APPENDIX Q

Air Quality Assessment

Clarrie Hall Dam Wall Raising

Air Quality Impact Assessment

Prepared for KBR Pty Ltd

August 2024

Clarrie Hall Dam Wall Raising

Air Quality Impact Assessment

KBR Pty Ltd

E230043 RP#2

August 2024

Version	Date	Prepared by	Approved by	Comments
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Approved by

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24 August 2024

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Executive Summary

This air quality impact assessment (AQIA) supports the environmental impact statement (EIS) for the proposed Clarrie Hall Dam Raising Project (the Proposal) located in the Northern Rivers region of NSW. Clarrie Hall Dam is a freshwater reservoir located on Doon Doon Creek, 15 kilometres (km) south-west of Murwillumbah.

The 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 the criteria.

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

Particulate matter emissions from the main construction activities associated with the Proposal were estimated and modelled. Analysis of existing meteorological and ambient air quality data was conducted to determine a representative year for modelling. The 2021 calendar year was selected based on this analysis.

Dispersion modelling was completed for a worst-case construction phase scenario of the Proposal using the TAPM and CALMET/CALPUFF model system. Two options for concrete batching plants (CBPs) were considered.

The results of the modelling show that the predicted concentrations and deposition rates for cumulative TSP, PM_{10}, $PM_{2.5}$ and dust deposition during the Proposal's construction phase did not exceed the applicable impact assessment criteria at any assessment locations and for both CBP options.

Several dust mitigation measures are proposed during the construction of the Proposal. These include water injection in drill holes, watering of exposed areas and stockpiles at the CBP, and watering of unpaved roads within rock movement areas. These measures were taken into consideration in the emissions estimation and modelling of the construction phase scenario.

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1 Introduction

1.1 Project overview

This air quality impact assessment (AQIA) has been prepared for the proposed Clarrie Hall Dam raising (the Proposal) in the Northern Rivers region of NSW. Clarrie Hall Dam is a freshwater reservoir located on Doon Doon Creek, 15 kilometres (km) south-west of Murwillumbah.

Clarrie Hall Dam was constructed in 1983 and is owned and operated by Tweed Shire Council for the primary purpose of providing drinking water to the Tweed Shire area. Tweed Shire Council is proposing to raise the wall of Clarrie Hall Dam by 8.5 metres (m), from a height of 61.5 m Australian Height Datum (m AHD) to a height of 70 m AHD. This will increase the capacity of the dam from 16,000 megalitres (ML) to approximately 42,300 ML. The purpose of the Proposal is to ensure water security for the Tweed Shire Council region until at least 2065.

The Proposal is State significant infrastructure (SSI). As SSI, the Proposal requires the preparation of an environmental impact statement (EIS) under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), and the secretary's environmental assessment requirements (SEARs) for the EIS were issued on 22 December 2023.

The SEARs do not specifically mention air quality. Nevertheless, this report has been prepared to address potential air quality impacts from the Proposal.

1.1 Purpose of this report

This AQIA has been completed in line with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* ('Approved Methods for Modelling') (NSW Environment Protection authority (EPA) 2022).

The key objectives of this AQIA are to:

- describe the local setting and surrounds of the Proposal
- detail the pollutants which are relevant to the assessment, and the applicable impact assessment criteria
- describe the existing environment, specifically:
  - the meteorology and climate
  - the existing air quality environment
- complete an air pollutant emission inventory for the Proposal
- complete atmospheric dispersion modelling for the quantified emissions, including an analysis of Proposal-only impacts and cumulative impacts that take into account baseline air quality
- provide an overview of mitigation measures proposed to be employed at the Proposal.

2 Proposal description

In 2018, a detailed concept design was prepared by NSW Public Works Advisory (PWA). The concept design for the raised dam and its components were based on hydrological studies, geotechnical investigations, and seismic and structural assessments. The preferred option for the dam raising incorporates increasing the height of the existing concrete-faced rockfill embankment and constructing a new concrete-lined spillway higher up in the left abutment. The existing intake tower and access bridge would also be raised.

The optimum capacity of the proposed raised Clarrie Hall Dam is 42,300 ML, based on raising the dam wall height by 8.5 m to a height of RL 70 m (AHD). The raised dam would, as a result, provide adequate water supply to the Tweed Shire until at least 2065. Raising the wall height further was not considered feasible due to topographical constraints in the catchment.

The concept design includes:

- constructing access roads to construction areas and establishing the construction site
- re-establishing the quarry used to construct the existing dam
- removing and storing parapet walls for reuse
- increasing the base width of the valley-side abutment, and raising the crest of the concrete-faced rockfill embankment to RL 70 m
- constructing a new concrete-lined spillway higher on the west abutment
- extending the upstream concrete face to the new crest height
- raising the intake tower and access bridge
- constructing a new section of the Clarrie Hall Dam Road to provide access to the east abutment of the dam wall
- establishing new recreation and operational facilities, including an amenities block, public shelters, viewing areas, interpretation signage, paths, car parks, landscaping, security fences, lighting, monitoring equipment and a boat ramp.

In addition, construction activities would include:

- upgrading the Kyogle Road and Clarrie Hall Dam Road intersection
- replacing McCabes Bridge and realigning Commissioners Creek Road
- removing or reconstructing impacted infrastructure and facilities at Crams Farm
- relocating Telstra assets
- realigning power line easements along Doon Doon Road and Commissioners Creek Road.

Further work has been completed that identified several options for locating worker accommodation, the concrete batching plant and site offices during construction. Two options for the locations of the worker accommodation and concrete batching plant are proposed, and the final locations will be decided during detailed design.

Figure 2.1 shows the Proposal in a regional context, the extent of the proposed full-supply level (FSL), and assessment locations including the worker accommodation (detailed in Section 3.2).

Figure 2.2 shows an overview of the project including the two concrete batching plant options and two worker accommodation options (further explained in Section 3.2).

The construction disturbance area and associated activities include the dam wall area and ancillary areas. The construction disturbance area is estimated to be approximately 49.6 ha and includes:

- the raised dam wall, spillway, road realignments/upgrades, quarry, stockpile sites and construction compounds, intake tower and bridge and recreational areas
- concrete batching plant
- worker accommodation
- upgrading the Kyogle Road and Clarrie Hall Dam Road intersection
- replacement of McCabes Bridge and realignment of Commissioners Creek Road
- removing or reconstructing impacted infrastructure and facilities at Crams Farm
- utilities relocations.

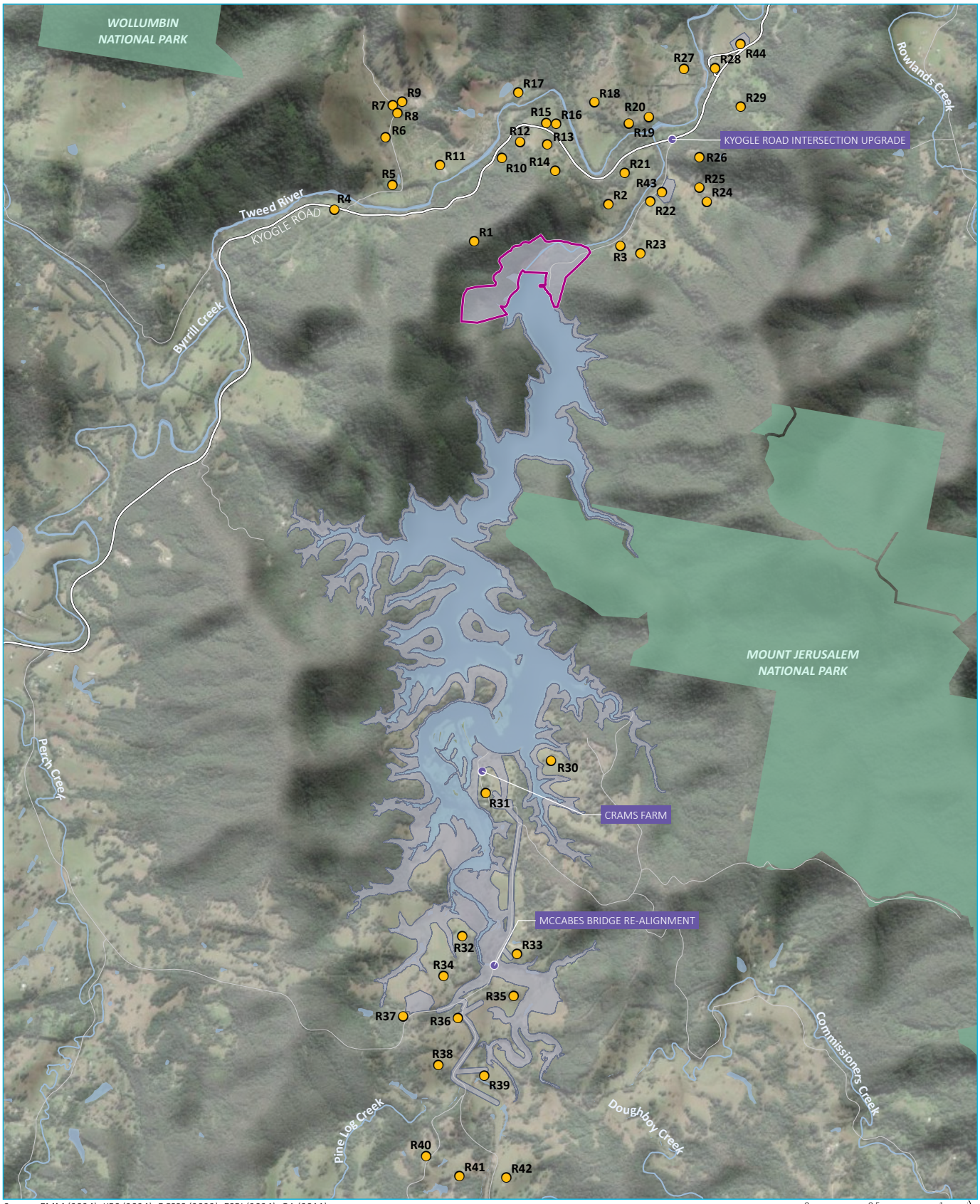
The operational footprint of the Proposal includes areas where there would be permanent operational elements or easements, including infrastructure needed to operate the raised Clarrie Hall Dam. This includes:

- raised inundation area (RL 70 m contour), which is the waterline boundary at FSL
- area between FSL and probable maximum flood (PMF)
- downstream areas, where there could be changes in flow.

A summary of the main elements of the Proposal is provided in Table 2.1, with further details provided in the EIS.

Table 2.1 Overview of the new Proposal elements

Proposal element	Summary
Operation	
Description	Raising the embankment wall of Clarrie Hall Dam by 8.5 m
Operational footprint	• Approximately 209 ha for the proposed FSL. • Approximately 248 ha for the area between the proposed FSL and the PMF.
Dam wall infrastructure	• Increasing the base width of the valley-side abutment and raising the crest of the concrete-faced rockfill embankment to RL 70 m. • Constructing a new concrete-lined spillway higher on the west abutment. • Extending the upstream concrete face to the new crest height. • Raising the intake tower and access bridge. • Constructing a new section of the Clarrie Hall Dam Road to provide access to the east abutment of the dam wall. • Establishing new recreation and operational facilities, including an amenities block, public shelters, viewing areas, interpretation signage, paths, car parks, landscaping, security fences, lighting, monitoring equipment and a boat ramp.
Ancillary works	• Upgrading the intersection of Clarrie Hall Dam Road and Kyogle Road. • Replacing McCabes Bridge over Doon Doon Creek. • Realigning an approximately 1,000 m section of Commissioners Creek Road. • Removing or reconstructing impacted infrastructure and facilities at Crams Farm. • Realigning overhead power lines and Telstra assets.
Construction	
Construction impact area	Approximately 49.6 ha, consisting of 26.2 ha at the dam wall, 6.6 ha of construction compound and workforce accommodation areas, and 16.8 ha of ancillary sites for road realignments and relocating overhead power lines. The removal of the existing overhead power line is not included in the impact area.
Workforce	Estimated peak of 180 persons at the main dam wall site.
Ancillary works	• Constructing access roads to construction areas and establishing the construction site. • Re-establishing the quarry used to construct the existing dam. • Establishing a concrete batching plant and areas for materials stockpiling. • Establishing construction compounds, including site offices • Establishing workforce accommodation compounds
Dewatering	Lowering dam storage by 300 mm below FSL during construction.
Property	Permanent and temporary property adjustments and property access refinements.



Source: EMM (2024); KBS (2024); DCSSS (2023); ESRI (2024); GA (2011)

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GDA2020 MGA Zone 56

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KEY

- Construction disturbance footprint
- Proposed construction disturbance footprint
- Assessment location
- Infrastructure upgrade location

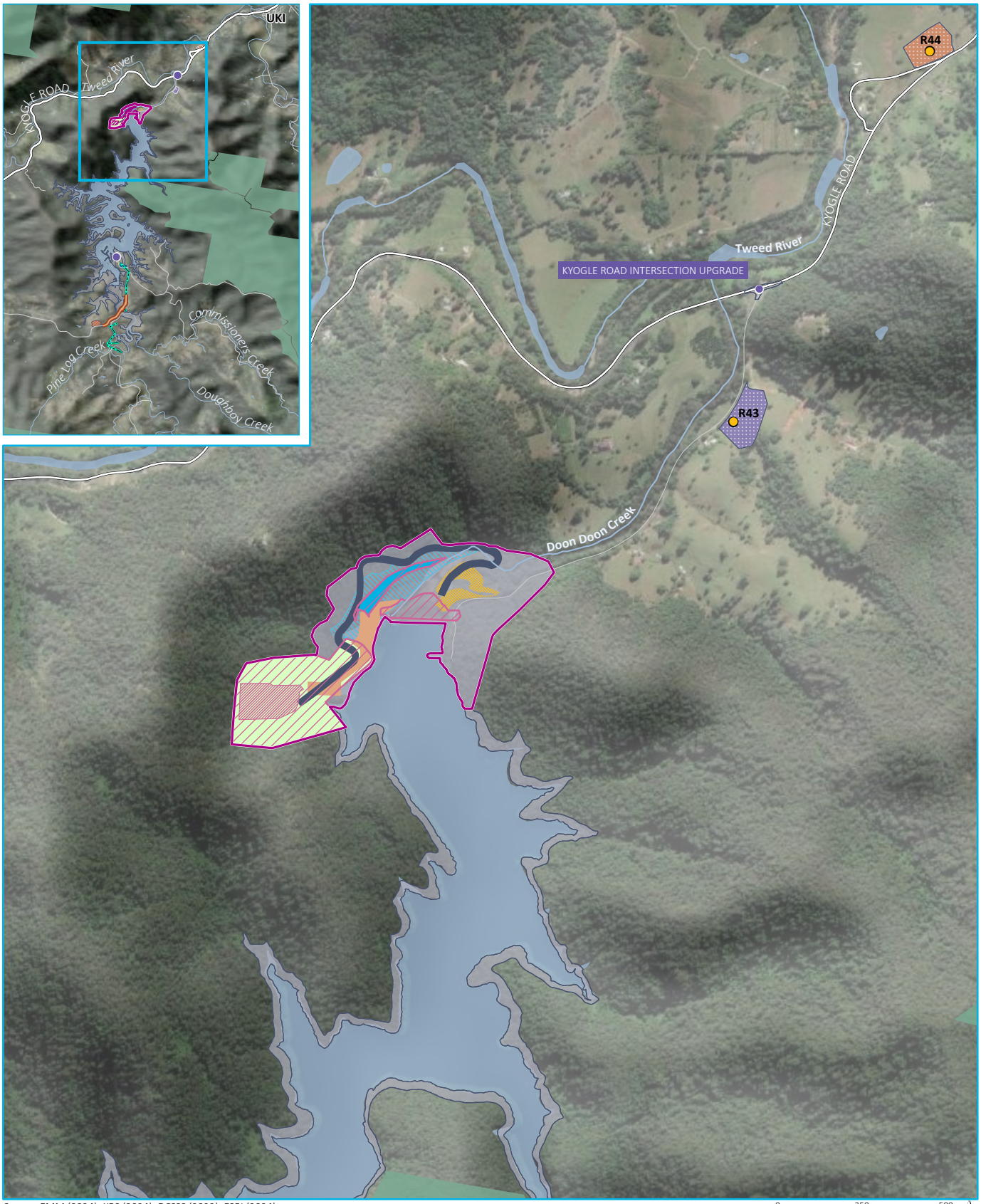
Existing environment

- Major road
- Minor road
- Named watercourse
- Waterbody
- NPWS reserve

Proposal footprint

Clarrie Hall Dam EIS
Air Quality Impact Assessment
Figure 2.1

EMM
creating opportunities



Source: EMM (2024); KBS (2024); DCSSS (2023); ESRI (2024)

0 250 500 m
GDA2020 MGA Zone 56
N

KEY

- Infrastructure upgrade location
- Worker accommodation option
- Construction disturbance footprint
- Proposed construction disturbance footprint

Proposed layout

- Concrete batching- option 1
- Concrete batching- option 2
- Haul Road- option 1
- Haul Road- option 2
- Office location
- Potential McCabes Bridge stockpile and construction office complex
- Quarry site- impact zone
- Spillway
- Spillway impact area
- Potential McCabes Bridge stockpile and construction office
- Quarry extraction area
- Direct disturbance footprint
- McCabes Bridge proposed realignment
- Proposed transmission line

Existing environment

- Rail line
- Major road
- Minor road
- Named watercourse
- Waterbody
- NPWS reserve

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Proposal overview

Clarrie Hall Dam EIS
Air Quality Impact Assessment
Figure 2.2

EMM
creating opportunities

3 Site and surrounding area

3.1 Terrain and topography

Clarrie Hall Dam is situated on Clarrie Hall Dam Road, Uki, in the small rural locality of Doon Doon, approximately 15 km south-west of Murwillumbah and 4 km south-west of Uki in the Tweed Shire local government area (LGA). The town of Murwillumbah is the largest town near the Proposal with approximately 10,000 residents.

The existing Clarrie Hall Dam is on Doon Doon Creek, which is a tributary of the Tweed River. It is bounded by the McPherson Range on the NSW/QLD border, the Burringbar, and Condong Ranges to the south-east, and the Tweed Range to the west.

Much of the Proposal area is surrounded by undulating and steep terrain, ranging in elevation from approximately 50 m to 1,000 m above sea level. Vegetation immediately surrounding the dam is dense and includes national park area. A three-dimensional representation of the local topography is presented in Figure 3.1.

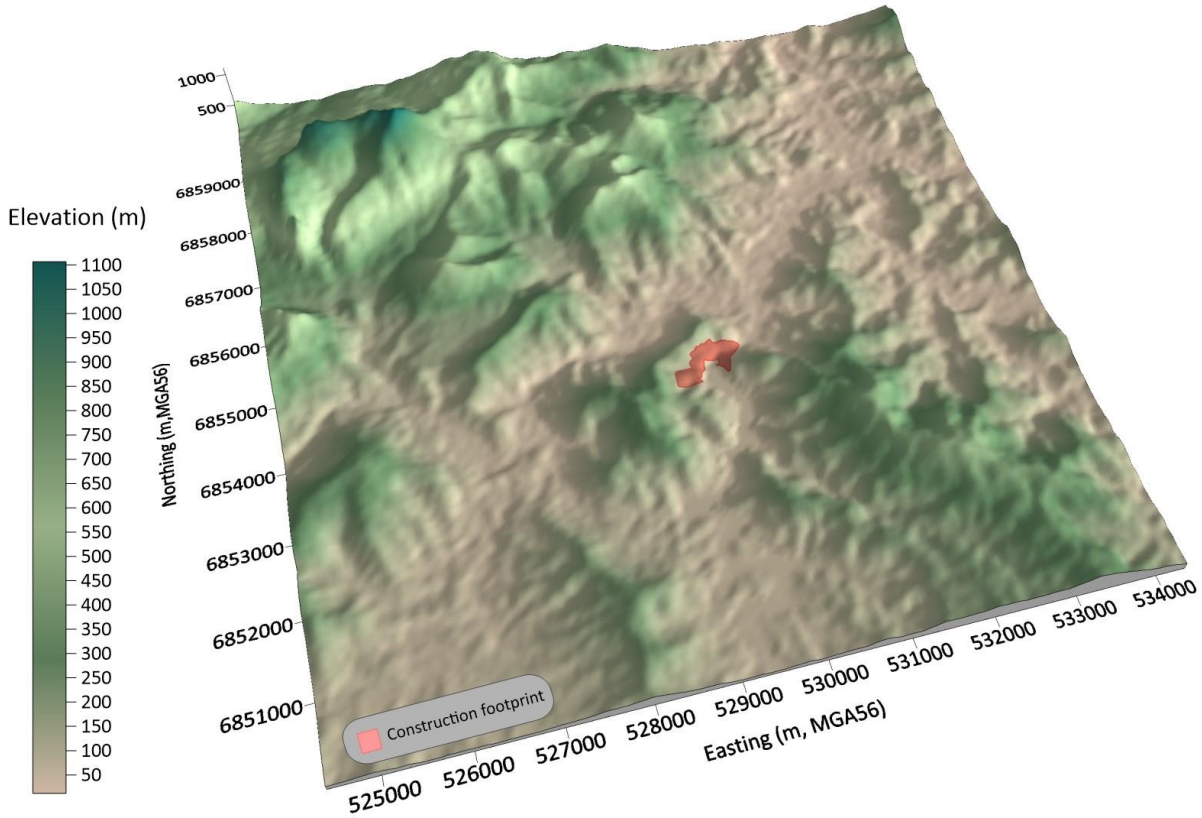


Figure 3.1 3-dimensional topography surrounding the Proposal area

Source: NASA Shuttle Radar Topography Mission data

3.2 Assessment locations

The nearest sensitive locations to the Proposal area have been identified for the purpose of assessing potential air quality impacts. These are referred to in this report as 'assessment locations'. Details of the assessment locations are provided in Table 3.1 and Figure 2.2.

The assessment locations include a mix of private residences, recreational facilities and Proposal accommodation.

Two locations for concrete batching plant (CBP) are being considered for the Proposal. If CBP option 1 is chosen, assessment location R43 will not exist. Inversely, where CBP option 2 is chosen, assessment location R44 will not exist. It is noted that there is another accommodation village proposed to the south of the project that is not related to the CBP options.

Table 3.1 Assessment locations

ID	Description	Classification	Coordinates (MGA 56)	
			Easting (m)	Northing (m)
R1	Private residence	Residential	529422	6854491
R2	Private residence	Residential	530420	6854767
R3	Private residence	Residential	530509	6854457
R4	Private residence	Residential	528384	6854729
R5	Private residence	Residential	528814	6854910
R6	Private residence	Residential	528763	6855264
R7	Private residence	Residential	528818	6855503
R8	Private residence	Residential	528852	6855444
R9	Private residence	Residential	528887	6855529
R10	Private residence	Residential	529629	6855112
R11	Private residence	Residential	529168	6855059
R12	Private residence	Residential	529763	6855231
R13	Private residence	Residential	529966	6855212
R14	Private residence	Residential	530024	6855017
R15	Private residence	Residential	529958	6855370
R16	Private residence	Residential	530032	6855365
R17	Private residence	Residential	529750	6855597
R18	Private residence	Residential	530316	6855526
R19	Private residence	Residential	530572	6855368
R20	Private residence	Residential	530721	6855415
R21	Private residence	Residential	530541	6855001
R22	Private residence	Residential	530731	6854789
R23	Private residence	Residential	530658	6854403

Table 3.1 Assessment locations

ID	Description	Classification	Coordinates (MGA 56)	
			Easting (m)	Northing (m)
R24	Private residence	Residential	531153	6854787
R25	Private residence	Residential	531097	6854891
R26	Private residence	Residential	531097	6855116
R27	Private residence	Residential	530982	6855774
R28	Private residence	Residential	531213	6855779
R29	Private residence	Residential	531403	6855492
R30	Private residence	Residential	529993	6850633
R31	Crams Farm reserve	Recreational	529509	6850392
R32	Private residence	Residential	529334	6849330
R33	Private residence	Residential	529741	6849196
R34	Private residence	Residential	529194	6849034
R35	Private residence	Residential	529716	6848885
R36	Private residence	Residential	529301	6848721
R37	Private residence	Residential	528894	6848734
R38	Private residence	Residential	529156	6848372
R39	Private residence	Residential	529497	6848292
R40	Private residence	Residential	529065	6847695
R41	Private residence	Residential	529313	6847545
R42	Private residence	Residential	529661	6847535
R43*	Potential Proposal worker accommodation	Accommodation	530818	6854857
R44*	Potential Proposal worker accommodation	Accommodation	531401	6855959

* Note: As noted above, if CBP option 1 is selected, R43 will not exist. If CBP option 2 is selected, R44 will not exist.

4 Pollutants and assessment criteria

4.1 Potential air pollutants

The construction phase of the Proposal will generate emissions of:

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

A detailed description of the emission sources associated with the Proposal's construction phase is presented in Section 8 of this report.

Operational phase emissions would principally consist of emissions from:

- wheel-generated dust emissions from the movement of vehicles along traffic routes between dam infrastructure on sealed roads
- fuel combustion (petrol, diesel) from vehicles travelling between dam infrastructure.

The volume of traffic and fuel combustion associated with the operation of the dam is likely to be significantly lower than the construction phase and similar to current operations. Additionally, the construction phase will involve the handling, transfer and emplacement of soil and rock and the construction of the worker accommodation. Consequently, air pollution emissions from the operations phase of the dam will be negligible relative to the construction phase. The construction phase therefore represents the most significant period of the dam for potential air quality impacts and is the focus of this report. The operational phase of the dam has not been considered further in this assessment.

This assessment focusses on particulate matter (TSP, PM_{10} and $PM_{2.5}$), given that the main concern during construction is likely to be dust from fugitive emission sources. Particles less than 10 µm and 2.5 µm in diameter are small enough to enter the human respiratory system and can lead to adverse health impacts. TSP, which relates to airborne particles less than around 30 µm in diameter, is used as a metric for assessing amenity impacts (reduction in visibility, dust deposition and soiling of buildings and surfaces) rather than health impacts (NSW EPA 2013).

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

Although there would be emissions of gaseous pollutants (e.g. NO_X, SO_2, CO, and VOCs) from mobile and stationary diesel equipment during construction, these were not included in the assessment. The reasons for this were as follows:

- There are no measurements of existing background concentrations for gaseous pollutants that would be representative of the Proposal area. For example, the closest NO_X and SO_2 measurements are around 80 km and 100 km from the Proposal, respectively. This means that a cumulative assessment for comparison with air quality criteria would have little value. However, the prevailing concentrations of these pollutants in the Proposal area are likely to be very low, given the absence of significant combustion sources.

- Of the pollutants identified above, the only one for which there could potentially be a material emission would be NO_X. The low-sulfur content of diesel would result in negligible SO_2 emissions, and CO and VOC emissions from diesel engines are inherently low.

- It would be very unlikely that diesel emissions during construction would result in high cumulative annual mean or maximum 1-hour NO_2 concentrations at the assessment locations, especially given the likelihood of a very low background and given the absence of significant combustion sources.

4.2 Assessment criteria

4.2.1 Airborne particulate matter

The air quality criteria that apply to the Proposal are stated in the Approved Methods for Modelling (NSW EPA 2022).

The criteria for airborne particulate matter are presented in Table 4.1. The Approved Methods for Modelling classifies TSP, PM_{10} and $PM_{2.5}$ as criteria pollutants, for which the criteria apply at the nearest existing or likely future off-site sensitive receptor and compared against the 100th percentile (i.e., the highest) dispersion modelling prediction in the case of 24-hour impacts. Both the incremental (Proposal impacts only) and cumulative (Proposal impacts plus background) impacts need to be presented, the latter requiring consideration of existing ambient background concentrations for the criteria pollutants assessed. The criteria provided in Table 4.1 relate to cumulative impacts.

Table 4.1 Impact assessment criteria for airborne particulate matter

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

Notes: µg/m^3: micrograms per cubic metre.

4.2.2 Dust deposition

The criteria for dust deposition in the Approved Methods for Modelling are given in Table 4.2. The criteria are for the Proposal increment and cumulative dust deposition levels. Dust deposition impacts are derived from TSP emission rates and particle deposition calculations in the dispersion modelling process.

Table 4.2 Impact assessment criteria for dust deposition (NSW EPA 2022)

Metric	Averaging period	Impact assessment criterion
Dust deposition	Annual	2 g/m^2/month (Proposal increment only)
		4 g/m^2/month (cumulative)

Notes: g/m^2/month: gram per square metre per month

5 Assessment methodology

5.1 Overview

As noted earlier the air quality assessment addresses the impacts of the Proposal's main construction activities on airborne particulate matter (TSP, PM_{10}, $PM_{2.5}$) and dust deposition.

This section provides a summary of the methodology for the AQIA, with more detail provided in subsequent section of this report. The methodology generally followed the guidance in the Approved Methods for Modelling (NSW EPA 2022).

Construction impacts were assessed based on emission estimates for key Proposal sources and dispersion modelling to predict ground-level pollutant concentrations at assessment locations. Concentrations were also calculated for a cartesian grid of points to produce contour plots.

5.2 Characterisation of the existing environment

There are no meteorological stations in the vicinity of the Proposal. Meteorological data recorded by the BoM Canungra (Defence) AWS from March 2018 to December 2022 were analysed for the purposes of selecting a representative year for dispersion modelling.

There are no air quality monitoring stations (AQMSs) in the vicinity of the Proposal. The closest AQMSs to the Proposal are in QLD and are operated by the QLD Department of Environment, Science and Innovation (DESI). Air quality monitoring data from the closest stations (North Maclean, Flinders View and Mutdapilly) were considered for the purposes of defining a background dataset to be used in the cumulative assessment.

Details of the meteorological and background air quality analysis are provided in Section 6, Section 7 and Appendix A of this report.

5.3 Assessment scenario

The assessment considered a single construction scenario. Construction is estimated to be completed within 18 months. The assessment assumes that all materials are moved within one year for conservatism.

As there are two potential CBP location options, both options were assessed, and the results have been presented separately in this report.

5.4 Emissions estimation

Emissions from fugitive dust sources associated with the construction emission scenario were quantified through the application of USEPA AP-42 emission factor equations. Particulate matter emissions were quantified for the three size fractions – TSP, PM_{10} and $PM_{2.5}$.

A description of the emission sources associated with the Proposal, and an inventory of emissions, are presented in Section 8 and Appendix B of this report.

5.5 Meteorological modelling and dispersion modelling

The dispersion modelling for this assessment involved the use of The Air Pollution Model (TAPM) and CALMET/CALPUFF.

Upper air profiles were generated by the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) TAPM meteorological model. CALMET was used as the meteorological pre-processor for the dispersion model CALPUFF.

TAPM was used to generate required parameters that are not routinely measured, specifically mixing height and vertical wind/temperature profile.

The CALMET/CALPUFF model suite is commonly used in NSW for applications where non-steady state conditions may occur (i.e., complex terrain or coastal locations) or when calm wind conditions are important (i.e., for odour assessment). CALMET is endorsed by the USEPA and recommended by the NSW EPA for these conditions.

The modelling system worked as follows:

- TAPM was used to generate gridded three-dimensional meteorological data for each hour of the model run period.
- CALMET was used to calculate fine-resolution, three-dimensional meteorological data based upon observed surface data, as well as upper air data generated for example by TAPM. From this, a 1 year representative meteorological dataset suitable for use in the 3-dimensional plume dispersion model, CALPUFF, was compiled.
- CALPUFF was used to calculate the dispersion of air pollutants within the 3-dimensional meteorological field.

Each emission source was represented in CALPUFF as a line-volume or volume source, located according to the layout of the Proposal's main construction areas.

In addition to the 45 individual assessment locations (documented in Section 3.2), pollutant concentrations were predicted over a 10 km (x-axis) by 14 km (y-axis) domain with 200 m resolution.

Simulations were undertaken for the 12-month period of 2021.

Further details of the meteorological and dispersion modelling are provided in Section 5.5, Appendix A and Appendix C.

6 Meteorology

6.1 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.

There are no meteorological stations in the vicinity of the Proposal. The closest meteorological station to the Proposal is operated by the BoM at Murwillumbah (Bray Park). This station however only records meteorological data at 9 am and 3 pm and therefore is not suitable for use in this assessment. The next closest stations to the Proposal are the BoM stations at Coolangatta and Byron Bay. As these sites are located along the coast, they are not considered to be representative of the Proposal's location and therefore were not used in the assessment. The BoM Canungra (Defence) AWS is approximately 46 km to the north of the Proposal. The station collects hourly measurements of wind speed, wind direction, temperature, relative humidity, standard deviation and rainfall. Data from this station were analysed for assessment but were not included in the meteorological modelling. This is explained further below.

6.2 Selection of a representative year

Meteorological data recorded by the BoM Canungra (Defence) AWS from March 2018 to the end of 2022 were analysed for the purposes of selecting a representative year for dispersion modelling. Details of the analysis are presented in Appendix A.

Analysis of wind speed, wind direction, temperature, and humidity data showed general correlation between years 2018 and 2022. It is noted that 2022 was affected by the La Niña phenomenon which resulted in significantly higher than average rainfall across the region.

The meteorological analysis resulted in the 2021 calendar year being chosen as the most representative year within 2018 to 2022.

6.3 Meteorological modelling

Atmospheric dispersion modelling for this assessment has been completed using the TAPM and CALMET meteorological models, as previously described.

As stated above, the closest meteorological station to the Proposal recording hourly data is the BoM Canungra (Defence) AWS which is 46 km from the Proposal. The CALMET model requires a 'radius of influence' value for each meteorological station dataset used in the model as observations. This value (usually in kilometres) will define the distance of 'influence' that the dataset will have on the CALMET meteorological predictions. These values will differ according to the characteristics of each project however, typical values are normally between 1 and 10 km. Beyond this distance, it is difficult to determine that meteorological data will be representative of a specific project location. In the case of the Proposal, it may even be more difficult owing to the significant terrain and topographical features that surround the construction works. For these reasons, data from the BoM Canungra (Defence) AWS were not included in the CALMET model as observations. As described in Section 6.2, the data from the BoM Canungra (Defence) AWS were analysed but only for the purposes of defining a representative calendar year for modelling.

As a result of the above, the 'no obs' (no observations) mode was selected in CALMET, which meant that no measured surface observations were included in the CALMET model.

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

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

Figure 6.1 illustrates the diurnal variation of atmospheric stability, derived from the Monin-Obukhov- L calculated by CALMET at the Proposal location. 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 will be greatest during daytime hours and lowest during evening through to early morning hours.

Further details of the TAPM and CALMET meteorological modelling are presented in Appendix A.

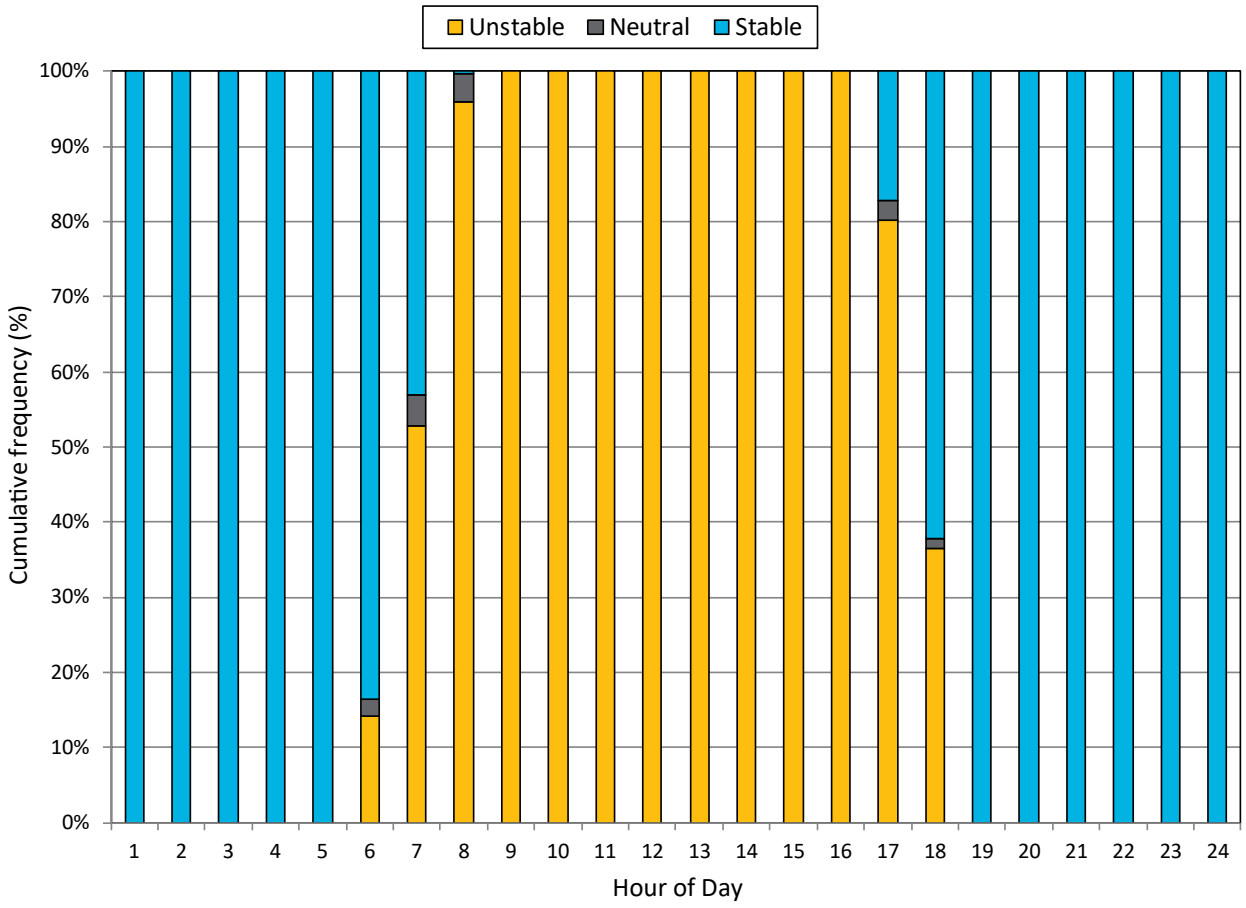


Figure 6.1 CALMET-calculated diurnal variation in atmospheric stability – CALMET ('no obs' mode)

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 L analysis above, higher daytime wind speeds and the onset of incoming solar radiation increase 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 6.2 presents the hourly-varying atmospheric boundary layer depths generated by CALMET. Greater boundary layer depths occur during the daytime hours, peaking in the mid to late afternoon.

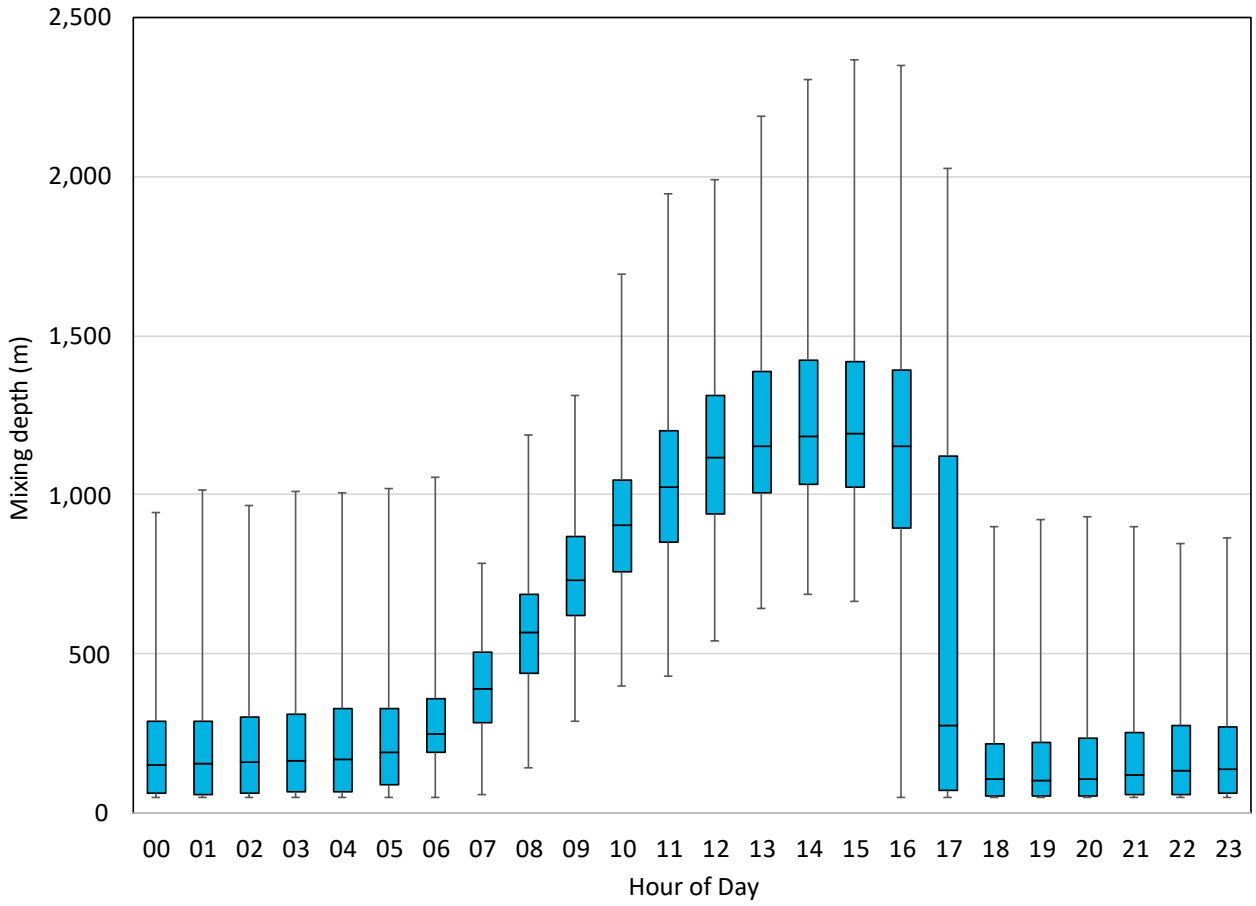


Figure 6.2 CALMET-calculated diurnal variation in atmospheric mixing depth – CALMET ('no obs' mode)

7 Baseline air quality

7.1 Introduction

Apart from the Proposal itself, air quality in the local airshed will also be influenced by:

- agricultural practices
- wind generated dust from exposed areas
- bushfires
- dust entrainment and exhaust emissions from vehicle movements along unsealed and sealed roads
- seasonal emissions from household wood heaters
- 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 the above emission sources are accounted for in the monitoring data analysed in the following sections of this report.

7.2 Air quality monitoring

There are no air quality monitoring stations at or in the vicinity of the Proposal. The closest AQMSs to the Proposal are in QLD and are operated by the QLD DESI. Characteristics of these AQMSs are summarised in Table 7.1. It is noted that DESI also operates an AQMS at Southport. However, this station was excluded from analysis given its coastal location which is in contrast to the inland location of the Proposal.

Table 7.1 Characteristics of AQMSs closest to the Proposal

Parameter	North Maclean	Mutdapilly	Flinders View	*Proposal area*
Distance to Proposal	78 km	99 km	101 km	-
Direction	NW	NW	NW	-
Region	South-East Queensland	South-East Queensland	South-East Queensland	Northern Rivers NSW
Elevation	22 m	89 m	59 m	*Approx. 50 m–290 m*
Data available from	PM_{10} and $PM_{2.5}$ commenced February 2021.	PM_{10} and $PM_{2.5}$ commenced February 2021.	PM_{10} from pre-2009. $PM_{2.5}$ commenced February 2021.	-
Pollutants (PM only)	PM_{10}, $PM_{2.5}$	PM_{10}, $PM_{2.5}$	PM_{10}, $PM_{2.5}$	-
Compliant with AS/NZS 3580.1.1:2007	Yes	Yes	Yes	-
Notes		Located approximately 20 m from an unsealed road		-

The following points about the monitoring stations are made:

- The closest DESI AQMS to the Proposal area is North Maclean, followed by Mutdapilly and Flinders View.
- The North Maclean and Mutdapilly AQMSs began collection of PM_{10} and $PM_{2.5}$ measurements in February 2021.
- The Flinders View AQMS has collected PM_{10} for over 10 years. However, monitoring of $PM_{2.5}$ concentrations commenced in February 2021.
- The Mutdapilly AQMS is located in proximity to a site with stockpiles, exposed ground, and unsealed haul routes. It is also approximately 20 m away from a main unsealed road. These factors could cause concentrations of PM_{10} and $PM_{2.5}$ at this site to be elevated and may therefore be less representative of the location of the Proposal. For this reason, the DESI Mutdapilly AQMS has not been considered further in this assessment.
- The Flinders View AQMS is located the furthest from the Proposal (101 km) and is within a high-density residential area. In contrast, the Proposal is located within a rural/forested area away from large population centres.

For the reasons presented above, the North Maclean AQMS was chosen to represent the baseline air quality conditions for the Proposal and for use in the cumulative assessment. The North Maclean AQMS is the closest to the Proposal and is surrounded by semi-rural land use. The area immediately surrounding the AQMS is sparsely populated. The North Maclean AQMS has monitored PM_{10} and $PM_{2.5}$ concentrations since February 2021. A summary of these data is provided in the following sections.

7.3 Summary of existing data

7.3.1 PM_{10}

Hourly PM_{10} concentration data from the North Maclean AQMS were converted to 24-hour average data, and the 24-hour values were analysed for the period of 4 February 2021 to 31 December 2022. The cumulative assessment in this study requires a full year of background air quality data. As there were no data available for the North Maclean AQMS between 1 January and 4 February 2021, the data gaps were filled using PM_{10} concentrations for the same period in 2022 at the North Maclean AQMS.

A summary of key statistics for the two years of analysed data is presented in Table 7.2. The data presented does not include the period of filled data as described above.

In 2021, the maximum 24-hour average PM_{10} concentration was almost at the impact assessment criterion of 50 µg/m^3. This was due to a regional dust event that resulted in elevated particulate matter concentrations at several other DESI AQMSs including at Flinders View and Mutdapilly. There were no exceedances of the 24-hour average criterion in 2021 or 2022.

Table 7.2 Statistics for PM_{10} concentrations – DESI North Maclean AQMS – 2021 to 2022

Monitoring year	Maximum 24-hour average concentration (µg/m^3)	Annual average concentration (µg/m^3)	Number of days greater than 50 µg/m^3	Data recovery (%)
2021	49.4	14.6	0	91
2022	29.0	13.3	0	98

7.3.2 $PM_{2.5}$

Hourly $PM_{2.5}$ concentration data from the North Maclean AQMS were converted to 24-hour average data, and the 24-hour values were analysed for the period of 4 February 2021 to 31 December 2022. As with the PM_{10} data, missing data between 1 January and 4 February 2021, were filled using $PM_{2.5}$ concentrations for the same period in 2022 at the North Maclean AQMS.

A summary of key statistics for the two years of analysed data is presented in Table 7.3

In 2021, the maximum 24-hour average $PM_{2.5}$ concentration was above the impact assessment criterion of 25 µg/m^3 on one day. This elevated concentration was most likely due to smoke from hazard-reduction burning conducted at Buccan Conservation Park located approximately 11 km away. The measured PM_{10} concentration on this day was also elevated (38.2 µg/m^3). The next highest measurement in the dataset was 21.6 µg/m^3.

Table 7.3 Statistics for $PM_{2.5}$ concentrations – DESI North Maclean AQMS – 2021 to 2022

Monitoring year	Maximum 24-hour average concentration (µg/m^3)	Annual average concentration (µg/m^3)	Number of days greater than 25 µg/m^3	Data recovery (%)
2021	25.7	5.9	1	91%
2022	17.0	5.4	0	98%

7.4 Selection of a representative year

There are no criteria for selecting a representative year for modelling, but it is desirable to use a recent year that reflects 'typical' meteorology and air quality. At present, however, the concept of 'typical' is difficult to interpret, as the data for recent years (especially those for particulate matter) have been strongly affected by drought conditions, extensive bush fires and the La Niña phenomenon[2].

For this assessment, 2021 was selected as the representative year. The reasons for this were as follows:

- 2022 was impacted by significantly higher than average rainfall due to the La Niña phenomenon. This is reflected in the lower maximum 24-hour average and annual average concentrations shown in the previous sections. Data in 2022 may therefore not be representative of long-term averages and may underestimate cumulative concentrations.
- Consistency between years in the meteorological data.

[2] La Niña is the colder counterpart of El Niño and is part of the broader El Niño–Southern Oscillation (ENSO) climate pattern.

7.5 Assumed background concentrations

The background pollutant values adopted for cumulative assessment, based on the analysis presented in the preceding sections, are described below.

7.5.1 PM_{10} and $PM_{2.5}$

A time series of the 24-hour average PM_{10} concentrations dataset at North Maclean for 2021 is presented in Figure 7.1. This dataset was used to represent PM_{10} background data in the cumulative assessment. The maximum 24-hour average PM_{10} concentration was 49.4 µg/m^3 and the annual average concentration was 14.5 µg/m^3.

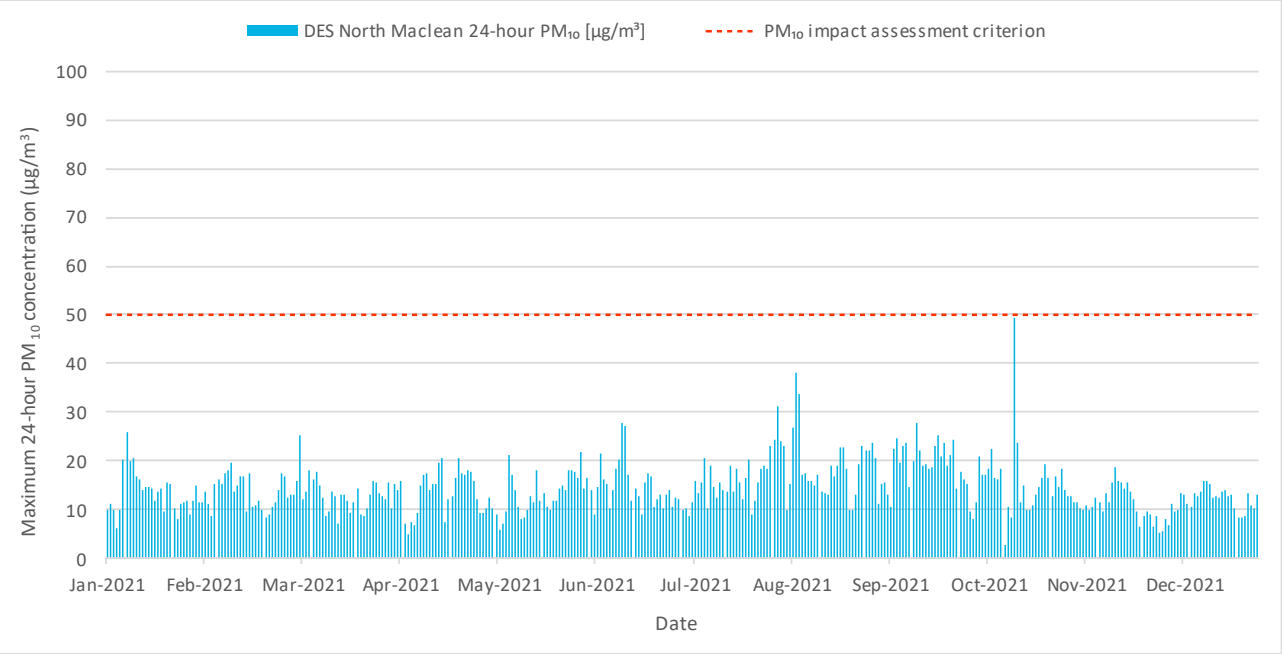


Figure 7.1 Time series of 24-hour average PM_{10} concentrations – North Maclean AQMS – 2021

A time series of the 24-hour average $PM_{2.5}$ concentrations dataset at North Maclean for 2021 is presented in Figure 7.2. This dataset was used to represent $PM_{2.5}$ background data in the cumulative assessment. The maximum 24-hour average $PM_{2.5}$ concentration was 21.6 µg/m^3 and the annual average concentration was 5.8 µg/m^3.

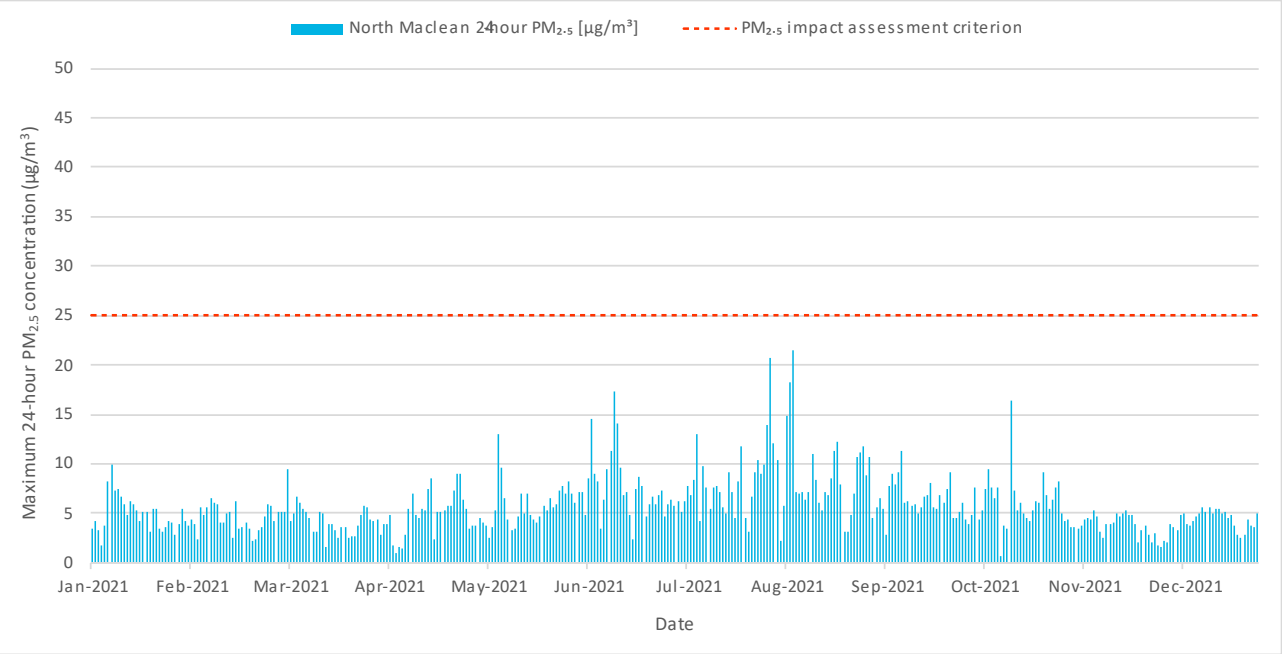


Figure 7.2 Time series of 24-hour average $PM_{2.5}$ concentrations – North Maclean AQMS – 2021

7.5.2 TSP

Concentrations of TSP are not measured at any of the aforementioned DESI AQMSs. The percentage of PM_{10} in 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 DESI North Maclean dataset for 2021 (of 14.5 µg/m³). The resulting TSP background concentration is 36.3 µg/m³.

7.5.3 Dust deposition

Dust deposition is not recorded at the DESI AQMSs. A background value of 2 g/m²/month has been adopted for this air quality assessment (EPA Victoria 2022). This is likely to be conservative given the lack of dust-generating sources in the area.

8 Emissions inventory

8.1 Sources of emissions

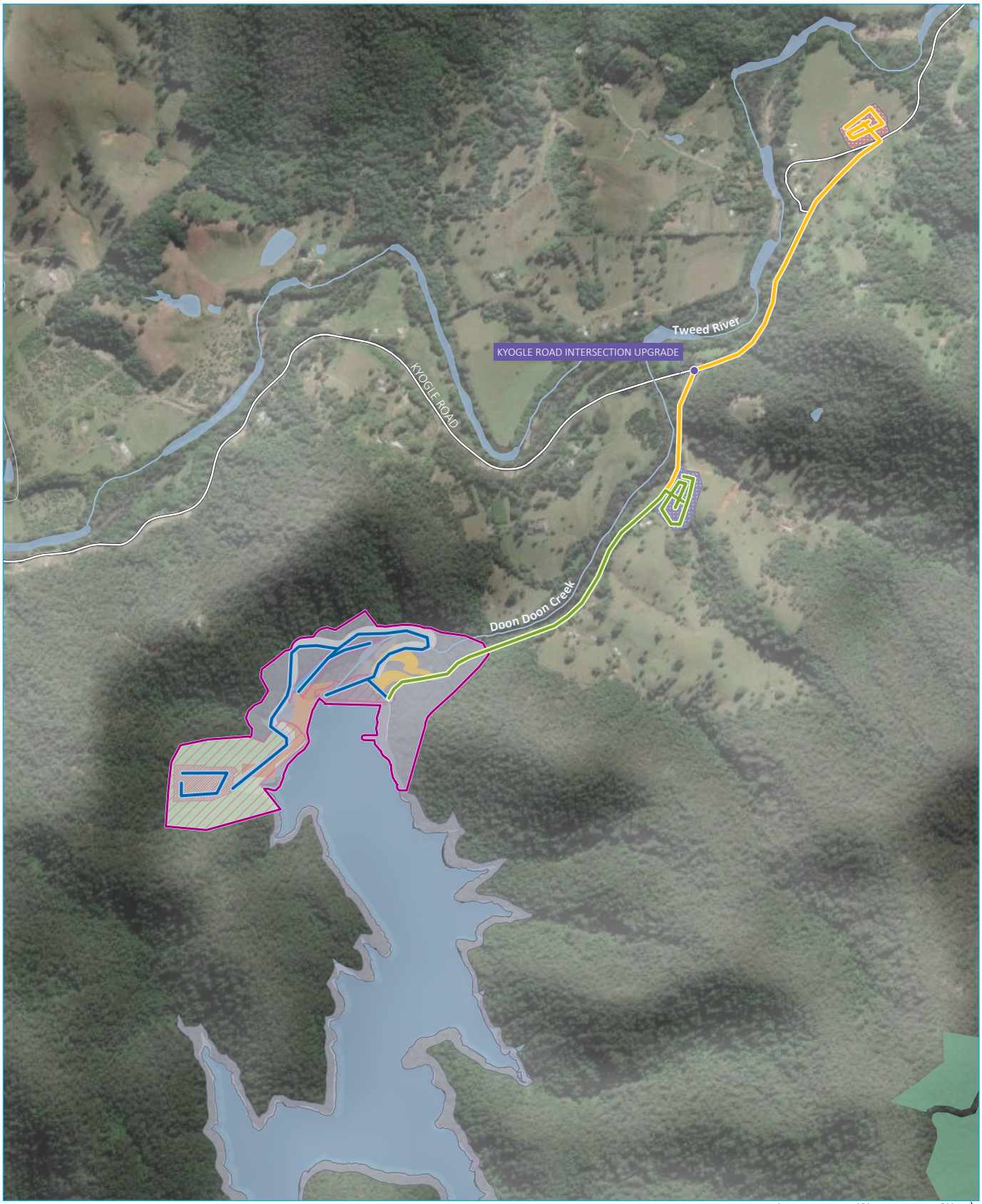
An emissions inventory was developed to quantify emissions of various pollutants resulting from the construction of the Proposal. The emissions inventory only considered a single 'worst-case' construction year. This year was representative of the majority of spoil movement. It also was assumed that the construction of the worker accommodation would occur before this worst-case year, and this was therefore excluded. The most significant areas of dust generation will be at the quarry, spillway, embankment and concrete batching plant. The main dust-generating sources included in the inventory were:

- stripping soil and overburden
- loading and unloading soil, overburden and rock
- drilling and blasting
- excavating rock
- crushing and screening rock
- hauling materials on unpaved roads
- hauling concrete on paved roads
- concrete batching plant operations
- wind erosion from exposed areas
- diesel combustion from plant equipment and trucks.

Each activity has been represented in the modelling as a volume or line-volume source. The modelled source locations are shown in Figure 8.1.

There will also be some ancillary construction works associated with the realignment of Commissioners Creek Road and the replacement of McCabes Bridge approximately 5.2 km south of the Proposal. The main dust-generating activities associated with these activities will be trucks hauling materials to and from the area, wind erosion from stockpiles, and diesel combustion from trucks. It is noted that the haul routes to and from the Commissioners Creek Road/McCabes Bridge construction areas are paved and stockpile areas prone to wind erosion are likely to be small in comparison to the main works at the spillway and embankment area. The closest residences to the McCabes Bridge works are approximately 200 m away and predominantly separated by large trees. Given the relatively minor works proposed in the Commissioners Creek Road/McCabes Bridge construction areas in comparison to the main works assessed (i.e. the spillway and embankment), potential dust impacts have not been further assessed. It is noted that predicted impacts from the Proposal alone at assessment locations surrounding the main construction works were well below the assessment criteria (see Sections 9.1.1 and 9.2.1). Therefore, it can be reasonably assumed that residences surrounding these ancillary works are also likely to be below the criteria given the smaller scale of the works. Dust mitigation measures (see Section 10 of this report) will be applied in these areas to manage any potential air quality impacts at surrounding residences.

It should be noted that, for Concrete Batching Plant Option 1, the air quality modelling was based on access along Kyogle Road, as shown in Figure 8.1. However, access will actually be from Tarcoola Lane. However, the closest receptors had very low predicted concentrations (see section 9), and this change would not have had a material effect on the results.



Source: EMM (2024); KBS (2024); DCSSS (2023); ESRI (2024)

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KEY

- Infrastructure upgrade location
- Construction disturbance footprint
- Proposed construction disturbance footprint

Proposed layout

- Concrete batching - option 1
- Concrete batching - option 2
- Haul Road - option 1
- Haul Road - option 2
- Office location
- Quarry site - impact zone
- Spillway
- Quarry extraction area
- Direct disturbance footprint

Model source

- Clarrie Hall Dam sources
- CBP option 1 sources
- CBP option 2 sources

Existing environment

- Rail line
- Major road
- Minor road
- Named watercourse
- Waterbody
- NPWS reserve

Model source locations

Clarrie Hall Dam EIS
Air Quality Impact Assessment
Figure 8.1

EMM
creating opportunities

8.2 Emissions estimates

The calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions for each activity occurring at the Proposal are shown in Table 8.1. The emissions for the two CBP options are shown separately.

Emissions from diesel combustion were attributed equally to all activities generating diesel emissions. Emissions from activities were estimated for between the hours of 7:00 am and 6:00 pm, except for wind erosion which was calculated for 24 hours per day.

A graphical summary of the relative contributions to annual dust emissions of the various source types is provided in Figure 8.2. The figure represents emissions that include CBP option 2 being the worst-case (i.e. highest emissions) scenario due to it being closer to the Proposal. Particulate matter control measures, as documented in Section 10, are included in these emission totals.

From the data presented in the following figures and tables, the most significant source of particulate matter emissions from the Proposal's construction activities were hauling materials on unpaved and paved roads, diesel combustion, and material handling. For TSP, the major sources of emissions were from unpaved roads and diesel combustion. For PM_{10} and $PM_{2.5}$, the dominating source was diesel combustion.

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

Table 8.1 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions

Emission source	Calculated annual emissions (kg/year) by source		
	TSP	PM_{10}	$PM_{2.5}$
Rock quarrying			
Stripping soil and overburden	<0.1	<0.1	<0.1
Loading soil to trucks	<0.1	<0.1	<0.1
Drilling	850	442	25
Blasting	334	174	10
Excavating rock	76	36	5
Crushing rock	137	62	11
Screening rock	251	84	6
Loading rockfill to trucks	76	36	5
Trucks hauling rockfill from the quarry to the embankment	9,348	2,402	240
Spillway			
Stripping soil and overburden	1	<0.1	<0.1
Loading soil and overburden to trucks	1	<0.1	<0.1
Hauling soil and overburden across spillway area	106	27	3
Unloading soil and overburden to stockpile	4	2	<0.1

Table 8.1 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions

Emission source	Calculated annual emissions (kg/year) by source		
	TSP	PM_{10}	$PM_{2.5}$
Drilling	106	55	3
Blasting	42	22	1
Excavating rock for the embankment	30	14	2
Crushing rock	55	25	5
Screening rock	100	34	2
Rehandle to trucks	30	14	2
Hauling rockfill from spillway to embankment placement	2,301	591	59
Embankment			
Trucks unloading rockfill from quarry to embankment stockpile	76	36	5
Trucks unloading rockfill from the spillway excavation zone to embankment stockpile	5	2	<0.1
Excavating rock in existing embankment	19	9	1
FELs loading excavated rock to trucks	4	2	<0.1
Hauling rock to embankment stockpile	398	102	10
Trucks unloading excavated rock to stockpile	4	2	<0.1
Crushing rock	8	4	1
Screening rock	14	5	<0.1
FELs loading stockpiled rock to trucks	4	2	<0.1
Hauling rock to embankment construction area	89	23	2
Unloading rock to embankment construction area	4	2	<0.1
FELs/excavators shaping/spreading rock	80	38	6
All wind erosion (excl. the CBPs)			
Wind erosion from the quarry	1,483	741	111
Wind erosion from exposed spillway ground	1,275	638	96
Wind erosion from exposed embankment ground and stockpile	252	126	19
Other			

Table 8.1 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions

Emission source	Calculated annual emissions (kg/year) by source		
	TSP	PM_{10}	$PM_{2.5}$
Diesel combustion (whole site)	10,878	10,878	9,972
CBP - OPTION 1			
Trucks unloading cement to silo	42	20	3
Trucks unloading aggregate/sand to stockpiles	7	4	1
Trucks/FELs transferring aggregate/sand to hopper	7	4	1
Conveyors transferring sand and aggregate on-site	7	4	1
Weigh hopper loading	0.1	0.0	0.0
Truck loading (truck mixing)	3.4	0.9	0.1
Trucks hauling concrete from CBP to dam wall embankment (paved roads)	3,077	591	143
Wind erosion at CBP1	570	285	43
Diesel combustion (CBP1)	110	110	101
CBP - OPTION 2			
Conveyors transferring materials on-site	42	20	3
Trucks unloading cement to silo	7	4	1
Trucks unloading aggregate/sand to bunkers	7	4	1
Conveyors transferring sand and aggregate on-site	7	4	1
Weigh hopper loading	0.1	0.0	0.0
Truck loading (truck mixing)	3.4	0.9	0.1
Trucks hauling concrete from CBP to dam wall embankment (paved roads)	6,648	1,276	309
Wind erosion at CBP2	421	210	32
Diesel combustion (CBP2)	110	110	101
Total kg/y with CBP Option 1	**32,268**	**17,648**	**10,898**
Total kg/y with CBP Option 2	**35,691**	**18,259**	**11,053**

Note: Totals may not add up exactly due to rounding.

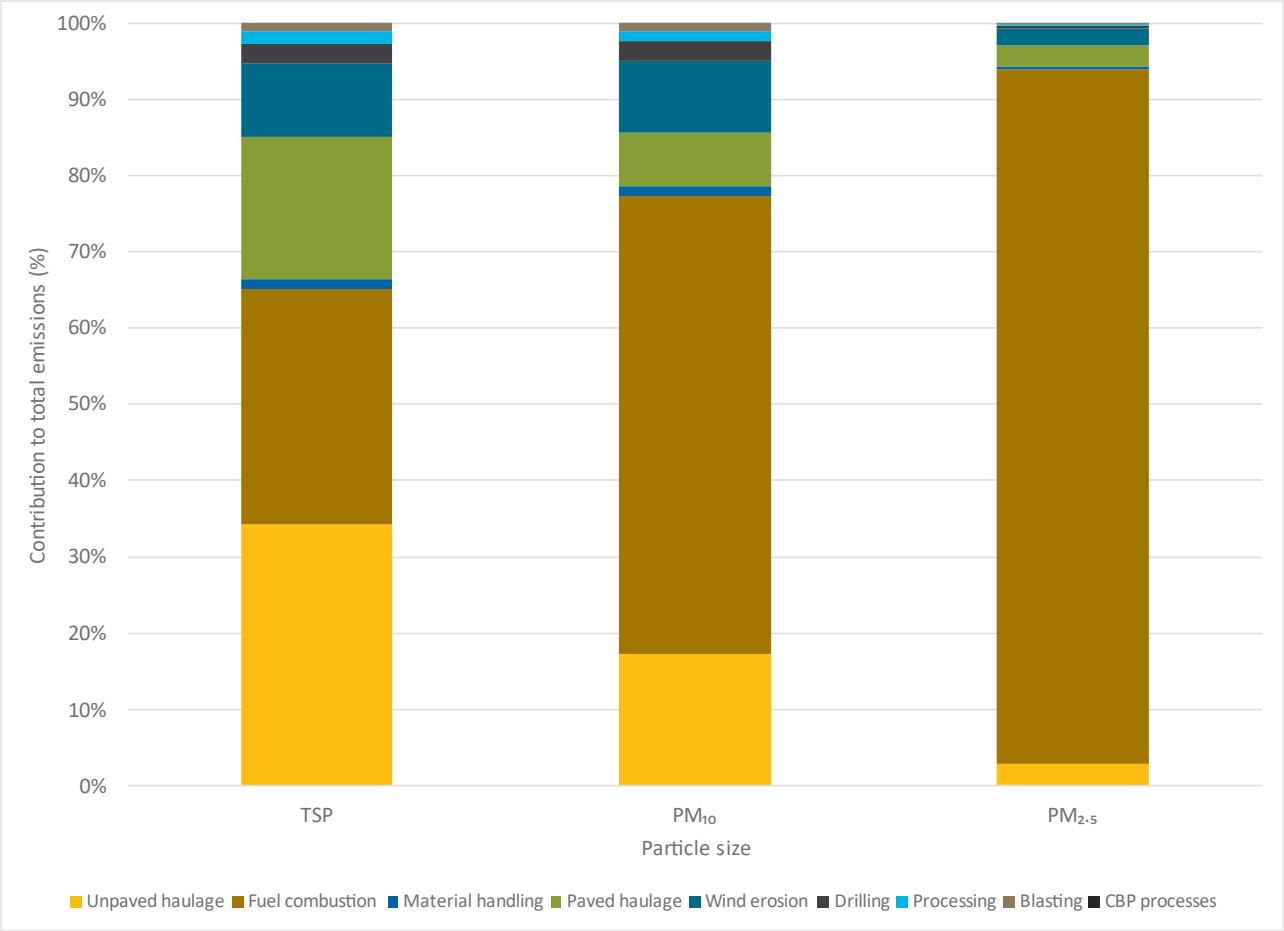

Figure 8.2 **Contribution to annual particulate matter emissions by emissions source type and particle size metric (CBP option 2)**

9 Dispersion modelling results

9.1 The Proposal with CBP option 1

9.1.1 Incremental results

Predicted incremental TSP, PM_{10}, $PM_{2.5}$, and dust deposition levels from the Proposal's construction phase with CBP option 1 are presented in Table 9.1 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.

The predicted contribution of air quality sources at the CBP was minor when compared to the total concentrations and the impact assessment criteria. For example, for 24-hour PM_{10} concentrations, the maximum predicted contribution from the CBP was 0.79 µg/m^3 at R22 (the closest to the CBP). This represents 1.6% of the impact assessment criterion of 50 µg/m^3.

Except for dust deposition, the assessment criteria listed are applicable to cumulative concentrations. An analysis of cumulative impacts is presented in Section 9.2.2.

Table 9.1 Incremental (Proposal-only with CBP option 1) concentration and deposition results

Assessment location ID	Predicted incremental concentration (µg/m^3) and deposition rate (g/m^2/month)					
	TSP	PM_{10}		$PM_{2.5}$		Dust deposition
Criterion	**90**	**50**	**25**	**25**	**8**	**2**
R1	0.7	3.8	0.6	2.9	0.4	<0.1
R2	0.4	1.6	0.2	1.2	0.2	<0.1
R3	0.6	1.9	0.2	1.3	0.1	0.1
R4	0.1	0.6	0.1	0.5	<0.1	<0.1
R5	0.1	0.6	0.1	0.4	0.1	<0.1
R6	0.1	0.5	0.1	0.4	<0.1	<0.1
R7	0.1	0.4	0.1	0.3	<0.1	<0.1
R8	0.1	0.4	0.1	0.4	<0.1	<0.1
R9	0.1	0.4	0.1	0.8	<0.1	<0.1
R10	0.2	0.9	0.1	0.7	0.1	<0.1
R11	0.1	0.7	0.1	0.5	0.1	<0.1
R12	0.1	0.8	0.1	0.7	0.1	<0.1
R13	0.2	0.8	0.1	0.7	0.1	<0.1
R14	0.2	1.3	0.2	1.1	0.2	<0.1
R15	0.1	0.7	0.1	0.6	0.1	<0.1
R16	0.1	0.7	0.1	0.6	0.1	<0.1
R17	0.1	0.6	0.1	0.5	0.1	<0.1

Table 9.1 Incremental (Proposal-only with CBP option 1) 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
Criterion	**90**	**50**	**25**	**25**	**8**	**2**
R18	0.1	0.6	0.1	0.5	0.1	<0.1
R19	0.1	0.7	0.1	0.6	0.1	<0.1
R20	0.1	0.6	0.1	0.5	0.1	<0.1
R21	0.2	1.0	0.1	0.7	0.1	<0.1
R22	1.4	1.6	0.4	0.9	0.2	0.3
R23	0.1	1.5	0.1	1.1	0.1	<0.1
R24	0.1	0.6	<0.1	0.5	<0.1	<0.1
R25	0.1	0.7	0.1	0.5	<0.1	<0.1
R26	0.1	0.7	0.1	0.5	<0.1	<0.1
R27	0.1	0.4	<0.1	0.3	<0.1	<0.1
R28	<0.1	0.4	<0.1	0.3	<0.1	<0.1
R29	<0.1	0.4	<0.1	0.3	<0.1	<0.1
R30	<0.1	0.1	<0.1	0.3	<0.1	<0.1
R31	<0.1	0.1	<0.1	0.2	<0.1	<0.1
R32	<0.1	0.1	<0.1	0.5	<0.1	<0.1
R33	<0.1	0.1	<0.1	0.4	<0.1	<0.1
R34	<0.1	0.1	<0.1	0.2	<0.1	<0.1
R35	<0.1	0.1	<0.1	0.3	<0.1	<0.1
R36	<0.1	0.1	<0.1	0.1	<0.1	<0.1
R37	<0.1	0.1	<0.1	0.1	<0.1	<0.1
R38	<0.1	0.1	<0.1	0.1	<0.1	<0.1
R39	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
R40	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
R41	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
R42	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
R43	This assessment location will not exist under CBP option 1.					
R44	<0.1	0.3	<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 are provided for comparison purposes only.

9.1.2 Cumulative results

Cumulative impacts (i.e. the Proposal plus the CBP and background) at each of the assessment locations 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 Proposal and the CBP has been combined with the corresponding concentrations from the adopted 2021 background concentration datasets (Section 7.5).

For annual average concentrations – the predicted annual average concentrations have been paired with the corresponding background annual average concentration (Section 7.5).

As stated in Section 7.3.2, the adopted 24-hour average $PM_{2.5}$ background dataset contains one day above the impact assessment criterion which was the result of a smoke from hazard-reduction burning event. For cumulative impact assessment purposes, this day is therefore classed as existing exceedance.

Section 5.1.3 of the Approved Methods for Modelling (EPA 2022) states that in the event of existing ambient air pollutant concentrations in exceedance of applicable impact assessment criteria, the assessment must:

> …demonstrate that no additional exceedances of the impact assessment criteria will occur as a result of the proposed activity and that best management practices will be implemented to minimise emissions of air pollutants as far as is practical (EPA 2022)

To demonstrate whether additional exceedances of the applicable criteria will occur as a result of emissions from the Proposal, the exceedance day described above was removed from the dataset and the gap was filled using interpolation.

Predicted cumulative TSP, PM_{10}, $PM_{2.5}$, and dust deposition levels from the Proposal's construction phase with CBP option 1 are presented in Table 9.2 for each of the assessment locations.

The predicted concentrations and deposition rates for cumulative TSP, PM_{10}, $PM_{2.5}$ and dust deposition did not exceed the applicable impact assessment criteria at any of the assessment locations.

Table 9.2 Cumulative (Proposal with CBP option 1 and 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
Criterion	90	50	25	25	8	4
R1	36.9	49.4	15.1	21.9	6.2	2.0
R2	36.7	49.4	14.8	21.7	6.0	2.0
R3	36.9	50.0	14.7	21.6	5.9	2.1
R4	36.3	49.4	14.6	21.6	5.8	2.0
R5	36.4	49.4	14.6	21.6	5.9	2.0
R6	36.3	49.4	14.6	21.6	5.8	2.0
R7	36.3	49.4	14.6	21.6	5.8	2.0
R8	36.3	49.4	14.6	21.6	5.8	2.0
R9	36.3	49.4	14.6	21.6	5.8	2.0

Table 9.2 Cumulative (Proposal with CBP option 1 and 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
Criterion	90	50	25	25	8	4
R10	36.5	49.4	14.7	21.8	5.9	2.0
R11	36.4	49.4	14.6	21.7	5.9	2.0
R12	36.4	49.4	14.6	21.8	5.9	2.0
R13	36.4	49.4	14.6	21.8	5.9	2.0
R14	36.5	49.4	14.7	22.0	5.9	2.0
R15	36.4	49.4	14.6	21.7	5.9	2.0
R16	36.4	49.4	14.6	21.8	5.9	2.0
R17	36.4	49.4	14.6	21.7	5.9	2.0
R18	36.4	49.4	14.6	21.7	5.9	2.0
R19	36.4	49.4	14.6	21.7	5.9	2.0
R20	36.4	49.4	14.6	21.6	5.8	2.0
R21	36.5	49.4	14.7	21.7	5.9	2.0
R22	37.6	49.8	14.9	21.6	6.0	2.3
R23	36.4	50.0	14.6	21.6	5.9	2.0
R24	36.3	49.6	14.6	21.6	5.8	2.0
R25	36.4	49.5	14.6	21.6	5.8	2.0
R26	36.4	49.4	14.6	21.6	5.8	2.0
R27	36.3	49.4	14.6	21.6	5.8	2.0
R28	36.3	49.4	14.5	21.6	5.8	2.0
R29	36.3	49.4	14.5	21.6	5.8	2.0
R30	36.3	49.4	14.5	21.6	5.8	2.0
R31	36.3	49.4	14.5	21.6	5.8	2.0
R32	36.3	49.4	14.5	21.6	5.8	2.0
R33	36.3	49.4	14.5	21.6	5.8	2.0
R34	36.3	49.4	14.5	21.6	5.8	2.0
R35	36.3	49.4	14.5	21.6	5.8	2.0
R36	36.3	49.4	14.5	21.6	5.8	2.0
R37	36.3	49.4	14.5	21.6	5.8	2.0
R38	36.3	49.4	14.5	21.6	5.8	2.0

Table 9.2 Cumulative (Proposal with CBP option 1 and 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
Criterion	**90**	**50**	**25**	**25**	**8**	**4**
R39	36.3	49.4	14.5	21.6	5.8	2.0
R40	36.3	49.4	14.5	21.6	5.8	2.0
R41	36.3	49.4	14.5	21.6	5.8	2.0
R42	36.3	49.4	14.5	21.6	5.8	2.0
R43	This assessment location will not exist under CBP option 1.					
R44	36.3	49.4	14.5	21.6	5.8	2.0

9.2 The Proposal with CBP option 2

9.2.1 Incremental results

Predicted incremental TSP, PM_{10}, $PM_{2.5}$, and dust deposition levels from the Proposal's construction phase with CBP option 2 are presented in Table 9.3 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.

The predicted contribution of air quality sources at the CBP was minor when compared to the total concentrations and the impact assessment criteria. For 24-hour PM_{10} concentrations, the maximum predicted contribution from the CBP was 0.87 µg/m^3 at R28 (the closest to the CBP). This represents 1.7% of the impact assessment criterion of 50 µg/m^3.

Except for dust deposition, the assessment criteria listed are applicable to cumulative concentrations. An analysis of cumulative impacts is presented in Section 9.1.2.

Table 9.3 Incremental (Proposal-only with CBP option 2) 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
Criterion	**90**	**50**	**25**	**25**	**8**	**2**
R1	0.7	3.8	0.6	2.9	0.4	<0.1
R2	0.4	1.6	0.3	1.2	0.2	<0.1
R3	0.6	1.8	0.2	1.3	0.1	0.1
R4	0.1	0.6	0.1	0.5	0.0	<0.1
R5	0.1	0.6	0.1	0.4	0.1	<0.1
R6	0.1	0.5	0.1	0.4	0.0	<0.1
R7	0.1	0.4	0.1	0.3	0.0	<0.1
R8	0.1	0.4	0.1	0.4	0.0	<0.1
R9	0.1	0.4	0.1	0.8	0.0	<0.1
R10	0.2	0.9	0.1	0.7	0.1	<0.1
R11	0.1	0.7	0.1	0.5	0.1	<0.1
R12	0.2	0.8	0.1	0.7	0.1	<0.1
R13	0.2	0.8	0.1	0.7	0.1	<0.1
R14	0.3	1.3	0.2	1.1	0.2	<0.1
R15	0.1	0.7	0.1	0.6	0.1	<0.1
R16	0.1	0.7	0.1	0.6	0.1	<0.1
R17	0.1	0.6	0.1	0.5	0.1	<0.1
R18	0.1	0.6	0.1	0.5	0.1	<0.1
R19	0.2	0.7	0.1	0.6	0.1	<0.1

Table 9.3 Incremental (Proposal-only with CBP option 2) 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
Criterion	**90**	**50**	**25**	**25**	**8**	**2**
R20	0.2	0.7	0.1	0.5	0.1	<0.1
R21	0.3	1.0	0.2	0.7	0.1	<0.1
R22	1.4	1.7	0.4	0.9	0.1	0.4
R23	0.1	1.5	0.1	1.1	0.1	<0.1
R24	0.1	0.6	<0.1	0.5	<0.1	<0.1
R25	0.1	0.7	0.1	0.5	<0.1	<0.1
R26	0.1	0.7	0.1	0.5	<0.1	<0.1
R27	0.2	0.5	0.1	0.3	0.1	<0.1
R28	1.2	0.9	0.3	0.3	0.1	0.2
R29	0.1	0.5	<0.1	0.3	<0.1	<0.1
R30	<0.1	0.1	<0.1	0.3	<0.1	<0.1
R31	<0.1	0.1	<0.1	0.2	<0.1	<0.1
R32	<0.1	0.1	<0.1	0.5	<0.1	<0.1
R33	<0.1	0.1	<0.1	0.4	<0.1	<0.1
R34	<0.1	0.1	<0.1	0.2	<0.1	<0.1
R35	<0.1	0.1	<0.1	0.3	<0.1	<0.1
R36	<0.1	0.1	<0.1	0.1	<0.1	<0.1
R37	<0.1	0.1	<0.1	0.1	<0.1	<0.1
R38	<0.1	0.1	<0.1	0.1	<0.1	<0.1
R39	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
R40	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
R41	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
R42	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
R43	0.9	1.4	0.3	0.8	0.1	0.2
R44	This assessment location will not exist under CBP option 2.					

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

9.2.2 Cumulative results

Predicted cumulative TSP, PM_{10}, $PM_{2.5}$, and dust deposition levels from the Proposal's construction phase with CBP option 2 are presented in Table 9.4 for each of the assessment locations.

The predicted concentrations and deposition rates for cumulative TSP, PM_{10}, $PM_{2.5}$ and dust deposition did not exceed the applicable impact assessment criteria at any of the assessment locations.

Table 9.4 Cumulative (Proposal with CBP option 2 and 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
Criterion	90	50	25	25	8	4
R1	36.9	49.4	15.1	21.9	6.2	1.0
R2	36.7	49.4	14.8	21.7	6.0	1.0
R3	36.8	50.0	14.7	21.6	5.9	1.1
R4	36.3	49.4	14.6	21.6	5.8	1.0
R5	36.4	49.4	14.6	21.6	5.9	1.0
R6	36.3	49.4	14.6	21.6	5.8	1.0
R7	36.3	49.4	14.6	21.6	5.8	1.0
R8	36.3	49.4	14.6	21.6	5.8	1.0
R9	36.3	49.4	14.6	21.6	5.8	1.0
R10	36.5	49.4	14.7	21.8	5.9	1.0
R11	36.4	49.4	14.6	21.7	5.9	1.0
R12	36.4	49.4	14.6	21.8	5.9	1.0
R13	36.4	49.4	14.6	21.8	5.9	1.0
R14	36.5	49.4	14.7	22.0	5.9	1.0
R15	36.4	49.4	14.6	21.7	5.9	1.0
R16	36.4	49.4	14.6	21.8	5.9	1.0
R17	36.4	49.4	14.6	21.7	5.9	1.0
R18	36.4	49.4	14.6	21.7	5.9	1.0
R19	36.5	49.4	14.6	21.6	5.9	1.0
R20	36.5	49.4	14.6	21.6	5.9	1.0
R21	36.5	49.4	14.7	21.6	5.9	1.0
R22	37.7	49.7	14.9	21.6	5.9	1.4

Table 9.4 Cumulative (Proposal with CBP option 2 and 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
Criterion	90	50	25	25	8	4
R23	36.4	50.0	14.6	21.6	5.9	1.0
R24	36.3	49.5	14.6	21.6	5.8	1.0
R25	36.4	49.5	14.6	21.6	5.8	1.0
R26	36.4	49.5	14.6	21.6	5.8	1.0
R27	36.5	49.4	14.6	21.6	5.9	1.0
R28	37.5	49.4	14.9	21.6	5.9	1.2
R29	36.4	49.5	14.6	21.6	5.8	1.0
R30	36.3	49.4	14.5	21.6	5.8	1.0
R31	36.3	49.4	14.5	21.6	5.8	1.0
R32	36.3	49.4	14.5	21.6	5.8	1.0
R33	36.3	49.4	14.5	21.6	5.8	1.0
R34	36.3	49.4	14.5	21.6	5.8	1.0
R35	36.3	49.4	14.5	21.6	5.8	1.0
R36	36.3	49.4	14.5	21.6	5.8	1.0
R37	36.3	49.4	14.5	21.6	5.8	1.0
R38	36.3	49.4	14.5	21.6	5.8	1.0
R39	36.3	49.4	14.5	21.6	5.8	1.0
R40	36.3	49.4	14.5	21.6	5.8	1.0
R41	36.3	49.4	14.5	21.6	5.8	1.0
R42	36.3	49.4	14.5	21.6	5.8	1.0
R43	37.2	49.8	14.8	21.6	5.9	1.2
R44	This assessment location will not exist under CBP option 2.					

9.3 Summary of modelling results

The following points are made in regard to the dispersion modelling results:

- The predicted cumulative concentrations and deposition rates for all pollutants and averaging periods were at or below the applicable NSW EPA assessment criterion at all assessment locations when both CBP options were considered.
- A cumulative maximum 24-hour average PM_{10} concentration of 50 µg/m^3 was predicted to occur on one day at assessment locations R3 and R23. This result was due to an existing background concentration of 49.4 µg/m^3 which was the result of a regional scale dust event which caused elevated concentrations across large parts of south-east QLD. On this day, the predicted contribution from the Proposal was 0.6 µg/m^3 at both R3 and R23.
- The CBP option 2 location produced slightly higher predictions. However, as above, modelling results for both options did not exceed the impact assessment criterion.
- Predicted 24-hour PM_{10} concentrations from both CBP options contributed up to 1.7% of the impact assessment criterion at the nearest assessment locations.

Contour plots, illustrating spatial variations in the most critical pollutants for this study (PM_{10} and $PM_{2.5}$) are provided in Appendix D for the worst-case CBP option (option 2). Contour 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 2021 modelling period.

Although a much larger area was modelled (14 km x 10 km), contour plots were provided for a smaller area focusing on the main construction activities at the spillway and embankment.

10 Mitigation measures

Tweed Shire Council is committed to the management of particulate matter emissions from the Proposal's construction activities.

10.1 Particulate matter emissions

A range of mitigation measures will be implemented during the Proposal's construction phase. These measures were incorporated into the emissions calculations and dispersion modelling wherever an appropriate emission control factor (or reduction factor) was available. Proposed mitigation measures as well as the control factor assumed in the modelling, include the following:

- dust from drilling will be controlled through water injection in drill holes
- wind erosion from exposed areas and stockpiles at the CBP will be controlled through watering (50% control factor)
- unpaved roads within rock movement areas will be watered using water carts (75% control factor).

Water sprays or carts will also be used to control dust on other exposed areas at worksites and on paved roads where required (e.g. where there is a prolonged instance of visible dust). Controls for these measures have not been applied in the dispersion modelling for conservatism.

10.2 Diesel combustion emissions

The following mitigation measures will be implemented where feasible to minimise emissions from the combustion of diesel during the Proposal's construction and operational phases:

- where feasible, mobile and stationary equipment compliant with a more recent emission standard than USEPA Tier 2[3] will be sourced
- unpaved roads will be routinely maintained to reduce truck tyre rolling resistance
- all equipment will be routinely serviced to maintain manufacturers' emission specifications
- idling of diesel equipment will be minimised wherever feasible.

10.3 Construction Environmental Management Plan (CEMP)

A CEMP will be prepared prior to commencement of construction activities. In relation to air quality, the CEMP will include:

- air quality objectives, targets, and key performance indicators
- relevant legislation and guidelines
- sources of air quality emissions
- mitigation measures

[3] This refers to the exhaust emission standards prescribed by the USEPA for non-road compression-ignition engines. Tier 2 standards took effect from 2001 to 2006 and are less stringent than Tier 3 standards.

- roles and responsibilities
- complaints procedure.

11 Conclusions

Dispersion modelling was completed for a worst-case construction phase scenario of the Proposal using the TAPM and CALMET/CALPUFF model system. Two options for concrete batching plants were considered.

Emissions of TSP, PM_{10} and $PM_{2.5}$ were estimated and modelled for the 2021 calendar year.

In order to manage particulate matter emissions during the construction phase of the Proposal, dust mitigation measures are required. These measures include:

- water injection in drill holes
- watering of exposed areas and stockpiles at the CBP
- watering of unpaved roads within rock movement areas.

These measures were taken into consideration in the emissions estimation and modelling of the construction phase scenario.

The results of the modelling show that the predicted concentrations and deposition rates for cumulative TSP, PM_{10}, $PM_{2.5}$ and dust deposition during the Proposal's construction phase did not exceed the applicable impact assessment criteria at all assessment locations and for both CBP options.

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USEPA AP-42 Chapter 11, Table 11.9-2 – Blasting (USEPA 1998a).

USEPA AP-42 Chapter 11, Table 11.9-2 – Drilling (USEPA 1998b).

USEPA AP-42 Chapter 11, Table 11.9-4 – Wind erosion of exposed areas (USEPA 1998c).

USEPA AP-42 Section 11.19.2 – Crushed stone processing and pulverized mineral processing (USEPA 2004).

USEPA AP-42 Section 11.12 – Concrete batching (USEPA 2006a).

USEPA AP-42 Section 13.2.2 – Unpaved roads (USEPA 2006b).

USEPA AP-42 Section 13.2.4.4 – Aggregate handling and storage piles (USEPA 2006c).

USEPA AP-42 Section 13.2.1 – Paved roads (USEPA 2011).

USEPA 2016, Nonroad Compression-Ignition Engines: Exhaust Emission Standards (EPA-420-B-16-022, March 2016).

Abbreviations

AHD	Australian height datum
AQIA	air quality impact assessment
AQMS	air quality monitoring station
AWS	automatic weather station
BoM	Bureau of Meteorology
CBP	concrete batching plant
CO	carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DESI	QLD Department of Environment, Science and Innovation
EIS	environmental impact statement
EPA	Environment Protection Authority
FEL	front-end loader
FSL	full supply level
g	grams
ha	hectares
km	kilometres
L	litres
LGA	local government area
NPI	National Pollutant Inventory
m	metres
m/s	metres per second
m^2	square metres
m^3	cubic metres
ML	megalitre
NO_x	oxides of nitrogen
NO_2	nitrogen dioxide
NSW	New South Wales
NW	north-west
PM_{10}	Particulate matter less than 10 microns in aerodynamic diameter
$PM_{2.5}$	Particulate matter less than 2.5 microns in aerodynamic diameter
PWA	Public Works Advisory
QLD	Queensland

SEARs	Secretary's Environmental Assessment Requirements
SO_2	sulfur dioxide
SSI	State significant infrastructure
TAPM	The Air Pollution Model
TSP	total suspended particles
USEPA	United States Environmental Protection Agency
VOC	volatile organic compounds

Appendix A
Meteorological analysis and modelling

EMM
creating opportunities

A.1 Meteorological data analysis for the BoM Canungra (Defence) AWS, 2018-2022

Table A.1 provides a summary of the annual average wind speed, percentage of calms (wind speeds less than 0.5 metres per second (m/s)), and data recovery for each year.

The statistics in Table A.1 show that there was a general inter-annual consistency in the recorded annual average wind speed and annual percentage of calms for each year. There was also a high percentage of data recovery for the station from 2019 onward.

Table A.1 Summary of average wind speed, percentage calms and data recovery for BoM Canungra (Defence) AWS

Year	Average wind speed (m/s)	Calms (%)	Data recovery (%)*
2018	0.9	41.5	78
2019	1.0	49.9	100
2020	0.9	41.4	100
2021	0.8	53.5	100
2022	0.8	49.8	100

* Note: Based on availability of wind speed data.

Inter-annual profiles for wind speed, wind direction and air temperature by hour of the day were also analysed for the BoM Canungra (Defence) AWS (see Figure A.1 to Figure A.4). Data for years 2018 to 2022 are considered generally comparable between years. The largest variation in the data is for relative humidity. During daytime hours relative humidity was similar in 2018 and 2019 but became progressively higher in the following years. This is mostly likely due to the shift from drought-like conditions felt across the region leading up to 2020 when cooler and wetter La Niña conditions set in.

Annual, seasonal and diurnal wind roses created from wind speed and direction data collected from the BoM Canungra (Defence) AWS are presented in Figure A.5 to Figure A.7. Annually, the winds recorded by the BoM Canungra (Defence) AWS show a similarity across years for both wind speed and wind direction. Winds were predominately from the south-east and the north-west. On a seasonal basis, winds are also generally from the south-east and north-west, but these south-easterlies are most prominent in summer and autumn, with the north-westerlies most prevalent during winter. Diurnally, the dominant winds are again from the south-east both during the day and night-time. Average wind speeds were higher during the day and the percentage of calms was higher at night-time.

In addition to the above analysis, long-term annual average rainfall data from several BoM stations closest to the Proposal area were analysed. Each station showed that 2022 experienced higher than average rainfall than previous years due to La Niña conditions.

As a result of the analysis provided above, the 2021 calendar year was adopted as the 12-month modelling period for the purpose of the air quality assessment.

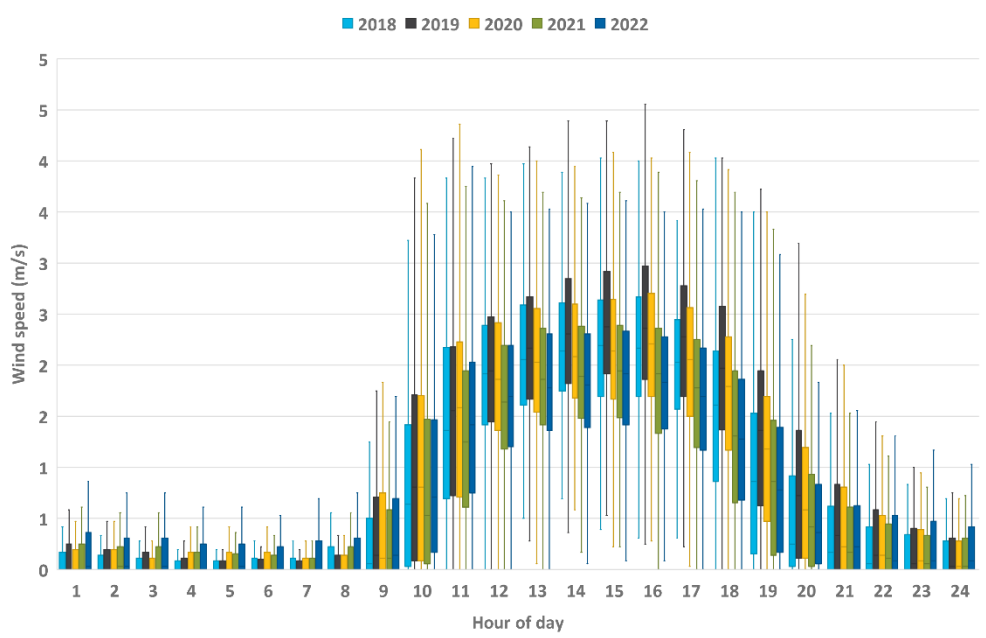


Figure A.1 **Inter-annual variability in diurnal wind speed – BoM Canungra Defence (AWS) – 2018 to 2022**

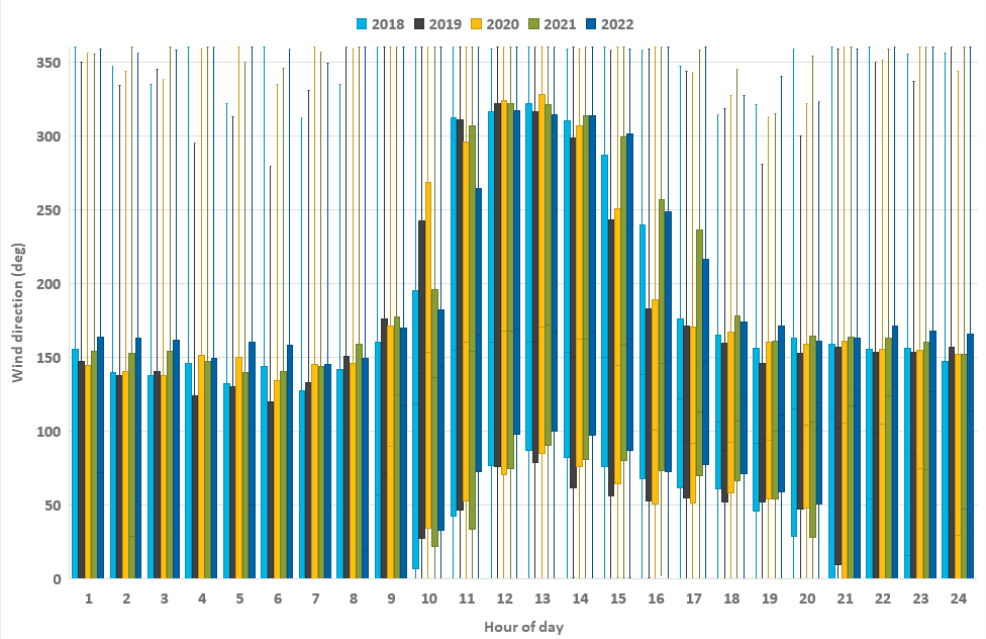


Figure A.2 **Inter-annual variability in diurnal wind direction – BoM Canungra Defence (AWS) – 2018 to 2022**

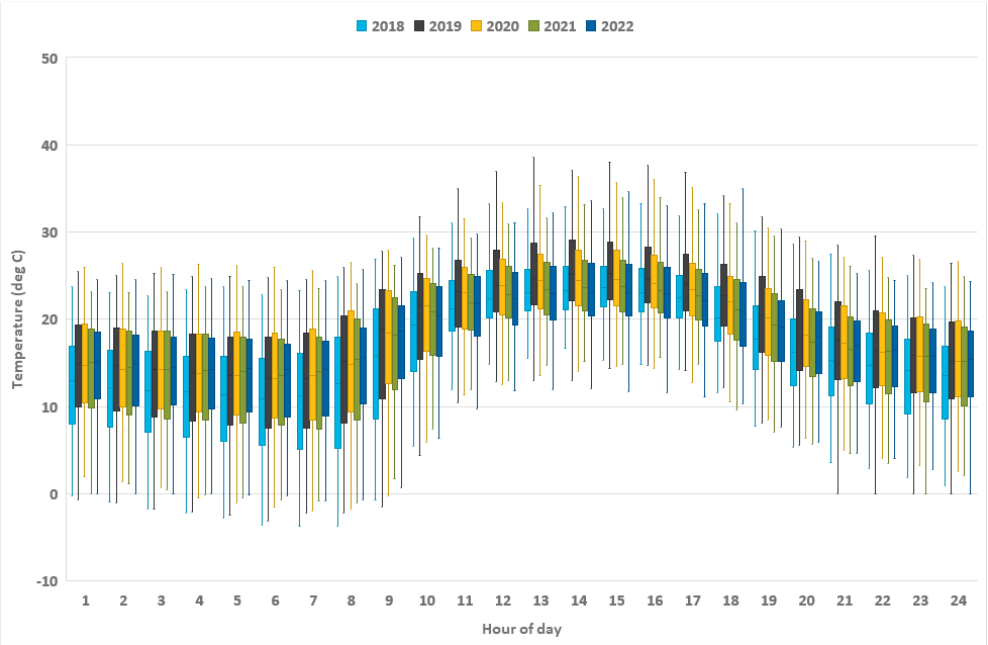


Figure A.3 **Inter-annual variability in diurnal air temperature – BoM Canungra Defence (AWS) – 2018 to 2022**

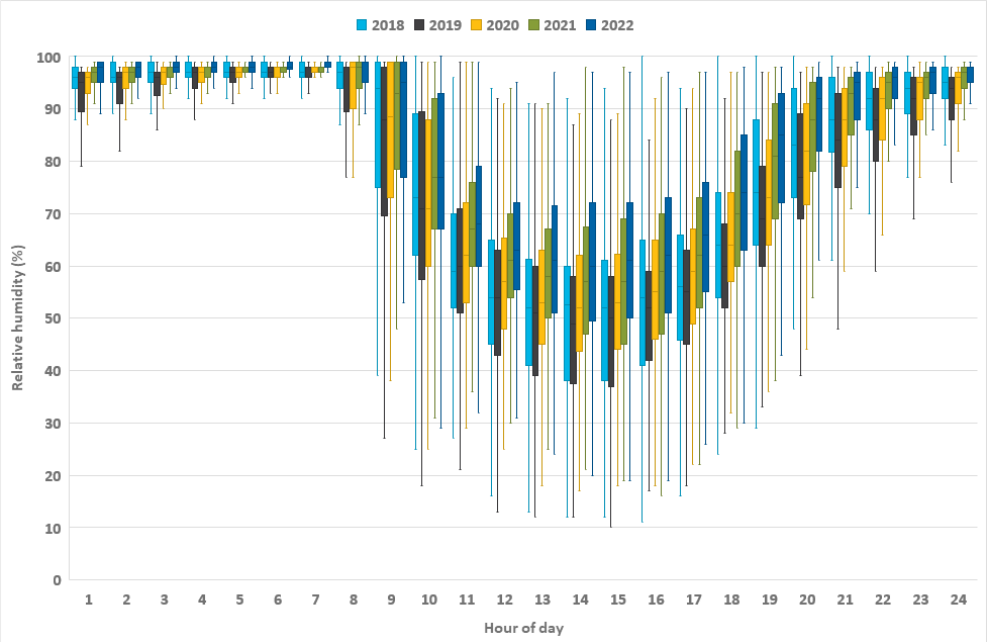


Figure A.4 **Inter-annual variability in diurnal relative humidity – BoM Canungra Defence (AWS) – 2018 to 2022**

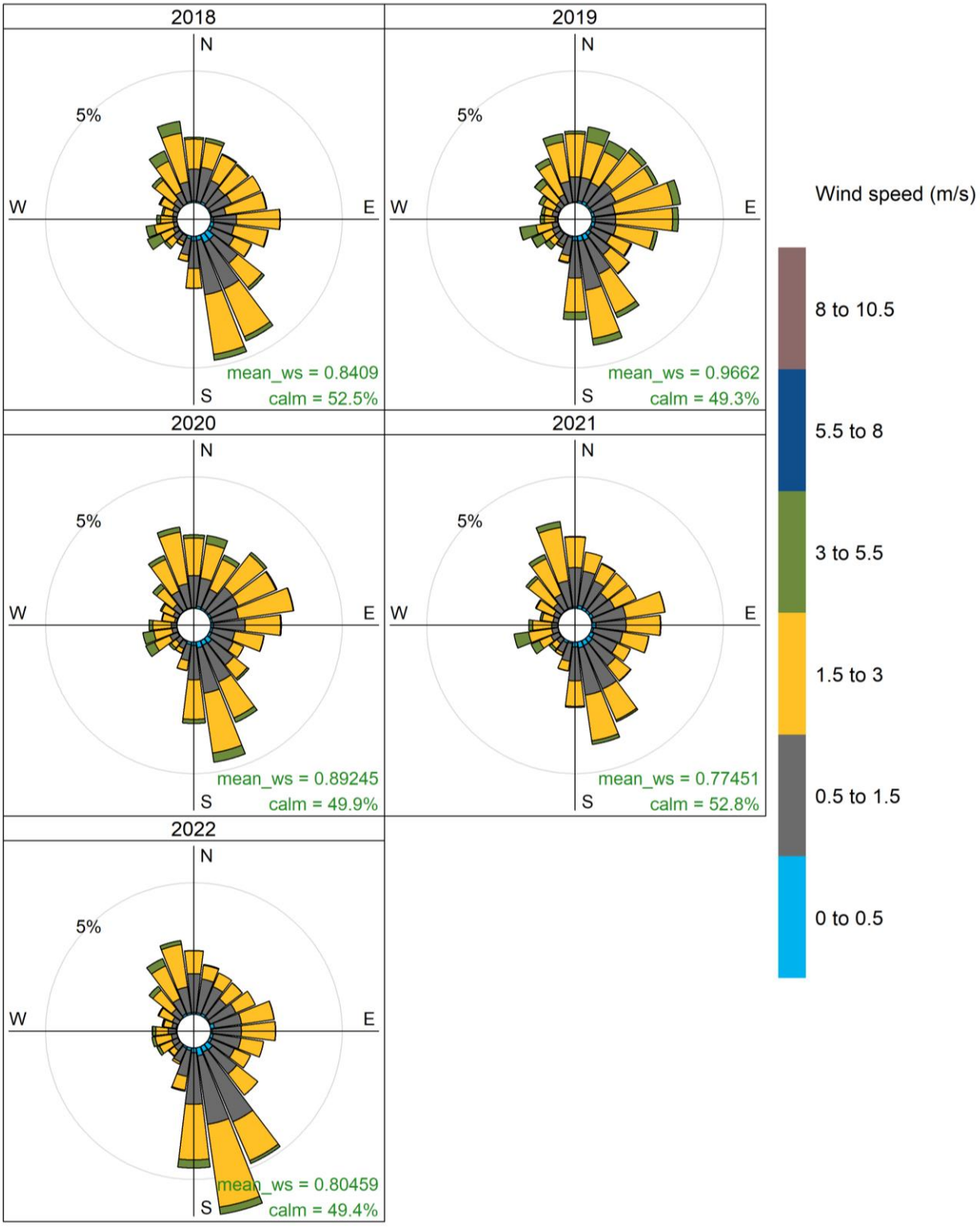


Figure A.5 Inter-annual comparison of recorded wind speed and direction – BoM Canungra Defence (AWS) – 2018 to 2021

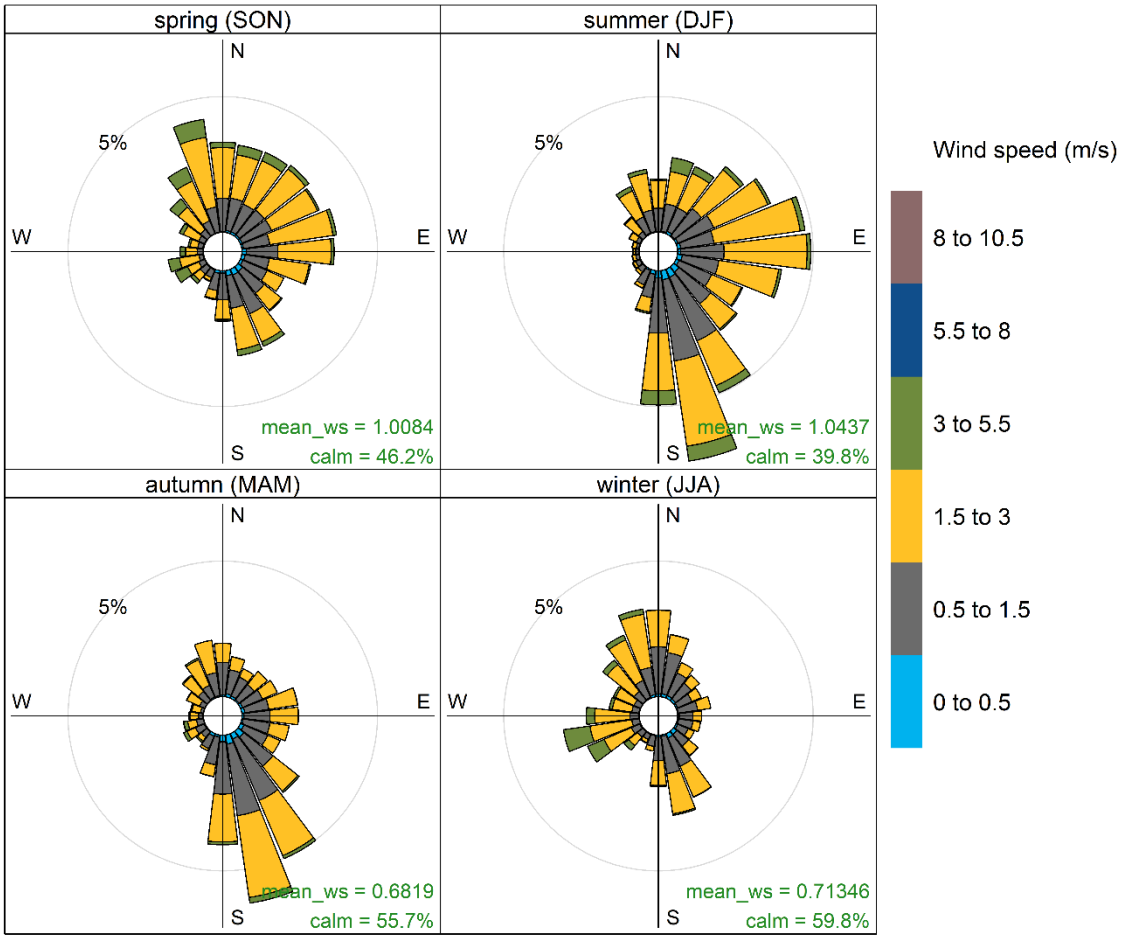


Figure A.6 **Seasonal wind speed and direction – BoM Canungra Defence (AWS) – 2018 to 2021**

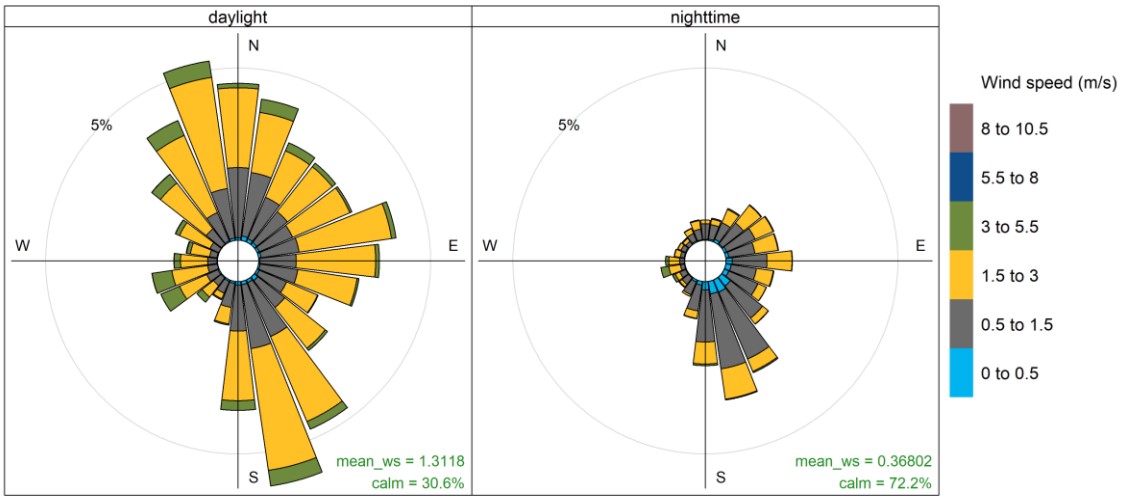


Figure A.7 **Diurnal wind speed and direction – BoM Canungra Defence (AWS) – 2018 to 2021**

A.2 Meteorological modelling

i TAPM modelling

To supplement the meteorological monitoring datasets adopted for this assessment, the CSIRO prognostic meteorological 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.

ii CALMET modelling

The CALMET/CALPUFF model suite was chosen for this study. CALMET was used to produce 3-dimensional meteorological fields for use in the CALPUFF model.

The detailed CALMET model options used are presented in Table A.2. These were selected in accordance with recommendations in the Approved Methods for Modelling and in TRC (2011). Surface observations were included in the modelling (referred to as data assimilation) to provide real-world observations and improve the accuracy of the wind fields.

Table A.2 CALMET model options used

Flag	Descriptor	Default	Value used
IEXTRP	Extrapolate surface wind observations to upper layers	Similarity theory	Similarity theory
BIAS (NZ)	Relative weighting given to vertically extrapolated surface observations versus upper air data	No default	-1.0, -0.5, -0.25, -0.1, 0.0, 0.5, 1.0, 1.0, 1.0, 1.0
TERRAD	Radius of influence of terrain	No default	2
RMAX1 and RMAX2	Maximum radius of influence over land observations in layer 1 and aloft	No default	1 (RMAX 1) and 1 (RMAX 2)
R1 and R2	Distance from observations in layer 1 and aloft at which observations and Step 1 wind field are weighted equally	No default	1.5 (R1) and 1.5 (R2)

Appendix B
Emissions inventory detail

EMM
creating opportunities

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 (USEPA) AP-42 Air Pollutant Emission Factors and USEPA Exhaust Emissions Standards, including the following:

USEPA AP-42 Chapter 11, Table 11.9-2 – Blasting (USEPA 1998a)

USEPA AP-42 Chapter 11, Table 11.9-2 – Drilling (USEPA 1998b)

USEPA AP-42 Chapter 11, Table 11.9-4 – Wind erosion of exposed areas (USEPA 1998c)

USEPA AP-42 Section 11.19.2 – Crushed stone processing and pulverized mineral processing (USEPA 2004)

USEPA AP-42 Section 11.12 – Concrete batching (USEPA 2006a)

USEPA AP-42 Section 13.2.2 – Unpaved roads (USEPA 2006b)

USEPA AP-42 Section 13.2.4.4 – Aggregate handling and storage piles (USEPA 2006c)

USEPA AP-42 Section 13.2.1 – Paved roads (USEPA 2011)

USEPA Nonroad Compression-Ignition Engines: Exhaust Emission Standards (EPA-420-B-16-022, March 2016).

Diesel consumption was estimated for the Proposal. Assumptions adopted were:

Annual diesel consumption for construction machinery, mobile equipment and vehicles of 3,052,300 litres for a 12-month period. This diesel use is actually for the 18-month construction period but was used for the model year for conservatism.

Emission factors from the NPI Emission Estimation Technique Manual for Combustion Engines (NPI 2008) – (diesel industrial vehicles - miscellaneous).

Apportioning the total diesel emissions across the Proposal site based on ratio of estimated TSP, PM_{10} and $PM_{2.5}$ emissions for each activity.

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

Emissions from wind erosion of exposed areas were estimated and are shown in Section 8 and in Section B.2. As there were no wind speeds above 5.4 m/s in the 2021 meteorological dataset, there was determined to be no wind erosion. This threshold was taken from NPI 2012 defined as the wind speed at which wind erosion may occur. A study prepared by SKM in 2005 also states that below a wind speed threshold of 5 to 10 m/s, particulate matter is not generated (SKM 2005).

B.2 Particulate matter emissions inventory

An emissions inventory developed for the worst-case construction phase of the Proposal is presented in Table B.1.

Specific assumptions made in the inventory are detailed in Table B.2. Some information was supplied by KBR as related to the Proposal and other information was assumed based on other studies due to a lack of information.

Table B.1 Emissions inventory

Activity	Emission estimate TSP (kg/y)	Emission estimate PM_{10} (kg/y)	Emission estimate $PM_{2.5}$ (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	Control (%)	Emission control	Emission factor source
Rock quarrying																				
Stripping soil and overburden	0	0	0	5,640	t/y	0.0001	0.0000	0.00000	kg/t	1.8	Ave wind speed (m/s)	13.5	Moisture (%)							AP-42 13.2.4 - Materials handling
Loading soil to trucks	0	0	0	5,640	t/y	0.0001	0.0000	0.00000	kg/t	1.8	Ave wind speed (m/s)	13.5	Moisture (%)							AP-42 13.2.4 - Materials handling
Drilling	850	442	25	4,800	holes/y	0.5900	0.3068	0.0177	kg/hole									0.7	Water injection	AP-42 11.9.4 - Drilling overburden
Blasting	334	174	10	48	blasts/y	6.9570	3.6176	0.2087	kg/blast	1,000	Area of blast in m2									AP-42 11.9.2 - Blasting overburden
Excavating rock	76	36	5	228,000	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
Crushing rock	137	62	11	228,000	t/y	0.0006	0.0003	0.00005	kg/t											AP-42 11.19.2-1 - Crushed stone processing
Screening rock	251	84	6	228,000	t/y	0.0011	0.00037	0.000025	kg/t											AP-42 11.19.2-1 - Crushed stone processing
Loading rockfill to trucks	76	36	5	228,000	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
Trucks hauling rockfill from the quarry to the embankment	9,348	2,402	240	14,704	VKT/y	2.54	0.65	0.07	kg/VKT	5.0	Road silt content (%)	2.7	Return haul distance (km)	5,529	Loads/y	41	Ave weight (t)	0.75	Watering	AP-42 13.2.2 - Unpaved roads
Spillway																				
Stripping soil and overburden	1	0	0	13,000	t/y	0.0001	0.0000	0.00000	kg/t	1.8	Ave wind speed (m/s)	13.5	Moisture (%)							AP-42 13.2.4 - Materials handling
Loading soil and overburden to trucks	1	0	0	13,000	t/y	0.0001	0.0000	0.00000	kg/t	1.8	Ave wind speed (m/s)	13.5	Moisture (%)							AP-42 13.2.4 - Materials handling
Hauling soil and overburden across spillway area	106	27	3	167	VKT/y	2.54	0.65	0.07	kg/VKT	5.0	Road silt content (%)	0.5	Return haul distance (km)	315	Loads/y	41	Ave weight (t)	0.75	Watering	AP-42 13.2.2 - Unpaved roads
Unloading soil and overburden to stockpile	4	2	0	13,000	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
Drilling	106	55	3	600	holes/y	0.5900	0.3068	0.0177	kg/hole									0.7	Water injection	AP-42 11.9.4 - Drilling overburden
Blasting	42	22	1	6	blasts/y	6.9570	3.6176	0.2087	kg/blast	1,000	Area of blast in m2									AP-42 11.9.2 - Blasting overburden
Excavating rock for the embankment	30	14	2	91,200	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
Crushing rock	55	25	5	91,200	t/y	0.0006	0.0003	0.00005	kg/t											AP-42 11.19.2-1 - Crushed stone processing
Screening rock	100	34	2	91,200	t/y	0.0011	0.00037	0.000025	kg/t											AP-42 11.19.2-1 - Crushed stone processing
Rehandle to trucks	30	14	2	91,200	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
Hauling rockfill from spillway to embankment placement	2,301	591	59	3,620	VKT/y	2.54	0.65	0.07	kg/VKT	5.0	Road silt content (%)	1.6	Return haul distance (km)	2,211	Loads/y	41	Ave weight (t)	0.75	Watering	AP-42 13.2.2 - Unpaved roads
Embankment																				
Trucks unloading rockfill from quarry to embankment stockpile	76	36	5	228,000	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
Trucks unloading rockfill from the spillway excavation zone to embankment stockpile	5	2	0	14,704	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
Excavating rock in existing embankment	19	9	1	58,080	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
FELs loading excavated rock to trucks	4	2	0	13,000	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
Hauling rock to embankment stockpile	398	102	10	626	VKT/y	2.54	0.65	0.07	kg/VKT	5.0	Road silt content (%)	0.4	Return haul distance (km)	1,408	Loads/y	41	Ave weight (t)	0.75	Watering	AP-42 13.2.2 - Unpaved roads
Trucks unloading excavated rock to stockpile	4	2	0	13,000	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
Crushing rock	8	4	1	13,000	t/y	0.0006	0.0003	0.00005	kg/t											AP-42 11.19.2-1 - Crushed stone processing
Screening rock	14	5	0	13,000	t/y	0.0011	0.00037	0.000025	kg/t											AP-42 11.19.2-1 - Crushed stone processing
FELs loading stockpiled rock to trucks	4	2	0	13,000	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
Hauling rock to embankment construction area	89	23	2	140	VKT/y	2.54	0.65	0.07	kg/VKT	5.0	Road silt content (%)	0.4	Return haul distance (km)	315	Loads/y	41	Ave weight (t)	0.75	Watering	AP-42 13.2.2 - Unpaved roads
Unloading rock to embankment construction area	4	2	0	13,000	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
FELs/excavators shaping/spreading rock	80	38	6	241,000	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.1	Moisture (%)							AP-42 13.2.4 - Materials handling
All wind erosion (excl. CBP)																				
Wind erosion from the quarry	1,483	741	111	1.7	Area (ha)	850	425	64	kg/ha/y											AP-42 11.9 - Wind erosion of exposed areas
Wind erosion from exposed spillway ground	1,275	638	96	1.5	Area (ha)	850	425	64	kg/ha/y											AP-42 11.9 - Wind erosion of exposed areas
Wind erosion from exposed embankment ground and stockpile	252	126	19	0.3	Area (ha)	850	425	64	kg/ha/y											AP-42 11.9 - Wind erosion of exposed areas
Other																				
Diesel combustion (whole site)	10,878	10,878	9,972																	Miscellaneous - engine specifications
Concrete batching plant (CBP) - OPTION 1																				
Trucks unloading cement to silo	42	20	3	6,082	t/y	0.0069	0.0033	0.00050	kg/t	1.8	Ave wind speed (m/s)	0.5	Moisture (%)							AP-42 13.2.4 - Materials handling
Trucks unloading aggregate/sand to stockpiles	7	4	1	21,539	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.0	Moisture (%)							AP-42 13.2.4 - Materials handling
Trucks/FELs transferring aggregate/sand to hopper	7	4	1	21,539	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.0	Moisture (%)							AP-42 13.2.4 - Materials handling
Conveyors transferring sand and aggregate on-site	7	4	1	21,539	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.0	Moisture (%)							AP-42 13.2.4 - Materials handling
Weigh hopper loading (aggregate and sand)	0.1	0.0	0.0	21,539	t/y	0.0026	0.0013	0.0002	kg/t											AP-42 11.12 - Weigh hopper loading
Truck loading (truck mixing cement)	3.4	0.9	0.1	6,082	t/y	0.5590	0.1550	0.0233	kg/t											AP-42 11.12 - Central mix equation
Trucks hauling concrete from CBP to dam wall embankment	3,077	591	143	70,982	VKT/y	0.0433	0.0083	0.00201	kg/VKT	0.6	Road silt loading (g/m²)	2.3	Return haul distance (km)	31,300	Loads/y	18	Ave weight (t)			AP-42 13.2.1 - Paved roads
Wind erosion at CBP1	570	285	43	1.34	Area (ha)	850	425	64	kg/ha/y									0.5	Watering	AP-42 11.9 - Wind erosion of exposed areas
Diesel combustion (CBP1)	110	110	101																	Miscellaneous - engine specifications
Concrete batching plant (CBP) - OPTION 2																				
Trucks unloading cement to silo	42	20	3	6,082	t/y	0.0069	0.0033	0.00050	kg/t	1.8	Ave wind speed (m/s)	0.5	Moisture (%)							AP-42 13.2.4 - Materials handling
Trucks unloading aggregate/sand to stockpiles	7	4	1	21,539	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.0	Moisture (%)							AP-42 13.2.4 - Materials handling
Trucks/FELs transferring aggregate/sand to hopper	7	4	1	21,539	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.0	Moisture (%)							AP-42 13.2.4 - Materials handling
Conveyors transferring sand and aggregate on-site	7	4	1	21,539	t/y	0.0003	0.0002	0.00002	kg/t	1.8	Ave wind speed (m/s)	4.0	Moisture (%)							AP-42 13.2.4 - Materials handling
Weigh hopper loading (aggregate and sand)	0.1	0.0	0.0	21,539	t/y	0.0026	0.0013	0.0002	kg/t											AP-42 11.12 - Weigh hopper loading
Truck loading (truck mixing cement)	3.4	0.9	0.1	6,082	t/y	0.5590	0.1550	0.0233	kg/t											AP-42 11.12 - Central mix equation
Trucks hauling concrete from CBP to dam wall embankment	6,648	1,276	309	153,376	VKT/y	0.0433	0.0083	0.00201	kg/VKT	0.6	Road silt loading (g/m²)	4.9	Return haul distance (km)	31,300	Loads/y	18	Ave weight (t)			AP-42 13.2.1 - Paved roads
Wind erosion at CBP2	421	210	32	0.99	Area (ha)	850	425	64	kg/ha/y									0.5	Watering	AP-42 11.9 - Wind erosion of exposed areas
Diesel combustion (CBP2)	110	110	101																	Miscellaneous - engine specifications
Total (kg/y) with CBP option 1	**32,268**	**17,648**	**10,898**																	
Total (kg/y) with CBP option 2	**35,691**	**18,259**	**11,053**																	

Table B.2 Emissions inventory assumptions

Parameter	Value adopted	Source
Topsoil/overburden moisture content (%)	13.5	Taken from Dungowan Dam AQIA (EMM 2022).
Topsoil/overburden and rock density (m^3/t)	1.3	Assumed per similar studies.
Rock moisture content (%)	4.1	Taken from Dungowan Dam AQIA (EMM 2022).
Unpaved road silt content (%)	5.0	Taken from Dungowan Dam AQIA (EMM 2022).
Paved road silt loading (g/m^2)	0.6	Ubiquitous baseline (for public roads) from USEPA AP-42, Table 13.2.1-2.
Cement moisture content (%)	0.5	Average of cement moistures from USEPA AP-42, Table 17.17.
Truck average weights (t)	• CHD main construction area trucks – 41.2 t average weight • CBP trucks – 18.3 t	Per information provided by KBR.

Appendix C
CALPUFF settings

EMM
creating opportunities

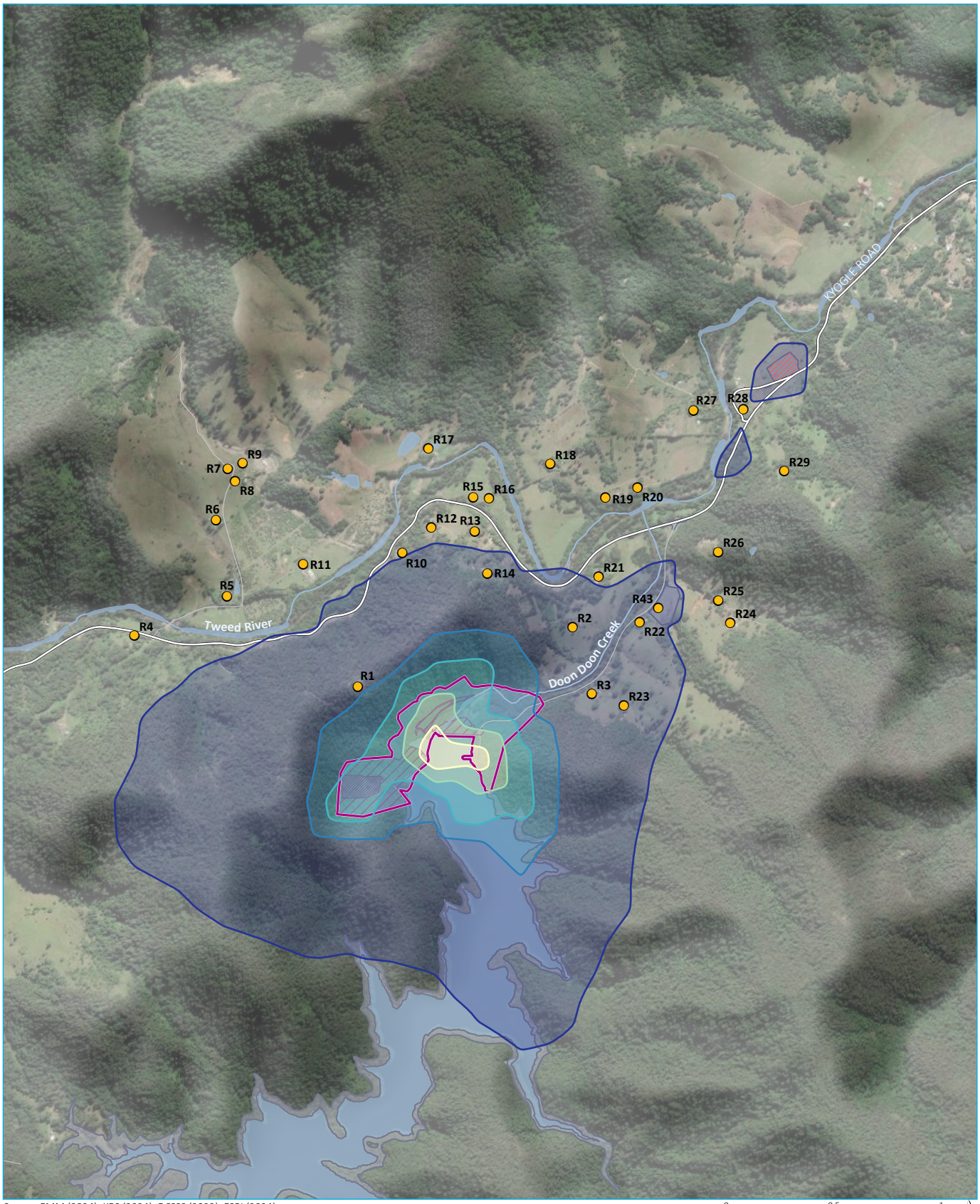
A summary of the CALPUFF model options selected for dispersion modelling is presented in Table C.1.

Table C.1 CALPUFF model options

Parameter	Descriptor	Value adopted	Value description
MCHEM	Chemical transformation	0	Chemical transformation not modelled
MDRY	Dry deposition	1	Yes
MTRANS	Transitional plume rise allowed	1	Yes
MRISE	Method to compute plume rise	1	Briggs plume rise
MPARTL	Partial plume penetration of elevated inversion	1	Yes
MDISP	Dispersion coefficients	2	Based on micrometeorology
MPDF	Probability density function used for dispersion under convective conditions	1	Yes
MROUGH	PG sigma y, z adjusted for z	0	No
MCTADJ	Terrain adjustment method	3	Partial plume adjustment
MBDW	Method for building downwash	1	ISC method

Appendix D
Contour plots

EMM
creating opportunities



Source: EMM (2024); KBS (2024); DCSSS (2023); ESRI (2024)

0 0.5 1 km

GDA2020 MGA Zone 56

N

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KEY

- Construction disturbance footprint
- Proposed construction disturbance footprint
- Quarry extraction area
- Direct disturbance footprint
- Concrete batching- option 2
- Assessment location

24-hour average PM_{10} concentration

- 1 µg/m^3
- 5 µg/m^3
- 10 µg/m^3
- 20 µg/m^3
- 30 µg/m^3

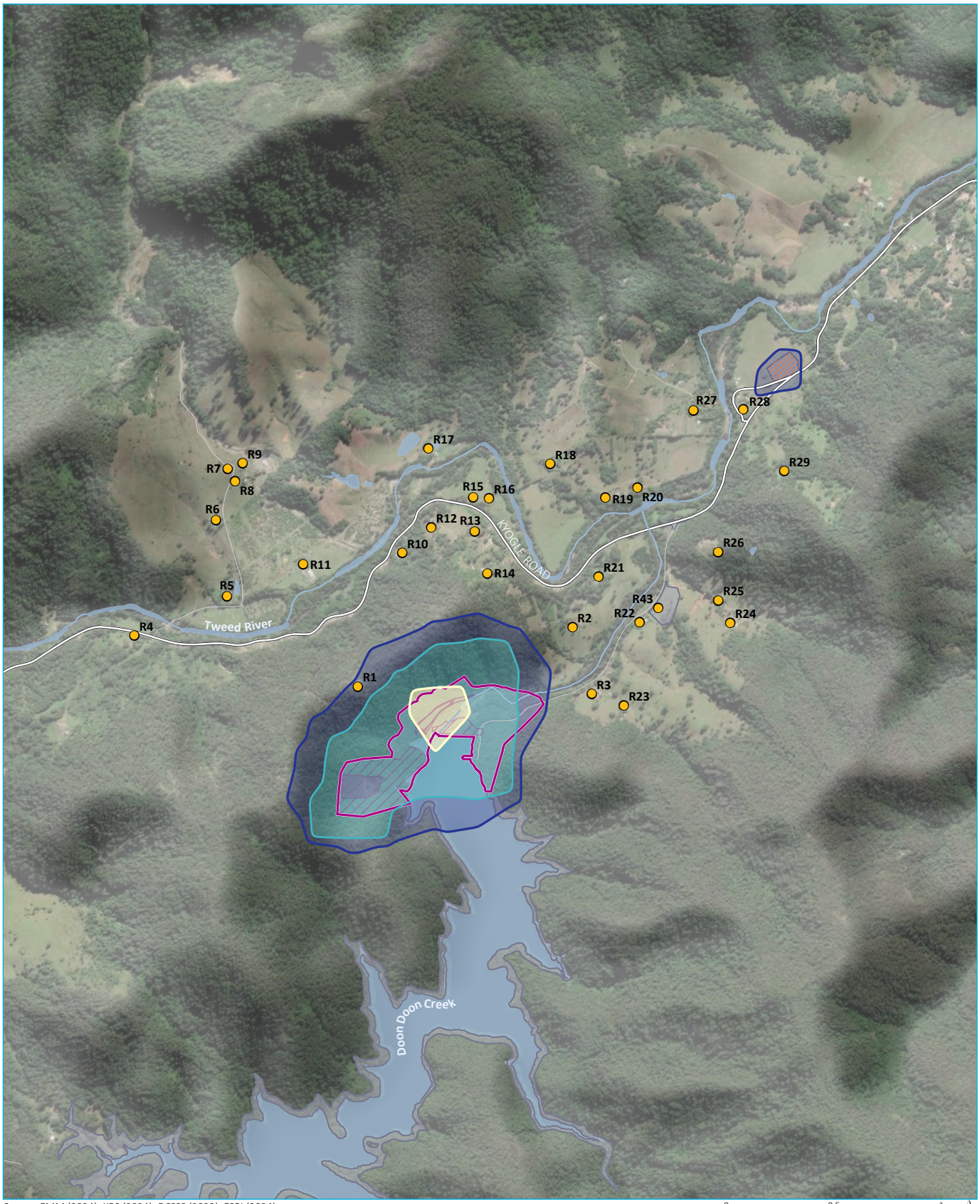
Existing environment

- Rail line
- Major road
- Minor road
- Named watercourse
- Waterbody

Predicted maximum 24-hour average PM_{10} concentrations (µg/m^3) – Proposal with CBP option 2 only

Clarrie Hall Dam EIS
Air Quality Impact Assessment
Figure D.1

EMM
creating opportunities



Source: EMM (2024); KBS (2024); DCSSS (2023); ESRI (2024)

0 0.5 1 km

GDA2020 MGA Zone 56

N

KEY

- Construction disturbance footprint
- Proposed construction disturbance footprint
- Quarry extraction area
- Direct disturbance footprint
- Concrete batching- option 2
- Assessment location

Annual average PM_{10} concentration

- 0.5 µg/m^3
- 1 µg/m^3
- 5 µg/m^3

Existing environment

- Rail line
- Major road
- Minor road
- Named watercourse
- Waterbody

Predicted annual average PM_{10} concentrations (µg/m^3) – Proposal with CBP option 2 only

Clarrie Hall Dam EIS
Air Quality Impact Assessment
Figure D.2

EMM
creating opportunities

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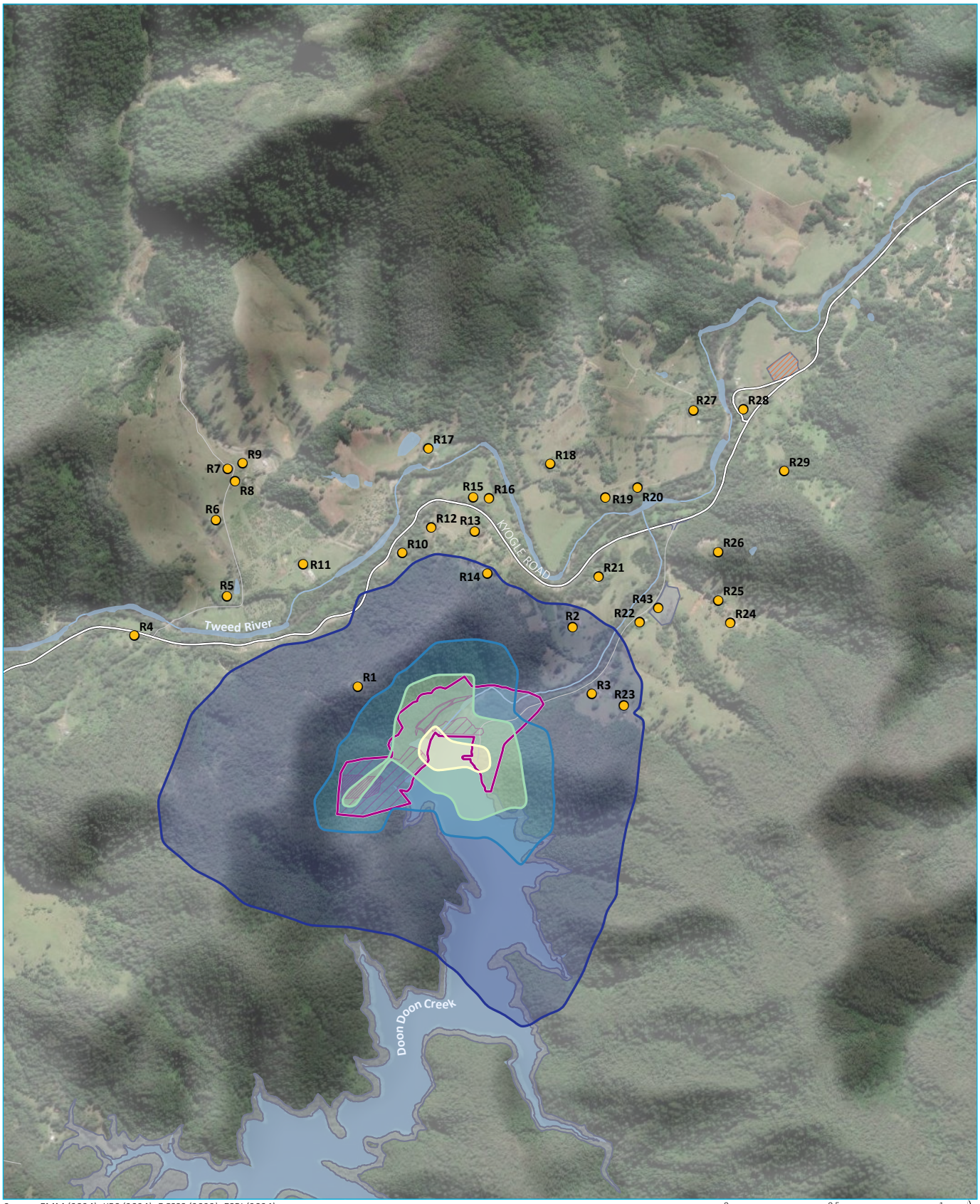

Source: EMM (2024); KBS (2024); DCSSS (2023); ESRI (2024)

0 0.5 1 km

GDA2020 MGA Zone 56

N

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KEY

- Construction disturbance footprint
- Proposed construction disturbance footprint
- Quarry extraction area
- Direct disturbance footprint
- Concrete batching- option 2
- Assessment location

24-hour average $PM_{2.5}$ concentration

- 1 µg/m^3
- 5 µg/m^3
- 10 µg/m^3
- 25 µg/m^3

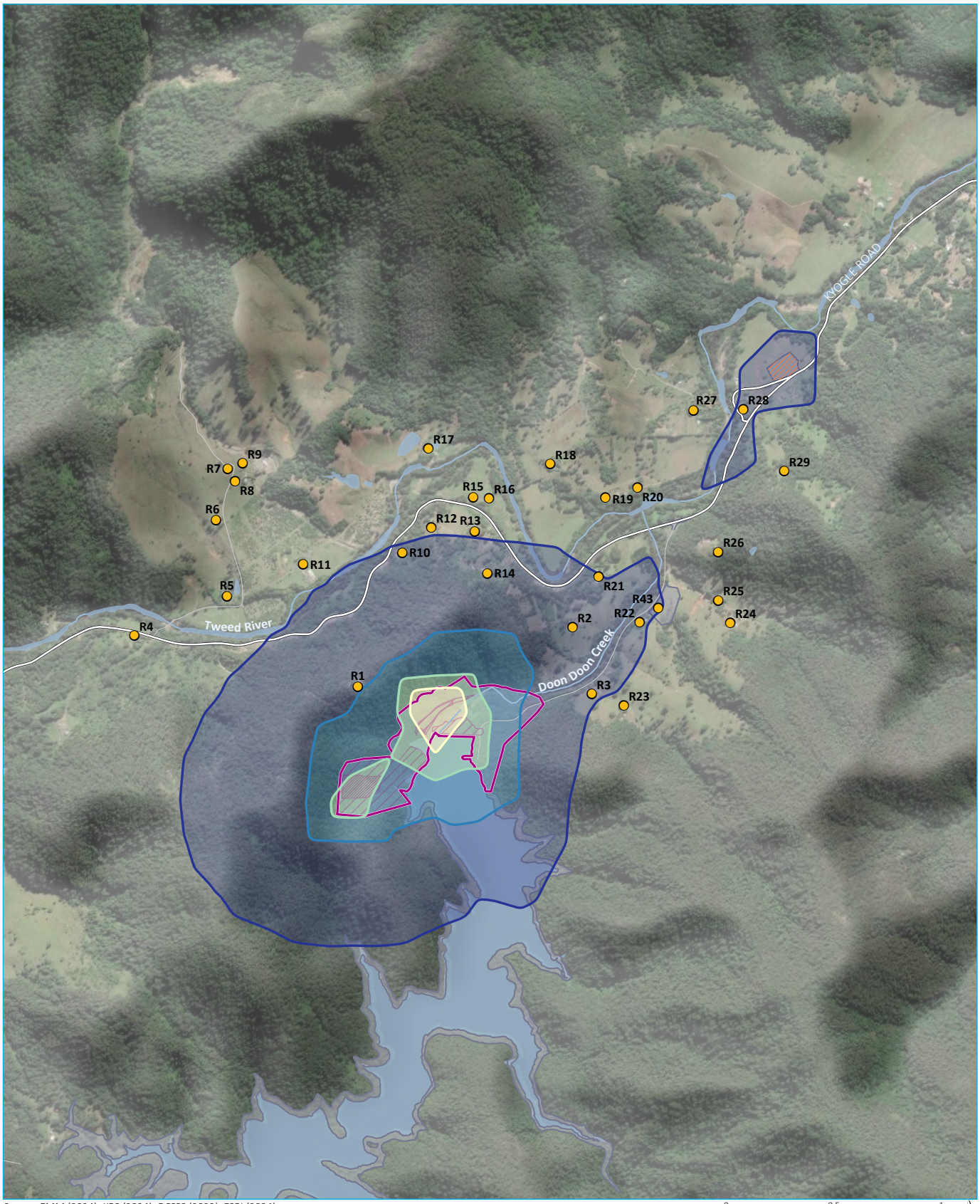
Existing environment

- Rail line
- Major road
- Minor road
- Named watercourse
- Waterbody

Predicted maximum 24-hour average $PM_{2.5}$ concentrations (µg/m^3) – Proposal with CBP option 2 only

Clarrie Hall Dam EIS
Air Quality Impact Assessment
Figure D.3

EMM
creating opportunities



Source: EMM (2024); KBS (2024); DCSSS (2023); ESRI (2024)

0 0.5 1 km

GDA2020 MGA Zone 56

N

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KEY

- Construction disturbance footprint
- Proposed construction disturbance footprint
- Quarry extraction area
- Direct disturbance footprint
- Concrete batching- option 2
- Assessment location

Annual average $PM_{2.5}$ concentration

- 0.1 µg/m^3
- 0.5 µg/m^3
- 2 µg/m^3
- 4 µg/m^3

Existing environment

- Rail line
- Major road
- Minor road
- Named watercourse
- Waterbody

Predicted annual average $PM_{2.5}$ concentrations (µg/m^3) – Proposal with CBP option 2 only

Clarrie Hall Dam EIS
Air Quality Impact Assessment
Figure D.4

EMM
creating opportunities

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