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

Bolgers Pit Noise, Vibration & Air Quality Impact Assessment

Air Quality Assessment

70B-22-0096-TRP-47532-1

9 February 2023

Job Title:	Bolgers Pit Noise, Vibration & Air Quality Impact Assessment
Report Title:	Air Quality Assessment
Document Reference:	70B-22-0096-TRP-47532-1

Prepared For:	**Prepared By:**
Outline Planning Consultants Pty ltd Level 3, Suite 2301 4 Daydream Street Warriwood, New South Wales, 2102, Australia **Contact:** Gary Peacock **Tel:** 0418242762	Vipac Engineers and Scientists Limited Level 2, 146 Leichhardt Street, Spring Hill, QLD 4000, Australia **Tel:** +61 7 3377 0400

Author:	Stephen Thomas 9 Feb 2023	Air Quality Principal
Reviewer:	Jackson Yu 9 Feb 2023	Team Leader B.I.E.
Issued By:	Stephen Thomas 9 Feb 2023	Air Quality Principal

Revision History:

Rev. #	*Comments / Details of change(s) made*	*Date*	*Revised by:*
Rev. 01	Revised issue	9 Feb 2023	

Executive Summary

An Air Quality Impact Assessment has been carried out in support a to support a development consent for the lateral expansion of an active quarry at No. 809 Oakey Creek Road, Piallaway NSW 2342, known as 'Bolgers Pit'. The Proponent wishes to regularise the use of this quarry and to laterally expand the active quarry pit through the development approval process. The existing disturbed quarry has an area of approximately 3.4ha. A lateral expansion of a further 0.8ha is proposed.

The purpose of this assessment is to evaluate the potential impacts of air pollutants generated by the expansion and to provide recommendations to mitigate any potential impacts that might have an effect on any sensitive receptors.

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

- An emissions inventory of TSP, PM10, PM2.5, 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.
- 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 as part of the impact assessment. Air quality controls are applied to reduce emission rates where applicable.

As summarised in Table ES-1 and Table ES-2, the results of the modelling have shown that the TSP, PM10, PM2.5 and dust deposition predictions comply with the relevant criteria and averaging periods at all sensitive receptors modelled for the Project in isolation.

TSP, dust deposition, PM2.5 and annual average PM10 and predictions are also less than criteria for the Project including background at all sensitive receptors modelled. Whilst the 24-hour average PM10 predictions are above, the exceedances are driven by the elevated background adopted for the assessment, which are already above the criteria. No additional exceedances of the criteria at these receptors are predicted to occur as a result of the proposed quarry operations and best management practices will be implemented to minimise emissions as far as is practical. In the absence of the elevated background therefore, we would anticipate no exceedances of the 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 at these receptors.

Emissions controls for dust abatement were included in the assessment. It should also be noted that some of the planned dust control measures are not easily quantifiable but will also 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.

It is therefore concluded that air quality should not be a constraint to proposed quarry expansion.

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

ID	Predicted Concentrations (µg/m³)					Dust deposition (g/m2/month)	Compliant
	PM10		PM2.5		TSP		
	24 h	Annual	24 h	Annual	Annual	Month	
R1[a]	8.34	0.96	1.55	0.18	1.46	0.20	✓
SR2	8.51	0.45	1.52	0.08	0.57	0.13	✓
SR3	5.37	0.32	0.97	0.06	0.36	0.09	✓
SR4	10.11	0.65	1.84	0.12	1.00	0.09	✓
SR5	2.12	0.09	0.38	0.02	0.09	0.03	✓
Criteria	**50**	**25**	**25**	**8**	**90**	**2**	

a Not identified as a sensitive receptor

Table ES-2: Summary of Results – Cumulative

ID	Predicted Concentrations (µg/m³)					Dust deposition (g/m2/month)	Compliant
	PM10		PM2.5		TSP		
	24 h[b]	Annual	24 h	Annual	Annual	Month	
R1[a]	60.04	16.26	19.15	7.78	58.46	2.20	✓
SR2	60.21	15.75	19.12	7.68	57.57	2.13	✓
SR3	57.07	15.62	18.57	7.66	57.36	2.09	✓
SR4	61.81	15.95	19.44	7.72	58.00	2.09	✓
SR5	53.82	15.39	17.98	7.62	57.09	2.03	✓
Criteria	**50**	**25**	**25**	**8**	**90**	**4**	

a Not identified as a sensitive receptor

b No additional exceedances of the 24 hour average PM10 criteria are predicted to occur as a consequence of the proposed quarry operations. 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 at these receptors.

Table of Contents

1 INTRODUCTION

1.1 OVERVIEW

Vipac Engineers and Scientists Ltd (Vipac) was engaged by Outline Planning Consultants Pty Ltd on behalf of Gunnedah Shire Council (the Proponent) to prepare an air quality assessment to support a development consent for the lateral expansion of an active quarry (the Project) at No. 809 Oakey Creek Road, Piallaway NSW 2342, known as 'Bolgers Pit'.

1.2 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 to issue its general terms of approval[1]. 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
3.1. The EIS must demonstrate the proposal's ability to comply with the relevant regulatory framework, specifically the Protection of the Environment Operations (POEO) Act (1997) and the POEO (Clean Air) Regulation (2022). Particular consideration should be given to section 129 of the POEO Act concerning control of "offensive odour".	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 modest lateral extension of the quarry. It is noted that the proposed activities are not expected to generate any "offensive odour".
3.2. 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 (2016)[1].	A quantitative Level 2 air quality assessment is prepared in accordance with the Approved Methods (2022). See Section 6.
3.3. 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 and associated air quality limits or guideline criteria.	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 7.

1. A 2022 update to the 'Approved Methods' was gazetted in 2022 and replaces the document dated August 2016

[1] SEARs are yet to be issued. However, the EPA has identified the information it requires to issue its general terms of approval (letter communication dated 5/9/22) which are addressed here.

2 PROJECT DESCRIPTION

2.1 SITE DESCRIPTION

'Bolgers Pit' is one of Council's larger borrow pits, located at No. 809 Oakey Creek Road, Piallaway NSW 2342, in the south-east portion of the Gunnedah Shire, located approximately 32km to the south-east of the Gunnedah township.The Proponent wishes to regularise the use of this quarry and to laterally expand the active quarry pit through the development approval process. The existing disturbed quarry has an area of approximately 3.4ha. A lateral expansion of a further 0.8ha is proposed.

The Project Site location, approximate quarry footprint and proposed expansion are illustrated in Figure 2-1 and Figure 2-2.

2.2 SURROUNDING ENVIRONMENT

Bolgers Pit site is located in the Gunnedah Shire in northern NSW. Gunnedah Shire is a largely rural area, with most of the population living in the township of Gunnedah and the villages of Breeza, Carroll, Curlewis, Mullaley and Tambar Springs. The nearest village, Breeza, lies approximately 29km to the south west.

The surrounding area comprises mainly rural properties on large agricultural holdings, with livestock grazing and the growing of grain the predominant land uses. Most of the land to the west is cleared and cultivated land, with forested land immediately to the east and to the north.

The locality is sparsely populated, with the nearest rural residences described in the following:

- R1 – Approximately 500m south of the active quarry face and is a Bolgers Pit property ('Mimbil') and therefore not a sensitive receptor, R1.
- SR2 – The active quarry face is approximately 645m to the south-west of the nearest rural dwelling, located on the west side of Oakey Creek Road ('Coppins'), SR2.
- SR3 – The active quarry face is approximately 660m to the south of a rural dwelling, located on the east side of Oakey Creek Road ('Wyalla'), SR3.
- SR4 – The quarry is approximately 684m to the north-east of a rural dwelling, located on the west side of Oakey Creek Road ('Yarralee'), SR4.

The locations of the nearest potentially affected residences (air sensitive receptors) to the quarry are shown in Figure 2-3.

Figure 2-1: Project Site Location

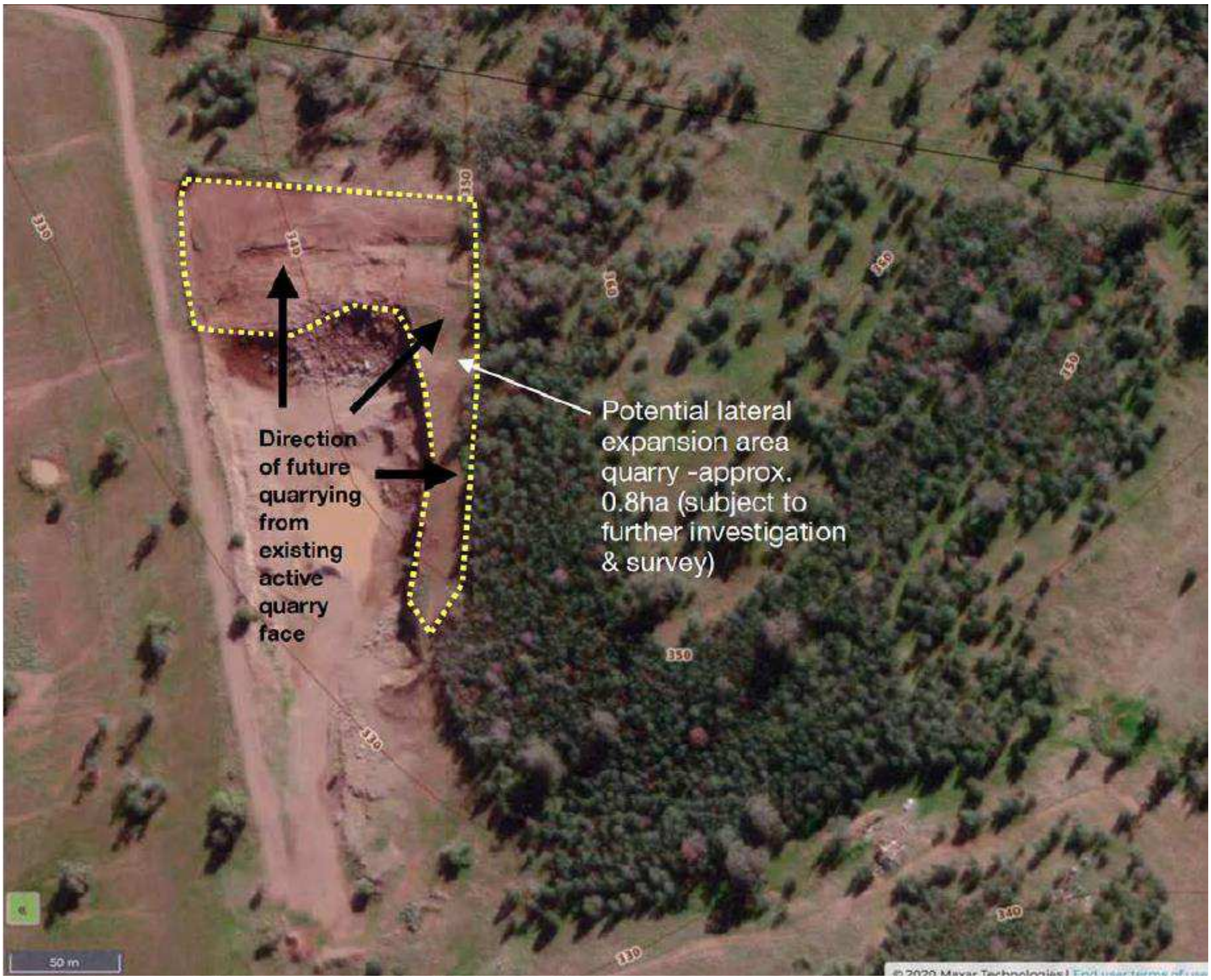


Figure 2-2: Proposed Expansion

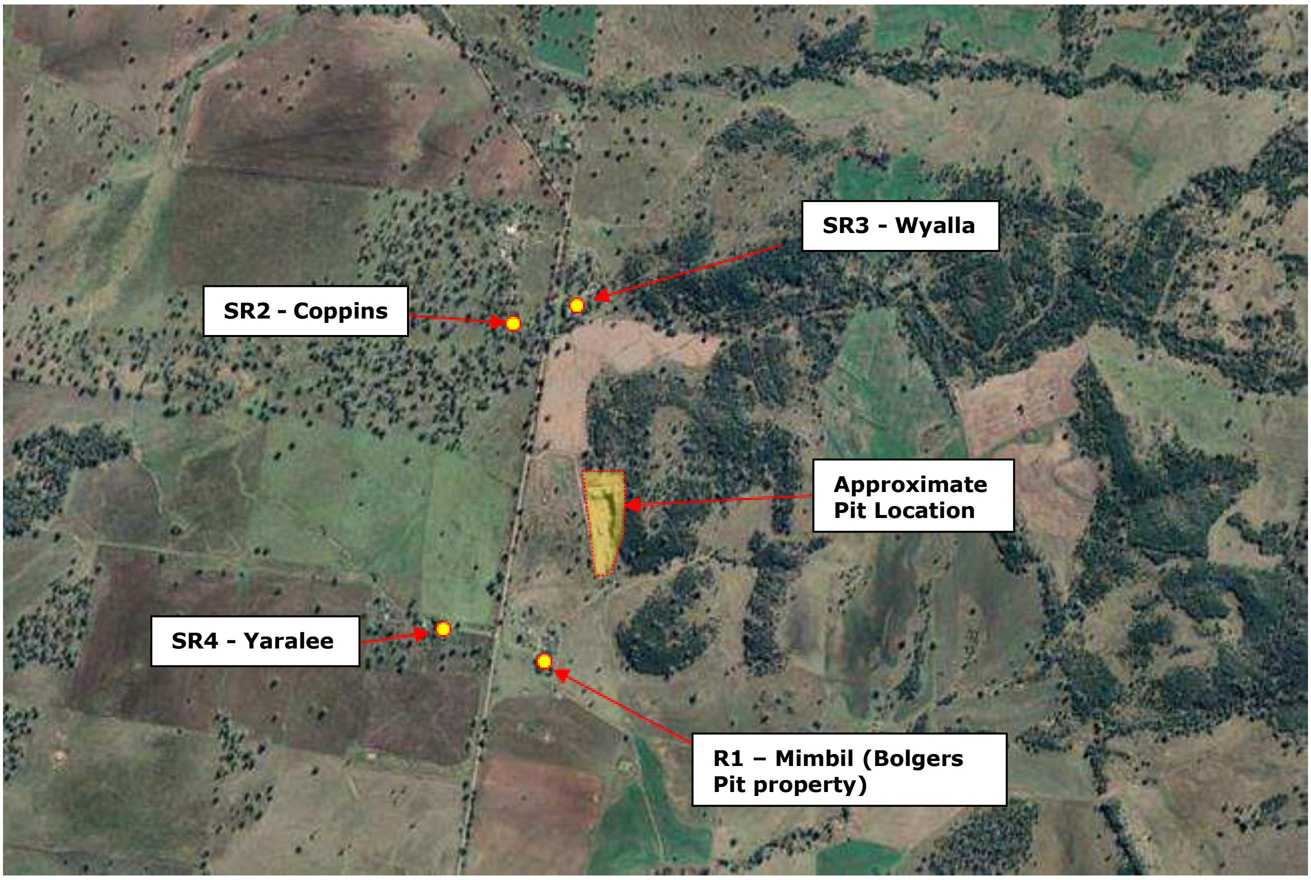


Figure 2-3: Sensitive Receptor Locations

2.3 QUARRY OPERATION

2.3.1 EXISTING

The existing operations involve extraction from the north-eastern part of the quarry pit, with processing of quarry products in the processing area and stockpiling of quarry products prior to dispatch by road via Oakey Creek Road.

The site does not contain any existing infrastructure, save for sediment ponds and road access back from the quarry pit to Oakey Creek Road. All quarry processing plant is brought into the site on a campaign basis, as required. To date, the quarry has produced up to 18,355 tonnes of quarry product in any one year (2018). The quarry material at this quarry is won by blasting of the quarry rock.

2.3.2 PROPOSED OPERATIONS

Council proposes to regularise the use of the site as a quarry at the same time as seek approval for a modest lateral extension of the quarry. A lateral expansion of a further 0.8ha or more is proposed, with a rate of extraction of up to 40,000 tonnes per annum and a total additional resource of just over 125,000 cubic metres-equivalent to about 300,000 tonnes. Table 2-1 summarises the key project components.

Table 2-1: Key Project Components

Quarry component	Summary description
Extraction Method	Bulldozer used to remove weathered sandstone, with drill and blast used for unweathered sandstone.
Resource	Weathered and unweathered sandstone, benched where required.
Disturbance area	A lateral expansion of a further 0.8ha or more is proposed [subject to further design and site review].
Processing	Crushing and screening of unweathered and weathered sandstone material.
Annual extraction	Up to 40,000 tonnes per annum.

Transport	Access to the quarry to be from Oakey Creek Road, the existing quarry haul route. A mix of 6-7 axle quarry trucks (24-30 tonnes carrying capacity) and truck and dog combination (32 tonnes), with smaller trucks may be used. It is anticipated that the quarry may generate up to 40 loaded quarry trucks per day.
Hours of operation	Limited to 7.00am to 6.00pm Monday to Friday (ie. 11 hours operation per day) and 7.00am to 1.00pm on Saturdays (ie. 6 hours operation). Hours of blasting are to be restricted to 9.00am to 3.00pm Monday to Friday.

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 MEASURE FOR AMBIENT AIR QUALITY

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 $PM_{2.5}$ standards. 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 CONSERVATIONS 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.

4.2.2 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997

The general obligations of the Protection of the Environment Operations Act, 1997 and the Regulations made under the Act (namely the Protection of the Environment Operations (Clean Air) Regulation, 2010) would be followed at the Project and the Project would be operated in accordance with the relevant regulatory framework for air quality to ensure compliance with this legislation.

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 of the quarry is undulating to moderate, with slopes of up to about 11% or more and with elevations ranging from RL 350m at the northern end of the quarry, down to about RL 325m at the southern end. The quarry floor slopes in a southerly direction from about RL340m to RL325m. The Melville Range is a dominant terrain feature that lies approximately 3.5km east of the quarry extending 25km in a north to south direction. The range peaks at about 850m and may be expect to influence wind conditions in its surrounding environment.

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.

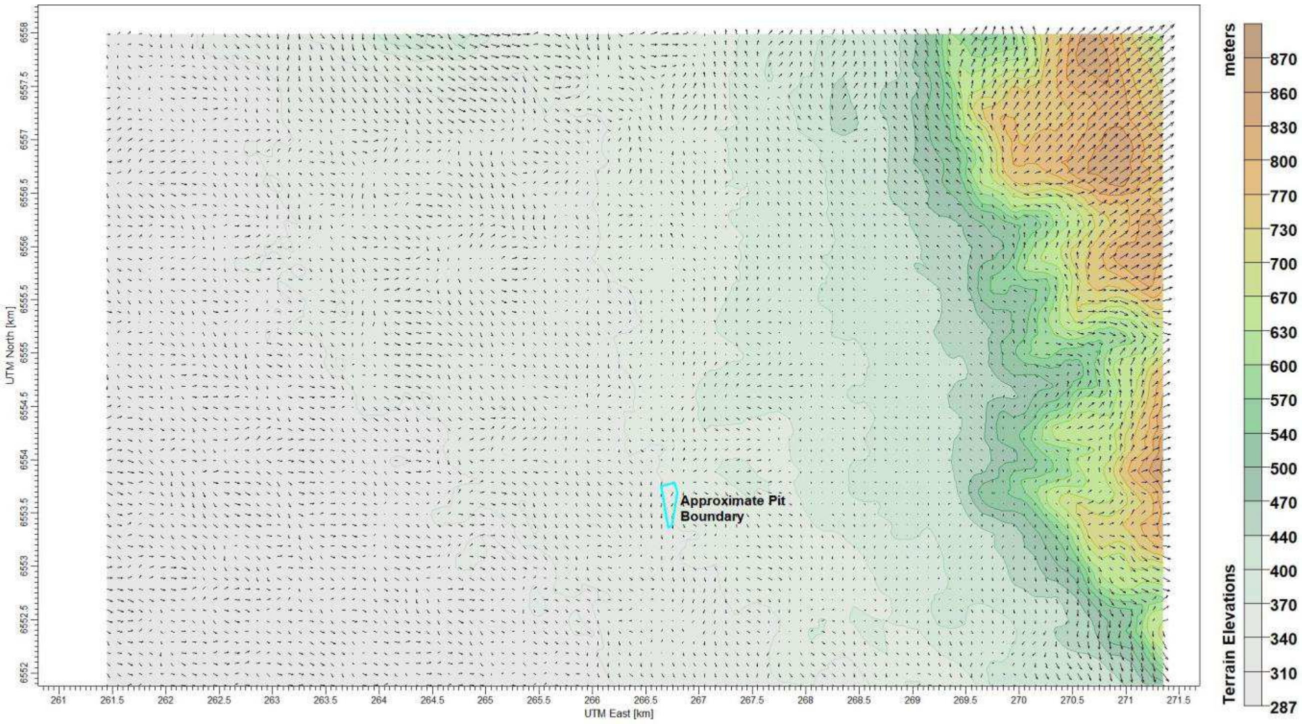


Figure 5-1: Terrain Wind Influences

5.2 DISPERSION METEOROLOGY

5.2.1 REGIONAL METEOROLOGY

The nearest Bureau of Meteorology (BOM) station with long term data is at Gunnedah Pool (Site number 055023), located approximately 32 km north west of the Project site. This monitoring station has recorded data since 1876 and a summary of the climate is presented in Table 5-1.

The long term mean temperature range is between 3°C and 34°C with the coldest month being July and the hottest months being December to March. On average, most of the annual rainfall is received between December and February. Rainfall is lowest between April and September, with a low mean annual rainfall of 621 mm. Rainfall reduces the dispersion of air emissions and therefore the potential impact on visual amenity and health.

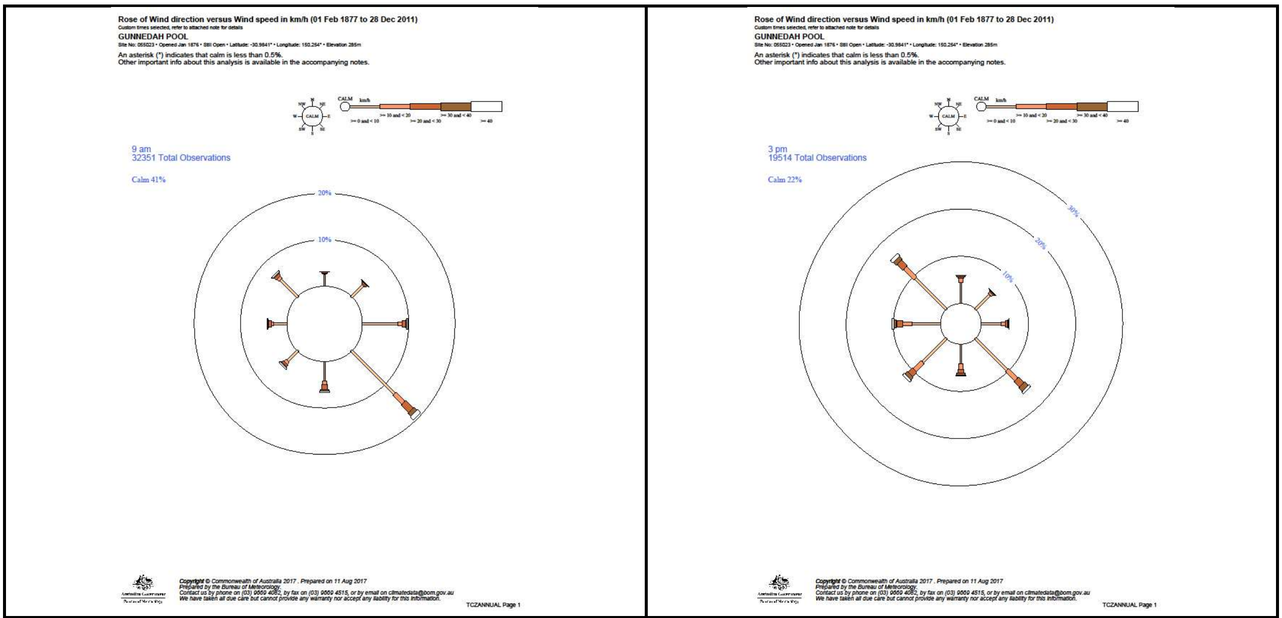
Table 5-1: Long-term weather data for Gunnedah Pool [BOM]

Month	Temperature		Rainfall		9 am Conditions			3 pm Conditions		
	Max (°C)	Min (°C)	Mean Rain Days	No. of Days ≥ 1 mm	Temp (°C)	RH (%)	Wind Speed (km/h)	Temp (°C)	Mean RH (%)	Wind Speed (km/h)
Jan	34.0	18.4	70.6	5.5	25	61	7.6	31.2	43	9.6

Feb	32.9	18.1	66.1	5.0	23.8	65	8.3	30.3	45	9.1
Mar	30.7	15.8	48.9	4.0	22.1	65	8.1	28.7	44	9.4
Apr	26.4	11.4	36.6	3.4	18.3	67	6.7	24.9	46	8.7
May	21.3	7.1	42.0	4.0	13.3	73	5.8	20.0	51	7.5
Jun	17.6	4.3	44.0	4.8	9.8	79	5.8	16.7	55	8.8
Jul	16.9	3.0	41.5	4.7	8.8	77	5.3	15.8	53	9.8
Aug	18.9	4.2	40.9	4.7	10.9	71	5.8	17.7	48	10.6
Sep	22.8	7.0	40.2	4.5	15.0	65	6.7	21.3	44	10.9
Oct	26.7	10.8	54.2	5.3	19.1	61	7.9	24.5	43	10.4
Nov	30.3	14.2	61.4	5.6	22.1	59	7.8	27.7	40	11.0
Dec	32.9	16.8	69.6	6.0	24.4	58	7.3	30.2	40	10.3
Annual	**26**	**10.9**	**615.7**	**57.5**	**17.7**	**67**	**6.9**	**24.1**	**46**	**9.7**

A review of the number of rainfall days per year at Gunnedah shows that on average rainfall, is recorded on 57.5 days per year and the number of days where rainfall is ≥ 1 mm is 16% of the annual rainfall days are ≥ 1 mm.

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



Location: **Gunnedah BoM Station**	**Data Period: 1876 to 2011**	**Data Type: Measured Data**

Figure 5-2: Annual wind roses for Gunnedah Weather Station (1876 to 2011)

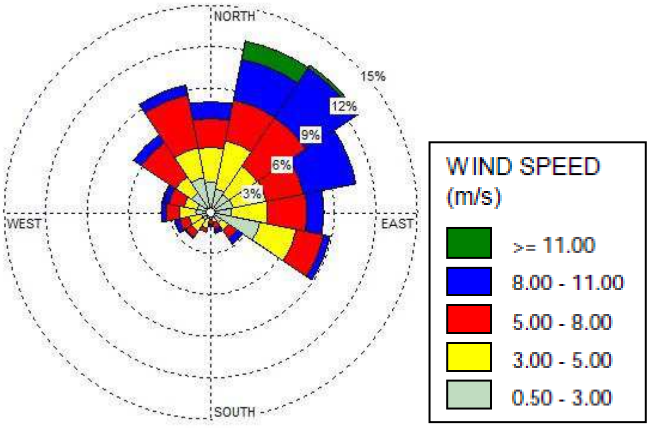
5.2.2 LOCAL METEOROLOGY

5.2.2.1 INTRODUCTION

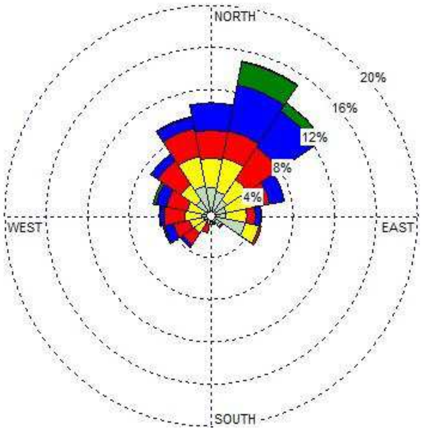
A three dimensional meteorological field was required for the air dispersion modelling that includes a wind field generator accounting for slope flows, terrain effects and terrain blocking effects. The Air Pollution Model, or TAPM, is a three-dimensional meteorological and air pollution model developed 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 2016 and approximately centred at the proposed Project has been used to provide further information on the local meteorological influences. Details of the modelling approach are provided in Section 6.2.

5.2.2.2 WIND SPEED AND DIRECTION

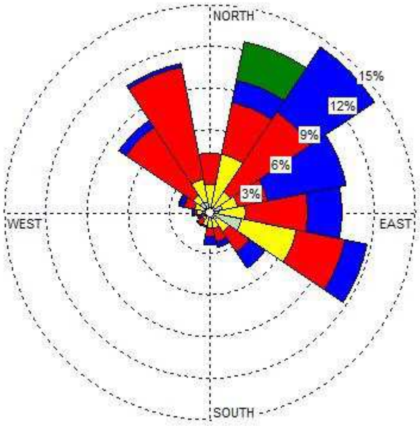
The wind roses from the TAPM-CALMET derived dataset for the year 2016 are presented in Figure 5-3 and Figure 5-4 for the Project site. Figure 5-3 shows that the dominant wind direction is from the north east direction for all season. Overall, winds from the south are infrequent which would have the potential to carry any generated dust in the northerly direction towards SR2, SR3 and SR5.



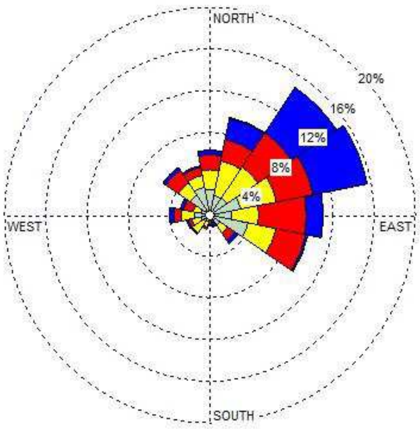
Annual (Calm – 3.2 %)



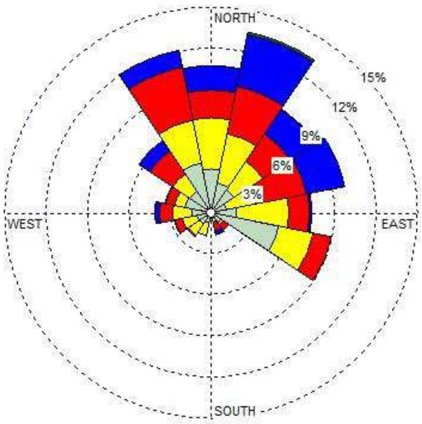
Spring (Calm – 3.3 %)



Summer (Calm – 1.3 %)



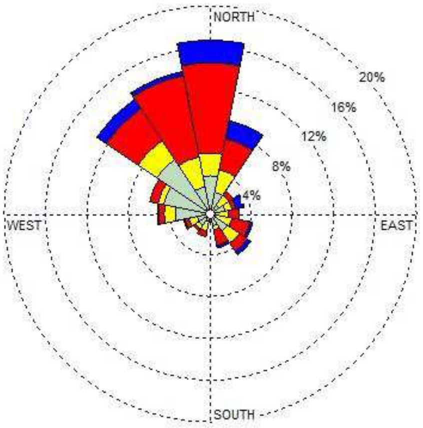
Autumn (Calm – 3.7 %)



Winter (Calm – 4.3 %)

Figure 5-3: Site-specific wind roses by season for the TAPM-CALMET derived dataset, 2016

Figure 5-4 shows the wind roses for the time of day during the year for 2016. It can be seen that winds are primarily from the north to north west directions in the morning and that there are more frequent and stronger winds from the west during the afternoon periods.



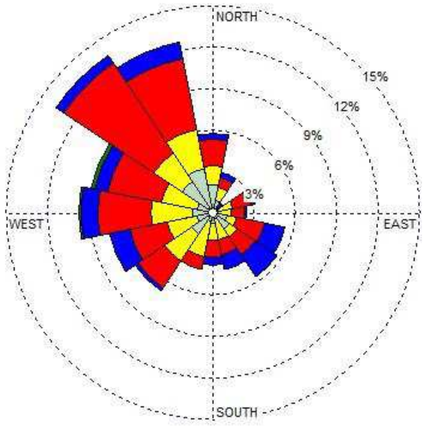


Figure 5-4: Site-specific wind roses by time of day for the TAPM-CALMET derived dataset, 2016

A comparison of the wind roses at 9am and 3pm hours for the TAPM-CALMET derived dataset (Figure 5-4) at the Project site was also undertaken with the BOM long-term wind roses at Gunnedah (Figure 5-2). There are similarities between the wind roses from BOM and derived dataset, most notably the dominance of winds from the north west in both datasets and more frequent winds from the west in the afternoon. As discussed in Section 5.1, the terrain in the environment surrounding Bolgers Pit is dominated by Melville Range which influences wind patterns and may explain some of the differences between the wind roses from the measured and model derived datasets.

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 2016 is shown in Figure 5-5.

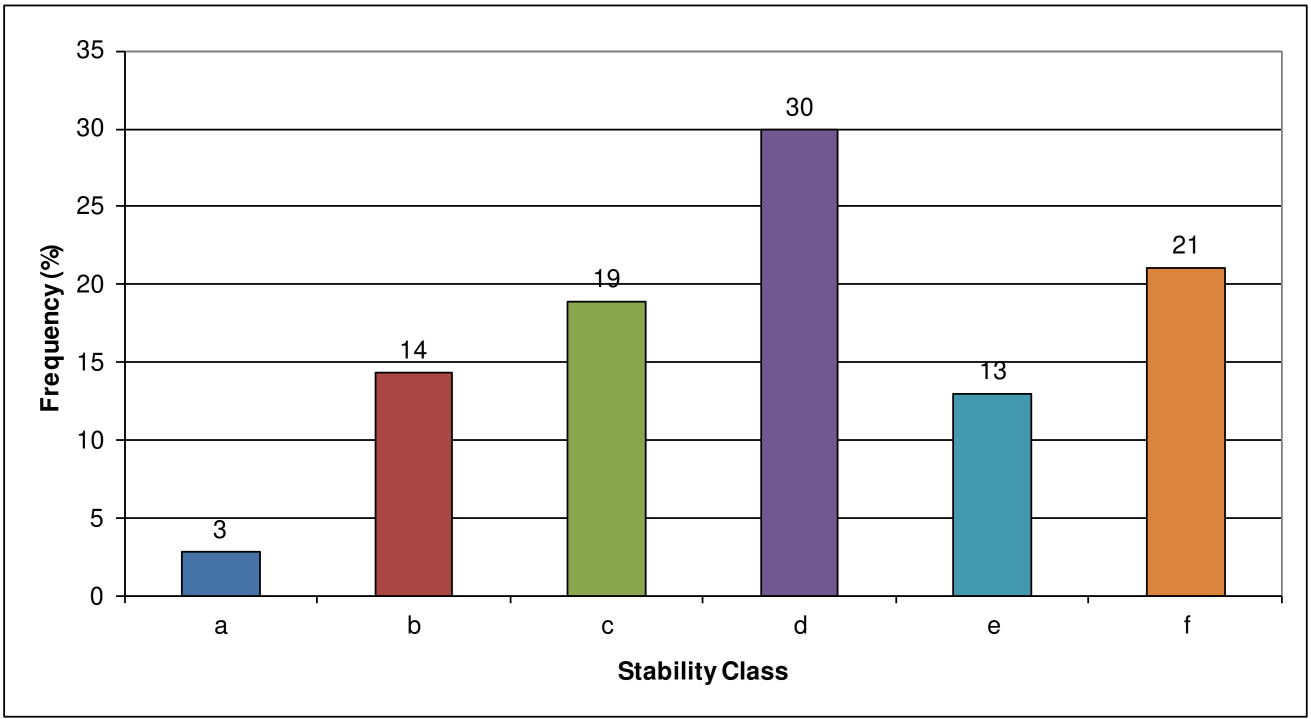


Figure 5-5: Stability class frequency for the TAPM-CALMET derived dataset, 2016

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.

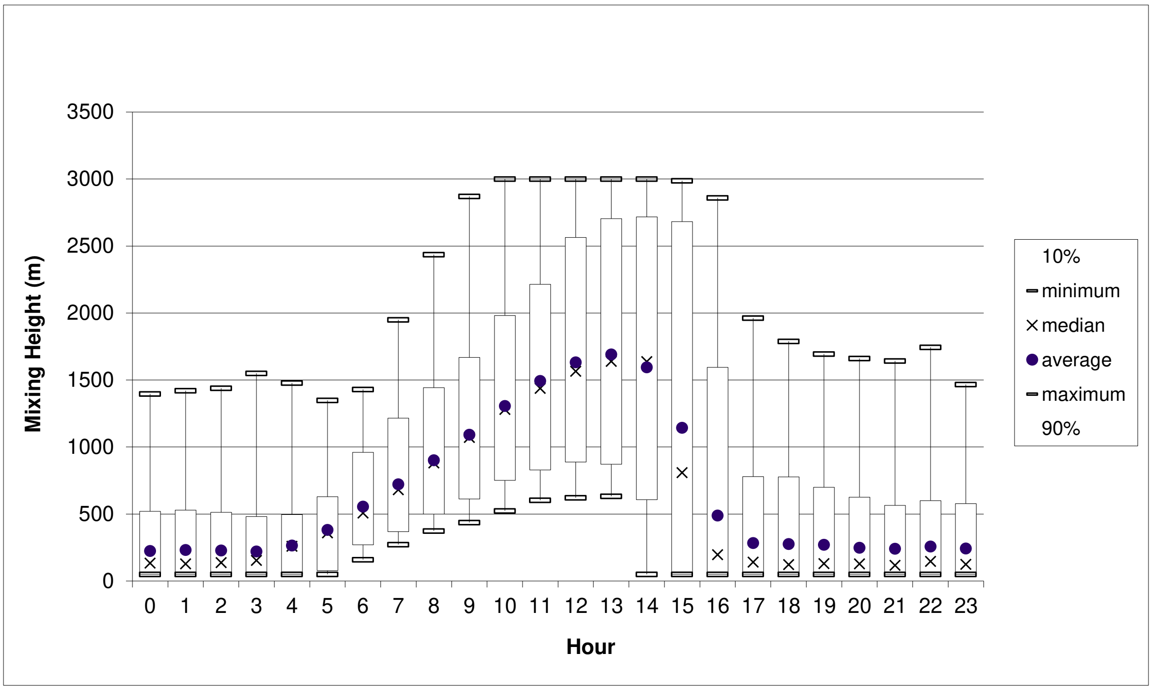


Figure 5-6: Mixing height for the TAPM-CALMET derived dataset, 2016

5.3 EXISTING AIR QUALITY

5.3.1 OVERVIEW

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 Tamworth, approximately 70 km to the east. The Tamworth air quality monitoring station is located in Hyman Park, off Robert Road and Vue Street in the rural service town of Tamworth on the north-west slopes. Of the pollutants of interest, PM10 and PM2.5 are measured at the Tamworth site.

5.3.2 ADOPTED BACKGROUND

Table 5-2 summarises the measured data collected at Tamworth for 2016. It is noted that the adopted background for 24 hour average PM10 as measured at Tamworth is above the project criteria.

Where unavailable, a conservative assumption is adopted. For example, annual TSP background is derived as 2.5 x measured PM10 based on data collected around Australian mines (ACARP, 1999).

Table 5-2: Assigned Background Concentrations

Parameter	Air Quality Criteria	Period	Maximum Measured	Adopted background	Comments
TSP	90 µg/m^3	**Annual**	n.d.	57 µg/m^3	Conservative assumption
PM_{10}	50 µg/m^3	**24 Hour**	51.7 µg/m^3	Varying	NSW EPA Measurement
	25 µg/m^3	**Annual**	15.3 µg/m^3	15.3 µg/m^3	
$PM_{2.5}$	25 µg/m^3	**24 Hour**	17.6 µg/m^3	17.6 µg/m^3	
	8 µg/m^3	**Annual**	7.6 µg/m^3	7.6 µg/m^3	

Dust Deposition	2 g/m^2/month	**Month**	n.d.	-	-
	4 g/m^2/month	**Month**	n.d.	2 g/m^2/month	Conservative assumption

n.d. do data

6 METHODOLOGY

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

- An emissions inventory of TSP, PM10, PM2.5, 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 4.3 as part of the impact assessment (Section 7). 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 quarry 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
- blasting and drilling

In addition, air pollutants from diesel combustion may release other air pollutants such as particulate matter, (PM10 and PM2.5), 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

The operational scenario representing maximum activities for the proposed expansion of the pit has been modelled for this assessment.

6.1.4 EMISSION CONTROLS

Emissions controls for dust abatement were included in the emissions estimation, summarised in 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.
- Stockpile limits to 6m in height.
- Drill Rig fitted with engineered dust extraction / suppression as appropriate.
- Progressively establish vegetation on any topsoil/overburden stockpiles and rehabilitated landforms and in buffers.
- Material drop-height will be minimised during stockpile building.

6.1.5 EMISSIONS BY SOURCE

As discussed in Section 6.1, 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. It should be noted that all sources are classed as fugitive and there are no point sources associated with this project.

Table 6-1: Calculated Annual Emissions by Source (t/year)

Fugitive Source	TSP	PM10	PM2.5
Wind erosion (Pit & Stockpiles)	7.4	3.7	0.8
Wheel generated dust (Hauling internal and external)	28.4	8.6	0.5
Pit activities (Pit)	15.8	7.1	1.7
Blasting/drilling (Pit)	1.1	0.6	0.1
Processing	4.7	1.9	0.1
Total	**52.8**	**20.0**	**3.0**

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 – 31.1333° S, 150.55° E;
- Dates modelled – 30th December 2015 to 31st December 2016 (2 start up days);
- 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 Gunnedah; 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 change in topography as discussed in Section 5.1, the radius of influence of terrain features was set at 20 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'*.

6.2.4 OTHER MODELLING INPUT PARAMETERS

6.2.4.1 PARTICLE SIZE DISTRIBUTION

CALPUFF requires particle distribution data (geometric mass mean diameter, standard deviation) to compute the dispersion of particulates (Table 6-2).

Table 6-2: Particle size distribution data

Particle size	Mean particle diameter (µm)	Geometric standard deviation (µm)
TSP	15	2
PM10	4.88	1
PM2.5	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, PM10 and PM2.5 and dust deposition for the proposed operation of the Project.

The results of the dispersion modelling include individual sensitive receptor and contour plots that are indicative of ground-level concentrations and deposition. This impact assessment requires the predictions to be presented as follows:

- The incremental impact of each pollutant as per the criterion units and time periods;
- The cumulative impact (incremental plus background) for the 100th percentile (i.e. maximum value) in units as per the criterion and time periods.

7.1 TSP

The predicted annual average TSP 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/m^3)

ID	Predicted Annual Average TSP Concentrations (µg/m^3)	
	Incremental	**Cumulative**
R1[a]	1.46	58.46
SR2	0.57	57.57
SR3	0.36	57.36
SR4	1.00	58.00
SR5	0.09	57.09
Criteria	**90**	

a	Not identified as a sensitive receptor

7.2 PM10

The maximum predicted 24 hour (including maximum measured background of 51.7 µg/m^3) and annual average (including measured annual background of 15.3 µg/m^3) PM10 are presented in *Table 7-2* and *Table 7-3*.

Table 7-2 shows that the model predictions for annual average PM10 are below the criteria of 25 µg/m^3 at all sensitive receptors modelled.

The model predictions for cumulative 24 hour average PM10 are above the criteria of 50 µg/m^3. As noted in Section 5.3, the measured 24 hour background PM10 of 51.7 µg/m^3 is already above the criteria of 50 µg/m^3. 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 measured background and predicted data is therefore undertaken here in accordance with the worked example.

Table 7-3 provides the maximum cumulative concentrations at each receptor including contemporaneous background concentrations and associated number of exceedances of the criteria for the modelled year. As shown in *Table 7-3*, one exceedance of the 24 hour average PM10 criteria (50 µg/m^3) is predicted at the sensitive receptors modelled (R1 to SR5). The greatest contribution of the quarry emissions on the day of the exceedance to the cumulative PM10 is 1.1 µg/m^3 at R1 and does not contribute to any additional exceedances of the relevant criteria on any other day. 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 for the sensitive receptors.

The 24 hour and annual average PM_{10} emissions from the proposed Project are therefore 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 PM10 Concentrations (μg/m³)

ID	Predicted 24 Hour Average PM10 Concentrations (μg/m³)		Predicted Annual Average PM10 Concentrations (μg/m³)	
	Incremental	**Cumulative**	**Incremental**	**Cumulative**
R1[a]	8.34	60.04	0.96	16.26
SR2	8.51	60.21	0.45	15.75
SR3	5.37	57.07	0.32	15.62
SR4	10.11	61.81	0.65	15.95
SR5	2.12	53.82	0.09	15.39
Criteria	**50**		**25**	

a Not identified as a sensitive receptor

Table 7-3: Predicted Cumulative 24 Hour Average PM10 Concentrations and Number of Exceedances

ID	Predicted Cumulative 24 Hour Average PM10 Concentrations (μg/m³)	Number of Exceedances[a]
R1[b]	52.8	1
SR2	51.7	1
SR3	51.7	1
SR4	51.7	1
SR5	51.7	1
Criteria	**50**	

a Note - number of exceedances of criteria by measured background data is 1

b Not identified as a sensitive receptor

7.3 PM2.5

The maximum predicted 24 hour (including maximum measured background of 17.6 μg/m³) and annual average (including measured annual background of 7.6 μg/m³) PM2.5 are presented in Table 7-4.

As shown in Table 7-4, the cumulative model predictions for 24 hour and annual average PM2.5 are below the 25 μg/m³ and 8 μg/m³ criteria, respectively.

The 24 hour and annual average PM2.5 emissions from the proposed Project are therefore 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 PM2.5 Concentrations

ID	Predicted 24 Hour Average PM2.5 Concentrations (μg/m³)		Predicted Annual Average PM2.5 Concentrations (μg/m³)	
	Incremental	**Cumulative**	**Incremental**	**Cumulative**
R1[a]	1.55	19.15	0.18	7.78
SR2	1.52	19.12	0.08	7.68
SR3	0.97	18.57	0.06	7.66
SR4	1.84	19.44	0.12	7.72
SR5	0.38	17.98	0.02	7.62
Criteria	**25**		**8**	

a Not identified as a sensitive receptor

7.4 DUST DEPOSITION

The maximum predicted monthly average dust deposition are presented in Table 7-5.

The model predictions for incremental and cumulative monthly average dust deposition are well 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. Contour plots are provided in ***Appendix B***.

Table 7-5: Predicted Monthly Average Dust Deposition

ID	Predicted Monthly Average Dust Deposition (g/m^2/month)	
	Incremental	**Cumulative**
R1[a]	0.20	2.20
SR2	0.13	2.13
SR3	0.09	2.09
SR4	0.09	2.09
SR5	0.03	2.03
Criteria	**2**	**4**

a Not identified as a sensitive receptor

8 CONCLUSION

An Air Quality Impact Assessment has been carried out in support a to support a development consent for the lateral expansion of an active quarry at No. 809 Oakey Creek Road, Piallaway NSW 2342, known as 'Bolgers Pit'. The Proponent wishes to regularise the use of this quarry and to laterally expand the active quarry pit through the development approval process. The existing disturbed quarry has an area of approximately 3.4ha. A lateral expansion of a further 0.8ha is proposed.

As summarised in Table 8-1 and Table 8-2, the results of the modelling have shown that the TSP, PM10, PM2.5 and dust deposition predictions comply with the relevant criteria and averaging periods at all sensitive receptors modelled for the Project in isolation.

TSP, dust deposition, PM2.5 and annual average PM10 predictions are also less than criteria for the Project including background at all sensitive receptors modelled. Whilst the cumulative 24 hour average PM10 predictions are slightly above criteria at all sensitive receptors, the exceedances are driven by the elevated background adopted for the assessment, which are already above the criteria. No additional exceedances of the criteria at these receptors are predicted to occur as a result of the proposed quarry operations and best management practices will be implemented to minimise emissions as far as is practical. In the absence of the elevated background, there are no exceedances of the criteria predicted. 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.

It is therefore concluded that air quality should not be a constraint to proposed quarry increase in extraction.

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

ID	Predicted Concentrations (µg/m³)					Dust deposition (g/m²/month)	Compliant
	PM10		PM2.5		TSP		
	24 h	Annual	24 h	Annual	Annual	Month	
R1[a]	8.34	0.96	1.55	0.18	1.46	0.20	✓
SR2	8.51	0.45	1.52	0.08	0.57	0.13	✓
SR3	5.37	0.32	0.97	0.06	0.36	0.09	✓
SR4	10.11	0.65	1.84	0.12	1.00	0.09	✓
SR5	2.12	0.09	0.38	0.02	0.09	0.03	✓
Criteria	**50**	**25**	**25**	**8**	**90**	**2**	

Table 8-2: Summary of Results – Cumulative

ID	Predicted Concentrations (µg/m³)					Dust deposition (g/m²/month)	Compliant
	PM10		PM2.5		TSP		
	24 h[b]	Annual	24 h	Annual	Annual	Month	
R1[a]	60.04	16.26	19.15	7.78	58.46	2.20	✓
SR2	60.21	15.75	19.12	7.68	57.57	2.13	✓
SR3	57.07	15.62	18.57	7.66	57.36	2.09	✓
SR4	61.81	15.95	19.44	7.72	58.00	2.09	✓
SR5	53.82	15.39	17.98	7.62	57.09	2.03	✓
Criteria	**50**	**25**	**25**	**8**	**90**	**4**	

a Not identified as a sensitive receptor

b No additional exceedances of the 24 hour average PM10 criteria are predicted to occur as a consequence of the proposed quarry operations. 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 at these receptors.

Appendix A EMISSIONS ESTIMATION

A.1 Emission Estimation Equations

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.

Excavators, Front Wheel Loaders on Overburden

The default emission rates in the NPI EET for Mining have been used for this emission factor.

Crushing and Screening

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

Drilling

The default emission rates in the NPI EET for Mining and have been used for these emission factors. 10% PM_{10} is $PM_{2.5}$. 100 holes per day is the estimated rate.

Blasting

The TSP emission rate for blasting has been calculated using the following equation:

$$Emissions_{\text{TSP}} = 0.00022\ x\ Area\ blasted\ (m^2)^{1.5}\ \text{kg /blast}$$

PM_{10} is TSP multiplied by 0.47 and 10% of PM_{10} is $PM_{2.5}$. Area blasted is 930 m^2 with 1 blast per weekday of operation.

Haul Roads

The default emission rates in the NPI EET for Mining and have been used for these emission factors, where:

TSP = 4.23 kg/VKT

PM_{10} = 1.25 kg/VKT

$PM_{2.5}$ = 17% of TSP is $PM_{2.5}$

Trucks Dumping Overburden

Emission rates for dust from trucks dumping overburden have been calculated using the default emission rates in the NPI EET for Mining:

TSP = 0.012 kg/t

PM_{10} = 0.0043 kg/t

$PM_{2.5}$ = 10.5% of TSP is $PM_{2.5}$

Loading Trucks

Emission rates for dust from loading trucks have been calculated using the default emission rates in the NPI EET for Mining:

TSP = 0.0004 kg/t

PM_{10} = 0.00017 kg/t

$PM_{2.5}$ = 10.5% of TSP is $PM_{2.5}$

Wind Erosion

Emission rates for dust from wind erosion have been calculated using the default emission rates in the NPI EET for Mining:

TSP = 0.4 kg/ha/hr

PM_{10} = 0.2 kg/ha/hr

$PM_{2.5}$ = 10.5% of TSP is $PM_{2.5}$

A.2 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	PM10/TSP ratio	PM2.5/TSP ratio	Units	Controls applied
Pit Activities						
Excavator, FEL on Overburden	0.025	-	0.47	0.105	kg/t	Water sprays, 50%
Trucks dumping overburden	0.012	-	0.36	0.105	kg/t	Water sprays, 50%
Loading trucks	0.0004	-	0.36	0.105	kg/t	Water sprays, 50%
Blasting/drilling:						
Drilling	0.59	-	0.52	0.052	kg/hole	Water sprays, 70%
Blasting	-	6.24	0.47	0.03	kg/blast	No control
Wind erosion:						
stockpiles/pits/haul roads	0.4	-	0.5	0.075	kg/ha/h	Water sprays, 50%
Processing & Handling:						
Primary Crushing	0.01	-	0.40	0.083	kg/t	Water sprays, 50%
Screening	0.08	-	0.75	0.023	kg/t	Water sprays, 50%
Trucks dumping overburden	0.012	-	0.36	0.105	kg/t	Water sprays, 50%
Loading trucks	0.0004	-	0.36	0.105	kg/t	Water sprays, 50%
Wheel generated dust:						
Unpaved roads	4.23	-	0.22	0.02	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	3.3	m/s	mean wind speed	BoM meteorological data
W	32	t	Truck capacity	client supplied
p	58	days	rainfall > 0.25mm	BoM meteorological data
f	16	%	% time winds > 5.4m/s	BoM meteorological data
Holes	100	Holes/day	Holes drilled per day	Client supplied
A	930	m^2/blast	Area blasted	Default
B	1	Blast/day	Blasts per day	Client supplied
s	7.9	%	Silt content	Default
M	6.9	%	Moisture	Default
t	1,280	t/day	Maximum material moved	Client supplied
a	42,000	m^2	Area of land subject to wind erosion	Client supplied

Operating Hours

Extraction and processing of material has been modelled as 7 am to 6 pm on weekdays and 7 am to 1 pm on Saturdays.

Extraction Rates

The project proposes an annual average future extraction rate of 0.04 Mtpa.

Haul Roads

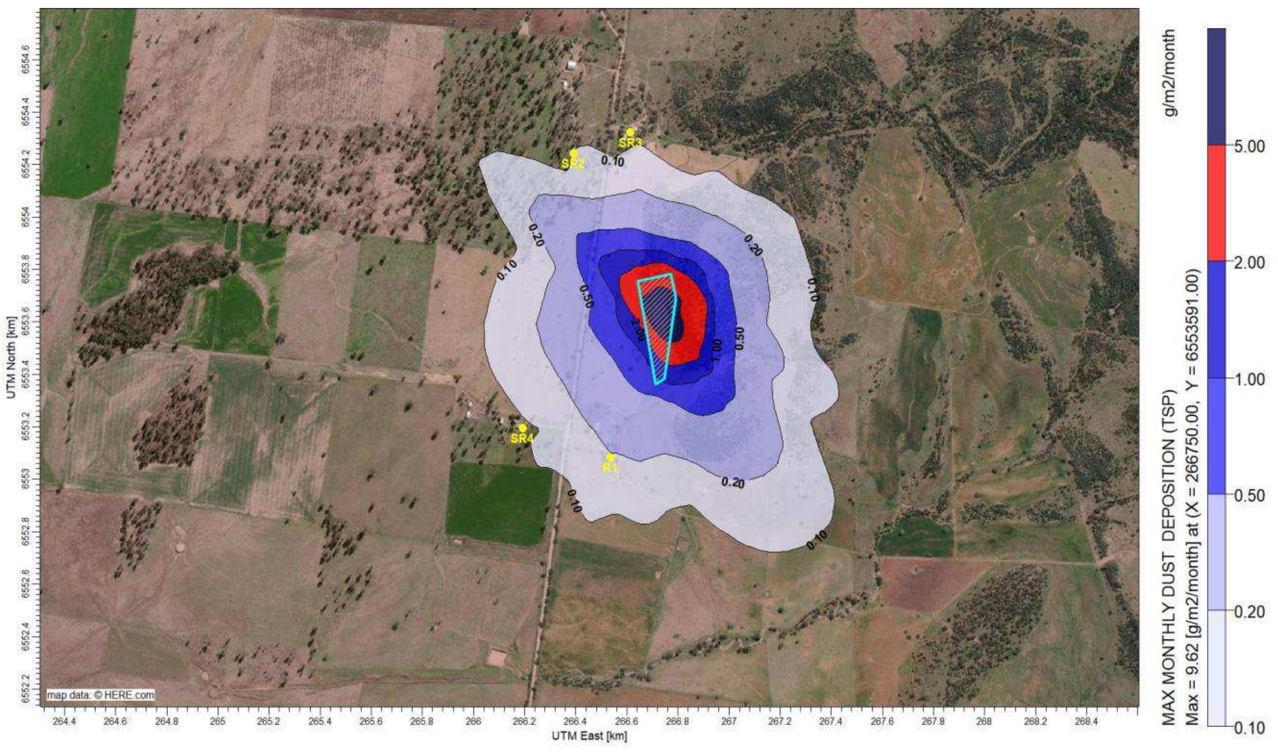
Haul road locations provided and incorporated into the model are summarised below.

Total Haul Road	Modelled Parameter (km)	VKT
External	0.36	2.6 VKT/h
Internal	0.47	3.0 VKT/h

Appendix B Contour Plots

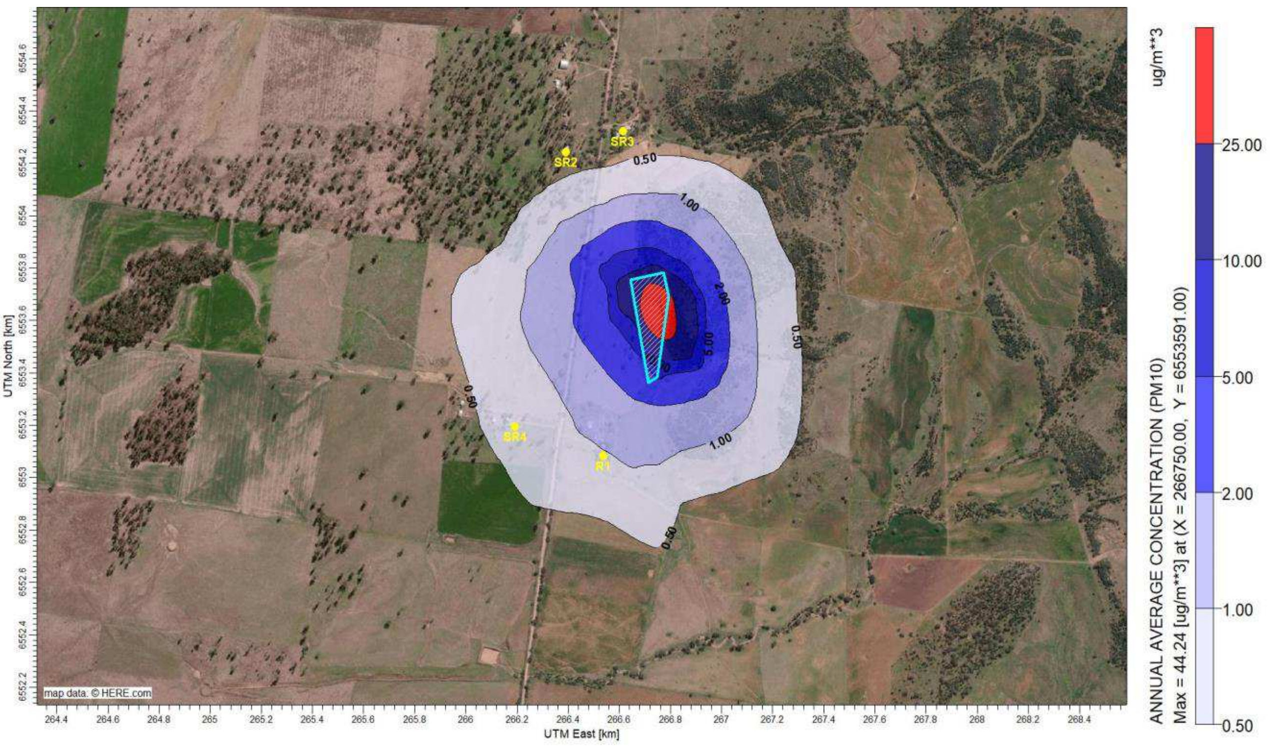
The contour plots are created from the predicted ground-level concentrations at the network of gridded receptors within the modelling domain at frequent intervals. These gridded values are converted into contours using triangulation interpolation in the CALPOST post-processing software within the CALPUFF View software (Version 7.2 - June 2014).

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.



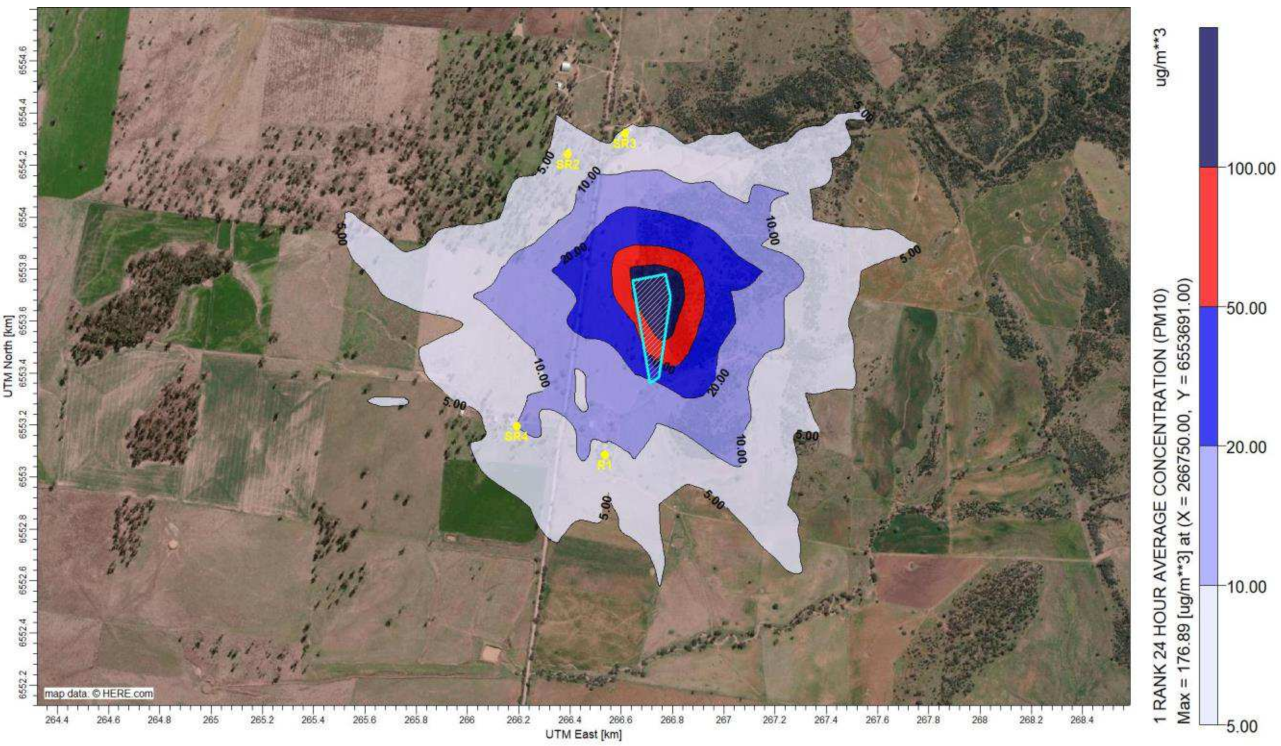
Pollutant: Dust Deposition	Averaging Period: Month	Percentile: 100th	Criteria: 2 g/m^2/month

Comment:
Incremental



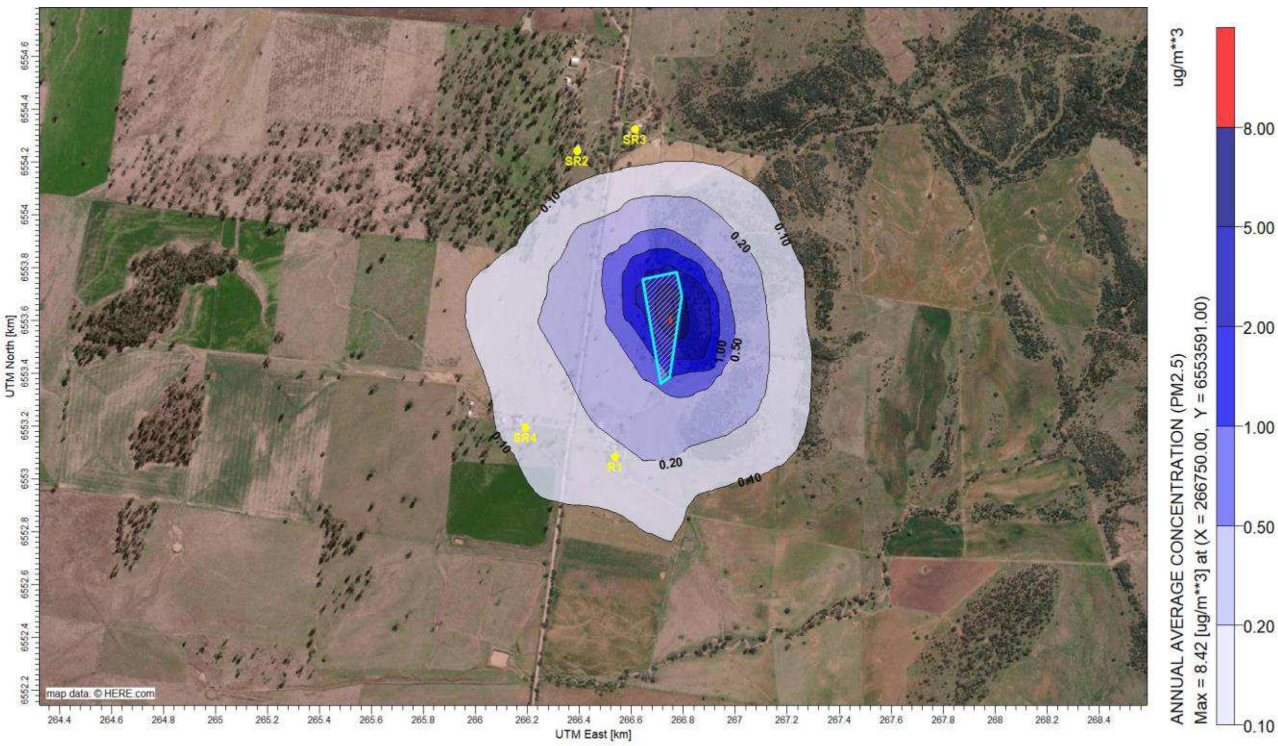
Pollutant:	Averaging Period:	Percentile:	Criteria:
PM_{10}	Annual	100th	25 µg/m^3

Comment:
Incremental



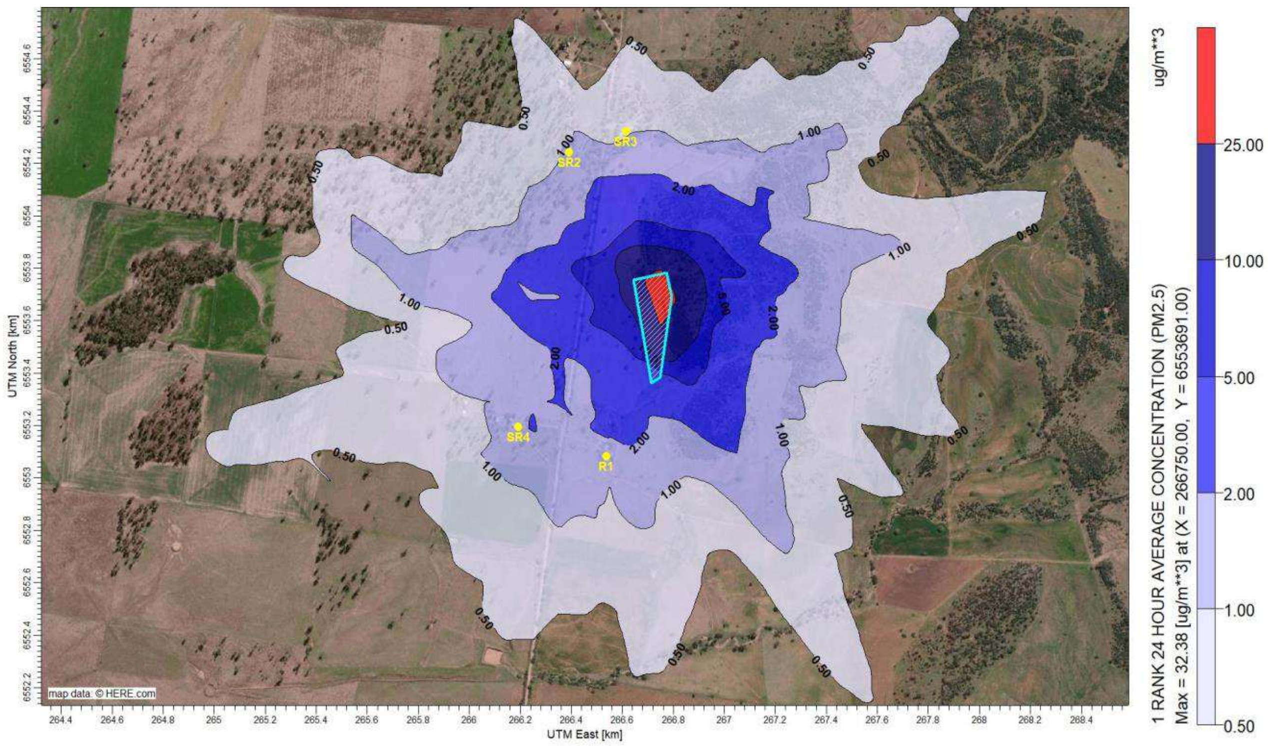
Pollutant:	Averaging Period:	Percentile:	Criteria:
PM_{10}	24 Hour	100th	50 µg/m^3

Comment:
Incremental



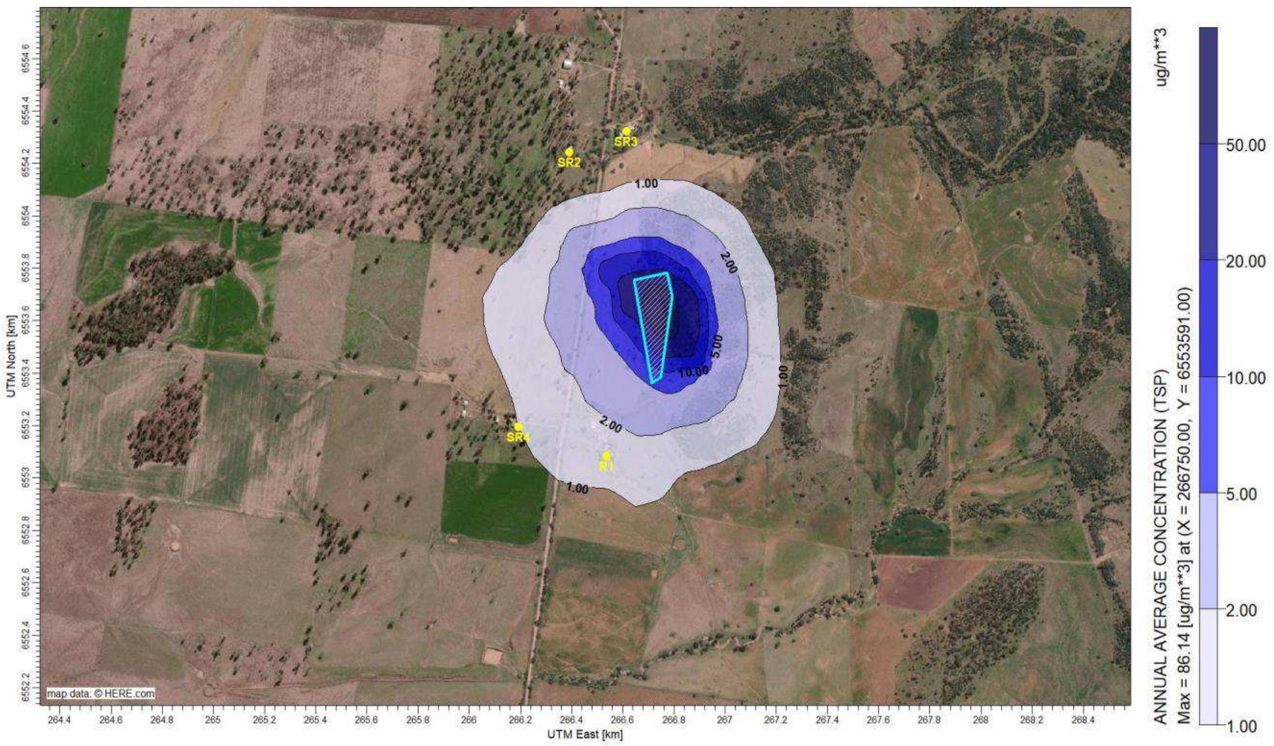
Pollutant:	Averaging Period:	Percentile:	Criteria:
$PM_{2.5}$	Annual	100th	8 µg/m³

Comment:
Incremental



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

Comment:
Incremental



Pollutant:	Averaging Period:	Percentile:	Criteria:
TSP	Annual	100th	90 µg/m^3

Comment:
Incremental