Vipac Engineers and Scientists Limited
Level 2, 146 Leichhardt Street, Spring Hill, QLD 4000, Australia
PO Box 47, Spring Hill, Qld, 4000 Australia
t. +61 7 3377 0400 | **e.** brisbane@vipac.com.au
w. www.vipac.com.au | A.B.N. 33 005 453 627 | A.C.N. 005 453 627

Outline Planning Consultants Pty ltd

Braidwood Sand Pit Expansion

Air Quality Assessment

70B-25-0169-TRP-106715-1

23 October 2025

Job Title:	Braidwood Sand Pit Expansion
Report Title:	Air Quality Assessment
Document Reference:	70B-25-0169-TRP-106715-1

Prepared For:	**Prepared By:**
Outline Planning Consultants Pty ltd [redacted] **Contact:** Gary Peacock [redacted]	Vipac Engineers and Scientists Limited Level 2, 146 Leichhardt Street, Spring Hill, QLD 4000, Australia **Tel:** +61 7 3377 0400

Author:	Samir Sidhu 20 Oct 2025	Consulting Scientist
Reviewer:	Steve Thomas 21 Oct 2025	Air Quality Principal
Issued By:	Steve Thomas 21 Oct 2025	Air Quality Principal

Revision History:

Rev. #	*Comments / Details of change(s) made*	*Date*	*Revised by:*
Rev. 00	Original issue	06 August 2025	
Rev. 01	Revised issue	20 Oct 2025	ST

Executive Summary

Vipac Engineers and Scientists Ltd (Vipac) was engaged by Outline Planning Consultants Pty Ltd on behalf of Braidwood Sand and Gravel and Lentro Earthmoving to prepare an air quality assessment to support the proposed expansion of the approved sand extraction operation from a sand pit at 552 Larbert Rd, Larbert NSW (the Project).

The Project involves the staged, progressive expansion of the existing sand extraction area of 1.92 ha by an additional 18.1 ha approximately as well as an increase in the rate of sand extraction, from the currently approved 25,000 tonnes per annum to 200,000 tonnes per annum. The proposal also includes an increase in truck movements, with an average of 20 loaded trucks per day and a maximum of up to 50 loaded trucks per day.

The air quality impact assessment has been carried out as follows:

- An emissions inventory of TSP, PM_{10}, $PM_{2.5}$, and deposited dust for the proposed maximum and normal operations of the proposed Project was compiled using National Pollutant Inventory (NPI) and United States Environmental Protection Agency (USEPA) AP-42 emissions estimation methodology.
- Estimated emissions data was used as input for air dispersion modelling. The modelling techniques were based on a combination of The Air Pollution Model (TAPM) prognostic meteorological model (developed by CSIRO), and the CALMET model suite used to generate a three-dimensional meteorological dataset for use in the CALPUFF dispersion model.
- The atmospheric dispersion modelling results were assessed against the air quality assessment criteria described in the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (Approved Methods) as part of the impact assessment. Air quality controls are applied to reduce emission rates where applicable.

Two emissions scenarios were assessed:

- the average daily operational scenario of 20 loaded truck movements with an extraction and processing rate of approximately 740 tonnes per day, and;
- a maximum operational scenario with 50 loaded truck movements with an extraction and processing rate of approximately 1,850 tonnes per day.

The results of the modelling show that the TSP, PM_{10}, $PM_{2.5}$ and dust deposition predictions comply with the relevant criteria and averaging periods at all modelled sensitive receptors, both for the Project in isolation and with the adopted background levels, for both the modelled average and maximum operations scenario.

It is noted that the predictions of the 24-hour average PM_{10} for the worst-affected receptor (R1) were found to be close to but still below the relevant criterion (50 µg/m^3), and were significantly contributed to by the adopted background level of 29 µg/m^3. Further investigation (i.e. a Level 2 assessment as outlined in the EPA's Approved Methods) of the contemporaneous background and predicted data was therefore undertaken. The Level 2 assessment, which considered maximum cumulative concentrations at each receptor including contemporaneous background levels, found that predicted 24-hour average PM_{10} concentrations were well below the criterion at any of the modelled sensitive receptors.

The modelling results for the maximum operational scenario are summarised in Table ES-1 and Table ES-2.

Table ES-1: Summary of Results – Maximum Operations Scenario – Project in Isolation

ID	Predicted Concentrations (µg/m^3)					Dust deposition (g/m^2/month)	Compliant
	PM_{10}		$PM_{2.5}$		TSP		
	24 h	Annual	24 h	Annual	Annual	Month	
SR1	20.05	0.74	2.07	0.18	0.17	0.01	✓
SR2	15.35	0.90	2.43	0.20	0.33	0.02	✓
SR3	4.74	0.34	0.89	0.10	0.06	0.01	✓
Criteria	**50**	**25**	**25**	**8**	**90**	**2**	

Table ES-2: Summary of Results – Maximum Operations Scenario – Cumulative

ID	Predicted Concentrations (µg/m³)					Dust deposition (g/m²/month)	Compliant
	PM_{10}		$PM_{2.5}$		TSP		
	24 h[1]	Annual	24 h	Annual	Annual	Month	
SR1	34.02	11.54	20.67	6.08	27.17	1.61	✓
SR2	33.22	11.70	21.03	6.10	27.33	1.62	✓
SR3	29.01	11.14	19.49	6.00	27.06	1.61	✓
Criteria	**50**	**25**	**25**	**8**	**90**	**4**	

1. Level 2 assessment

Table of Contents

1 Introduction

Vipac Engineers and Scientists Ltd (Vipac) was engaged by Outline Planning Consultants Pty Ltd on behalf of Braidwood Sand and Gravel and Lentro Earthmoving (the Proponent) to prepare an air quality assessment to support the proposed expansion of the approved sand extraction operation from a sand pit at 552 Larbert Rd, Larbert NSW (the Project).

The Proponent seeks consent for the staged, progressive expansion of the existing sand extraction area of 1.92 ha by an additional 18.1 ha approximately as well as an increase in the rate of sand extraction, from the currently approved 25,000 tonnes per annum to 200,000 tonnes per annum. The proposal also includes an increase in truck movements, with an average of 20 loaded trucks per day and a maximum of up to 50 loaded trucks per day.

The current sand extraction area and the proposed expansion is illustrated in Figure 1-1.

FIGURE 1.2: Project Site- Larbert locality

(Map Base Source: NSW Government SDT Explorer online mapping website, boundaries approx. only)

Outline Planning Consultants
Town Planning | Environmental Assessment

17

Figure 1-1: Larbert Sand Extraction Area Aerial View (Existing and Proposed)

1.1 Study Objectives and Requirements

The NSW Environment Protection Authority (EPA) has considered the details of the proposal as provided by the Department of Planning, Industry and Environment (DPIE) and has identified the information it requires for the Environmental Impact Statement (EIS). The key requirements specified in relation to air quality and how the requirements are addressed within this document are summarised in Table 1-1.

The purpose of this assessment is to evaluate the potential impacts of air pollutants generated from the Project which addresses the specific EPA requirements and provides recommendations to mitigate any potential impacts that might have an effect on nearby sensitive receptors.

Table 1-1: Summary of EAR

Requirements	How requirement is addressed
The EIS must demonstrate the proposal's ability to comply with the relevant regulatory framework, specifically the POEO Act and the Protection of the Environment Operations (Clean Air) Regulation 2022. This consideration should include section 129 of the POEO Act concerning control of "offensive odour".	An emissions inventory has been developed that considers the primary pollutants of concern (see Section 3) and the emissions generating activities from sand extraction activities and disturbed surfaces within the site boundaries (Section 6.1). Odorous substances are not considered to be emitted in sufficient quantities to affect air quality at sensitive receptors beyond the Project boundary; and have not been modelled in the air quality assessment.
The EIS must include an air quality impact assessment (AQIA). The AQIA must be carried out in accordance with the document, Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2022).	A quantitative air quality assessment is prepared in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2022). See Section 6.
The EIS must detail emission control techniques/practices that will be employed at the site and identify how the proposed control techniques/practices will meet the requirements of the POEO Act, POEO (Clean Air) Regulation (2022) and criteria within Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2022).	The object of the POEO Act is to achieve the protection, restoration and enhancement of the quality of the NSW environment. The activities listed in Schedule 1 to the POEO Act (broadly, activities with potentially significant environmental impacts) require an environmental protection licence (EPL). This Report seeks development approval for a extraction of up to 200,000 tpa. Proposed controls are described in Section 6.1.4 and Appendix A and the assessment of model predictions is undertaken against criteria specified in the Approved Methods (2022) in Section 4.

2 Project Description

2.1 Site Location

The proponent, Braidwood Sand and Gravel and Lentro Earthworks Pty Ltd operates a sand extraction operation (sand quarry) from a site covering 1.92ha on Lot 332 in Deposited Plan (DP) 755915, at No. 552 Larbert Road, Larbert. The proponent seeks to expand the sand quarry footprint into Lot 332 and adjoining Lot 33 DP 755915 by an additional 18.1 ha.

The existing sand extraction area is situated on the eastern side of Larbert Road, approximately 5.5 km north of the intersection with the Kings Highway, and about 14 km northwest of the township of Braidwood.

Larbert Road is a rural, no-through road comprising one lane of traffic in each direction. It extends from a cul-de-sac in the north to its southern connection with the Kings Highway. The road primarily services extractive industry operations within the locality.

The site at 552 Larbert Road falls within the Queanbeyan-Palerang Regional Council (QPRC) local government area and is zoned RU1 – Primary Production under the Queanbeyan-Palerang Regional Local Environmental Plan 2022 (QPRLEP 2022).

Figure 2-1 shows the existing extraction area, the proposed expansion and other existing extraction operations in the area.

FIGURE 0.1: Project Site- regional setting
(Map Base Source: NSW Spatial Portal online mapping)

Figure 2-1: Project Site Location

Project Site

2.2 Sensitive Receptors

The region surrounding the project site is sparsely populated, with the nearest air sensitive receptors (SRs) described in Table 2-1. A map of these receptors is presented in *Figure 2-2*. Three rural residential receptors not associated with the project have been identified within a 2km radius from the proposed expansion.

Table 2-1: List of Nearest Air Sensitive Receptors (ASRs)

Identifier	Lot Number	Address	Approximate Distance & Direction to Site
SR 1	99//DP755915	481 Larbert Road, Larbert	700m SW from project site
SR 2	62//DP755915	412 Larbert Road, Larbert	860m S from project site
SR 3	3//DP1192360	428 Mayfield Rd, Larbert	1700m NW from project site

Haul Route

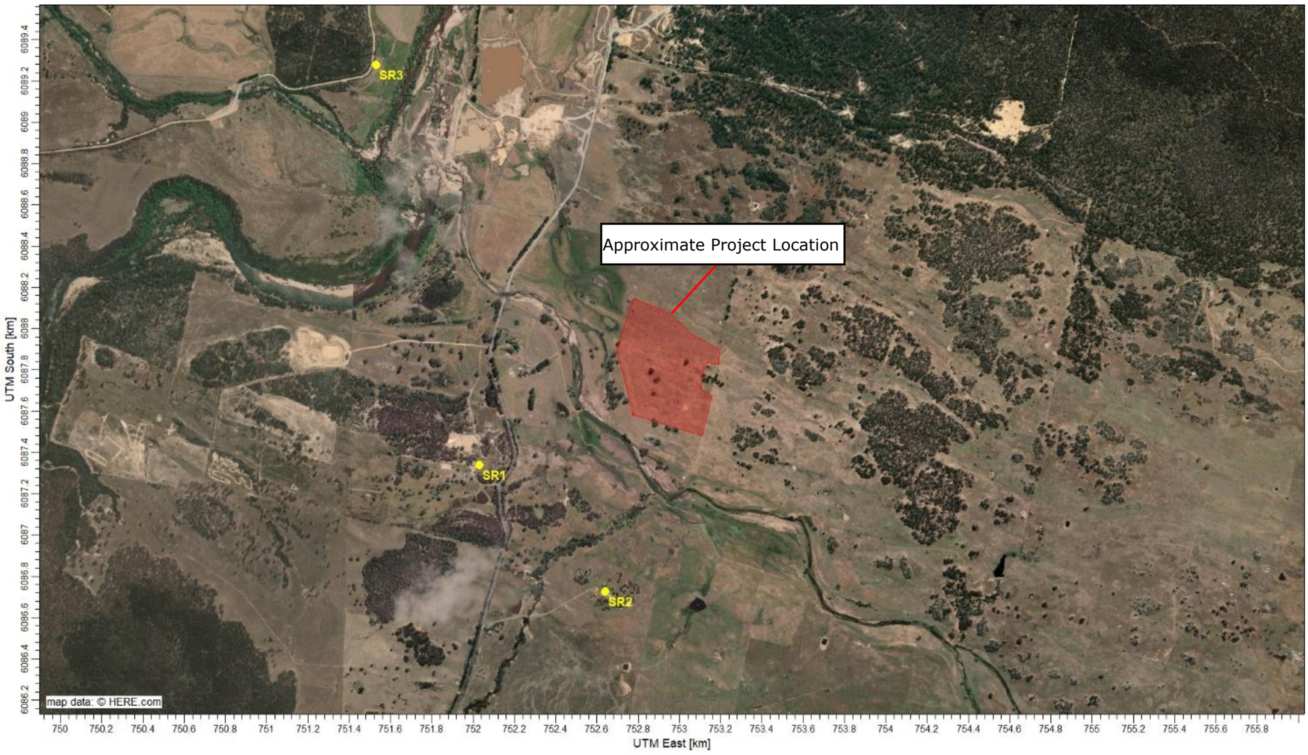


Figure 2-2: Map of Air Sensitive Receivers

2.3 Sand Extraction Operations

The Project would comprise an increase to the annual production rate to 200,000 tonnes per annum and expansion into an additional extraction area over Lots 332 and 333 DP 755915 of approximately 18.1ha, with a resource of approximately 1.2 million tonnes. Extraction to a depth of 5-6 metres is planned, consistent with the current approval.

Key elements of the currently approved sand extraction operation includes:

- The extraction of up to 25,000 tonnes per annum of sand, being 800 tonnes per week over 48 weeks.
- Sand extraction area of 1.92ha approximately.
- Material extracted with an excavator and front-end loader and processed on site.
- Access to and from the sand pit back to Larbert Road, with sand products transported via Larbert Road and the Kings Highway heading towards Canberra only. Intersection of site access with Larbert Road upgraded, in accordance with the consent.
- Approved hours of operation of the facility being 7.00am to 5.00pm Monday to Friday and 8.00am to 1.00pm on Saturdays with truck movements associated with the delivery of the material during these hours. No work undertaken on Sunday's or Public Holidays.
- Extraction to occur on a staged basis.

The key Project elements for the proposed expansion can be summarised as:

- The staged, progressive expansion of the existing sand extraction area by an additional 18.1 ha approximately.
- An increase in the rate of sand extraction, to 200,000 tonnes per annum.
- Reliance on existing approved access to and from the sand pit back to Larbert Road.
- A slight change in the currently approved hours of operation of the facility to 6:00am to 6:00pm Monday to Friday and 7:00am to 2:00pm Saturday.
- An increase in loaded truck volumes, equivalent to an average of 20 loaded trucks per day, with a maximum of up to about 50 loaded trucks per day.
- Avoidance of stand of trees located to the north of the currently approved extraction area.
- Rehabilitation once as each sand extraction stage is completed.
- Increase the number of jobs within extractive industry sectors in the region.
- Operational Management Plan proposed.

It is noted that no drilling or blasting activity is proposed for the project. The current and proposed hours of operation of the project are outlined in Table 2-2.

Table 2-2: Current and Proposed Operating Hours

Activity	Monday – Friday	Saturday	Sunday & Public Holidays
Current Extraction & Processing of the Resource	7:00am – 5:00pm	8:00am – 1:00pm	Not permitted
Proposed Extraction & Processing of the Resource	6:00am – 6:00pm	7:00am – 2:00pm	Not permitted

2.3.1 Staging

Sand extraction operations are proposed to be undertaken in a staged and progressive manner across four stages. Rehabilitation is proposed to occur progressively, with each stage rehabilitated upon completion of sand extraction. This assessment does not account for the progressive staging of the operations. Instead, it adopts a conservative approach by assessing potential air quality impacts for the entire sand extraction area operating simultaneously.

The proposed staging plan is illustrated in Figure 2-3.

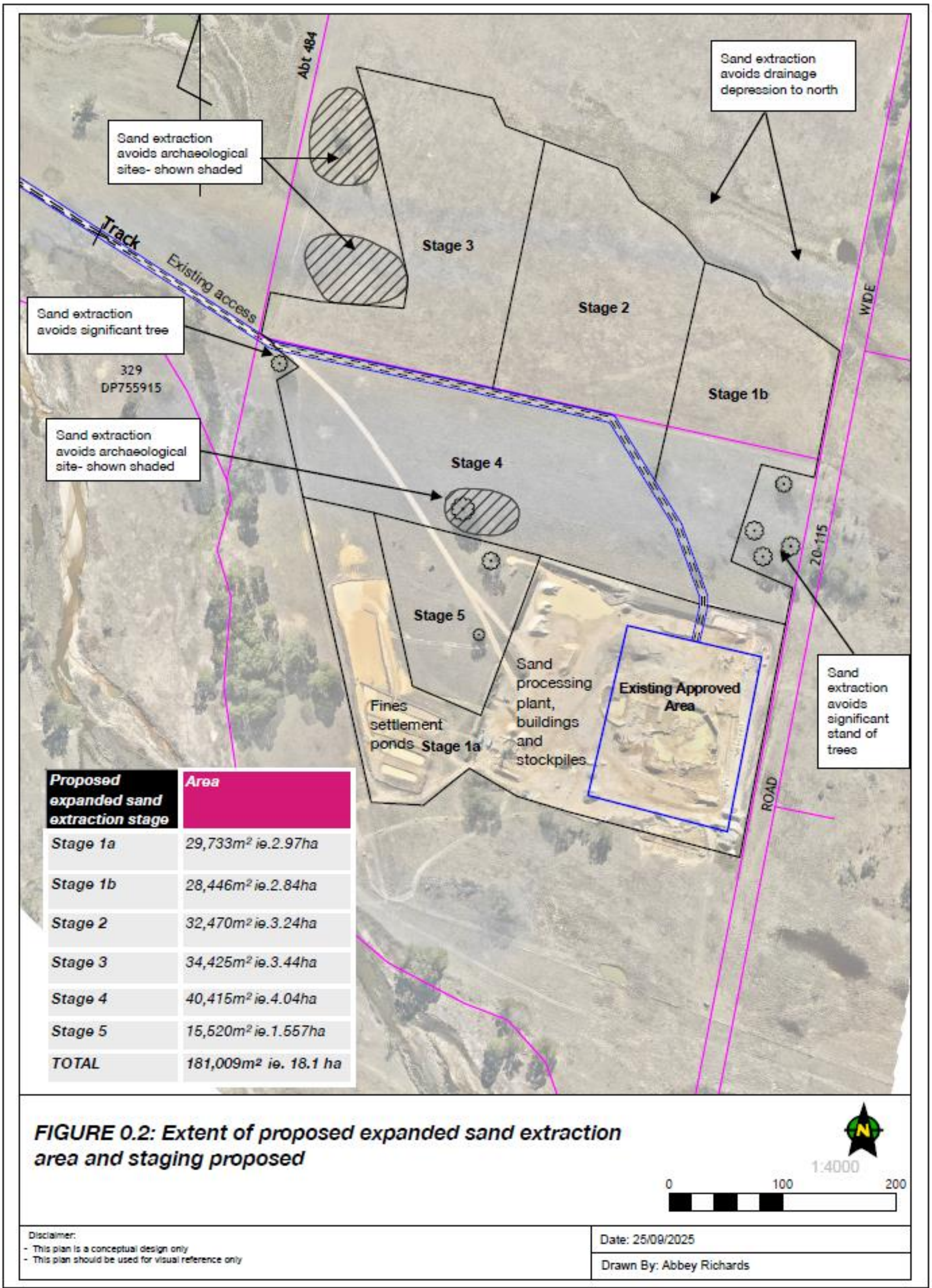


Figure 2-3 –Proposed Staging Plan

3 Pollutants of Concern

The main emissions to air from quarrying operations are caused by wind-borne dust, vehicle usage, materials handling and transfers. Fugitive air emissions can be estimated using emission factors combined with site-specific information such as the silt and moisture content of material being handled.

Dust is a generic term used to describe fine particles that are suspended in the atmosphere. The dust emissions considered in this report are particulate matter in various sizes:

- Total Suspended Particles (TSP) - Particulate matter with a diameter up to 50 microns;
- PM_{10} - Particulate matter less than 10 microns in size;
- $PM_{2.5}$ - Particulate matter less than 2.5 microns in size; and
- Dust Deposition – deposited matter that falls out of the atmosphere.

4 Regulatory Framework

4.1 National Legislation

4.1.1 National Environment Protection (Ambient Air Quality) Measure

Australia's first national ambient air quality standards were outlined in 1998 as part of the National Environment Protection Measure for Ambient Air Quality**.**

The Ambient Air Measure (referred to as Air NEPM) sets national standards for the key air pollutants; carbon monoxide, ozone, sulfur dioxide, nitrogen dioxide, lead and particles (PM_{10}). A revision to the Measure was issued in 2003 with the inclusion of advisory PM2.5 standards and the most recent revision being active as of 26 May 2021. The Air NEPM requires the State's governments to monitor air quality and to identify potential air quality problems.

4.2 State Legislation and Guidelines

4.2.1 Department of Environment and Planning Approved Methods

The *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW Environment Protection Authority, 2022) detail both the assessment methodology and criteria for air quality assessments. Due to the type of industry and proximity to sensitive receptors, the requirements for a Level 2 assessment have been followed.

4.3 Project Criteria

The applicable criteria selected for this assessment are presented in Table 4-1.

Table 4-1: Project Air Quality Goals

Pollutant	Basis	Criteria	Averaging Time	Source
TSP	Human Health	90 $\mu g/m^3$	Annual	Approved Methods
PM_{10}	Human Health	50 $\mu g/m^3$	24-hour	Approved Methods
	Human Health	25 $\mu g/m^3$	Annual	Approved Methods
$PM_{2.5}$	Human Health	25 $\mu g/m^3$	24-hour	Approved Methods
	Human Health	8 $\mu g/m^3$	Annual	Approved Methods
Dust deposition	Amenity	Maximum incremental increase of 2 g/m^2/month	Annual	Approved Methods
	Amenity	Maximum total of 4 g/m^2/month	Annual	Approved Methods

5 Existing Environment

5.1 Terrain

The topography in the vicinity of the project site is variable, with ridgelines and peaks reaching around 700 metres (m) Australian Height Datum (AHD) to the northeast and southwest. The highest point, approximately 700 m AHD, is located to the southeast of the site. The project site itself lies between these ridgelines, within an area of relatively flat terrain at approximately 600 m AHD which extends further to the north and south of the site.

Figure 5-1 shows the topography and the influences it has on the wind patterns in the surrounding environment. The wind fields are seen to follow the terrain well and indicate the simulation produces realistic fine scale flow fields (such as terrain forced flows) in surrounding areas.

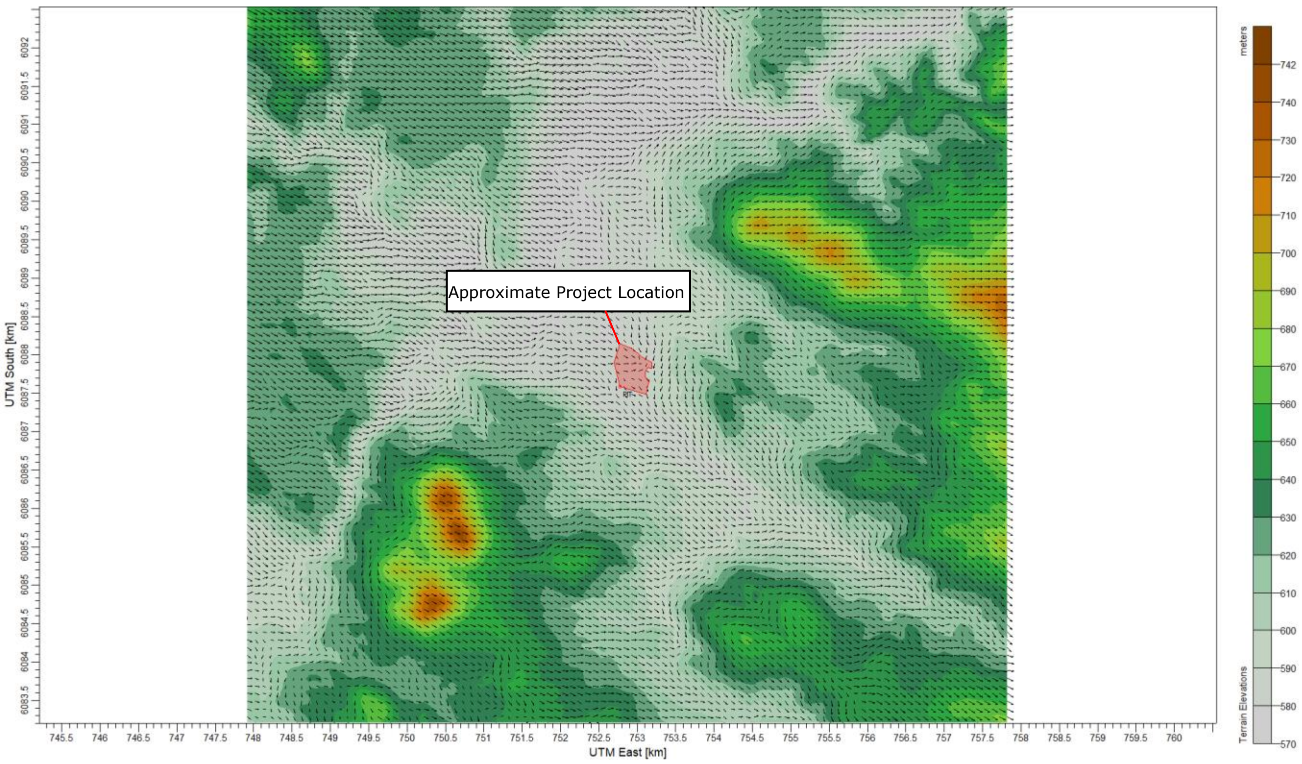


Figure 5-1: Terrain Wind Influences

5.2 Dispersion Meteorology

5.2.1 Regional Meteorology

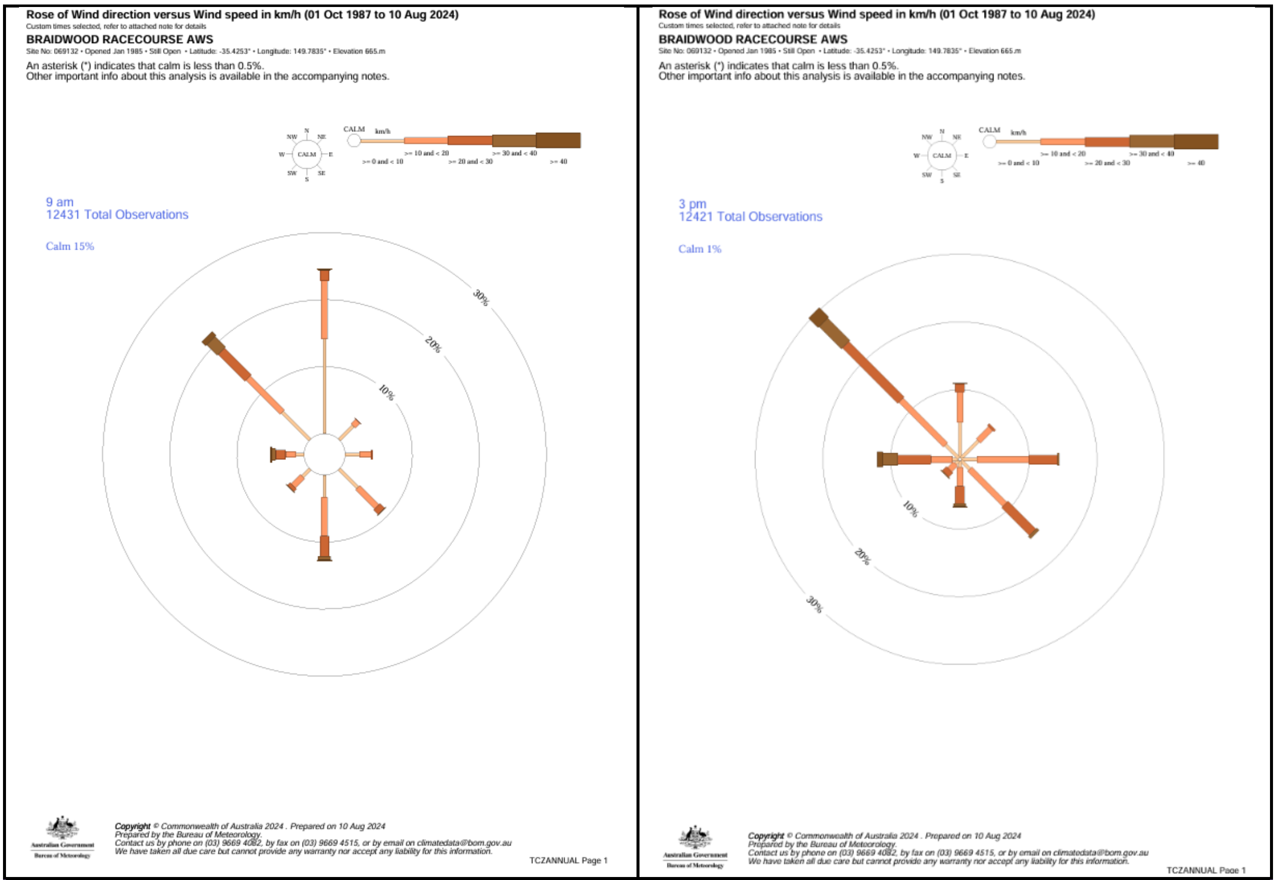
The nearest open Bureau of Meteorology (BOM) station with long term data is at Braidwood Racecourse (Site number 069132), located approximately 11.1 km south of the Project site. This monitoring station has recorded data since 1985 and a summary of the climate is presented in Table 5-1.

The long term mean temperature range is between 0.2°C and 26.85°C with the coldest month being July and the hottest months being January. On average, most of the annual rainfall is received between January and March. Rainfall is lowest between March and October, with a mean annual rainfall of 689 mm. Rainfall reduces the dispersion of air emissions and therefore the potential impact on visual amenity and health.

Table 5-1: Long-term weather data for Braidwood Racecourse [BOM]

Month	Mean Temperature		Rainfall		9 am Conditions			3 pm Conditions		
	Max (°C)	Min (°C)	Mean (mm)	Mean No. of Days ≥ 1 mm	Temp (°C)	RH (%)	Wind Speed (km/h)	Temp (°C)	RH (%)	Wind Speed (km/h)
Jan	26.8	12.5	67.2	7.1	18.3	74	14	24.9	49	20.7
Feb	25.3	12.3	67.7	5.9	17.1	83	12.4	23.8	54	19.1
Mar	22.9	10.2	63.3	7.2	14.8	82	11	21.5	52	18.6
Apr	19.5	6.2	43.9	4.8	12.7	79	11.6	18.2	51	18
May	15.9	2.8	44.3	4.7	9.1	83	10.8	14.7	55	18.2
Jun	12.6	1.3	56.3	5.6	6.1	85	12	11.5	61	19.5
Jul	12.1	0.2	33.1	4.8	5.2	84	11.8	11	57	20.5
Aug	13.6	0.8	53.6	5.1	7	78	14.7	12.5	50	23.5
Sep	16.6	3.3	48.6	5.9	10.8	70	17	15.1	50	24.3
Oct	19.3	5.8	57.7	6.6	13.5	66	17.2	17.3	52	24.1
Nov	22.1	8.5	83.8	7.7	14.8	72	15.8	19.9	53	23
Dec	24.7	10.6	68	6.6	16.9	71	14.6	22.8	49	21.8
Annual	**19.3**	**6.2**	**689**	**72**	**12.2**	**77**	**13.6**	**17.8**	**53**	**20.9**

The long term wind roses recorded daily at the Braidwood Racecourse station at 9am and 3pm are provided in Figure 5-2. Winds are shown to be primarily from the north and northwest at 9am and from the northwest directions at 3pm. Stronger winds (>40km/hr or >11.1m/s) occur infrequently, mostly from the northwest at 9am and from the northwest and west at 3pm.



Location: **Braidwood Racecourse BoM Station**	**Data Period:** **1987 to 2024**	**Data Type:** **Measured Data**

Figure 5-2: Annual wind roses for Braidwood Racecourse Station (1987 to 2024)

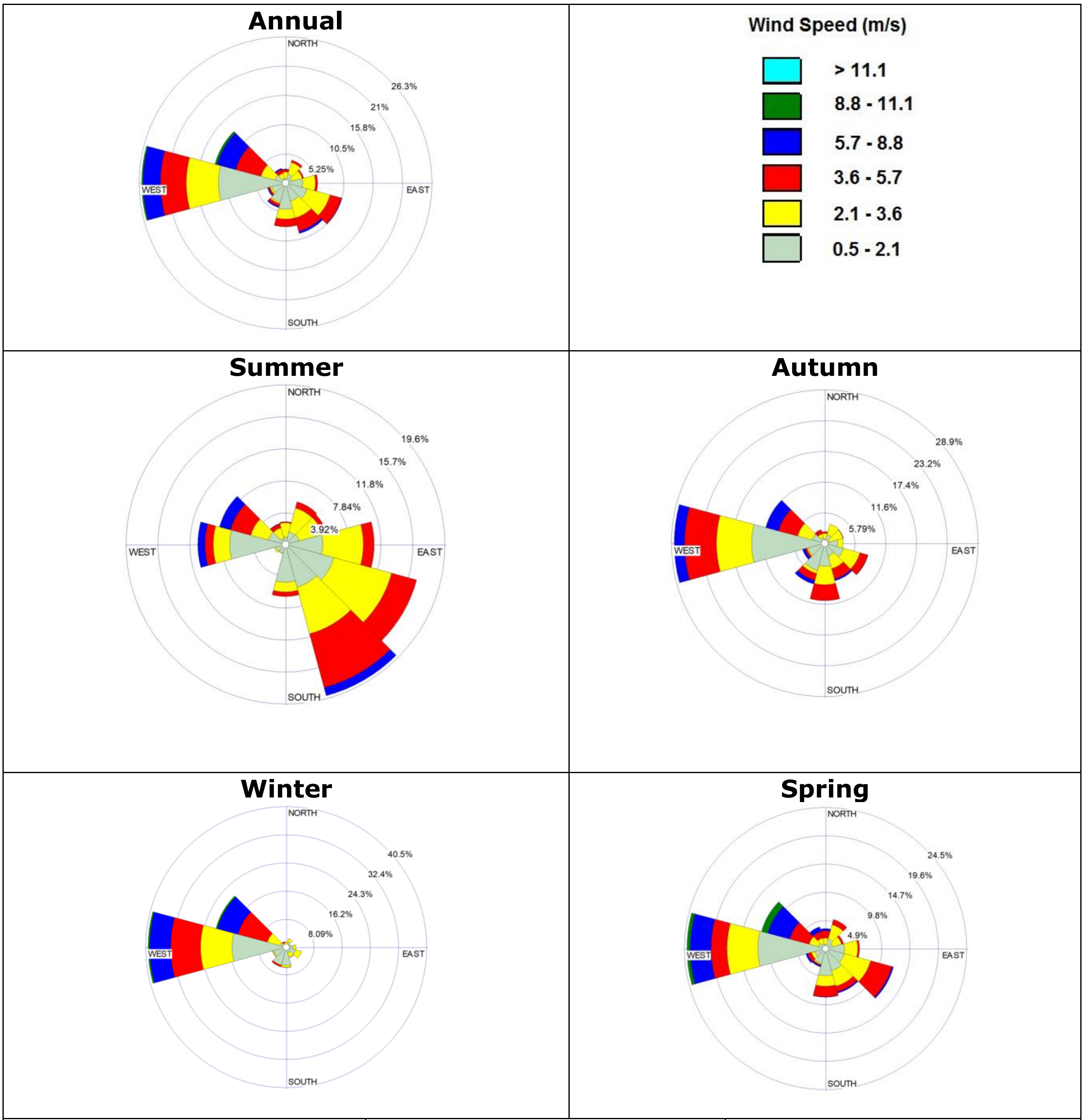
5.2.2 Local Meteorology

5.2.2.1 Introduction

A three dimensional meteorological field was required for the air dispersion modelling that includes a wind field generator accounting for slope flows, terrain effects and terrain blocking effects. The Air Pollution Model, or TAPM, is a three-dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research and can be used as a precursor to CALMET which produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables for each hour of the modelling period. The TAPM-CALMET derived dataset for 12 continuous months of hourly data from the year 2023 and approximately centred at the proposed Project has been used to provide further information on the local meteorological influences.

5.2.2.2 Wind Speed and Direction

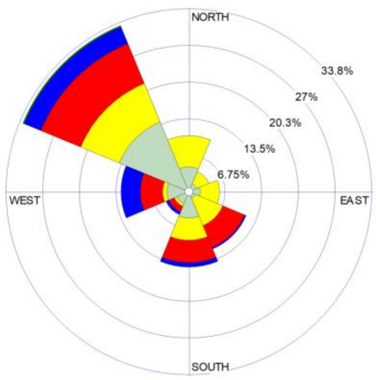
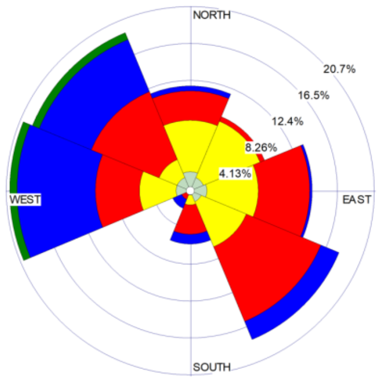
The wind roses from the TAPM-CALMET derived dataset for the year 2023 are presented in Figure 5-3 and Figure 5-4 for the Project site. Figure 5-3 shows that westerly winds are dominant in the annual wind pattern, as well as during the autumn spring and winter. During summer, southeasterly winds are most prevalent, with stronger winds (>5.7 m/s) also occurring from the west and northwest. Overall, winds from the west dominate throughout the year, with stronger winds commonly observed from the west and northwest. Winds from the north and south are infrequent year-round, while easterly winds are uncommon except during summer.



Location: Site	*Data Period:* Jan 2023 to Dec 2023	*Data Type:* TAPM-CALMET extract
Period	**Average windspeed (m/s)**	**Percent calm (%)**
All hours	2.7	6.4
Summer	2.4	8.7
Autumn	2.6	4.9
Winter	2.9	5.1
Spring	2.9	6.9

Figure 5-3: Site-specific wind roses by season for the TAPM-CALMET derived dataset, 2023

Figure 5-4 shows the wind roses for the time of day during the year for 2023 for the modelled data at a site as close as possible to the Braidwood BoM Station site. It can be seen that north-westerly winds are dominant at 9am and winds from the west and northwest at 3pm. Winds from the east and southeast are also frequent at 3pm, with stronger winds (>5.7 m/s) occurring more frequently from the west and northwest. These wind patterns are generally consistent with those shown for the long term measured data at the Braidwood BoM Station in Figure 5-2.

9am	3pm
	

Location: South of site	*Data Period:* Jan 2023 to Dec 2023	*Data Type:* TAPM-CALMET extract
Period 9am 3pm	**Average windspeed (m/s)** 2.9 4.3	**Percent calm (%)** 4.1 0.0

Figure 5-4: Site-specific wind roses at 9am and 3pm for the TAPM-CALMET derived dataset, 2023

5.2.2.3 Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion of pollutants. The Pasquill-Turner assignment scheme identifies six Stability Classes (Stability Classes A to F) to categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions and are used in various air dispersion models. The frequency of occurrence for each stability class for 2023 is shown in Figure 5-5. The data identifies that Stability Class D is most common; this stability class is indicative of neutral dispersion conditions.

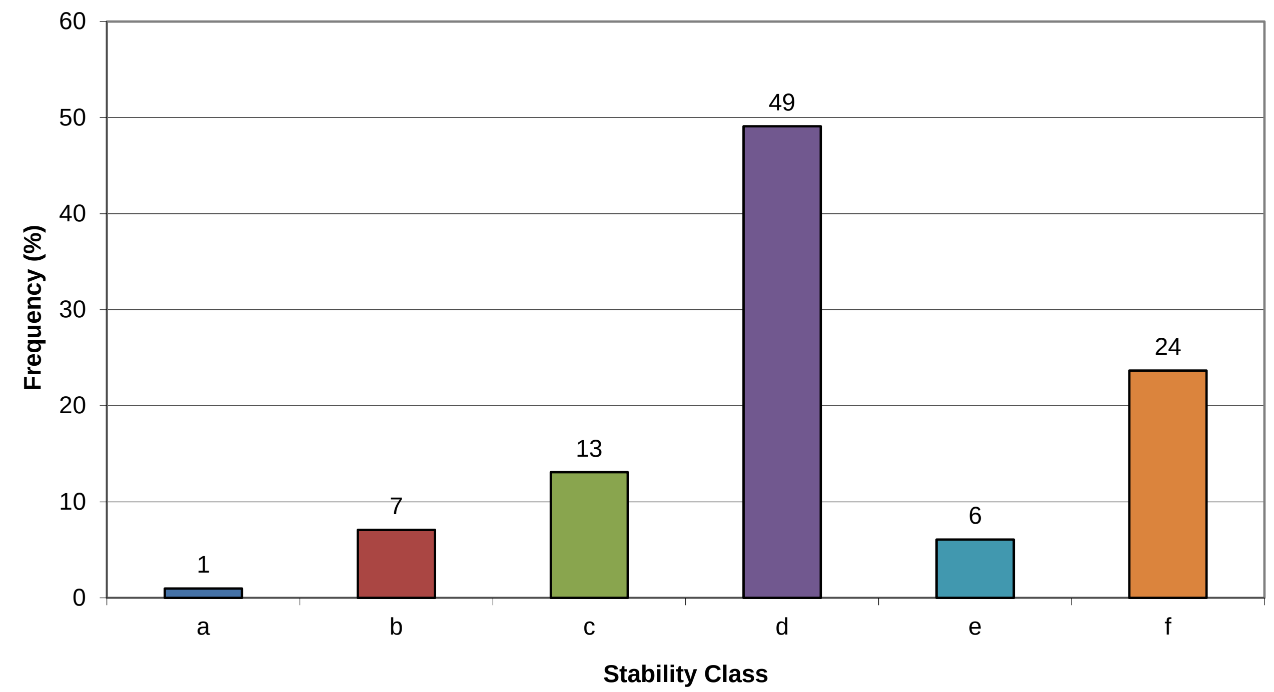


Figure 5-5: Stability class frequency for the TAPM-CALMET derived dataset, 2023

5.2.2.4 Mixing Height

Mixing height refers to the height above ground within which particulates or other pollutants released at or near ground can mix with ambient air. During stable atmospheric conditions, the mixing height is often quite low and particulate dispersion is limited to within this layer.

Diurnal variations in mixing depths are illustrated in Figure 5-6. As would be expected, an increase in the mixing depth during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and the growth of convective mixing layer.

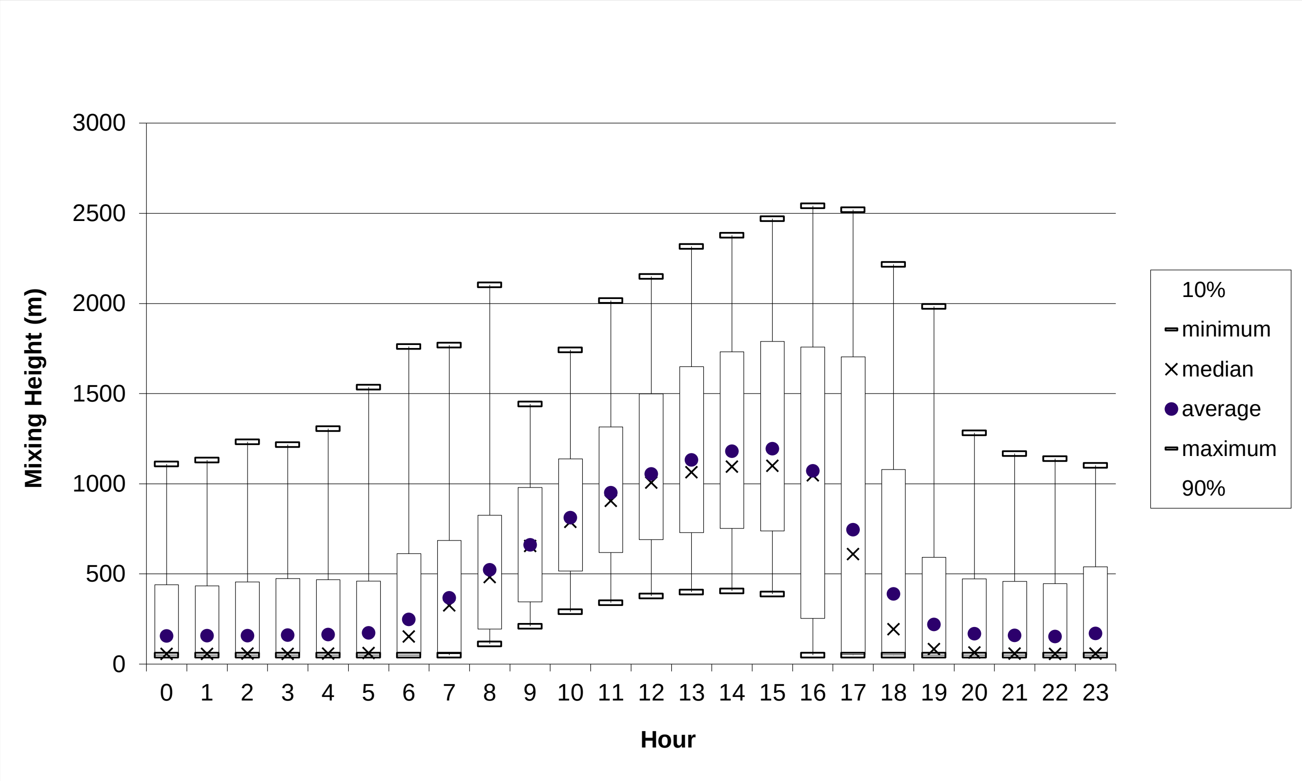


Figure 5-6: Mixing height for the TAPM-CALMET derived dataset, 2023

5.2.2.5 Temperature

Figure 5-7 shows the temperature profile of the TAPM-CALMET derived dataset. As shown in the figure, temperature predictions for the modelled data are lowest at 5^{0}C at night and early morning and highest at 39^{0}C in the afternoon, which is consistent with expectations for the region.

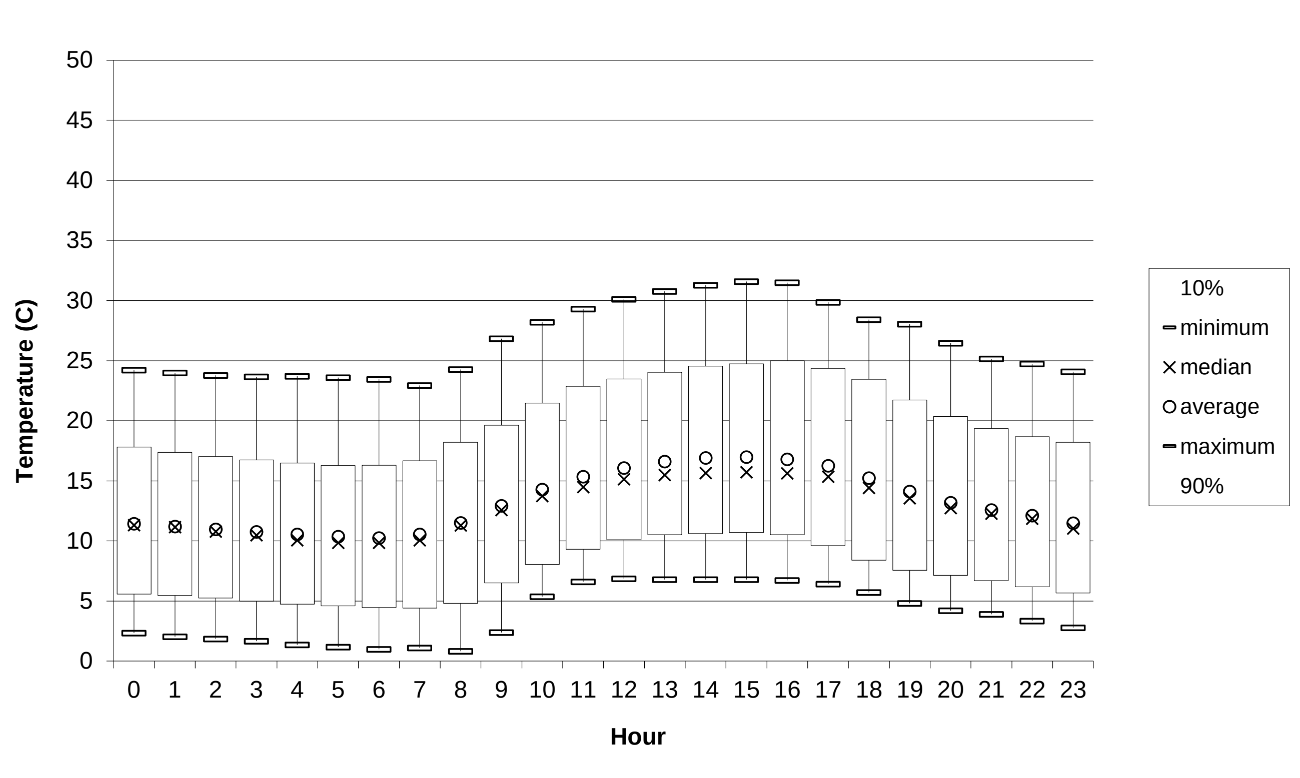


Figure 5-7: Temperature for the TAPM-CALMET derived dataset, 2023

5.3 Existing Air Quality

The project site is situated within a sparsely populated rural area. Background dust levels are expected to be primarily impacted by other resource extraction operations and agricultural activities.

An extensive network of NATA-accredited air quality monitoring stations which use Standards Australia methods, where available is operated by the NSW EPA. The closest monitoring site to the Project site is at Goulburn, approximately 65 km to the north and is considered to provide a generally representative background estimation of the remote rural concentration levels expected for the project site. Of the pollutants of interest, PM_{10} and $PM_{2.5}$ are measured at the Goulburn site. As with all NSW air quality monitoring stations concentration levels of these pollutants were elevated by smoke from bushfires in summer. Where available, the maximum 24 hour average data collected at this site for 2023 is outlined in Table 5-2 for a Level 1 Assessment as specified in the Approved Methods (2022). Individual 24-hour average predicted PM_{10} concentrations paired in time with the corresponding 24-hour concentration within the adopted 2023 monitoring dataset to obtain total impact at each receptor is provided for the Assessment. In addition, annual average concentration data are adopted for the background levels of pollutants requiring assessment for these periods (e.g. $PM_{2.5}$ and PM_{10}).

Where unavailable, a conservative assumption is adopted. For example, annual TSP background is derived as 2.5 x measured PM_{10} based on data collected around Australian mines (ACARP, 1999).

It is noted that other resource extraction operations are active in the area, and contributions to dust levels from these sources should be considered. An Air Quality Assessment (AQA) was prepared by Zephyr Environmental Pty Ltd in 2023 (report reference: 0063 Larbert Quarry Expansion AQGHGA) to support a development application (DA 2024.0047) for the expansion of an existing resource extraction operation located approximately 1 km southeast of the proposed expansion at 552 Larbert Road.

The Zephyr AQA evaluated potential air quality impacts at nearby sensitive receptors associated with the nearby quarry expansion. As these receptors are located within the same area as the proposed expansion at 552 Larbert Road, they are also relevant to this assessment.

To account for cumulative impacts from the existing sources as well as regional background levels, the worst-case predicted concentrations at the most affected sensitive receptor (as identified in the Zephyr AQA and relevant to this assessment) have been adopted in addition to the measured background levels, as a conservative approach.

Table 5-2 provides the maximum concentrations measured at the Goulburn station, the predicted contributions from the existing nearby quarry and the background concentration levels adopted for this assessment.

Table 5-2: Assigned Background Concentrations

Parameter	Air quality criteria	Period	Maximum measured	Maximum reported predicted by Zephyr AQA for nearby quarry	Total adopted background
TSP	90 µg/m³	Annual	25.9 µg/m³	1 µg/m³	27.0 µg/m³
PM_{10}	50 µg/m³	24 Hour	23.8 µg/m³	5.2 µg/m³	29.0 µg/m³
	25 µg/m³	Annual	10.4 µg/m³	0.4 µg/m³	10.8 µg/m³
$PM_{2.5}$	25 µg/m³	24 Hour	17.7 µg/m³	0.9 µg/m³	18.6 µg/m³
	8 µg/m³	Annual	5.9 µg/m³	0.1 µg/m³	6.0 µg/m³
Dust Deposition	2 g/m²/month	Month	-	-	-
	4 g/m²/month	Month	-	1.6 g/m²/month	1.6 g/m²/month

6 Methodology

The air quality impact assessment has been carried out as follows:

- An emissions inventory of TSP, PM_{10}, $PM_{2.5}$, and deposited dust for the proposed Project was compiled using National Pollutant Inventory (NPI) and United States Environmental Protection Agency (USEPA) AP-42 emissions estimation methodology for the Project (outlined in Section 6.1).
- Estimated emissions data was used as input for air dispersion modelling. The modelling techniques were based on a combination of The Air Pollution Model (TAPM) prognostic meteorological model (developed by CSIRO), and the CALMET model suite used to generate a three-dimensional meteorological dataset for use in the CALPUFF dispersion model (Section 6.2).
- The atmospheric dispersion modelling results were assessed against the air quality assessment criteria described in Section 7 as part of the impact assessment. Air quality controls are applied to reduce emission rates where applicable.

6.1 Estimated Emissions

6.1.1 Pollution Causing Activities

The air quality assessment takes into account dust generating activities from extraction activities and disturbed surfaces within the site boundaries. The main emissions to air are dust and particulate matter generated by the onsite activities which primarily occur as a result of the following activities:

- site clearance of areas including vegetation clearance, topsoil removal and storage, and earthworks
- excavation
- loading/unloading of haul trucks
- bulldozer and grader operations
- wind erosion from disturbed areas and stockpiles
- transfer points
- conveyors
- crushing and screening
- vehicle movements

In addition, air pollutants from diesel combustion may release other air pollutants such as particulate matter, (PM_{10} and $PM_{2.5}$), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO) and trace quantities of volatile organic compounds. These substances are not considered to be emitted in sufficient quantities to affect air quality at sensitive receptors beyond the Project boundary; and have not been modelled in the air quality assessment.

6.1.2 Emission Estimation

Emission factors can be used to estimate emissions of TSP and PM_{10} to the air from various sources. Emission factors relate the quantity of a substance emitted from a source to some measure of activity associated with the source. Common measures of activity include distance travelled, quantity of material handled, or the duration of the activity.

Emission factors are used to estimate a facility's emissions by the general equation:

$$E_{i\,(kg/yr)} = \left[A_{(t/h)} \times OP_{(h/yr)} \right] \times EF_{i\,I(kg/t)} \times \left[1 - \frac{CE_i}{100} \right]$$

Where:

$E_{i\,(kg/yr)}$ = Emission rate of pollutant

$A_{(t/h)}$ = Activity rate

$OP_{(h/yr)}$ = operating hours

$EF_{i\,I(kg/t)}$ = uncontrolled emission factor of pollutant

CE_i = overall control efficiency for pollutant

The equations and activity rates are presented in Appendix A.

6.1.3 Emissions Scenarios Modelled

Two operational scenarios were modelled for this assessment:

- **Maximum operations scenario:** The operational scenario representing maximum daily activities allowing for 50 loaded truck movements which provides for extraction and processing of approximately 1,850 t/day.
- **Average operations scenario:** The operational scenario representing average daily activities allowing for 20 loaded truck movements which provides for extraction and processing of approximately 740 t/day.

6.1.4 Emission Controls

Emissions controls for dust abatement were included in the emissions estimation, summarised in Appendix A, Table A-1.

It should also be noted that some of the planned dust control measures are not easily quantifiable but will still serve to reduce dust emissions. The dispersion modelling study has taken a conservative approach and have not incorporated the effectiveness of these controls in the development of the emissions inventory.

- Routine visual monitoring and hazard minimisation.
- Planned activities will not occur during adverse weather conditions.
- All loads leaving the site are covered, to minimise dust and debris.
- Maintaining a high level of repair and servicing for all trucks associated with the quarry.
- Miscellaneous dust sources such as spillages from trucks and silt from sediment controls are regularly cleaned up.
- The internal quarry haul route will be maintained in a good condition.
- Sand extraction will be undertaken in a staged approach with a progressive expansion of the existing sand extraction area.

6.1.5 Emission by Source

The emission estimation for individual activities accounting for control factors (outlined in ***Appendix A***) has been derived from NPI Emission Estimation Technique manuals and US EPA AP42 documentation. The annual calculated emissions for TSP, PM_{10} and $PM_{2.5}$ are presented in for each source type inclusive of adopted control factor. Further details including the activity data applied in the emissions estimations are provided in ***Appendix A.*** It should be noted that all sources are classed as fugitive and there are no point sources associated with this project.

Table 6-1 provides the calculated annual emissions for the maximum operating scenario used for the model input, while Table 6-2 provides the calculated annual emissions for the average operating scenario.

Table 6-1: Calculated Annual Emissions by Source (kg/y) – Maximum Operations

Fugitive Source	TSP	PM_{10}	$PM_{2.5}$
Wind erosion (Pit & Stockpiles)	14967	7484	3742
Wheel generated dust (Hauling internal and external)	24899	6118	612
Processing	25782	19336	539
Pit activities	3504	1595	355
Total	**69152**	**34534**	**5248**

Table 6-2: Calculated Annual Emissions by Source (kg/y) – Average Operations

Fugitive Source	TSP	PM_{10}	$PM_{2.5}$
Wind erosion (Pit & Stockpiles)	14967	7484	3742
Wheel generated dust (Hauling internal and external)	8627	2120	212
Processing	8933	6700	187
Pit activities	1724	796	174
Total	**34253**	**17100**	**4314**

6.2 Air Dispersion Modelling

6.2.1 TAPM

A 3-dimensional dispersion wind field model, CALPUFF, has been used to simulate the impacts from the Project. CALPUFF is an advanced non-steady-state meteorological and air quality modelling system developed and distributed by Earth Tech, Inc. The model has been approved for use in the '*Guideline on Air Quality Models*' (Barclay and Scire, 2011) as a preferred model for assessing applications involving complex meteorological conditions such as calm conditions.

To generate the broad scale meteorological inputs to run CALPUFF, this study has used the model The Air Pollution Model (TAPM), which is a 3-dimensional prognostic model developed and verified for air pollution studies by the CSIRO.

TAPM was configured as follows:-

- Centre coordinates – 30° 24.5 S, 151° 43.5 E;
- Dates modelled – 31st December 2022 to 31st December 2023 (1 start up day);
- Four nested grid domains of 30 km, 10 km, 3 km and 1 km;
- 30 x 30 grid points for all modelling domains;
- 25 vertical levels from 10 m to an altitude of 8000 m above sea level;
- Data assimilation using measured meteorological data from the NSW EPA Air Quality Monitoring Station at Goulburn and from the BOM Braidwood Racecourse station (Site number 069132); and
- The default TAPM databases for terrain, land use and meteorology were used in the model;

6.2.2 CALMET

CALMET is an advanced non-steady-state diagnostic three-dimensional meteorological model with micro-meteorological modules for overwater and overland boundary layers. The model is the meteorological pre-processor for the CALPUFF modelling system.

The CALMET simulation was run as No-Obs simulation with the gridded TAPM three-dimensional wind field data from the innermost grid. CALMET then adjusts the prognostic data for the kinematic effects of terrain, slope flows, blocking effects and three-dimensional divergence minimisation.

6.2.3 CALPUFF

CALPUFF is a non-steady-state Lagrangian Gaussian puff model. CALPUFF employs the three-dimensional meteorological fields generated from the CALMET model by simulating the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal.

Emission sources can be characterised as arbitrarily-varying point, area, volume and lines or any combination of those sources within the modelling domain.

Due to the elevated topography around the project site, as discussed in Section 5.1, the radius of influence of terrain features was set at 6 km while the minimum radius of influence was set as 0.1 km. The terrain data incorporated into the model had a resolution of 1 arc-second (approximately 30 m) in accordance with 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'*.

6.2.1 Other Modelling Input Parameters

6.2.1.1 Particle Size Distribution

CALPUFF requires particle distribution data (geometric mass mean diameter, standard deviation) to compute the dispersion of particulates (*Table 6-3*).

Table 6-3: Particle Size Distribution Data

Particle size	Mean particle diameter (µm)	Geometric standard deviation (µm)
TSP	15	2
PM_{10}	4.88	1
$PM_{2.5}$	0.89	1

7 Assessment of Impacts

This section presents the results of the air quality impact assessment for predicted ground level concentrations of TSP, PM_{10} and $PM_{2.5}$ and dust deposition for the proposed operation of the Project for the two modelled scenarios.

The results of the dispersion modelling include individual sensitive receptor and contour plots that are indicative of ground-level concentrations and deposition. As outlined in the *'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia'* a Level 1 impact assessment is presented for pollutants without elevated background (i.e. TSP, dust deposition and annual average PM_{10} and $PM_{2.5}$) as follows:

- The incremental impact of each pollutant as per the criterion units and time periods; and
- The maximum background concentration added to the 100th percentile model prediction.

A Level 2 impact assessment is presented for the 24 hour average PM_{10} for the maximum operations modelling scenario and the predictions are presented as follows:

- The results of the Level 1 impact assessment for these pollutants; and
- The sum for each individual dispersion model prediction with the corresponding measured background concentration (e.g. add the first hourly average dispersion model prediction to the first hourly average background concentration) to obtain hourly predictions of total impact.

7.1 Maximum Operations

7.1.1 TSP

The predicted Level 1 assessment annual average TSP for the maximum operations modelling scenario is presented in Table 7-1.

The model predictions for TSP are well below the criteria of 90 µg/m^3. TSP emissions from the proposed Project are not predicted to adversely impact upon the sensitive receptors. A contour plot is presented in Appendix B.

Table 7-1: Predicted Annual Average TSP Concentrations (µg/m³) – Level 1 Assessment – Maximum Operations

ID	Predicted Annual Average TSP Concentrations (µg/m³)	
	Incremental	**Cumulative**
R1	0.17	27.17
R2	0.33	27.33
R3	0.06	27.06
Criteria	**90**	

7.1.2 PM_{10}

The Level 1 assessment maximum predicted 24 hour (including maximum measured background and contribution from other quarries of 29.0 µg/m³) and annual average (including measured annual background and contribution from other quarries of 10.8 µg/m³) PM_{10} for the maximum operations modelling scenario are presented in Table 7-2.

As shown in Table 7-2, the model predictions for annual average PM_{10} are below the criteria of 25 µg/m³. The model predictions for cumulative 24-hour average PM_{10} are also below the criteria of 50 µg/m³. Predictions for the worst affected receptor (R1) were found to be close to but still below the criteria, however, are significantly contributed to by the elevated background levels of 29 µg/m³. The *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* provides the following guidance when dealing with elevated background:

In some locations, existing ambient air pollutant concentrations may exceed the impact assessment criteria from time to time. In such circumstances, a licensee must demonstrate that no additional exceedances of the impact assessment criteria will occur as a result of the proposed activity and that best management practices will be implemented to minimise emissions of air pollutants as far as is practical.

A worked example involving elevated background is also provided in the Approved Methods in which a modelling assessment is refined by adding each individual dispersion model prediction to the corresponding measured background concentration (i.e. a Level 2 assessment). Further investigation of the contemporaneous background and predicted data is therefore undertaken here in accordance with the worked example.

Table 7-3 provides the Level 2 assessment maximum cumulative concentrations at each sensitive receptor including contemporaneous background concentrations for the modelled year and Figure 7-1 and Figure 7-2 show the time series data for incremental and cumulative results for the two highest effected sensitive receptors.

As shown in Table 7-3 and Figure 7-1 and Figure 7-2, no exceedances of the 24 hour average PM_{10} criteria (50 µg/m³) are predicted at each of the receptors modelled. Furthermore, the greatest contribution of the quarry emissions to the cumulative PM_{10} does not contribute to any exceedances of the relevant criteria. As specified in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, under these circumstances no additional assessment is therefore required.

The 24 hour and annual average PM_{10} emissions from the proposed Project are not predicted to adversely impact upon the sensitive receptors. Contour plots are provided in Appendix B.

Table 7-2: Predicted 24 Hour and Annual Average PM_{10} Concentrations (μg/m³) - Level 1 assessment – Maximum Operations

ID	Predicted 24 Hour Average PM_{10} Concentrations (μg/m³)		Predicted Annual Average PM_{10} Concentrations (μg/m³)	
	Incremental	**Cumulative**	**Incremental**	**Cumulative**
R1	20.05	49.05	0.74	11.54
R2	15.35	44.35	0.90	11.70
R3	4.74	33.74	0.34	11.14
Criteria	**50**		**25**	

Table 7-3: Predicted Cumulative 24 Hour Average PM_{10} Concentrations (μg/m³)[a] - Level 2 assessment – Maximum Operations

ID	Predicted Cumulative 24 Hour Average PM_{10} Concentrations (μg/m³)
R1	34.02
R2	33.22
R3	29.01
Criteria	**50**

a Note – There are no exceedances of criteria by measured background data

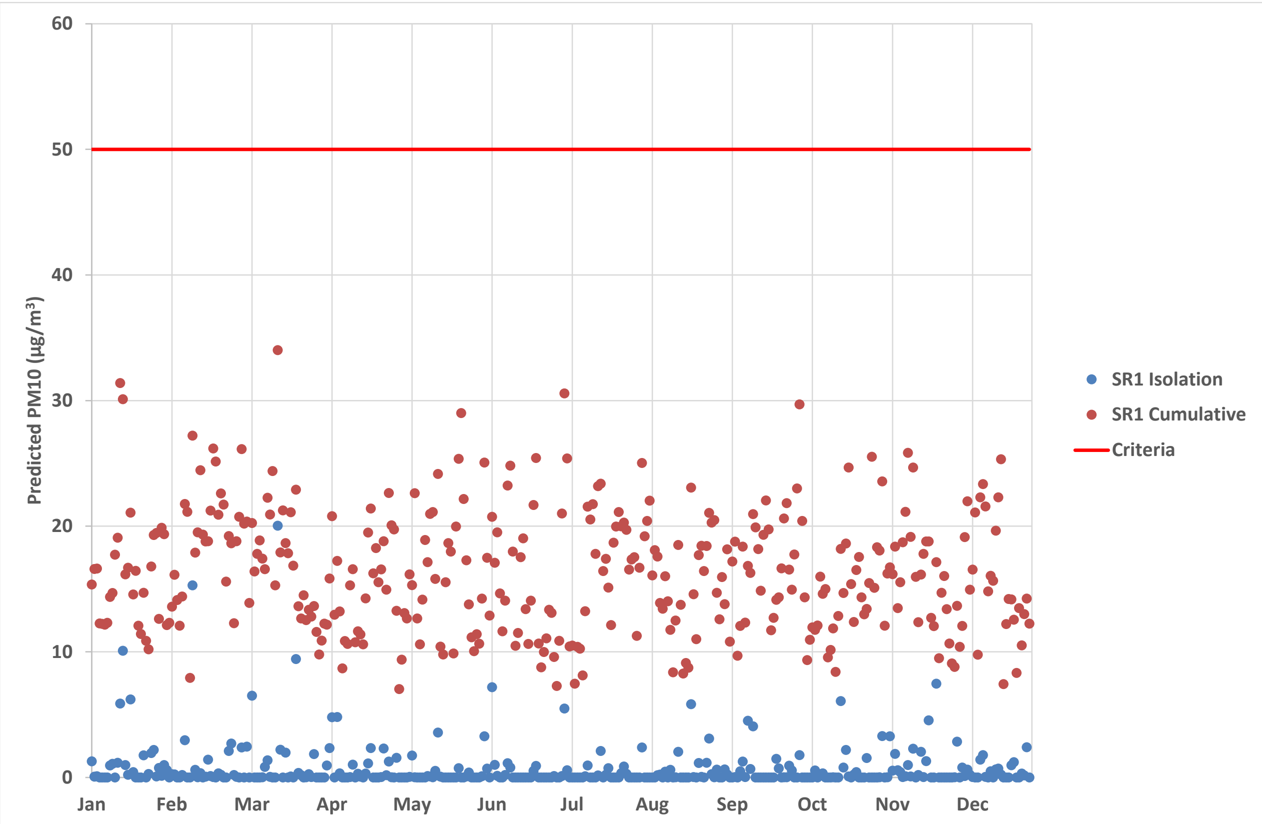


Figure 7-1: Timeseries of 24 hour predicted PM_{10} concentrations in isolation and cumulative at SR1 for maximum Operations

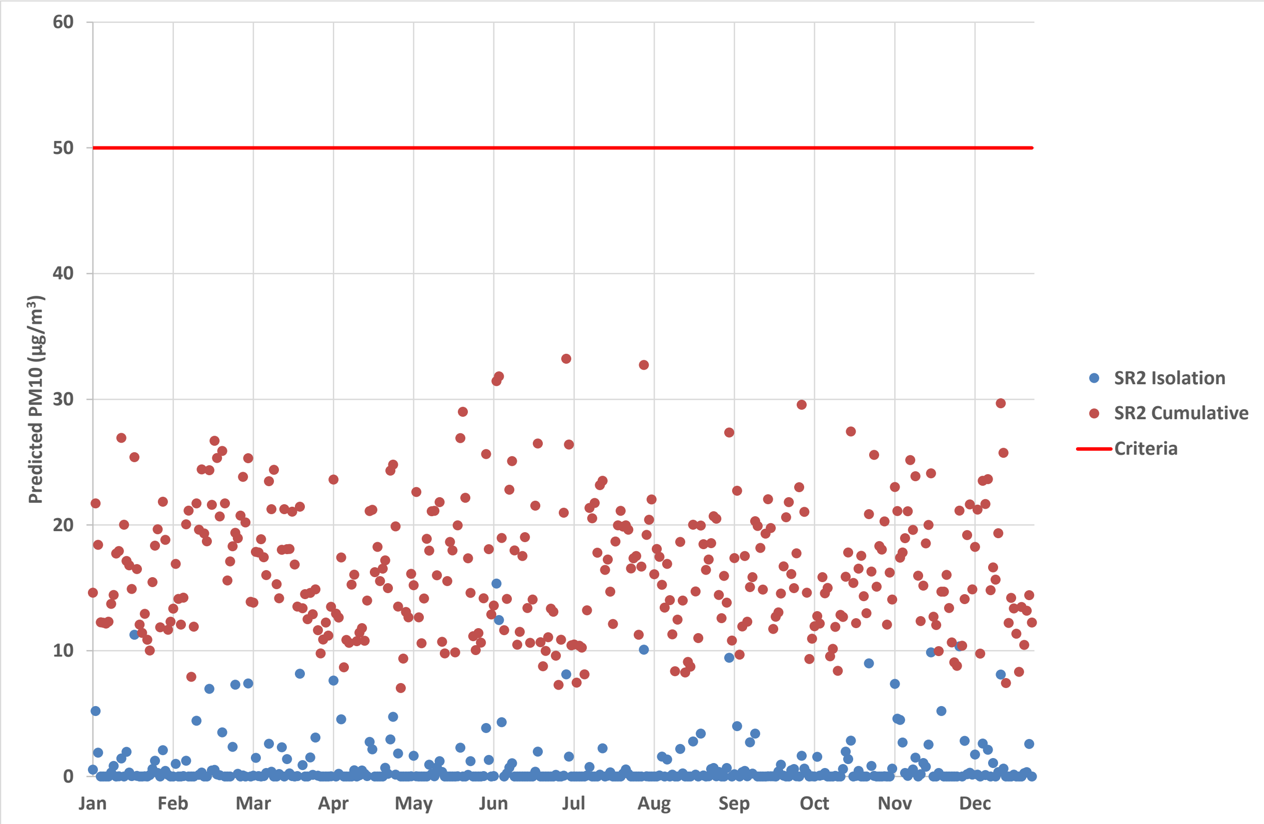


Figure 7-2: Timeseries of 24 hour predicted PM_{10} concentrations in isolation and cumulative at SR2 for maximum Operations

7.1.3 $PM_{2.5}$

The Level 1 assessment maximum predicted 24 hour (including maximum measured background and contribution from other quarries of 18.6 µg/m^3) and annual average (including measured annual background and contribution from other quarries of 5.9 µg/m3) $PM_{2.5}$ for the maximum operations modelling scenario are presented in Table 7-4.

The model predictions for annual average $PM_{2.5}$ are below the criteria of 8 µg/m^3. The predicted 24 hour average concentrations are also below the criteria of 25 µg/m^3.

The 24 hour and annual average $PM_{2.5}$ emissions from the proposed Project are not predicted to adversely impact upon the sensitive receptors. Contour plots are provided in Appendix B.

Table 7-4: Predicted 24 Hour and Annual Average $PM_{2.5}$ Concentrations (µg/m^3) - Level 1 Assessment – Maximum Operations

ID	Predicted 24 Hour Average $PM_{2.5}$ Concentrations (µg/m^3)		Predicted Annual Average $PM_{2.5}$ Concentrations (µg/m^3)	
	Incremental	Cumulative	Incremental	Cumulative
R1	2.07	20.67	0.18	6.08
R2	2.43	21.03	0.20	6.10
R3	0.89	19.49	0.10	6.00
Criteria	**25**		**8**	

7.1.4 Dust Deposition

The Level 1 assessment maximum predicted monthly average dust deposition for the maximum operations modelling scenario are presented in Table 7-5.

The model predictions for incremental and cumulative maximum monthly average dust deposition are below the criteria of 2 g/m^2/month and 4 g/m^2/month. Dust deposition from the proposed Project is not predicted to adversely impact upon the sensitive receptors.

Table 7-5: Predicted Monthly Average Dust Deposition (g/m^2/month) - Level 1 Assessment – Maximum Operations

ID	Predicted Monthly Average Dust Deposition (g/m^2/month)	
	Incremental	**Cumulative**
R1	0.01	1.61
R2	0.02	1.62
R3	0.01	1.61
Criteria	**2**	**4**

7.2 Average Operations

7.2.1 TSP

The predicted Level 1 assessment annual average TSP for the average operations modelling scenario is presented in Table 7-6.

The model predictions for TSP are well below the criteria of 90 µg/m^3. TSP emissions from the proposed Project are not predicted to adversely impact upon the sensitive receptors.

Table 7-6: Predicted Annual Average TSP Concentrations (µg/m^3) – Level 1 Assessment – Average Operations

ID	Predicted Annual Average TSP Concentrations (µg/m^3)	
	Incremental	**Cumulative**
R1	0.10	27.10
R2	0.18	27.18
R3	0.03	27.03
Criteria	**90**	

7.2.2 PM_{10}

The Level 1 assessment maximum predicted 24 hour (including maximum measured background and contribution from other quarries of 29.0 µg/m^3) and annual average (including measured annual background and contribution from other quarries of 10.8 µg/m^3) PM_{10} for the average operations modelling scenario are presented in Table 7-7.

The model predictions for annual average PM_{10} are below the criteria of 25 µg/m^3. The predicted 24 hour average concentrations are also below the criteria of 50 µg/m^3.

The 24 hour and annual average $PM_{2.5}$ emissions from the proposed Project are not predicted to adversely impact upon the sensitive receptors.

Table 7-7: Predicted 24 Hour and Annual Average PM_{10} Concentrations (µg/m^3) - Level 1 assessment – Average Operations

ID	Predicted 24 Hour Average PM_{10} Concentrations (µg/m^3)		Predicted Annual Average PM_{10} Concentrations (µg/m^3)	
	Incremental	**Cumulative**	**Incremental**	**Cumulative**
R1	8.80	37.80	0.44	11.24
R2	6.75	35.75	0.51	11.31
R3	2.61	31.61	0.21	11.01
Criteria	**50**		**25**	

7.2.3 $PM_{2.5}$

The Level 1 assessment maximum predicted 24 hour (including maximum measured background and contribution from other quarries of 18.6 µg/m^3) and annual average (including measured annual background and contribution from other quarries of 5.9 µg/m^3) $PM_{2.5}$ for the average operations modelling scenario are presented in Table 7-8.

The model predictions for annual average $PM_{2.5}$ are below the criteria of 8 µg/m^3. The predicted 24 hour average concentrations are also below the criteria of 25 µg/m^3.

The 24 hour and annual average $PM_{2.5}$ emissions from the proposed Project are not predicted to adversely impact upon the sensitive receptors.

Table 7-8: Predicted 24 Hour and Annual Average $PM_{2.5}$ Concentrations (µg/m^3) - Level 1 assessment

ID	Predicted 24 Hour Average $PM_{2.5}$ Concentrations (µg/m^3)		Predicted Annual Average $PM_{2.5}$ Concentrations (µg/m^3)	
	Incremental	Cumulative	Incremental	Cumulative
R1	1.63	20.23	0.16	6.16
R2	2.07	20.67	0.18	6.18
R3	0.80	19.40	0.09	6.09
Criteria	**25**		**8**	

7.2.4 Dust Deposition

The Level 1 assessment maximum predicted monthly average dust deposition for the average operations modelling scenario are presented in Table 7-9.

The model predictions for incremental and cumulative monthly average dust deposition are below the criteria of 2 g/m^2/month and 4 g/m^2/month. Dust deposition from the proposed Project is not predicted to adversely impact upon the sensitive receptors.

Table 7-9: Predicted Monthly Average Dust Deposition (g/m^2/month) - Level 1 assessment – Average Operations

ID	Predicted Monthly Average Dust Deposition (g/m^2/month)	
	Incremental	Cumulative
R1	7.8E-03	1.61
R2	9.8E-03	1.61
R3	2.4E-03	1.60
Criteria	**2**	**4**

8 Conclusion

Vipac Engineers and Scientists Ltd (Vipac) was engaged by Outline Planning Consultants Pty Ltd on behalf of Braidwood Sand and Gravel and Lentro Earthmoving to prepare an air quality assessment to support the proposed expansion of the approved sand extraction operation from a sand pit at 552 Larbert Rd, Larbert NSW.

The Project involves the staged, progressive expansion of the existing sand extraction area of 1.92 ha by an additional 16 ha approximately as well as an increase in the rate of sand extraction, from the currently approved 25,000 tonnes per annum to 200,000 tonnes per annum. The proposal also includes an increase in truck movements, with an average of 20 loaded trucks per day and a maximum of up to 50 loaded trucks per day.

Two emissions scenarios have been modelled, including the average daily operational scenario of 20 loaded truck movements and an extraction and processing rate of approximately 740 tonnes per day, and a maximum operational scenario with 50 loaded truck movements and an extraction and processing rate of approximately 1,850 tonnes per day.

The results of the modelling have shown that the TSP, PM_{10}, $PM_{2.5}$ and dust deposition predictions comply with the relevant criteria and averaging periods at all modelled sensitive receptors, both for the Project in isolation and with the adopted background levels, for both the modelled average and maximum operations scenario.

Table 8-1 and Table 8-2 summarise the modelling results for the maximum operational scenario. The results show that predicted concentrations of TSP, PM_{10}, $PM_{2.5}$ and dust deposition comply with the relevant criteria and averaging periods at all sensitive receptors, both for the Project in isolation and with the adopted background levels.

The model predictions for cumulative 24-hour average PM_{10} were below the criterion of 50 µg/m³, however, the predictions for the worst-affected receptor (R1) were found to be close to the criterion, which is heavily contributed to by the adopted background level. Further investigation of the contemporaneous background and predicted data has therefore been undertaken.

The level 2 assessment for maximum cumulative concentrations at each receptor including contemporaneous background concentrations found that no exceedances of the 24 hour average PM_{10} criteria (50 µg/m3) are predicted at any of the receptors modelled. Additionally, the greatest contribution of the quarry emissions to the cumulative PM_{10} levels does not result in any exceedances of the criterion. It is also noted that best management practices will be implemented to minimise emissions as far as is practical.

It is therefore concluded that air quality should not be a constraint for the proposed expansion.

Table 8-1: Summary of Results – Maximum Operations Scenario – Project in Isolation

ID	Predicted Concentrations (µg/m³)					Dust deposition (g/m²/month)	Compliant
	PM_{10}		$PM_{2.5}$		TSP		
	24 h	Annual	24 h	Annual	Annual	Month	
SR1	20.05	0.74	2.07	0.18	0.17	0.01	✓
SR2	15.35	0.90	2.43	0.20	0.33	0.02	✓
SR3	4.74	0.34	0.89	0.10	0.06	0.01	✓
Criteria	**50**	**25**	**25**	**8**	**90**	**2**	

Table 8-2: Summary of Results – Maximum Operations Scenario – Cumulative

ID	Predicted Concentrations (µg/m³)					Dust deposition (g/m²/month)	Compliant
	PM_{10}		$PM_{2.5}$		TSP		
	24 h[1]	Annual	24 h	Annual	Annual	Month	
SR1	34.02	11.54	20.67	6.08	27.17	1.61	✓
SR2	33.22	11.70	21.03	6.10	27.33	1.62	✓
SR3	29.01	11.14	19.49	6.00	27.06	1.61	✓
Criteria	**50**	**25**	**25**	**8**	**90**	**4**	

1. Level 2 assessment

Appendix A Emissions Estimation

The major air emission from extraction activities is fugitive dust. Emission factors can be used to estimate emissions of TSP, PM_{10} and $PM_{2.5}$ to the air from various sources. Emission factors relate the quantity of a substance emitted from a source to some measure of activity associated with the source. Common measures of activity include distance travelled, quantity of material handled, or the duration of the activity.

The National Pollutant Inventory Emission Estimation Technique Manual for Mining (January 2012) provide the equations and emission factors to determine the emissions of TSP and PM_{10} from mining and quarrying activities. These emission factors incorporate emission factors published by the USEPA in their AP-42 documentation.

The following equation from the manual has been used to calculate the emissions for the project's pit activities including:

- Excavators on overburden;
- Trucks dumping overburden;
- Miscellaneous transfers; and
- Unloading and loading stockpiles.

$$EF_{TSP\ (kg/t)} = k_{TSP} \times 0.0016 \times \frac{\left(\frac{U_{(m/s)}}{2.2}\right)^{1.3}}{\left(\frac{M_{(\%)}}{2}\right)^{1.4}}$$

Where:

$EF_{TSP(kg/t)}$ = emission factor for total suspended particles (kg/t)

$EF_{PM10(kg/t)}$ = emission factor for PM_{10} (kg/t)

K_{TSP} = 0.74 for particles less than 30 micrometres aerodynamic diameter

K_{PM10} = 0.35 for particles less than 10 micrometres aerodynamic diameter

$U_{(m/s)}$ = mean wind speed (m/s)

$M_{(\%)}$ = moisture content (% by weight)

The calculated emission factors for these emission factors are:

TSP = 0.0014 kg/t

PM_{10} = 0.00064 kg/t

$PM_{2.5}$ = 0.00014 kg/t

Screening

The default emission factors in the NPI EET for Mining and AP42 11.19.2 have been used.

Haul Roads

The dust emission rate from haul roads has been calculated using the following equation:

$$Emissions = \left(\frac{0.4536}{1.6093}\right) x\ k\ x \left(\frac{s_{(\%)}}{12}\right)^{\alpha} x \left(\frac{W_{(t)}}{3}\right)^{0.45} \text{ kg /VKT}$$

Where:

k = 4.9 for TSP, 1.5 for PM_{10} and 0.15 for $PM_{2.5}$.

$s_{(\%)}$ = surface material silt content

W = mean vehicle weight (tons converted to tonnes)

a = 0.7 for TSP, 0.9 for PM_{10} and $PM_{2.5}$

The calculated emission factors used are:

TSP = 2.34 kg/VKT

PM_{10} = 0.58 kg/VKT

$PM_{2.5}$ = 0.058 kg/VKT

Wind Erosion

The emission rate for dust from stockpile has been calculated using the following equation for TSP:

$$Emissions = 1.9\ x \left(\frac{s_{(\%)}}{1.5}\right) x\ 365\ x \left(\frac{365-p}{235}\right) x \left(\frac{f_{(\%)}}{15}\right) \text{ kg /ha /yr}$$

Where:

$s_{(\%)}$ = silt content.

P = number of days per year when rainfall is greater than 0.25 mm. A review of the BoM meteorological data collected at the Goulburn from 2019 to 2024 has determined there are on average 81 days per year where rainfall is greater than 0.25 mm.

$f_{(\%)}$ = percentage of time that wind speed is greater than 5.4 m/s at the mean height of the stockpile. The frequency of wind speed >5.4 m/s has been measured at Goulburn to be 11.1%.

The fraction of PM_{10} in TSP is 50% and $PM_{2.5}$ is 50% of PM_{10}

The calculated emission factors for wind erosion are:

TSP = 0.19 kg/ha/hr

PM_{10} = 0.094 kg/ha/hr

$PM_{2.5}$ = 0.047 kg/ha/hr

A.1 Activity Overview

Tables A-1 and A-2 summarise the emission factors and key parameters applied in the emissions estimation.

Table A-1: Source type Emission Factors applied

Source type	Default TSP Emission factor	Derived TSP Emission factor	PM_{10}/TSP ratio	$PM_{2.5}$/TSP ratio	Units	Controls applied
Pit Activities						
Excavator on Overburden	-	0.0014	0.47	0.105	kg/t	No control
Truck dumping overburden	-	0.0014	0.47	0.105	kg/t	No control
Unloading stockpiles	-	0.0014	0.35	0.02	kg/t	Water sprays, 50%
Loading stockpiles	-	0.0014	0.35	0.02	kg/t	Water sprays, 50%
Wind erosion:						
stockpiles/pits/haul roads	-	0.19	0.5	0.075	kg/ha/h	Water sprays, 50%
Processing						
Screening	0.08	-	0.75	0.023	kg/t	Water sprays, 50%
Wheel generated dust:						
Unpaved roads	-	2.34	0.25	0.025	kg/VKT	Watering Level 2 + speed limit < 40 km/h (86%)

Table A-2: Parameters applied in emissions estimation

Parameter ID	Value	Units	Description	Data source
U	2.45	m/s	mean wind speed	BoM meteorological data
W	37	t	Truck capacity	client supplied
p	81	days	rainfall > 0.25mm	BoM meteorological data
f	11.1	%	% time winds > 5.4m/s	BoM meteorological data
s	4.0	%	Silt content	Zephyr AQA
M	2.0	%	Moisture	Zephyr AQA
t	1,850	t/day	Maximum material moved	Client supplied
a	181,009	m^2	Total area of land subject to wind erosion[1].	Client supplied

1. Conservatively assuming no staging of extraction activities

Operating Hours

Extraction and processing of material has been modelled as 6 am to 6 pm on weekdays and 7 am to 2 pm on Saturdays.

Haul Roads

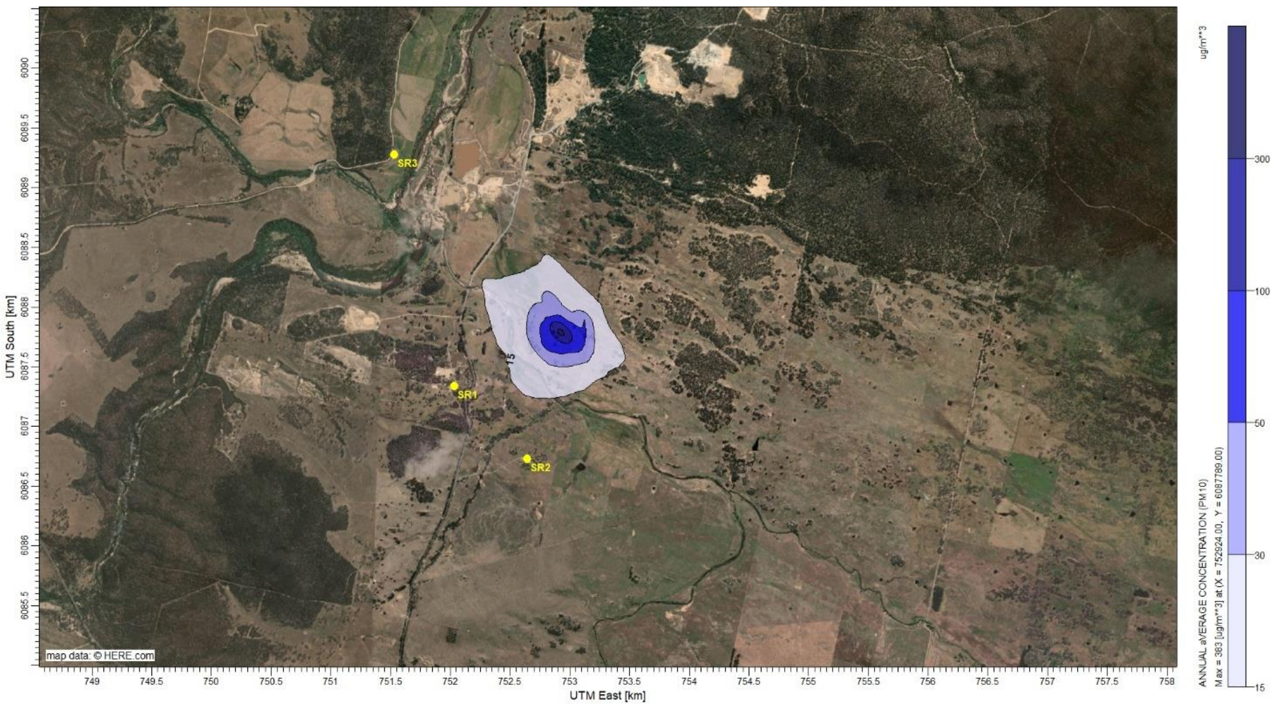
Haul road locations provided and incorporated into the model are summarised below.

Total Haul Road	Modelled Parameter (km)	VKT (laden + unladen)
External	2.42	121.2 VKT/day
Internal	1.92	96.6 VKT/day

Appendix B Contour Plots

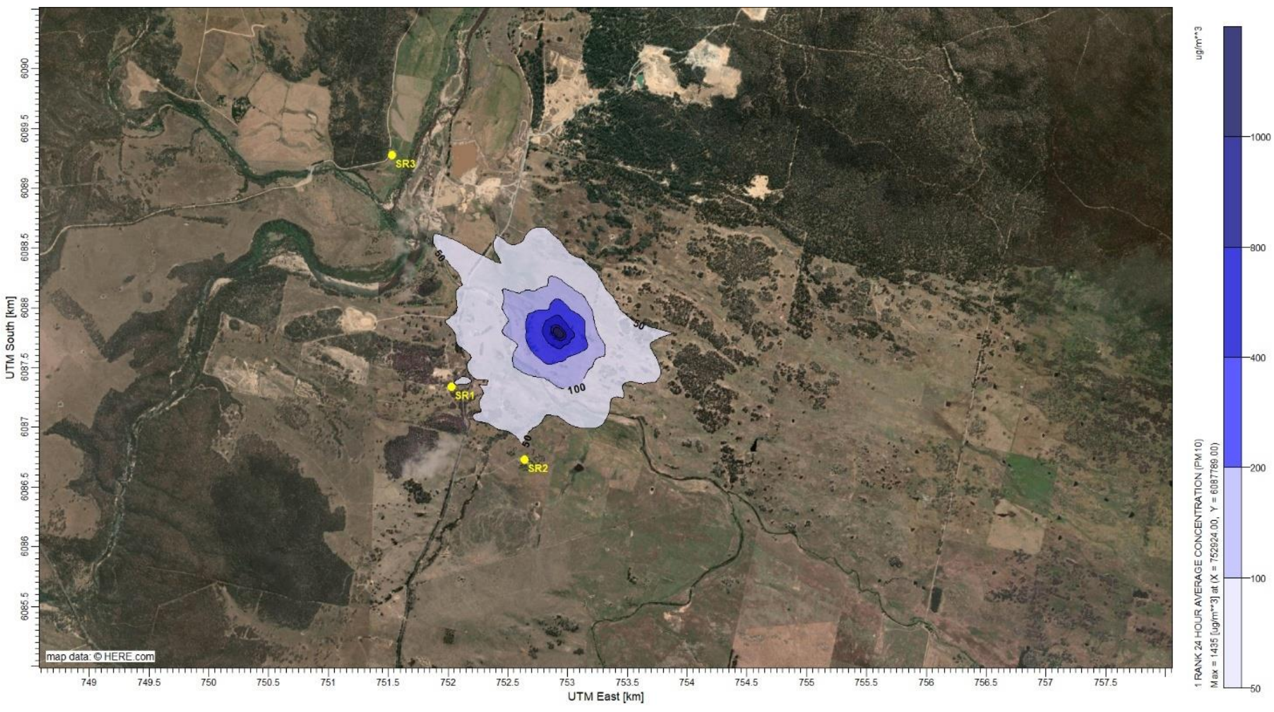
The contour plots are created from the predicted ground-level concentrations at the network of gridded receptors within the modelling domain at frequent intervals. These gridded values are converted into contours using triangulation interpolation in the CALPOST post-processing software within the CALPUFF View software (Version 10.0.0).

Contour plots illustrate the spatial distribution of ground-level concentrations across the modelling domain for each time period of concern. However, this process of interpolation causes a smoothing of the base data that can lead to minor differences between the contours and discrete model predictions.



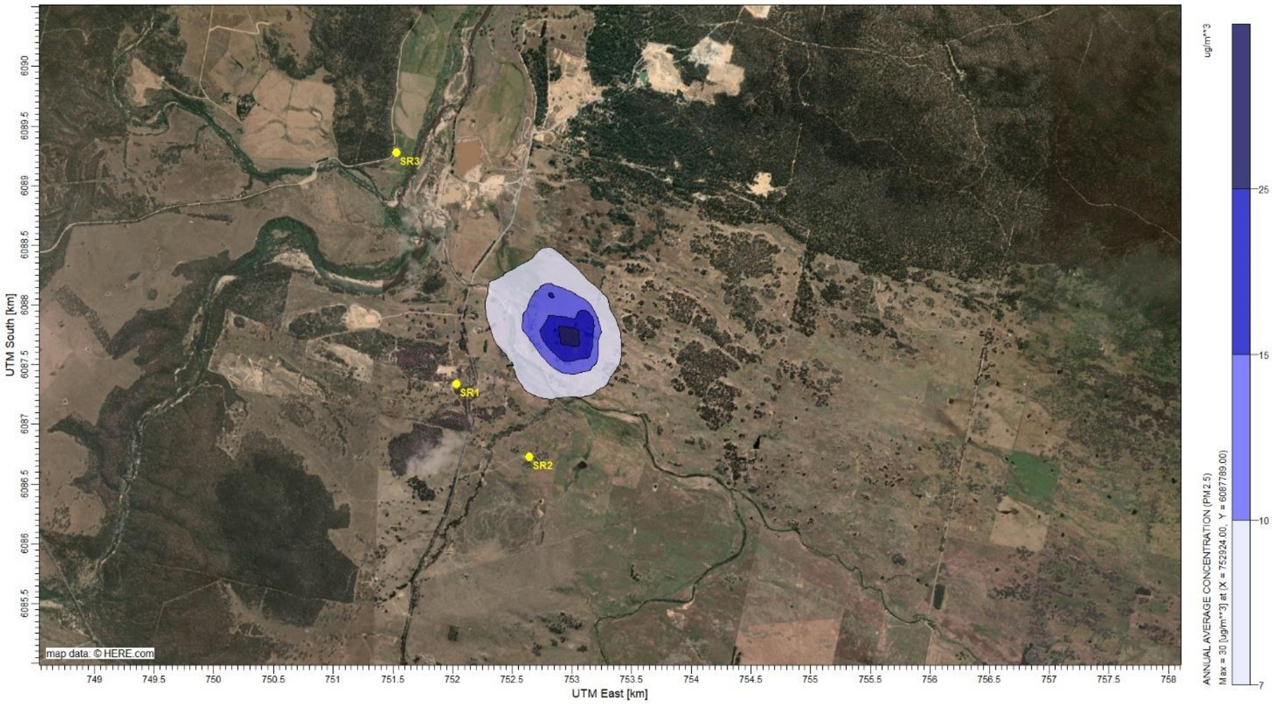
Pollutant:	Averaging Period:	Percentile:	Criteria:
PM_{10}	Annual	100^{th}	25 µg/m^3

Comment:
Cumulative



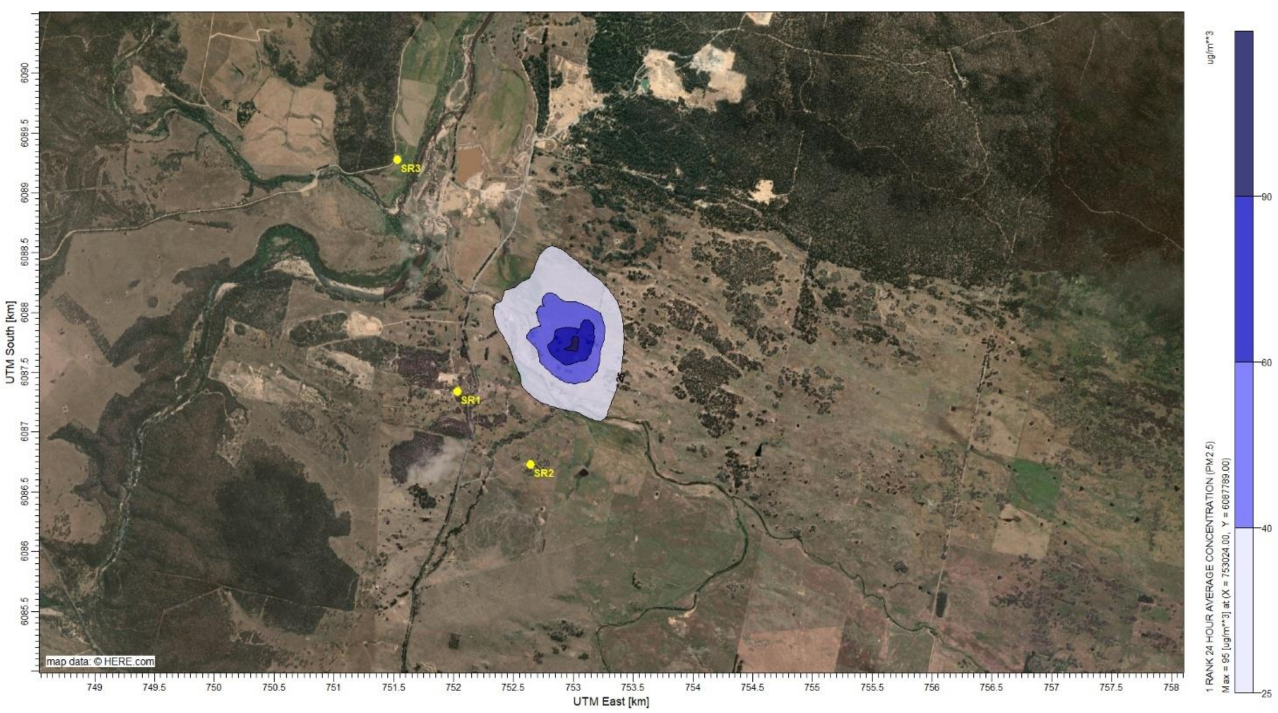
Pollutant: PM10	**Averaging Period:** 24 Hour	**Percentile:** 100th	**Criteria:** 50 µg/m^3

Comment:
Cumulative



Pollutant: $PM_{2.5}$	**Averaging Period:** Annual	**Percentile:** 100th	**Criteria:** 8 µg/m^3

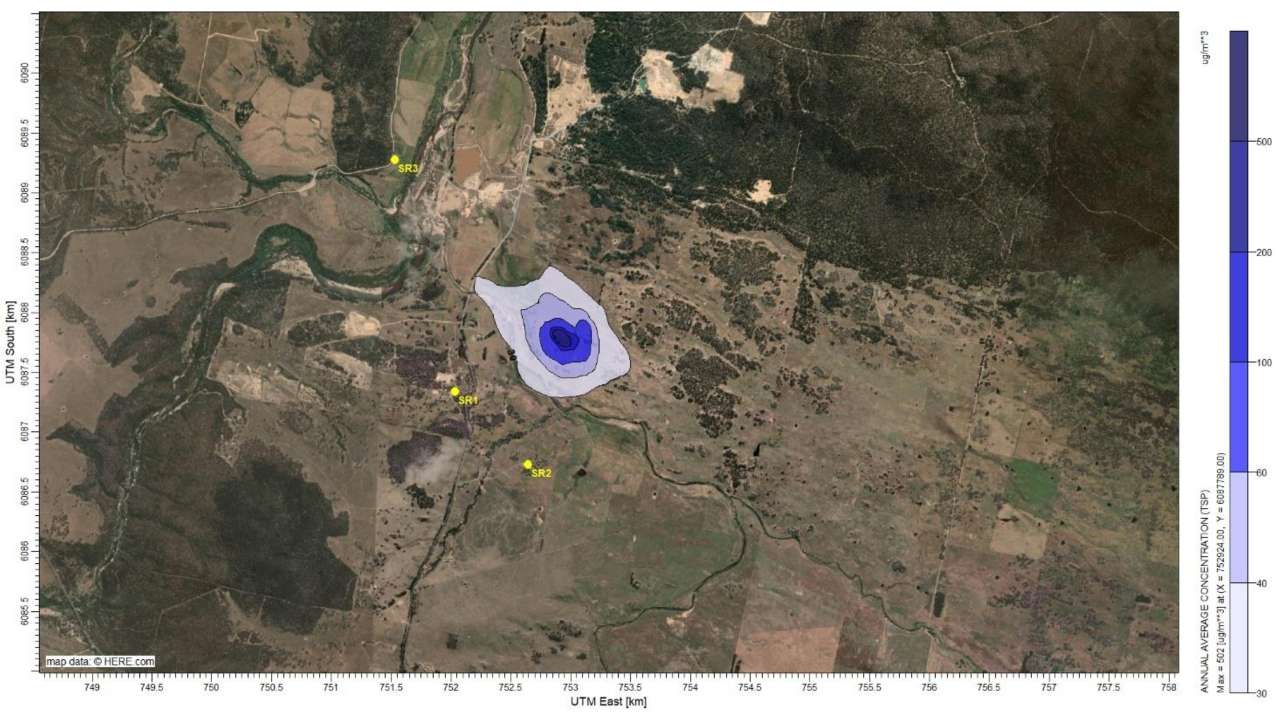
Comment:
Cumulative



Pollutant:	Averaging Period:	Percentile:	Criteria:
$PM_{2.5}$	24 Hour	100th	25 µg/m^3

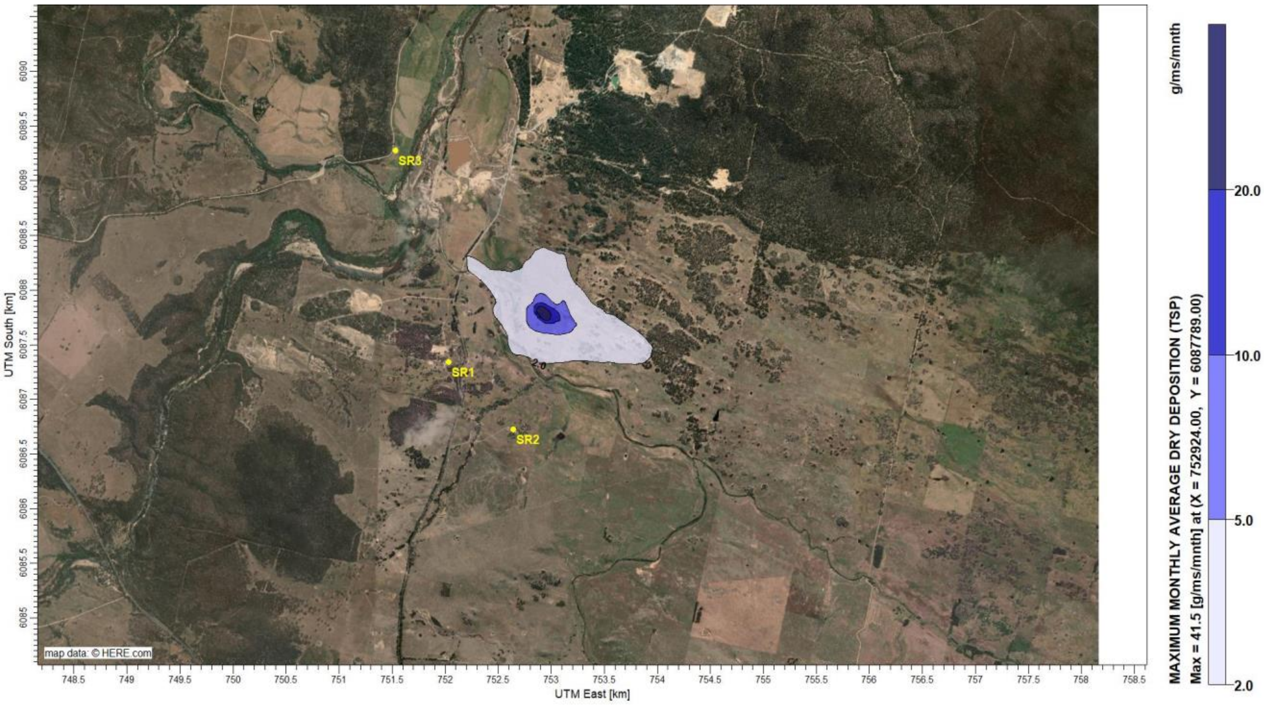
Comment:
Cumulative

VIPAC



Pollutant:	Averaging Period:	Percentile:	Criteria:
TSP	Annual	100th	90 µg/m³

Comment:
Cumulative



Pollutant: Dust Deposition	**Averaging Period:** Month	**Percentile:** 100th	**Criteria:** 4 g/m^2/month

Comment:
Cumulative