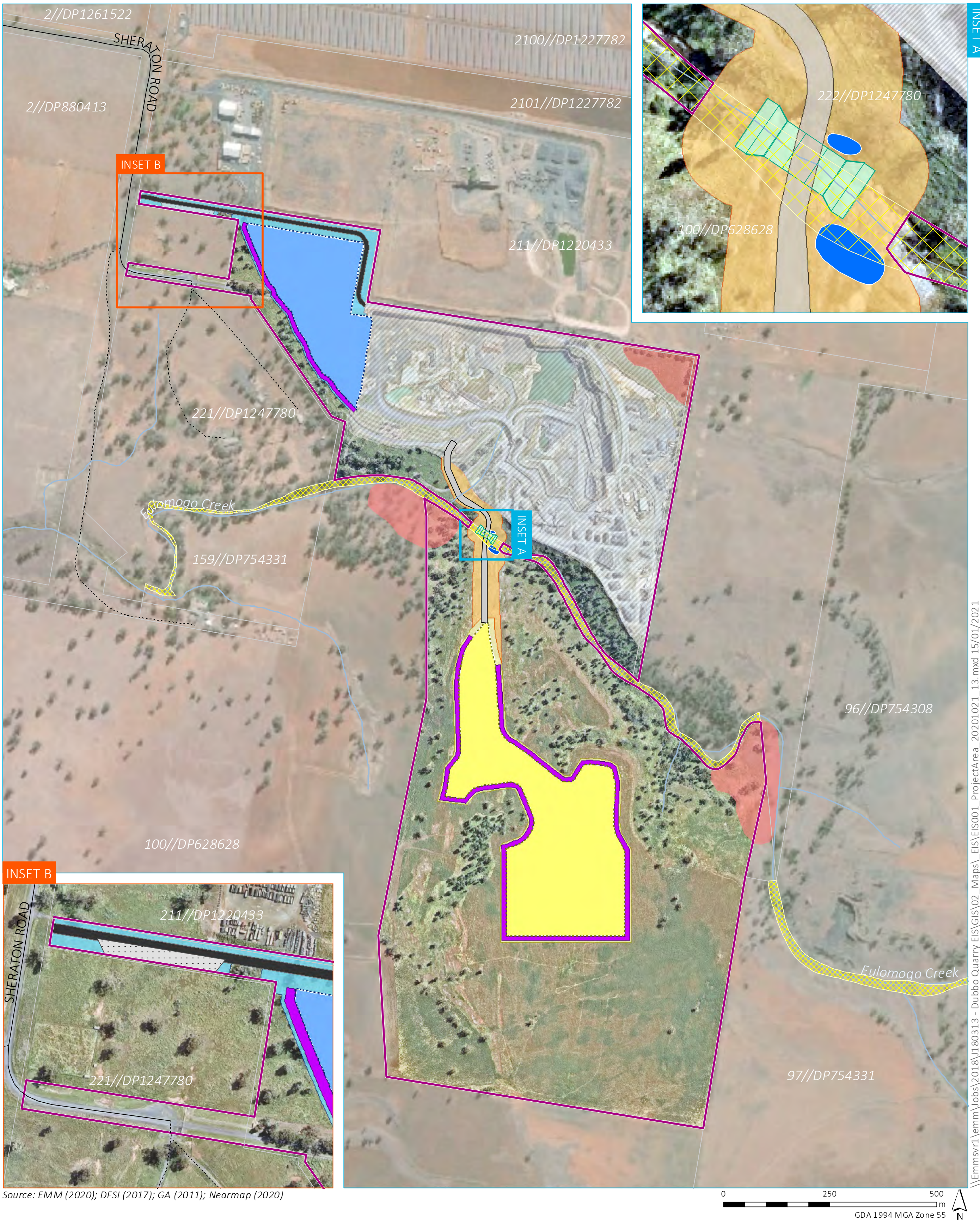
The quarry produces high quality aggregates for use in the construction industry, such as concrete and asphalt production, and for use as road base. Precoated sealing aggregates from crushed basalt are produced at the quarry. The quarry produces many types of road base, both specification and non-specification, such as the premium road base product Heavy Duty DGB20 which is frequently used by local councils and Transport for NSW for the construction and upgrade of roads.

The project involves continued operations within the existing site and into two new resource areas as described below (refer Figure 1.3):

- the existing approved disturbance boundary within Lot 222 DP 1247780;
- the Western Extension Area (WEA) which is west and north-west of the existing quarry boundary, located within Lot 222 DP 1247780 (north and south of Sheraton Road; and
- the Southern Extension Area (SEA) which is south of the existing quarry boundary on the southern side of Eulomogo Creek, located within part Lot 100 DP 628628.

A new haul road and crossing over Eulomogo Creek would also be constructed as part of the project to connect the existing site with the SEA. The quarry's access road, which connects to Sheraton Road, is to be relocated around the boundary of the WEA.

The existing consent for quarry operations places no restriction on production, with the existing infrastructure having the capacity to produce a maximum of 500,000 tpa. At a production rate of 500,000 tpa, consistent with the existing operations, the two proposed extension areas provide sufficient resource for quarry operations to continue for up to 25 years.



KEY

- Project area
- Sediment pond
- Aboriginal protection zone
- Indicative existing disturbance area
- Proposed haul road
- Indicative proposed water crossing
- Bund wall
- Proposed access road
- Truck tarping area
- Western extension area
- Western disturbance area
- Haul road disturbance area
- Southern extension area
- Southern disturbance area
- Minor road
- Vehicular track
- Watercourse/drainage line
- Waterbody
- Cadastral boundary (data does not align with surveyed site boundary)
- Crown land

Project area

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure 2.1

creating opportunities

1.4 Site and surrounding area

The quarry is located within Dubbo Regional Local Government Area (LGA) approximately 1.9 km west of the city of Dubbo. The quarry is accessed via Sheraton Road which connects to the Mitchell Highway approximately 2 km north-west of the quarry. The project area is shown on Figure 1.3.

Land uses surrounding the quarry include rural residences, agriculture, extractive industry (the South Keswick Quarry immediately north) and solar power generation.

There are a number of private residences surrounding Dubbo Quarry. The closest is located approximately 280 m to the south-east. Section 1.5 provides details of the residences and other sensitive locations included in the dispersion modelling.

The terrain surrounding the Dubbo Quarry is considered to be relatively flat with little distinguishing features. Elevation ranges from approximately 260 mAHD to 320 mAHD within approximately 5 km of the Dubbo Quarry. A three-dimensional representation of the local topography is shown in Figure 1.4.

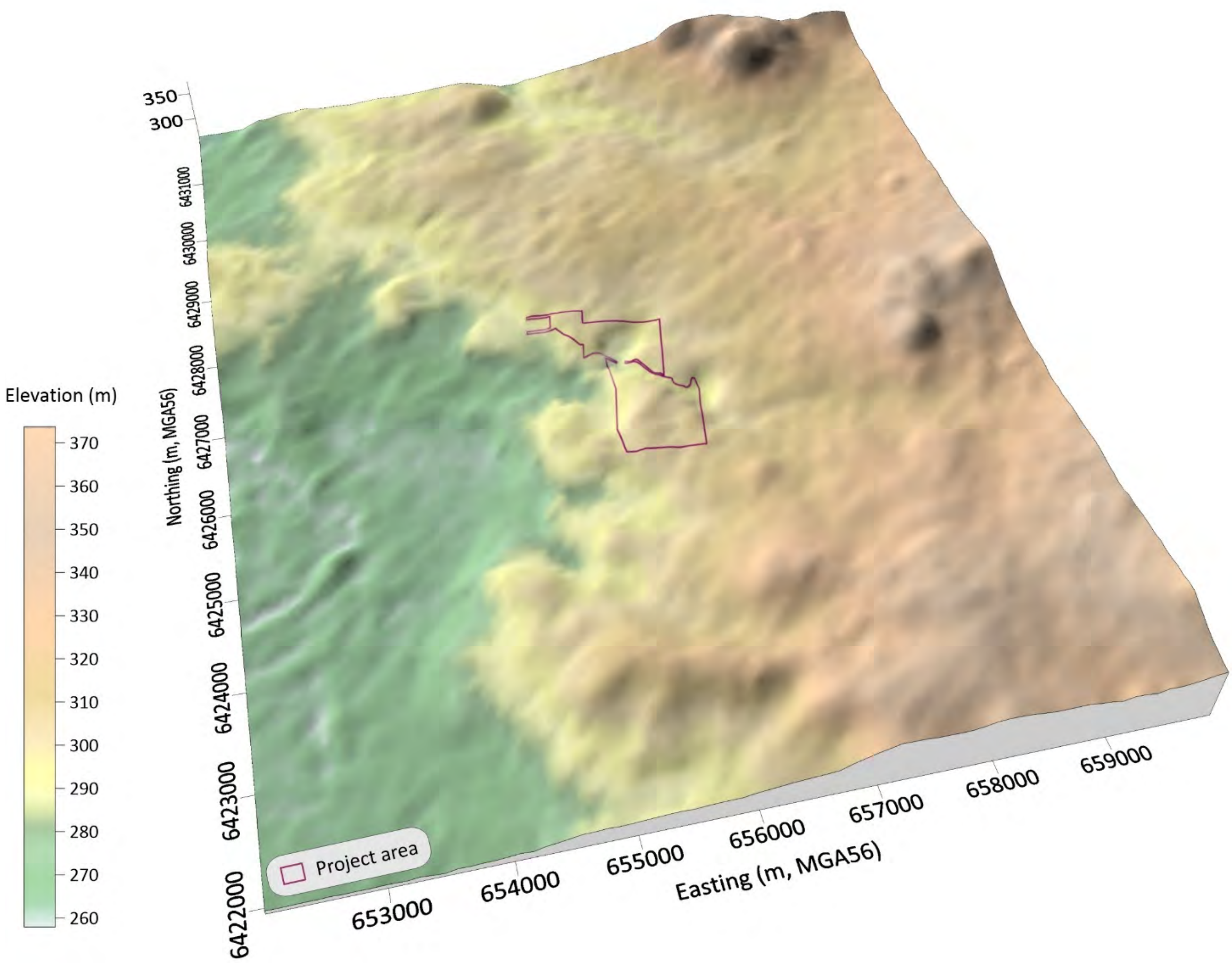


Figure 1.4 3-dimensional topography surrounding Dubbo Quarry

Source: NASA Shuttle Radar Topography Mission data

1.5 Assessment locations

The nearest representative sensitive locations to the quarry have been identified for the purpose of assessing potential air quality impacts from the project. These locations were selected to represent the range and extent of noise impacts from the project and are referred to in this report as assessment locations. Details are provided in Table 1.1 and their locations are shown in Figure 1.2.

Table 1.1 Air quality assessment locations

Assessment location ID	Receiver type	Easting	Northing
R1[1]	Residential	655384	6427170
R2	Residential	655320	6426775
R3	Residential	654875	6427538
R4	Residential	655838	6428439
R5	Residential	657491	6427569
R6a	Residential	654596	6425165
R6b	Residential	654523	6425082
R7	Residential	655905	6424191
R8	Residential	655746	6424154
R9	Commercial	654823	6428948
R10	School	654942	6429244
R11	School	655013	6429009
R12	School	655075	6429237
R13	Residential	656466	6428804
R14	Residential	657233	6428009
R15	Residential	657521	6428016
R16	Residential	657768	6427678
R17	Industrial	656193	6428115
R18	Residential	653862	6427551
R19	Residential	654038	6427592
R20	Residential	656647	6424074
R21	Residential	656142	6423858
R22	Residential	657799	6427195
R23	Residential subdivision (approved)	655196	6428133

1 Holcim currently have an agreement with R1 for impacts from the quarry.

1.6 Regulatory requirements

1.6.1 Secretary's Environmental Assessment Requirements (SEARs)

The SEARs for the project were issued on 3 April 2020. The SEARs related to air quality are provided in Table 1.2.

Table 1.2 SEARs requirements – air quality

SEARs		Report section
1.	A detailed assessment of potential construction and operational air quality impacts, in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*, and with a particular focus on dust emissions including $PM_{2.5}$ and PM_{10}, and having regard to the *Voluntary Land Acquisition and Mitigation Policy*.	Chapter 6
2.	A detailed consideration of cumulative impacts of developments in the area having particular regard to sensitive receivers to the west.	Section 6.3

1.6.2 NSW EPA

The NSW EPA has also provided a list of requirements for the AQIA. These are replicated in Table 1.3 below.

Table 1.3 NSW EPA requirements – air quality

SEARs		Report section
1.	Identify all potential discharges of fugitive and point source emissions of pollutants including dust for all stages of the proposal and assess the risk associated with those emissions. All processes that could result in air emissions must be identified and described. Sufficient detail to accurately communicate the characteristics and quantity of all emissions must be provided. Assessment of risk relates to environmental harm, risk to human health and amenity.	Chapter 5
2.	Justify the level of assessment undertaken on the basis of risk factors, including but not limited to: a) proposal location; b) characteristics of the receiving environment; c) type and quantity of pollutants emitted.	Whole report. A Level 2 assessment has been completed in line with the Approved Methods for Modelling.
3.	Describe the receiving environment in detail. The proposal must be contextualised within the receiving environment (local, regional and inter-regional as appropriate). The description must include but need not be limited to: a) meteorology and climate; b) topography c) surrounding land-use d) ambient air quality	Chapter 3 and Chapter 4
4.	Include a consideration of 'worst case' emission scenarios and impacts at proposed emission limits.	Chapter 5
5.	Account for cumulative impacts associated with existing emission sources as well as any currently approved developments linked to the receiving environment.	Section 6.3

Table 1.3 NSW EPA requirements – air quality

SEARs		Report section
6.	Include air dispersion modelling where there is a risk of adverse air quality impacts, or where there is sufficient uncertainty to warrant a rigorous numerical impact assessment. Air dispersion modelling must be conducted in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2016), available at: *https://www.epa.nsw.gov.au/your-environment/air/industrial-emissions/modelling-assessing-airemissions.*	Chapter 6
7.	Demonstrate the proposal's ability to comply with the relevant regulatory framework, specifically the Protection of the Environment Operations (POEO) Act 1997 and the POEO (Clean Air) Regulation (2010).	Section 2.3
8.	Detail emission control techniques/practices that will be employed by the proposal. Consideration should be given to dust management techniques where water is unavailable or limited, and the development of a Trigger Action Response Plan (TARP).	Section 5.3 and Section 5.4

2 Pollutants and assessment criteria

2.1 Potential air pollutants

This assessment includes consideration of potential impacts from operational emissions at the quarry for existing and proposed scenarios (explained further in Chapter 5).

Emissions will principally consist of particulate matter emissions from loading and unloading materials (topsoil, subsoil and rock), conveying and transfer of rock, rock sizing, hauling materials and wind erosion of exposed areas.

The project will include some minor construction activities which have the potential to generate dust emissions. Construction phase emissions will principally consist of particulate matter emissions related to the construction of a new quarry access road, the crossing of Eulomogo Creek, and an internal road and modifications to the existing water management infrastructure within the existing quarry. These would be constructed within the first two years of the project with the construction activity with the longest duration being the creek crossing which would take approximately nine weeks. Given the short timeframe and small-scale of the construction activities, this has not been assessed further.

A detailed description of the emission sources associated with the existing and proposed operations at the quarry is presented in Chapter 5. The main air pollutants emitted will be:

- particulate matter, specifically:
  - total suspended particulate matter (TSP);
  - particulate matter less than 10 micrometres (µm) in aerodynamic diameter (PM_{10}); and
  - particulate matter less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$).
- gaseous pollutants, specifically:
  - oxides of nitrogen (NO_x)[2], including nitrogen dioxide (NO_2);
  - sulphur dioxide (SO_2);
  - carbon monoxide (CO); and
  - volatile organic compounds (VOCs).

Of the above listed pollutants, this assessment will focus on emissions and impacts from particulate matter (TSP, PM_{10} and $PM_{2.5}$). Impact assessment criteria applicable to particulate matter is presented in the following sections as defined in the *Approved Methods for Modelling* (EPA 2016). The impact assessment criteria are designed to maintain ambient air quality that allows for the adequate protection of human health and well-being.

The combustion of diesel in quarrying equipment results in combustion-related emissions, including $PM_{2.5}$, NO_x, SO_2, CO, carbon dioxide (CO_2) and VOCs. Gaseous combustion emissions from quarrying equipment does not generally result in significant off-site concentrations and are unlikely to compromise ambient air quality goals. Accordingly, with the exception of PM, combustion emissions have not been quantitatively assessed.

[2] By convention, NOx = nitrous oxide (NO) + NO_2.

2.2 Applicable air quality assessment criteria

2.2.1 Particulate matter

The NSW EPA's impact assessment criteria for particulate matter, as documented in Section 7 of the Approved Methods for Modelling, are presented in Table 2.1. The assessment criteria for PM_{10} and $PM_{2.5}$ are consistent with the *National Environment Protection (Ambient Air Quality) Measure* (AAQ NEPM) national reporting standards (DoE 2016).

TSP, which relates to airborne particles less than 50 µm in diameter (US EPA 1998a), is used as a metric for assessing amenity impacts (reduction in visibility, dust deposition and soiling of buildings and surfaces) rather than health impacts. Particles less than 10 µm and 2.5 µm in diameter, a subset of TSP, are fine enough to enter the human respiratory system and can lead to adverse human health impacts. The NSW EPA impact assessment criteria for PM_{10} and $PM_{2.5}$ are, therefore, used to assess the potential impacts on human health of particulate matter concentrations.

The Approved Methods for Modelling classifies TSP, PM_{10}, $PM_{2.5}$ and dust deposition as criteria pollutants. Assessment criteria for pollutants are applied at the nearest existing or likely future off-site sensitive receptor and compared against the 100th percentile (ie the highest) dispersion modelling prediction in the case of 24-hour impacts. Both the incremental (assessed project impacts only) and cumulative (project including background) impacts need to be presented, the latter requiring consideration of existing ambient background concentrations for the pollutants assessed.

For dust deposition, the Approved Methods for Modelling specifies criteria for incremental and cumulative dust deposition levels. Dust deposition impacts are derived from TSP emission rates and particle deposition calculations in the dispersion modelling process.

Table 2.1 Impact assessment criteria for particulate matter

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

Notes: µg/m^3: micrograms per cubic metre; g/m^2/month: gram per square metre per month.
Source: Approved Methods for Modelling (EPA 2016).

2.3 Protection of the Environment Operations Act 1997

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

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

The quarry will comply with the POEO regulations as follows:

- as a scheduled activity under the POEO regulations, the quarry operates under EPL 2212 issued by the NSW EPA and is required to comply with requirements including emission limits, monitoring and pollution-reduction programmes (PRPs);
- the quarry does not feature significant odour-generating emission sources and is, therefore, unlikely to generate odorous emissions; and
- no large-scale open burning is performed on-site.

2.4 Voluntary land acquisition and mitigation policy

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

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

In relation to dust, voluntary mitigation rights apply when a development contributes to exceedances of the criteria set out in Table 2.2. Voluntary acquisition rights apply when a development contributes to exceedances of the criteria set out in Table 2.3. The criteria for voluntary mitigation and acquisition are the same, except for the number of days the short-term impact assessment criteria for PM_{10} and $PM_{2.5}$ can be exceeded, which is zero for mitigation and five for acquisition.

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

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

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

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

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

Table 2.2 VLAMP mitigation criteria

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

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

Table 2.3 VLAMP acquisition criteria

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

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

3 Meteorology and climate

3.1 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.

The closest meteorological station to the quarry is the Bureau of Meteorology (BoM) Dubbo Airport Automatic Weather Station (AWS) located approximately 10.5 km to the north-west. The station records data at 1-minute intervals and includes wind speed, wind direction, temperature, relative humidity, rainfall, station level pressure, cloud content and cloud height.

Figure 1.2 shows the location of the BoM Dubbo Airport AWS in relation to the quarry.

3.2 Prevailing winds and selection of a representative year

Meteorological data recorded by the BoM Dubbo Airport AWS for the period between 2015 and 2019 were analysed for the purposes of characterising the existing environment and selecting a representative year for dispersion modelling. Details are presented in Appendix A.

Figure A.1 shows that data availability for all years was between 96% and 100% across the most important parameters for modelling.

Inter-annual profiles for wind speed, wind direction, air temperature and relative humidity for 2015 to 2019 are shown in Figure A.3 to Figure A.6 were also generally comparable between 2015 and 2019. The largest variation was seen in the relative humidity data. Relative humidity recordings in 2015 and 2016 were consistently higher than for 2017 to 2019. 2017 was also higher than 2018 and 2019. The reason for this is unknown but may be due to drought conditions during that time.

Annual wind roses created from wind speed and direction data collected at the BoM Dubbo Airport AWS from 2015 to 2019 are presented in Figure A.6. The wind roses show a similarity across years for both wind speed and wind direction. The winds recorded by the BoM Dubbo Airport AWS across all five years were predominately from the east and south. Annual average wind speeds ranged between 4.1 m/s and 4.5 m/s. The annual average frequency of calm conditions (wind speeds less than 0.5 m/s) ranged between 2.2% and 5.1%.

Seasonal wind roses for the BoM Dubbo Airport AWS from 2015 to 2019 are shown in Figure A.7. The mean wind speed ranges from 3.8 m/s in winter to 4.8 m/s in winter and summer. The annual percentage of calm conditions ranged from 1.9% in summer and 5.3% in winter. The wind patterns in spring and autumn were very similar displaying dominant easterly and southerly winds. In summer there were more pronounced easterlies and in winter the dominant winds were from the south-east.

Diurnal wind roses for the BoM Dubbo Airport AWS are shown in Figure A.8. The wind patterns are similar between the two periods however easterlies are more prominent at night-time. The average wind speed during the day was 4.6 m/s compared to 4 m/s at night-time. The percentage of calms during the day was 1.9% compared to 5.3% at night.

The 2017 calendar year was adopted as the 12-month modelling period for the purpose of this AQIA given the data availability and consistency of the data year-on-year. The modelling year was also chosen with regard to background air quality which is discussed in Section 4.3. The annual wind rose for the BoM Dubbo Airport AWS for 2017 is shown in Figure 3.1. The wind rose displays the same characteristics as that described above, specifically dominated by winds from the eastern and southern quadrants.

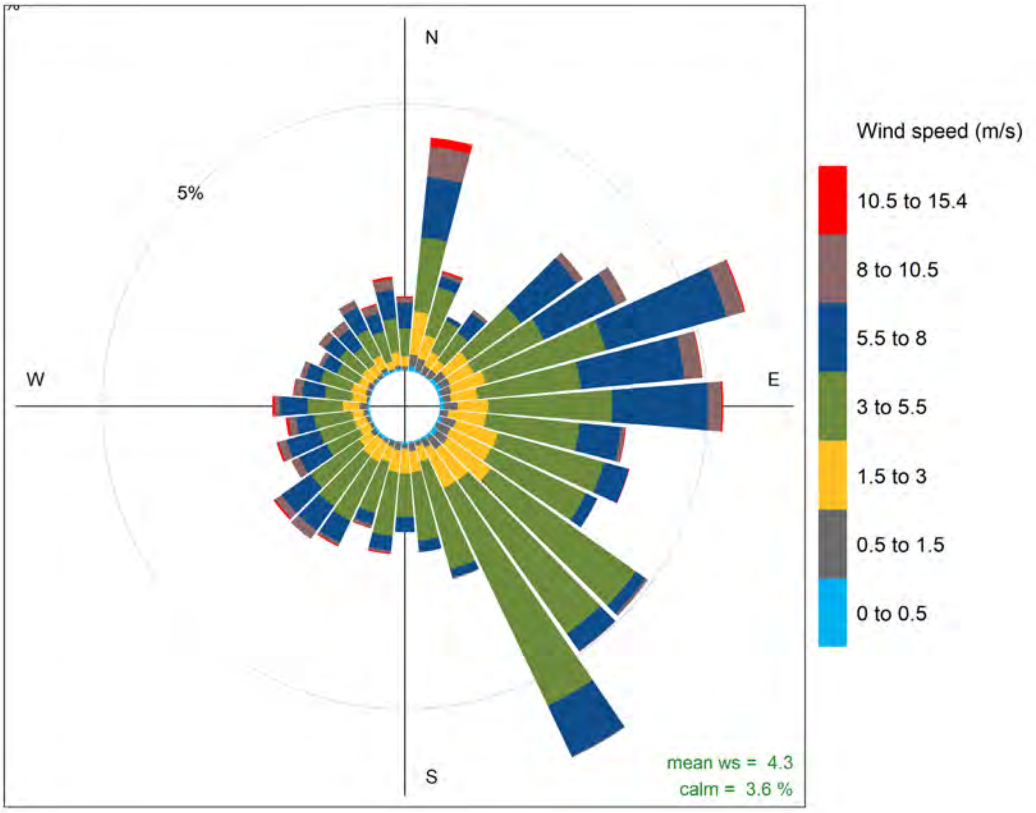


Figure 3.1 Recorded wind speed and direction – BoM Dubbo Airport AWS – 2017

3.3 Meteorological modelling

3.3.1 Overview

Atmospheric dispersion modelling for this assessment has been completed using the AMS[6]/USEPA[7] regulatory model (AERMOD) (model version v19191). The meteorological inputs for AERMOD were generated using the AERMET meteorological processor using local surface observations and upper air profiles generated by CSIRO's The Air Pollution Model (TAPM) meteorological model.

Section 4.1 of the Approved Methods for Modelling specifies that meteorological data representative of a site can be used in the absence of suitable on-site observations. The data should cover a period of at least one year with a percentage completeness of at least 90%. Data can be obtained from either a nearby meteorological monitoring station or synthetically generated using the CSIRO prognostic meteorological model TAPM.

6 AMS - American Meteorological Society

7 USEPA - United States Environmental Protection Agency

Hourly average meteorological data from the BoM Dubbo Airport AWS was used as observations in the TAPM and AERMET modelling.

Further details of the TAPM and AERMET meteorological modelling is presented in Appendix A.

3.3.2 Atmospheric stability and mixing depth

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

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

Figure 3.2 illustrates the diurnal variation of atmospheric stability, derived from the Monin-Obukhov length calculated by AERMET at the BoM Dubbo Airport AWS. The diurnal profile shows that atmospheric instability increases during the daylight hours as the sun generated convective energy increases, whereas stable atmospheric conditions prevail during the night-time. This profile indicates that the potential for effective atmospheric dispersion of emissions would be greatest during daytime hours and lowest during evening through to early morning hours.

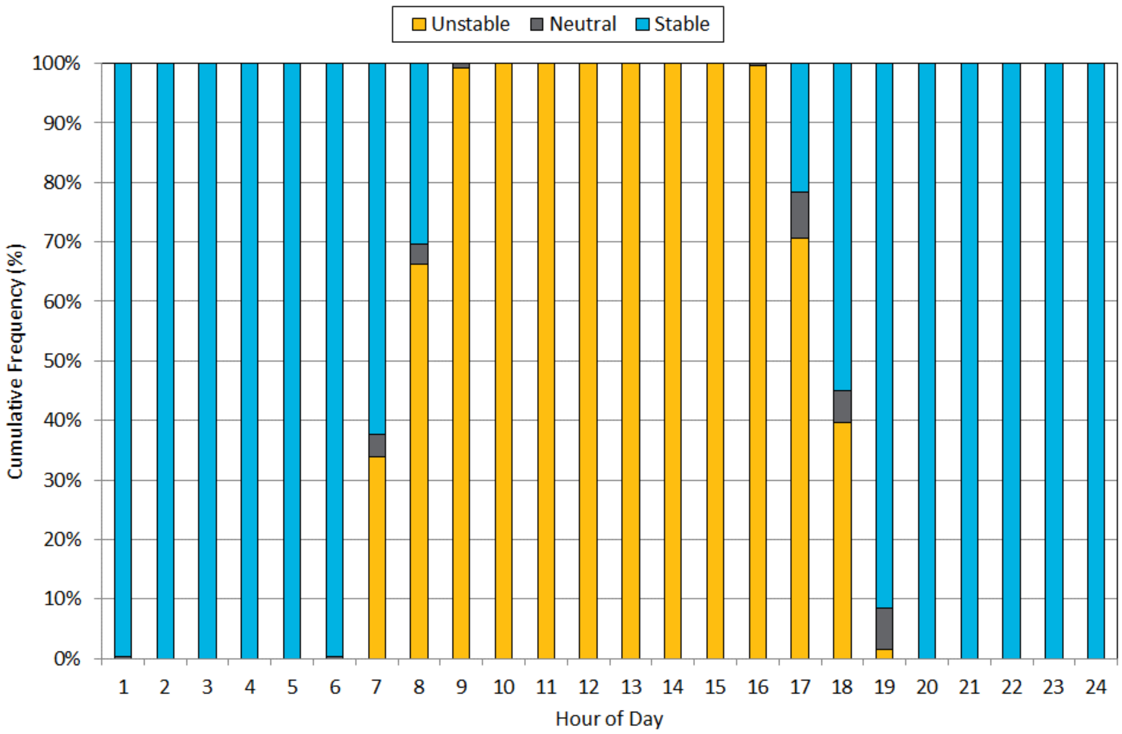


Figure 3.2 CALMET-calculated diurnal variation in atmospheric stability – BoM Dubbo Airport AWS 2017

Mixing depth refers to the height of the atmosphere above ground level within which air pollution can be dispersed. The mixing depth of the atmosphere is influenced by mechanical (associated with wind speed) and thermal (associated with solar radiation) turbulence. Similar to the Monin-Obukhov length analysis above, higher daytime wind speeds and the onset of incoming solar radiation increases the amount of mechanical and convective turbulence in the atmosphere. As turbulence increases, so too does the depth of the boundary layer, generally contributing to higher mixing depths and greater potential for the atmospheric dispersion of pollutants.

Figure 3.3 presents the hourly-varying atmospheric boundary layer depths generated by AERMET. Greater boundary layer depths occur during the daytime hours, peaking in the mid to late afternoon.

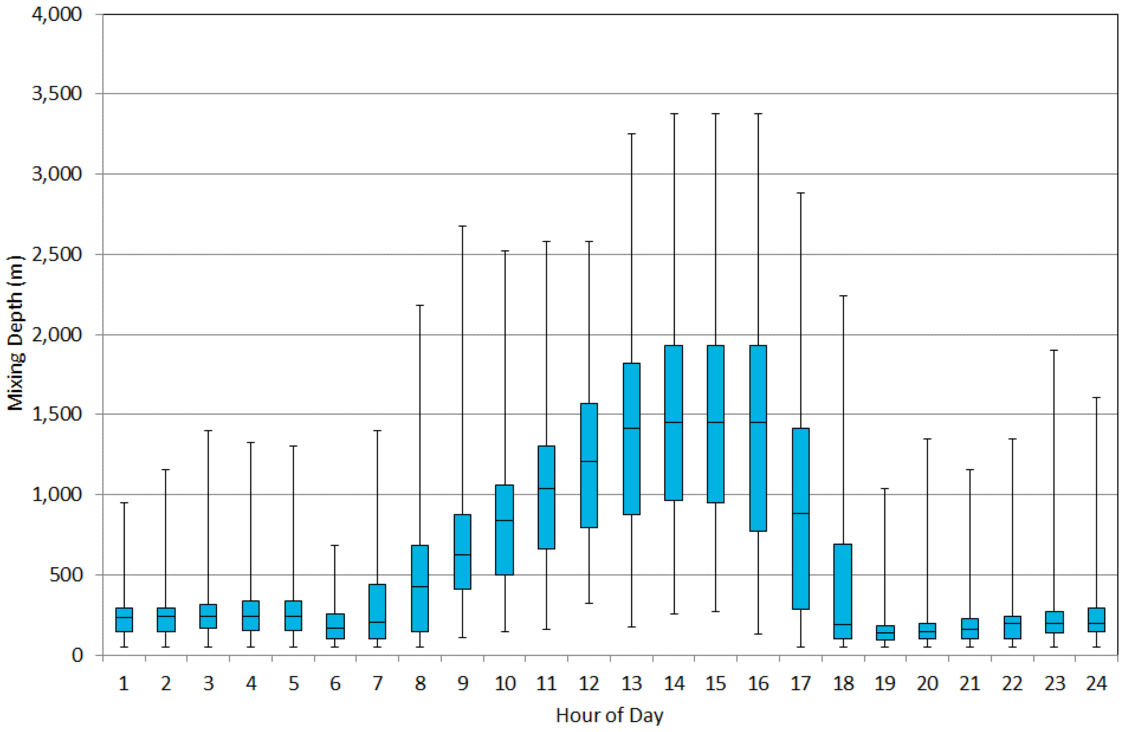


Figure 3.3 CALMET-calculated diurnal variation in atmospheric mixing depth – BoM Dubbo Airport AWS 2017

4 Baseline air quality

4.1 Introduction

Apart from the quarry itself, the local airshed will also be influenced by:

- emissions from existing surrounding operations such as the South Keswick Quarry;
- wind generated dust from exposed areas;
- dust entrainment and tailpipe emissions from vehicle movements along unsealed and sealed roads;
- seasonal emissions from household wood heaters; and
- long-range transport of fine particles into the region.

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

4.2 Air quality monitoring data resources

There are no site specific or Department of Planning Industry and Environment (DPIE) air quality monitors in the vicinity of the project. The closest DPIE monitoring station is located at Orange approximately 114 km south-east of the project. As the project is located in a largely rural area, air quality measurements from regional DPIE monitoring stations were analysed for the purposes of selecting a dataset to characterise existing background concentrations and for use in the cumulative assessment (Section 6.3). The air quality surrounding the project is likely to be similar to other regional areas in NSW. Relevant to the project area, DPIE collects PM_{10} and $PM_{2.5}$ data in Tamworth, Bathurst, and Wagga Wagga North. Based on Köppen climate classification maps provided by the BoM[8], the climate classification of the project area (temperate/no dry season/hot summer) matches that of the Tamworth, Bathurst and Wagga Wagga North stations.

Analysis showed, however, that the Wagga Wagga North station consistently records higher concentrations than at the Tamworth and Bathurst stations. A summary of the annual average PM_{10} concentrations recorded from 2015 to 2019 at the DPIE Tamworth, Bathurst and Wagga Wagga North stations is shown in Table 4.1. The table shows that annual average PM_{10} concentrations recorded at Wagga Wagga North are on average around 5 µg/m^3 higher than at Tamworth and Bathurst. It is noted that 2019 concentrations are elevated at all three sites due to the widespread bushfire events that occurred during November and December. The higher concentrations at Wagga Wagga North are from agricultural stubble burning. As a result, the ambient air quality data from the Wagga Wagga North station was excluded from the background dataset used in this assessment.

8 http://www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp

Table 4.1 Annual average PM_{10} concentration for DPIE Tamworth, Bathurst and Wagga Wagga North air quality monitoring stations (µg/m³)

Year	Tamworth	Bathurst	Wagga Wagga North
2015	14.1	13.4	19.9
2016	15.3	13.3	20.6
2017	15.3	14.1	20.6
2018	20.1	18.8	27.4
2019	33.7	27.4	35.3
Average	**19.7**	**17.4**	**24.8**

4.3 Background air quality

4.3.1 PM_{10}

A summary of key statistics for the five years of analysed data from the DPIE Tamworth and Bathurst stations is presented in Table 4.2. Exceedances of the air quality criteria of 50 µg/m³ were recorded in all years at Tamworth and in 2015, 2018 and 2019 at Bathurst. There are also clear increases in concentrations from 2018. The increase is attributed to state-wide extreme drought conditions, exacerbated in 2019 due to the extensive bushfires during November and December. As a result, 2018 and 2019 were not considered representative of the local area for use in describing background air quality levels.

Table 4.2 Statistics for PM_{10} concentrations – DPIE Tamworth and Bathurst – 2015–2019

Year	Maximum 24-hour average concentration (µg/m³)	Annual average concentration (µg/m³)	Number of days greater than 50 µg/m³	Data recovery
DPIE Tamworth				
2015	52.7	14.1	1	99%
2016	51.7	15.3	1	100%
2017	54.1	15.3	2	99%
2018	145.4	20.1	9	99%
2019	240.2	33.7	52	99%
DPIE Bathurst				
2015	94.6	13.4	2	99%
2016	34.1	13.3	0	93%
2017	49.9	14.1	0	97%
2018	274.1	18.8	8	98%
2019	296.6	27.4	40	99%

A time series of recorded 24-hour average PM_{10} concentrations at the DPIE Tamworth and Bathurst stations for the period 2015 to 2019 is presented in Figure 4.1. The recorded 24-hour average PM_{10} concentrations fluctuated throughout the period; however, there is a clear upward trend of concentrations since 2015 with concentrations attributed to dust storm and bushfire events clearly shown in 2018 and 2019. It is noted that the maximum concentrations recorded were 240 µg/m^3 at Tamworth and 296 µg/m^3 in 2019. These are not shown on the plot to allow the remaining data to be shown clearly.

Due to the regional bushfire and dust storm events that occurred in 2018 and 2019, these years were excluded for use in the background dataset and data from the Tamworth and Bathurst stations in 2017 were used to define background concentrations of PM_{10} and $PM_{2.5}$ for this assessment.

To provide a representative dataset for cumulative modelling, the concurrent daily concentrations recorded at the Tamworth and Bathurst were combined into a regional average. Some gap filling was required (two days in the year), as there were no data for the two stations. The values for each day were defined as the mean for the whole dataset. The regional average PM_{10} dataset is shown in Figure 4.2.

Table 4.2 shows that there were two exceedances of the daily PM_{10} criterion at Tamworth in 2017 and none at Bathurst. When combined into a regional average, there are no existing exceedances of the daily PM_{10} criterion in the regional average background dataset.

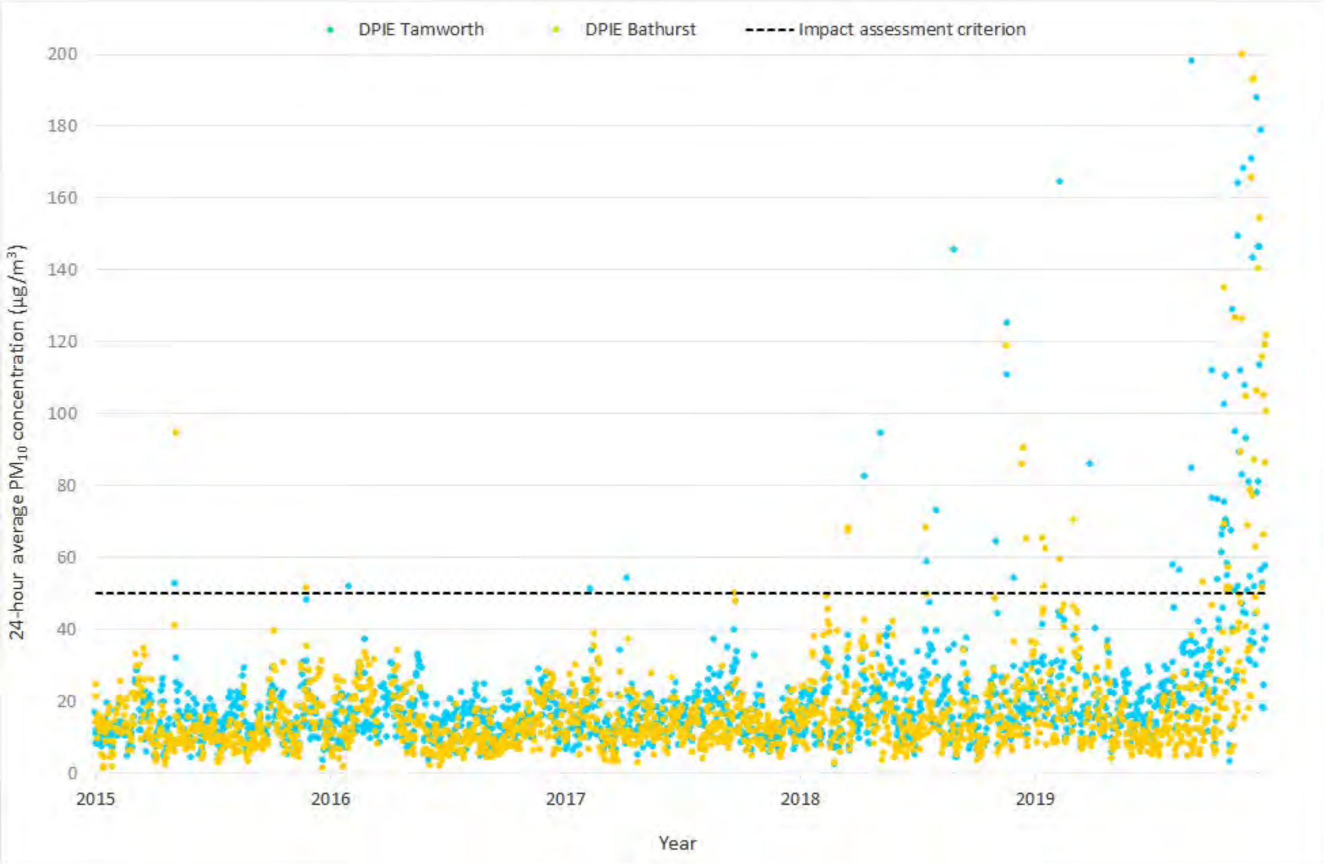


Figure 4.1 **Time series of 24-hour average PM_{10} concentrations – DPIE Tamworth and Bathurst – 2015–2019**

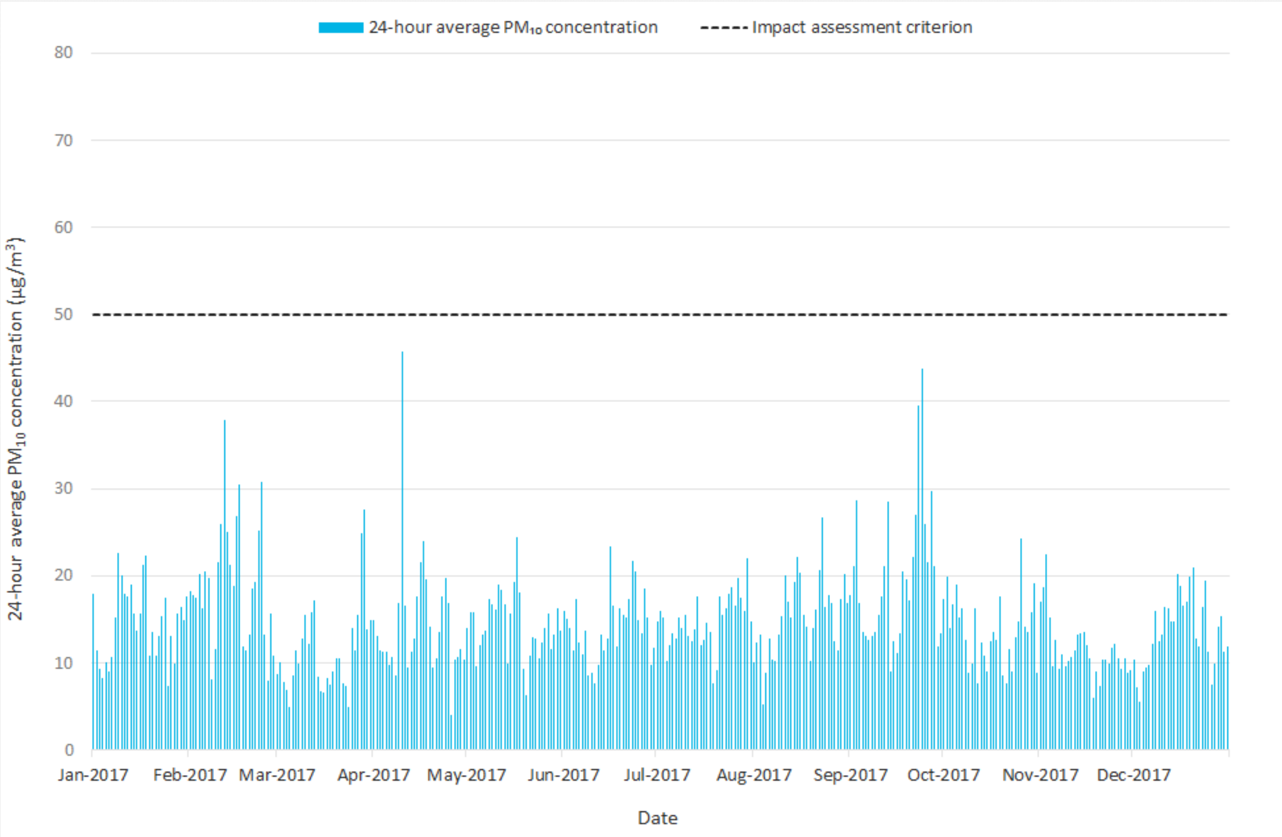


Figure 4.2 Background timeseries for 24-hour average PM_{10} concentrations – 2017

4.3.2 $PM_{2.5}$

A summary of key statistics for the five years of analysed data from the DPIE Tamworth and Bathurst stations is presented in Table 4.2. Exceedances of the air quality criteria of 25 µg/m³ were recorded in 2019 at Tamworth and in 2018 and 2019 at Bathurst. As with the PM_{10} data, there are also clear increases in concentrations from the end of 2018 attributed to the bushfire events.

Table 4.3 Statistics for $PM_{2.5}$ concentrations – DPIE Tamworth and Bathurst – 2015–2019

Year	Maximum 24-hour average concentration (µg/m³)	Annual average concentration (µg/m³)	Number of days greater than 50 µg/m³	Data recovery
DPIE Tamworth				
2015	ND	ND	-	-
2016	17.6	7.6	0	75%
2017	21.6	7.8	0	95%
2018	24.2	8.3	0	92%
2019	164.2	14.4	32	98%
DPIE Bathurst				
2015	ND	ND	-	-
2016	15.0	5.9	0	65%
2017	17.5	6.1	0	97%
2018	40.5	7.0	2	98%
2019	199.5	11.3	24	99%

Notes: ND = no data. Data collection in 2016 began in March at Tamworth and in April at Bathurst.

A time series of recorded 24-hour average $PM_{2.5}$ concentrations at the DPIE Tamworth and Bathurst stations for the period 2015 to 2019 is presented in Figure 4.3. The recorded 24-hour average $PM_{2.5}$ concentrations fluctuated throughout the period; however, there is a clear upward trend of concentration since 2015 with concentrations attributed to dust storm and bushfire events again shown in 2018 and 2019. It is noted that the maximum concentrations recorded were 164 µg/m³ at Tamworth and 199 µg/m³ in 2019. These are not shown on the plot to allow the remaining data to be shown clearly.

Following the same approach for PM_{10}, a regional average background profile was created from the Tamworth and Bathurst data in 2017. The regional average $PM_{2.5}$ dataset is shown in Figure 4.4.

Table 4.3 shows that there were no exceedances of the daily $PM_{2.5}$ criterion at Tamworth or Bathurst in 2017 and, therefore, there are no existing exceedances of the daily PM_{10} criterion in the regional average background dataset.

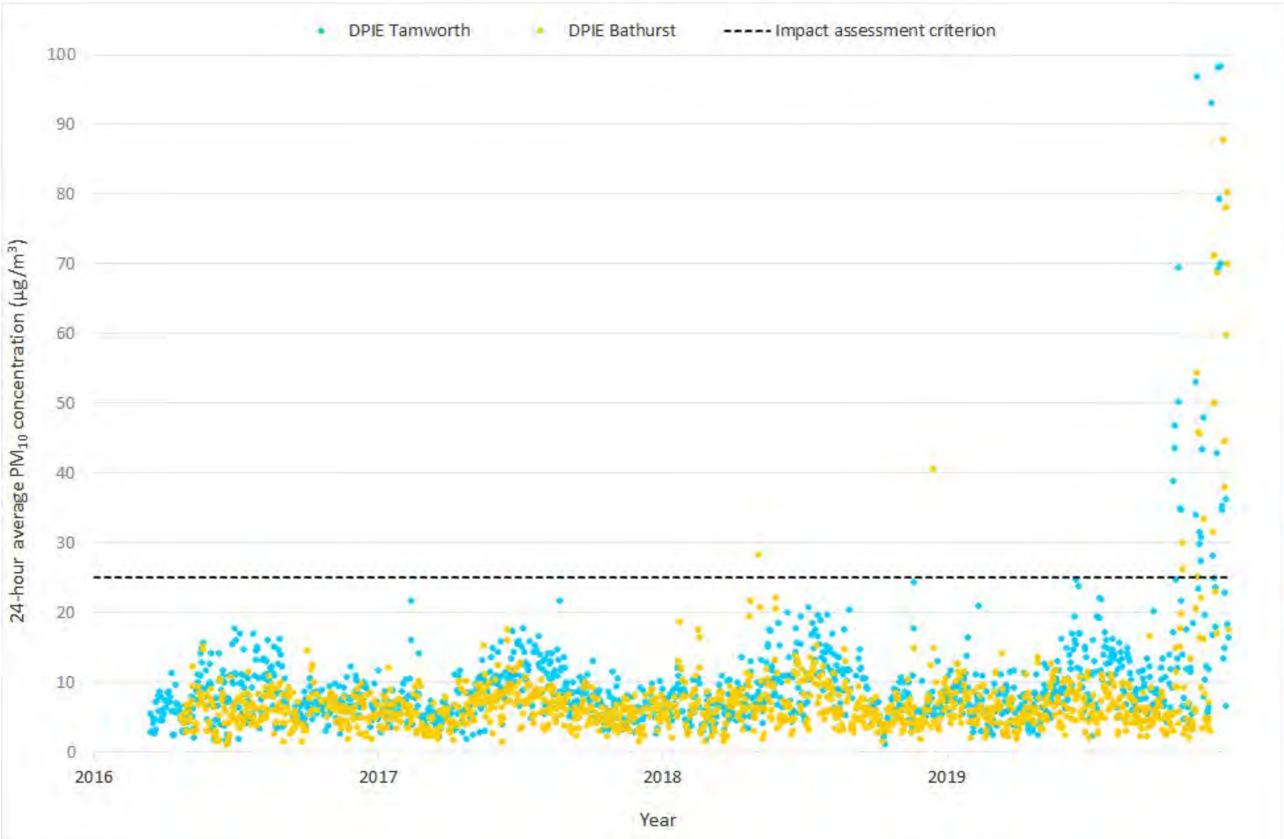


Figure 4.3 **Time series of 24-hour average $PM_{2.5}$ concentrations – DPIE Tamworth and Bathurst – 2015–2019**

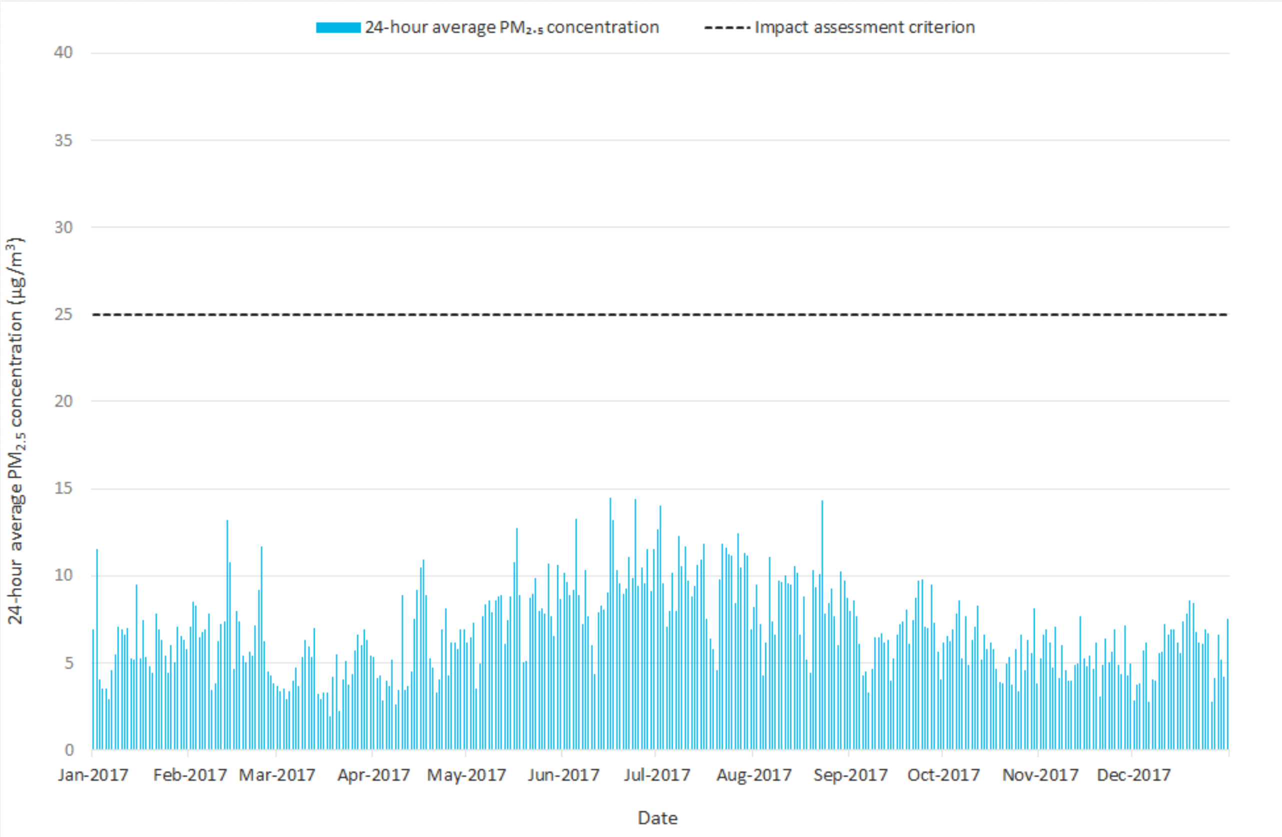


Figure 4.4 Background timeseries for 24-hour average $PM_{2.5}$ concentrations – 2017

4.3.3 TSP

TSP data is not recorded at the DPIE air quality monitoring stations. The percentage of PM_{10} to TSP for rural areas typically ranges from 40% to 50% In the absence of appropriate local TSP monitoring data, the annual average TSP concentration has been derived by applying a PM_{10} to TSP ratio of 40% to the annual average PM_{10} concentration from the synthetic profile for 2017 (of 14.7 µg/m³). The resultant derived TSP background concentration is 36.7 µg/m³.

4.3.4 Dust deposition

Dust deposition is not recorded at the DPIE air quality monitoring stations. The South Keswick Quarry AQIA (Pacific Environment 2016) presented dust deposition data collected at the Dubbo Zirconia Project (approximately 17 km from the project) between 2001 and 2003 at nine dust deposition gauges. The maximum monthly average concentration recorded was 1.32 g/m²/month. The AQIA adopted a conservative background value of 2 g/m²/month. Given the lack of dust deposition data in the vicinity of the project, the same approach has been taken here.

4.4 Assumed background concentrations

In summary, the following background values were adopted for cumulative assessment:

- 24-hour PM_{10} concentration – daily varying with a maximum of 45.6 µg/m^3;
- annual average PM_{10} concentration – 14.7 µg/m^3;
- 24-hour $PM_{2.5}$ concentration –daily varying with a maximum of 14.5 µg/m^3;
- annual average $PM_{2.5}$ concentration – 6.9 µg/m^3;
- annual average TSP concentration – 36.7 µg/m^3; and
- annual average dust deposition concentration – 2 g/m^2/month.

5 Emissions inventory

5.1 Introduction

Three emission scenarios have been developed to quantify particulate matter impacts from the project and to understand the significance of the proposed operations compared to current operations. These scenarios are:

- existing scenario – existing pit operations only;
- proposed (Scenario 2) – extraction occurring in both the WEA and SEA with additional 'floor rock' excavated from the existing pit; and
- proposed (Scenario 3) – majority of extraction occurring in the SEA with floor rock extracted from the WEA.

5.2 Emissions estimates

Fugitive dust sources associated with the existing and proposed operations at the quarry were quantified through the application of US-EPA AP-42 emission factor equations. Particulate matter emissions were quantified for the three size fractions – TSP, PM_{10} and $PM_{2.5}$. Emission rates for coarse particles (PM_{10}) and fine particles ($PM_{2.5}$) were estimated using ratios for the different particle size fractions available in the literature (principally the US-EPA AP-42).

The calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions for each activity occurring at the quarry are shown in Section 5.3 below. Each activity has been represented in the modelling as an area, volume or line-volume source. Site diesel combustion was attributed equally to all activities generating diesel emissions. The modelled source locations for the existing scenario, Scenario 2 and Scenario 3 are shown in Figure 5.1, Figure 5.2 and Figure 5.3 respectively. Activities were modelled between the hours of 6 am and 6 pm with the exception of blasting (9 am to 4 pm) and wind erosion (all hours).

A detailed description of the assumptions and emission factors adopted in the development of the emissions inventory are provided in Appendix B.

5.2.1 Neighbouring operations

Regional Quarries Australia Pty Ltd's South Keswick Quarry is immediately north of the project area. Given its proximity to the quarry and the surrounding assessment locations, emissions from this site were calculated and sources included in the cumulative dispersion modelling.

An AQIA was completed for the South Keswick Quarry in 2016 (Pacific Environment 2016). Two operational scenarios were included in the assessment with Scenario 2 resulting in the highest estimated emissions. TSP, PM_{10} and $PM_{2.5}$ emissions from the South Keswick Quarry Scenario 2 were, therefore, adopted for the cumulative assessment of both proposed scenarios for the project.

Line-volume sources were distributed across the South Keswick Quarry according to the source locations provided in the AQIA. These were broken down into extraction, processing, wind erosion and hauling off-site for this project. The South Keswick Quarry AQIA stated that hours of operation for product loading and transport were proposed to be between 5 am and 10 pm. Therefore, the South Keswick Quarry operations were modelled for these hours, with the exception of wind erosion which was modelled for every hour of the day.

The source locations for the South Keswick Quarry are shown in Figure 5.1, Figure 5.2 and Figure 5.3 for the existing scenario, Scenario 2 and Scenario 3, respectively.

Source: EMM (2020); DFSI (2017); Nearmap (2020)

\\Emmsvr1\emm\Jobs\2018\J180313 - Dubbo Quarry EIS\GIS\02_Maps_EIS_TechReports\AQIA\AQIA004_ModelSourceLocationsExisting_20201218_02.mxd 15/01/2021

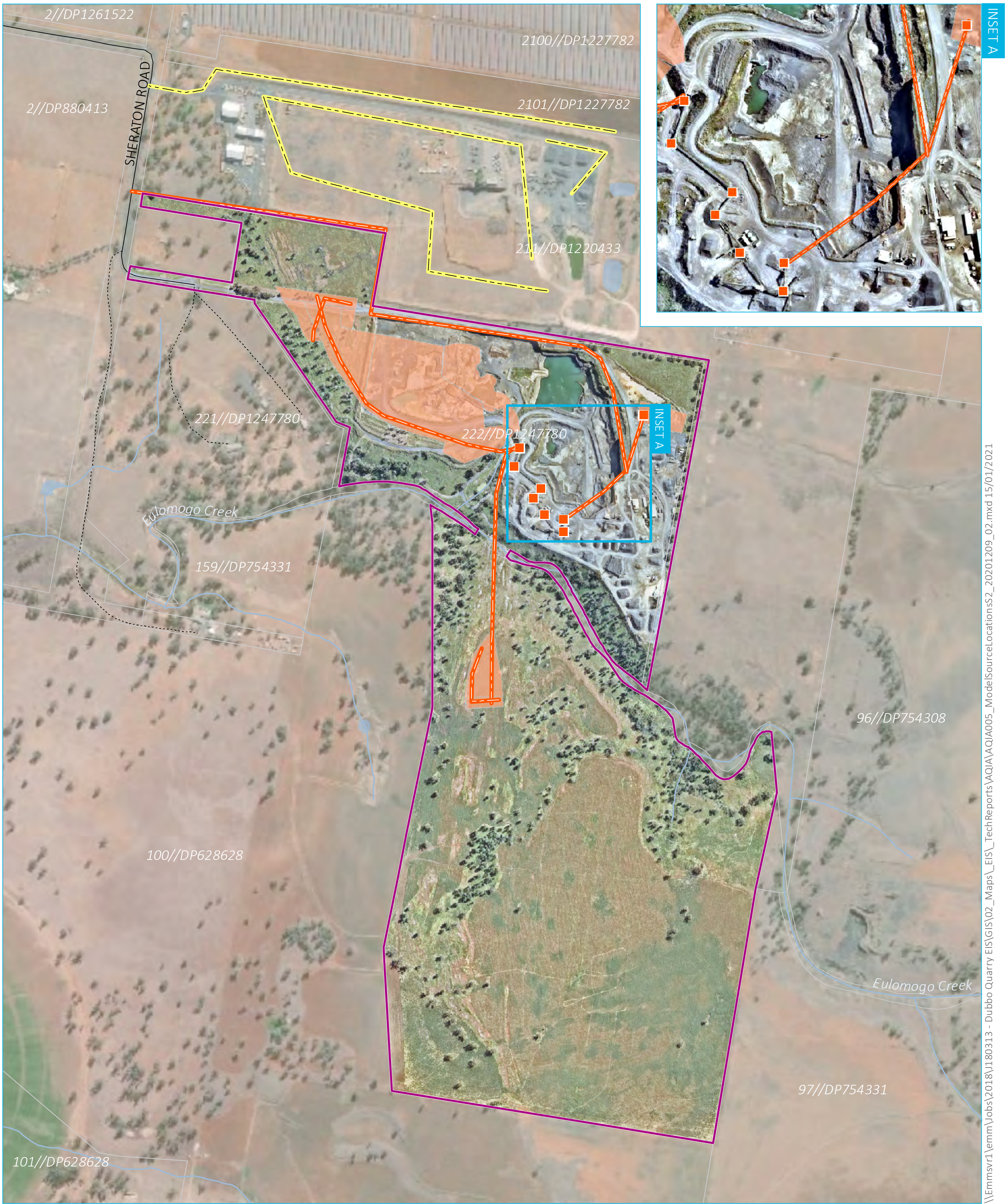
KEY

- Project area
- Volume source
- South Keswick source
- Line-volume source
- Watercourse/drainage line
- Cadastral boundary (data does not align with surveyed site boundary)
- Minor road
- Vehicular track
- Area source
- Waterbody

Model source locations – existing scenario

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure 5.1

EMM
creating opportunities



Source: EMM (2020); DFSI (2017); Nearmap (2020)

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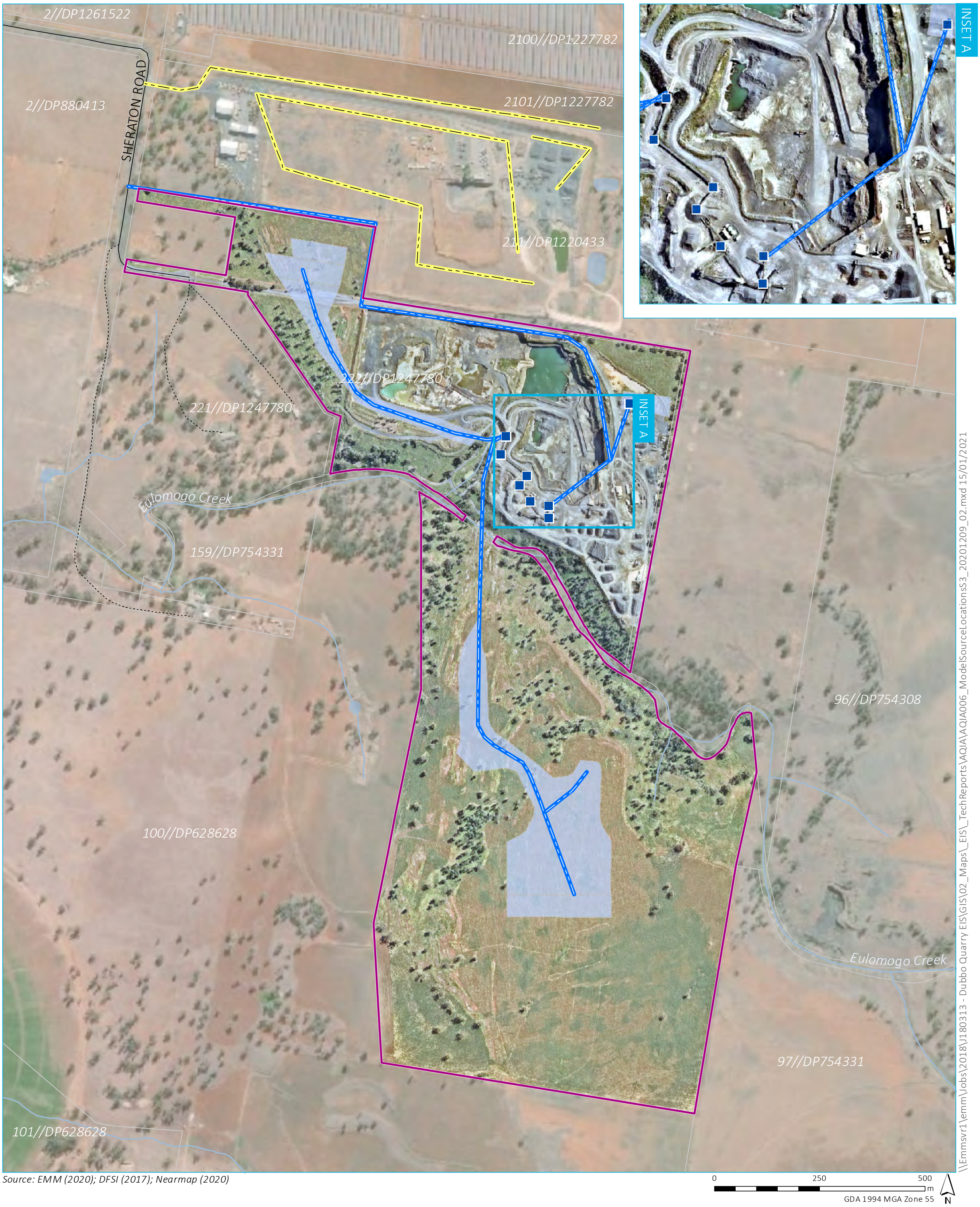
Model source locations - scenario 2

- Project
- Volume
- Line-volume
- South Keswick
- Watercourse/drainage
- Minor road
- Vehicular
- Cadastral boundary (data does not align
- Area

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure 5.2

creating opportunities



Source: EMM (2020); DFSI (2017); Nearmap (2020)

KEY

- Project area
- Volume source
- Line-volume source
- South Keswick source
- Watercourse/drainage line
- Minor road
- Vehicular track
- Cadastral boundary (data does not align with surveyed site boundary)
- Area source
- Waterbody

Model source locations - scenario 3

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure 5.3

EMM
creating opportunities

5.3 Emissions summary

A graphical summary of the contribution to annual dust emissions by source type is provided in Figure 5.4 for the existing scenario, Figure 5.5 for Scenario 2, and Figure 5.6 for Scenario 3. Calculated annual emissions by emissions source is presented in Table 5.1, Table 5.2 and Table 5.3 for the three Dubbo Quarry scenarios. Emissions estimates for the South Keswick Quarry are shown in Table 5.4. Particulate matter control measures, as documented in Section 5.4 are accounted for in these emission totals.

From the data presented in the following figures and tables, the most significant source of particulate matter emissions from the project's operations is associated with material handling, hauling and wind erosion. The data shows that there is an increase in emissions under Scenario 3.

Further details regarding emission estimation factors and assumptions are provided in Appendix B.

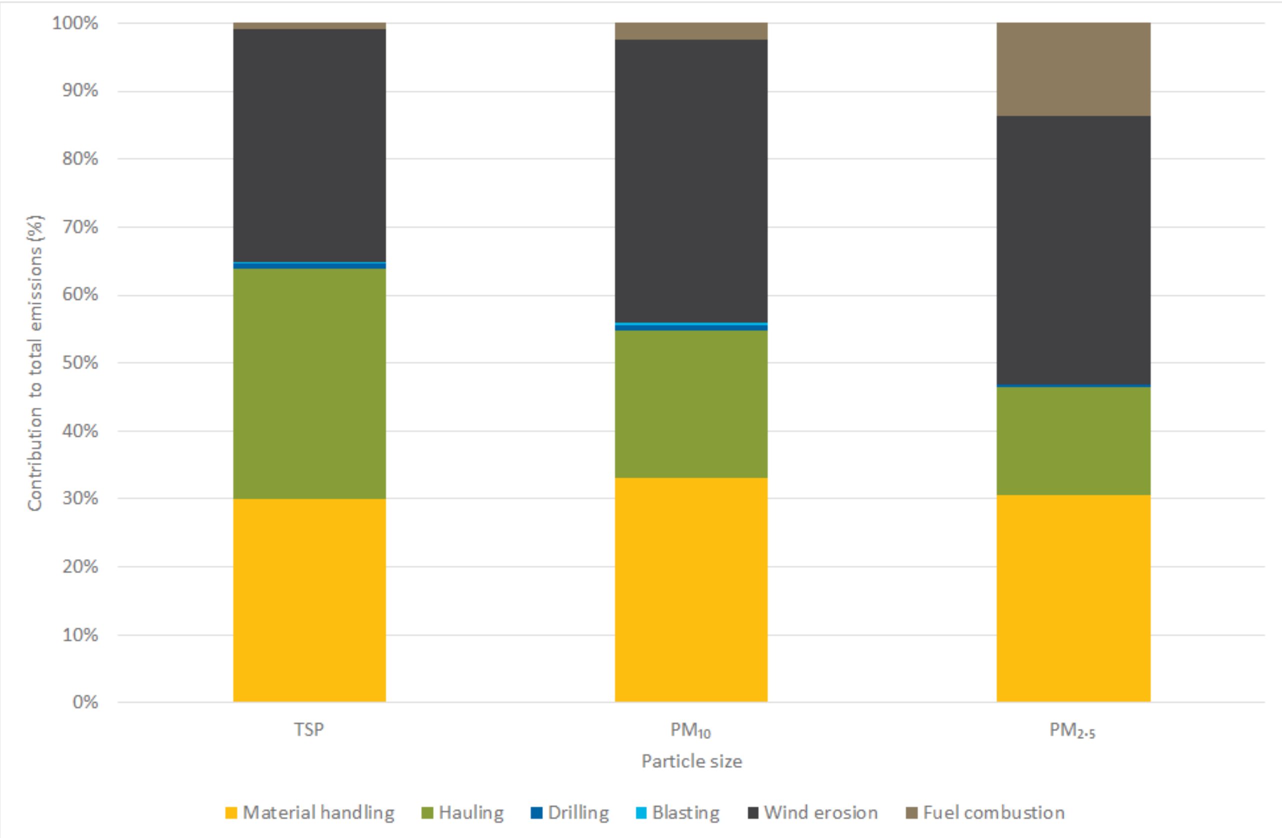


Figure 5.4 Contribution to annual emissions by emissions source type and particle size – existing scenario

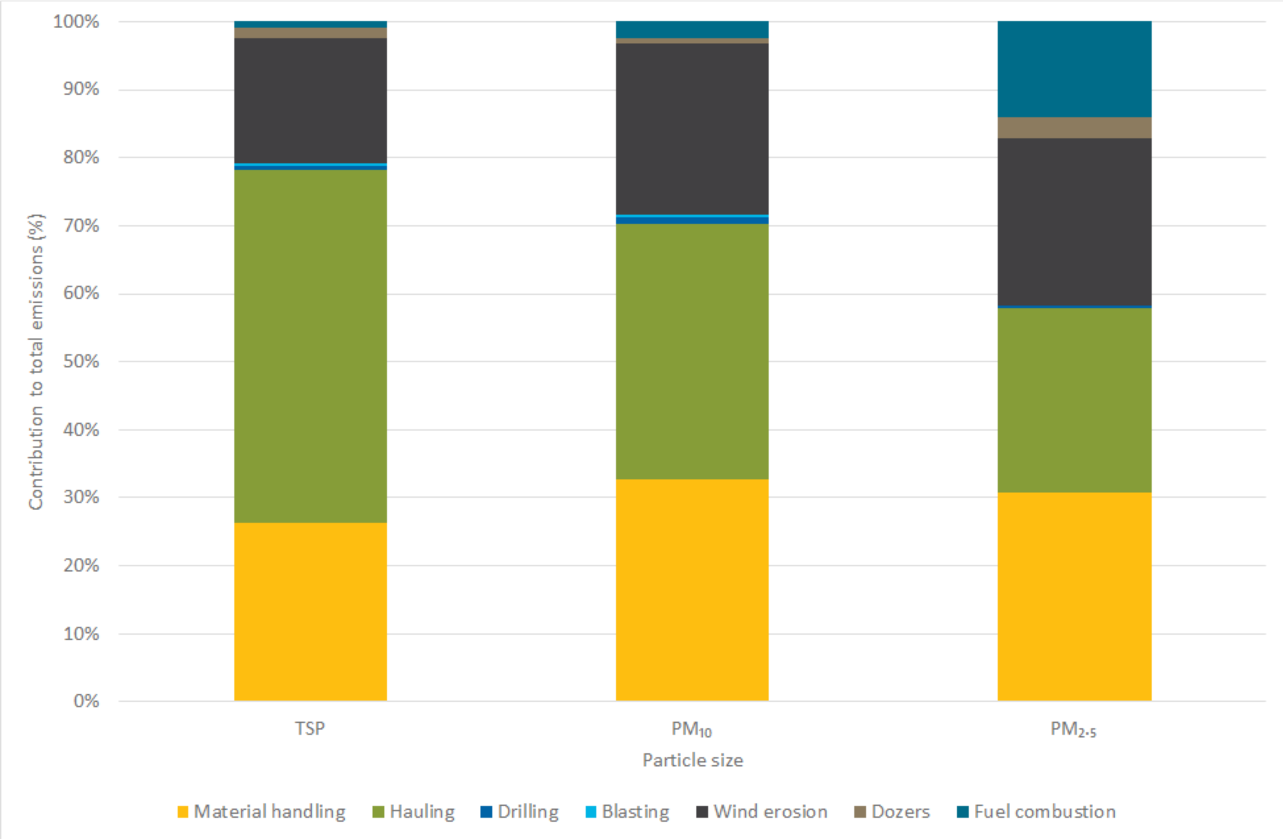


Figure 5.5 Contribution to annual emissions by emissions source type and particle size – Scenario 2

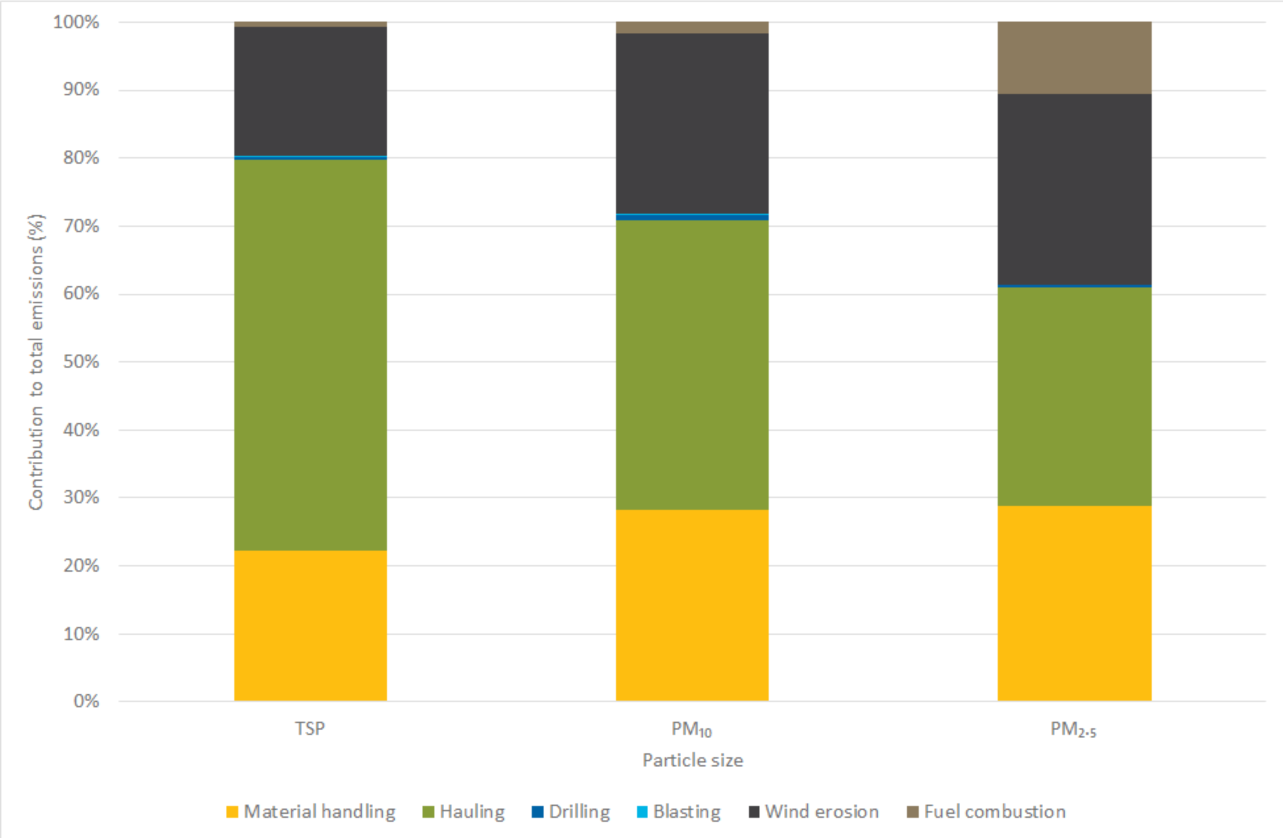


Figure 5.6 Contribution to annual emissions by emissions source type and particle size – Scenario 3

Table 5.1 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions – existing scenario

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM_{10}	$PM_{2.5}$
Topsoil activities			
Excavators stripping topsoil	2.1	1.0	0.1
Excavator loading topsoil to trucks	2.1	1.0	0.1
Hauling topsoil to emplacement area	77.6	21.2	2.1
Trucks unloading topsoil to emplacement area	2.1	1.0	0.1
Subsoil activities			
Excavators stripping subsoil	18.8	8.9	1.3
Excavator loading subsoil to trucks	18.8	8.9	1.3
Hauling subsoil to emplacement area	698.8	191.1	19.1
Trucks unloading subsoil to emplacement area	23.2	11.0	1.7
Rock extraction			
Drilling rock	197.4	102.6	5.9
Blasting rock	80.7	41.9	2.4
FEL loading rock to trucks	1,103.8	522.1	79.1
Trucks hauling rock to hopper at crushing plant	5,161.0	1,411.1	141.1
FEL unloading rock to hopper at crushing plant	1,103.8	522.1	79.1
Rock processing			
Primary crushing (by grizzly)	236.1	106.2	19.7
Conveyor transfer of crushed rock to surge pile	551.9	261.0	39.5
Conveyor transfer of crushed rock to primary screen	551.9	261.0	39.5
Primary screening	432.8	145.6	9.8
Conveyor transfer of screened rock to secondary crusher (75%)	413.9	195.8	29.6
Conveyor transfer of screened rock to road base stockpile (25%)	138.0	65.3	9.9
Secondary crushing	177.1	79.7	14.8
Conveyor transfer of crushed rock to secondary screen	413.9	195.8	29.6
Secondary screening	324.6	109.2	7.4
Conveyor transfer of screened rock to tertiary crusher	413.9	195.8	29.6
Tertiary crushing	177.1	79.7	14.8
Conveyor transfer of crushed rock to tertiary screen	413.9	195.8	29.6
Tertiary screening	324.6	109.2	7.4

Table 5.1 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions – existing scenario

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM_{10}	$PM_{2.5}$
Conveyor unloading rock to trucks	413.9	195.8	29.6
Trucks loading road base to trucks	138.0	65.3	9.9
Trucks hauling rock to product stockpiles	2,174.6	594.6	59.5
Trucks unloading rock to product stockpile	1,103.8	522.1	79.1
Trucks hauling materials off-site (paved)	1,544.2	296.4	71.7
Wind erosion from exposed areas			
Wind erosion of extraction area	960.1	480.0	72.0
Wind erosion of exposed areas	6,358.5	3,179.3	476.9
Wind erosion of stockpiles/southern exposed areas	2,390.4	1,195.2	179.3
Diesel combustion			
Site diesel combustion	246.3	246.3	225.8
Diesel combustion (hauling off-site)	27.4	27.4	25.1
Total	**28,417.1**	**11,646.0**	**1,843.7**

Note: FEL = Front-end-loader

Table 5.2 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions – Scenario 2

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM_{10}	$PM_{2.5}$
Western Extension Area			
Topsoil activities at Western Extension Area			
Excavators stripping topsoil	8.2	3.9	0.6
Excavator loading topsoil to trucks	8.2	3.9	0.6
Hauling topsoil to bund area	12.4	3.4	0.3
Hauling topsoil to rehab area	52.9	14.5	1.4
Trucks unloading subsoil to bund area	1.6	0.7	0.1
Trucks unloading subsoil to rehab area	6.6	3.1	0.5
Dozers working on bund	251.5	46.1	26.4
Subsoil activities at Western Extension Area			
Excavators stripping subsoil	65.7	31.1	4.7
Excavator loading subsoil to trucks	65.7	31.1	4.7
Hauling subsoil to bund area	99.0	27.1	2.7
Hauling subsoil to rehab area	391.5	107.0	10.7
Hauling subsoil to stockpile	32.4	8.9	0.9
Trucks unloading subsoil to bund area	12.4	5.9	0.9
Trucks unloading subsoil to rehab area	49.2	23.3	3.5
Trucks unloading subsoil to stockpile	4.1	1.9	0.3
Rock extraction at Western Extension Area			
Drilling rock	154.0	80.1	4.6
Blasting rock	63.0	32.7	1.9
FEL loading rock (incl. floor rock) to trucks	343.3	162.4	24.6
Trucks hauling rock to hopper at crushing plant	7,249.6	1,982.1	198.2
FEL unloading rock to hopper at crushing plant	343.3	162.4	24.6
Southern Extension area			
Topsoil activities at Southern Extension Area			
Excavators stripping topsoil	1.0	0.5	0.1
Excavator loading topsoil to trucks	1.0	0.5	0.1
Hauling topsoil to bund area	9.4	2.6	0.3

Table 5.2 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions – Scenario 2

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM_{10}	$PM_{2.5}$
Trucks unloading subsoil to bund area	1.0	0.5	0.1
Subsoil activities at Southern Extension Area			
Excavators stripping subsoil	7.0	3.3	0.5
Excavator loading subsoil to trucks	7.0	3.3	0.5
Hauling subsoil to bund area	65.5	17.9	1.8
Trucks unloading subsoil to bund area	7.0	3.3	0.5
Dozers working on bund	251.5	46.1	26.4
Rock extraction at Southern Extension Area			
Drilling rock	43.3	22.5	1.3
Blasting rock	17.7	9.2	0.5
FEL loading rock to trucks	280.5	132.7	20.1
Trucks hauling rock to hopper at crushing plant	2,123.0	580.5	58.0
FEL unloading rock to hopper at crushing plant	280.5	132.7	20.1
Rock processing			
Primary crushing (by grizzly)	253.8	114.2	21.1
Conveyor transfer of crushed rock to surge pile	593.2	280.6	42.5
Conveyor transfer of crushed rock to primary screen	593.2	280.6	42.5
Primary screening	465.2	156.5	10.6
Conveyor transfer of screened rock to secondary crusher (75%)	444.9	210.4	31.9
Conveyor transfer of screened rock to road base stockpile (25%)	148.3	70.1	10.6
Secondary crushing	190.3	85.6	15.9
Conveyor transfer of crushed rock to secondary screen	444.9	210.4	31.9
Secondary screening	348.9	117.4	7.9
Conveyor transfer of screened rock to tertiary crusher	444.9	210.4	31.9
Tertiary crushing	190.3	85.6	15.9
Conveyor transfer of crushed rock to tertiary screen	444.9	210.4	31.9
Tertiary screening	348.9	117.4	7.9
Conveyor unloading rock to trucks	444.9	210.4	31.9
Trucks loading road base to trucks	296.6	140.3	21.2
Trucks hauling rock to product stockpiles	4,661.9	1,274.6	127.5

Table 5.2 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions – Scenario 2

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM_{10}	$PM_{2.5}$
Trucks unloading rock to product stockpile	1,186.5	561.2	85.0
Trucks hauling materials off-site (paved)	1,659.9	318.6	77.1
Wind erosion from exposed areas			
Wind erosion of Western Extension area (exposed)	1,034.5	517.3	77.6
Wind erosion of Western Extension extraction area	271.3	135.6	20.3
Wind erosion of Western Extension area partial rehab area 1	62.2	31.1	4.7
Wind erosion of Western Extension area partial rehab area 2	25.6	12.8	1.9
Wind erosion of existing pit partial rehab area	369.2	184.6	27.7
Wind erosion of existing pit exposed area	3,189.4	1,594.7	239.2
Wind erosion of Southern Extension area (exposed)	514.9	257.4	38.6
Wind erosion of Southern Extension extraction area	129.7	64.9	9.7
Wind erosion of product stockpile	221.0	110.5	16.6
Diesel combustion			
Site diesel combustion	246.3	246.3	225.8
Diesel combustion (hauling off-site)	27.4	27.4	25.1
Total	**31,563.2**	**11,524.3**	**1,774.7**

Table 5.3 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions – Scenario 3

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM_{10}	$PM_{2.5}$
Western Extension Area			
Rock extraction at ex-pit			
Excavator/FEL loading floor rock to trucks	31.6	14.9	2.3
Trucks hauling floor rock to hopper at crushing plant	196.1	48.8	4.9
FEL unloading floor rock to hopper at crushing plant	31.6	14.9	2.3
Southern Extension area			
Topsoil activities at Southern Extension Area			
Excavators stripping topsoil	3.4	1.6	0.2
Excavator loading topsoil to trucks	3.4	1.6	0.2
Hauling topsoil to bund area	58.1	15.9	1.6
Trucks unloading subsoil to bund area	3.4	1.6	0.2
Subsoil activities at Southern Extension Area			
Excavators stripping subsoil	23.9	11.3	1.7
Excavator loading subsoil to trucks	23.9	11.3	1.7
Hauling subsoil to bund area	394.8	107.9	10.8
Hauling subsoil to stockpile	12.2	3.3	0.3
Trucks unloading subsoil to bund area	23.2	11.0	1.7
Trucks unloading subsoil to stockpile	0.7	0.3	0.1
Excavators/FELs working on bund	27.3	12.9	2.0
Rock extraction at Southern Extension Area			
Drilling rock	197.4	102.6	5.9
Blasting rock	80.7	41.9	2.4
FEL loading rock to trucks	1,298.9	614.3	93.0
Trucks hauling rock to hopper at crushing plant	18,976.6	5,188.4	518.8
FEL unloading rock to hopper at crushing plant	1,298.9	614.3	93.0
Rock processing			
Primary crushing (by grizzly)	284.6	128.1	23.7
Conveyor transfer of crushed rock to surge pile	665.2	314.6	47.6
Conveyor transfer of crushed rock to primary screen	665.2	314.6	47.6

Table 5.3 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions – Scenario 3

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	**PM_{10}**	**$PM_{2.5}$**
Primary screening	521.7	175.5	11.9
Conveyor transfer of screened rock to secondary crusher (75%)	498.9	236.0	35.7
Conveyor transfer of screened rock to road base stockpile (25%)	166.3	78.7	11.9
Secondary crushing	213.4	96.0	17.8
Conveyor transfer of crushed rock to secondary screen	498.9	236.0	35.7
Secondary screening	391.3	131.6	8.9
Conveyor transfer of screened rock to tertiary crusher	498.9	236.0	35.7
Tertiary crushing	213.4	96.0	17.8
Conveyor transfer of crushed rock to tertiary screen	498.9	236.0	35.7
Tertiary screening	391.3	131.6	8.9
Conveyor unloading rock to trucks	498.9	236.0	35.7
Trucks loading road base to trucks	166.3	78.7	11.9
Trucks hauling rock to product stockpiles	4,908.6	1,342.1	134.2
Trucks unloading rock to product stockpile	1,330.5	629.3	95.3
Trucks hauling materials off-site (paved)	1,861.3	357.3	86.4
Wind erosion from exposed areas			
Wind erosion of Southern Extension area (not used for extraction)	5,349.8	2,674.9	401.2
Wind erosion of Southern Extension extraction area	769.7	384.8	57.7
Wind erosion of Western Extension area (not used for extraction)	933.8	466.9	70.0
Wind erosion of Western Extension extraction area	534.7	267.3	40.1
Wind erosion of existing quarry exposed area	872.1	436.1	65.4
Wind erosion of Western Extension area partial rehab	97.1	48.6	7.3
Wind erosion of product stockpile	221.0	110.5	16.6
Diesel combustion			
Site diesel combustion	246.3	246.3	225.8
Diesel combustion (hauling off-site)	27.4	27.4	25.1
Total	**46,012 .7**	**16,536.9**	**2,355.0**

Table 5.4 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions for South Keswick Quarry

Emission source	Calculated annual emissions (kg/annum)		
	TSP	PM_{10}	$PM_{2.5}$
Extraction	27,408	7,904	1,853
Processing	1,144	502	71
Hauling off-site	4,401	1,084	108
Wind erosion	8,015	4,008	601
Total	**40,968**	**13,498**	**2,633**

Notes:

1. As it appears that the TSP emissions for hauling material off-site were incorrectly transcribed in the South Keswick Quarry AQIA, these have been scaled up here using the ratio between TSP and PM_{10} emissions for other hauling activities listed in the South Keswick Quarry AQIA.
2. Totals may not add up exactly to those shown in the South Keswick Quarry AQIA due to rounding.

5.4 Overview of best practice dust control

To manage particulate matter emissions from the quarry's existing and proposed operations, a range of mitigation measures and management practices are required. Table 5.5 provides an overview of the relevant applicable best practice dust control management measures as listed in the *NSW Coal Benchmarking Study: International Best Practice to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Katestone 2011) (The Best Practice Report). The Best Practice Report was a study prepared by Katestone Environmental Pty Ltd in 2011 and was commissioned by the NSW EPA. The table also includes the percentage control factor applied in the dispersion modelling.

Measures implemented at the quarry and included in the emissions estimation (where emission reduction factors exist) for both the existing and proposed scenarios include:

- water sprays at conveyor transfer points;
- scrapers used to clean conveyor belts;
- cyclone and water injection on drills;
- minimising truck and dozer travel speeds;
- ensure dozer routes are kept moist with the use of water carts;
- minimising trucks and FEL drop height;
- watering of exposed areas where practical;
- watering unpaved haul routes;
- paved haul routes;
- bunds in the SEA and WEA;
- partial and full rehabilitation; and
- watering at coal crusher and screen.

It can be seen from the summary provided in Table 5.5 that, wherever practical to do so, the quarry currently implements, or will implement under the project, dust control measures that are consistent with accepted best practice mitigation measures for significant operational sources of particulate matter emissions.

Table 5.5 Overview of best practice measures employed at Dubbo Quarry

Emissions source category	Best practice control measures (Katestone 2011)	Currently adopted or proposed for implementation	Comments	Effectiveness of reduction in emissions inventory
Conveyors and transfers	Application of watering at transfer points	Yes	Watering applied at transfer points.	50%
	Enclosure of transfer points	No	-	-
	Wind shielding of conveyor belts – roof and/or side wall	No	-	-
	Belt cleaning and spillage minimisation	Yes	Scrapers used to clean belts.	50% control applied for watering.
Drilling	Fabric filter	No	Unlikely to be used in future.	-
	Cyclone	Yes	-	-
	Water injection	Yes	-	70%
Blasting	Delay shot to avoid unfavourable weather conditions	Yes	-	Not quantified in emissions estimates.
	Minimise area blasted in design phase	Yes	Blast areas designed to minimise the number needed per year.	Not quantified in emissions estimates.
Dozers	Minimise travel speed and distance	Yes	-	-
	Keep travel routes and materials moist	Yes	Water carts used to keep dozer routes moist.	50%
Haul roads	Surface treatment - watering	Yes	Water carts used on unpaved haul routes.	75%
	Surface treatment - chemical suppressants	No	Haul roads sufficiently controlled through watering.	-
	Surface improvements - low silt aggregate	Yes	Road surfaces are gravel and water applied on unpaved haul routes.	Water carts in operation as above.
	Surface improvements - pave the surface	Yes	Access road up to the quarry weighbridge will be sealed.	Paved roads US-EPA equation adopted and watering (50%).

Table 5.5 Overview of best practice measures employed at Dubbo Quarry

Emissions source category	Best practice control measures (Katestone 2011)	Currently adopted or proposed for implementation	Comments	Effectiveness of reduction in emissions inventory
	Reduction in vehicle travel speed	Yes	Truck travel speeds will be maintained below 20km/hr	Not quantified in emissions estimates.
	Use larger vehicles rather than smaller vehicles to minimise number of trips	Yes	Average truck load carrying capacity is 33 t.	Haul truck weight included. No specific control applied.
	Use conveyors in place of haul roads	Yes	Conveyors used in the processing area in the existing pit.	Conveyors used in place of hauling.
Wind erosion from stockpiles	Avoidance - bypassing stockpiles	No	Not practical. The stockpiles at Dubbo Quarry are necessary for the routine operation of site and cannot be avoided.	-
	Surface stabilisation - watering	Yes	Watering stockpiles when in use	50%
	Surface stabilisation - chemical suppressants and crusting agents	No	Not practicable for implementation as stockpiles are regularly disturbed through loading and unloading.	-
	Surface stabilisation - carry over from wetting from load in	No	Water sprays applied during crushing and screening processes.	-
	Enclosure - silo with baghouse	Partial	Pug mill fitted with bag house.	-
	Enclosure - cover storage pile with tarp during high winds	No	Not practicable for implementation as stockpiles are regularly disturbed through loading and unloading.	-
	Wind speed reduction - vegetative wind breaks	No	Not specifically surrounding stockpiles however rehabilitation and bunds are used around the site when practical.	-
	Wind speed reduction - reduced pile height	No	Where possible.	-
	Wind speed reduction - wind screens/wind fences	No	Not practical for the constraints of site.	-
	Wind speed reduction - pile shaping/orientation	No	Not practical for the constraints of site.	-

Table 5.5 Overview of best practice measures employed at Dubbo Quarry

Emissions source category	Best practice control measures (Katestone 2011)	Currently adopted or proposed for implementation	Comments	Effectiveness of reduction in emissions inventory
	Wind speed reduction - three-sided enclosure around storage piles	No	Not practicable. The constraints of site and safe operation of equipment around stockpiles.	-
Wind erosion from exposed areas	Surface stabilisation - watering	Yes	Water carts used when possible.	Given large size of areas and watering when possible, controls have not been applied for these activities. This may be considered conservative.
	Surface stabilisation - chemical suppressants	No	-	-
	Surface stabilisation - paving and cleaning	No	-	-
	Surface stabilisation - apply gravel to stabilise disturbed open areas	Yes	All roads are gravel roads.	Watering applied only for conservatism.
	Surface stabilisation - rehabilitation	Partial	Areas progressively rehabilitated.	70% for partially rehabilitated areas.
	Wind speed reduction - fencing, bunding, shelterbelts or in-pit dump	No	Bunds established in the SEA and WEA.	30%
	Wind speed reduction - vegetative wind breaks	No	Not practical for the constraints of site.	-
Loading and dumping rock	Truck dumping - minimise drop height	Yes	Wherever possible, material drop heights will be minimised when unloading trucks.	-
	Truck dumping - water sprays	No	-	-
	Truck dumping - three-sided enclosure at truck unloading area	No	-	-
Crushing/screening	Water spays	Yes	Application of water sprays at crushing/screening area.	50%

Table 5.5 Overview of best practice measures employed at Dubbo Quarry

Emissions source category	Best practice control measures (Katestone 2011)	Currently adopted or proposed for implementation	Comments	Effectiveness of reduction in emissions inventory
	Enclosed building	No	-	-

6 Air dispersion modelling

6.1 Dispersion model selection and configuration

The atmospheric dispersion modelling completed for this assessment used the AERMOD dispersion model (version v19191). AERMOD is designed to handle a variety of pollutant source types, including surface and buoyant elevated sources, in a wide variety of settings such as rural and urban as well as flat and complex terrain.

In addition to the 23 individual assessment locations (documented in Section 1.5), air pollutant concentrations were predicted over a 6.25 km by 7.25 km domain with 250 m resolution.

The modelled source locations for the existing scenario, Scenario 2 and Scenario 3 are shown in Figure 5.1 and Figure 5.2 respectively. The modelled sources for the South Keswick Quarry are also shown on these figures.

Simulations were undertaken for January to December 2017 using the AERMET-generated file based on the BoM Dubbo Airport AWS as input (see Chapter 3 for a description of input meteorology).

6.2 Incremental results

Figure 6.1 and Figure 6.2 shows a comparison of the predicted maximum 24-hour average PM_{10} $PM_{2.5}$ concentrations at each assessment location for the existing and proposed scenarios, respectively. The results show that at some locations, predicted concentrations are higher in the existing scenario, and at others, they are higher in the proposed scenarios. These differences will be largely related to the spatial movement of activities in these scenarios. It is noted that the change between scenarios is generally minor.

Predicted incremental TSP, PM_{10}, $PM_{2.5}$, and dust deposition levels from the existing and proposed scenarios are presented in Table 6.1, Table 6.2 and Table 6.3 for each of the assessment locations.

The predicted concentrations and deposition rates for all pollutants and averaging periods are below the applicable NSW EPA assessment criterion at all assessment locations. Except for dust deposition, the assessment criteria listed are applicable to cumulative concentrations. Analysis of cumulative impact compliance is presented in Section 6.3.

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

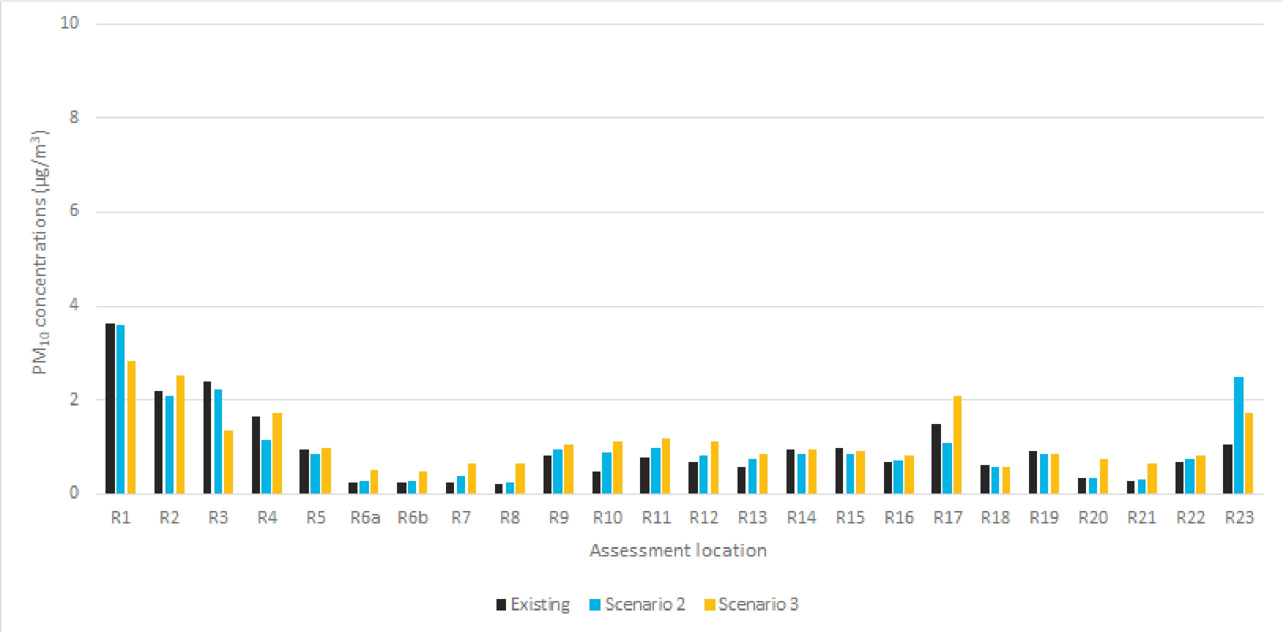


Figure 6.1 **Comparison of predicted maximum 24-hour average PM_{10} concentrations for the existing and proposed scenarios**

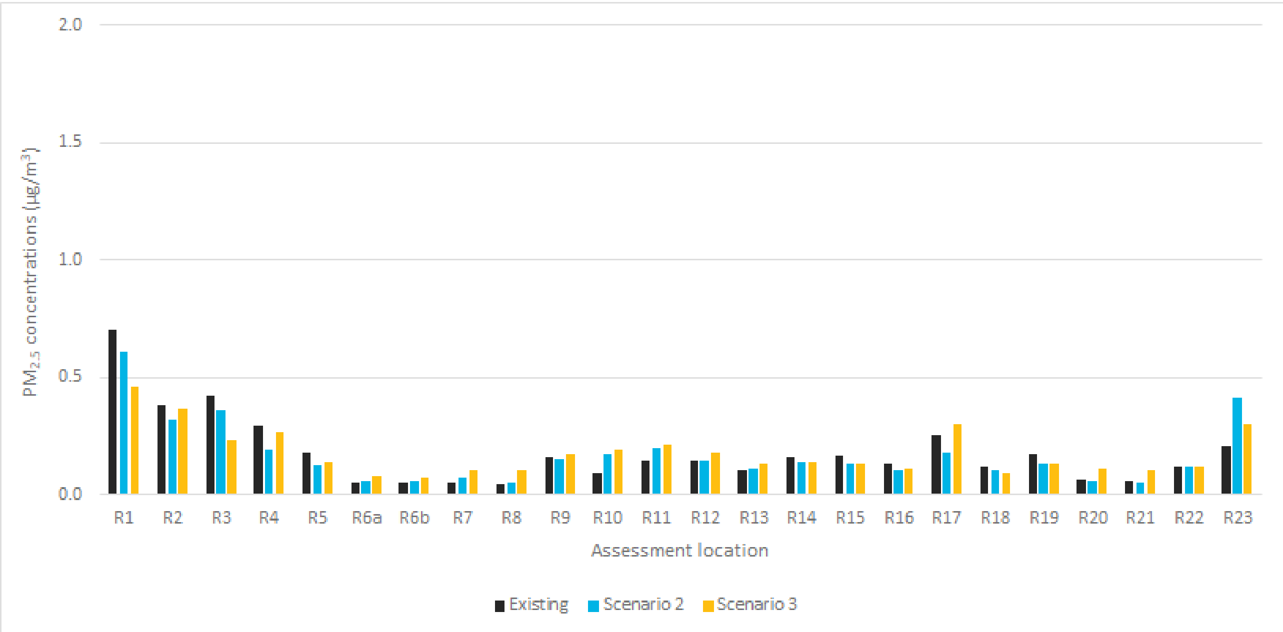


Figure 6.2 **Comparison of predicted maximum 24-hour average $PM_{2.5}$ concentrations for the existing and proposed scenarios**

Table 6.1 Incremental (existing scenario only) concentration and deposition results

Assessment location ID	Predicted incremental concentration (µg/m³) and deposition rate (g/m²/month)					
	TSP	PM_{10}		$PM_{2.5}$		Dust deposition
	Annual	24-hour maximum	Annual	24-hour maximum	Annual	Annual
Criterion	**90**	**50**	**25**	**25**	**8**	**2**
R1	0.9	3.6	0.5	0.7	0.1	0.1
R2	0.3	2.2	0.2	0.4	<0.1	<0.1
R3	0.3	2.4	0.1	0.4	<0.1	<0.1
R4	0.1	1.7	0.1	0.3	<0.1	<0.1
R5	0.1	1.0	0.1	0.2	<0.1	<0.1
R6a	<0.1	0.2	<0.1	0.1	<0.1	<0.1
R6b	<0.1	0.2	<0.1	0.0	<0.1	<0.1
R7	<0.1	0.3	<0.1	0.1	<0.1	<0.1
R8	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
R9	<0.1	0.8	<0.1	0.2	<0.1	<0.1
R10	<0.1	0.5	<0.1	0.1	<0.1	<0.1
R11	<0.1	0.8	<0.1	0.1	<0.1	<0.1
R12	<0.1	0.7	<0.1	0.1	<0.1	<0.1
R13	0.1	0.6	<0.1	0.1	<0.1	<0.1
R14	0.1	0.9	0.1	0.2	<0.1	<0.1
R15	0.1	1.0	<0.1	0.2	<0.1	<0.1
R16	0.1	0.7	<0.1	0.1	<0.1	<0.1
R17	0.2	1.5	0.1	0.3	<0.1	<0.1
R18	0.1	0.6	0.1	0.1	<0.1	<0.1
R19	0.1	0.9	0.1	0.2	<0.1	<0.1
R20	<0.1	0.3	<0.1	0.1	<0.1	<0.1
R21	<0.1	0.3	<0.1	0.1	<0.1	<0.1
R22	0.1	0.7	<0.1	0.1	<0.1	<0.1
R23	0.1	1.1	0.1	0.2	<0.1	<0.1

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

Table 6.2 Incremental (Scenario 2 only) concentration and deposition results

Assessment location ID	Predicted incremental concentration (µg/m³) and deposition rate (g/m²/month)					
	TSP	PM_{10}		$PM_{2.5}$		Dust deposition
	Annual	24-hour maximum	Annual	24-hour maximum	Annual	Annual
Criterion	**90**	**50**	**25**	**25**	**8**	**2**
R1	1.2	3.6	0.6	0.6	0.1	0.1
R2	0.4	2.1	0.2	0.3	<0.1	<0.1
R3	0.4	2.2	0.2	0.4	<0.1	<0.1
R4	0.2	1.1	0.1	0.2	<0.1	<0.1
R5	0.1	0.9	<0.1	0.1	<0.1	<0.1
R6a	<0.1	0.3	<0.1	0.1	<0.1	<0.1
R6b	<0.1	0.3	<0.1	0.1	<0.1	<0.1
R7	<0.1	0.4	<0.1	0.1	<0.1	<0.1
R8	<0.1	0.3	<0.1	0.0	<0.1	<0.1
R9	0.1	1.0	<0.1	0.2	<0.1	<0.1
R10	0.1	0.9	<0.1	0.2	<0.1	<0.1
R11	0.1	1.0	<0.1	0.2	<0.1	<0.1
R12	0.1	0.8	<0.1	0.1	<0.1	<0.1
R13	0.1	0.7	<0.1	0.1	<0.1	<0.1
R14	0.1	0.9	0.1	0.1	<0.1	<0.1
R15	0.1	0.9	<0.1	0.1	<0.1	<0.1
R16	0.1	0.7	<0.1	0.1	<0.1	<0.1
R17	0.3	1.1	0.1	0.2	<0.1	<0.1
R18	0.1	0.6	0.1	0.1	<0.1	<0.1
R19	0.1	0.8	0.1	0.1	<0.1	<0.1
R20	<0.1	0.3	<0.1	0.1	<0.1	<0.1
R21	<0.1	0.3	<0.1	0.1	<0.1	<0.1
R22	0.1	0.8	<0.1	0.1	<0.1	<0.1
R23	0.2	2.5	0.1	0.4	<0.1	<0.1

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

Table 6.3 Incremental (Scenario 3 only) concentration and deposition results

Assessment location ID	Predicted incremental concentration (µg/m³) and deposition rate (g/m²/month)					
	TSP	PM_{10}		$PM_{2.5}$		Dust deposition
	Annual	24-hour maximum	Annual	24-hour maximum	Annual	Annual
Criterion	**90**	**50**	**25**	**25**	**8**	**2**
R1	0.8	2.8	0.4	0.5	0.1	0.1
R2	0.6	2.5	0.3	0.4	<0.1	0.1
R3	0.3	1.4	0.1	0.2	<0.1	<0.1
R4	0.2	1.7	0.1	0.3	<0.1	<0.1
R5	0.1	1.0	0.1	0.1	<0.1	<0.1
R6a	0.1	0.5	<0.1	0.1	<0.1	<0.1
R6b	0.1	0.5	<0.1	0.1	<0.1	<0.1
R7	0.1	0.7	<0.1	0.1	<0.1	<0.1
R8	0.1	0.6	<0.1	0.1	<0.1	<0.1
R9	0.1	1.1	<0.1	0.2	<0.1	<0.1
R10	0.1	1.1	<0.1	0.2	<0.1	<0.1
R11	0.1	1.2	<0.1	0.2	<0.1	<0.1
R12	0.1	1.1	<0.1	0.2	<0.1	<0.1
R13	0.1	0.9	<0.1	0.1	<0.1	<0.1
R14	0.1	0.9	0.1	0.1	<0.1	<0.1
R15	0.1	0.9	<0.1	0.1	<0.1	<0.1
R16	0.1	0.8	<0.1	0.1	<0.1	<0.1
R17	0.3	2.1	0.1	0.3	<0.1	<0.1
R18	0.1	0.6	0.1	0.1	<0.1	<0.1
R19	0.1	0.8	0.1	0.1	<0.1	<0.1
R20	0.1	0.8	<0.1	0.1	<0.1	<0.1
R21	<0.1	0.7	<0.1	0.1	<0.1	<0.1
R22	0.1	0.8	0.1	0.1	<0.1	<0.1
R23	0.2	1.7	0.1	0.3	<0.1	<0.1

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

6.3 Cumulative results

Cumulative impacts (ie the quarry plus background) at each of the assessment locations surrounding the quarry have been assessed in the following way:

- for 24-hour average concentrations – each daily-varying predicted 24-hour average concentration for PM_{10} and $PM_{2.5}$ from the quarry has been combined with the corresponding concentrations from the adopted 2017 background concentration datasets (Section 4.3 and Section 4.3); and
- for annual average concentrations – the predicted annual average concentrations have been paired with the corresponding background annual average concentration (Section 4.3.4).

As identified in Section 5.4, the quarry currently implements, or will implement under the project, particulate matter control measures that are consistent with accepted industry best practice measures.

Predicted cumulative TSP, PM_{10}, $PM_{2.5}$, and dust deposition levels from the quarry's existing and proposed scenarios are presented in Table 6.4, Table 6.5 and Table 6.6 for each of the assessment locations.

The predicted cumulative concentrations and deposition rates for all pollutants and averaging periods are below the applicable NSW EPA assessment criterion at all assessment locations.

Table 6.4 Cumulative (existing scenario plus background) concentration and deposition results

Assessment location ID	Predicted cumulative concentration (μg/m³) and deposition rate (g/m²/month)					
	TSP	PM_{10}		$PM_{2.5}$		Dust deposition
	Annual	6th highest 24-hour[1]	Annual	3rd highest 24-hour[2]	Annual	Annual
Criterion	90	50	25	25	8	4
R1	37.9	45.7	15.8	14.6	7.1	2.1
R2	37.2	45.7	15.2	14.5	7.0	2.0
R3	37.9	45.7	15.4	14.6	7.1	2.1
R4	38.3	45.8	15.6	14.8	7.1	2.1
R5	36.8	46.4	14.8	14.5	6.9	2.0
R6a	36.8	45.7	14.8	14.5	6.9	2.0
R6b	36.8	45.7	14.8	14.5	6.9	2.0
R7	36.7	45.7	14.7	14.5	6.9	2.0
R8	36.7	45.7	14.7	14.5	6.9	2.0
R9	37.0	45.7	14.9	14.5	6.9	2.0
R10	37.0	45.7	14.9	14.5	6.9	2.0
R11	37.1	45.7	14.9	14.5	6.9	2.0
R12	37.0	45.7	14.9	14.5	6.9	2.0
R13	37.1	45.7	14.9	14.6	6.9	2.0
R14	36.9	47.4	14.8	14.5	6.9	2.0
R15	36.8	46.9	14.8	14.5	6.9	2.0
R16	36.8	46.3	14.8	14.5	6.9	2.0
R17	39.2	49.4	16.0	14.9	7.2	2.2
R18	37.0	45.7	14.9	14.5	6.9	2.0
R19	37.1	45.7	15.0	14.5	6.9	2.0
R20	36.7	45.7	14.7	14.5	6.9	2.0
R21	36.7	45.7	14.7	14.5	6.9	2.0
R22	36.8	45.8	14.8	14.5	6.9	2.0
R23	38.9	45.8	15.8	14.9	7.1	2.2

Table 6.5 Cumulative (Scenario 2 plus background) concentration and deposition results

Assessment location ID	Predicted cumulative concentration (µg/m³) and deposition rate (g/m²/month)					
	TSP	PM_{10}		$PM_{2.5}$		Dust deposition
	Annual	6th highest 24-hour[1]	Annual	3rd highest 24-hour[2]	Annual	Annual
Criterion	**90**	**50**	**25**	**25**	**8**	**4**
R1	37.9	45.7	15.9	14.7	7.1	2.1
R2	37.2	45.7	15.2	14.5	7.0	2.0
R3	37.9	45.7	15.5	14.6	7.1	2.1
R4	38.3	45.8	15.6	14.8	7.1	2.1
R5	36.8	46.3	14.8	14.5	6.9	2.0
R6a	36.8	45.7	14.8	14.5	6.9	2.0
R6b	36.8	45.7	14.8	14.5	6.9	2.0
R7	36.7	45.7	14.7	14.5	6.9	2.0
R8	36.7	45.7	14.7	14.5	6.9	2.0
R9	37.0	45.7	14.9	14.5	6.9	2.0
R10	37.0	45.7	14.9	14.5	6.9	2.0
R11	37.1	45.7	14.9	14.5	6.9	2.0
R12	37.0	45.7	14.9	14.5	6.9	2.0
R13	37.1	45.7	14.9	14.6	6.9	2.0
R14	36.9	47.3	14.8	14.5	6.9	2.0
R15	36.8	46.8	14.8	14.5	6.9	2.0
R16	36.8	46.2	14.8	14.5	6.9	2.0
R17	39.2	49.5	16.0	14.9	7.2	2.2
R18	37.0	45.7	14.9	14.5	6.9	2.0
R19	37.1	45.7	15.0	14.5	7.0	2.0
R20	36.7	45.7	14.7	14.5	6.9	2.0
R21	36.7	45.7	14.7	14.5	6.9	2.0
R22	36.8	45.8	14.8	14.5	6.9	2.0
R23	38.9	45.8	15.9	14.9	7.1	2.2

Table 6.6 Cumulative (Scenario 3 plus background) concentration and deposition results

Assessment location ID	Predicted cumulative concentration (μg/m³) and deposition rate (g/m²/month)					
	TSP	PM_{10}		$PM_{2.5}$		Dust deposition
	Annual	6th highest 24-hour[1]	Annual	3rd highest 24-hour[2]	Annual	Annual
Criterion	**90**	**50**	**25**	**25**	**8**	**4**
R1	37.9	45.7	15.7	14.6	7.1	2.1
R2	37.2	45.7	15.3	14.5	7.0	2.0
R3	37.9	45.7	15.5	14.6	7.1	2.1
R4	38.3	45.8	15.6	14.8	7.1	2.1
R5	36.8	46.4	14.8	14.5	6.9	2.0
R6a	36.8	45.7	14.8	14.5	6.9	2.0
R6b	36.8	45.7	14.8	14.5	6.9	2.0
R7	36.7	45.7	14.7	14.5	6.9	2.0
R8	36.7	45.7	14.7	14.5	6.9	2.0
R9	37.0	45.7	14.9	14.5	6.9	2.0
R10	37.0	45.7	14.9	14.5	6.9	2.0
R11	37.1	45.7	14.9	14.5	6.9	2.0
R12	37.0	45.7	14.9	14.5	6.9	2.0
R13	37.1	45.7	14.9	14.6	6.9	2.0
R14	36.9	47.3	14.9	14.5	6.9	2.0
R15	36.8	46.8	14.8	14.5	6.9	2.0
R16	36.8	46.3	14.8	14.5	6.9	2.0
R17	39.2	49.5	16.0	14.9	7.2	2.2
R18	37.0	45.7	14.9	14.5	6.9	2.0
R19	37.1	45.7	15.0	14.5	6.9	2.0
R20	36.7	45.7	14.7	14.5	6.9	2.0
R21	36.7	45.7	14.7	14.5	6.9	2.0
R22	36.8	46.1	14.8	14.5	6.9	2.0
R23	38.9	45.8	15.9	14.9	7.1	2.2

7 Conclusion

Dispersion modelling has been completed for three operational emission scenarios:

- existing scenario – existing pit operations only;
- proposed (Scenario 2) – extraction occurring in both the WEA and SEA with additional 'floor rock' excavated from the WEA; and
- proposed (Scenario 3) – majority of extraction occurring in the SEA with floor rock extracted from the WEA.

Atmospheric dispersion modelling was completed using the AERMOD model system. Hourly meteorological observations from 2017, collected from the BoM's Dubbo Airport AWS, were used as input to the dispersion modelling.

The results of the modelling show that the predicted concentrations and deposition rates for incremental particulate matter (TSP, PM_{10}, $PM_{2.5}$ and dust deposition) are below the applicable impact assessment criteria at all assessment locations for both the existing and proposed scenarios.

Cumulative impacts were assessed by combining modelled impacts with recorded ambient background levels. The cumulative results showed that compliance with applicable NSW EPA impact assessment criteria is predicted at all assessment locations for all pollutants and averaging periods.

A range of best practice dust mitigation measures are, and will continue to be, employed at the quarry. These include the use of water carts and sprays, paved roads, watering conveyor transfer point, watering exposed areas where possible, and progressive rehabilitation of exposed areas. These measures have been taken into account in the emissions estimation and modelling of each scenario.

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Abbreviations

AHD	Australian height datum
Approved Methods for Modelling	*Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*
AQIA	Air quality impact assessment
AWS	Automatic weather station
BoM	Bureau of Meteorology
CO	carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DoE	Commonwealth Department of the Environment
DPIE	Department of Planning, Industry and Environment
EPA	Environment Protection Authority
EPL	Environment protection licence
LGA	Local government area
NO_x	Oxides of nitrogen
PM_{10}	Particulate matter less than 10 microns in aerodynamic diameter
$PM_{2.5}$	Particulate matter less than 2.5 microns in aerodynamic diameter
SO_2	Sulfur dioxide
SSD	State significant development
TAPM	The Air Pollution Model
TSP	Total suspected particulates
US-EPA	United States Environmental Protection Agency

Appendix A

Meteorological processing and modelling

A.1 Meteorological data analysis for the BoM Dubbo AWS, 2015-2019

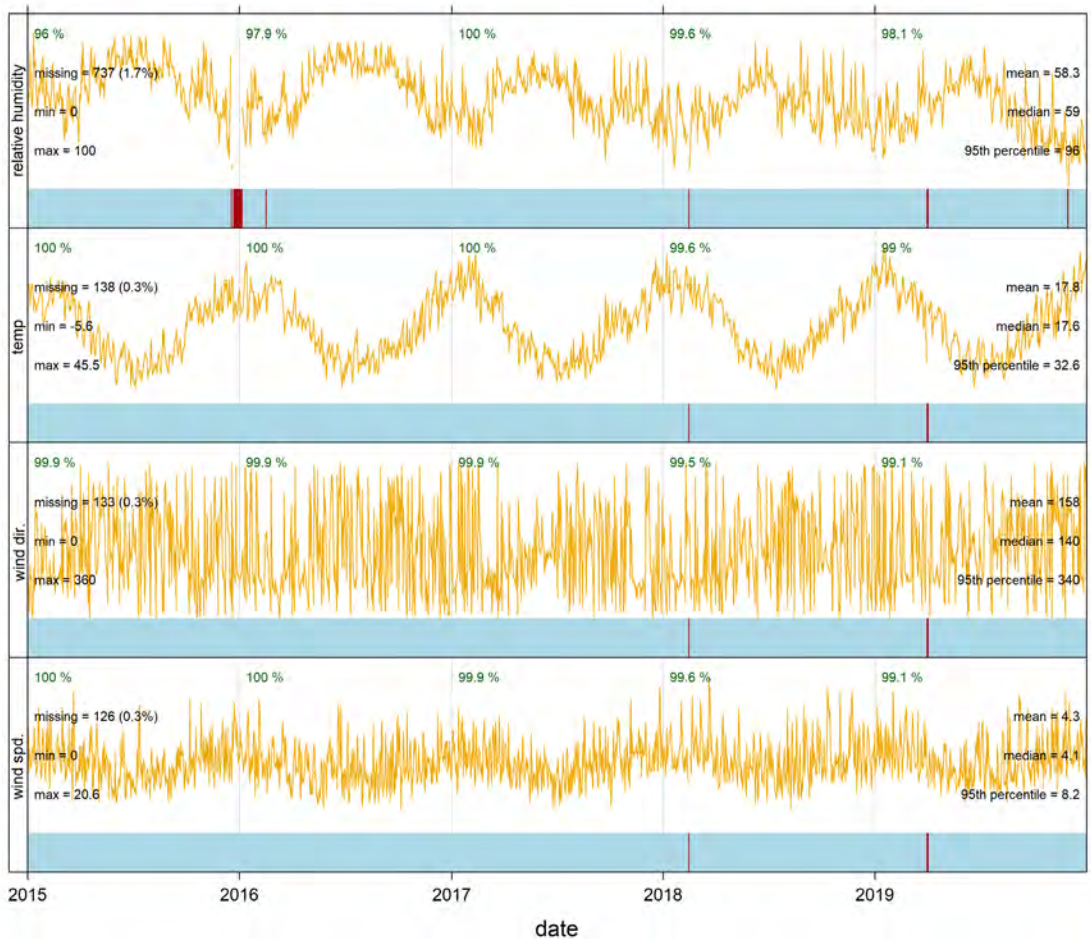


Figure A.1 Five-year data completeness analysis plot – BoM Dubbo Airport AWS – 2015 to 2019

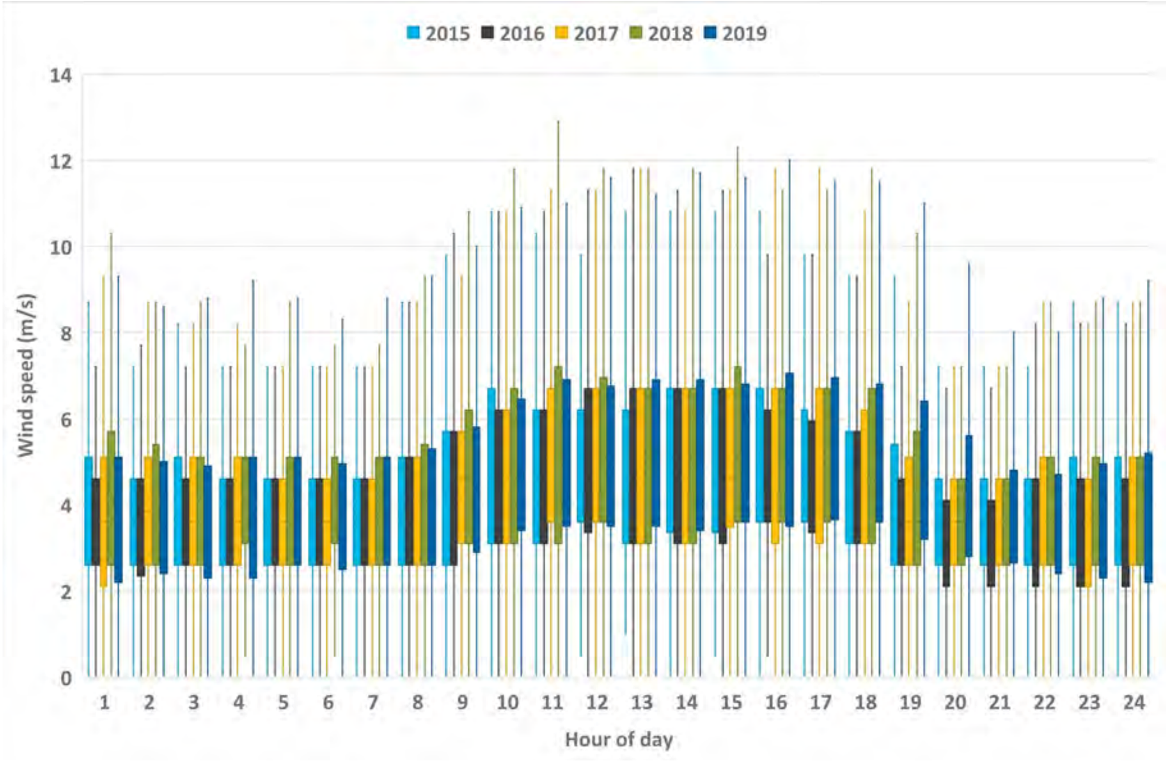


Figure A.2 Inter-annual variability in diurnal wind speed – BoM Dubbo Airport AWS – 2015 to 2019

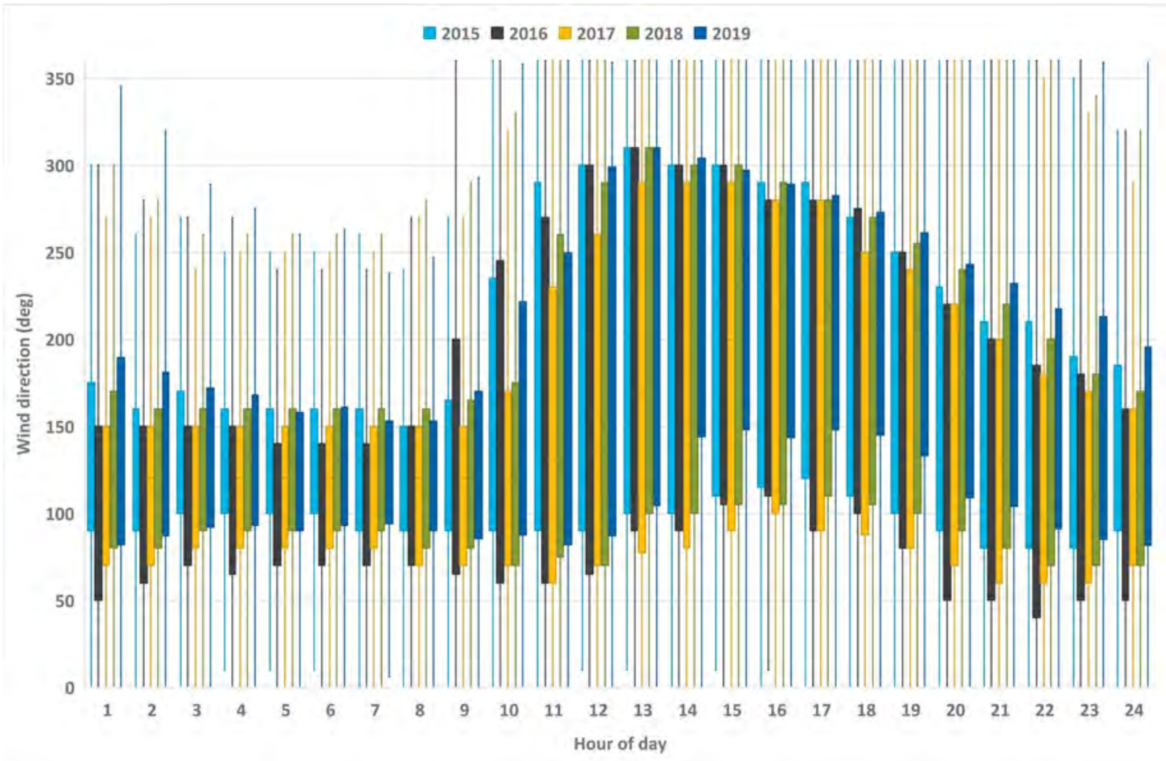


Figure A.3 Inter-annual variability in diurnal wind direction – BoM Dubbo Airport AWS – 2015 to 2019

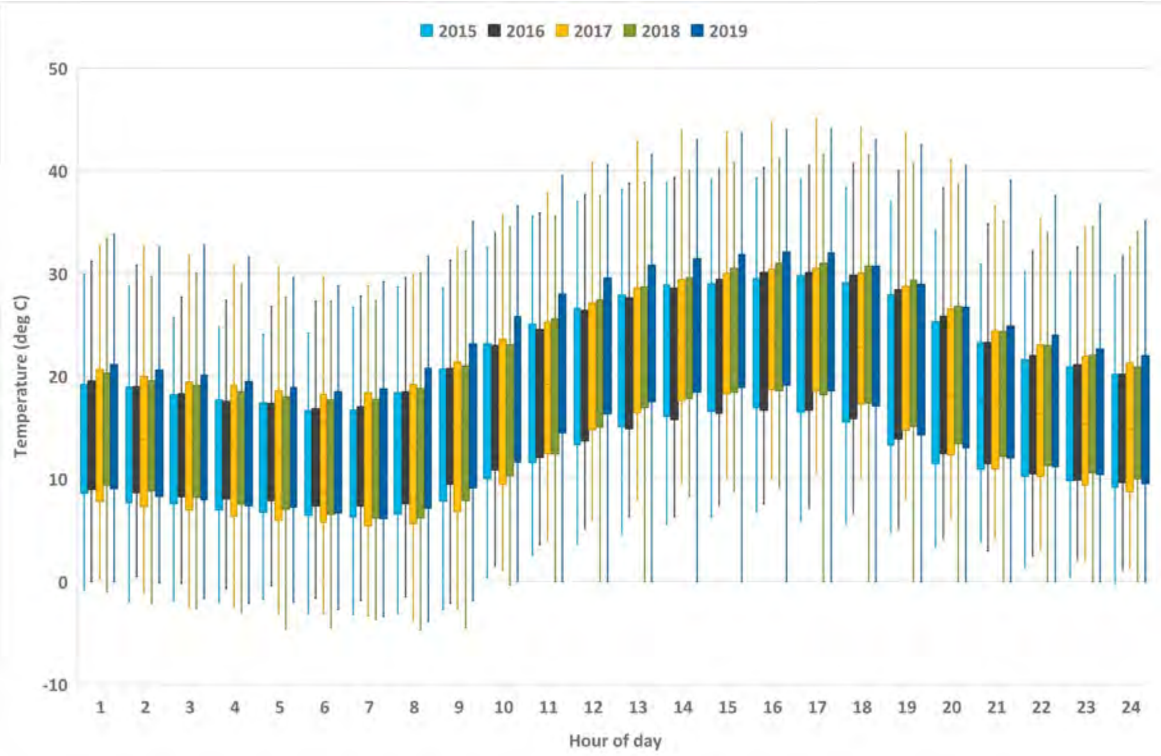


Figure A.4 Inter-annual variability in diurnal air temperature – BoM Dubbo Airport AWS – 2015 to 2019

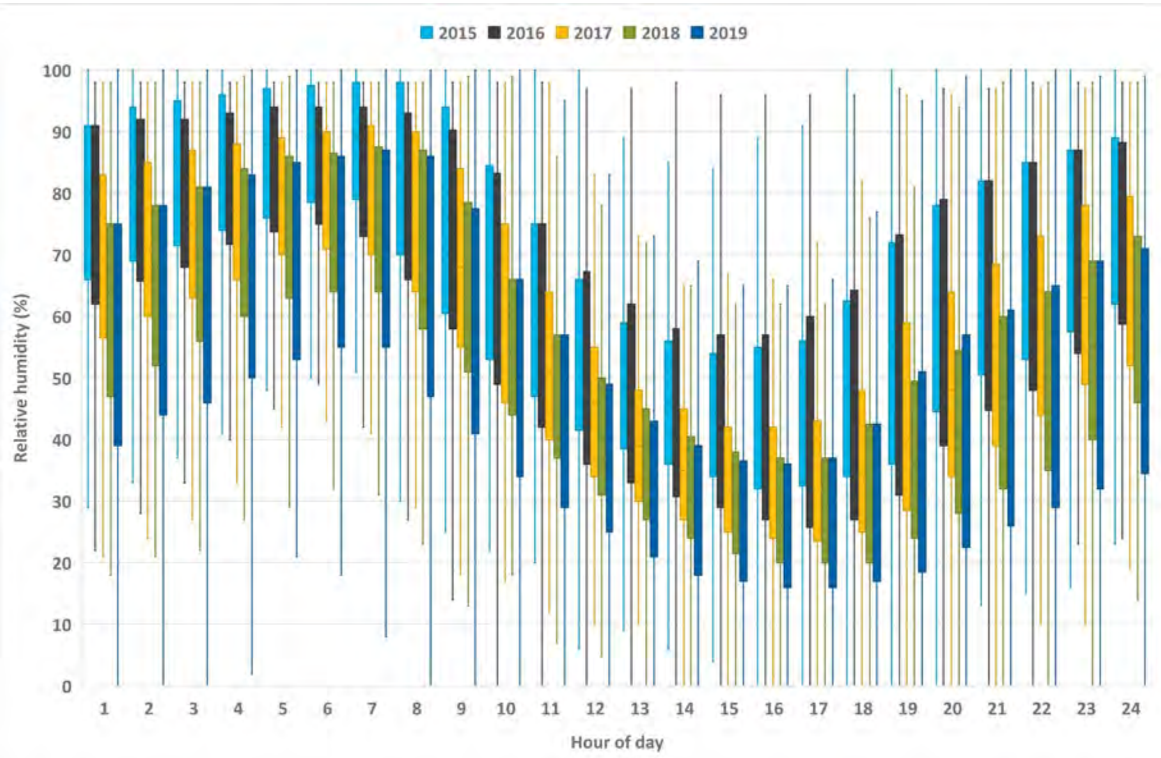


Figure A.5 Inter-annual variability in diurnal relative humidity – BoM Dubbo Airport AWS – 2015 to 2019

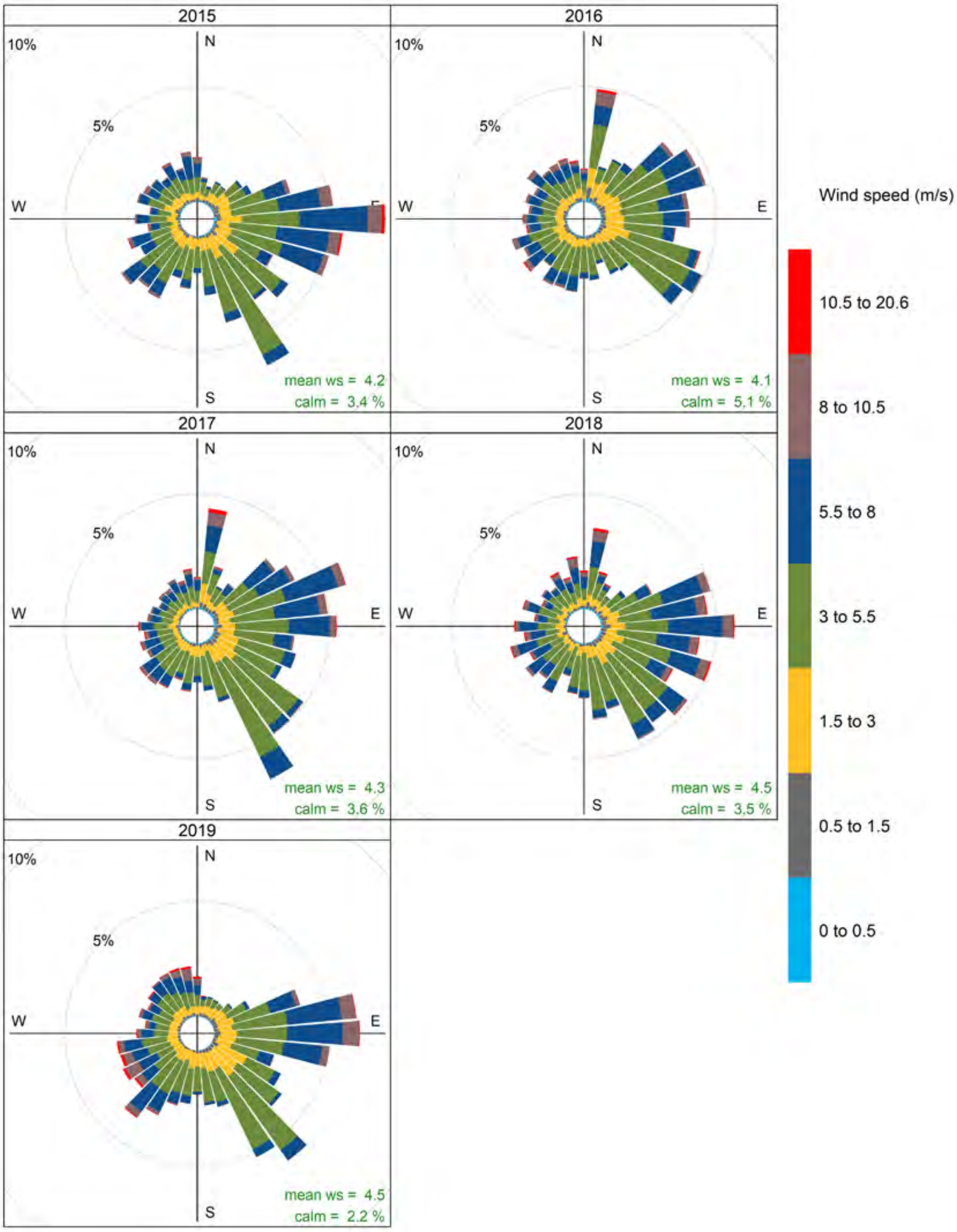


Figure A.6 Inter-annual comparison of recorded wind speed and direction – BoM Dubbo Airport AWS – 2015 to 2019

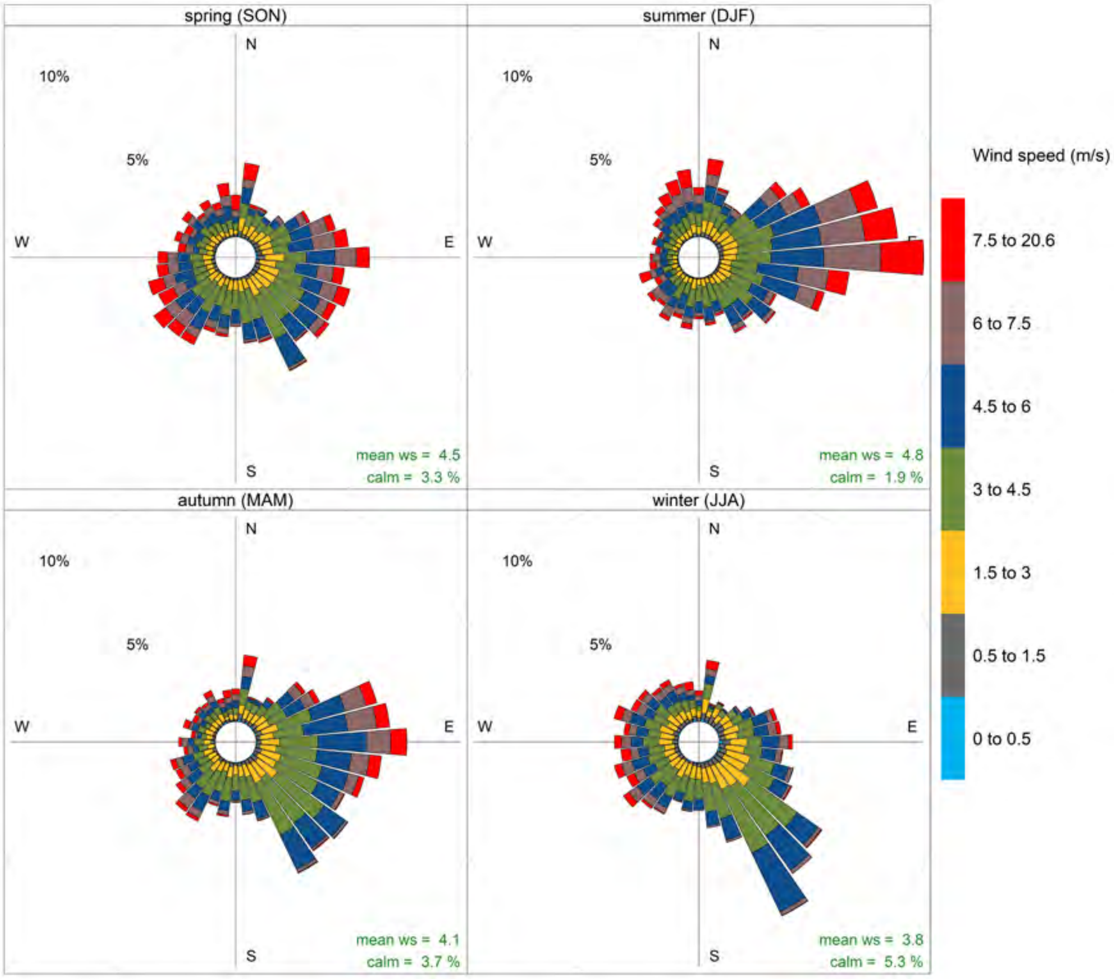


Figure A.7 Seasonal wind speed and direction – Myuna AWS – 2017-2019

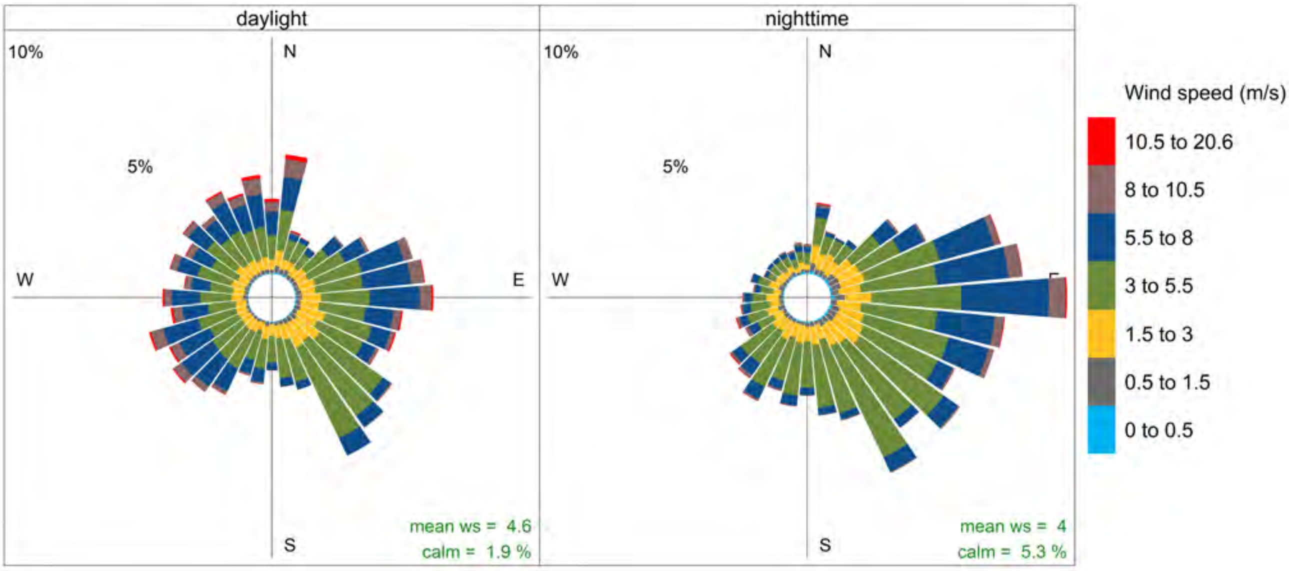


Figure A.8 Diurnal wind speed and direction – BoM Dubbo Airport AWS – 2014 to 2018

A.2 Meteorological modelling

i TAPM modelling

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

TAPM was configured and run as follows:

- TAPM version 4.0.5;
- inclusion of high resolution (90 m) regional topography (improvement over default 250 m resolution data);
- grid domains with cell resolutions of 30 km, 10 km and 3 km. Each grid domain features 25 x 25 horizontal grid points and 35 vertical levels;
- TAPM default databases for land use, synoptic analyses and sea surface temperature;
- TAPM defaults for advanced meteorological inputs;
- two 'spin-up' days allowed at the beginning and end of the run; and
- a surface observations file was included with meteorological data from BoM Dubbo Airport AWS.

A.3 AERMET meteorological processing

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

A.3.1 Surface characteristics

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

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

As detailed by USEPA (2013), the surface roughness length is related to the height of obstacles to the wind flow (eg vegetation, built environment) and is, in principle, the height at which the mean horizontal wind speed is zero based on a logarithmic profile. The surface roughness length influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer. The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

Land cover over an area of approximately 9 km (y axis) and 10 km (x axis) surrounding the project was mapped using aerial photography and specific land-use codes in AERMET. The AERSURFACE tool then determined the appropriate surface roughness, albedo and Bowen ratio values using the resultant land-use file and internal algorithms. The quarry area was assigned a land-use type of 'quarries', the town of Dubbo was assigned a land-use type of 'high intensity residential', and the remaining land was assigned a land-use type of 'grassland'.

Monitoring data from the BoM Dubbo Airport AWS were combined with TAPM meteorological modelling outputs for input to AERMET. The following parameters were input as on-site data to AERMET:

- wind speed and direction;
- sigma-theta (standard deviation of wind direction);
- temperature (10 m);
- relative humidity;
- cloud cover and height;
- station level pressure; and
- mixing depth – TAPM at the location of the Dubbo Quarry.

The period of meteorological data input to AERMET was 1 January 2017 to 31 December 2017.

A.3.2 Upper air profile

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

Appendix B

Emissions inventory detail

B.1 Introduction

Particulate matter emissions were quantified through the application of accepted published emission estimation factors, collated from a combination of United States Environmental Protection Agency (US-EPA) AP-42 Air Pollutant Emission Factors and US-EPA Exhaust Emissions Standards, including the following:

- US-EPA AP-42 Chapter 13.2.4.4 – Aggregate handling and storage piles (US-EPA 2006a);
- US-EPA AP-42 Chapter 13.2.2 – Unpaved roads (US-EPA 2011);
- US-EPA AP-42 Chapter 13.2.1.3 – Paved roads (US-EPA 2011);
- US-EPA AP-42 Chapter 11, Table 11.19.2-1 – Tertiary crushing (controlled) (US-EPA 2004);
- US-EPA AP-42 Chapter 11, Table 11.19.2-1 – Screening (controlled) (US-EPA 2004);
- US-EPA AP-42 Chapter 11, Table 11.19.2-1 – Tertiary crushing (controlled) (US-EPA 2004);
- US-EPA AP-42 Chapter 11, Table 11.9-4 – Wind erosion of exposed areas (US-EPA 1998b); and
- US-EPA Nonroad Compression-Ignition Engines: Exhaust Emission Standards (EPA-420-B-16-022, March 2016).

Diesel consumption was provided by Holcim. Assumptions adopted were:

- the proposed construction equipment fleet comprised primarily of equipment with an engine power greater than 130 kW;
- for engines greater than 130 kW, the corresponding USEPA (USEPA 2016) Tier 2 emission standards for PM of 0.2 g/kWh was selected;
- the g/kWh emission standard was converted to g per litre of diesel by applying a scaling factor of 3, as per the notes for Table 35 in *NPI Emission Estimation Technique Manual for Combustion Engines* (NPI 2008); and
- the PM emission standard is assumed to correspond to PM_{10}, with $PM_{2.5}$ emissions derived from the relationship between PM_{10} and $PM_{2.5}$ emission factors presented in Table 35 in NPI, 2008 (91.7%).

Particulate releases were quantified for TSP, PM_{10} and $PM_{2.5}$ as documented in subsequent sections.

B.2 Particulate matter emissions inventory

Emissions inventories developed for the existing and proposed scenarios are presented in Table B.1. Table B.2 and Table B.3 .

Table B.1 Existing scenario emissions inventory

Source name	TSP emissions for Existing Scenario (kg/year)	PM_{10} emissions for Existing Scenario (kg/year)	$PM_{2.5}$ emissions for Existing Scenario (kg/year)	Activity rate	Units	TSP emission factor	PM_{10} emission factor	$PM_{2.5}$ emission factor	Unit	Parameter 1	Unit	Parameter 2	Unit	Parameter 3	Unit	Parameter 4	Unit	Reduction factor	Emission control	Emission factor source
Topsoil activities at Southern Extension area																				
Excavators stripping topsoil	2.1	1.0	0.1	1,967	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Excavator loading topsoil to trucks	2.1	1.0	0.1	1,967	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Hauling topsoil to emplacement area	77.6	21.2	2.1	91	VKT/year	3.42	0.94	0.09	kg/VKT	6.8	% silt content	1.5	km/return trip	60	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading topsoil to emplacement area	2.1	1.0	0.1	1,967	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Subsoil activities at Southern Extension area																				
Excavators stripping subsoil	18.8	8.9	1.3	17,707	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Excavator loading subsoil to trucks	18.8	8.9	1.3	17,707	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Hauling subsoil to emplacement area	698.8	191.1	19.1	817	VKT/year	3.42	0.94	0.09	kg/VKT	6.8	% silt content	1.5	km/return trip	537	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading subsoil to emplacement area	23.2	11.0	1.7	21,831	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Rock extraction at Southern Extension area																				
Drilling rock	197.4	102.6	5.9	1,115	holes/y	0.59	0.3068	0.01770	kg/hole									0.7	Water injection	USEPA AP-42 11.9.4 - Drilling OB
Blasting rock	80.7	41.9	2.4	10	blasts/y	8.07	4.1941	0.24197	kg/blast	1,104	Area of blast in m^2									USEPA AP-42 11.9.4 - Drilling OB
FEL loading rock to trucks	1,103.8	522.1	79.1	393,480	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Trucks hauling rock to hopper at crushing plant	5,161.0	1,411.1	141.1	9,067	VKT/year	2.28	0.62	0.06	kg/VKT	6.8	% silt content	0.8	km/return trip	11,924	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
FEL unloading rock to hopper at crushing plant	1,103.8	522.1	79.1	393,480	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Rock processing																				
Primary crushing (by grizzly)	236.1	106.2	19.7	393,480	t/y	0.0006	0.00027	0.00005	kg/t											USEPA AP-42 11.19.2-1 - Tertiary crushing
Conveyor transfer of crushed rock to surge pile	551.9	261.0	39.5	393,480	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Conveyor transfer of crushed rock to primary screen	551.9	261.0	39.5	393,480	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Primary screening	432.8	145.6	9.8	393,480	t/y	0.0011	0.00037	0.00003	kg/t											USEPA AP-42 11.19.2-1 - Screening
Conveyor transfer of screened rock to secondary crusher (75%)	413.9	195.8	29.6	295,110	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Conveyor transfer of screened rock to road base stockpile (25%)	138.0	65.3	9.9	98,370	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Secondary crushing	177.1	79.7	14.8	295,110	t/y	0.0006	0.00027	0.00005	kg/t											USEPA AP-42 11.19.2-1 - Tertiary crushing
Conveyor transfer of crushed rock to secondary screen	413.9	195.8	29.6	295,110	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Secondary screening	324.6	109.2	7.4	295,110	t/y	0.0011	0.00037	0.00003	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 11.19.2-1 - Screening
Conveyor transfer of screened rock to tertiary crusher	413.9	195.8	29.6	295,110	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Tertiary crushing	177.1	79.7	14.8	295,110	t/y	0.0006	0.00027	0.00005	kg/t											USEPA AP-42 11.19.2-1 - Tertiary crushing
Conveyor transfer of crushed rock to tertiary screen	413.9	195.8	29.6	295,110	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Tertiary screening	324.6	109.2	7.4	295,110	t/y	0.0011	0.00037	0.00003	kg/t											USEPA AP-42 11.19.2-1 - Screening
Conveyor unloading rock to trucks	413.9	195.8	29.6	295,110	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Trucks loading road base to trucks	138.0	65.3	9.9	98,370	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Trucks hauling rock to product stockpiles	2,174.6	594.6	59.5	3,820	VKT/year	2.28	0.62	0.06	kg/VKT	6.8	% silt content	0.3	km/return trip	11,924	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading rock to product stockpile	1,103.8	522.1	79.1	393,480	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Trucks hauling materials off-site (paved)	1,544.2	296.4	71.7	38,346	VKT/year	0.0805	0.0155	0.0037	kg/VKT	0.6	Road silt loading (g/m^2)	3.2	km/return trip	11,924	Loads/y	34	Ave weight (t)	0.5	Water sprays	USEPA AP-42 13.2.1 - Paved roads
Wind erosion from exposed areas																				
Wind erosion of extraction area	960.1	480.0	72.0	1.1	Area (ha)	850	425	64	kg/ha/year											USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of exposed areas	6,358.5	3,179.3	476.9	7.5	Area (ha)	850	425	64	kg/ha/year											USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of stockpiles/southern exposed areas	2,390.4	1,195.2	179.3	5.6	Area (ha)	850	425	64	kg/ha/year									0.5	Water sprays	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Diesel combustion																				
Site diesel combustion	246.3	246.3	225.8																	
Diesel combustion (hauling off-site)	27.4	27.4	25.1																	
Total	**28,417.1**	**11,646.0**	**1,843.7**																	

Table B.2 Scenario 2 emissions inventory

Source name	TSP emissions for Scenario 2 (kg/year)	PM_{10} emissions for Scenario 2 (kg/year)	$PM_{2.5}$ emissions for Scenario 2 (kg/year)	Activity rate	Units	TSP emission factor	PM_{10} emission factor	$PM_{2.5}$ emission factor	Unit	Parameter 1	Unit	Parameter 2	Unit	Parameter 3	Unit	Parameter 4	Unit	Reduction factor	Emission control	Emission factor source
Western Extension area (Camerons land)																				
Topsoil activities at Western Extension Area																				
Excavators stripping topsoil	8.2	3.9	0.6	7,716	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Excavator loading topsoil to trucks	8.2	3.9	0.6	7,716	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Hauling topsoil to bund area	12.4	3.4	0.3	14	VKT/y	3.42	0.94	0.09	kg/VKT	6.8	% silt content	0.3	km/return trip	44	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Hauling topsoil to rehab area	52.9	14.5	1.4	62	VKT/y	3.42	0.94	0.09	kg/VKT	6.8	% silt content	0.3	km/return trip	190	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading subsoil to bund area	1.6	0.7	0.1	1,461	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Trucks unloading subsoil to rehab area	6.6	3.1	0.5	6,255	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Dozers working on bund	251.5	46.1	26.4	170	h/y	2.958	0.542	0.311	kg/h	4	Moisture content (%)	5	Silt (%)					0.5	Water carts	USEPA AP-42 11.9.2 - Dozers on OB
Subsoil activities at Western Extension Area																				
Excavators stripping subsoil	65.7	31.1	4.7	61,795	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Excavator loading subsoil to trucks	65.7	31.1	4.7	61,795	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Hauling subsoil to bund area	99.0	27.1	2.7	116	VKT/y	3.42	0.94	0.09	kg/VKT	6.8	% silt content	0.3	km/return trip	355	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Hauling subsoil to rehab area	391.5	107.0	10.7	458	VKT/y	3.42	0.94	0.09	kg/VKT	6.8	% silt content	0.3	km/return trip	1,402	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Hauling subsoil to stockpile	32.4	8.9	0.9	38	VKT/y	3.42	0.94	0.09	kg/VKT	6.8	% silt content	0.3	km/return trip	116	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading subsoil to bund area	12.4	5.9	0.9	11,702	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Trucks unloading subsoil to rehab area	49.2	23.3	3.5	46,260	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Trucks unloading subsoil to stockpile	4.1	1.9	0.3	3,833	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Rock extraction at Western Extension Area																				
Drilling rock	154.0	80.1	4.6	870	holes/y	0.59	0.3068	0.01770	kg/hole									0.7	Water injection	USEPA AP-42 11.9.4 - Drilling OB
Blasting rock	63.0	32.7	1.9	8	blasts/y	8.07	4.1941	0.24197	kg/blast	1,104	Area of blast in m^2									USEPA AP-42 11.9.4 - Blasting OB
FEL loading rock (incl. floor rock) to trucks	343.3	162.4	24.6	322,950	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Trucks hauling rock to hopper at crushing plant	7,249.6	1,982.1	198.2	12,736	VKT/y	2.28	0.62	0.06	kg/VKT	6.8	% silt content	1.3	km/return trip	9,786	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
FEL unloading rock to hopper at crushing plant	343.3	162.4	24.6	322,950	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Southern Extension area (Skinners)																				
Topsoil activities at Southern Extension Area																				
Excavators stripping topsoil	1.0	0.5	0.1	942	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Excavator loading topsoil to trucks	1.0	0.5	0.1	942	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Hauling topsoil to bund area	9.4	2.6	0.3	11	VKT/y	3.42	0.94	0.09	kg/VKT	6.8	% silt content	0.4	km/return trip	29	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading subsoil to bund area	1.0	0.5	0.1	942	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Subsoil activities at Southern Extension Area																				
Excavators stripping subsoil	7.0	3.3	0.5	6,597	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Excavator loading subsoil to trucks	7.0	3.3	0.5	6,597	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Hauling subsoil to bund area	65.5	17.9	1.8	77	VKT/y	3.42	0.94	0.09	kg/VKT	6.8	% silt content	0.4	km/return trip	200	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading subsoil to bund area	7.0	3.3	0.5	6,597	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Dozers working on bund	251.5	46.1	26.4	170	h/y	2.958	0.542	0.311	kg/h	4	Moisture content (%)	5	Silt (%)					0.5	Water carts	USEPA AP-42 11.9.2 - Dozers on OB
Rock extraction at Southern Extension Area																				
Drilling rock	43.3	22.5	1.3	245	holes/y	0.59	0.3068	0.01770	kg/hole									0.7	Water injection	USEPA AP-42 11.9.4 - Drilling OB
Blasting rock	17.7	9.2	0.5	2	blasts/y	8.07	4.1941	0.24197	kg/blast	1,104	Area of blast in m2									USEPA AP-42 11.9.4 - Blasting OB
FEL loading rock to trucks	280.5	132.7	20.1	100,000	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Trucks hauling rock to hopper at crushing plant	2,123.0	580.5	58.0	3,730	VKT/y	2.28	0.62	0.06	kg/VKT	6.8	% silt content	1.2	km/return trip	3,030	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
FEL unloading rock to hopper at crushing plant	280.5	132.7	20.1	100,000	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Rock processing																				
Primary crushing (by grizzly)	253.8	114.2	21.1	422,950	t/y	0.0006	0.00027	0.00005	kg/t											USEPA AP-42 11.19.2-1 - Tertiary crushing
Conveyor transfer of crushed rock to surge pile	593.2	280.6	42.5	422,950	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Conveyor transfer of crushed rock to primary screen	593.2	280.6	42.5	422,950	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Primary screening	465.2	156.5	10.6	422,950	t/y	0.0011	0.00037	0.00003	kg/t											USEPA AP-42 11.19.2-1 - Screening
Conveyor transfer of screened rock to secondary crusher (75%)	444.9	210.4	31.9	317,213	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Conveyor transfer of screened rock to road base stockpile (25%)	148.3	70.1	10.6	105,738	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Secondary crushing	190.3	85.6	15.9	317,213	t/y	0.0006	0.00027	0.00005	kg/t											USEPA AP-42 11.19.2-1 - Tertiary crushing
Conveyor transfer of crushed rock to secondary screen	444.9	210.4	31.9	317,213	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Secondary screening	348.9	117.4	7.9	317,213	t/y	0.0011	0.00037	0.00003	kg/t											USEPA AP-42 11.19.2-1 - Screening
Conveyor transfer of screened rock to tertiary crusher	444.9	210.4	31.9	317,213	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Tertiary crushing	190.3	85.6	15.9	317,213	t/y	0.0006	0.00027	0.00005	kg/t											USEPA AP-42 11.19.2-1 - Tertiary crushing
Conveyor transfer of crushed rock to tertiary screen	444.9	210.4	31.9	317,213	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Tertiary screening	348.9	117.4	7.9	317,213	t/y	0.0011	0.00037	0.00003	kg/t											USEPA AP-42 11.19.2-1 - Screening
Conveyor unloading rock to trucks	444.9	210.4	31.9	317,213	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling
Trucks loading road base to trucks	296.6	140.3	21.2	105,738	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Trucks hauling rock to product stockpiles	4,661.9	1,274.6	127.5	8,190	VKT/y	2.28	0.62	0.06	kg/VKT	6.8	% silt content	0.6	km/return trip	12,817	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading rock to product stockpile	1,186.5	561.2	85.0	422,950	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling
Trucks hauling materials off-site (paved)	1,659.9	318.6	77.1	41,218	VKT/y	0.0805	0.0155	0.0037	kg/VKT	0.6	Road silt loading (g/m^2)	3.2	km/return trip	12,817	Loads/y	34	Ave weight (t)	0.5	Water sprays	USEPA AP-42 13.2.1 - Paved roads
Wind erosion from exposed areas																				
Wind erosion of Western Extension area (exposed)	1,034.5	517.3	77.6	1.7	Area (ha)	850	425	64	kg/ha/y									0.3	Bund	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of Western Extension extraction area	271.3	135.6	20.3	0.5	Area (ha)	850	425	64	kg/ha/y									0.3	Bund	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of Western Extension area partial rehab area 1	62.2	31.1	4.7	0.3	Area (ha)	850	425	64	kg/ha/y									0.79	Bund and rehab	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of Western Extension area partial rehab area 2	25.6	12.8	1.9	0.1	Area (ha)	850	425	64	kg/ha/y									0.79	Bund and rehab	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of existing pit partial rehab area	369.2	184.6	27.7	1.4	Area (ha)	850	425	64	kg/ha/y									0.7	Partial rehab	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of existing pit exposed area	3,189.4	1,594.7	239.2	5.4	Area (ha)	850	425	64	kg/ha/y									0.3	Rehab bund	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of Southern Extension area (exposed)	514.9	257.4	38.6	0.9	Area (ha)	850	425	64	kg/ha/y									0.3	Bund	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of Southern Extension extraction area	129.7	64.9	9.7	0.2	Area (ha)	850	425	64	kg/ha/y									0.3	Bund	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of product stockpile	221.0	110.5	16.6	0.5	Area (ha)	850	425	64	kg/ha/y									0.5	Water sprays	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Diesel combustion																				
Site diesel combustion	246.3	246.3	225.8																	
Diesel combustion (hauling off-site)	27.4	27.4	25.1																	
Total	**31,563.2**	**11,524.3**	**1,774.7**																	

Table B.3 Scenario 3 emissions inventory

Source name	TSP emissions for Y15 (kg/y)	PM_{10} emissions for Y15 (kg/y)	$PM_{2.5}$ emissions for Y15 (kg/y)	Activity rate	Units	TSP emission factor	PM_{10} emission factor	$PM_{2.5}$ emission factor	Unit	Parameter 1	Unit	Parameter 2	Unit	Parameter 3	Unit	Parameter 4	Unit	Reduction factor	Emission control	Emission factor source
Western Extension area (Camerons)																				
Rock extraction at ex-pit																				
Excavator/FEL loading floor rock to trucks	31.6	14.9	2.3	11,254	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Trucks hauling floor rock to hopper at crushing plant	196.1	48.8	4.9	478	VKT/y	1.64	0.41	0.04	kg/VKT	4.3	Silt (%)	1.4	km/return trip	341	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
FEL unloading floor rock to hopper at crushing plant	31.6	14.9	2.3	11,254	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Southern Extension area (Skinners)																				
Topsoil activities at Southern Extension Area																				
Excavators stripping topsoil	3.4	1.6	0.2	3,215	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Excavator loading topsoil to trucks	3.4	1.6	0.2	3,215	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Hauling topsoil to bund area	58.1	15.9	1.6	68	VKT/y	3.42	0.94	0.09	kg/VKT	6.8	Silt (%)	0.7	km/return trip	97	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading subsoil to bund area	3.4	1.6	0.2	3,215	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Subsoil activities at Southern Extension Area																				
Excavators stripping subsoil	23.9	11.3	1.7	22,508	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Excavator loading subsoil to trucks	23.9	11.3	1.7	22,508	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Hauling subsoil to bund area	394.8	107.9	10.8	462	VKT/y	3.42	0.94	0.09	kg/VKT	6.8	Silt (%)	0.7	km/return trip	662	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Hauling subsoil to stockpile	12.2	3.3	0.3	14	VKT/y	3.42	0.94	0.09	kg/VKT	6.8	Silt (%)	0.7	km/return trip	20	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading subsoil to bund area	23.2	11.0	1.7	21,831	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Trucks unloading subsoil to stockpile	0.7	0.3	0.1	676	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Excavators/FELs working on bund	27.3	12.9	2.0	25,723	t/y	0.0011	0.0005	0.00008	kg/t	4.3	Ave wind speed (m/s)	4	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Rock extraction at Southern Extension area																				
Drilling rock	197.4	102.6	5.9	1,115	holes/y	0.59	0.3068	0.01770	kg/hole									0.7	Water injection	USEPA AP-42 11.9.4 - Drilling OB
Blasting rock	80.7	41.9	2.4	10	blasts/y	8.07	4.1941	0.24197	kg/blast	1,104	Area of blast in m^2									USEPA AP-42 11.9.4 - Drilling OB
FEL loading rock to trucks	1,298.9	614.3	93.0	463,023	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Trucks hauling rock to hopper at crushing plant	18,976.6	5,188.4	518.8	33,338	VKT/y	2.28	0.62	0.06	kg/VKT	6.8	Silt (%)	2.4	km/return trip	14,031	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
FEL unloading rock to hopper at crushing plant	1,298.9	614.3	93.0	463,023	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Rock processing																				
Primary crushing (by grizzly)	284.6	128.1	23.7	474,277	t/y	0.0006	0.00027	0.00005	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 11.19.2-1 - Tertiary crushing
Conveyor transfer of crushed rock to surge pile	665.2	314.6	47.6	474,277	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Conveyor transfer of crushed rock to primary screen	665.2	314.6	47.6	474,277	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Primary screening	521.7	175.5	11.9	474,277	t/y	0.0011	0.00037	0.00003	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 11.19.2-1 - Screening
Conveyor transfer of screened rock to secondary crusher (75%)	498.9	236.0	35.7	355,708	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Conveyor transfer of screened rock to road base stockpile (25%)	166.3	78.7	11.9	118,569	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Secondary crushing	213.4	96.0	17.8	355,708	t/y	0.0006	0.00027	0.00005	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 11.19.2-1 - Tertiary crushing
Conveyor transfer of crushed rock to secondary screen	498.9	236.0	35.7	355,708	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Secondary screening	391.3	131.6	8.9	355,708	t/y	0.0011	0.00037	0.00003	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 11.19.2-1 - Screening
Conveyor transfer of screened rock to tertiary crusher	498.9	236.0	35.7	355,708	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Tertiary crushing	213.4	96.0	17.8	355,708	t/y	0.0006	0.00027	0.00005	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 11.19.2-1 - Tertiary crushing
Conveyor transfer of crushed rock to tertiary screen	498.9	236.0	35.7	355,708	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Tertiary screening	391.3	131.6	8.9	355,708	t/y	0.0011	0.00037	0.00003	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 11.19.2-1 - Screening
Conveyor unloading rock to trucks	498.9	236.0	35.7	355,708	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Trucks loading road base to trucks	166.3	78.7	11.9	118,569	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)					0.5	Water sprays	USEPA AP-42 13.2.4 - Materials handling equation
Trucks hauling rock to product stockpiles	4,908.6	1,342.1	134.2	8,623	VKT/y	2.28	0.62	0.06	kg/VKT	6.8	Silt (%)	0.6	km/return trip	14,372	Loads/y	49	Ave weight (t)	0.75	Water sprays	USEPA AP-42 13.2.2 - Unpaved roads
Trucks unloading rock to product stockpile	1,330.5	629.3	95.3	474,277	t/y	0.0028	0.0013	0.00020	kg/t	4.3	Ave wind speed (m/s)	2	Moisture (%)							USEPA AP-42 13.2.4 - Materials handling equation
Trucks hauling materials off-site (paved)	1,861.3	357.3	86.4	46,220	VKT/y	0.0805	0.0155	0.0037	kg/VKT	0.6	Road silt loading (g/m^2)	3.2	km/return trip	14,372	Loads/y	34	Ave weight (t)	0.5	Water sprays	USEPA AP-42 13.2.1 - Paved roads
Wind erosion from exposed areas																				
Wind erosion of Southern Extension area (not used for extraction)	5,349.8	2,674.9	401.2	9.0	Area (ha)	850	425	64	kg/ha/y									0.3	Bund	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of Southern Extension extraction area	769.7	384.8	57.7	1.3	Area (ha)	850	425	64	kg/ha/y									0.3	Bund	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of Western Extension area (not used for extraction)	933.8	466.9	70.0	1.6	Area (ha)	850	425	64	kg/ha/y									0.3	Bund	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of Western Extension extraction area	534.7	267.3	40.1	0.9	Area (ha)	850	425	64	kg/ha/y									0.3	Bund	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of existing quarry exposed area	872.1	436.1	65.4	1.0	Area (ha)	850	425	64	kg/ha/y											USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of Western Extension area partial rehab	97.1	48.6	7.3	0.5	Area (ha)	850	425	64	kg/ha/y									0.79	Bund and partial rehab	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Wind erosion of product stockpile	221.0	110.5	16.6	0.5	Area (ha)	850	425	64	kg/ha/y									0.5	Water sprays	USEPA AP-42 11.9.4 - Wind erosion of exposed areas
Diesel combustion																				
Site diesel combustion	246.3	246.3	225.8																	
Diesel combustion (hauling off-site)	27.4	27.4	25.1																	
Total	**46,011.7**	**16,535.9**	**2,355.0**																	

B.3 Project-related input data used for particulate matter emission estimates

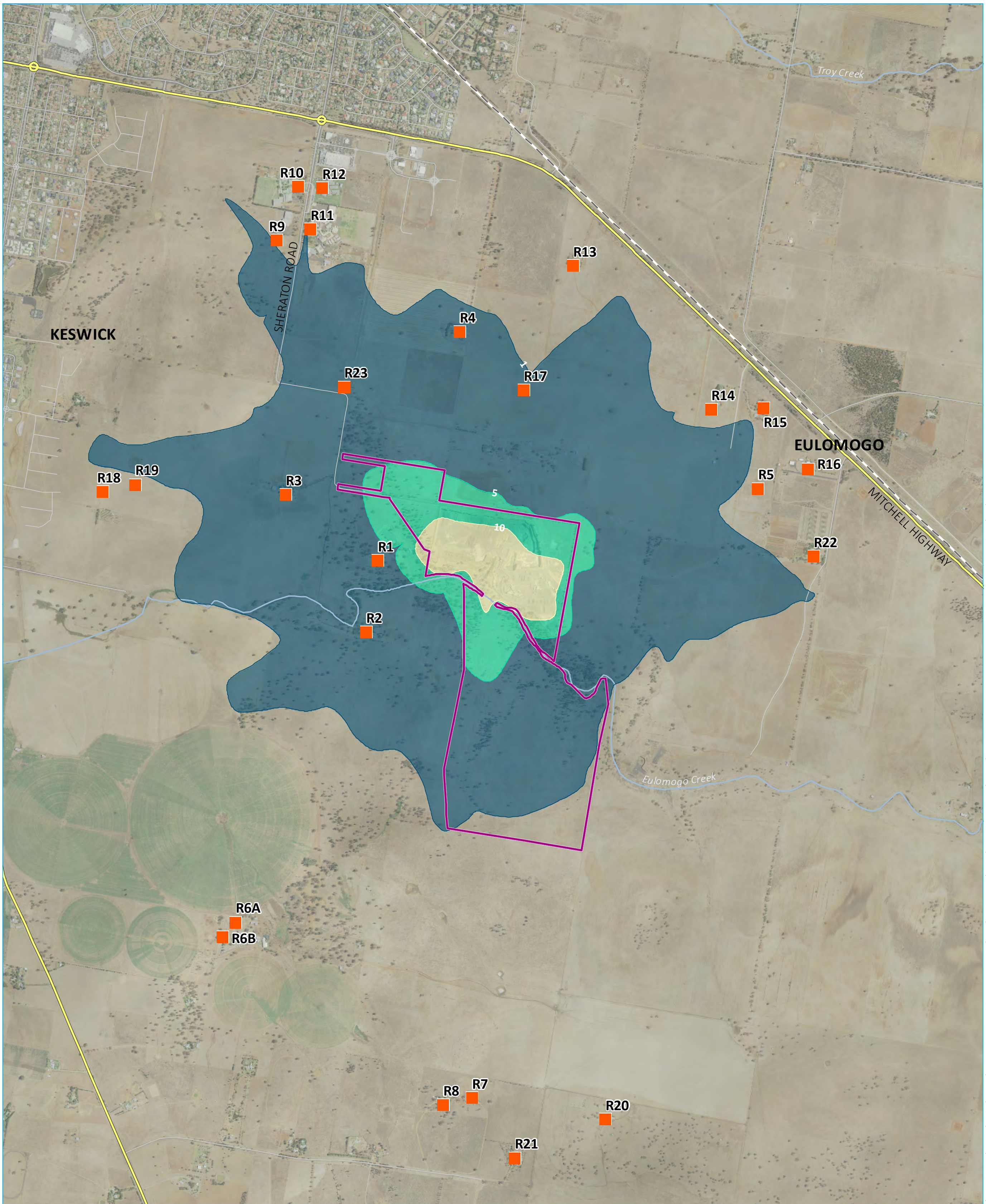
The main inputs used in the emission estimates are summarised in Table B.4. Material volumes and loads per year were calculated based on information provided by Holcim.

Table B.4 Inputs for emission estimation

Material properties	Value	Source of information
Unpaved road silt content (%)	6.8	Site-specific data were not available, therefore 6.8% was taken as the average unpaved road silt content a range of similar quarry studies (Bombala, Blayney, Bombo, Coraki, Sandy Point, Wallerawang, South Keswick, Karuah East, Teralba and New Berrima Clay Shale quarries).
Paved road silt loading (%)	0.6	Site-specific data were not available, therefore 0.6% was taken from USEPA AP-42 Section 13.2.1 (Paved Roads) as 'ubiquitous baseline'.
Topsoil and overburden moisture (%)	4	Taken from Pacific Environment 2016.
Rock moisture (%)	2	Taken from Pacific Environment 2016.
Diesel consumption for (L/y)	319,257 (existing scenario) 456,081 (proposed scenarios)	Existing diesel provided by Holcim and scaled to 500,000 t maximum for future years as advised by Holcim.
Average wind speed (m/s)	4.3	Calculated from BoM Dubbo Airport AWS data for 2017.
Average truck capacity (t)	33	Provided by Holcim.

Appendix C

Contour plots



\\Emmsvr1\emm\Jobs\2018\J180313 - Dubbo Quarry EIS\GIS\02_Maps_EIS_TechReports\AQIA\AQIA007_AQContoursC1S2_20201218_02.mxd 15/01/2021

Source: EMM (2020); DFSI (2017); DFSI (2020)

0 0.5 1 km
GDA 1994 MGA Zone 55
N

KEY

- Project area
- Assessment location
- Rail line
- Major road
- Minor road
- Named watercourse

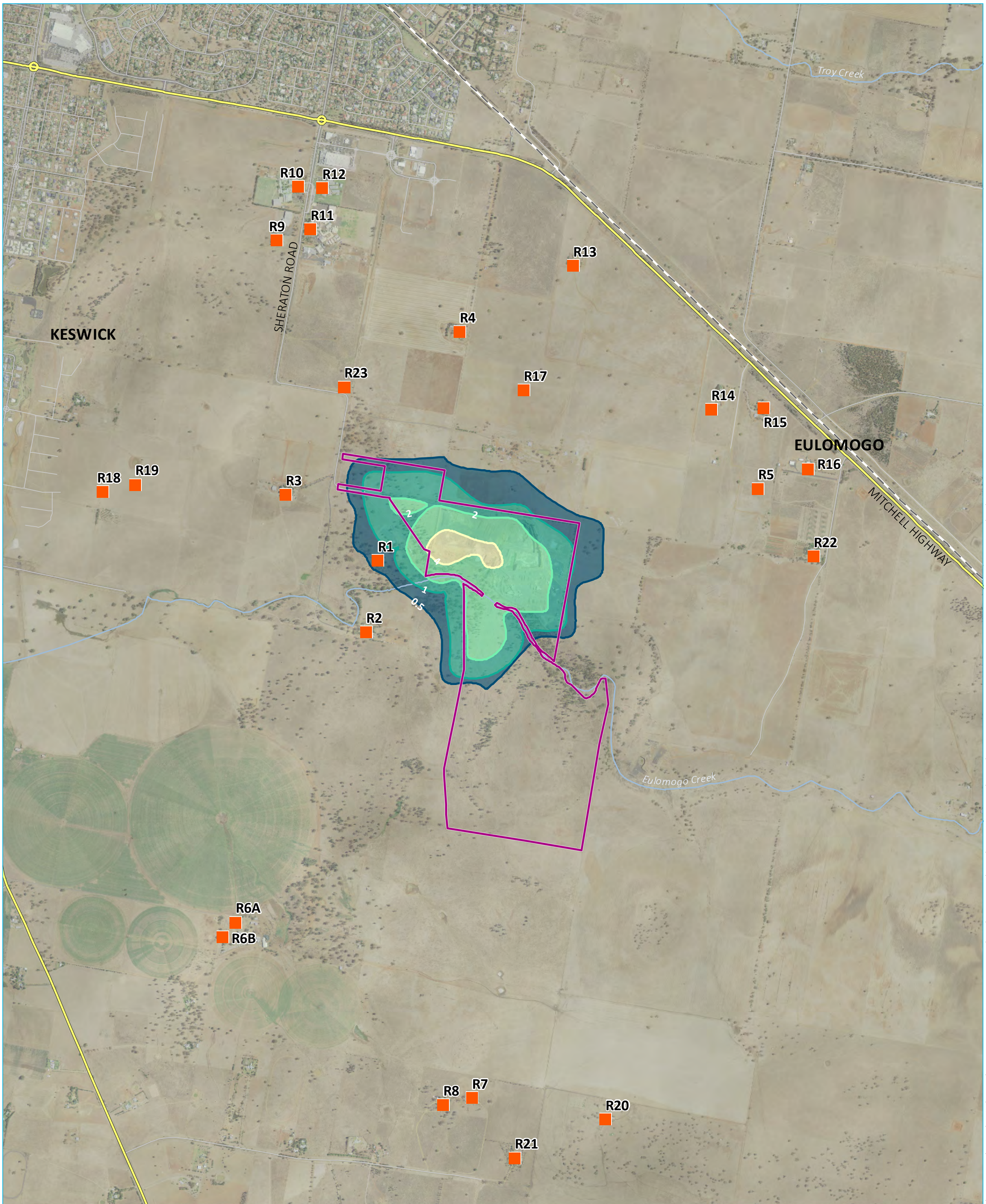
24-hour PM_{10} concentration range (µg/m^3)

- 1 - 5
- 5 - 10
- > 10

Maximum predicted 24-hour average PM_{10} concentrations – Dubbo Quarry only (scenario 2)

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure C.1

EMM creating opportunities



Source: EMM (2020); DFSI (2017); DFSI (2020)

0 0.5 1 km
GDA 1994 MGA Zone 55
N

KEY

Project area
Assessment location
Rail line
Major road
Minor road
Named watercourse

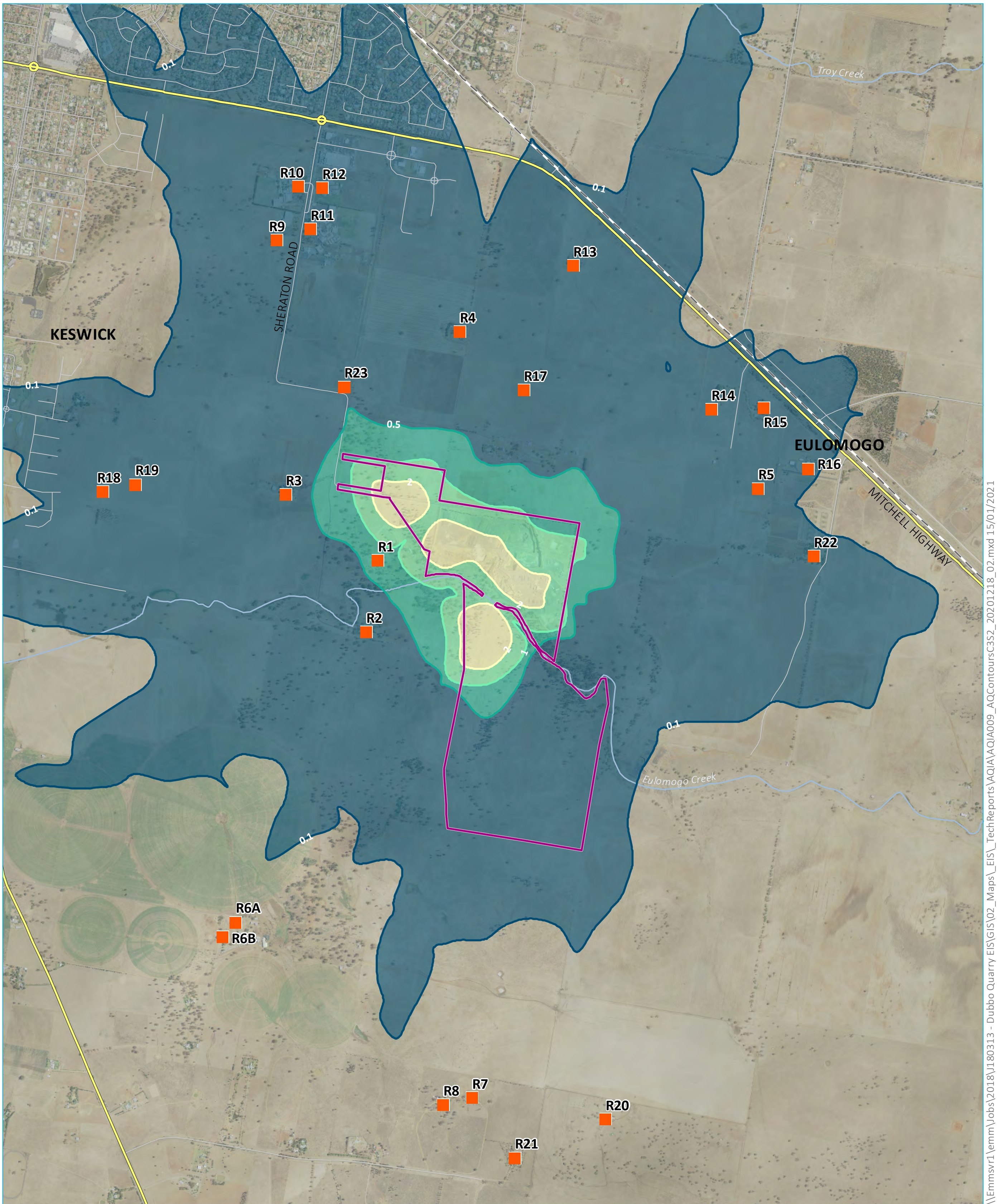
Annual PM_{10} concentration range (µg/m^3)

0.5 - 1
1 - 2
2 - 4
> 4

Predicted annual average PM_{10} concentrations – Dubbo Quarry only (scenario 2)

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure C.2

creating opportunities



Source: EMM (2020); DFSI (2017); DFSI (2020)

0 0.5 1 km
GDA 1994 MGA Zone 55
N

KEY

- Project area
- Assessment location
- Rail line
- Major road
- Minor road
- Named watercourse

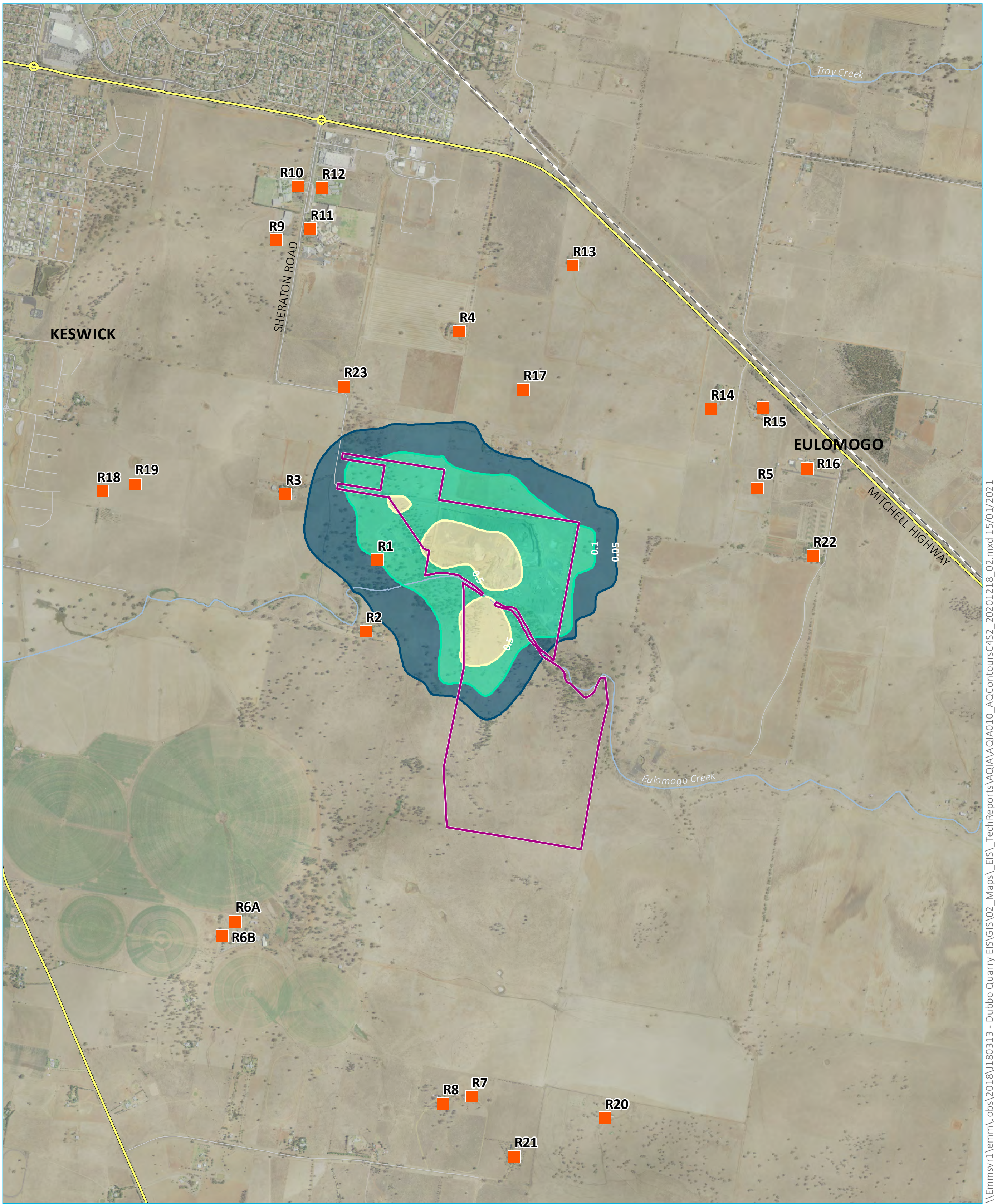
24-hour $PM_{2.5}$ concentration range (µg/m^3)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

Maximum predicted 24-hour average $PM_{2.5}$ concentrations – Dubbo Quarry only (scenario 2)

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure C.3

EMM
creating opportunities



Source: EMM (2020); DFSI (2017); DFSI (2020)

0 0.5 1 km

GDA 1994 MGA Zone 55

KEY

- Project area
- Assessment location
- Rail line
- Major road
- Minor road
- Named watercourse

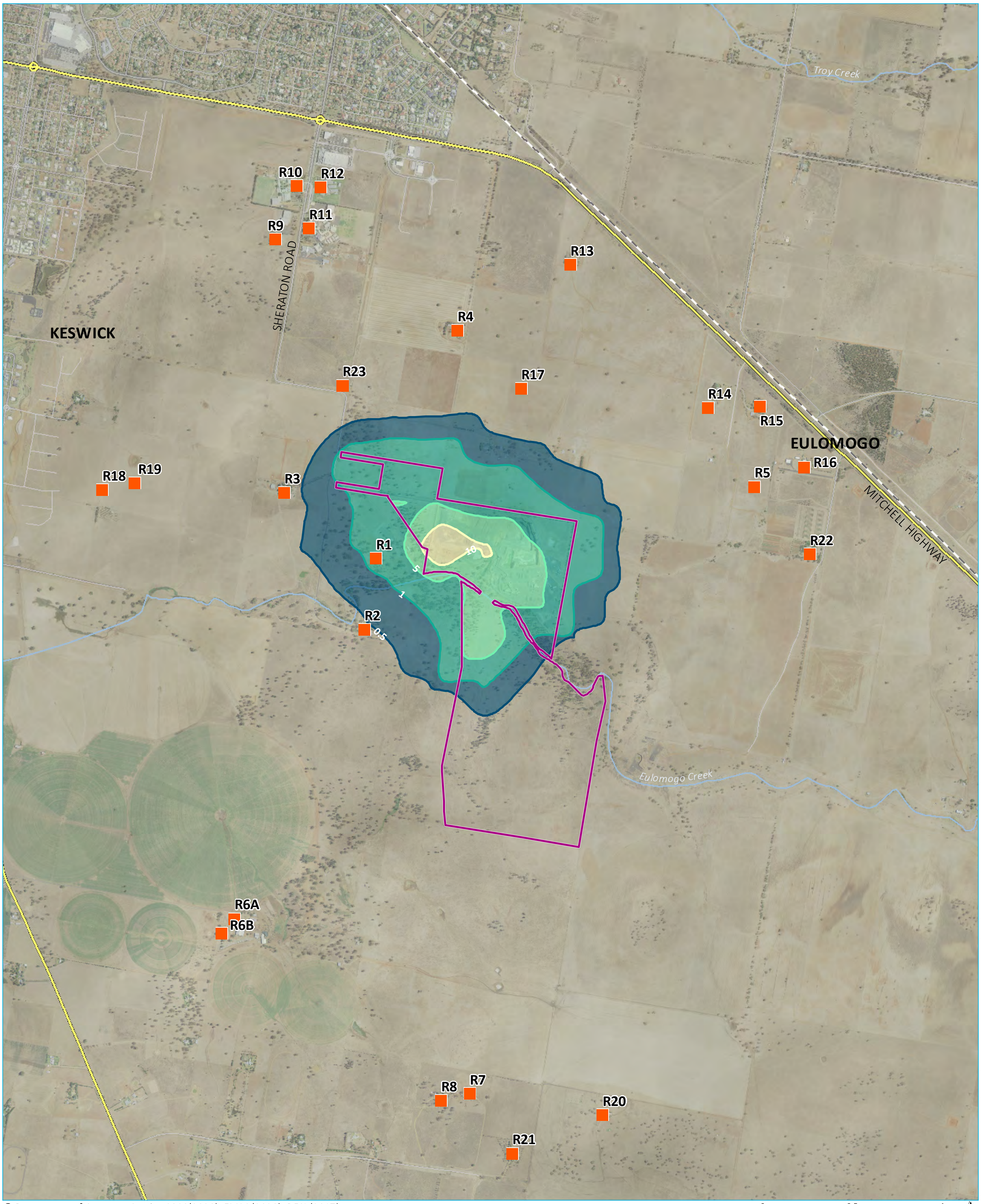
Annual $PM_{2.5}$ concentration range ($\mu g/m^3$)

- 0.05 - 0.1
- 0.1 - 0.5
- > 0.5

Predicted annual average $PM_{2.5}$ concentrations – Dubbo Quarry only (scenario 2)

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure C.4

EMM creating opportunities



© Department of Customer Service 2020(2020); EMM (2020); DFSI (2017)

0 0.5 1 km
GDA 1994 MGA Zone 55
N

KEY

- Project area
- Assessment location
- Rail line
- Major road
- Minor road
- Named watercourse

Annual TSP concentration range (µg/m^3)

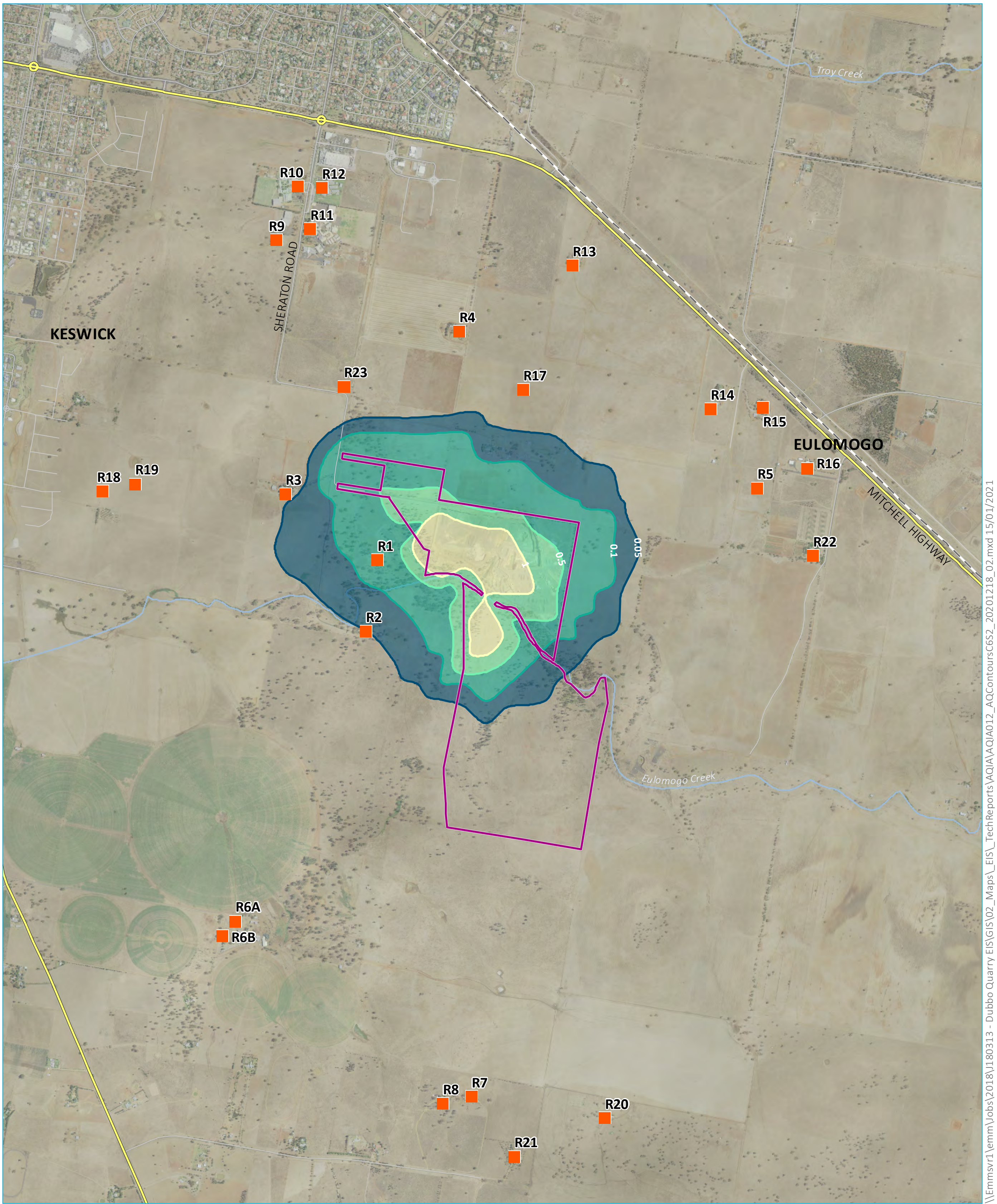
- 0.5 - 1
- 1 - 5
- 5 - 10
- > 10

Predicted annual average TSP concentrations – Dubbo Quarry only (Scenario 2)

Dubbo Quarry Continuation Project
Air quality impact assessment
Figure C.5

EMM
creating opportunities

\\Emmsvr1\emm\Jobs\2018\J180313 - Dubbo Quarry EIS\GIS\02_Maps_EIS_TechReports\AQIA\AQIA011_AQContoursC5S2_20201218_02.mxd 21/12/2020



Source: EMM (2020); DFSI (2017); DFSI (2020)

KEY

- Project area
- Assessment location
- Rail line
- Major road
- Minor road
- Named watercourse

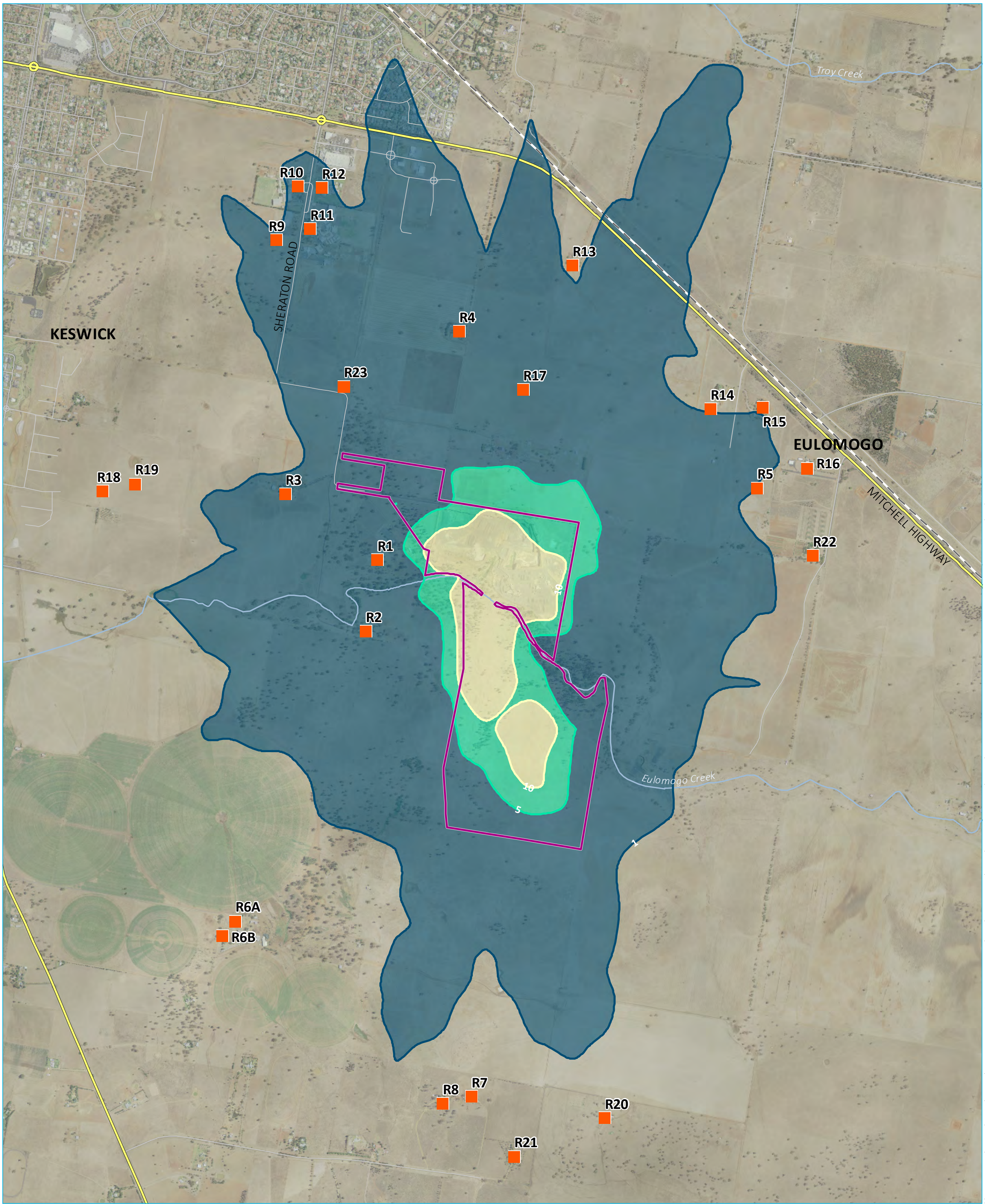
Annual dust deposition level range ($g/m^2/month$)

- 0.05 - 0.1
- 0.1 - 0.5
- 0.5 - 1
- > 1

Predicted annual average dust deposition levels – Dubbo Quarry only (scenario 2)

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure C.6

EMM creating opportunities



Source: EMM (2020); DFSI (2017); DFSI (2020)

0 0.5 1 km
GDA 1994 MGA Zone 55

KEY

Project area

Assessment location

Rail line

Major road

Minor road

Named watercourse

24-hour PM_{10} concentration range (µg/m[3])

1 - 5

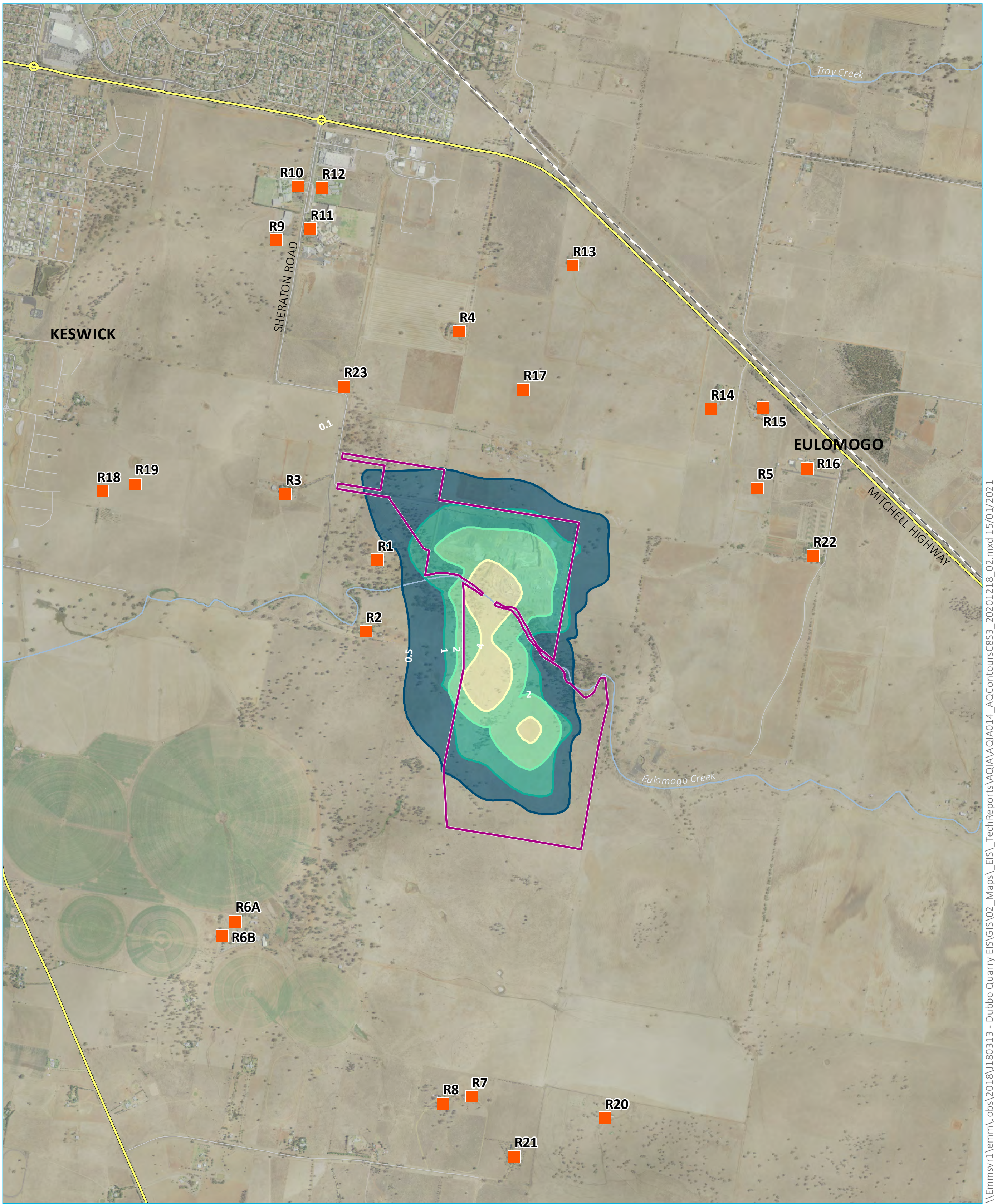
5 - 10

> 10

Maximum predicted 24-hour average PM_{10} concentrations – Dubbo Quarry only (scenario 3)

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure C.7

EMM
creating opportunities



Source: EMM (2020); DFSI (2017); DFSI (2020)

0 0.5 1 km

GDA 1994 MGA Zone 55

N

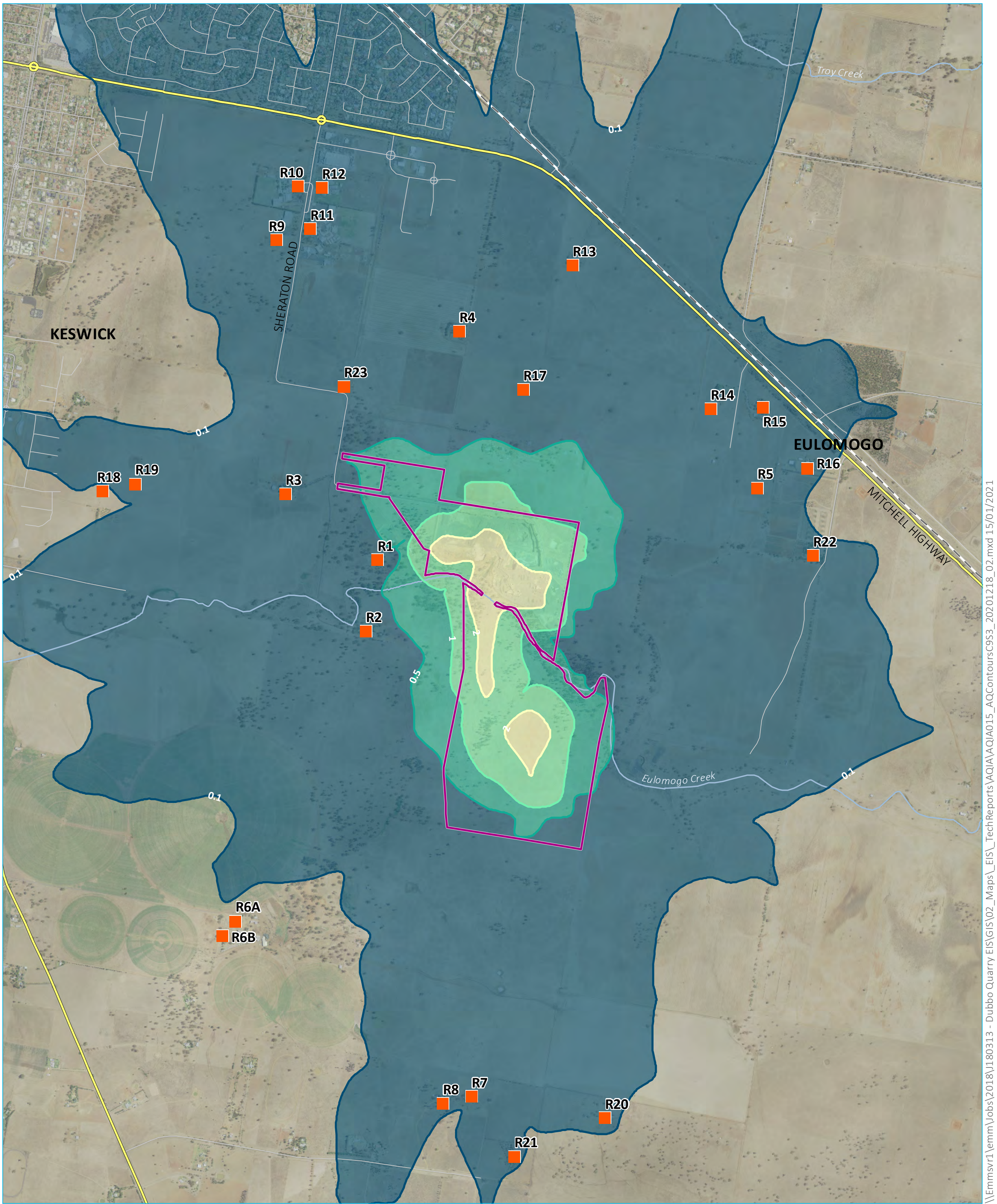
KEY

Project area	Annual PM_{10} concentration range (µg/m^3)
Assessment location	0.5 - 1
Rail line	1 - 2
Major road	2 - 4
Minor road	> 4
Named watercourse	

Predicted annual average PM_{10} concentrations – Dubbo Quarry only (scenario 3)

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure C.8

creating opportunities



Source: EMM (2020); DFSI (2017); DFSI (2020)

KEY

- Project area
- Assessment location
- Rail line
- Major road
- Minor road
- Named watercourse

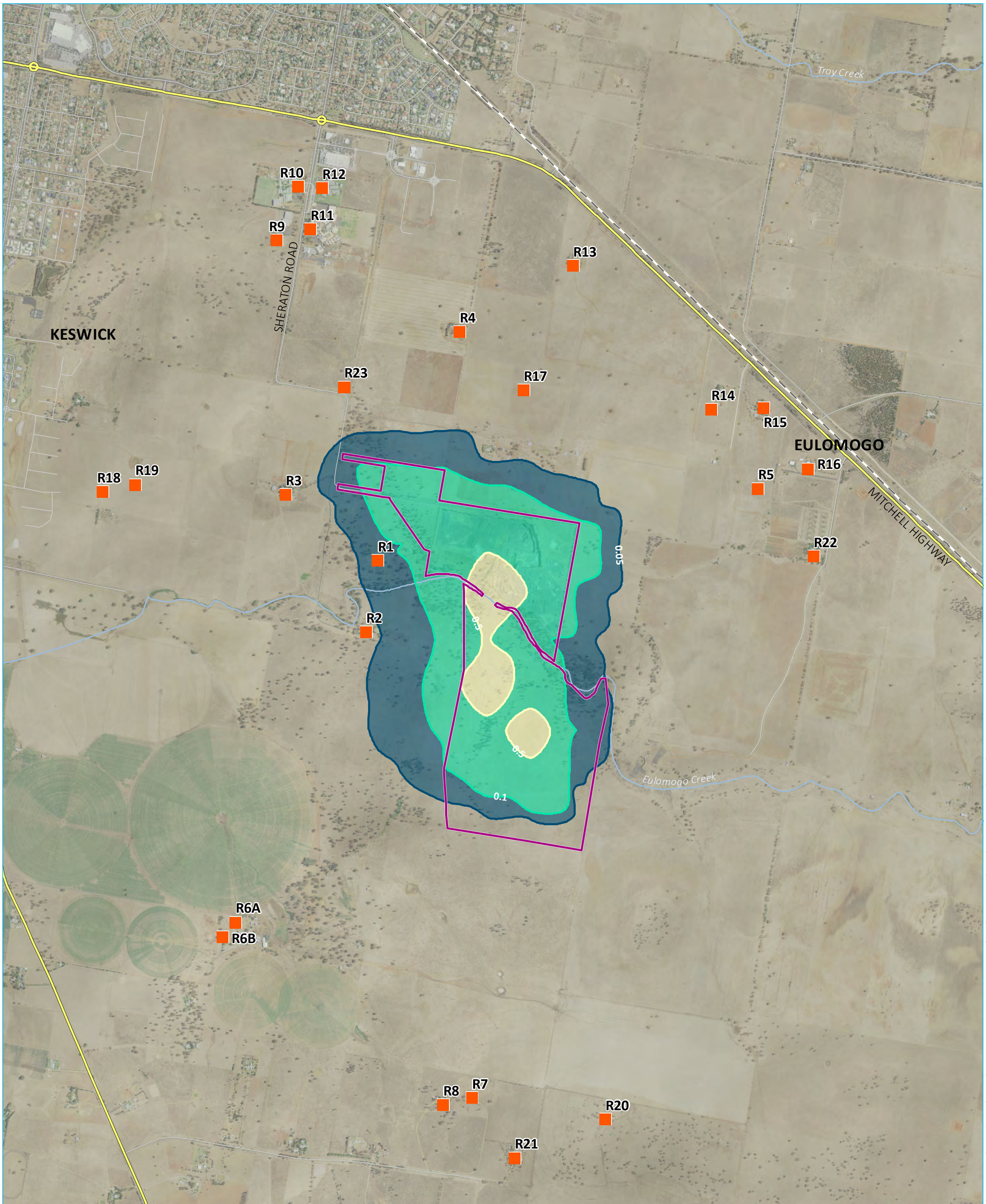
24-hour $PM_{2.5}$ concentration range (µg/m^3)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- > 2

Maximum predicted 24-hour average $PM_{2.5}$ concentrations – Dubbo Quarry only (scenario 3)

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure C.9

EMM creating opportunities



Source: EMM (2020); DFSI (2017); DFSI (2020)

0 0.5 1 km

GDA 1994 MGA Zone 55

N

KEY

- Project area
- Assessment location
- Rail line
- Major road
- Minor road
- Named watercourse

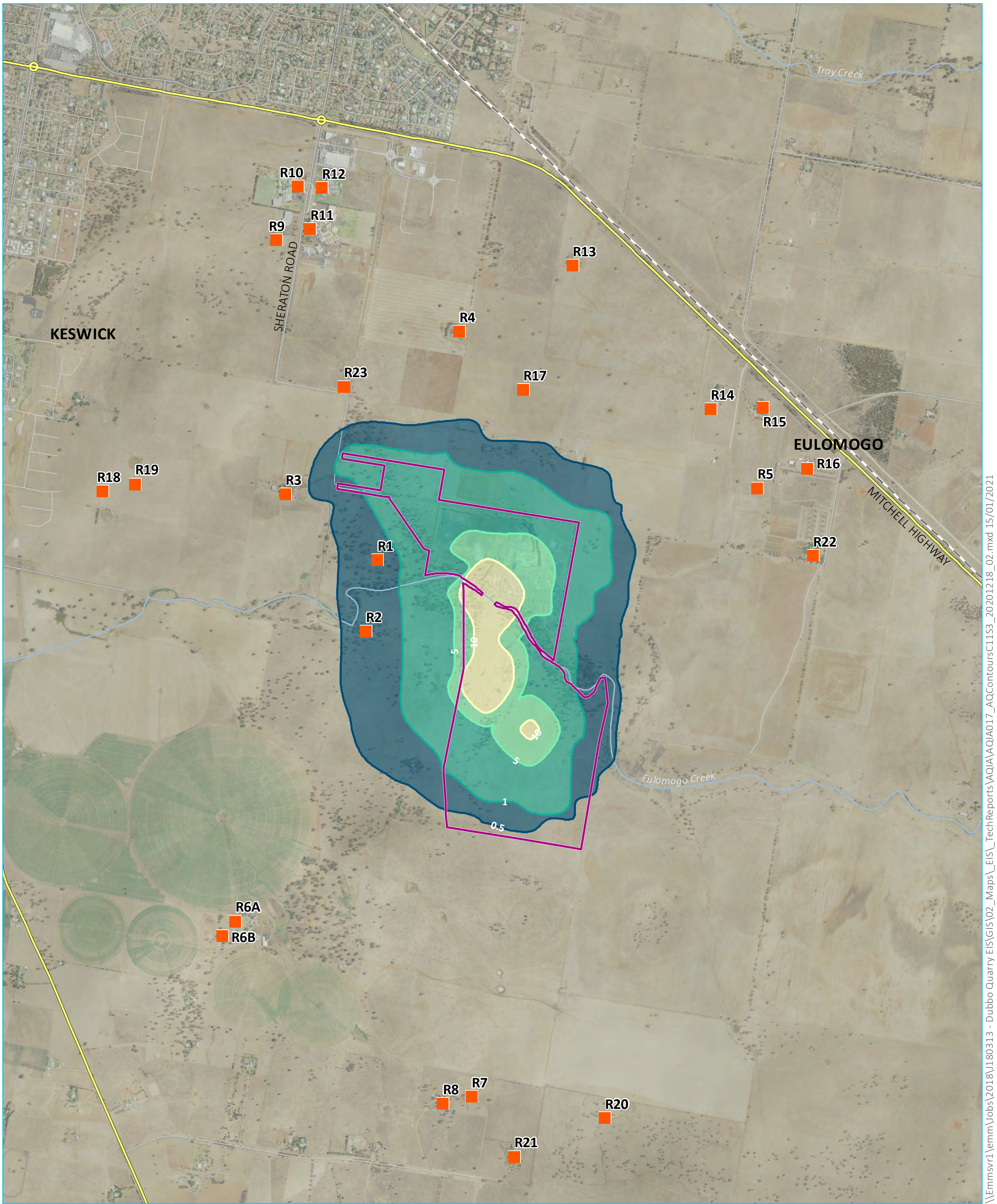
Annual $PM_{2.5}$ concentration range (μg/m^3)

- 0.05 - 0.1
- 0.1 - 0.5
- > 0.5

Predicted annual average $PM_{2.5}$ concentrations – Dubbo Quarry only (scenario 3)

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure C.10

EMM creating opportunities



Source: EMM (2020); DFSI (2017); DFSI (2020)

0 0.5 1 km
GDA 1994 MGA Zone 55

KEY

- Project area
- Assessment location
- Rail line
- Major road
- Minor road
- Named watercourse

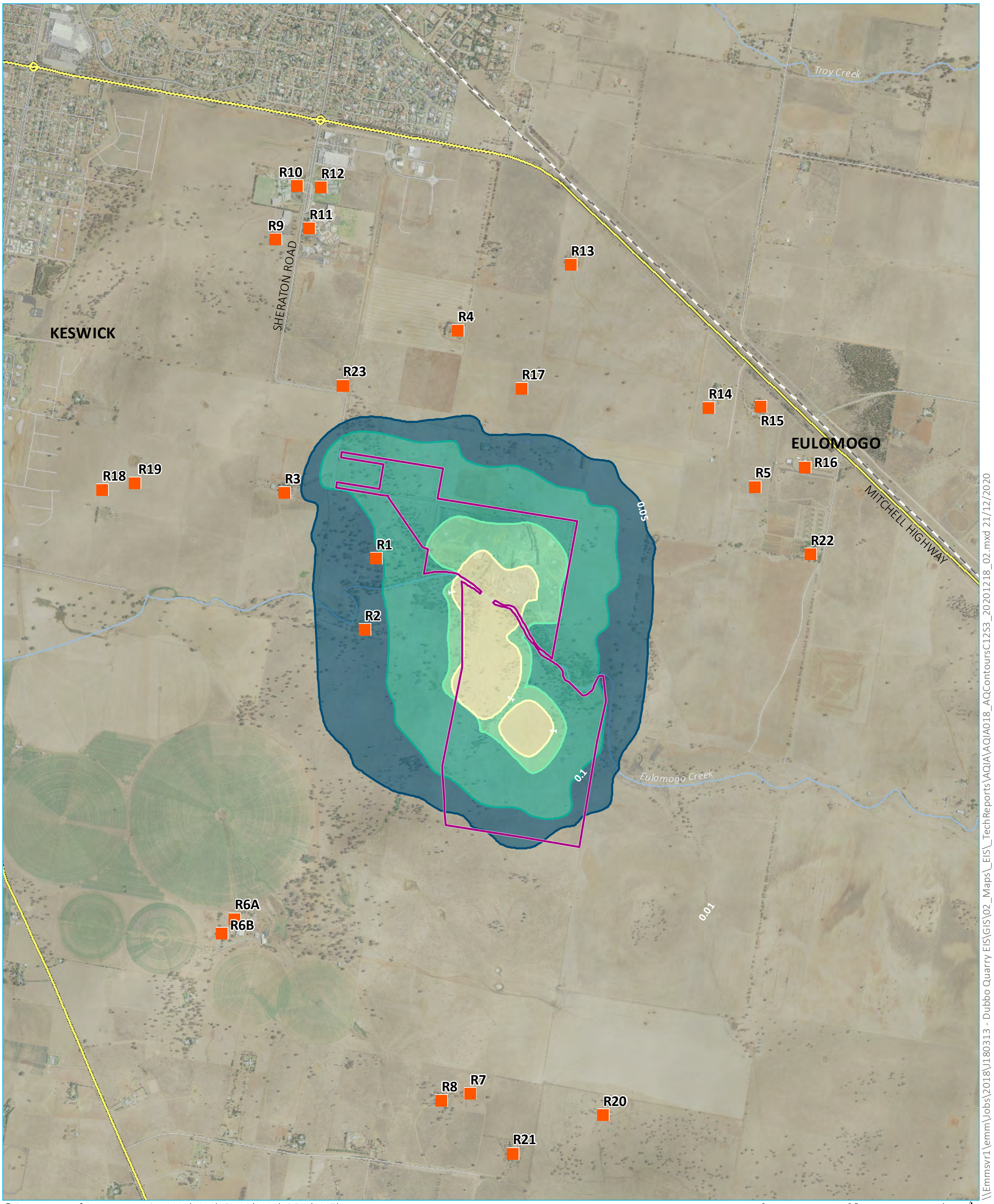
Annual TSP concentration range (µg/m³)

- 0.5 - 1
- 1 - 5
- 5 - 10
- > 10

Predicted annual average TSP concentrations – Dubbo Quarry only (scenario 3)

Dubbo Quarry Continuation Project
Air Quality Impact Assessment
Figure C.11

EMM
creating opportunities



0 0.5 1 km
GDA 1994 MGA Zone 55 N

KEY

- Project area
- Assessment location
- Rail line
- Major road
- Minor road
- Named watercourse

Annual dust deposition level range (g/m²/month)

- 0.05 - 0.1
- 0.1 - 0.5
- 0.5 - 1
- > 1

Predicted annual average dust deposition levels – Dubbo Quarry only (Scenario 3)

Dubbo Quarry Continuation Project
Air quality impact assessment
Figure C.12

EMM
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