Marulan Quarry

Response to submissions – Part 2 of 3

Global Quarries Australia Pty Ltd

03 June 2025

→ **The Power of Commitment**

Appendix G

Air Quality Impact Assessment

Marulan Quarry EIS

Air quality impact assessment

Global Quarries Australia Pty Ltd

3 June 2025

→ **The Power of Commitment**

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Executive Summary

Global Quarries Australia Pty Ltd seeks to develop a quarrying operation on Lots 3 and 4 of DP 247199 and Lot 7001 of DP 1025585, in Marulan in the Southern Tablelands of NSW (the project). The project involves establishment of hard rock quarry and progressive rehabilitation of the pits with virgin excavated natural material (VENM), excavated natural material (ENM) and other clean fill material. The project involves extraction of up to 500,000 tonnes per year of hard rock from the tuffaceous hard rock target resource estimated at approximately 7.7 million tonnes (Mt) at the site.

An air quality assessment was undertaken of the proposed quarrying operation. The assessment followed the NSW EPA *Approved Methods for the modelling and assessment of air pollutants in NSW* (NSW EPA, 2017) and *National environmental protection (ambient air quality) measure* (National Environmental Protection Council, 2021) and included meteorological and dispersion modelling and impacts were predicted in the surrounding environment including at nearby sensitive receptors.

A total of 41 sensitive receptors were identified within 2.5 kilometres of the project site. Detailed modelling results are presented for the eight nearest receptors in each direction, as these are where the worst case impacts will occur. Impacts at all other receptors will be lower. Contour plots of predicted dust concentrations and deposition are presented which show approximate impacts at all identified receptors.

Dust emissions from the proposed activities were estimated using NPI Emission estimation technique manual for mining (2012) and Emission estimation technique manual for mining and processing of non-metallic minerals (2014) for both construction and operation of the quarry. Using the estimated emissions, conservative dispersion modelling scenarios were undertaken assuming maximum dust emissions over an entire year for both construction and operation of the quarry.

The dust impacts on the six nearest receptors have been assessed for three scenarios:

– Construction
– Worst-case general operations
– Blasting events

No exceedances of $PM_{2.5}$, PM_{10} or TSP (including background) are predicted during any of the scenarios. The assessment includes a number of conservative assumptions and provided management actions outlined are implemented air quality impacts as per the EPA guidance are not anticipated. Weather conditions that cause maximum dust impact are generally consistent winds in the direction of the nearest sensitive receivers throughout the daytime period outside of rain events however dust generating activities can be managed during these conditions to prevent dust impacts.

Modelling of nitrogen dioxide (NO_2) was also undertaken for the blasting scenario. Predicted particulate and NO_2 concentrations during blasting were shown to comply with the criteria if undertaken between the hours of 10:00 am and 3:00 pm which avoid adverse meteorological conditions. A blast management plan would be prepared which identifies appropriate times for blasting to occur and the need to limit blasting under certain meteorological conditions such as wind speed and direction.

The assessment includes a number of conservative assumptions and provided management actions outlined in Section 8 air quality impacts as per the EPA guidance are not anticipated.

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Glossary

Term	Meaning
Air NEPM	National Environment Protection Council (NEPC) National Environment Protection (Ambient Air Quality) Measure 2021
Approved Methods	NSW EPA Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2017)
AQIA	Air quality impact assessment
AQMS	Air quality monitoring station
AWS	Automatic weather station
BoM	Bureau of Meteorology
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DPE	Department of Planning and Environment
EIS	Environmental impact statement
ENM	Excavated natural material
GHD	GHD Pty Ltd
Global Quarries	Global Quarries Australia Pty Ltd
HHRA	Human health risk assessment
NEPC	National Environment Protection Council
NO_2	Nitrogen dioxide
NPI	National Pollutant Inventory
$PM_{2.5}$	Particulate matter (airborne dust) with a size of 2.5 micrograms
PM_{10}	Particulate matter (airborne dust) with a size of 10 micrograms
SEARs	Secretary's Environmental Assessment Requirements
Sensitive receptor	A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area. An air quality impact assessment should also consider the location of known or likely future sensitive receptors.
SO_2	Sulphur dioxide
SSD	State Significant Development
TSP	Total suspended particulates – airborne dust
VENM	Virgin excavated natural material

1. Introduction

1.1 Background and project overview

Global Quarries Australia Pty Ltd seeks to develop a quarrying operation on Lots 3 and 4 of DP 247199 and Lot 7001 of DP 1025585, in Marulan in the Southern Tablelands of NSW (the project). The project involves establishment of hard rock quarry and progressive rehabilitation of the pits with virgin excavated natural material (VENM), excavated natural material (ENM) and other clean fill material. The project involves extraction of up to 500,000 tonnes per year of hard rock from the tuffaceous hard rock target resource estimated at approximately 7.7 million tonnes (Mt) at the site.

The project would also involve the progressive rehabilitation of the extraction area through emplacement of VENM, ENM and other clean fill materials. The emplacement material would be sourced through back-loading of haulage vehicles with clean fill from construction projects throughout the Sydney basin. This would allow the site to be progressively returned to a condition more closely representing the original landscape and would maximise resource recovery through diversion of clean fill away from landfills.

The project constitutes development for the purpose of an extractive industry that extracts up to 500,000 tonnes of material per year from a total resource area of more than 7 million tonnes. The project is therefore defined as State Significant Development (SSD) under Clause 7 of Schedule 1 of the State Environmental Planning Policy Planning Systems) 2021.

This report has been prepared by GHD Pty Ltd (GHD) to provide an air quality impact assessment of the project as an input to the environmental impact statement (EIS).

The report addresses the requirements of the Secretary of the NSW Department of Planning, Industry and Environment (the Secretary's Environmental Assessment Requirements (SSD 65146459)) dated 21 December 2023.

1.2 Purpose of this report

GHD Pty Ltd (GHD) has been engaged by Global Quarries Australia Pty Ltd (Global Quarries) to prepare documentation to support Global Quarries with the planning and approval requirements necessary for the project.

This report has been prepared to provide an assessment of potential air quality impacts as an input to the EIS. This report addresses the Secretary's Environmental Assessment Requirements (SSD 65146459) dated 21 December 2023.

1.3 Limitations and assumptions

The following assumptions were made when undertaking the air quality assessment:

– Sensitive receptors were identified using aerial photography and land use planning and may not include all existing or future receptors in the project area.
– Ambient air quality and meteorological data is considered representative however may vary year to year and be influenced by external factors including climate trends and bushfires.
– Information provided by Global Quarries including construction and operational details, site layout, throughputs, etc. is assumed to be correct and free of errors.

Additional assumptions have been used in the assessment and are documented in the relevant sections.

This report: has been prepared by GHD for Global Quarries Australia Pty Ltd and may only be used and relied on by Global Quarries Australia Pty Ltd for the purpose agreed between GHD and Global Quarries Australia Pty Ltd as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Global Quarries Australia Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

2. Legislative and policy context

2.1 Secretary's Environmental Assessment Requirements

The SEARs relevant to air quality, together with a reference to where they are addressed in this report, are outlined in Table 2.1.

Table 2.1 SEARs relevant to this assessment

SEARs requirement (SSD-65146459)	Where addressed in this report
Air quality – including:	
A detailed assessment of potential construction and operational air quality impacts, in accordance with the *Approved methods for the modelling and assessment of air pollutants in NSW,* and with a particular focus on dust emissions including $PM_{2.5}$ and PM_{10}, and having regard to the *Voluntary Land Acquisition and Mitigation Policy;*	This report
An assessment of potential dust and other emissions generated from processing, operational activities and transportation of quarry products;	Section 5 to Section 7
Reasonable and feasible mitigation measures to minimise dust and emissions;	Section 8
Monitoring and management measures, in particular, real-time air quality monitoring;	Section 8
A greenhouse gas assessment of the operation of the development;	Refer GHG report
Details of proposed mitigation, management and monitoring measures.	Section 8
Environmental planning instruments, policies, guidelines and plans:	
Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments (DP&E)	Section 2.2
Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (EPA)	
Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (EPA)	
Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia'	Section 3.2

2.2 Legislative and policy context to the AQIA

The relevant legislation and government guidance for the air quality assessment of the project are:

- NSW *Protection of the Environment Operations Act 1997* (POEO Act)
- NSW Protection of the Environment Operations (Clean Air) Regulation 2021 (POEO Clean Air Regulation) (NSW Government, 2021)
- National Environment Protection Council (NEPC) National Environment Protection (Ambient Air Quality) Measure 2021 (the Air NEPM) (National Environmental Protection Council, 2021)
- NSW EPA Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales (NSW EPA, 2022)
- Technical framework - Assessment and management of odour from stationary sources in NSW (the Technical Framework) (NSW Department of Environment and Conservation , 2006)
- NSW EPA Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (the Approved Methods) (NSW EPA, 2022)
- DP&E Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments (Department of Planning and Environment, 2018).

The POEO Act provides the statutory framework for managing pollution in NSW, including the procedures for issuing licences for environmental protection on aspects such as waste, air, water and noise pollution control. The POEO Act requires that no occupier of any premises causes air pollution (including odour) through a failure to maintain or operate equipment or deal with materials in a proper and efficient manner. The operator must also take all practicable means to minimise and prevent air pollution (sections 124, 125, 126 and 128 of the POEO Act). The POEO Act includes the concept of ‘offensive odour’ (section 129) and states it is an offence for scheduled activities to emit ‘offensive odour’.

The POEO Clean Air Regulation provides regulatory measures to control emissions from motor vehicles, fuels, and industry.

The National Environment Protection Council of Environmental Ministers, now the National Environment Protection Council (NEPC), set uniform national standards for ambient air quality in February 2016. This is known as the Air NEPM. The Air NEPM sets non-binding standards and goals (for 2025). The Air NEPM contains goals for the identified relevant pollutants inclusive of particulates and concentration limits, averaging periods and number of allowed exceedances for each of the identified pollutants.

The NSW EPA Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales (2022) lists the methods to be used for the sampling and analysis of air pollutants in NSW for statutory purposes. While no emission sampling was conducted as part of this assessment, Global Quarries Australia has a responsibility to undertake, where possible, all sampling in accordance with requirements outlined in the NSW EPA Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales (2022). This includes sampling type, duration, location and a number of other requirements.

The Technical Framework provides a legislative context for the control of odour and presents odour assessment criteria guidelines. It provides a framework for different levels of odour assessment, strategies to mitigate odour, and guidance for performance monitoring, regulation and enforcement.

The Approved Methods lists the statutory methods for modelling and assessing emissions of air pollutants from stationary sources in NSW. It considers the above-mentioned legislation and guidance to provide pollutant assessment criteria.

The Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments requires assessment for particulate matter for mining, petroleum and extractive industry developments under the Approved Methods. It provides allowances where criteria cannot be met even with implementation of best practice management in place.

2.3 Assessment criteria

Assessment criteria for the Project were taken from the Approved Methods. Reference is also provided to the Air NEPM air quality objectives, which has more stringent air quality goals for NO_2 and SO_2.

The objective of the criteria is ambient air quality that minimises the risk of adverse health impacts from exposure to air pollution. Achieving compliance with the impact assessment criteria will help demonstrate that the Project will operate in a manner that protects human and environmental health and amenity.

Relevant assessment criteria for the primary pollutants associated with construction and operation of the Project are presented in Table 2.2. The criteria apply to the total impact (increment plus background) and must be reported as the 100th percentile (maximum).

Table 2.2 Air quality impact assessment criteria

Pollutant	Averaging period	Impact location	Impact type	Criteria (µg/m³)	
				EPA Assessment Criteria	Air NEPM
Airborne particulate matter and common gaseous pollutants					
TSP	Annual	Sensitive receptor	Cumulative	90	-
PM_{10}	24 hour	Sensitive receptor	Cumulative	50	50
	Annual	Sensitive receptor	Cumulative	25	25
$PM_{2.5}$	24 hour	Sensitive receptor	Cumulative	25	20
	Annual	Sensitive receptor	Cumulative	8	7
Deposited dust	Annual (maximum increase)	Sensitive receptor	Cumulative	2 g/m²/month	-
	Annual (maximum total)	Sensitive receptor	Cumulative	4 g/m²/month	-
NO_2	1 hour	Sensitive receptor	Cumulative	246	164
	Annual	Sensitive receptor	Cumulative	62	31
SO_2	1 hour	Sensitive receptor	Cumulative	570	214
	24 hour	Sensitive receptor	Cumulative	228	57

Neither the Approved Methods nor the Air NEPM provide a criterion for respirable crystalline silica (RCS). Therefore the *Workplace Exposure Standards for Airborne Contaminants* (Safe Work Australia, 2019) and the *Guideline for assessing and minimizing air pollution in Victoria* (EPA Publication 1961.2) (EPA Victoria, 2025) have been used to set the impact assessment criteria for RCS for the project.

Pollutant	Averaging period	Impact location	Impact type	Criteria (µg/m³)	
				Safe Work	EPA Victoria
RCS	8 hour	At or beyond site boundary	Cumulative	50	-
	Annual	Sensitive receptor	Cumulative	-	3

3. Methodology

3.1 General

This AQIA of the construction and operation of the project was completed in accordance with EPA and contemporary guidance to assess air quality impacts from the project. Atmospheric dispersion modelling was undertaken to evaluate the potential worst-case impacts from the project during construction and under routine operations and inform recommendations of appropriate mitigation measures to minimise any potential impacts.

3.1.1 Pollutants of interest

Air quality may be impacted by a number of pollutants, each of which has different emission sources and effects on human health, amenity and the environment.

Based on a review of the construction methodology and operational activities, dust and particulate matter was identified as the pollutant most likely to impact nearby sensitive receptors in both cases. The assessment of dust and particulate matter includes TSP, PM_{10}, $PM_{2.5}$ and dust deposition.

Dispersion and deposition of TSP, PM_{10} and $PM_{2.5}$ has been modelled for both construction and operation, as described in Section 3.2.4.

Dispersion and deposition of TSP, PM_{10} and $PM_{2.5}$ has also been modelled for a blasting scenario as well as nitrogen dioxide (NO_2) from the explosive.

3.2 Modelling methodology

3.2.1 Dispersion model selection

CALPUFF was found to be the most appropriate dispersion modelling software to use for this project due to the distance and topography between the meteorological observations and sensitive receptors, and the site.

CALPUFF is an advanced non-steady-state, Gaussian puff dispersion model that uses a three dimensional spatially varying wind field that is capable of accounting for complex terrain features and varying wind fields.

3.2.2 Emission inventory development

A detailed emissions inventory for the site was developed based on NPI's *Emissions estimation technique manual for mining* (NPI, 2012) and *Emission estimation technique manual for mining and processing of non-metallic minerals* (NPI, 2014).

As the above guidance does not include the $PM_{2.5}$ fraction for assessed activities, ratios provided in *AP-42 Section 11.19.2 Crushed stone processing and pulverized material processing* (US EPA, 2004) and *Background document for revisions to fine fraction ratios used for AP-42 fugitive dust emission factors* (Midwest Research Institute, 2006) were used in this assessment.

3.2.3 Meteorological modelling

Local meteorology including long term wind speed and direction, as well as atmospheric stability, influence how air pollutants are dispersed into the local environment.

Site specific meteorological data used to drive the dispersion model was generated by use of TAPM and CALMET meteorological models to produce a three-dimensional wind field which also accounts for local variations in the terrain. Prognostic TAPM data was used as an 'initial guess field' for the CALMET meteorological model as well as surface observations from the BoM Goulburn Airport AWS.

A representative year was chosen for modelling purposes based on review of Southern Oscillation Index (SOI) for the past 10 years and an analysis of BoM data recorded at Goulburn Airport Automatic Weather Station (AWS) for the last 5 year calendar years (01/01/2019 – 31/12/2023). The review resulted in the selection of the 2023 calendar year (01/01/2023 – 01/01/2024) as the representative year for modelling purposes.

Details of the procedure undertaken to produce the site-specific meteorology are provided in Appendix B.

3.2.4 Dispersion modelling

Predicted air quality impacts were modelled in accordance with the Approved Methods using an approved computer software model CALPUFF.

CALPUFF model settings were selected with reference to the *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia* (Barclay and Scire; Atmospheric Studies Group, 2011).

For this assessment, the CALPUFF dispersion model was used to predict ground-level concentrations from the project. The CALPUFF dispersion model utilised a meteorological dataset of one year in duration. The grid size used in the CALPUFF model was equivalent to the CALMET domain (use of CALMET further discussed in Appendix B). The same grid resolution of 200 metres used for the CALMET model was used in CALPUFF.

The source properties and emission rates utilised in the dispersion modelling are detailed in Section 5. Emissions sources are active for a total of 11 hours per day, from 7:00 am to 6:00 pm, except for wind erosion sources which are active at all times.

The dispersion model was configured to predict dust concentration and deposition at identified sensitive receptor locations and for a sampling grid centred on the site. Impacts at and beyond the site boundary were calculated using the sampling grid.

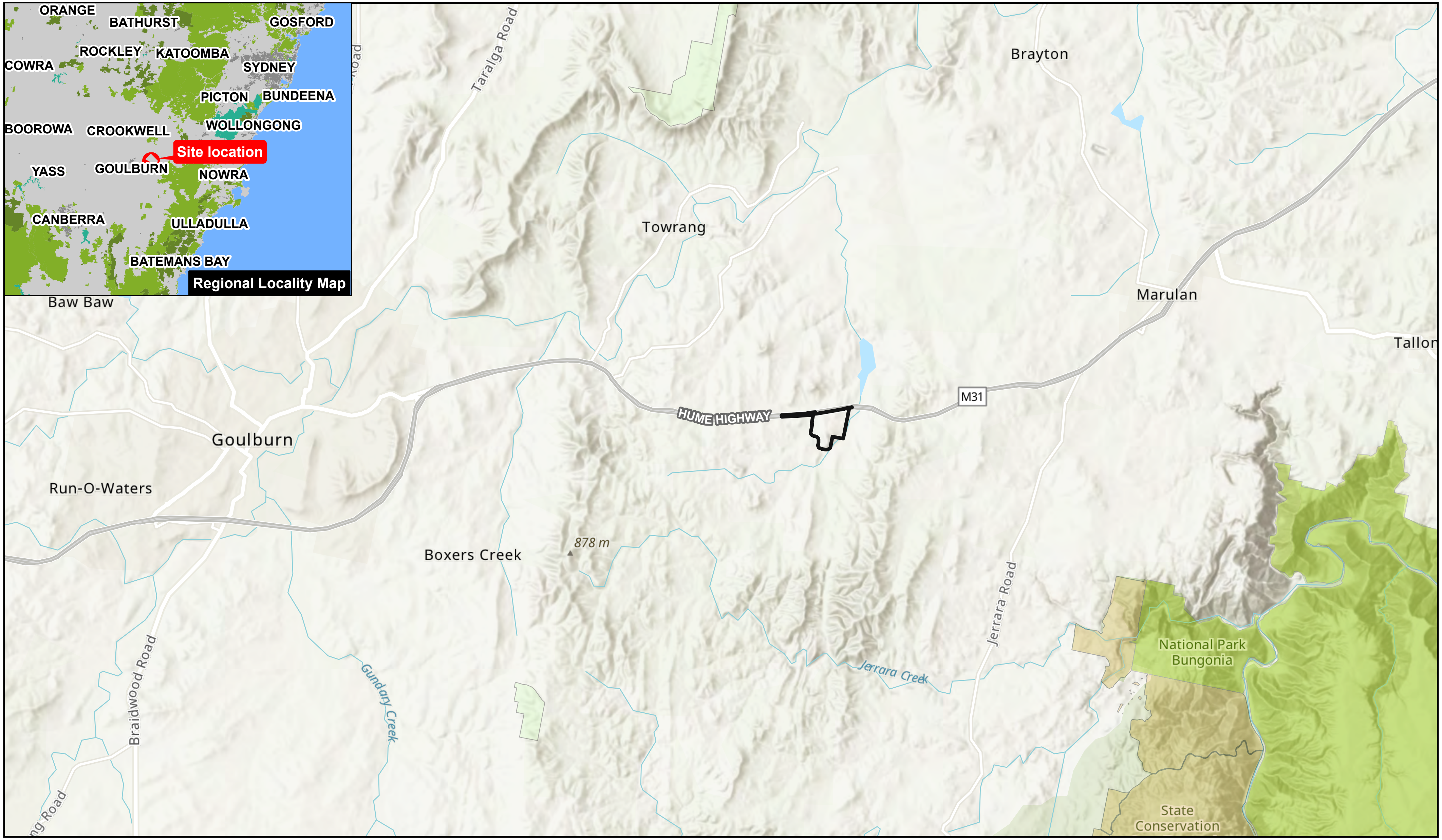
When modelling particulate matter, both the size of the particulate and its density must be accounted for. In this model, the geometric mass mean diameter was 5 microns for PM_{10} and 20 microns for TSP, and the geometric standard deviation was 1.24 microns for both (Department of Environment & Conservation, 2012) (URS, 2012). The default CALPUFF settings were used for $PM_{2.5}$ of 0.48 microns for the geometric mass mean diameter and 2 microns for the geometric standard deviation.

4. Existing environment

4.1 Project location

The proposed quarry site is located within the Goulburn Mulwaree local government area, around 10 kilometres southwest of Marulan in NSW, as shown in Figure 4.1.

Situated on the eastern side of the Hume Highway, the site is accessed via a new purpose built haul route, from a new intersection with the Hume Highway with dedicated left and right turn lanes and slip lanes.



Legend
- Project Application Area
- National Park
- Nature Reserve
- State Conservation Area

Paper Size ISO A4
0 1 2 3 4
Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Marulan quarry EIS

Project No. **2127708**
Revision No. **0**
Date **12/09/2024**

Site locality map

FIGURE 4.1

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Print date: 12 Sep 2024 - 14:08

Data source:LPI:DCDB/DTDB, 2012, EPI: LandZoning, 2012. World Topographic Map: Vicmap, Esri, TomTom, Garmin, Foursquare, METI/NASA, USGS
World Hillshade: Esri, Geoscience Australia, NASA, NGA, USGS. Created by: pfield

4.2 Receiving environment

4.2.1 Land use

The site has been divided into 3 lots, as shown in Figure 4.1. The eastern lot (Lot 4) is 14.7 hectares and consists almost entirely of cleared land. There is evidence of a small disused quarry in the northern portion of the lot, possibly created during the construction of the Hume Highway.

Lot 3, on the western side, is 67.5 hectares and is primarily light bushland. There is a small dam on the western side of the lot.

Lot 7001 of DP 1025585 is located in the middle of Lot 3 and is primarily light bushland.

The project site is located within the Wollondilly River catchment within the upper reaches of the Hawkesbury Nepean basin and forms part of Sydney's drinking water catchment. Water drains from the site to the south and east into Narambulla Creek, which runs along the southern and eastern boundary of the property. An existing in-line water storage is located on Narambulla Creek to the north of the Hume Highway (referred to as Narambulla Lake), which subsequently flows to the Wollondilly River and Lake Burragorang.

The site is immediately surrounded by a mixture of cleared land and light bushland. It is located on bush fire prone land (vegetation category 1).

Goulburn city is located approximately 18 kilometres to the west of the site, and Marulan is located approximately 10 kilometres to the northeast of the site. There are some rural residences closer to the site which have been identified in Section 4.2.3.

4.2.2 Terrain

The site is located in an area of small hills of approximately 40 to 70 metres in height. A valley is located to the east of the site and there is some elevated topography approximately 1.2 kilometres to the east and nine kilometres to the northwest. Terrain contours are shown in Figure B.6.

4.2.3 Sensitive receptors

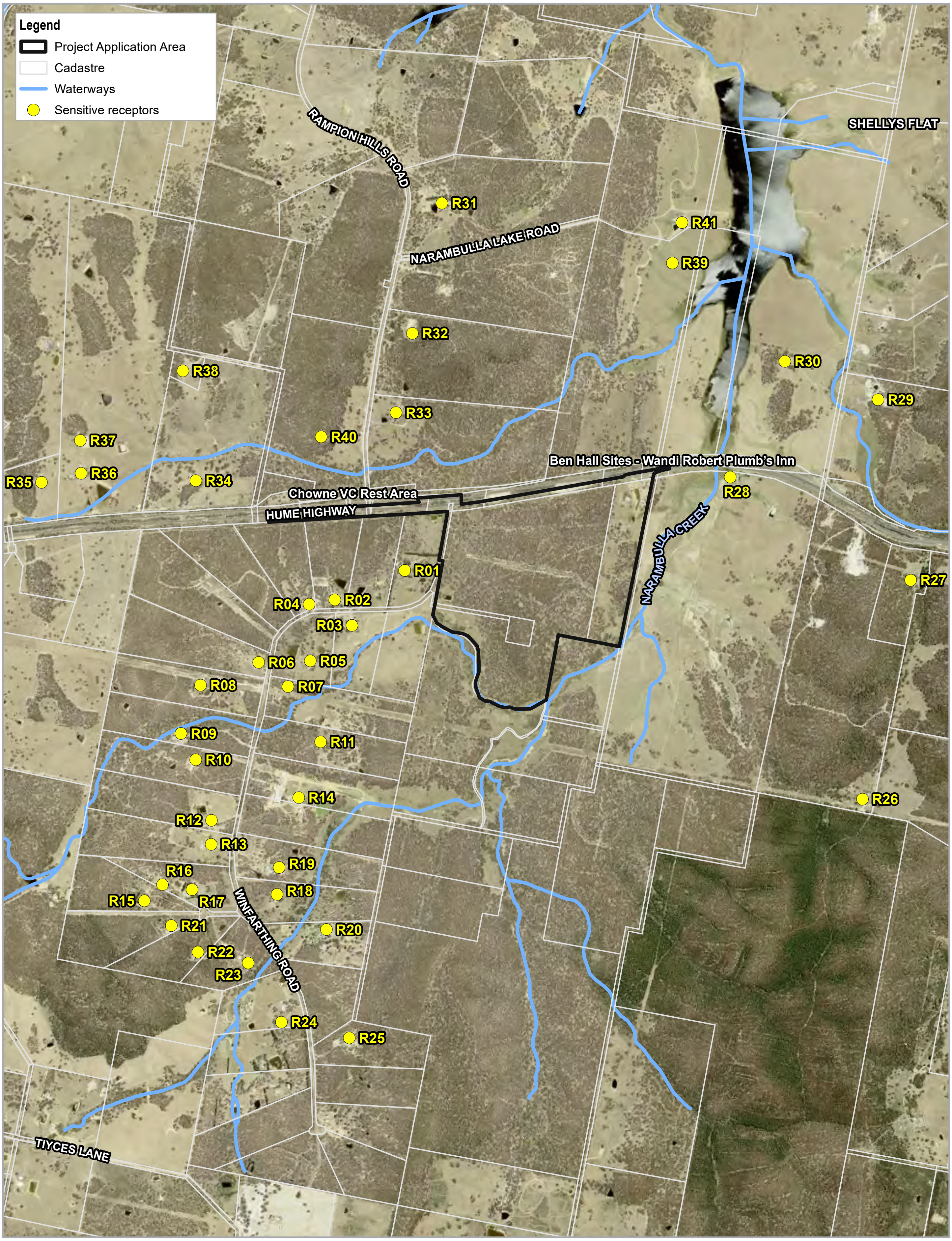
Sensitive receivers are defined based on the type of occupancy and the activities performed in the land use. Sensitive receivers could include both existing and proposed:

- Residences.
- Educational institutes.
- Hospitals and medical facilities.
- Places of worship.
- Commercial or industrial premises.
- Passive recreational areas such as parks and reserves.
- Active recreational areas such as sporting fields, golf courses. Note that these recreational areas are only considered sensitive when they are in use or occupied.

A total of 41 residential receivers have been identified within approximately 2.5 kilometres from the quarry site. The identified sensitive receptors are mainly rural residential properties located along Winfarthing Road. These are detailed in Table 4.1 and shown in Figure 4.2. Distances are stated from the receiver to the nearest point at the of the quarry site boundary.

Table 4.1 Nearest sensitive receptors

Receptor	Easting (m)	Northing (m)	Type of receptor	Address	Min distance to quarry site (m)	Direction from quarry centre
R01	764958	6151224	Residential	26 Winfarthing Road Marulan	525	NW
R02	764600	6151074	Residential	96 Winfarthing Road Marulan	825	W
R03	764688	6150943	Residential	89 Winfarthing Road Marulan	725	W
R04	764469	6151051	Residential	114 Winfarthing Road Marulan	950	W
R05	764474	6150761	Residential	143 Winfarthing Road Marulan	975	W
R06	764210	6150753	Residential	146 Winfarthing Road Marulan	1225	W
R07	764360	6150630	Residential	155 Winfarthing Road Marulan	1125	W
R08	763913	6150637	Residential	156 Winfarthing Road Marulan	1550	W
R09	763813	6150389	Residential	190 Winfarthing Road Marulan	1700	W
R10	763888	6150255	Residential	208 Winfarthing Road Marulan	1675	W
R11	764528	6150347	Residential	189 Winfarthing Road Marulan	1050	SW
R12	763969	6149945	Residential	226 Winfarthing Road Marulan	1750	SW
R13	763967	6149822	Residential	248 Winfarthing Road Marulan	1800	SW
R14	764415	6150061	Residential	205 Winfarthing Road Marulan	1300	SW
R15	763625	6149533	Residential	26 Faviell Close Marulan	2275	SW
R16	763718	6149616	Residential	22 Faviell Close Marulan	2150	SW
R17	763869	6149590	Residential	22 Faviell Close Marulan	2050	SW
R18	764304	6149566	Residential	227 Winfarthing Road Marulan	1750	SW
R19	764315	6149703	Residential	245 Winfarthing Road Marulan	1650	SW
R20	764557	6149386	Residential	309 Winfarthing Road Marulan	1775	SW
R21	763763	6149406	Residential	25 Faviell Close Marulan	2250	SW
R22	763899	6149271	Residential	21 Faviell Close Marulan	2275	SW
R23	764156	6149215	Residential	296 Winfarthing Road Marulan	2150	SW
R24	764327	6148911	Residential	336 Winfarthing Road Marulan	2325	SW
R25	764674	6148831	Residential	359 Winfarthing Road Marulan	2250	SW
R26	767301	6150053	Residential	16431 Hume Highway Marulan	2100	SE
R27	767548	6151174	Residential	16399 Hume Highway Marulan	2125	E
R28	766624	6151702	Non-sensitive	16501 Hume Highway Marulan	1400	NE
R29	767381	6152098	Residential	16448 Hume Highway Marulan	2250	NE
R30	766904	6152294	Residential	16450 Hume Highway Marulan	1950	NE
R31	765148	6153104	Residential	132 Rampion Hills Road Carrick	2100	N
R32	764998	6152437	Residential	84 Rampion Hills Road Carrick	1475	N
R33	764914	6152032	Residential	42 Rampion Hills Road Carrick	1125	NW
R34	763889	6151684	Residential	16748 Hume Highway Marulan	1675	NW
R35	763099	6151675	Residential	16 Dalmeny Lane Carrick	2450	W
R36	763301	6151721	Residential	16830 Hume Highway Marulan	2275	W
R37	763298	6151890	Residential	16830 Hume Highway Marulan	2325	NW
R38	763823	6152246	Residential	16786 Hume Highway Marulan	2050	NW
R39	766322	6152797	Residential	108 Narambulla Lake Road Carrick	1925	N
R40	764536	6151923	Residential	23 Rampion Hills Road Carrick	1300	NW
R41	766378	6153012	Residential	107 Narambulla Lake Road Carrick	2125	N



Paper Size ISO A4

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Marulan quarry EIS

Nearest sensitive receptors to the project site

Project No. 2127708
Revision No. 0
Date 31/10/2024

FIGURE 4-2

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Data source: General topography - LPI 2017. sixmaps/LPI_Imagery_Best: © Department of Finance, Services & Innovation 2018. Created by: pfield

4.3 Existing and future sources of air pollutants

4.3.1 Nearby facilities

The National Pollutant Inventory (NPI), operated under the *National Environment Protection (National Pollutant Inventory) Measure 1998*, provides publicly available information about emissions of 93 pollutants throughout Australia. Facilities that exceed prescribed threshold values are required to report their emissions to the NPI on a yearly basis.

A review of facilities reporting to the NPI in the area surrounding the project site revealed two facilities, Lynwood Quarry (Holcim Australia) and Marulan Meter Station, within a 10 kilometre radius of the site.

The Lynwood Quarry is located approximately 6 km northeast of the site and reported emissions of 150 tonnes of PM_{10} and 5.1 tonnes of $PM_{2.5}$ during the 2022/2023 reporting period. The Marulan Meter Station did not report any emissions of PM_{10} or $PM_{2.5}$.

In addition to a review of the NPI, the Marulan South Limestone Mine and Boral Quarries were identified approximately 11 km southeast of the site.

For further detail on emissions from these sites, the following reports were reviewed:

– *Lynwood Quarry Extraction Area Modification Project – Air Quality Impact Assessment* (Pacific Environment Limited, 2015)

– *Air Quality Impact Assessment - Marulan South Limestone Mine Continued Operations* (Todoroski Air Sciences Pty Ltd, 2019) (including emissions from the adjoining Peppertree Quarry)

Annual emissions for each site for the proposed stages described in the reports are presented in Table 4.2.

Table 4.2 Reported emissions from external sources

Stage	Annual emissions (kg/year)		
	TSP	PM10	PM2.5
Lynwood Quarry			
Stage 1	252192	84070	11040
Stage 2	388180	133635	17925
Stage 3	384950	137381	18707
Maximum	**388180**	**137381**	**18707**
Marulan South Limestone Mine			
Stage 1 – Mining activities	850820	345597	53065
Stage 2 – Mining activities	1008235	395268	59246
Stage 3 – Mining activities	1025438	407796	62233
Maximum – Mining activities	1025438	407796	62233
Stage 1 - Peppertree quarry	402700	201350	20135
Stage 2 - Peppertree quarry	264096	132048	13204.8
Stage 3 - Peppertree quarry	264096	132048	13204.8
Maximum – Peppertree quarry	402700	201350	20135
Stack emissions	946	315	315
Total (maximum)	**1290480**	**547262**	**75753**

4.3.2 State significant projects

A review of the NSW Government Major Projects website was completed to understand future sources of air pollutants which may contribute to cumulative impacts with the project.

One new state significant project (including both State Significant Developments and State Significant Infrastructure) has been identified within 10 kilometres of the project. This is the Marulan Solar Farm, located at 750 Carrick Road, Carrick approximately 8.5 kilometres northeast of the project site. The status of the solar farm is currently 'Determination'. This project has the potential to have minimal dust impacts during its construction and minimal are expected during operation. The SEARs for this project do not require an air quality assessment.

4.4 Background air quality

An assessment of the total impact, which includes the project impact as well as the background concentrations, is required for PM_{10}, $PM_{2.5}$,TSP and NO_2.

4.4.1 Background DCCEEW AQMS data

The NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) operates air quality monitoring stations (AQMS) in many locations across NSW. The nearest station to the site is the Goulburn AQMS which is located approximately 16.3 km east of the site. This station was commissioned in November 2019. The next two nearest stations are Albion Park South and Bargo, located approximately 83 km east and 79 km northeast respectively.

TSP is not recorded at these AQMSs and therefore a TSP to PM_{10} ratio of 2:1 was assumed (NPI, 2012).

A summary of the ambient air quality data recorded at the Goulburn AQMS is provided in Table 4.3.

Table 4.3 Summary of available background air quality data recorded by the Goulburn DCCEEW AQMS

Pollutant	Averaging period	Recorded background concentration by year ($\mu g/m^3$)				
		2019	2020	2021	2022	2023
PM_{10}	24 hour maximum	494	557	38	20	24
	24 hour maximum (below assessment criteria)	48	42	38	20	24
	70th percentile	67	14	11	9	12
	Annual average	82	19	9	7	10
	Data availability	15%	98%	99%	98%	99%
TSP	Annual average	164	38	18	14	21
$PM_{2.5}$	24 hour maximum	334	516	30	15	18
	24 hour maximum (below assessment criteria)	47	46	30	15	18
	70th percentile	38	8	6	5	7
	Annual average	59	12	6	4	6
	Data availability	15%	98%	99%	98%	99%
NO_2	1 hour maximum	303	186	55	51	64
	1 hour maximum (below assessment criteria)	105	115	55	51	64
	Annual average	8	6	6	3	6
	Data availability	14%	93%	93%	88%	95%

The representative year chosen for the assessment is 2023 based on the methodology described in Appendix B. Figure 4.3 shows the 24 hour average PM_{10} and $PM_{2.5}$ concentrations recorded at the Goulburn AQMS.

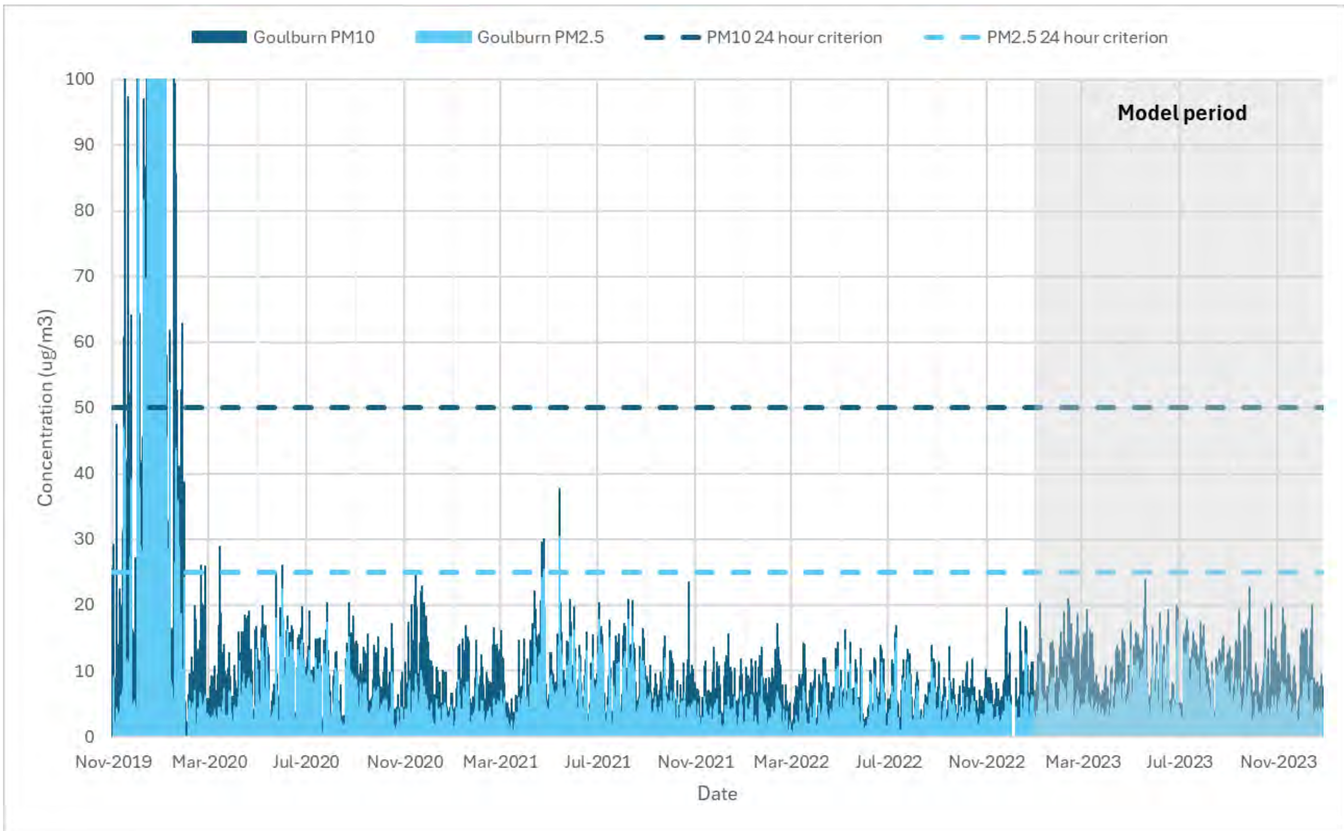


Figure 4.3 24 hour average particulate matter concentrations (µg/m³) from DCCEEW Goulburn AQMS

4.5 Climate and meteorology

The local climate and meteorology (weather) within the study area is of critical importance when assessing the potential for air quality impacts at sensitive receptors.

The meteorological environment relevant to a project site is best understood through review of data collected from long-running monitoring weather stations, most commonly operated by the Bureau of Meteorology (BoM) as well as state authorities (DCCEEW in this case) and in some instances private entities. Simulation of the meteorological environment (modelling) is a useful tool in understanding the environment where suitable meteorological observations are not available.

4.5.1 Available observations

The BoM operates a network of automatic weather stations (AWS) across Australia. A BoM AWS typically measures critical meteorological parameters including wind speed, wind direction, temperature, relative humidity, and pressure, with some stations also measuring cloud coverage. The nearest AWS to the project is the BoM AWS located at the Goulburn Airport, approximately 17 kilometres southwest of the site.

4.5.1.1 Temperature

Figure 4.4 shows monthly mean temperature statistics for data measured at BoM Goulburn Airport AWS for the period 2019 through 2023. The 50th percentile monthly maximum and minimum temperatures are used to show the typical temperature range for each month of the year, as well as the average monthly maximum and minimum temperatures. These are shown along with the monthly average temperature.

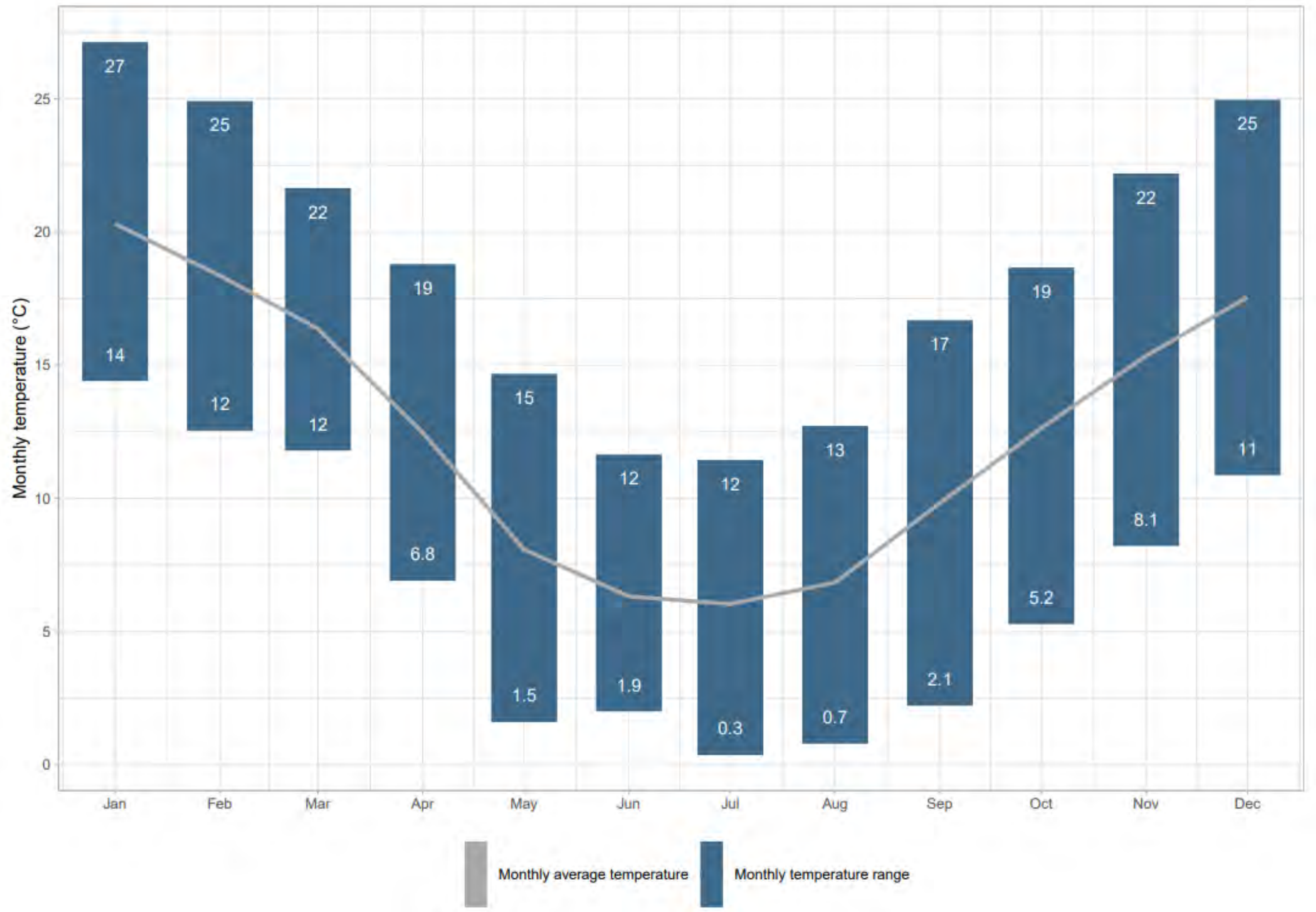


Figure 4.4 Monthly climate temperature statistics from BoM Goulburn Airport (2019-2023)

4.5.1.2 Rainfall

Figure 4.5 shows monthly rainfall statistics for data measured at BoM Goulburn Airport AWS for the period 2019 through 2023. The statistics shown include average monthly rainfall amount (mm) and average number of days per month where rainfall is greater than 0.25 mm.

The data shows that the number of rain days and the total rainfall amounts are greater during the spring and summer months.

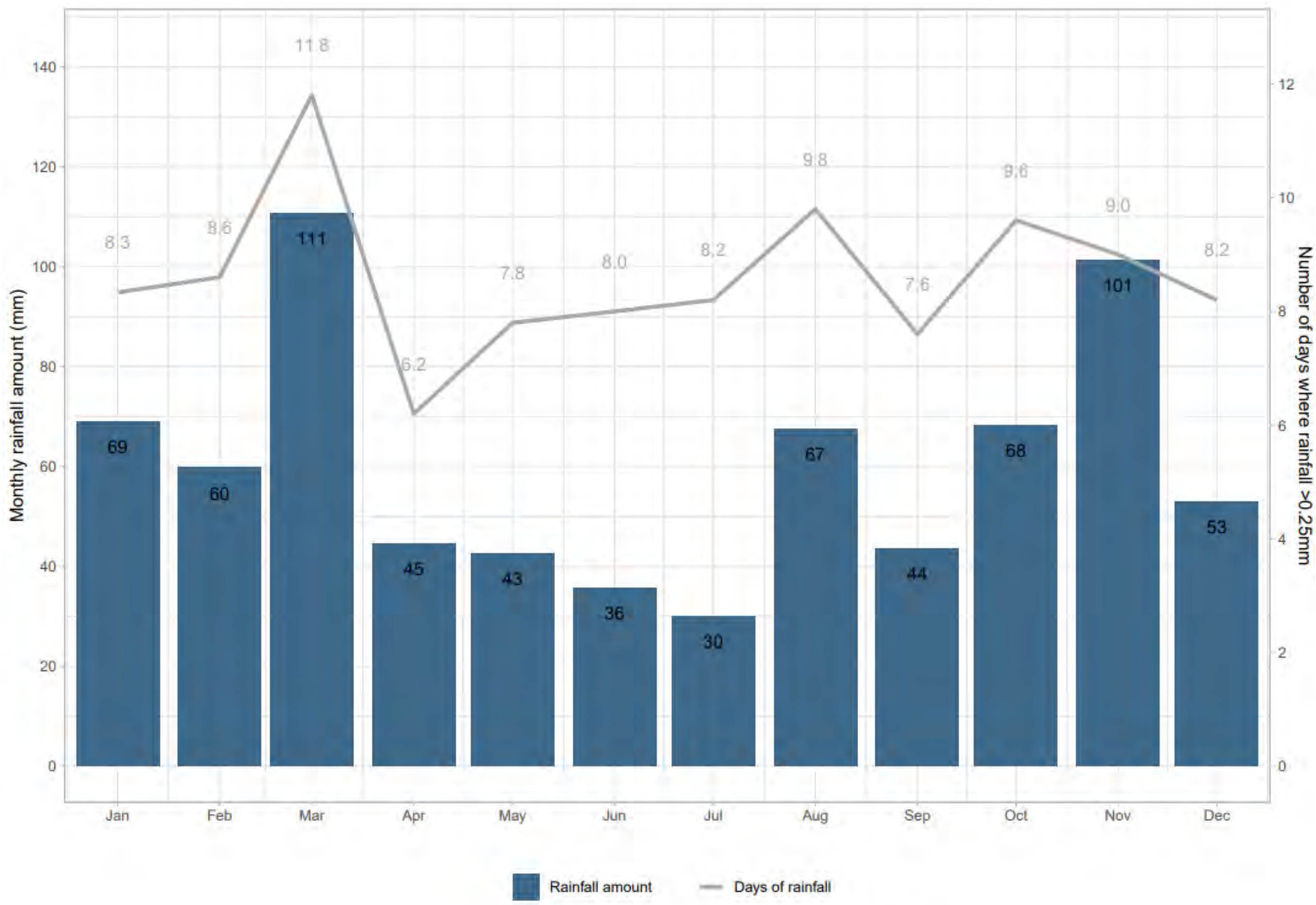


Figure 4.5 Average monthly rainfall collected from BoM Goulburn Airport (2019-2023)

4.5.1.3 Wind

Figure 4.6 shows the average annual wind rose and Figure 4.7 shows the average seasonal wind roses, both measured at BoM Goulburn Airport AWS for the period 2019 through 2023. Figure 4.6 shows the following features:

– The predominant annual average wind direction is from the northwest.
– The average wind speed measured was 4.1 metres per second.
– Calm conditions (wind speeds less than 0.5 m/s) occurred 11.8% of the time.
– High wind speeds (winds greater than 5 m/s which are often attributed to dust lift off) mostly occur from the northwest and east.

Figure 4.7 extends these observations, showing that:

– The winds from the northwest mainly occur during spring and winter.
– Autumn has a slightly lower average wind speed than the other seasons.
– Summer has the smallest proportion of calm conditions.

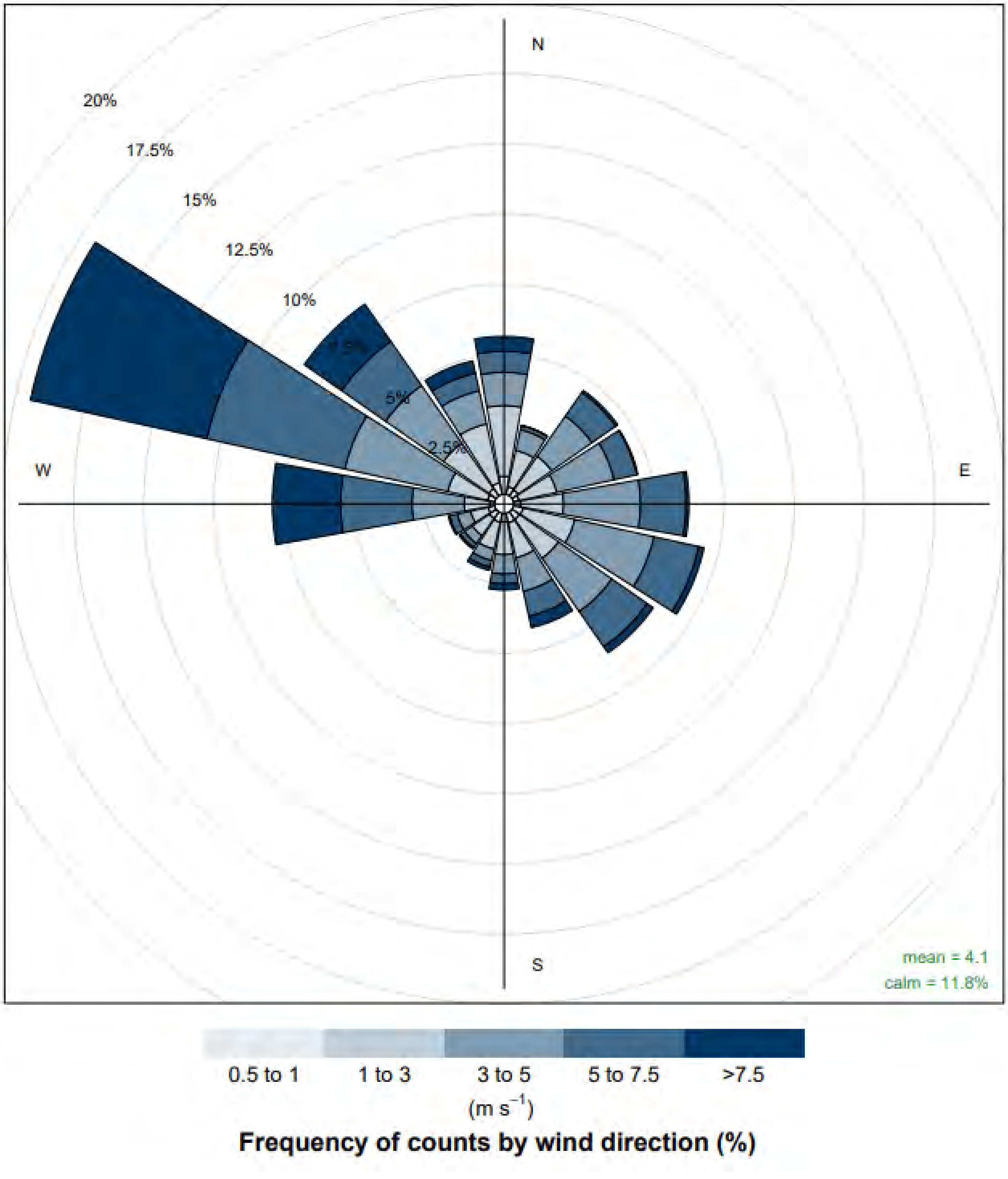


Figure 4.6 Annual average wind rose collected from BoM Goulburn Airport (2019-2023)

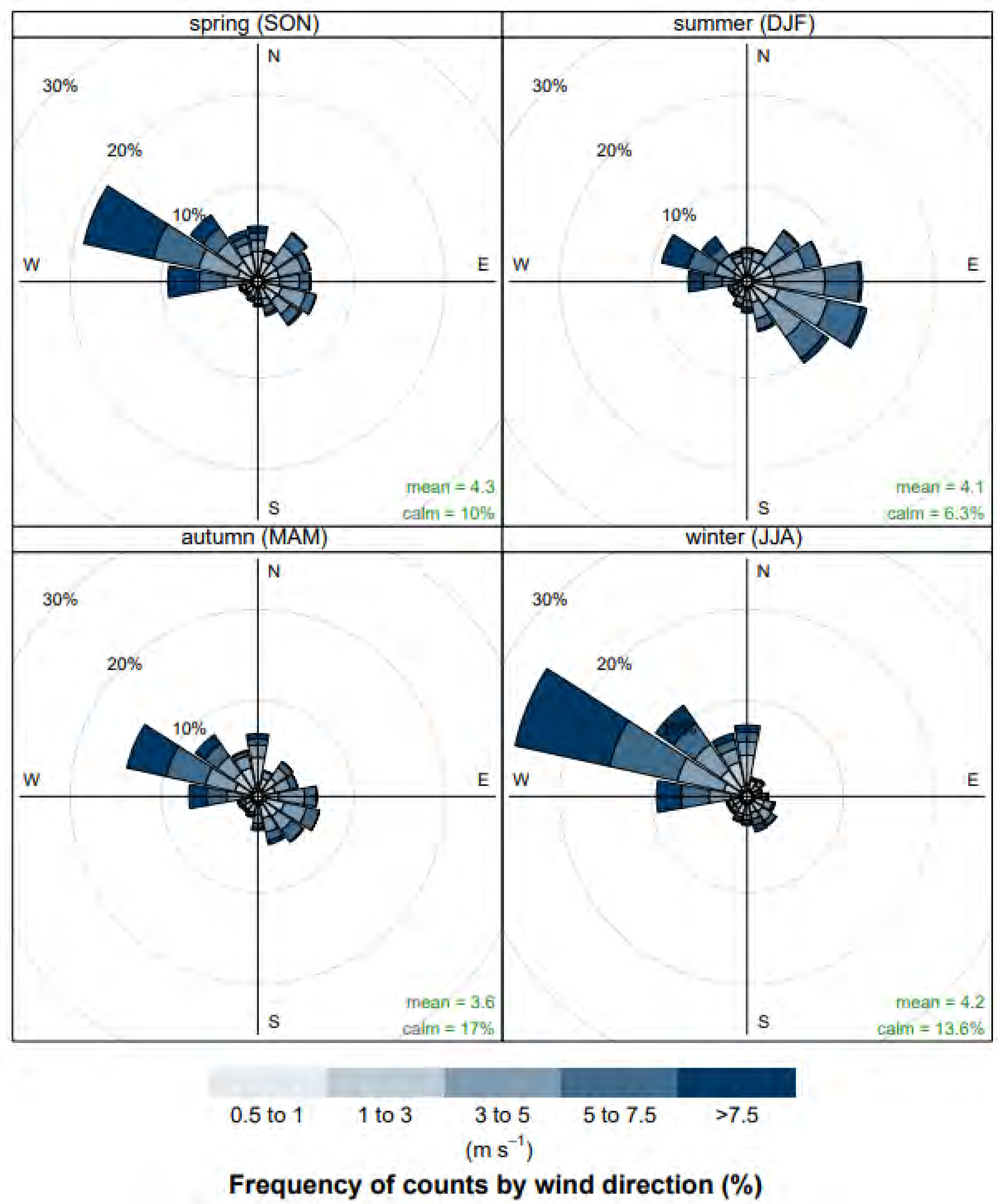


Figure 4.7 Average seasonal wind roses collected from BoM Goulburn Airport (2019-2023)

5. Project air emissions

5.1 Project construction

5.1.1 Construction overview

The main construction activities undertaken for the project would broadly involve the following key steps:

- Enabling works and site establishment including environmental controls, vegetation removal, topsoil stripping and earthworks.
- Construction of new intersection and site access.
- Construction of site offices and processing plant.

A dozer, excavator and haul trucks are the main items of equipment likely to be required during construction. Other equipment may include:

- Roller
- Grader
- Water cart
- Compactor
- Light vehicles
- Hand tools

The construction works would take place over a period of approximately five months.

The majority of works would be undertaken during the following work hours:

- Monday to Friday: 7:00 am to 6:00 pm
- Saturday: 8:00 am to 1:00 pm
- Sundays and public holidays: no work

Traffic movements during construction would generally be made between standard construction hours. Vehicles would access the site via the newly installed site access from the Hume Highway.

Construction traffic would include heavy and light vehicles associated with material and equipment deliveries, and the arrival and departure of construction workers. The indicative construction traffic volumes are based on the following vehicle types as described in the Marulan Quarry EIS – Traffic Study:

- 30 of light vehicles per day – up to 4.5 tonnes
- 30 heavy vehicles per day – truck and trailers of up to 42.5 tonne capacity.

5.1.2 Construction emissions

Dust and particulate matter would be the primary pollutants during the construction phase of the project. Other potential emissions to air include exhaust emissions from vehicles and machinery. These have been qualitatively considered.

The main sources of dust emissions would be:

- Wheel generated dust from vehicles traversing the site.
- Vegetation removal, topsoil stripping and excavation.
- Dust generated by wind across cleared areas and stockpiles.

The equipment used which would generate dust, as described in Table 5.1, includes dozers, excavators and both light and heavy vehicles.

Emission factors for each of these activities were taken from NPI's *Emission estimation technique manual for mining* (NPI manual A) (NPI, 2012) and rates were calculated based on an assumed 2,500 tonnes of overburden moved per day. Construction haul road emissions are made up of both light and heavy vehicles however it is the heavy vehicles which are the major source of dust. Modelling assumes 10 light vehicles and 50 heavy vehicles per day which is very conservative compared to the anticipated vehicle numbers as described in Section 5.1.1.

Emission rates are given in Table 5.1 and calculations can be found in Appendix A.

Level 1 watering would be applied to haul roads and stockpiles, which reduces wheel generated dust and wind erosion factors by 50% as per Table 4 of the NPI manual A. This is included in derived emission rates.

As specific emission rates are not given for $PM_{2.5}$, the following $PM_{2.5}/PM_{10}$ ratios have been applied:

– 0.15 for wind erosion (Midwest Research Institute, 2006)
– 0.1 for all other sources

The fraction of TSP emissions from each activity during the construction scenario is shown in Figure 5.1. Wheel generated dust from heavy vehicles is the largest emitter of TSP whereas construction activities in the quarry area are the largest contributor to PM_{10} and $PM_{2.5}$ emissions (refer Table 5.1).

Details of the modelled sources are provided in Table 5.2.

Table 5.1 Construction scenario emission rates

Site area	Area (m^2)	Dust emission sources	TSP emission rate	PM_{10} emission rate	$PM_{2.5}$ emission rate	Units
Stage 1 quarry	68621.1	Dozer, excavator	0.208	0.072	0.007	g/s
Overburden stockpile #1	29640.5	Truck unloading	0.758	0.271	0.027	g/s
		Wind erosion	5.56E-06	2.78E-06	4.17E-07	$g/m^2/s$
Construction haul road	-	Wheel generated dust from both heavy and light vehicles	7.965	2.365	0.236	g/s

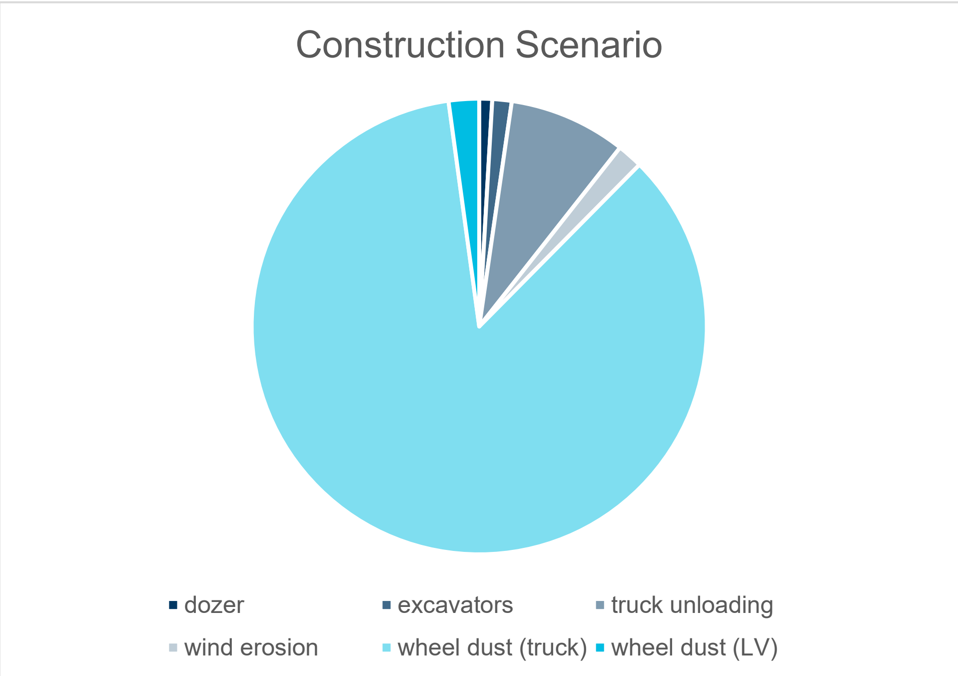
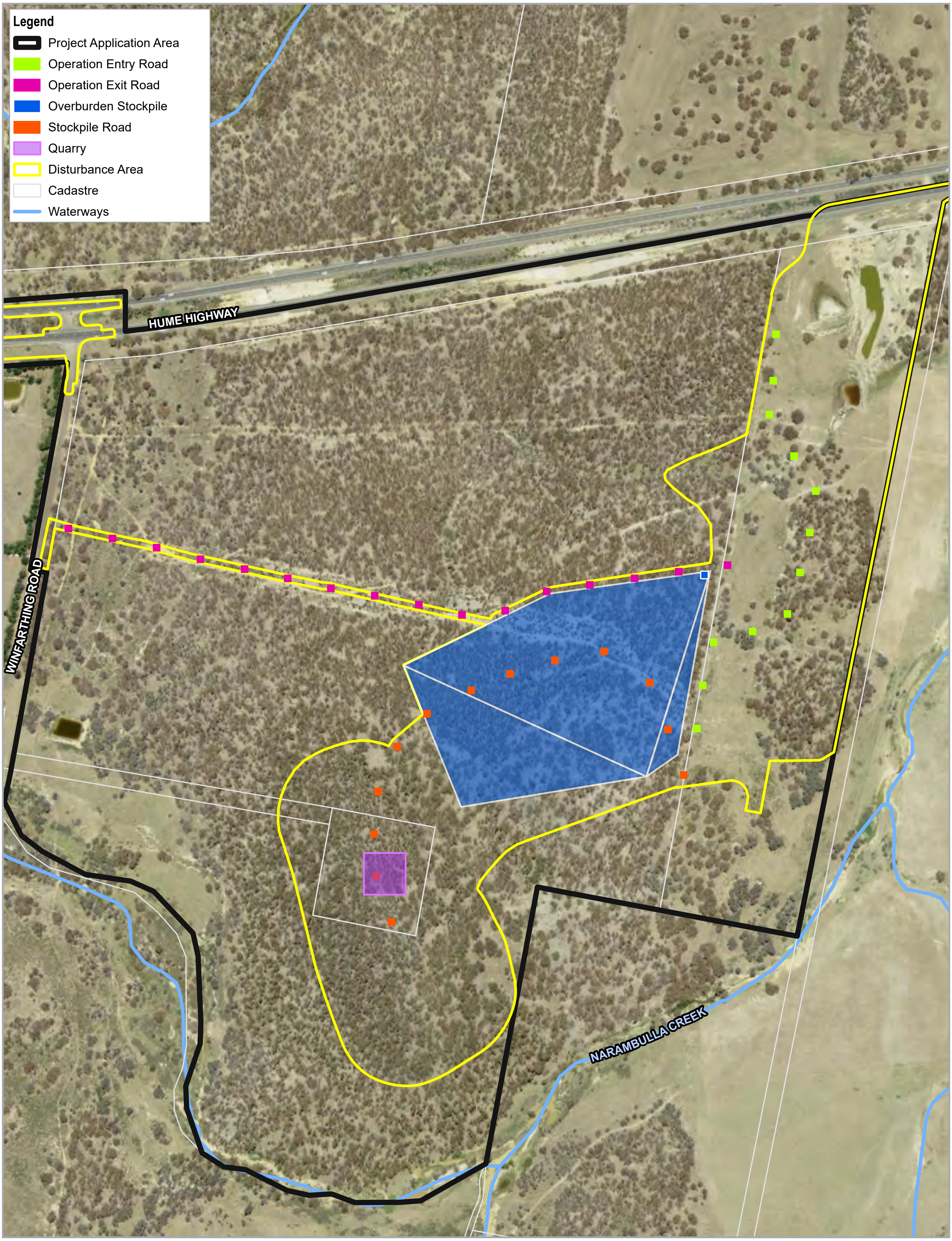


Figure 5.1 Fraction of overall TSP emissions from construction scenario activities

Table 5.2 Construction scenario modelled source parameters

Source	Location		Source details	
	Easting (m)	Northing (m)		
Stage 1 quarry	765,560	6,150,910	Volume source Effective height: 2 m Side length: 50 m	
Overburden stockpile	765,945	6,151,270	Volume source (truck unloading) Effective height: 2.55 m Side length: 9 m	Area source (wind erosion) Area: 71,211 m^2
Entry road	766,060	6,151,273	Line volume source Effective height: 2.55 m Side length: 9 m Road length: 745 m	
Road between stockpiles	765,664	6,151,131	Line volume source Effective height: 2.55 m Side length: 9 m Road length: 668 m	
Exit road	765,601	6,151,234	Line volume source Effective height: 2.55 m Side length: 9 m Road length: 828 m	



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0 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Global Quarries
Marulan quarry EIS

Construction Scenario
Modelled Sources

Project No. 2127708
Revision No. 1
Date 5/7/2025

FIGURE 5.2

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Data source: General topography - LPI 2017. sixmaps/LPI_Imagery_Best: © Department of Customer Service 2020. Created by: aulayao

5.2 Project operation

5.2.1 Operational overview

The quarry would be developed in two stages to minimise the initial amount of clearing. The first stage would consist of a circular shape approximately 2.85 ha in area and extend to a depth of R685m (or 15 m below the existing ground surface).

The extraction would progress in 10 m deep benches. As the benches progress, more overburden will need to be removed, so the area of the pit will gradually increase with depth. Initially, approximately 2.3 ha will be disturbed for the extraction, increasing to 5.3 ha once Stage 1 is exhausted. The area of Stage 2 would be approximately 2.6 ha hectares and extend to a depth of RL595 m, as Stage 1.

The actual extraction rate will vary depending on demand; however extraction would not exceed 500,000 tonnes in any twelve-month period. The extraction rate relates to the material sold from the site, not the overburden.

The maximum daily extraction and haul rate would be about 2,000 tonnes but this extraction rate would be rare.

The volume of material extracted from the quarry would be recorded using a weighbridge.

The resource would be progressively drilled and blasted, with material extracted between each blasting event through use of in pit plant including excavators, bulldozers and haul trucks. The size, shape and orientation of the resource suggest blasting events would be spaced over a 50 to 200 metre area with 10 metre depth. Traditional drill and blast methods would be used, requiring a drill rig stationed on top of each production bench. This rig would drill a series of holes that are later charged with explosives, detonators and delays. It is anticipated that blasting would be undertaken in 20-30,000 tonne shots with up to two blasts per month during peak periods.

The blasted rock would be excavated and loaded on to trucks for transport to the processing area. The processing area is located in the eastern portion of the site and is approximately 7.1 ha in area. The crushing and screening plant are located in the southern portion of the processing area.

The tuff would be processed in the crusher and screened into the various product specifications required. The processed materials would be stockpiled in the processing area.

Equipment at the quarry would depend on levels of activity which would vary from time to time. A description of the plant and equipment to be used is provided in Table 5.3. The frequency of use is relevant to the periods when the quarry is operating. As an example, following a blast, the crusher will be operating 100% of the time but once the material is crushed, the crusher would not be operating until the next blast, so it is estimated that the crusher is used for about 70% of the operating period of the quarry.

Table 5.3 Proposed quarry plant and equipment

Type	Approximate Number	Typical Frequency of use during operation	Description
Dozer	1	25%	Clearing and grubbing of vegetation and stripping of topsoil. Construction of processing area. Rehabilitation.
Excavators	2	100%	Excavating material and stockpiling. Clearing and grubbing of vegetation and stripping of topsoil.
Jaw, cone and impact crusher	1	70%	Crushing rock.
Screen	1	70%	Aggregate/gravel production and screening.
Front-end Loader	2	100%	Loading material onto the haul trucks and stockpiling material.

Type	Approximate Number	Typical Frequency of use during operation	Description
Onsite articulated dump truck	100 movements per day	100% during extraction	Trucks hauling: – Stripped overburden material. – Extracted materials from the extraction area to transfer to the crusher.
Haul Trucks	Up to 50/day	100%	Up to 50 road haulage vehicles entering and leaving site per day.
Water Cart	1	60%	To water haul roads and stockpiles.
Water Pump	2	40%	To dewater excavation/basin and to fill watercart from standpipe. To water stockpiles and put moisture in products.
Hand tools	5	5%	General activities maintaining plant.
Light vehicles	Up to 5	20%	Transporting staff to, from and around site.

Access to the quarry site by heavy vehicles will be via a new left in only intersection to the Hume Highway incorporating a 189 metre deceleration lane, located approximately 860 metres east of Winfarthing Road. All haulage vehicles will enter the site via the new left-in only intersection directly from the Hume Highway and travel via the weighbridge for access to either the VENM / ENM stockpile or product stockpile areas. Haulage vehicles will exit the site via the weighbridge and new internal haulage road around the perimeter of the overburden stockpile and along an upgraded forestry haulage road to Winfarthing Road.

Haulage vehicles will then travel north for approximately 220 metres along Winfarthing Road for a left only movement via the new acceleration lane. All haulage vehicles will enter the westbound carriageway of the Hume Highway and utilise the Goulburn South interchange for loads destined for the Sydney market.

Based on a conservative assumption of an average 34 tonne load for each heavy vehicle and a relatively consistent flow of trucks throughout the day, the expected daily and peak hour heavy vehicle traffic generation is outlined in Table 5.4.

Table 5.4 Operational traffic movements per day

Vehicle	Quantity	Movements	Peak hour generation
HGV Vehicle type	50	50 in 50 out	5 in 5 out
Light vehicle	10	10 in and 10 out	10 in during AM peak and 10 out during PM peak

Light vehicles associated with the quarry operations will be permitted to enter the site via the new Quarry intersection or via Winfarthing Road. Light vehicles may utilise the improved Winfarthing Road intersection line markings to access either the eastbound or westbound carriageways on the Hume Highway.

Light vehicle movements would mainly be associated with staff but there may be the occasional client or maintenance vehicle that also visits the site. The majority of the workforce would arrive between 6:30 am and 7:30 am and depart generally between 3.00 pm and 6:30 pm. Other vehicles would arrive at various times but would be infrequent.

An onsite operational traffic management plan would establish standard traffic rules, signage, site speed limits and designated traffic movement areas through the site for delivery vehicles.

Parking would be provided for 15 vehicles adjacent to the site office.

During dry conditions, exposed areas would be sprayed with water from a water cart to suppress dust. Water will be sourced from the water storage dam or sediment basins.

5.2.2 Operational emissions

Dust and particulate matter would be the primary pollutants during the operational phase of the project. Other potential emissions to air include exhaust emissions from vehicles and machinery. These have been qualitatively considered.

The main sources of dust emissions would be:

- Wheel generated dust from vehicles traversing the site
- Drilling and blasting (intermittent)
- Excavation of blasted rock
- Handling of blasted rock and other products including truck loading and unloading
- Crushing and screening
- Wind erosion from stockpiles

The equipment used which would generate dust, as described in Table 5.3, includes dozers, excavators, front-end loaders, the crusher and screen, and light and heavy vehicles.

Assessment of the local geology indicates that geological formations in the vicinity of the site include:

- Mica quartz sandstone, interbedded with laminated siltstone and mudstone
- Chert interbedded with grey massive to laminated siltstone, mudstone and sandstone
- Pyritic carbonaceous shale
- Siltstone with minor black graptolitic shale horizons; small limestone and ironstone deposits
- Lithic quartz to quartzose sandstone
- Felsic volcanic breccia with pumice and perlitic felsite fragments

Risk assessment of silica emissions has been undertaken as part of a separate assessment (GHD, 2022). A quantitative human health risk assessment (HHRA) was undertaken, the outcomes of which indicate that the silica content of the dust emissions from the project represent a low risk to the health of the community living in the area surrounding the project site.

The extracted rock is assumed to generally be made up of non-metallic minerals. Emission factors for this type of mining are defined in NPI's *Emission estimation technique manual for mining and processing of non-metallic minerals* (NPI manual B) (NPI, 2014). Emission factors used from NPI manual B include those for crushing (which is assumed to include screening) and truck loading and unloading. Emission factors for the remaining activities have been defined using NPI manual A.

A maximum daily extraction rate of 2,000 tonnes has been estimated based on 50 movements of a 40 tonne truck and dog. To be conservative, a maximum daily extraction rate of 2,500 tonnes has been assumed to occur all year. The emission factors for each activity are described in Table 5.5 and calculations can be found in Appendix A.

Level 1 watering would be applied to stockpiles, which reduces wind erosion factors by 50% as per Table 4 of NPI manual A. Level 2 watering would be applied to haul roads, which reduces wind erosion factors by 75%. This is included in the following emission factors. More discussion is provided in Section 8 about dust mitigation including watering.

As specific emission rates are not given for $PM_{2.5}$, the following $PM_{2.5}/PM_{10}$ ratios have been applied:

- 0.185 for tertiary crushing (US EPA, 2004)
- 0.15 for wind erosion (Midwest Research Institute, 2006)
- 0.1 for all other sources

A relatively low moisture content of 5% and a silt content of 3% have been assumed based on the material extracted at the quarry and assumptions used in other nearby quarries (Pacific Environment Limited, 2015) (EMM Consulting, 2019).

The fraction of TSP emissions from each activity during the general operations scenario is shown in Figure 5.3. Wheel generated dust on the haul roads is the largest emitter of TSP.

An additional scenario has been assessed for blasting events as these are expected to occur only twice per month and be short term in duration.

Details of the modelled sources are provided in Table 5.6.

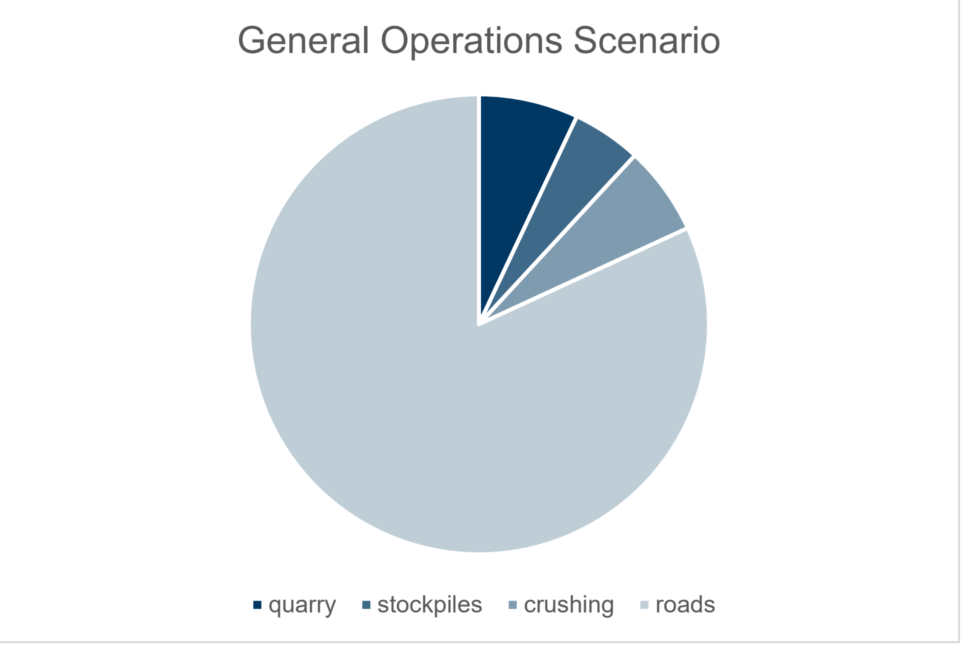


Figure 5.3 Fraction of overall TSP emissions from general operations scenario activities

Table 5.5 Emission rates used in the operational scenarios

Site area	Area (m^2)	Dust emission sources	TSP emission rate	PM_{10} emission rate	$PM_{2.5}$ emission rate	Units
General operations scenario						
Stage 1 quarry	-	Dozer, excavator, front end loader, truck loading	0.34	0.13	0.01	g/s
Overburden stockpile #1	71211	Truck unloading	1.20E-03	5.05E-04	5.05E-05	g/s
		Wind erosion	5.56E-06	2.78E-06	4.17E-07	$g/m^2/s$
Road base stockpile	4877	Truck unloading	1.20E-03	5.05E-04	5.05E-05	g/s
		Wind erosion	5.56E-06	2.78E-06	4.17E-07	$g/m^2/s$
Crusher dust stockpile	1940	Truck unloading	1.20E-03	5.05E-04	5.05E-05	g/s
		Wind erosion	5.56E-06	2.78E-06	4.17E-07	$g/m^2/s$
Scalps stockpile	1301	Truck unloading	1.20E-03	5.05E-04	5.05E-05	g/s
		Wind erosion	5.56E-06	2.78E-06	4.17E-07	$g/m^2/s$
7 mm aggregate stockpile	1286	Truck unloading	1.20E-03	5.05E-04	5.05E-05	g/s
		Wind erosion	5.56E-06	2.78E-06	4.17E-07	$g/m^2/s$
10 mm aggregate stockpile	1234	Truck unloading	1.20E-03	5.05E-04	5.05E-05	g/s
		Wind erosion	5.56E-06	2.78E-06	4.17E-07	$g/m^2/s$
14 mm aggregate stockpile	1293	Truck unloading	1.20E-03	5.05E-04	5.05E-05	g/s
		Wind erosion	5.56E-06	2.78E-06	4.17E-07	$g/m^2/s$
20 mm aggregate stockpile	2021	Truck unloading	1.20E-03	5.05E-04	5.05E-05	g/s
		Wind erosion	5.56E-06	2.78E-06	4.17E-07	$g/m^2/s$

Site area	Area (m^2)	Dust emission sources	TSP emission rate	PM_{10} emission rate	$PM_{2.5}$ emission rate	Units
Crushing and screening plant	-	Tertiary crushing (which includes screening), truck loading and unloading	0.179	0.079	0.014	g/s
Conveyor	-	Conveying material to/from trucks at the stockpiles	0.125	0.059	0.006	g/s
Operational haul road	-	Wheel generated dust from both heavy and light vehicles	3.98	1.18	0.12	g/s
Drilling and blasting scenario						
Stage 1 quarry	-	Drilling and blasting	61.28	31.75	3.18	g/s

In addition to the PM emissions described above, emissions of NOx were modelled from the blast in the drilling and blasting scenario. Ammonium Nitrate Fuel Oil (ANFO) explosives were used to estimate the NOx emissions from the blast, based on a maximum instantaneous charge of 40 kg. During blasting hours, a NOx emission rate of 0.09 g/s was modelled.

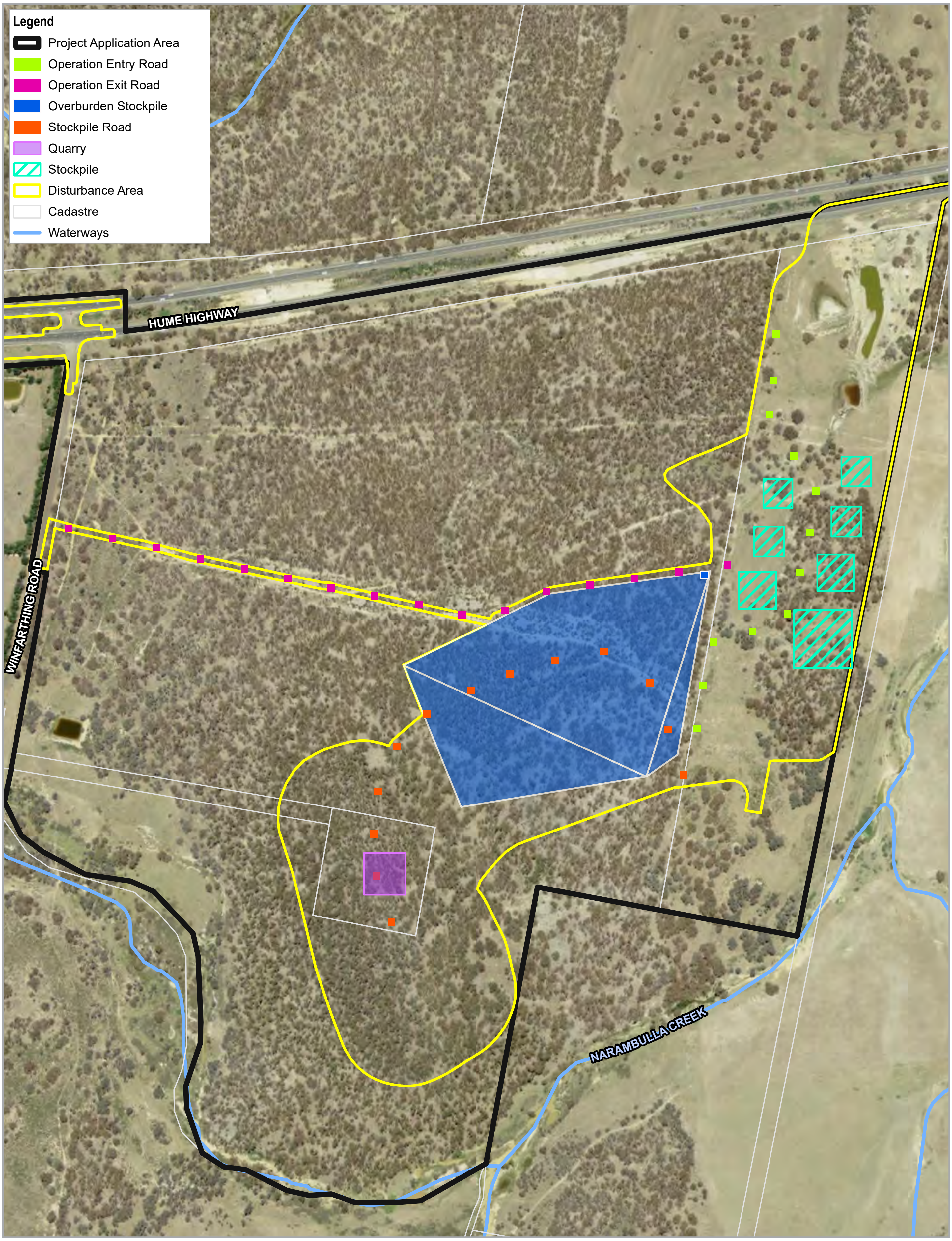
Table 5.6 Operational scenarios modelled source parameters

Source	Location		Source details	
	Easting (m)	Northing (m)		
Stage 1 quarry	765,560	6,150,910	Volume source Effective height: 2 m Side length: 50 m	
Overburden stockpile 1	765,945	6,151,270	Volume source (truck unloading) Effective height: 2.55 m Side length: 9 m	Area source (wind erosion) Area: 71,211 m^2
Road base stockpile	766,018	6,151,218	Volume source (truck unloading) Effective height: 2.55 m Side length: 9 m	Area source (wind erosion) Area: 4877 m^2
Crusher dust stockpile	766,118	6,151,285	Volume source (truck unloading) Effective height: 2.55 m Side length: 9 m	Area source (wind erosion) Area: 1940 m^2
Scalps stockpile	766,127	6,151,342	Volume source (truck unloading) Effective height: 2.55 m Side length: 9 m	Area source (wind erosion) Area: 1301 m^2
7 mm aggregate stockpile	766,137	6,151,404	Volume source (truck unloading) Effective height: 2.55 m Side length: 9 m	Area source (wind erosion) Area: 1286 m^2

Source	Location		Source details	
	Easting (m)	Northing (m)		
10 mm aggregate stockpile	766,044	6,151,376	Volume source (truck unloading) Effective height: 2.55 m Side length: 9 m	Area source (wind erosion) Area: 1234 m^2
14 mm aggregate stockpile	766,030	6,151,321	Volume source (truck unloading) Effective height: 2.55 m Side length: 9 m	Area source (wind erosion) Area: 1293 m^2
20 mm aggregate stockpile	766,018	6,151,264	Volume source (truck unloading) Effective height: 2.55 m Side length: 9 m	Area source (wind erosion) Area: 2021 m^2
Crushing and screening plant	766,034	6,151,147	Volume source Effective height: 3 m Side length: 21.8 m	
Conveyor	766,033	6,151,190	Volume source Effective height: 10 m Side length: 10 m	
Entry road	766,060	6,151,273	Line volume source Effective height: 2.55 m Side length: 9 m Road length: 745 m	
Road between stockpiles	765,664	6,151,131	Line volume source Effective height: 2.55 m Side length: 9 m Road length: 668 m	
Exit road	765,601	6,151,234	Line volume source Effective height: 2.55 m Side length: 9 m Road length: 828 m	
Drilling and blasting	765,560	6,150,910	Volume source Effective height: 2 m Side length: 50 m	

5.2.3 Site layout

The project application area is around 93 ha as shown in Figure 5.4.



Paper Size ISO A4

0 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Global Quarries
Marulan quarry EIS

Operation Scenario
Modelled Sources

Project No. **2127708**
Revision No. **1**
Date **5/7/2025**

FIGURE 5.4

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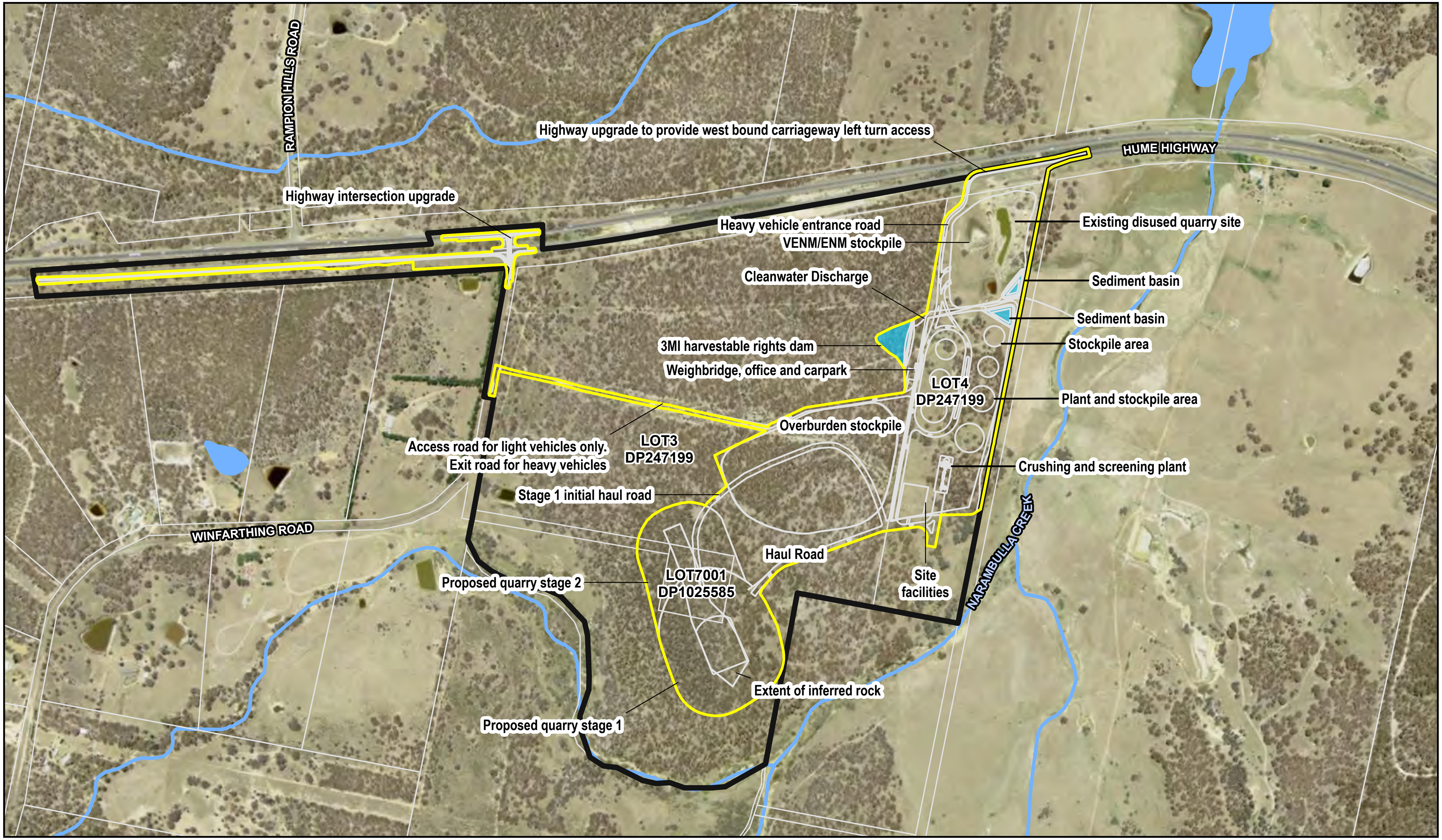
Data source: General topography - LPI 2017. sixmaps/LPI_Imagery_Best: © Department of Customer Service 2020. Created by: aulayao



Legend

- Project Application Area
- Disturbance Area
- Design
- Basins and water storage areas
- Waterways
- Cadastre

Paper Size ISO A4

0 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Global Quarries
Marulan quarry EIS

Project No. 2127708
Revision No. 0
Date 5/7/2025

Project Site

FIGURE 5.5

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Print date: 07 May 2025 - 16:13

Data source:LPI:DCDB/DTDB, 2012, EPI: LandZoning, 2012. sixmaps/LPI_Imagery_Best: © Department of Customer Service 2020. Created by: aulayao

6. Construction air quality assessment

Air quality dispersion modelling was undertaken to predict potential worst-case air quality impacts from construction of the project in accordance with the methodology outlined in Section 3.

Three key site areas where emissions will occur during construction have been identified along with the sources of dust in these areas. These are shown in Table 5.1 with the emission rates used in the CALPUFF model scenario.

Detailed modelling results for concentration and deposition impacts have been assessed at the nearest receptors in each direction: R01, R02, R03, R11, R20, R28, R33 and R39. These receptors will experience the worst case impacts and impacts at all other receptors would be lower.

6.1 Predicted particulate concentration impacts

$PM_{2.5}$ and PM_{10} concentrations are assessed against a 24-hour averaged criterion of 20 and 50 µg/m^3 respectively, and an annual averaged criterion of 7 and 25 µg/m^3 respectively, and TSP is assessed against an annual averaged criterion of 90 µg/m^3.

The ten highest predicted 24-hour average values for $PM_{2.5}$ and PM_{10} at most impacted receptors are presented in Table 6.1. Results show that concentrations drop off rapidly from the highest predicted 24 hour period in the year. Maximum hourly impacts occur during light winds (<2.5 m/s) from the east.

Table 6.1 Predicted 24-hour $PM_{2.5}$ and PM_{10} incremental impacts at the nearest sensitive receptors during the construction scenario

Rank	R01	R02	R03	R11	R20	R28	R33	R39
Predicted $PM_{2.5}$ values (µg/m^3) (criterion = 20 µg/m^3)								
1	3.2	2.5	1.9	1.4	1.0	2.3	1.3	0.5
2	2.9	2.3	1.7	1.2	0.9	2.3	1.3	0.4
3	2.7	2.0	1.0	0.6	0.6	1.4	0.9	0.4
4	2.6	2.0	1.0	0.6	0.6	1.2	0.9	0.4
5	2.4	2.0	0.9	0.6	0.5	1.0	0.9	0.3
6	2.0	1.8	0.9	0.5	0.5	1.0	0.9	0.3
7	2.0	1.3	0.8	0.5	0.5	0.7	0.9	0.3
8	1.9	1.3	0.8	0.5	0.4	0.7	0.8	0.2
9	1.8	1.2	0.8	0.4	0.4	0.6	0.8	0.2
10	1.4	1.2	0.7	0.4	0.3	0.6	0.6	0.2
Predicted PM_{10} values (µg/m^3) (criterion = 50 µg/m^3)								
1	28.5	21.1	15.4	11.2	8.8	19.9	10.9	2.9
2	24.3	20.1	14.5	10.4	7.8	19.7	9.4	2.7
3	24.2	17.1	8.4	5.2	5.3	10.6	8.1	2.6
4	22.8	16.6	7.9	5.0	5.2	9.3	7.7	2.5
5	21.8	16.5	7.3	4.4	4.2	9.1	7.6	2.4
6	17.0	16.3	7.0	4.1	4.2	8.2	7.6	1.9
7	16.4	11.4	6.9	4.0	3.9	6.0	7.2	1.8
8	15.9	11.2	6.6	3.3	3.5	5.5	6.2	1.6
9	15.1	10.5	6.4	3.1	3.4	5.4	5.9	1.6
10	12.4	9.8	5.4	2.9	2.7	5.2	5.8	1.4

A contemporaneous assessment adds historical background concentrations to the predicted incremental concentrations to quantify the expected cumulative impacts. All days that contained background concentrations that already exceeded the criteria were discarded and are not considered further in this assessment.

Background values have been collected from the DCCEEW air quality monitoring station located in Goulburn for the year 2023. Including background values in the assessment indicates that R20 is the worst impacted receptor for $PM_{2.5}$ and R01 is the worst impacted receptor for PM_{10}. Contemporaneous assessments for these receptors are presented in Table 6.2 and Table 6.3.

The Goulburn DCCEEW AQMS is located west of the site and is therefore less impacted by emissions from the Lynwood Quarry and Marulan South Limestone Mine to the east of the site. To include potential impacts from these external sources, modelling at each of these sites was undertaken based on maximum total annual emissions reported in the relevant air quality assessments (Pacific Environment Limited, 2015) (Todoroski Air Sciences Pty Ltd, 2019), as described in Section 4.3.1. These results have been included as part of the cumulative assessment.

Table 6.2 Summary of highest measured (Goulburn DCCEEW AQMS) and predicted $PM_{2.5}$ concentrations ($\mu g/m^3$) (at R20) for the construction scenario

Date	$PM_{2.5}$ Background	Date	$PM_{2.5}$ – Quarry only	Date	$PM_{2.5}$ – External sources	Date	$PM_{2.5}$ total
Criterion = 20 $\mu g/m^3$							
4/07/2023	17.7	11/05/2023	1.0	14/05/2023	0.7	4/07/2023	18.3
3/07/2023	16.8	2/06/2023	0.9	19/10/2023	0.6	3/07/2023	17.4
12/06/2023	16.3	4/07/2023	0.6	28/02/2023	0.4	12/06/2023	16.4
24/05/2023	16.2	2/08/2023	0.6	1/03/2023	0.4	24/05/2023	16.2
16/07/2023	14.2	14/05/2023	0.5	3/11/2023	0.3	16/07/2023	14.4
11/06/2023	14.0	18/04/2023	0.5	27/09/2023	0.3	22/06/2023	14.2
22/06/2023	14.0	26/04/2023	0.5	15/11/2023	0.3	11/06/2023	14.1
5/08/2023	13.8	16/08/2023	0.4	24/09/2023	0.3	2/07/2023	13.9
2/07/2023	13.6	3/07/2023	0.4	3/07/2023	0.2	5/08/2023	13.8
6/05/2023	13.1	17/07/2023	0.3	23/01/2023	0.2	6/05/2023	13.1

Table 6.3 Summary of highest measured (Goulburn DCCEEW AQMS) and predicted PM_{10} concentrations ($\mu g/m^3$) (at R01) for the construction scenario

Date	PM_{10} Background	Date	PM_{10} – Quarry only	Date	PM_{10} – External sources	Date	PM_{10} total
Criterion = 50 $\mu g/m^3$							
24/05/2023	23.8	21/06/2023	28.5	14/05/2023	4.3	21/06/2023	45.4
2/10/2023	22.7	7/08/2023	24.3	15/03/2023	3.2	16/07/2023	42.4
17/02/2023	21.0	16/07/2023	24.2	19/10/2023	2.6	7/08/2023	37.4
30/10/2023	20.3	22/04/2023	22.8	27/10/2023	2.3	8/08/2023	36.0
12/01/2023	20.3	8/08/2023	21.8	6/04/2023	2.3	11/06/2023	34.1
18/02/2023	20.0	11/06/2023	17.0	24/09/2023	2.2	22/04/2023	33.6
19/12/2023	19.9	17/04/2023	16.4	8/08/2023	2.0	13/05/2023	32.6
3/07/2023	19.9	4/04/2023	15.9	26/09/2023	1.8	3/07/2023	29.4
13/11/2023	19.7	13/05/2023	15.1	1/03/2023	1.8	2/07/2023	27.6
4/07/2023	19.6	25/04/2023	12.4	3/07/2023	1.7	28/02/2023	27.6

No exceedances of the criterion are predicted. The assessment includes a number of conservative assumptions and provided management actions outlined in Section 8 are implemented, air quality impacts as per the EPA guidance are not anticipated.

The measured annual background for 2023 was 10.5 μg/m³ for PM_{10} and 5.9 μg/m³ for $PM_{2.5}$. TSP was not measured at this station and as such an estimated annual average background TSP of twice the PM_{10} concentration has been assumed (20.9 μg/m³) (NPI, 2012). The incremental and cumulative annual $PM_{2.5}$, PM_{10} and TSP concentrations are presented in Table 6.4. No criteria exceedances are predicted. Incremental concentrations are significantly lower than the assessment criteria of 25 μg/m³ for PM_{10} (maximum 7.8%), 7 μg/m³ for $PM_{2.5}$ (maximum 3.5%) and 90 μg/m³ for TSP (maximum 3.5%).

Table 6.4 Predicted incremental and cumulative annual concentrations (μg/m³) for the construction scenario

Receptor	$PM_{2.5}$			PM_{10}			TSP		
	Quarry	External	Total	Quarry	External	Total	Quarry	External	Total
Criteria	**7**	**7**	**7**	**25**	**25**	**25**	**90**	**90**	**90**
R01	0.2	0.0	6.2	2.0	0.2	12.7	3.1	0.1	24.1
R02	0.2	0.0	6.1	1.4	0.2	12.1	2.0	0.1	23.0
R03	0.1	0.0	6.1	0.9	0.2	11.6	1.2	0.1	22.2
R11	0.1	0.0	6.0	0.5	0.2	11.1	0.5	0.1	21.5
R20	0.0	0.0	6.0	0.3	0.2	11.0	0.2	0.1	21.2
R28	0.1	0.1	6.1	0.7	0.3	11.5	0.9	0.1	22.0
R33	0.1	0.0	6.0	0.5	0.3	11.2	0.6	0.1	21.5
R39	0.0	0.1	6.0	0.2	0.4	11.1	0.1	0.2	21.2

6.2 Predicted dust deposition impacts

Dust deposition impacts are assessed against a maximum increase of 2 g/m²/month and a maximum total of 4 g/m²/month. Monthly deposition of TSP has been assessed, as presented in Table 6.5. No exceedances of 2 g/m²/month at sensitive receptors were predicted. High deposition rates were predicted to occur in January, February and November at R01 and R02.

Table 6.5 Predicted incremental monthly deposition impacts from the construction scenario

Month	Criteria (g/m²/month)	Incremental impact at receptors (g/m²/month)							
		R01	R02	R03	R11	R20	R28	R33	R39
Jan	2	0.35	0.22	0.14	0.07	0.02	0.04	0.13	0.02
Feb	2	0.29	0.19	0.12	0.05	0.01	0.05	0.06	0.00
Mar	2	0.28	0.17	0.12	0.05	0.02	0.03	0.05	0.00
Apr	2	0.29	0.20	0.12	0.07	0.04	0.05	0.09	0.01
May	2	0.07	0.04	0.03	0.02	0.01	0.17	0.05	0.03
Jun	2	0.14	0.10	0.05	0.04	0.02	0.04	0.01	0.00
Jul	2	0.11	0.07	0.04	0.03	0.02	0.15	0.04	0.01
Aug	2	0.19	0.12	0.06	0.03	0.03	0.06	0.10	0.00
Sep	2	0.15	0.11	0.08	0.05	0.02	0.11	0.04	0.02
Oct	2	0.13	0.08	0.05	0.03	0.02	0.07	0.05	0.00
Nov	2	0.34	0.22	0.13	0.06	0.02	0.07	0.06	0.01
Dec	2	0.23	0.15	0.10	0.04	0.01	0.10	0.09	0.01

Cumulative deposition rates, including predicted deposition from the external sources of dust, are presented in Table 6.6. No exceedances of 2 g/m²/month at sensitive receptors were predicted.

Table 6.6 Predicted monthly cumulative deposition impacts from the construction scenario

Month	Criteria (g/m^2/month)	Cumulative impact at receptors (g/m^2/month)							
		R01	R02	R03	R11	R20	R28	R33	R39
Jan	2	0.38	0.25	0.16	0.10	0.03	0.08	0.15	0.06
Feb	2	0.31	0.21	0.13	0.06	0.02	0.06	0.08	0.02
Mar	2	0.29	0.19	0.13	0.07	0.03	0.05	0.07	0.03
Apr	2	0.30	0.21	0.13	0.08	0.05	0.07	0.10	0.02
May	2	0.07	0.04	0.03	0.02	0.01	0.18	0.06	0.03
Jun	2	0.14	0.10	0.06	0.05	0.03	0.05	0.02	0.01
Jul	2	0.11	0.07	0.04	0.03	0.02	0.15	0.04	0.01
Aug	2	0.20	0.13	0.06	0.03	0.03	0.07	0.11	0.01
Sep	2	0.16	0.11	0.08	0.05	0.02	0.12	0.04	0.03
Oct	2	0.13	0.09	0.06	0.03	0.02	0.08	0.06	0.02
Nov	2	0.36	0.24	0.15	0.08	0.05	0.10	0.09	0.05
Dec	2	0.24	0.16	0.11	0.04	0.02	0.12	0.10	0.03

6.3 Predicted respirable crystalline silica impacts

RCS concentrations are assessed against an 8-hour averaged criterion of 50 $\mu g/m^3$, and an annual averaged criterion of 3 $\mu g/m^3$.

Incremental RCS exposures have been estimated on the basis that the $PM_{2.5}$ dust concentrations at the key receptor locations are comprised of 20% to 60% RCS, in accordance with the laboratory analysis reported in the *Health Risk Assessment* (Marulan Quarry EIS – Appendix S).

The maximum offsite incremental 8-hour average RCS concentration was predicted to be 5.3 $\mu g/m^3$ for 60% RCS and 1.8 $\mu g/m^3$ for 20% RCS, below the criterion of 50 $\mu g/m^3$.

The annual RCS concentrations at the nearby sensitive receptors are shown in Table 7.4. Cumulative $PM_{2.5}$ RCS concentration in excess of the EPA Victoria (2022) annual average assessment criteria of 3 $\mu g/m^3$ were not identified at any of the key receptor locations, under either the 60% or 20% RCS concentration assumptions. Across the range of sensitive receptor locations, the incremental dust emissions also made only a minor (<8%) contribution to the predicted cumulative $PM_{2.5}$ RCS concentrations.

Table 6.7 Predicted incremental annual RCS concentrations ($\mu g/m^3$) for the construction scenario

Receptor	Predicted $PM_{2.5}$ RCS concentration ($\mu g/m^3$) Assuming 60% RCS in project dust emissions*			Predicted $PM_{2.5}$ RCS concentration ($\mu g/m^3$) Assuming 20% RCS in project dust emissions*		
	Incremental	Background	Cumulative	Incremental	Background	Cumulative
Criteria	3	3	3	3	3	3
R01	0.15	1.8	1.9	0.05	1.8	1.8
R02	0.11	1.8	1.9	0.04	1.8	1.8
R03	0.07	1.8	1.8	0.02	1.8	1.8
R11	0.04	1.8	1.8	0.01	1.8	1.8
R20	0.02	1.8	1.8	0.01	1.8	1.8
R28	0.05	1.8	1.8	0.02	1.8	1.8
R33	0.04	1.8	1.8	0.01	1.8	1.8
R39	0.02	1.8	1.8	0.01	1.8	1.8
* Calculations based on the $PM_{2.5}$ fraction and the assumption that the RCS of background dust impacts is 30%.						

6.4 Exhaust emissions

The main source of exhaust emissions would be the combustion of diesel fuel and petrol from heavy vehicles, mobile excavation machinery, and/or stationary combustion equipment.

The volume of emissions from construction vehicles and machinery would depend on the type of fuel used, the power output and condition of the engine, the number of light and heavy vehicles, and duration of use.

Exhaust emissions would involve periodically localised emissions of carbon monoxide, particulate matter (PM_{10} and $PM_{2.5}$), oxides of nitrogen, sulfur dioxide, volatile organic compounds and polycyclic aromatic hydrocarbons associated with the combustion of diesel fuel and petrol.

Minor vehicle exhaust emissions are expected during construction; however, relative to the vehicle numbers on the Hume Highway adjacent to the site, these emissions are not anticipated to have material effect on the air shed.

Exhaust emissions are therefore not considered further in this assessment.

7. Operational air quality assessment

Air quality dispersion modelling was undertaken to predict potential worst-case air quality impacts from operation of the project in accordance with the methodology outlined in Section 3.

Two operational scenarios have been considered:

– General operation of the site
– Drilling and blasting events (which only occurs intermittently and for a short period of time)

For general operation of the site the key site areas where emissions will occur during operation have been identified along with the sources of dust in these areas. These are shown in Table 5.5 with the emission rates used in the CALPUFF model scenario.

It is important to note that as the quarry progresses, many activities will be undertaken below ground, and dust impact from these sources would potentially reduce. Because of this, modelling has conservatively been undertaken of first years of operation which are considered worst-case.

The project would also involve the progressive rehabilitation of the extraction area through emplacement of VENM, ENM and other clean fill materials. The emplacement material would be sourced through back-loading of haulage vehicles with clean fill from construction projects throughout the Sydney basin. This would allow the site to be progressively returned to a condition more closely representing the original landscape and would maximise resource recovery through diversion of clean fill away from landfills. Based on information provided to date, during rehabilitation there would be no additional trucks per day, and total daily volumes would be the same or less than volumes extracted during quarrying. It is anticipated that dust emissions during rehabilitation would be less than during quarrying and therefore has not been assessed in detail at this stage.

Detailed modelling results for concentration and deposition impacts have been assessed at the nearest receptors in each direction: R01, R02, R03, R11, R20, R28, R33 and R39. These receptors will experience the worst case dust impacts and impacts at all other receptors would be lower, as can be seen in Figure 7.1, Figure 7.2, Figure 7.3 and Figure 7.4.

7.1 General operations scenario

7.1.1 Predicted particulate concentration impacts

$PM_{2.5}$ and PM_{10} concentrations are assessed against a 24-hour averaged criterion of 20 and 50 µg/m^3 respectively, and an annual averaged criterion of 7 and 25 µg/m^3 respectively, and TSP is assessed against an annual averaged criterion of 90 µg/m^3.

The ten highest predicted incremental 24-hour average values are shown for $PM_{2.5}$ and PM_{10} are presented in Table 7.1, and the contour plots are presented in Figure 7.1 and Figure 7.2.

Table 7.1 Predicted 24-hour $PM_{2.5}$ and PM_{10} incremental impacts at the nearest sensitive receptors during the general operations scenario

Rank	R01	R02	R03	R11	R20	R28	R33	R39
Predicted $PM_{2.5}$ values (µg/m^3) (criterion = 20 µg/m^3)								
1	2.3	1.9	1.2	0.9	0.6	1.8	0.8	0.6
2	2.1	1.5	1.2	0.8	0.6	1.8	0.8	0.6
3	1.7	1.4	1.0	0.5	0.5	1.2	0.7	0.4
4	1.6	1.3	0.7	0.5	0.4	1.1	0.7	0.4
5	1.6	1.2	0.7	0.5	0.4	1.0	0.6	0.3
6	1.4	1.1	0.7	0.4	0.4	0.9	0.6	0.3

Rank	R01	R02	R03	R11	R20	R28	R33	R39
7	1.3	1.1	0.7	0.4	0.3	0.9	0.6	0.3
8	1.2	1.1	0.7	0.4	0.3	0.9	0.6	0.3
9	1.2	1.0	0.7	0.4	0.3	0.8	0.6	0.2
10	1.1	1.0	0.7	0.3	0.3	0.7	0.5	0.2
Predicted PM_{10} values (µg/m^3) (criterion = 50 µg/m^3)								
1	18.1	14.5	8.9	7.0	5.2	13.8	6.1	3.5
2	15.9	11.5	8.9	6.2	4.6	13.8	5.4	3.4
3	13.6	11.4	6.4	3.5	3.5	7.9	5.4	2.6
4	12.9	10.1	5.7	3.3	3.1	7.6	5.1	2.2
5	11.8	9.5	5.3	3.2	3.0	6.6	4.9	1.9
6	10.9	9.5	5.1	3.0	2.7	6.2	4.9	1.9
7	9.9	7.6	4.7	2.8	2.7	6.1	4.8	1.9
8	9.8	7.3	4.7	2.7	2.4	5.6	4.6	1.5
9	9.7	6.9	4.3	2.3	2.3	5.6	4.3	1.4
10	8.0	6.5	4.2	2.2	1.8	4.5	3.5	1.3

Background values have been collected from the DCCEEW air quality monitoring station located in Goulburn for the year 2023. Including background values in the assessment indicates that R20 is the worst impacted receptor for $PM_{2.5}$ and R01 is the worst impacted receptor for PM_{10}. Contemporaneous assessments for these receptors are presented in Table 7.2 and Table 7.3.

A contemporaneous assessment adds historical background concentrations to the predicted incremental concentrations to quantify the expected cumulative impacts. All days that contained background concentrations that already exceeded the criteria were discarded and are not considered further in this assessment.

The Goulburn DCCEEW AQMS is located west of the site and is therefore less impacted by emissions from the Lynwood Quarry and Marulan South Limestone Mine to the east of the site. To include potential impacts from these external sources, modelling at each of these sites was undertaken based on total annual emissions reported in the relevant air quality assessments (Pacific Environment Limited, 2015) (Todoroski Air Sciences Pty Ltd, 2019), as described in Section 4.3.1. These results have been included as part of the cumulative assessment.

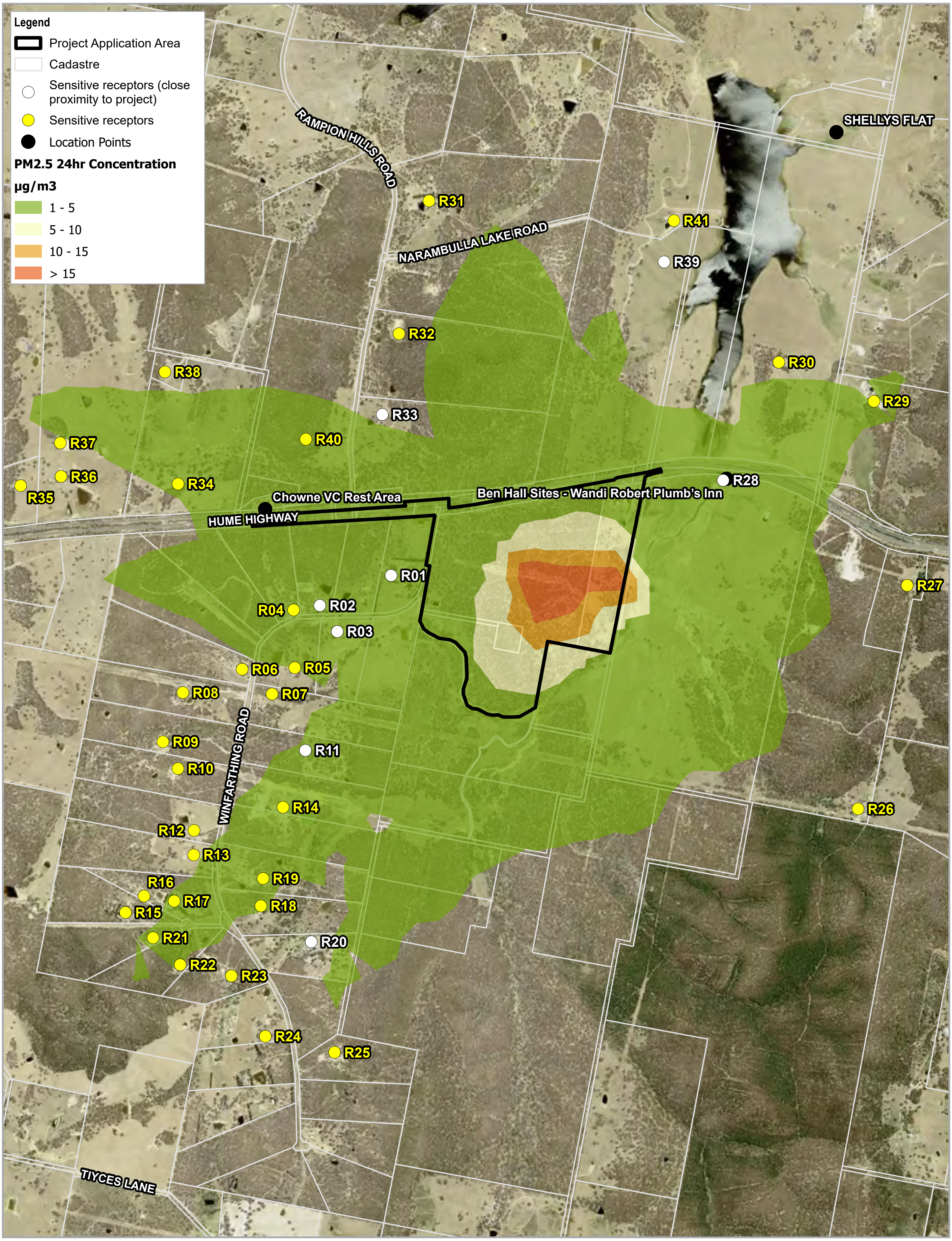
Table 7.2 Summary of highest measured (Goulburn DCCEEW AQMS) and predicted $PM_{2.5}$ concentrations (µg/m^3) (at R20) for the operational scenario

Date	$PM_{2.5}$ Background	Date	$PM_{2.5}$ – Quarry only	Date	$PM_{2.5}$ – External sources	Date	$PM_{2.5}$ total
Criterion = 20 µg/m^3							
4/07/2023	17.7	11/05/2023	0.6	14/05/2023	0.7	4/07/2023	18.2
3/07/2023	16.8	2/06/2023	0.6	19/10/2023	0.6	3/07/2023	17.3
12/06/2023	16.3	4/07/2023	0.5	28/02/2023	0.4	12/06/2023	16.4
24/05/2023	16.2	14/05/2023	0.4	1/03/2023	0.4	24/05/2023	16.2
16/07/2023	14.2	26/04/2023	0.4	3/11/2023	0.3	16/07/2023	14.4
11/06/2023	14.0	2/08/2023	0.4	27/09/2023	0.3	22/06/2023	14.2
22/06/2023	14.0	3/07/2023	0.3	15/11/2023	0.3	11/06/2023	14.1
5/08/2023	13.8	18/04/2023	0.3	24/09/2023	0.3	2/07/2023	13.9
2/07/2023	13.6	16/08/2023	0.3	3/07/2023	0.2	5/08/2023	13.8
6/05/2023	13.1	24/09/2023	0.3	23/01/2023	0.2	6/05/2023	13.1

Table 7.3 Summary of highest measured (Goulburn DCCEEW AQMS) and predicted PM_{10} concentrations (µg/m^3) (at R01) for the operational scenario

Date	PM_{10} Background	Date	PM_{10} – Quarry only	Date	PM_{10} – External sources	Date	PM_{10} total
Criterion = 50 µg/m^3							
24/05/2023	23.8	21/06/2023	18.1	14/05/2023	4.3	21/06/2023	34.9
2/10/2023	22.7	7/08/2023	15.9	15/03/2023	3.2	16/07/2023	31.8
17/02/2023	21.0	16/07/2023	13.6	19/10/2023	2.6	7/08/2023	29.0
30/10/2023	20.3	22/04/2023	12.9	27/10/2023	2.3	13/05/2023	28.3
12/01/2023	20.3	8/08/2023	11.8	6/04/2023	2.3	11/06/2023	27.0
18/02/2023	20.0	13/05/2023	10.9	24/09/2023	2.2	28/02/2023	26.6
19/12/2023	19.9	11/06/2023	9.9	8/08/2023	2.0	8/08/2023	26.0
3/07/2023	19.9	4/04/2023	9.8	26/09/2023	1.8	3/07/2023	25.9
13/11/2023	19.7	17/04/2023	9.7	1/03/2023	1.8	13/11/2023	24.9
4/07/2023	19.6	27/08/2023	8.0	3/07/2023	1.7	2/07/2023	24.4

No exceedances of the criteria are predicted. The assessment includes a number of conservative assumptions and provided management actions outlined in Section 8 are implemented, air quality impacts as per the EPA guidance are not anticipated.



Global Quarries
Marulan quarry EIS

Predicted maximum incremental 24-hour PM2.5 concentration (µg/m3) for the general operations scenario

Project No. 2127708
Revision No. 1
Date 5/7/2025

FIGURE 7-1

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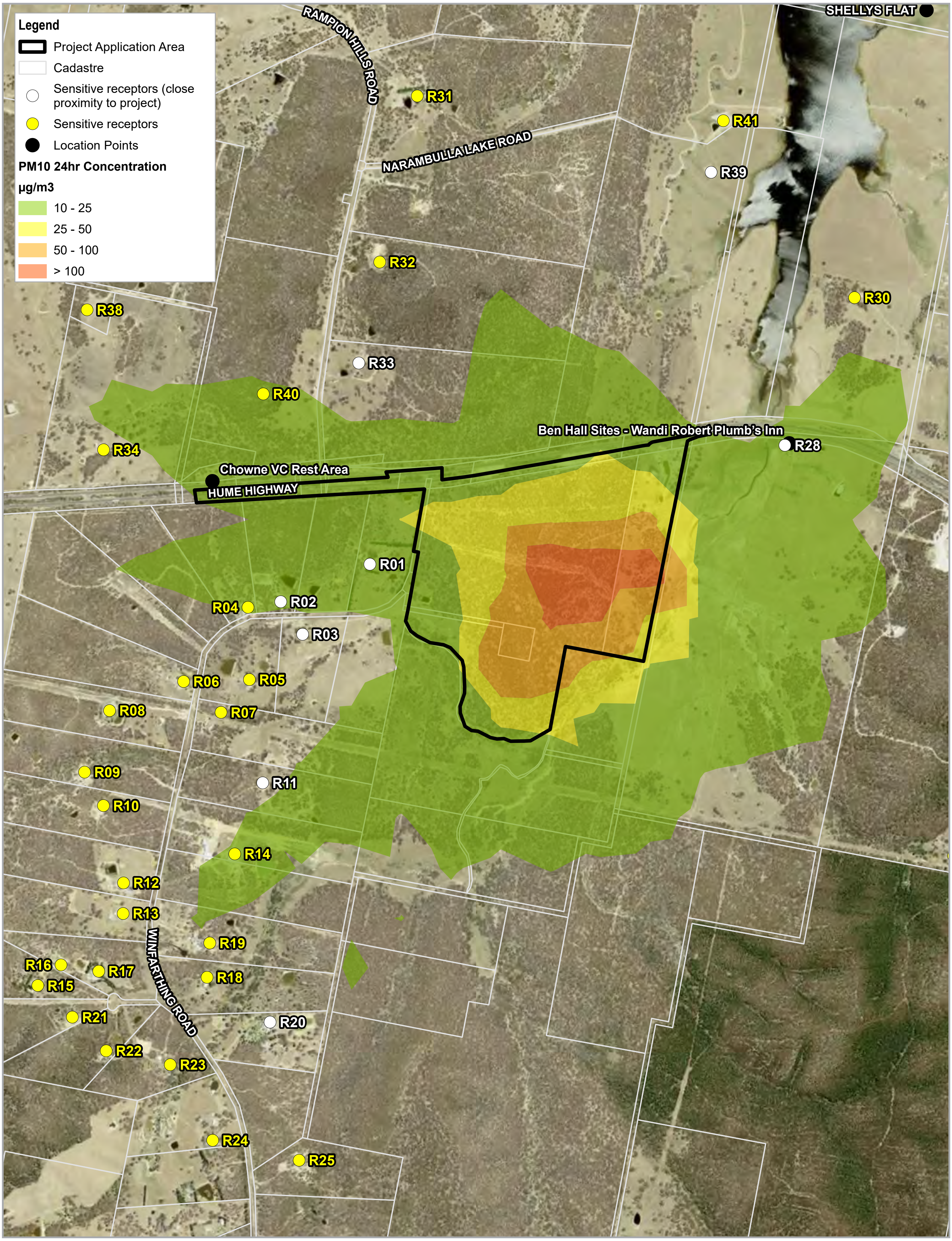
Data source: General topography - LPI 2017. sixmaps/LPI_Imagery_Best: © Department of Finance, Services & Innovation 2018. Created by: aulayao



Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Global Quarries
Marulan quarry EIS

Predicted maximum incremental 24-hour PM10 concentration (µg/m3) for the general operations scenario

Project No. 2127708
Revision No. 1
Date 5/7/2025

FIGURE 7-2

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Data source: General topography - LPI 2017. sixmaps/LPI_Imagery_Best: © Department of Customer Service 2020. Created by:

The measured annual background for 2023 was 10.5 µg/m^3 for PM_{10} and 5.9 µg/m^3 for $PM_{2.5}$. The incremental and cumulative annual $PM_{2.5}$, PM_{10} and TSP concentrations are shown in Table 7.4. No criteria exceedances are predicted. Incremental concentrations are significantly lower than the assessment criteria of 25 µg/m^3 for PM_{10} (maximum of 5.3%), 7 µg/m^3 for $PM_{2.5}$ (maximum of 2.6%) and 90 µg/m^3 for TSP (maximum of 3.6%). The contour plot for annual TSP is shown in Figure 7.3.

Table 7.4 Predicted incremental and cumulative annual PM and TSP concentrations (µg/m^3) for the general operations scenario

Receptor	$PM_{2.5}$			PM_{10}			TSP		
	Quarry	External	Total	Quarry	External	Total	Quarry	External	Total
Criteria	**7**	**7**	**7**	**25**	**25**	**25**	**90**	**90**	**90**
R01	0.2	0.0	6.1	1.3	0.2	12.0	1.7	0.1	22.7
R02	0.1	0.0	6.1	1.0	0.2	11.7	1.1	0.1	22.1
R03	0.1	0.0	6.1	0.7	0.2	11.4	0.7	0.1	21.7
R11	0.1	0.0	6.0	0.4	0.2	11.0	0.3	0.1	21.3
R20	0.0	0.0	6.0	0.2	0.2	10.9	0.2	0.1	21.1
R28	0.1	0.1	6.1	0.6	0.3	11.4	0.6	0.1	21.6
R33	0.1	0.0	6.0	0.4	0.3	11.1	0.3	0.1	21.3
R39	0.0	0.1	6.0	0.2	0.4	11.1	0.1	0.2	21.1

7.1.2 Predicted dust deposition impacts

Deposition impacts are assessed against a maximum increase of 2 g/m^2/month and a maximum total of 4 g/m^2/month. Monthly deposition of TSP has been assessed, as presented in Table 7.5 and the annual contour plot is presented in Figure 7.4. No exceedances of 2 g/m^2/month at sensitive receptors were predicted. Highest deposition rates were predicted to occur in January, February and November at R01, R02 and R03.

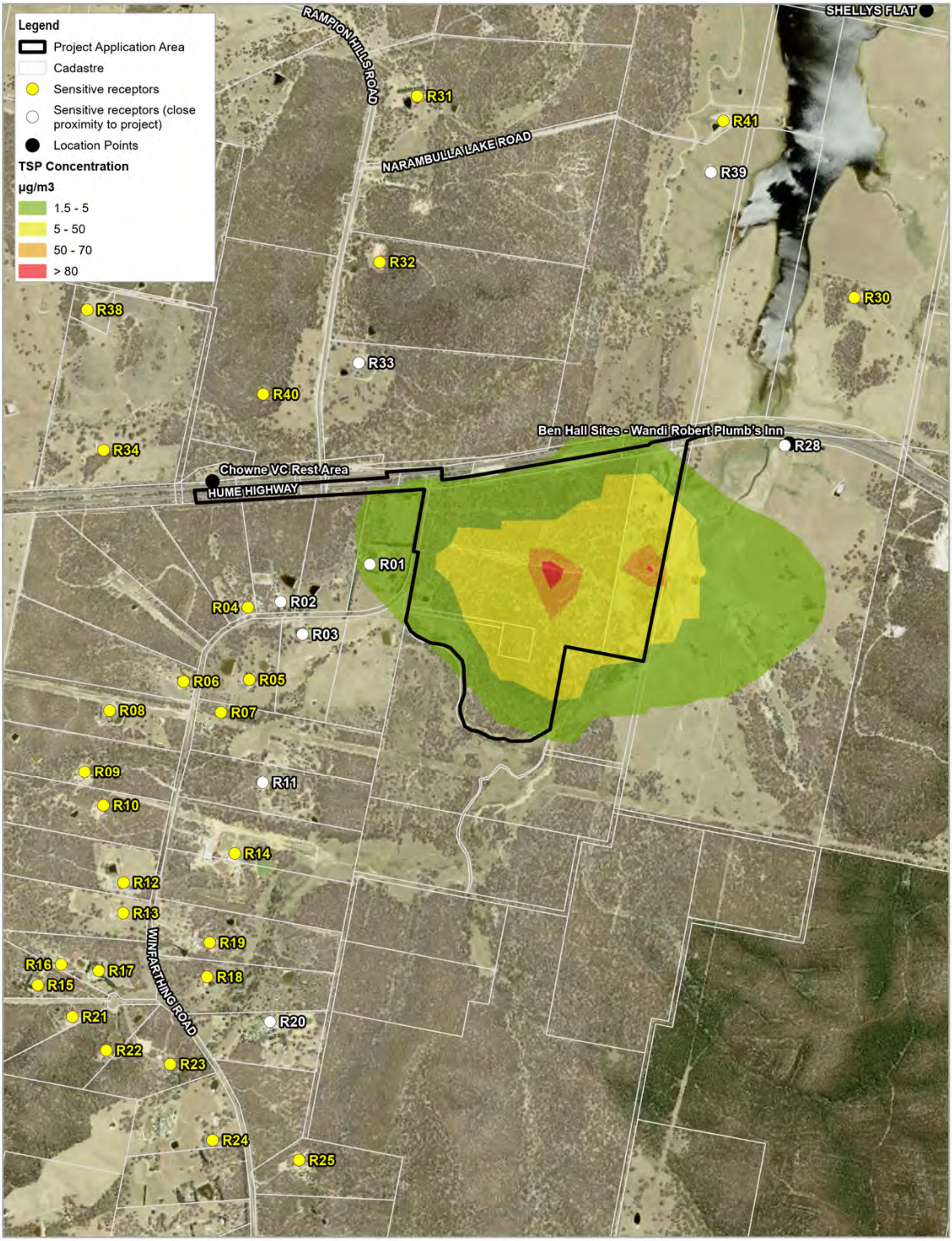
Table 7.5 Predicted incremental monthly deposition impacts from the general operations scenario

Month	Criteria (g/m^2/month)	Incremental impact at receptors (g/m^2/month)							
		R01	R02	R03	R11	R20	R28	R33	R39
Jan	2	0.18	0.12	0.08	0.04	0.01	0.02	0.07	0.01
Feb	2	0.16	0.11	0.07	0.03	0.01	0.03	0.03	0.00
Mar	2	0.15	0.09	0.06	0.03	0.01	0.02	0.03	0.00
Apr	2	0.15	0.11	0.07	0.04	0.02	0.03	0.05	0.01
May	2	0.03	0.02	0.01	0.01	0.01	0.09	0.03	0.02
Jun	2	0.07	0.05	0.03	0.02	0.01	0.02	0.01	0.00
Jul	2	0.06	0.04	0.02	0.01	0.01	0.09	0.02	0.01
Aug	2	0.11	0.07	0.03	0.02	0.01	0.04	0.06	0.00
Sep	2	0.08	0.06	0.04	0.03	0.01	0.06	0.02	0.01
Oct	2	0.07	0.05	0.03	0.02	0.01	0.03	0.03	0.00
Nov	2	0.18	0.12	0.08	0.03	0.01	0.04	0.03	0.00
Dec	2	0.12	0.08	0.05	0.02	0.01	0.05	0.05	0.01

Cumulative deposition rates, including predicted deposition from the external sources of dust, are presented in Table 6.6. No exceedances of 2 g/m^2/month at sensitive receptors were predicted.

Table 7.6 Predicted monthly cumulative deposition impacts from the general operations scenario

Month	Criteria (g/m^2/month)	Cumulative impact at receptors (g/m^2/month)							
		R01	R02	R03	R11	R20	R28	R33	R39
Jan	2	0.21	0.15	0.10	0.06	0.03	0.06	0.10	0.05
Feb	2	0.17	0.12	0.08	0.04	0.02	0.04	0.05	0.02
Mar	2	0.16	0.11	0.08	0.05	0.03	0.04	0.05	0.03
Apr	2	0.16	0.11	0.08	0.05	0.03	0.05	0.05	0.02
May	2	0.04	0.02	0.01	0.01	0.01	0.10	0.03	0.02
Jun	2	0.08	0.06	0.04	0.03	0.02	0.03	0.01	0.01
Jul	2	0.06	0.04	0.02	0.02	0.01	0.09	0.02	0.01
Aug	2	0.11	0.08	0.04	0.02	0.02	0.04	0.06	0.01
Sep	2	0.09	0.06	0.05	0.03	0.01	0.07	0.03	0.02
Oct	2	0.08	0.05	0.04	0.02	0.02	0.05	0.04	0.02
Nov	2	0.20	0.14	0.09	0.05	0.04	0.07	0.06	0.05
Dec	2	0.13	0.09	0.06	0.03	0.02	0.07	0.06	0.03



Paper Size ISO A4

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Global Quarries
Marulan quarry EIS

Predicted incremental annual TSP concentration (µg/m3) for the general operations scenario

Project No. 2127708
Revision No. 1
Date 5/8/2025

FIGURE 7-3

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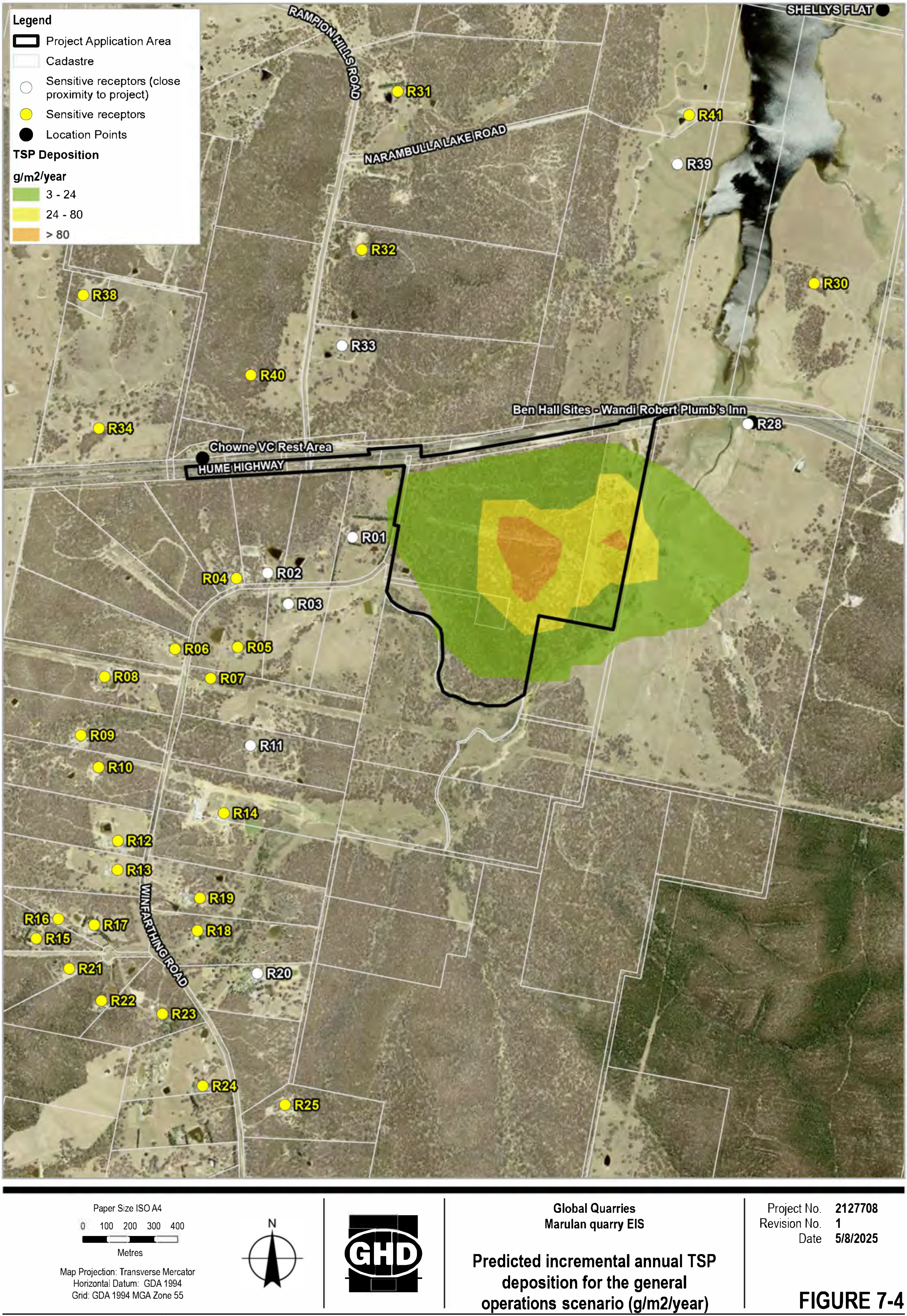
Data source: General topography - LPI 2017. sixmaps/LPI_Imagery_Best: © Department of Finance, Services & Innovation 2018. Created by: aulayao



Global Quarries
Marulan quarry EIS

Predicted incremental annual TSP deposition for the general operations scenario (g/m2/year)

Project No. 2127708
Revision No. 1
Date 5/8/2025

FIGURE 7-4

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7.1.3 Predicted respirable crystalline silica impacts

RCS concentrations are assessed against an 8-hour averaged criterion of 50 μg/m^3, and an annual averaged criterion of 3 μg/m^3.

Incremental RCS exposures have been estimated on the basis that the $PM_{2.5}$ dust concentrations at the key receptor locations are comprised of 20% to 60% RCS, in accordance with the laboratory analysis reported in the *Health Risk Assessment*.(Marulan Quarry EIS Appendix S).

The maximum offsite incremental 8-hour average RCS concentration was predicted to be 3.7 μg/m^3 for 60% RCS and 1.2 μg/m^3 for 20% RCS, below the criterion of 50 μg/m^3.

The annual RCS concentrations at the nearby sensitive receptors are shown in Table 7.4. Cumulative $PM_{2.5}$ RCS concentration in excess of the EPA Victoria (2022) annual average assessment criteria of 3 μg/m^3 were not identified at any of the key receptor locations, under either the 60% or 20% RCS concentration assumptions. Across the range of sensitive receptor locations, the incremental dust emissions also made only a minor (<6%) contribution to the predicted cumulative $PM_{2.5}$ RCS concentrations.

Table 7.7 Predicted incremental annual RCS concentrations (μg/m^3) for the general operations scenario

Receptor	Predicted $PM_{2.5}$ RCS concentration (μg/m^3)			Predicted $PM_{2.5}$ RCS concentration (μg/m^3)		
	Assuming 60% RCS in project dust emissions*			Assuming 20% RCS in project dust emissions*		
	Incremental	Background	Cumulative	Incremental	Background	Cumulative
Criteria	**3**	**3**	**3**	**3**	**3**	**3**
R01	0.11	1.8	1.9	0.04	1.8	1.8
R02	0.09	1.8	1.9	0.03	1.8	1.8
R03	0.06	1.8	1.8	0.02	1.8	1.8
R11	0.03	1.8	1.8	0.01	1.8	1.8
R20	0.02	1.8	1.8	0.01	1.8	1.8
R28	0.06	1.8	1.8	0.02	1.8	1.8
R33	0.03	1.8	1.8	0.01	1.8	1.8
R39	0.02	1.8	1.8	0.01	1.8	1.8
* Calculations based on the $PM_{2.5}$ fraction and the assumption that the RCS of background dust impacts is 30%						

7.1.4 Exhaust emissions

The main source of exhaust emissions would be the combustion of diesel fuel and petrol from heavy vehicles, mobile excavation machinery, and/or stationary combustion equipment.

The volume of emissions from vehicles and machinery would depend on the type of fuel used, the power output and condition of the engine, the number of light and heavy vehicles, and duration of use.

Exhaust emissions would involve periodically localised emissions of carbon monoxide, particulate matter (PM_{10} and $PM_{2.5}$), oxides of nitrogen, sulfur dioxide, volatile organic compounds and polycyclic aromatic hydrocarbons associated with the combustion of diesel fuel and petrol.

Minor vehicle exhaust emissions are expected during operation; however, relative to the vehicle numbers on the Hume Highway adjacent to the site, these emissions are not anticipated to have material effect on the air shed.

Exhaust emissions are therefore not considered further in this assessment.

7.1.5 Sensitivity analysis

A sensitivity analysis has been undertaken for the operation stage of the project to account for the potential for a higher frequency of calm conditions (wind speeds less than 0.5 m/s) than what has been included in the dispersion model. Calm conditions observed during the modelled period at the BoM Goulburn Airport AWS occurred 11.4% of the time. Using this observational data in the model and extending out to the site location included calm conditions at the site 3.9% of the time. This meteorological modelling file was used in the main modelling exercise, the results of which are presented above.

An additional meteorological modelling scenario was developed using observational data from the BoM Goulburn Airport AWS applied to the project site. This scenario resulted in calm conditions at the site for 11.4% of the time and was intended as a conservative worst-case assessment. Without weather observations, it cannot be concluded if the presence of calm conditions at the site would be this high, and the site also has distinct geographic differences to Goulburn Airport which influence meteorological conditions.

Dispersion modelling using Goulburn Airport AWS observations at the site has been undertaken of the operational phase of the project to get an understanding how this may influence results, even though it's not likely representative of actual site conditions. Maximum 24-hour average PM_{10} and $PM_{2.5}$ results at each receptor are presented in Table 7.8.

Table 7.8 Predicted maximum 24-hour average concentrations for the sensitivity analysis scenario

Receptor	$PM_{2.5}$ concentration (µg/m^3)		PM_{10} concentration (µg/m^3)	
	Quarry	Total	Quarry	Total
Criteria	**20**	**20**	**50**	**50**
R01	4.68	19.33	33.49	49.99
R02	3.67	19.05	26.79	43.27
R03	1.84	18.93	13.09	29.53
R11	1.35	19.06	9.06	28.81
R20	0.55	18.26	3.71	24.08
R28	1.35	19.11	8.42	28.37
R33	2.03	17.90	11.75	25.51
R39	0.47	17.81	2.56	23.81

$PM_{2.5}$ and PM_{10} concentrations comply with the adopted criteria at all receptors.

Real-time dust monitoring is recommended with a trigger action response plan (TARP) which would provide mitigation requirements based on the recorded particulate concentrations. Therefore it is considered unlikely that concentrations at the nearby receptors would exceed the criteria even during the worst case meteorological conditions.

7.2 Blasting scenario

Blasting will occur twice per month. Due to the short time period in which this event occurs (less than one hour), the approach to assessing the results is slightly different to that of the construction and general operations scenarios. Indicative modelling of blasting has been undertaken for each hour between 10:00 am and 3:00 pm. These hours were chosen to reflect a time when general amenity impacts such as noise would be lower and outside times of general poor dispersion, however blasting would not be undertaken during conditions which enhance dust impacts so modelling during these selected hours was undertaken to demonstrate that impacts from blasting can be managed.

The maximum hour for each day has conservatively been used to calculate the 24-hour and annual averages. All blasting would be undertaken following guidance of a blast management plan (refer Section 8) and blasts would be staged to ensure they are not undertaken on days when wind is blowing towards the closest receptors.

7.2.1 Predicted particulate concentration impacts

Given specific blasting times are unknown, worst-case predicted $PM_{2.5}$ and PM_{10} concentrations are used as a guide to compare against criteria of 20 and 50 µg/m^3 for $PM_{2.5}$ and PM_{10} respectively. The ten highest predicted 24-hour average values from between the hours 10:00 am and 3:00 pm are shown for $PM_{2.5}$ and PM_{10} are presented in Table 7.9.

Table 7.9 Predicted 24-hour $PM_{2.5}$ and PM_{10} incremental impacts at the nearest sensitive receptors during the blasting scenario

R01		R02		R03		R11		R20		R28		R33		R39	
Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment
Predicted $PM_{2.5}$ values (µg/m^3)															
11:00 am-12:00 pm 29/4/23	1.8	11:00 am-12:00 pm 4/4/23	1.2	12:00 pm-1:00 pm 29/4/23	1.1	10:00 am-11:00 am 16/8/23	0.5	2:00 pm-3:00 pm 4/7/23	0.4	2:00 pm-3:00 pm 10/10/23	0.3	10:00 am-11:00 am 22/9/23	0.3	11:00 am-12:00 pm 3/1/23	0.1
10:00 am-11:00 am 14/8/23	1.6	10:00 am-11:00 am 4/4/23	1.2	2:00 pm-3:00 pm 25/3/23	0.9	12:00 pm-1:00 pm 24/11/23	0.4	11:00 am-12:00 pm 4/7/23	0.3	1:00 pm-2:00 pm 22/7/23	0.2	10:00 am-11:00 am 7/8/23	0.3	2:00 pm-3:00 pm 11/4/23	0.1
10:00 am-11:00 am 20/4/23	1.4	10:00 am-11:00 am 20/4/23	1.2	12:00 pm-1:00 pm 20/4/23	0.9	2:00 pm-3:00 pm 6/11/23	0.4	12:00 pm-1:00 pm 4/7/23	0.2	1:00 pm-2:00 pm 11/4/23	0.2	10:00 am-11:00 am 29/11/23	0.3	11:00 am-12:00 pm 18/5/23	0.1
1:00 pm-2:00 pm 29/4/23	1.4	2:00 pm-3:00 pm 21/4/23	1.1	2:00 pm-3:00 pm 5/4/23	0.9	2:00 pm-3:00 pm 22/4/23	0.4	1:00 pm-2:00 pm 4/7/23	0.2	2:00 pm-3:00 pm 20/2/23	0.2	12:00 pm-1:00 pm 1/4/23	0.3	11:00 am-12:00 pm 11/4/23	0.1
11:00 am-12:00 pm 24/3/23	1.4	11:00 am-12:00 am 29/4/23	1.1	2:00 pm-3:00 pm 21/4/23	0.9	11:00 am-12:00 pm 24/11/23	0.4	10:00 am-11:00 am 4/7/23	0.2	1:00 pm-2:00 pm 17/4/23	0.2	12:00 pm-1:00 pm 31/1/23	0.3	10:00 am-11:00 am 28/8/23	0.1
11:00 am-12:00 pm 7/8/23	1.4	2:00 pm-3:00 pm 2/11/23	1.1	1:00 pm-2:00 pm 25/3/23	0.9	2:00 pm-3:00 pm 26/8/23	0.4	1:00 pm-2:00 pm 18/4/23	0.2	2:00 pm-3:00 pm 26/5/23	0.2	2:00 pm-3:00 pm 31/1/23	0.3	11:00 am-12:00 pm 22/7/23	0.1
10:00 am-11:00 am 4/4/23	1.3	1:00 pm-2:00 pm 29/4/23	1.0	11:00 am-12:00 pm 4/4/23	0.9	1:00 pm-2:00 pm 28/2/23	0.4	12:00 pm-1:00 pm 2/8/23	0.2	12:00 pm-1:00 pm 6/10/23	0.2	10:00 am-11:00 am 21/6/23	0.3	12:00 pm-1:00 pm 22/7/23	0.1
10:00 am-11:00 am 24/3/23	1.3	1:00 pm-2:00 pm 20/4/23	1.0	2:00 pm-3:00 pm 21/6/23	0.9	10:00 am-11:00 am 13/5/23	0.4	11:00 am-12:00 pm 6/4/23	0.2	11:00 am-12:00 pm 25/4/23	0.2	1:00 pm-2:00 pm 14/8/23	0.3	10:00 am-11:00 am 13/9/23	0.1
2:00 pm-3:00 pm 29/4/23	1.2	1:00 pm-2:00 pm 5/4/23	0.9	1:00 pm-2:00 pm 29/11/23	0.9	2:00 pm-3:00 pm 3/11/23	0.4	1:00 pm-2:00 pm 6/4/23	0.2	2:00 pm-3:00 pm 15/3/23	0.2	2:00 pm-3:00 pm 20/11/23	0.3	10:00 am-11:00 am 11/4/23	0.1
12:00 pm-1:00 pm 7/8/23	1.2	10-11:00 am 24/3/23	0.9	11:00 am-12:00 pm 13/2/23	0.8	1-2:00 pm 21/6/23	0.4	12-1:00 pm 22/6/23	0.2	11:00 am-12:00 pm 28/8/23	0.2	2-3:00 pm 1/12/23	0.2	2-3:00 pm 25/4/23	0.1

R01		R02		R03		R11		R20		R28		R33		R39	
Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment
Predicted PM_{10} values ($\mu g/m^3$)															
11:00 am-12:00 pm 29/4/23	17.8	11:00 am-12:00 pm 4/4/23	12.2	12:00 pm-1:00 pm 29/4/23	10.4	10:00 am - 11:00 am 16/8/23	4.9	2:00 pm-3:00 pm 4/7/23	3.3	2:00 pm-3:00 pm 10/10/23	2.6	10:00 am - 11:00 am 7/8/23	3.1	11:00 am-12:00 pm 3/1/23	1.5
10:00 am-11:00 am 14/8/23	15.2	10:00 am-11:00 am 4/4/23	11.8	12:00 pm - 1:00 pm 20/4/23	8.5	2:00 pm-3:00 pm 22/4/23	4.1	11:00 am-12:00 pm 4/7/23	2.7	1:00pm - 2:00 pm 22/7/23	2.3	10:00 am - 11:00 am 22/9/23	3.0	2:00 pm-3:00 pm 11/4/23	1.1
10:00 am-11:00 am 20/4/23	13.9	10:00 am-11:00 am 20/4/23	11.5	11:00 am-12:00 pm 4/4/23	8.4	2:00 pm-3:00 pm 26/8/23	3.8	1:00 pm-2:00 pm 4/7/23	2.1	2:00 pm-3:00 pm 20/2/23	2.3	10:00 am - 11:00 am 29/11/23	3.0	10:00 am - 11:00 am 28/8/23	1.0
1:00 pm-2:00 pm 29/4/23	13.4	11:00 am-12:00 pm 29/4/23	10.8	2:00 pm-3:00 pm 21/4/23	8.4	1:00 pm-2:00 pm 21/6/23	3.5	12:00 pm - 1:00 pm 4/7/23	2.0	1:00 pm-2:00 pm 17/4/23	2.1	10:00 am - 11:00 am 21/6/23	2.6	11:00 am-12:00 pm 18/5/23	1.0
11:00 am-12:00 pm 7/8/23	13.4	2:00 pm-3:00 pm 21/4/23	10.7	2:00 pm-3:00 pm 25/3/23	8.4	10:00 am - 11:00 am 13/5/23	3.5	10:00 am - 11:00 am 4/7/23	2.0	1:00 pm-2:00 pm 11/4/23	1.9	12:00 pm - 1:00 pm 1/4/23	2.4	12:00 pm - 1:00 pm 22/7/23	0.9
11:00 am-12:00 pm 24/3/23	13.2	2:00 pm-3:00 pm 2/11/23	10.7	2:00 pm-3:00 pm 21/6/23	8.2	2:00 pm-3:00 pm 6/11/23	3.4	11:00 am-12:00 pm 24/8/23	1.6	11:00 am-12:00 pm 28/8/23	1.9	12:00 pm - 1:00 pm 31/1/23	2.4	11:00 am-12:00 pm 22/7/23	0.9
10:00 am-11:00 am 4/4/23	13.1	1:00 pm-2:00 pm 29/4/23	9.2	11:00 am-12:00 pm 20/4/23	8.0	12:00 pm - 1:00 pm 24/11/23	3.3	12:00 pm - 1:00 pm 21/6/23	1.5	11:00 am-12:00 pm 25/4/23	1.9	2:00 pm-3:00 pm 1/12/23	2.4	2:00 pm-3:00 pm 25/4/23	0.9
10:00 am-11:00 am 24/3/23	12.1	1:00 pm-2:00 pm 20/4/23	8.8	12:00 pm - 1:00 pm 24/3/23	7.8	2:00 pm-3:00 pm 3/7/23	3.1	2:00 pm-3:00 pm 6/6/23	1.4	2:00 pm-3:00 pm 15/3/23	1.8	2:00 pm-3:00 pm 20/11/23	2.4	11:00 am-12:00 pm 11/4/23	0.9
2:00 pm-3:00 pm 29/4/23	11.5	10:00 am-11:00 am 24/3/23	8.5	10:00 am - 11:00 am 7/10/23	7.6	10:00 am - 11:00 am 6/11/23	3.1	1:00 pm-2:00 pm 18/4/23	1.4	12:00 pm - 1:00 pm 6/10/23	1.7	1:00 pm-2:00 pm 14/8/23	2.3	10:00 am - 11:00 am 13/9/23	0.8
12:00 pm - 1:00 pm 7/8/23	11.3	1:00 pm-2:00 pm 5/4/23	8.5	1:00 pm-2:00 pm 29/11/23	7.5	11:00 am-12:00 pm 20/4/23	3.1	12:00 pm - 1:00 pm 28/2/23	1.3	1:00 pm-2:00 pm 26/5/23	1.7	2:00 pm-3:00 pm 18/5/23	2.3	2:00 pm-3:00 pm 3/6/23	0.8

Predicted incremental concentrations do not exceed the $PM_{2.5}$ and PM_{10} criteria at any sensitive receptors between the hours of 10:00 am and 3:00 pm. Given blasting will be highly managed dust concentrations at receptors would likely be well below predicted worst-case concentrations above.

Based on an estimated two blasts per month the two days with the maximum 24-hour average (as calculated above) were selected and the annual average found based on these values. The measured annual background for 2023 was 10.5 µg/m^3 for PM_{10} and 5.9 µg/m^3 for $PM_{2.5}$. The incremental and cumulative annual $PM_{2.5,}$ PM_{10} and TSP concentrations are shown in Table 7.4. No criteria exceedances are predicted. Incremental concentrations are significantly lower than the assessment criteria of 25 µg/m^3 for PM_{10} (maximum of 1.9%) 7 µg/m^3 for $PM_{2.5}$ (maximum of 0.9%) and 90 µg/m^3 for TSP (maximum of 0.8%).

Table 7.10 Predicted incremental and cumulative annual PM and TSP concentrations (µg/m^3) for the blasting scenario

Receptor	$PM_{2.5}$			PM_{10}			TSP		
	Quarry	External	Total	Quarry	External	Total	Quarry	External	Total
Criteria	**8**	**8**	**8**	**25**	**25**	**25**	**90**	**90**	**90**
R01	0.06	0.05	6.0	0.56	0.25	11.3	0.73	0.08	21.7
R02	0.05	0.05	6.0	0.43	0.24	11.1	0.56	0.08	21.5
R03	0.05	0.04	6.0	0.41	0.23	11.1	0.55	0.08	21.5
R11	0.02	0.04	6.0	0.18	0.22	10.8	0.23	0.08	21.2
R20	0.01	0.04	6.0	0.07	0.21	10.7	0.10	0.07	21.1
R28	0.01	0.06	6.0	0.10	0.34	10.9	0.13	0.13	21.2
R33	0.01	0.05	6.0	0.13	0.26	10.8	0.16	0.08	21.2
R39	0.00	0.08	6.0	0.04	0.42	10.9	0.05	0.16	21.1

7.2.2 Predicted dust deposition impacts

Deposition impacts are assessed against a maximum increase of 2 g/m^2/month and a maximum total of 4 g/m^2/month. Monthly deposition of TSP has been calculated using the sum of the two hourly maximum predicted values for each month and has been assessed as presented in Table 7.11. No exceedances of 2 g/m^2/month were predicted. Predicted dust deposition levels are very low and would be below the criteria when added to predicted dust deposition impacts during operation as assessed in Section 7.1.

Table 7.11 Predicted incremental monthly deposition impacts from the drilling and blasting scenario

Month	Criteria (g/m^2/month)	Incremental impact at receptors (g/m^2/month)							
		R01	R02	R03	R11	R20	R28	R33	R39
Jan	2	0.02	0.02	0.02	0.02	0.01	0.00	0.01	0.01
Feb	2	0.02	0.03	0.02	0.03	0.01	0.00	0.02	0.00
Mar	2	0.02	0.02	0.02	0.02	0.00	0.00	0.01	0.00
Apr	2	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.00
May	2	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01
Jun	2	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
Jul	2	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Aug	2	0.02	0.02	0.01	0.01	0.01	0.00	0.01	0.00
Sep	2	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01
Oct	2	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.00
Nov	2	0.02	0.02	0.02	0.03	0.01	0.01	0.01	0.00
Dec	2	0.02	0.01	0.02	0.02	0.00	0.01	0.02	0.00

Cumulative deposition rates, including predicted deposition from the external sources of dust, are presented in Table 7.12. No exceedances of 2 g/m^2/month at sensitive receptors were predicted.

Table 7.12 Predicted cumulative monthly deposition impacts from the drilling and blasting scenario

Month	Criteria (g/m^2/month)	Cumulative impact at receptors (g/m^2/month)							
		R01	R02	R03	R11	R20	R28	R33	R39
Jan	2	0.05	0.05	0.04	0.04	0.03	0.04	0.04	0.04
Feb	2	0.03	0.04	0.03	0.04	0.02	0.02	0.03	0.02
Mar	2	0.04	0.04	0.03	0.03	0.02	0.02	0.03	0.03
Apr	2	0.03	0.03	0.02	0.03	0.02	0.02	0.03	0.01
May	2	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01
Jun	2	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01
Jul	2	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00
Aug	2	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Sep	2	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
Oct	2	0.03	0.02	0.02	0.02	0.01	0.02	0.03	0.01
Nov	2	0.04	0.04	0.04	0.05	0.03	0.04	0.04	0.04
Dec	2	0.03	0.02	0.03	0.03	0.01	0.02	0.03	0.02

7.2.3 Predicted respirable crystalline silica impacts

RCS concentrations are assessed against an 8-hour averaged criterion of 50 µg/m^3, and an annual averaged criterion of 3 µg/m^3.

Incremental RCS exposures have been estimated on the basis that the $PM_{2.5}$ dust concentrations at the key receptor locations are comprised of 20% to 60% RCS, in accordance with the laboratory analysis reported in the *Health Risk Assessment* (Marulan Quarry EIS – Appendix S).

The annual RCS concentrations at the nearby sensitive receptors are shown in Table 7.4. Cumulative $PM_{2.5}$ RCS concentration in excess of the EPA Victoria (2022) annual average assessment criteria of 3 µg/m^3 were not identified at any of the key receptor locations, under either the 60% or 20% RCS concentration assumptions. Across the range of sensitive receptor locations, the incremental dust emissions also made only a minor (<3%) contribution to the predicted cumulative $PM_{2.5}$ RCS concentrations.

Table 7.13 Predicted incremental annual RCS concentrations (µg/m^3) for the construction scenario

Receptor	Predicted $PM_{2.5}$ RCS concentration (µg/m^3)			Predicted $PM_{2.5}$ RCS concentration (µg/m^3)		
	Assuming 60% RCS in project dust emissions*			Assuming 20% RCS in project dust emissions*		
	Incremental	Background	Cumulative	Incremental	Background	Cumulative
Criteria	**3**	**3**	**3**	**3**	**3**	**3**
R01	0.04	1.8	1.8	0.01	1.8	1.8
R02	0.03	1.8	1.8	0.01	1.8	1.8
R03	0.03	1.8	1.8	0.01	1.8	1.8
R11	0.01	1.8	1.8	0.00	1.8	1.8
R20	0.01	1.8	1.8	0.00	1.8	1.8
R28	0.01	1.8	1.8	0.00	1.8	1.8
R33	0.01	1.8	1.8	0.00	1.8	1.8
R39	0.00	1.8	1.8	0.00	1.8	1.8

* Calculations based on the $PM_{2.5}$ fraction and the assumption that the RCS of background dust impacts is 30%

7.2.4 Predicted nitrogen dioxide concentration impacts

It has conservatively been assumed that all NOx emitted from the blast would immediately break down to NO_2.

Given specific blasting times are unknown, worst-case predicted NO_2 concentrations are used as a guide to compare against criteria of 164 µg/m^3. The ten highest predicted 1-hour average values from between the hours 10:00 am and 3:00 pm are presented in Table 7.14.

NO_2 concentrations have been assessed against the relevant environmental criteria with a minimum averaging period of one hour as per Section 2.3. Short term impacts (less than one hour) have not been assessed.

Table 7.14 Predicted 1-hour NO_2 incremental impacts at the nearest sensitive receptors during the blasting scenario

R01		R02		R03		R11		R20		R28		R33		R39	
Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment	Date	Increment
Predicted NO_2 values (µg/m^3)															
11:00 am-12:00 pm 29/4/23	1.1	11:00 am-12:00 pm 4/4/23	0.8	12:00 pm-1:00 pm 29/4/23	0.7	10:00 am-11:00 am 16/8/23	0.3	2:00 pm-3:00 pm 4/7/23	0.2	2:00 pm-3:00 pm 10/10/23	0.2	10:00 am-11:00 am 22/9/23	0.2	11:00 am-12:00 pm 3/1/23	0.1
10:00 am-11:00 am 14/8/23	1.0	10:00 am-11:00 am 4/4/23	0.7	2:00 pm-3:00 pm 25/3/23	0.6	12:00 pm-1:00 pm 24/11/23	0.3	11:00 am-12:00 pm 4/7/23	0.2	1:00 pm-2:00 pm 11/4/23	0.1	10:00 am-11:00 am 29/11/23	0.2	2:00 pm-3:00 pm 11/4/23	0.1
1:00 pm-2:00 pm 29/4/23	0.9	10:00 am-11:00 am 20/4/23	0.7	2:00 pm-3:00 pm 5/4/23	0.6	11:00 am-12:00 pm 24/11/23	0.3	12:00 pm-1:00 pm 4/7/23	0.2	1:00 pm-2:00 pm 22/7/23	0.1	10:00 am-11:00 am 7/8/23	0.2	11:00 am-12:00 pm 18/5/23	0.1
10:00 am-11:00 am 20/4/23	0.9	2:00 pm-3:00 pm 21/4/23	0.7	1:00 pm-2:00 pm 25/3/23	0.6	2:00 pm-3:00 pm 6/11/23	0.3	1:00 pm-2:00 pm 4/7/23	0.2	2:00 pm-3:00 pm 20/2/23	0.1	12:00 pm-1:00 pm 1/4/23	0.2	11:00 am-12:00 pm 11/4/23	0.1
11:00 am-12:00 pm 7/8/23	0.9	11:00 pm-12:00 am 29/4/23	0.7	1:00 pm-2:00 pm 29/11/23	0.6	1:00 pm-2:00 pm 28/2/23	0.3	10:00 am-11:00 am 4/7/23	0.2	2:00 pm-3:00 pm 26/5/23	0.1	1:00 pm-2:00 pm 14/8/23	0.2	11:00 am-12:00 pm 22/7/23	0.1
11:00 am-12:00 pm 24/3/23	0.9	2:00 pm-3:00 pm 2/11/23	0.7	2:00 pm-3:00 pm 21/6/23	0.5	2:00 pm-3:00 pm 26/8/23	0.3	1:00 pm-2:00 pm 18/4/23	0.1	12:00 pm-1:00 pm 6/10/23	0.1	12:00 pm-1:00 pm 31/1/23	0.2	10:00 am-11:00 am 28/8/23	0.1
10:00 am-11:00 am 24/3/23	0.8	1:00 pm-2:00 pm 29/4/23	0.6	12:00 pm-1:00 pm 20/4/23	0.5	2:00 pm-3:00 pm 22/4/23	0.3	12:00 pm-1:00 pm 2/8/23	0.1	12:00 pm-1:00 pm 30/11/23	0.1	2:00 pm-3:00 pm 31/1/23	0.2	12:00 pm-1:00 pm 22/7/23	0.1
10:00 am-11:00 am 4/4/23	0.8	1:00 pm-2:00 pm 20/4/23	0.6	2:00 pm-3:00 pm 21/4/23	0.5	2:00 pm-3:00 pm 3/11/23	0.2	1:00 pm-2:00 pm 6/4/23	0.1	10:00 am-11:00 am 2/12/23	0.1	2:00 pm-3:00 pm 20/11/23	0.2	10:00 am-11:00 am 13/9/23	0.1
2:00 pm-3:00 pm 29/4/23	0.8	1:00 pm-2:00 pm 5/4/23	0.6	11:00 pm-12:00 am 13/2/23	0.5	10:00 am-11:00 am 13/5/23	0.2	12:00 pm-1:00 pm 22/6/23	0.1	2:00 pm-3:00 pm 15/3/23	0.1	10:00 am-11:00 am 21/6/23	0.2	10:00 am-11:00 am 11/4/23	0.1
12:00 pm-1:00 pm 7/8/23	0.8	10:00 am-11:00 am 24/3/23	0.6	12:00 pm-1:00 pm 24/3/23	0.5	1:00 pm-2:00 pm 21/6/23	0.2	11:00 am-12:00 pm 6/4/23	0.1	11:00 am-12:00 pm 25/4/23	0.1	12:00 pm-1:00 pm 14/4/23	0.2	2:00 pm-3:00 pm 3/6/23	0.1

Predicted incremental concentrations do not exceed the NO_2 criteria at any sensitive receptors between the hours of 10:00 am and 3:00 pm.

Based on an estimated two blasts per month the two days with the maximum 1-hour average (as presented above) were selected and the annual average found based on these values. The measured annual background for 2023 was 6.2 µg/m^3. The incremental and cumulative annual NO_2 concentrations are shown in Table 7.15. No criteria exceedances are predicted. Incremental concentrations are significantly lower than the assessment criteria of 31 µg/m^3 (maximum of 0.01%).

Table 7.15 Predicted incremental and cumulative annual NO_2 concentrations (µg/m^3) for the blasting scenario

Receptor	NO_2	
	Incremental	Cumulative
Criteria	**31**	**31**
R01	0.002	6.2
R02	0.001	6.2
R03	0.001	6.2
R11	0.001	6.2
R20	0.000	6.2
R28	0.000	6.2
R33	0.000	6.2
R39	0.000	6.2

8. Management and mitigation

8.1 Construction

General air quality mitigation and management measure for construction of the project are provided below:

– Prepare a dust control protocol that forms part of the Construction Environmental Management Plan (CEMP) to detail management measures a method for recording dust complaints and monitoring requirements.
– On days with forecast and actual high winds (i.e. over 10 m/s) reduce work effort accordingly if wind blown dust is observed to be leaving the site boundary and trigger levels are exceeded on any real time dust monitoring program.
– During periods with forecast and actual light winds (i.e. under 2.5 m/s) to the west (towards the nearest receptors) work effort should be reduced accordingly if wind blown dust is observed to be leaving the site boundary and trigger levels are exceeded on any real time dust monitoring program.
– Plant and equipment should be maintained in good condition to minimise ignition risk spills and air emissions that may cause nuisance.
– Dust suppression should be undertaken as required using water sprays water extension agents soil stabilising polymers or other media on:
  - Unpaved work areas subject to traffic or wind
  - Spoil and aggregate stockpiles
  - During the loading and unloading of dust generating materials
  - Unpaved access tracks
– If the works are creating levels of dust which may significantly impact on residential amenity the works should be modified or stopped until the dust hazard is reduced to an acceptable level.
– On days with high background dust levels (due to fire or offsite dust events for example) increase dust mitigation in the form of watering or reduce dusty construction activities.
– Construction vehicles with potential for loss of loads (such as dust or litter) should be covered when using public roads.

A dust monitoring plan is recommended to be undertaken during the construction of the project. This would include:

– Monitoring should include at a minimum four dust deposition gauges and one real time particulate sampler for the first year of operation. Monitoring requirements can be updated after a year of sampling based on compliance.
– Development of a trigger action response plan (TARP) which would provide mitigation requirements based on the recorded particulate concentrations.
– An onsite weather station is to be installed to help plan when certain activities are undertaken such as blast events.
– Boundary and receptor monitoring (particularly at receptors R01 or R02) and daily wind forecasting to provide a daily dust risk rating is recommended. On days where the dust risk is high, works should be modified accordingly. Relevant management measures would be described and should be undertaken on days with lower risk ratings. Monitoring throughout each day would inform whether activities can proceed or whether they should be reduced due to high monitoring observations.

8.2 Operation

While general operation of the project is not expected to exceed air quality criteria at nearby receptors the following mitigation measures are recommended:

– Prepare a dust management plan for the site which details management measures a method for recording dust complaints and monitoring requirements.

- A dust audit to be undertaken at the end of the first year of operation to confirm site dust management and ensure no impacts at off-site receptors.
- If dust plumes are observed to be leaving the site boundary especially the road then dust generating activities are to cease until dust generation has stopped. Additional watering may be needed.
- During periods with forecast and actual light winds (i.e. under 2.5 m/s) to the west (towards the nearest receptors) work effort should be reduced accordingly if wind blown dust is observed to be leaving the site boundary and trigger levels are exceeded on any real time dust monitoring program.
- Water material prior to it being loaded for onsite haulage where appropriate.
- Regularly water all haul routes used by trucks (level 1 (2 litres/m^2/minute) at minimum and level 2 (>2 litres/m^2/minute) when dust plumes are observed to be a safety hazard or leaving the general road area.
- Aim to minimise the size of storage piles where possible.
- Limit areas of cleared land and clear only when necessary to reduce fugitive dust emissions.
- Control onsite traffic by designating specific routes for haulage and access and limiting vehicle speeds to below 25 kilometres per hour.
- Cover all truck hauling material on the way to the site and maintain a reasonable amount of vertical space between the top of the load and top of the trailer.
- Suspend operations conducted in areas of low moisture content material during high wind speed events or use water sprays if visible dust plumes are observed to be leaving site.
- A blast management plan is to identify appropriate times for blasting to occur and should limit blasting on days when wind is blowing directly towards nearby receptors.
- Prior to commencing progressive rehabilitation during Stage 2 undertake a revised dust assessment to determine whether additional mitigation measures are needed.
- A rehabilitation dust management plan would be prepared in order to manage potential dust impacts during that stage of the project.

A dust monitoring plan is proposed to be undertaken during the operation of the project. This would include:

- Monitoring should include at a minimum four dust deposition gauges and one real time particulate sampler for the first year of operation. Monitoring requirements can be updated after a year of sampling based on compliance.
- Development of a trigger action response plan (TARP) which would provide mitigation requirements based on the recorded particulate concentrations.
- An onsite weather station is to be installed to help plan when certain activities are undertaken such as blast events.
- Boundary and receptor monitoring (particularly at receptors R01 or R02) and daily wind forecasting to provide a daily dust risk rating is recommended. On days where the dust risk is high, works should be modified accordingly. Relevant management measures would be described and should be undertaken on days with lower risk ratings. Monitoring throughout each day would inform whether activities can proceed or whether they should be reduced due to high monitoring observations.

These measures will assist in reducing impacts on all areas offsite.

8.3 Water management

Water will be required for dust suppression during both the construction and operation stages of the project. Process water comprises water required (see Section 5.2.1):

- In the crusher operations.
- For dust suppression dry and windy days.

It is expected that the process water demand would be approximately 34 ML/year. For dust suppression, a water cart will be used to spray water on exposed (disturbed areas), stockpiles and the internal road network. Dust suppression water will be sourced from the water storage dam, the extraction area sump or sediment basins.

A site water balance was completed as part of the water resources assessment and found that the demand of 34 ML/year could be satisfied over 99 percent of the time through the provision of a surface runoff harvesting dam of 3 ML and a maximum annual groundwater extraction of 25 ML/year.

In the rare occasions where sufficient water is not available processing would be reduced as required and water for environmental purposes, such as dust suppression, would be sourced externally via tankering to the site.

The surface water could be collected under harvestable rights and the groundwater would be sourced under a Water Access Licence (WAL). Groundwater would be sourced from a production bore located alongside roadways or other site infrastructure, in areas already disturbed by the project activities.

9. Conclusion

An air quality assessment was undertaken of the proposed quarrying operation on Lots 3 and 4 of DP 247199 and Lot 7001 of DP 1025585 in Marulan. The assessment followed the NSW EPA *Approved Methods for the modelling and assessment of air pollutants in NSW* (NSW EPA, 2017) and *National environmental protection (ambient air quality) measure* (National Environmental Protection Council, 2021) and included meteorological and dispersion modelling and impacts were predicted in the surrounding environment including the eight nearest receptors.

Dust emissions from the proposed activities were estimated using NPI *Emission estimation technique manual for mining* (2012) and *Emission estimation technique manual for mining and processing of non-metallic minerals* (2014) for both construction and operation of the quarry. Using the estimated emissions, conservative dispersion modelling scenarios were undertaken assuming maximum dust emissions over an entire year for both construction and operation of the quarry.

The dust impacts on the eight nearest receptors have been assessed for three scenarios:

– Construction
– Worst-case general operations
– Blasting events

No exceedances of $PM_{2.5}$, PM_{10} or TSP (including background) are predicted during the any of the scenarios. The assessment includes a number of conservative assumptions and provided management actions outlined are implemented air quality impacts as per the EPA guidance are not anticipated. Weather conditions that cause maximum dust impact are generally consistent winds in the direction of the nearest sensitive receivers throughout the daytime period outside of rain events however dust generating activities can be managed during these conditions to prevent dust impacts.

Modelling of nitrogen dioxide (NO_2) was also undertaken for the blasting scenario. Predicted particulate and NO_2 concentrations during blasting were shown to comply with the criteria if undertaken between the hours of 10:00 am and 3:00 pm which avoid adverse meteorological conditions. A blast management plan would be prepared which identifies appropriate times for blasting to occur and the need to limit blasting under certain meteorological conditions such as wind speed and direction.

The assessment includes a number of conservative assumptions and provided management actions outlined in Section 8 air quality impacts as per the EPA guidance are not anticipated.

10. References

Barclay and Scire; Atmospheric Studies Group. (2011). Generic guidance and optimum model settings for the CALPUFF modelling system for inclusion into the 'Approved Methods for the modelling and assessments of air pollutants in NSW, Australia'.

Department of Environment & Conservation. (2012, September). Guideline for Plume Dispersion Modelling. Government of Newfoundland and Labrador.

Department of Planning and Environment. (2018). Voluntary land acquisition and mitigation police for state significant mining, petroleum and extractive industry developments.

EMM Consulting. (2019, March). Marulan South limestones mine continued operations state significant development application.

EPA Victoria. (2022). Guideline for assessing and managing air pollution in Victoria.

EPA Victoria. (2025). 1961: Guideline for assessing and minimising air pollution.

GHD. (2022). Marulan Quarry Silica Assessment.

Midwest Research Institute. (2006). Background document for revisions to fine fraction ratios used for AP-42 fugitive dust emission factors. USA.

National Environmental Protection Council. (2021). National Environment Protection (Ambient Air Quality) Measure - Variation .

NPI. (2012). Emissions estimation technique manual for mining.

NPI. (2014). Emission estimation technique manual for mining and processing of non-metallic minerals.

NSW Department of Environment and Conservation . (2006). Technical framework - Assessment and management of odour from stationary sources in NSW.

NSW EPA. (2017). Approved methods for the modelling and assessment of air pollutants in New South Wales.

NSW EPA. (2022, August). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. Parramatta, NSW: NSW Environment Protection Authority.

NSW EPA. (2022). Approved methods for the sampling and analysis of air pollutants in New South Wales.

NSW Government. (2021). NSW Protection of the Environment Operations (Clean Air) Regulation.

Pacific Environment Limited. (2015). Lynwood Quarry Extraction Area Modification Project - Air Quality Impact Assessment. Umwelt (Australia) Pty Ltd.

Pacific Environment Limited. (2015). Lynwood quarry extraction area modification project - Air quality impact assessment.

Safe Work Australia. (2019, December). Workplace Exposure Standards for Airborne Contaminants.

Todoroski Air Sciences Pty Ltd. (2019). Air Quality Impact Assessment - Marulan South Limestone Mine Continued Operations. Boral Cement Limited.

URS. (2012, January). Air Quality and Greenhouse Gas Assessment for the McArthur River Mine Phase 3 Development Project. Australia.

US EPA. (2004). AP 42 Section 11.19.2 Crushed stone processing and pulverized mineral processing. USA.

Appendices

Appendix A

Emissions inventory

Table A.1 Construction scenario emission rate calculations

Location	Activity	Emission rate (g/s)			Control	Intensity	Emission factor				Variables			Source
		TSP	PM_{10}	$PM_{2.5}$			TSP	PM_{10}	$PM_{2.5}$	Unit	$PM_{2.5}/PM_{10}$ ratio	Other variables	Hours per day	
Stage 1 quarry	Dozer	0.083	0.013	0.001	-	-	1.2	0.19	0.02	kg/h/veh	0.1	No. vehicles: 1 Frequency per hour: 0.25 Moisture content: 5% Silt content: 3%	11	NPI manual A Table 2
	Excavators	0.125	0.059	0.006	-	2500 t/day	0.025	0.012	0.0012	kg/t	0.1	Moisture content: 5% Mean wind speed: 3.9 m/s	11	NPI manual A Table 2
Overburden stockpile 1	Truck unloading	0.758	0.271	0.027	-	2500 t/day	0.012	0.0043	0.00043	kg/t	0.1	-	11	NPI manual A Table 2
	Wind erosion	0.165	0.082	0.012	0.5	29640.5 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
Construction access road	Truck wheel generated dust – entry road	1.989	0.588	0.059	0.5	0.745 km	4.23	1.25	0.125	kg/VKT	0.1	No. vehicles:50 Frequency per day: 1	11	NPI manual A Table 2
	Truck wheel generated dust – between stockpiles	3.568	1.054	0.105	0.5	0.668 km	4.23	1.25	0.125	kg/VKT	0.1	No. vehicles:50 Frequency per day: 2	11	NPI manual A Table 2
	Truck wheel generated dust – exit road	2.211	0.653	0.065	0.5	0.828 km	4.23	1.25	0.125	kg/VKT	0.1	No. vehicles:50 Frequency per day: 1	11	NPI manual A Table 2

Location	Activity	Emission rate (g/s)			Control	Intensity	Emission factor				Variables			Source
		TSP	PM_{10}	$PM_{2.5}$			TSP	PM_{10}	$PM_{2.5}$	Unit	$PM_{2.5}/PM_{10}$ ratio	Other variables	Hours per day	
	Light vehicle wheel generated dust	0.197	0.069	0.007	0.5	0.828 km	0.94	0.33	0.033	kg/VKT	0.1	No. vehicles:10 Frequency per day: 2	11	NPI manual A Table 2

Table A.2 General operations scenario emission rate calculations

Location	Activity	Emission rate (g/s)			Control	Intensity	Emission factor				Variables			Source
		TSP	PM10	PM2.5			TSP	PM_{10}	$PM_{2.5}$	Unit	$PM_{2.5}/PM_{10}$ ratio	Other variables	Hours per day	
Stage 1 quarry	Dozer	0.083	0.013	0.001	-	-	1.20	0.19	0.02	kg/h/veh	0.1	No. vehicles: 1 Frequency per hour: 0.25 Moisture content: 5% Silt content: 3%	11	NPI manual A Table 2
	Excavator	0.125	0.059	0.006	-	2500 t/day	0.002	0.001	9.37E-05	kg/t	0.1	Moisture content: 5% Mean wind speed: 3.9 m/s	11	NPI manual A Table 2
	Front end loader	0.125	0.059	0.006	-	2500 t/day	0.002	0.001	9.37E-05	kg/t	0.1	Moisture content: 5% Mean wind speed: 3.9 m/s	11	NPI manual A Table 2
	Truck loading	7.52E-05	3.16E-03	3.16E-04	-	2500 t/day	1.19E-04	5E-05	5E-06	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
Overburden stockpile 1	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.149	0.075	0.011	0.5	26847.2 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
Road base stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.027	0.014	0002	0.5	4876.9 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
Crusher dust stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.011	0.005	0.001	0.5	1940 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2

Location	Activity	Emission rate (g/s)			Control	Intensity	Emission factor				Variables			Source
		TSP	PM10	PM2.5			TSP	PM_{10}	$PM_{2.5}$	Unit	$PM_{2.5}/PM_{10}$ ratio	Other variables	Hours per day	
Scalps stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.007	0.004	0.001	0.5	1300.7 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
7 mm aggregate stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.007	0.004	0.001	0.5	1286 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
10 mm aggregate stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.007	0.003	0.001	0.5	1233.6 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
14 mm aggregate stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.007	0.004	0.001	0.5	1293.3 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
20 mm aggregate stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.011	0.006	0.001	0.5	2021.1 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
Crushing and screening plant	Tertiary crushing	0.170	0.076	0.014	-	2500 t/day	0.0027	0.0012	2.22E-04	kg/t	0.185	-	11	NPI manual B Table 17
	Truck loading	7.52E-03	3.16E-03	3.16E-04	-	2500 t/day	1.19E-04	5E-05	5E-06	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17

Location	Activity	Emission rate (g/s)			Control	Intensity	Emission factor				Variables			Source
		TSP	PM10	PM2.5			TSP	PM_{10}	$PM_{2.5}$	Unit	$PM_{2.5}/PM_{10}$ ratio	Other variables	Hours per day	
Conveyor	Material conveying	0.125	0.059	0.006	-	2500 t/day	0.002	0.001	9.37E-05	Kg/t	0.1	Moisture content: 5% Mean wind speed: 3.9 m/s	11	NPI manual A Table 2
Operational haul road	Truck wheel generated dust – entry road	0.995	0.294	0.029	0.75	0.745 km	4.23	1.25	0.125	kg/VKT	0.1	No. vehicles:50 Frequency per day: 1	11	NPI manual A Table 2
	Truck wheel generated dust – between stockpiles	1.784	0.527	0.053	0.75	0.668 km	4.23	1.25	0.125	kg/VKT	0.1	No. vehicles:50 Frequency per day: 2	11	NPI manual A Table 2
	Truck wheel generated dust – exit road	1.106	0.327	0.033	0.75	0.828 km	4.23	1.25	0.125	kg/VKT	0.1	No. vehicles:50 Frequency per day: 1	11	NPI manual A Table 2
	Light vehicle wheel generated dust	0.098	0.016	0.002	0.75	0.828 km	0.94	0.33	0.033	kg/VKT	0.1	No. vehicles:10 Frequency per day: 2	11	NPI manual A Table 2

Location	Activity	Emission rate (g/s)			Control	Intensity	Emission factor				Variables			Source
		TSP	PM10	PM2.5			TSP	PM_{10}	$PM_{2.5}$	Unit	$PM_{2.5}/PM_{10}$ ratio	Other variables	Hours per day	
Stage 1 quarry	Dozer	0.083	0.013	0.001	-	-	1.20	0.19	0.02	kg/h/veh	0.1	No. vehicles: 1 Frequency per hour: 0.25 Moisture content: 5% Silt content: 3%	11	NPI manual A Table 2
	Excavator	0.125	0.059	0.006	-	2500 t/day	0.002	0.001	9.37E-05	kg/t	0.1	Moisture content: 5% Mean wind speed: 3.9 m/s	11	NPI manual A Table 2
	Front end loader	0.125	0.059	0.006	-	2500 t/day	0.002	0.001	9.37E-05	kg/t	0.1	Moisture content: 5% Mean wind speed: 3.9 m/s	11	NPI manual A Table 2
	Truck loading	7.52E-05	3.16E-03	3.16E-04	-	2500 t/day	1.19E-04	5E-05	5E-06	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
Overburden stockpile 1	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.149	0.075	0.011	0.5	26847.2 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
Road base stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.027	0.014	0002	0.5	4876.9 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
Crusher dust stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.011	0.005	0.001	0.5	1940 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2

Location	Activity	Emission rate (g/s)			Control	Intensity	Emission factor				Variables			Source
		TSP	PM10	PM2.5			TSP	PM_{10}	$PM_{2.5}$	Unit	$PM_{2.5}/PM_{10}$ ratio	Other variables	Hours per day	
Scalps stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.007	0.004	0.001	0.5	1300.7 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
7 mm aggregate stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.007	0.004	0.001	0.5	1286 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
10 mm aggregate stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.007	0.003	0.001	0.5	1233.6 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
14 mm aggregate stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.007	0.004	0.001	0.5	1293.3 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
20 mm aggregate stockpile	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Wind erosion	0.011	0.006	0.001	0.5	2021.1 m^2	0.4	0.2	0.03	kg/ha/h	0.15	-	24	NPI manual A Table 2
Crushing and screening plant	Tertiary crushing	0.170	0.076	0.014	-	2500 t/day	0.0027	0.0012	2.22E-04	kg/t	0.185	-	11	NPI manual B Table 17
	Truck loading	7.52E-03	3.16E-03	3.16E-04	-	2500 t/day	1.19E-04	5E-05	5E-06	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17
	Truck unloading	1.2E-03	5.05E-04	5.05E-05	-	2500 t/day	1.905E-05	8E-06	8E-07	kg/t	0.1	PM_{10}/TSP ratio: 0.42	11	NPI manual B Table 17

Location	Activity	Emission rate (g/s)			Control	Intensity	Emission factor				Variables			Source
		TSP	PM10	PM2.5			TSP	PM_{10}	$PM_{2.5}$	Unit	$PM_{2.5}/PM_{10}$ ratio	Other variables	Hours per day	
Conveyor	Material conveying	0.125	0.059	0.006	-	2500 t/day	0.002	0.001	9.37E-05	Kg/t	0.1	Moisture content: 5% Mean wind speed: 3.9 m/s	11	NPI manual A Table 2
Operational haul road	Truck wheel generated dust – entry road	0.995	0.294	0.029	0.75	0.745 km	4.23	1.25	0.125	kg/VKT	0.1	No. vehicles:50 Frequency per day: 1	11	NPI manual A Table 2
	Truck wheel generated dust – between stockpiles	1.784	0.527	0.053	0.75	0.668 km	4.23	1.25	0.125	kg/VKT	0.1	No. vehicles:50 Frequency per day: 2	11	NPI manual A Table 2
	Truck wheel generated dust – exit road	1.106	0.327	0.033	0.75	0.828 km	4.23	1.25	0.125	kg/VKT	0.1	No. vehicles:50 Frequency per day: 1	11	NPI manual A Table 2
	Light vehicle wheel generated dust	0.098	0.016	0.002	0.75	0.828 km	0.94	0.33	0.033	kg/VKT	0.1	No. vehicles:10 Frequency per day: 2	11	NPI manual A Table 2

Table A.3 Drilling and blasting scenario PM emission rate calculations

Location	Activity	Emission rate (g/s)			Control	Intensity	TSP		PM_{10}		$PM_{2.5}$		Variables			Source
		TSP	PM10	PM2.5			Factor	Unit	Factor	Unit	Factor	Unit	Width (m)	Length (m)	Duration (min)	
Stage 1 quarry	Blasting	61.1	31.7	3.2	-	1 blast	220	kg/blast	114	kg/blast	11.4	kg/blast	50	200	60	NPI manual A Table 2
	Drilling	0.16	0.09	0.01	-	1 hole	0.59	kg/hole	0.31	kg/hole	0.031	kg/hole	-	-	60	NPI manual A Table 2

Table A.4 Drilling and blasting scenario PM emission rate calculations

Location	Activity	NOx emission rate (g/s)	Control	Intensity	TSP		Variables		Source
					Factor	Unit	Fuel / explosive	Tonnes of explosive	
Stage 1 quarry	Blasting	0.09	-	0.04 tonnes	8	kg/ton	ANFO (on site mix)	0.04 tonnes	Emission estimation technique manual for explosives detonation and firing ranges (NPI, 2016) Appendix C, Table 3

Appendix B

Meteorological modelling methodology

B-1 Overview

Local meteorology including long term wind speed and direction as well as atmospheric stability can influence how pollutants are dispersed into the local environment.

This appendix outlines the methodology used to synthesise site-representative meteorology for the project. The meteorology is used in CALPUFF to drive the dispersion model.

B-2 Methodology

The meteorology modelling methodology is summarised below:

– Selection of a model period.
– Development of coarsely gridded prognostic meteorological data set using The Air Pollution Model (TAPM).
– Development of fine gridded meteorological data set which takes in account local terrain features using the CALMET diagnostic meteorological model.
– Verification of model performance using data measured at BoM meteorological stations.
– Extraction of predicted meteorological parameters from the CALMET model.

B-2-1 Nearby BoM station review

Th nearest BoM station is the Goulburn Airport AWS (ID: 70330). It is located approximately 17 kilometres southwest of the site. This station began operation in January 1989 and collects all desired meteorological parameters including cloud data.

B-2-2 Representative year selection

A representative year was chosen for modelling purposes based on review of Southern Oscillation Index (SOI) for the past 10 years and an analysis of BoM data recorded at the Goulburn Airport AWS for the last five calendar years (01/01/2019 – 31/12/2023).

The SOI indicates the intensity of El Nino or La Nina events in the Pacific Ocean. A value of less than -7 often indicates El Nino episodes typically accompanied by sustained warming of the central and eastern tropical Pacific Ocean a decrease in the strength of the Pacific Trade Winds and a reduction in winter and spring rainfall over much of eastern Australia and the Top End. A value greater than 7 often indicates La Nina episodes typically associated with stronger Pacific Trade Winds and warmer sea temperatures to the north of Australia. Waters in the central and eastern tropical Pacific Ocean become cooler during this time. Together these give an increased probability that eastern and northern Australia will be wetter than normal.

The SOI for the past 10 years is shown in Figure B.1.

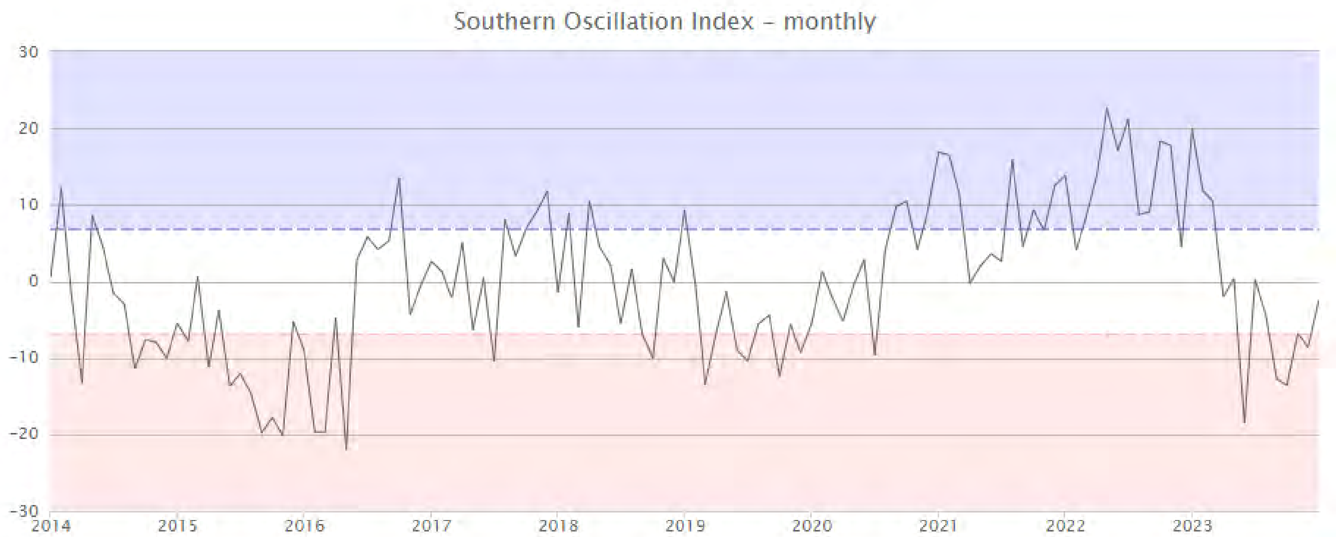


Figure B.1 Southern Oscillation Index for last 10 years (2014-2023 (BoM, 2024)

Probability density function plots of Goulburn Airport AWS data (2019-2023) for temperature relative humidity wind direction and wind speed are provided in Figure B.2, Figure B.3, Figure B.4 and Figure B.5 respectively.

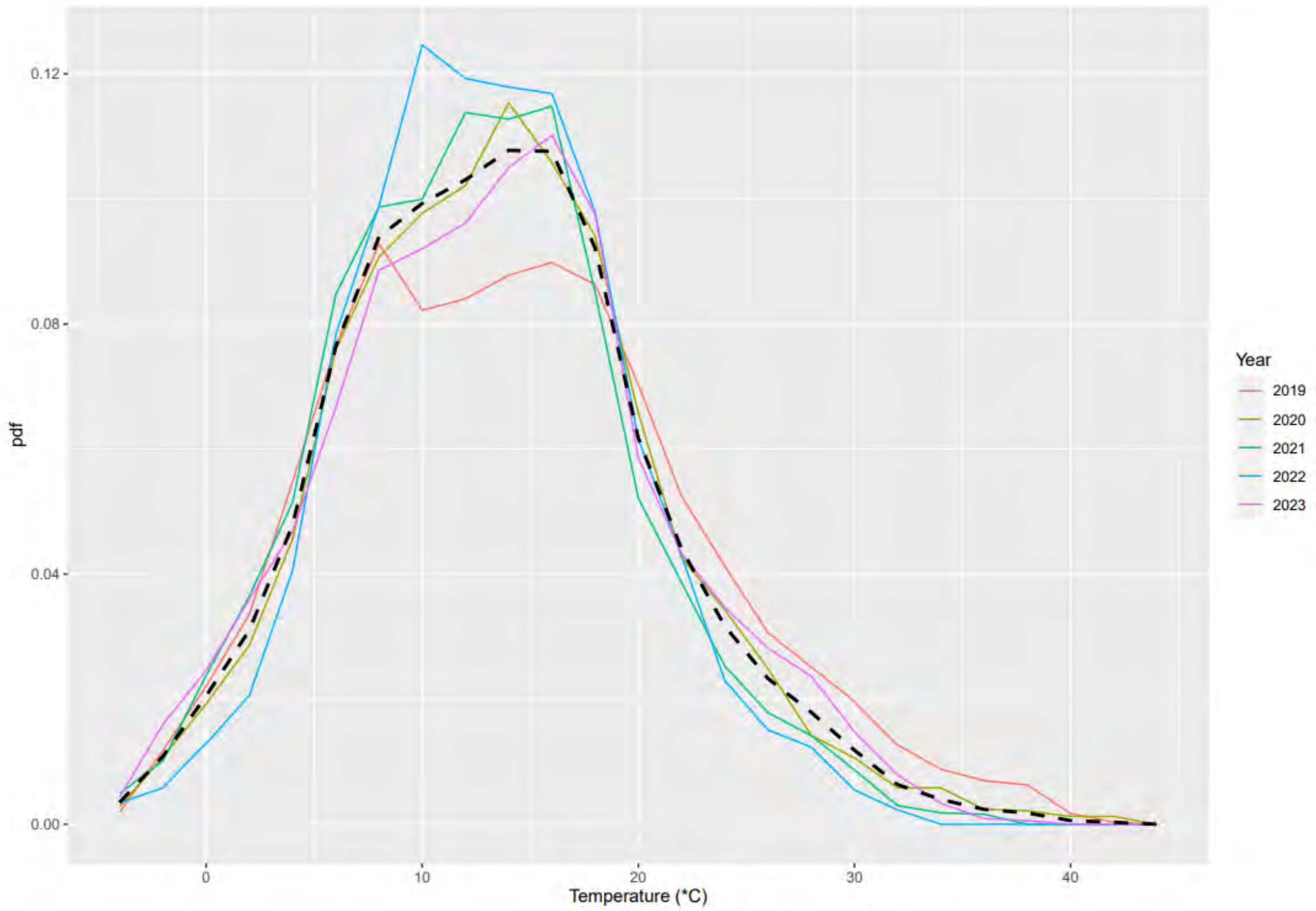


Figure B.2 Temperature plot (Goulburn Airport AWS 2019-2023)

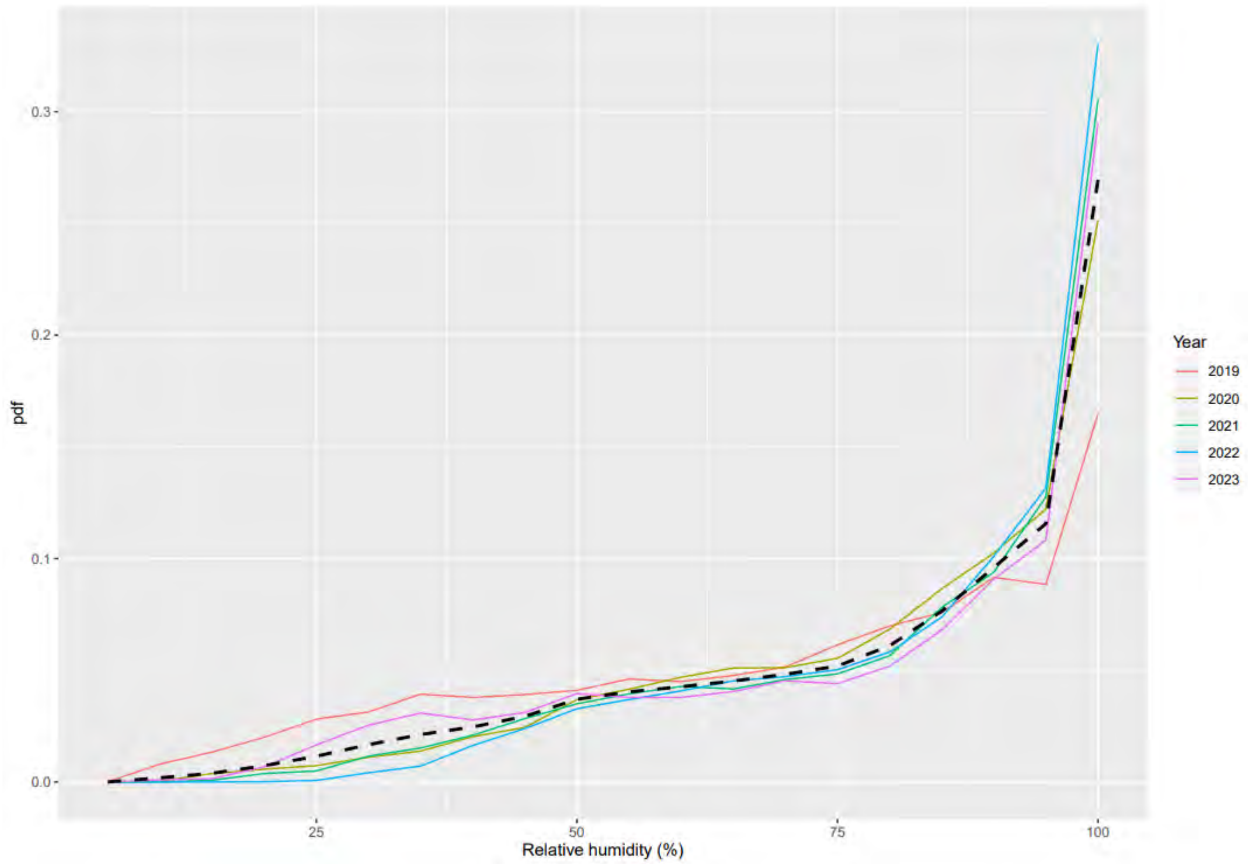


Figure B.3 Relative humidity plot (Goulburn Airport AWS 2019-2023)

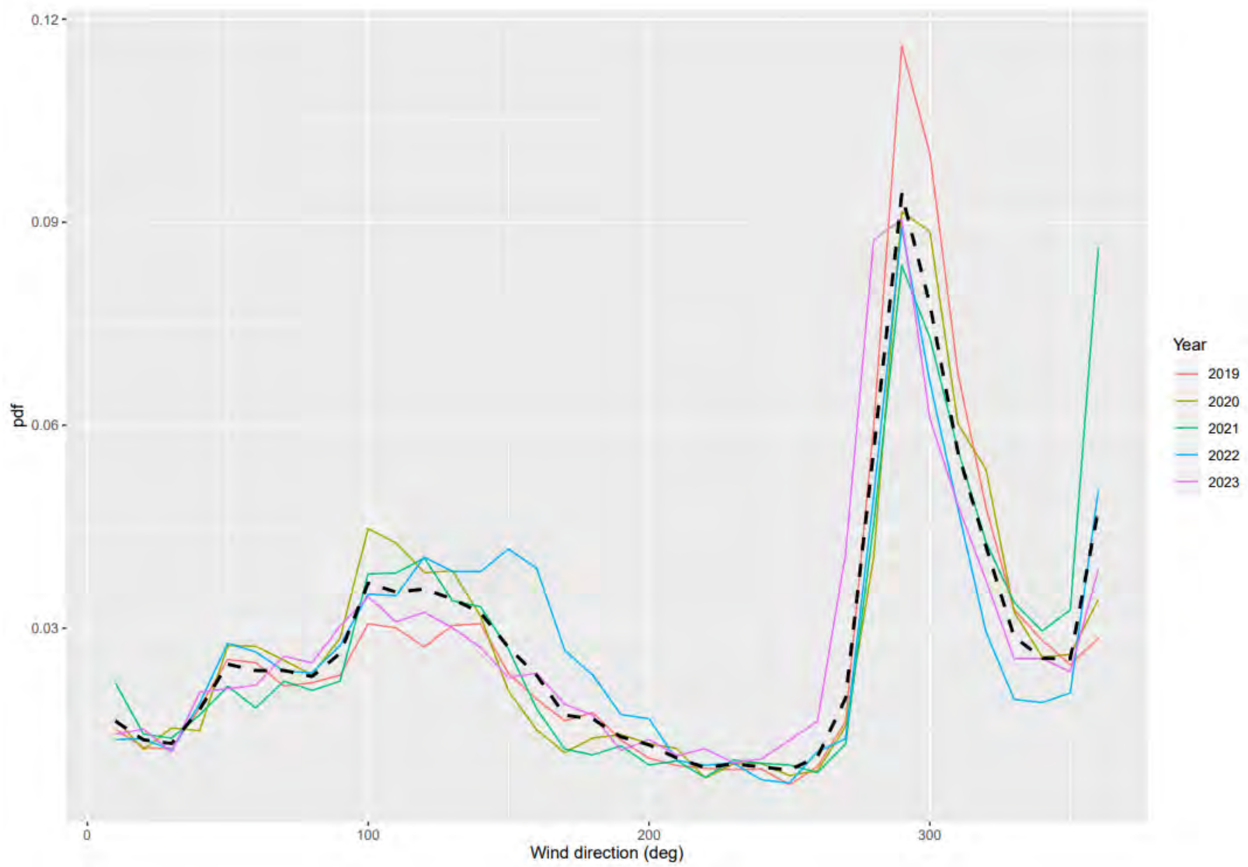


Figure B.4 Wind direction plot (Goulburn Airport AWS 2019-2023)

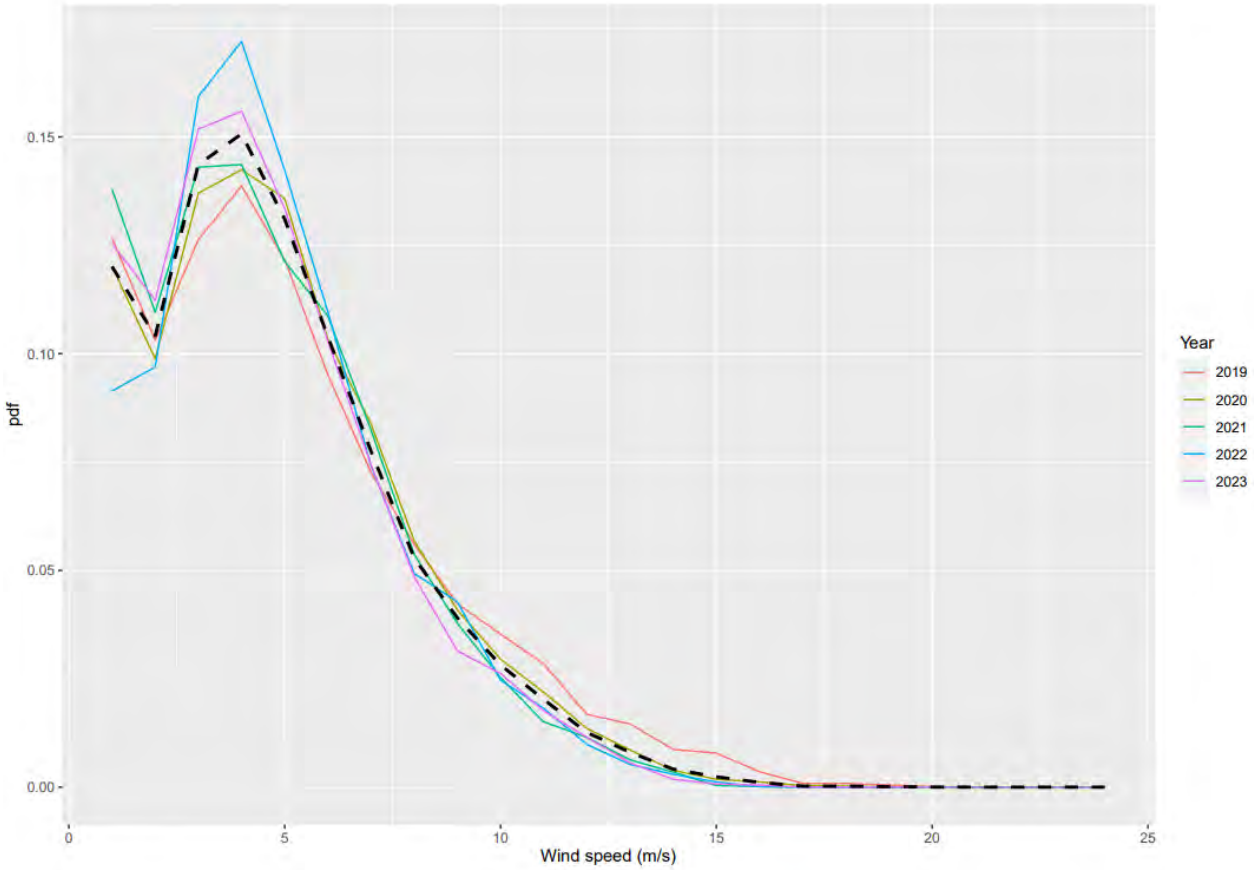


Figure B.5 Wind speed plot (Goulburn Airport AWS 2019-2023)

Based on the review of SOI data and meteorological conditions recorded at Goulburn Airport AWS the representative year selected for modelling purposes was 1 January 2023 through 1 January 2024.

B-2-3 Prognostic meteorology

The parameters for the prognostics TAPM are summarised in Table B.1.

Table B.1 APM parameters

Parameter	Value
Modelled period	01 January 2023 to 31 December 2023
Domain centre	UTM zone 55S Easting: 765585 m Northing: 6151105 m
Domain grid spacing	1 x 1 km
Domain size	35 x 35 km
Number of vertical levels	25

B-3 CALMET modelling

CALMET (Version 7) was used to resolve the wind field around the subject site to 200 metres spatial resolution. The application of CALMET for this purpose is an approved modelling approach in NSW as per the Approved Methods with model guidance documentation provided.

Upon completion of the TAPM runs a CALMET simulation was set up to run for the model period using the three dimensional gridded data output from TAPM as an initial guess field. This approach is consistent with guidance documentation.

CALMET was run using the 'Hybrid' mode (i.e. surface observational data from the Goulburn Airport AWS was included in the model).

All model settings were selected with consideration to the Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessments of Air Pollutants in NSW Australia (J Barclay and J Scire Atmospheric Studies Group TRC Environmental Corporation 2011).

The southwest corner of the CALMET domain or the origin was located at UTM Zone 55 coordinates 750 kilometres east and 6,135 kilometres north. The CALMET domain extended 22 kilometres to the east and north.

The CALMET domain consisted of 160 grids in both the east and north directions with a grid resolution of 0.2 kilometres.

The CALMET model parameters are summarised in Table B.2. The TERRAD value was selected based on inspection of the terrain elevations in the immediate vicinity of the subject site.

Terrain and land use data used for the CALMET modelling are presented in Figure B.6 and Figure B.7.

Table B.2 Summary of CALMET model parameters

Parameter	Value
Modelled period	1 January 2023 to 31 December 2023
Mode	Hybrid (NOOBS = 1)
UTM zone	55
Domain origin (southwest corner)	Easting: 750 km Northing: 6135 km
Domain size	160 x 160 at 0.2 km resolution (34.0 km x 34.0 km)
Number of vertical levels	11
Vertical levels (m)	0 20 40 80 160 320 640 1200 2000 3000 4000
CALMET settings for hybrid mode Settings selected in accordance with (OEH 2011)	TERRAD = 2 km
Initial guess field	TAPM .m3d file used as an initial guess field for CALMET
Surface data	2023 data from BoM Goulburn AWS Missing periods of wind direction data was patched using TAPM data exported from the BoM AWS location R1 = 20 km RMAX = 50 km
Upper air data	No site specific upper air data is used. Upper air data is included within the TAPM .m3d initial guess field.
Land use and terrain data	Land use data was manually developed through assessment of aerial imagery to accurately reflect the land use in the area. High-resolution terrain data was sourced from the STRM 1-second (~30 m) database.

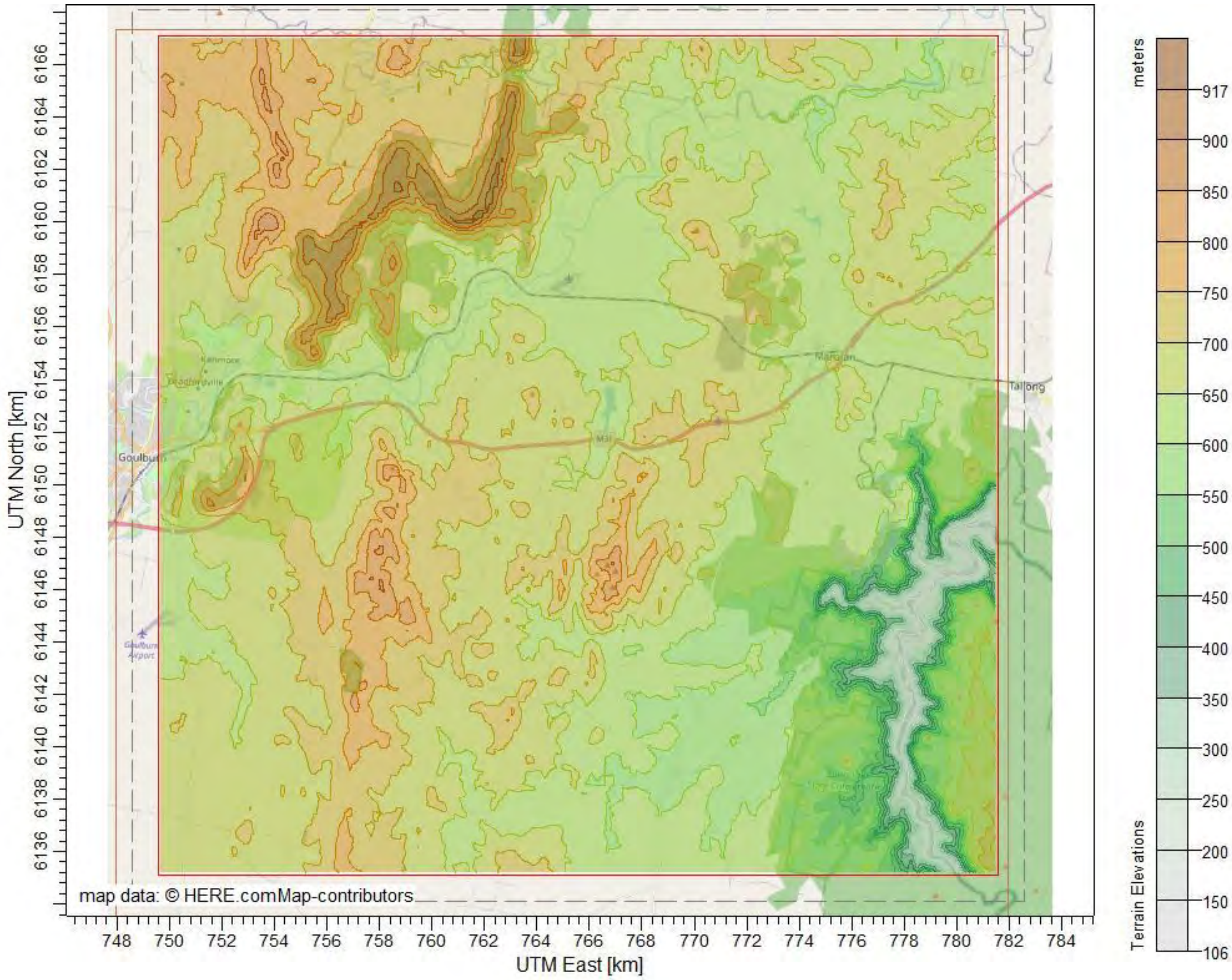


Figure B.6 *Terrain data used for CALMET modelling*

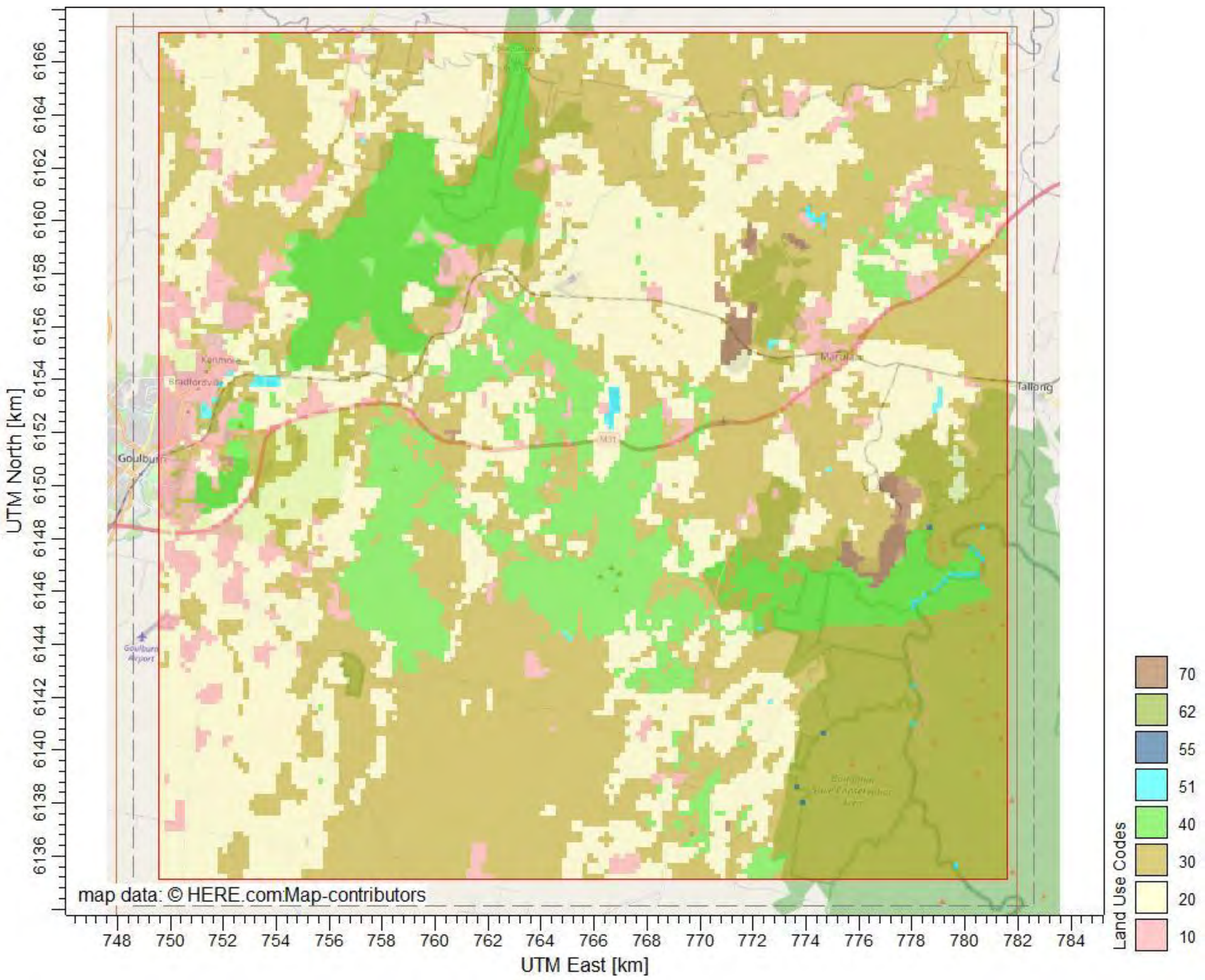


Figure B.7 Land use data used for CALMET modelling

The local meteorology largely determines the pattern of off-site air quality impact on receptors (houses businesses and industry). The effect of wind on dispersion patterns can be examined using the wind and stability class distributions at the site from the dataset that is produced by CALMET. The winds at the site are most readily displayed by means of wind rose plots giving the distribution of winds and the wind speeds from these directions.

The features of particular interest in this assessment are (i) the dominant wind directions and (ii) the relative incidence of stable light wind conditions that yield minimal mixing (defines peak impacts from ground-based sources).

B-3-1 Wind patterns

Wind flows during calm conditions and high wind speed conditions are shown in Figure B.8 and Figure B.9 respectively. During calm conditions at the BoM AWS, the effect of the terrain is evident with increased winds observed at the site. During high wind speeds, the winds are less affected by the terrain.

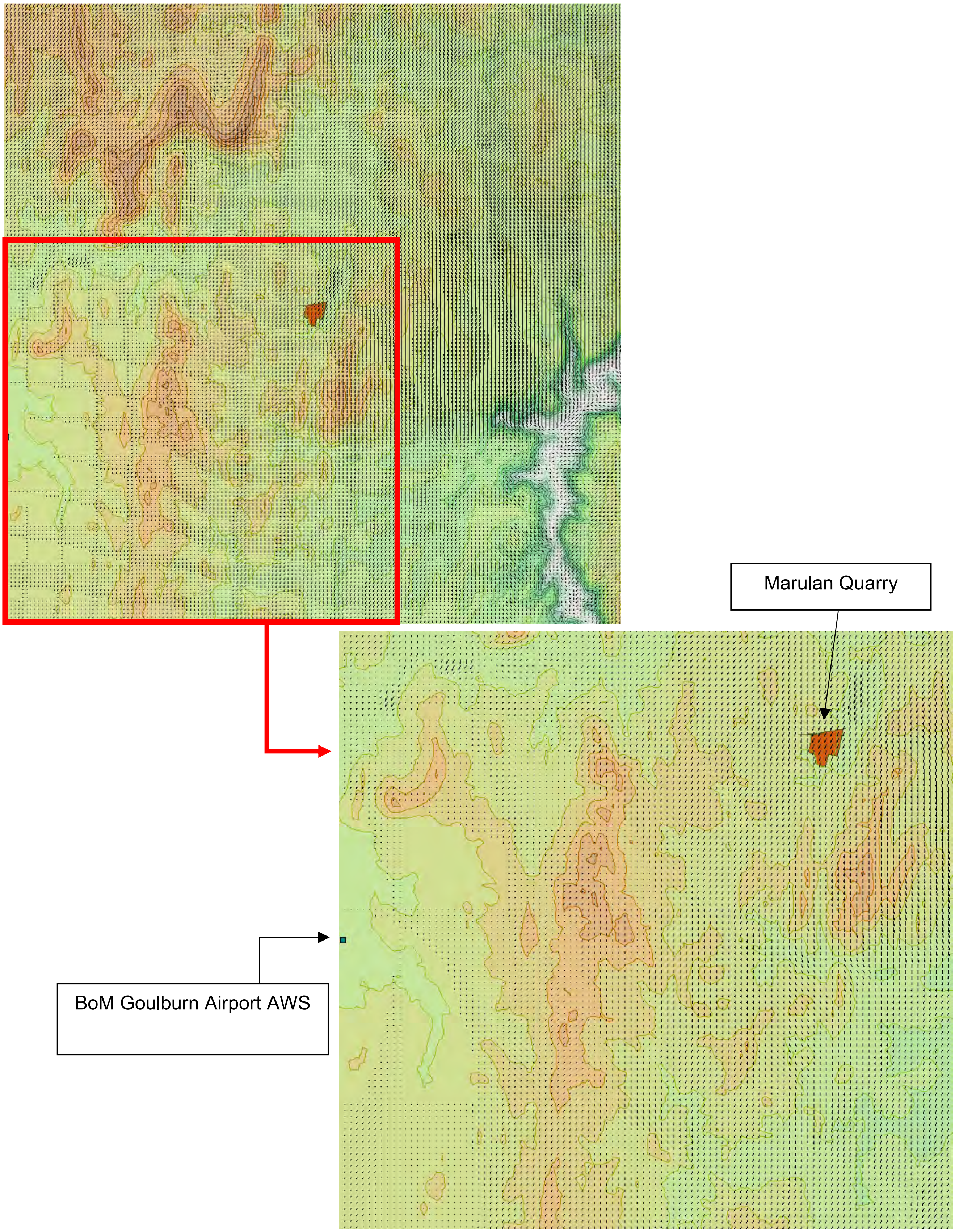


Figure B.8 Wind flows during calm conditions at the BoM Goulburn Airport AWS

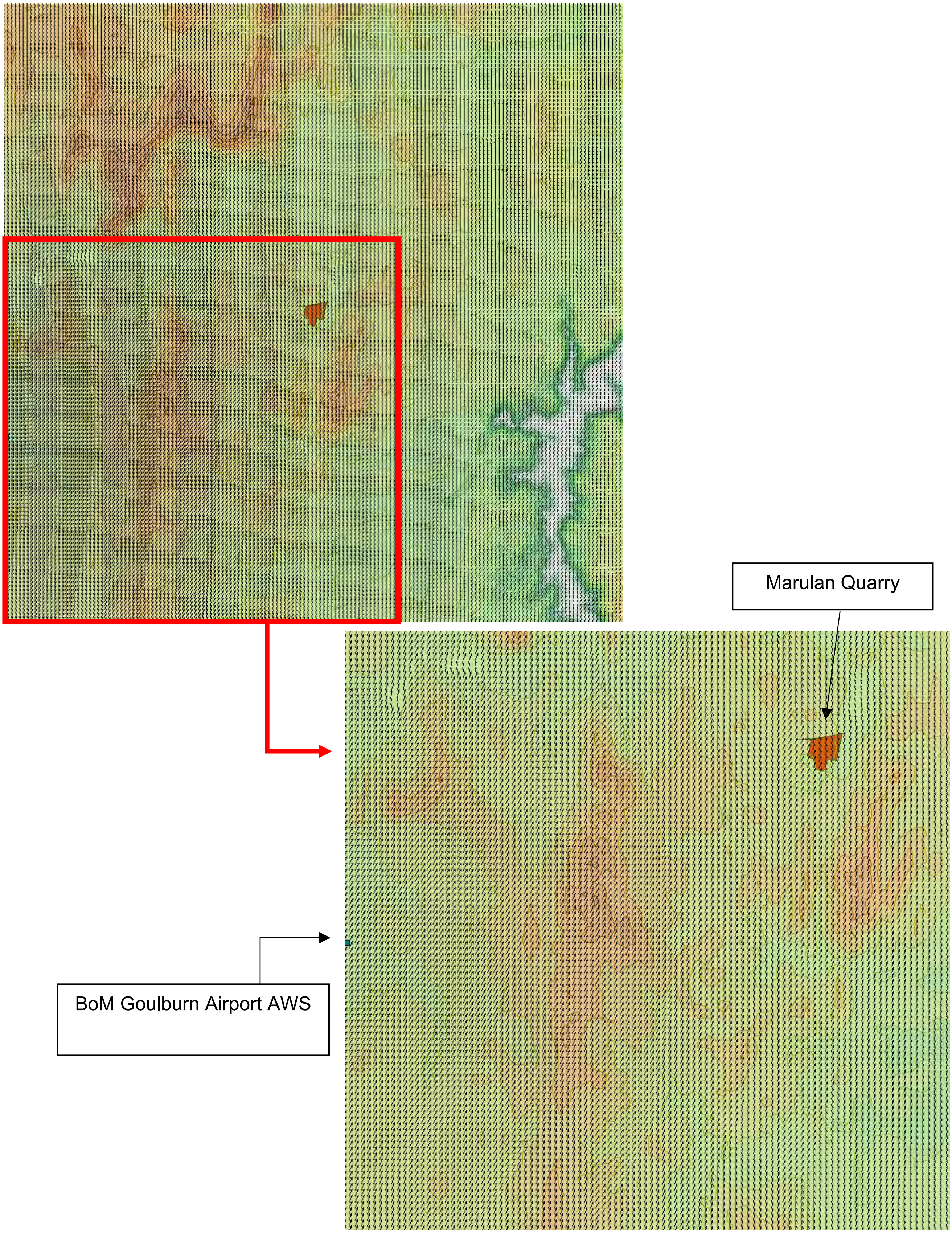


Figure B.9 Wind flows during high wind conditions (~11 m/s) at the BoM Goulburn Airport AWS

The wind rose for the entire data period taken at the project site is shown in Figure B.10 and shows the following features:

– The predominant annual average wind directions are from the west.
– The average wind speed predicted was 3.6 metres per second.
– Calm conditions (wind speeds less than 0.5 metres per second) occurred 3.9% of the time.
– High wind speeds (winds greater than 5 metres per second which are often attributed to dust lift off) mostly occur from the west.

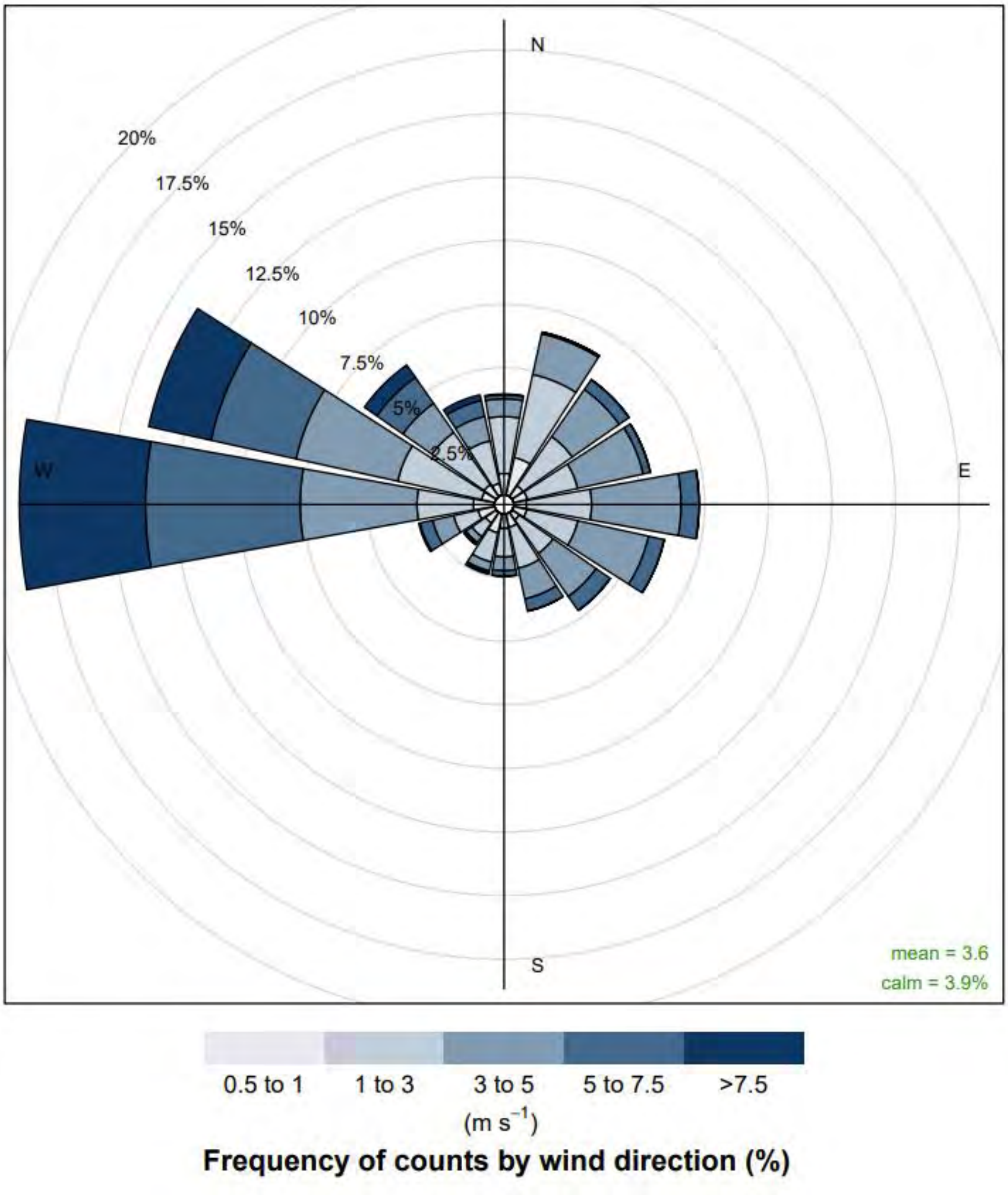


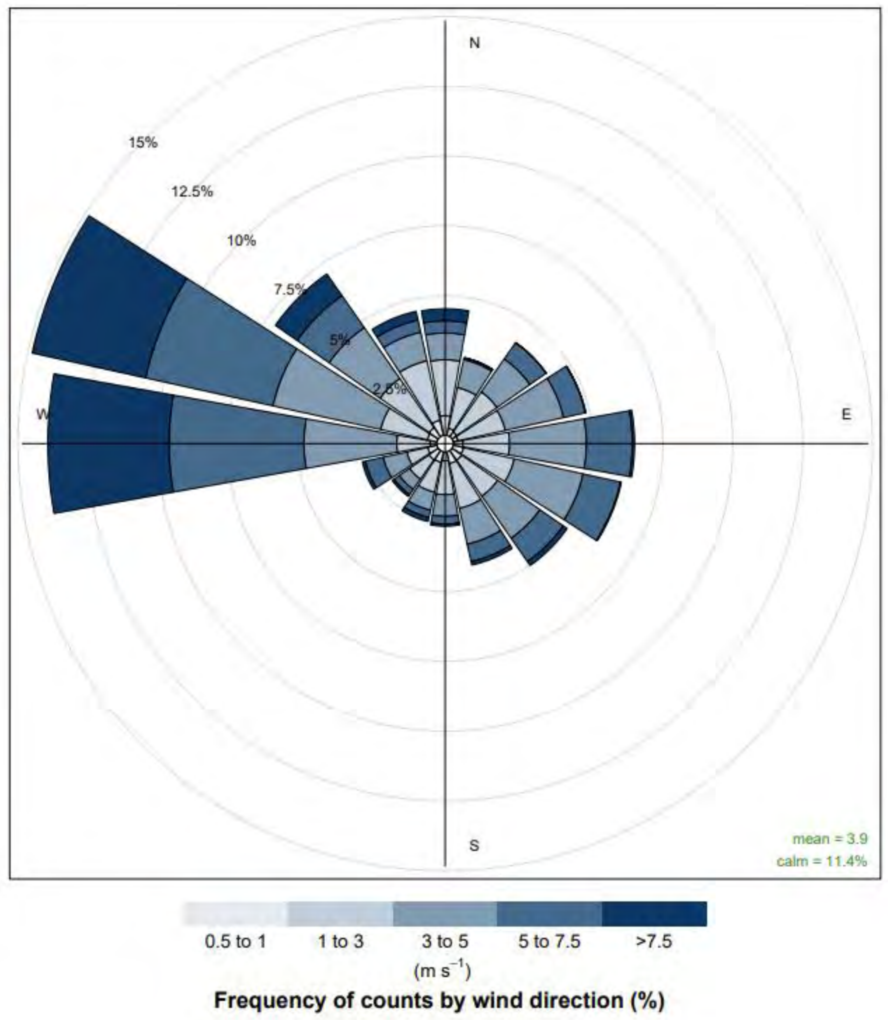
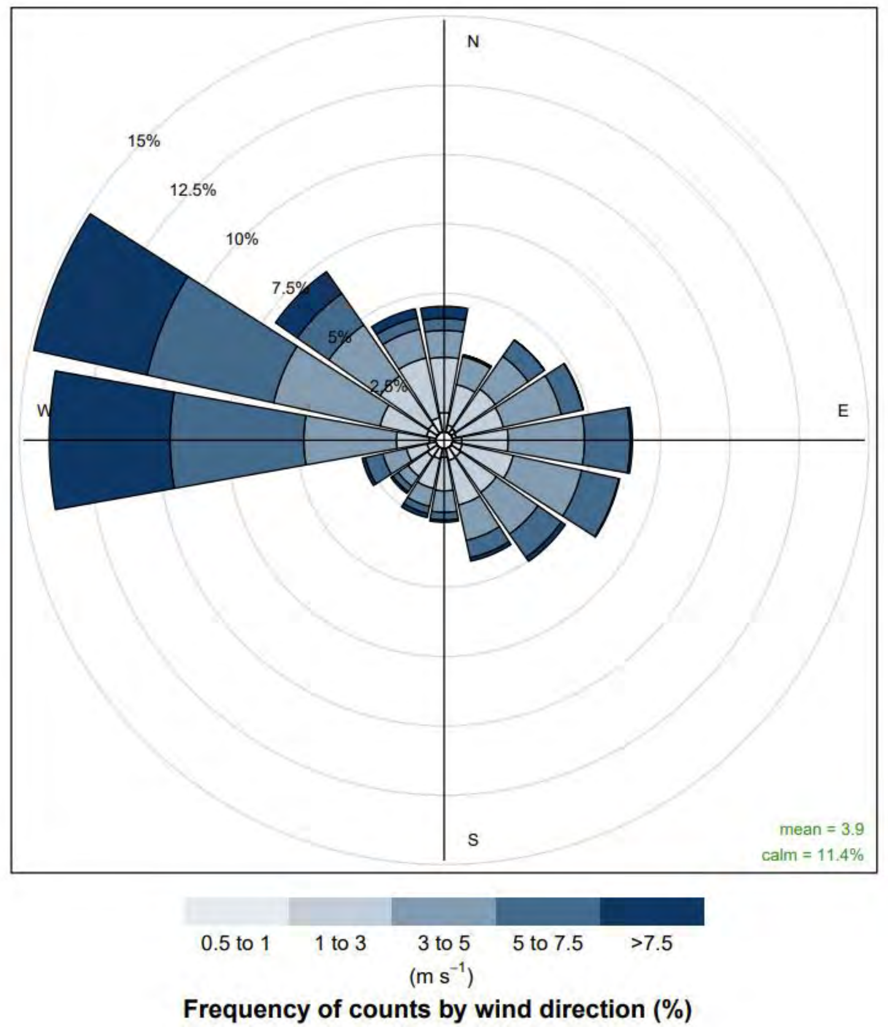
Figure B.10 Wind rose at site from CALMET (2023)

B-4 Model verification

Verification of the meteorological model performance was carried out by comparing the model outputs to BoM observations at Goulburn Airport.

BoM data was sourced for the same time period as that of the CALMET model period (01/01/2023 to 01/01/2024) for verification. The model was run in hybrid, incorporating the Goulburn AWS data, therefore the wind roses at the Goulburn location are identical.

Table B.3 Model verification of CALMET model output compared to observational data

Goulburn Airport AWS observation	CALMET output
	

Appendix H

Groundwater Addendum

GHD Tower, Level 3, 24 Honeysuckle Drive
Newcastle, New South Wales 2300
Australia
ghd.com

Our ref: 2127708

30 May 2025

Vergilio Serra
Global Quarries Pty Ltd
PO Box 51
Casula Mall LPO
Casula NSW 2170

Response to Submissions – Groundwater

Dear Vergilio

1. Background

The NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) provided the following submission in response to the Environmental Impact Statement (EIS) for Marulan Quarry (SSD-65146459):

The proponent should undertake further geological investigations and provide additional and improved information to substantiate that the proposal is a non-aquifer interference activity. The proponent should provide the following:

– *Hydrogeology of the project area and its surrounding, the geological formations intercepted during the test drilling and depth and aquifer formation type in each hole.*
– *Bore construction information, including casing/screen details and how water strike depth was determined.*
– *Substantiation for not drilling additional test holes in the proposed quarry precinct to determine the occurrence of aquifers underneath, and reason for not including hole #3 for water quality sampling.*

A Water Impact Assessment Report (GHD, 2024) was prepared by GHD to inform the EIS. In regard to the groundwater environment, the report contains a summary of site geology, details of the drilling of Holes 1, 2 and 3, desktop searches of registered groundwater bores and Groundwater Dependent Ecosystems (GDEs) and groundwater quality results.

1.1 Purpose of this report

This report outlines an additional desktop study undertaken to address the submission from DCCEEW. The following tasks have been undertaken:

– Further review of available geological and hydrogeological information.
– Development of a conceptual groundwater model for the proposed quarry site.

1.2 Limitations

This report has been prepared by GHD for Global Quarries Pty Ltd and may only be used and relied on by Global Quarries Pty Ltd for the purpose agreed between GHD and Global Quarries Pty Ltd as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Global Quarries Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

1.3 Assumptions

The following assumptions are relevant to this report:

– The publicly available information reviewed, including geological mapping and WaterNSW records of registered groundwater bores, is true and accurate.
– The results of drilling undertaken by Global Quarries Pty Ltd, including records of water strike, are true and accurate.

2. Information review

The following information and data were reviewed:

– Geological mapping.
– WaterNSW records of registered bores.
– Site drilling details.

2.1 Geological mapping

Review of the Goulburn 1:250,000 Geological Map indicates that the rocks encountered at the site are of the Ordovician Abercrombie Formation and Warbisco Formation. These rocks are described as quartzose sandstone interbedded with carbonaceous shale, siltstone and mudstone. To the east of the site, the Silurian Covan Creek Formation of the Mount Fairy Group is encountered, which is described as massive to graded medium to coarse grained well sorted lithic quartzoze sandstone, with pink to grey lithic volcanic breccia with a high proportion of pumice.

The cover are Quaternary units of residual deposits of clayey, coarse to fine grained sand and sandy clay, as shown on the Goulburn 1:100,000 Geological Map.

2.2 Registered bores

The WaterNSW real time data portal was reviewed to obtain work summaries for registered bores within a 2 km radius of the site. Registered bore locations are shown in Figure 3-3 of GHD (2024). Table 3-2 of GHD (2024) gives bore depth, drilled date, purpose, status, standing water level (SWL) and yield. Additional information obtained from work summaries is shown in Table 1.

Table 1 Registered bore lithology and water strike

Bore ID	Bore depth (m)	Depth to Water Strike[1] (m)	Depth to Standing Water (m)	Lithology
GW100054	36	30	11	Claystone to 17 m. Blue shale to end of hole
GW104643	49	33	19	Claystone to 26 m. Slate/shale to end of hole
GW043985	44	30	Unknown	Shale to end of hole with some sandstone at 30 m
GW111783	48	29	8	Clay to 12 m. Shale to end of hole
GW111928	108	57	1.5	Granite
GW113270	72	48	19	Sediment tp 24 m. Volcanic to end of hole

[1] Bores screened from depth of water strike to base of bore.

Comparison between the depth to water strike at drilling and the depth to standing water suggests some confinement of the groundwater source in this area. The groundwater source was encountered within fractured shale to the west and south of the site, and within volcanics to the north and east of the site.

2.3 Site drilling

Global Quarries Pty Ltd provided details of the monitoring bore installation and design at Hole 1, Hole 2 and Hole 3. Bore depth, surface RL, depth to water strike and depth to standing water for Hole 1, Hole 2 and Hole 3 are provided in Table 3-1 of GHD (2024). Water strike was recorded by the drilling contractor during the reverse circulation (RC) drilling process.

Further monitoring bore construction details are provided in Table 2. Hole 1 encountered limited groundwater (water strike at 106 m) and was not cased. Hole 2 and Hole 3 were cased with 50 mm PVC. Depths to screen are shown in Table 2. Blank PVC was used to case each bore between the top of screen and surface. A bentonite seal was installed above the sand filter.

No lithology information was provided, although the exploration drilling records in the vicinity of the proposed quarry suggests that sediment is generally encountered to depths of 30-40 m below ground level, followed by volcanics. It is likely that the volcanics of the Silurian Covan Creek Formation of the Mount Fairy Group, shown on the Goulburn 1:250,000 Geological Map as occurring to the east of the site, were encountered within Hole 1 and occur as a dyke in this area (since this Formation is younger than the Ordovician sedimentary rocks at the site).

Table 2 Monitoring bore construction details

ID	Casing diameter (mm)	Screen interval depth (m)	5 mm sand filter depth (m)
Hole 2	50	40-49	29-55
Hole 3	50	58-70	54-76

3. Conceptual groundwater model

The available geological and hydrogeological information outlined above and in GHD (2024) was used to develop a conceptual groundwater model for the quarry site. The conceptual groundwater model describes the hydrogeology of the project area and its surrounding.

An east-west schematic cross section is presented in Figure 1 and graphically represents the conceptual groundwater model.

Groundwater is encountered within fractured shale to the west and south of the site and within volcanic rocks to the north and east of the site, at depths of between 30 to 50 m below ground level. No groundwater was encountered below the proposed quarry, either within the sediment or volcanic rocks. This may be attributable to a flow barrier or very low permeability zone within the volcanic feature beneath the quarry site. There may be flow around this feature but not through it. Note that Global Quarries Pty Ltd drilled an additional five exploration holes at the quarry site at depths ranging from 80 to 130 m, with no water encountered. These exploration holes were not drilled vertically and therefore not able to be converted into monitoring bores.

Any alluvium associated with surface watercourses is likely to be thin and provide a limited supply of groundwater. There are no registered bores within alluvium within a 2 km radius of the site.

There is evidence of confinement of the groundwater sources, as shown by the SWL being above the recorded water strike at each monitoring bore and registered bore reviewed.

Changes in piezometric levels generally reflect topography. SWLs range from about 20 m below ground level at topographic highs, to approximately 4 m at Narambulla Creek. Piezometric level reduces towards Narrambulla Creek in the vicinity of the quarry site, although it is noted that there is no surface water / groundwater interaction at this location since the top of the confined aquifer at this location is approximately 50 m below the creek. Further evidence of no surface water / groundwater interaction is the comparison of major ion chemistry in groundwater at Hole 2 and surface water in Narambulla Creek, as presented in GHD (2024). Groundwater is fresh, slightly acidic and calcium bicarbonate dominant whereas surface water is generally more sodium chloride dominant.

Regionally, piezometric levels flow to the north / northeast towards the Wollondilly River, from approximately 630 m AHD at Narrambulla Creek to 600 m AHD at the Wollondilly River.

Inputs to the groundwater system include rainfall recharge and river leakage, particularly in areas where the confined fractured rocks are shallower. Recharge to the groundwater system in the vicinity of the quarry site is likely to be minimal due to the depth of confinement. Groundwater outputs include pumping from production bores, although this is likely to be limited due to the low density of registered bores and the limited take (stock and domestic), and discharge to the Wollondilly River.

No aquifer properties, such as hydraulic conductivity or specific storage values, are available for the quarry site.

Regards

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Technical Director - Water Resources

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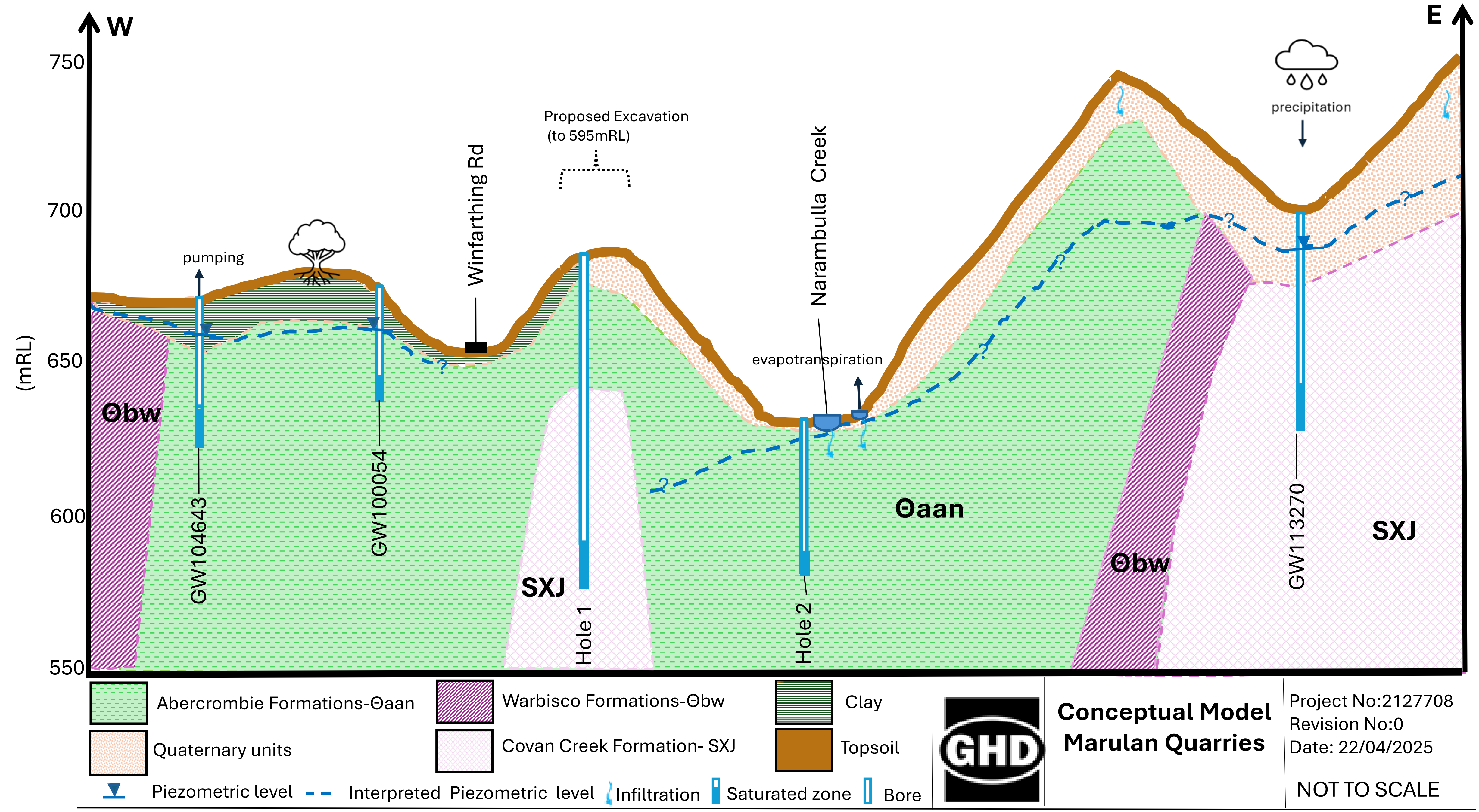
W
E
750
700
650
600
550
(mRL)
pumping
Winfarthing Rd
Proposed Excavation
(to 595mRL)
Narambulla Creek
evapotranspiration
precipitation
GW104643
GW100054
Hole 1
Hole 2
GW113270
Θbw
Θaan
SXJ
SXJ
Θbw
Abercrombie Formations-Θaan
Warbisco Formations-Θbw
Clay
Quaternary units
Covan Creek Formation- SXJ
Topsoil
Piezometric level
Interpreted Piezometric level
Infiltration
Saturated zone
Bore
Conceptual Model
Marulan Quarries
Project No:2127708
Revision No:0
Date: 22/04/2025
NOT TO SCALE

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