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Report

EAGLETON QUARRY PRODUCTION INCREASE- AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

Eagleton Rock Syndicate Pty Ltd

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EXECUTIVE SUMMARY

This report updates a previous Air Quality and Greenhouse Gas Assessment for the proposed quarry at Italia Road, Balickera (the Project), in accordance with the Secretary's Environmental Assessment Requirements. It reflects impacts associated with an increase in production output from a maximum of 500 kilotonnes per annum (ktpa) to a maximum of 600 ktpa.

One worst-case operational scenario was assessed based on maximum annual production at 600 ktpa with the assumption that the processing plant will operate on diesel power for the entire quarry life. In reality the plant is likely to be powered by electricity after Year 5. Dispersion modelling was conducted to predict the ground level concentrations for all relevant pollutants.

The results of the modelling indicate that the predicted incremental PM_{10}, $PM_{2.5}$, TSP and dust deposition at the closest residential receptors are all below the impact assessment criteria. The highest predicted ground-level concentrations (glcs) occur at R23 located adjacent to Gardenland, however these predicted glcs comply the assessment criteria.

As with the original assessment, cumulative impacts have also been addressed by considering emissions from existing dust sources in the area. Potential dust emissions from the existing Gardenland landscaping supplies facility, which forms part of the site, have been included in this assessment. There is also an existing quarry operation located approximate 1 km north. Background deposited dust data from a rural area with existing quarrying operations have been incorporated into the cumulative assessment to account for this source of dust. Background PM_{10} and $PM_{2.5}$ data were obtained from the Beresfield OEH monitoring station. The cumulative assessment indicates that the Project is unlikely to result in any additional exceedances of relevant impact assessment criteria at the neighbouring receivers.

Furthermore, a highly conservative assessment of the GHG emissions associated with the Project indicates that average annual scope 1 emissions would represent approximately 0.0003% of Australia's commitment under the Kyoto Protocol (591.5 Mt $CO_{2\text{-}e}$) and a very small portion of global greenhouse emissions.

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1 INTRODUCTION

1.1 Background/project description

Eagleton Rock Syndicate Pty Ltd (the Proponent) is proposing to develop a hard rock quarry at Lot 2 DP 1108702, off Italia Road, Balickera, NSW (Eagleton Quarry, hereafter referred to as "the Project"). The proposed quarry would extract a maximum of 260,000 m^3 with the potential to yield up to 4,613,000 m^3. The proposed quarry site is located approximately 14 km north of Heatherbrae, New South Wales.

Pacific Environment has previously prepared an Air Quality and Greenhouse Gas Assessment for this quarry which assessed two production scenarios (**Pacific Environment, 2012**). These scenarios included impacts associated with an expected annual production rate of 350,000 tonnes, and impacts associated with a peak annual product rate of 500,000 tonnes. It is now proposed that this rate be increased to a maximum of 600,000 tonnes per annum (tpa) for a maximum project life of 30 years. Additional changes since the previous assessment include the sealing of the haul road from Italia Road, the elimination of dozers, the proposed movement from a diesel powered plant to electrical powered plant after year 5, and changes to the haul road alignment and changes to the processing plant configuration. The air quality impacts have therefore been remodeled according to these changes.

The key features of the Project include:

- The construction and operation of an hard rock quarry operation extracting up to 600,000 tonnes of quarry products per year;
- Quarry activities and related activities will occur between the hours of 7am – 6pm Monday to Friday and 7am – 4pm on Saturdays for a maximum Project period of 30 years;
- Loading and transporting of quarry products between the hours of 5am – 6pm Monday to Friday and 7am – 4pm on Saturdays

The closest sensitive receptors are located 800 m to 900 m from the site and a re-assessment of the potential impacts during construction and operation of the quarry is required to address the Secretary's Environmental Assessment Requirements (SEARs).

This revised Air Quality and Greenhouse Gas Assessment has been prepared in accordance with the requirements of the SEARs for the Project, which were issued in November 2015 and the NSW Environment Protection Authority (NSW EPA) '*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*' (**NSW EPA, 2005**), hereafter referred to as the "Approved Methods"

The proposed general layout of the Project is shown in **Figure 1.1**.

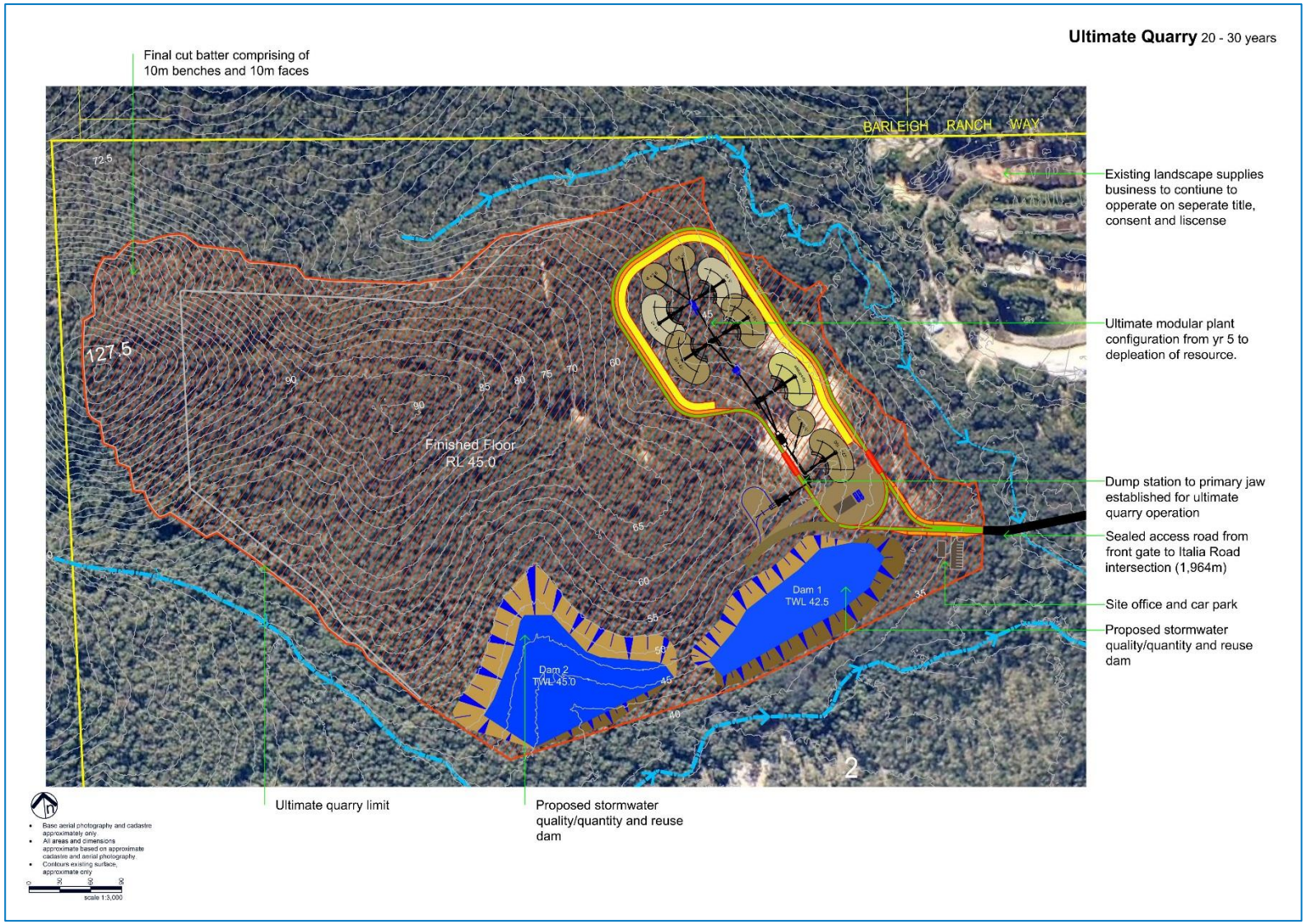


Figure 1.1: Eagleton Quarry ultimate layout

2 LOCAL SETTING

The site for the proposed quarry is located off Italia Rd., Balickera, which joins the Pacific Highway approximately 14 km north of Heatherbrae (see **Figure 2.1**). The site is located over the eastern spur of a ridge that extends from a peak 600 m to the west of the property boundary. The eastern proportion of the site is relatively flat.

There is an existing landscaping business (Port Stephens Gardenland) operating on the northeast portion of the site, as shown in **Figure 2.1** which produces various types of composting material for wholesale market. The Boral operated Seaham quarry is located approximately 1 km north of the proposed site.

Directly to the east of the site is an off road motorcycle riding complex which operates on weekends.

For the purposes of assessing impacts from the Project, discrete receptor locations were selected and presented in **Table 2.1** and **Figure 2.1**. These receptors represent assessment locations in proximity to the facilities for the Project, including the Manager's house (R23) located on the Gardenland property.

Figure 2.1 also shows a pseudo three-dimensional (3D) representation of the local topography in the area of the proposed quarry and surrounds. Vertical exaggeration is applied to emphasise terrain features.

Table 2.1: Relevant Receptor Locations

Receptor ID	Easting MGA Zone 56 (m)	Northing MGA Zone 56 (m)
R1	388827	6383505
R2	387768	6381329
R3	387572	6381391
R4	387377	6381179
R5	387369	6381613
R6	386885	6381606
R7	386770	6381656
R8	386697	6381752
R9	386570	6381640
R10	386335	6381648
R11	386301	6381444
R12	386201	6381191
R13	386159	6381756
R14	385821	6381740
R15	385775	6381494
R16	385817	6381337
R17	385356	6381752
R18	385413	6381990
R19	385329	6382001
R20	384699	6382781
R21	384737	6383719
R22	384845	6382063
R23	387594	6382870
R24	385763	6381195
R25	385191	6384475
R26	383400	6384026
R27	383290	6383246
R28	384298	6383050
R29	384331	6381879
R30	384805	6381671
R31	384675	6381456
R32	384936	6381313
R33	383927	6381645
R34	384418	6383104
R35	389474	6383637
R36	389569	6383725
R37	389650	6383817
R38	390135	6384588
R39	390480	6384739
R40	383792	6382916

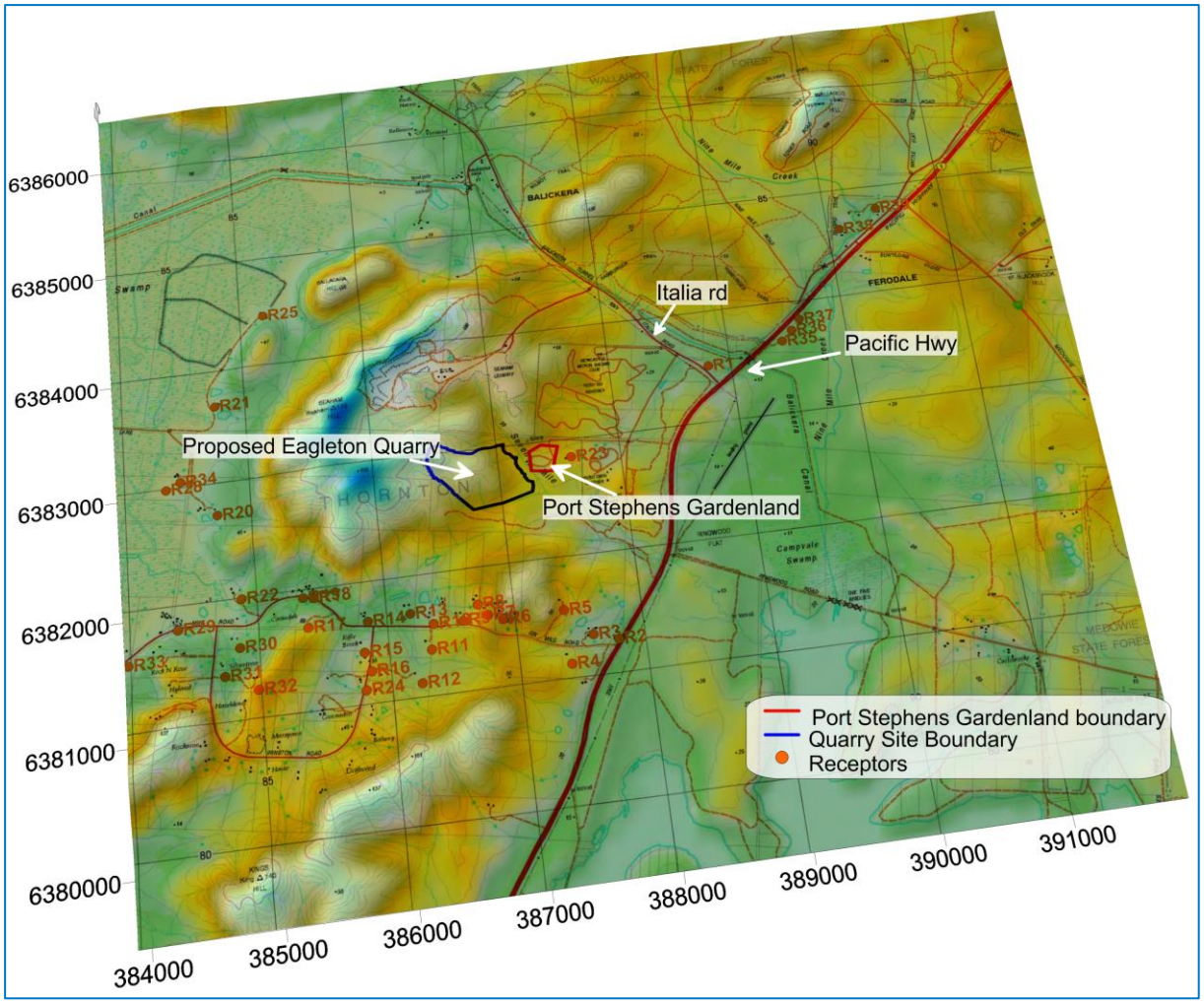


Figure 2.1: Pseudo 3-D representation of regional topography within modelling domain and location of receptors

3 AIR QUALITY CRITERIA

The potential emissions to air from the Project are summarised as follows:

- Project activities described in **Section 1.1** have the potential to generate fugitive dust emissions, particularly from material extraction, hauling and site rehabilitation.
- Combustion of diesel in quarrying equipment will result in emissions of fine fractions of particulate matter (PM_{10} and $PM_{2.5}$), oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2) and organic compounds. This assessment focuses on the key pollutants of fine PM.

It is noted that emissions of PM from diesel exhaust are considered to be accounted for in the emission factors for fugitive PM for relevant sources (i.e. dozers). This is discussed further in **Section 7.3**.

The Approved Methods specifies air quality assessment criteria relevant for assessing impacts from air pollution (**NSW DEC, 2005**). These criteria are health-based (i.e. they are set at levels to protect against health effects) and for PM_{10} are consistent with the now superseded National Environment Protection Measure for Ambient Air Quality (referred to as the Ambient Air-NEPM) (**NEPC, 1998a**). However, the Approved Methods include other measures of air quality, namely dust deposition and TSP which are not stated in the Ambient Air-NEPM.

In January 2016, the NEPC released an amended Ambient Air-NEPM (**NEPC, 2016**) to take into account the latest scientific evidence about the health impacts of particles. The amendment changed the 'advisory reporting standards' status for annual average and 24-hour average $PM_{2.5}$ (particulate matter with an equivalent aerodynamic diameter of 2.5 µm or less) to 'standards', but in absence of any other relevant standard/goal, the 2016 NEPM for $PM_{2.5}$ standards have been used in this report for comparison against dispersion modelling results.

Table 3.1 presents the air quality goals for pollutants that are relevant to this study. It is important to note that the criteria are applied to the cumulative impacts due to the Proposal and other sources.

Table 3.1: NSW EPA Air Quality Standards/Goals for Particulate Matter Concentrations

Pollutant	Standard	Averaging Period	Source
TSP	90 µg/m³	Annual	NSW DEC (2005) (assessment criteria)
PM_{10}	50 µg/m³	24-Hour	NSW DEC (2005) (assessment criteria)
	30 µg/m³	Annual	NSW DEC (2005) (assessment criteria)
$PM_{2.5}$	25 µg/m³	24-Hour	NEPC (2016)
	8 µg/m³	Annual	NEPC (2016)
Nitrogen Dioxide	246 µg/m³	1-Hour	NSW DEC (2005) (assessment criteria)
	62 µg/m³	Annual	NSW DEC (2005) (assessment criteria)

Notes: µg/m³ – micrograms per cubic metre.

In addition to health impacts, airborne dust also has the potential to cause nuisance effects by depositing on surfaces, including vegetation. Larger particles do not tend to remain suspended in the atmosphere for long periods of time and will fall out relatively close to source. Dust deposition can soil materials and generally degrade aesthetic elements of the environment, and are assessed for nuisance or amenity impacts.

Table 3.2 shows the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust deposition levels are set to protect against nuisance impacts (**NSW DEC, 2005**).

Table 3.2: EPA Criteria for Dust (Insoluble Solids) Fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

Notes: g/m^2/month – grams per square metre per month.

4 EXISTING ENVIRONMENT

4.1 Meteorology

4.1.1 Local Climatic Conditions

The Bureau of Meteorology (BoM) collects climatic information in the vicinity of the Project. A range of climatic information collected from the Williamtown RAAF Automated Weather Station (Williamtown AWS), located approximately 13 km southeast of the Project is presented in **Table 4.1**. Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Monthly daily averages of maximum and minimum temperatures are also provided. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures recorded at the Williamtown AWS are 23.1 °C and 12.4°C respectively. On average, January is the hottest month, with an average maximum temperature of 28.1°C. July is the coldest month, with average minimum temperature of 6.4°C.

The annual average relative humidity reading collected at 9.00 am from the Williamtown station is 73% and at 3.00 pm the annual average is 57%. The month with the highest relative humidity on average is June with 9.00 am averages of 80% and the months with the lowest relative humidity is August and September 3.00 pm averages of 50%.

Rainfall data collected at the Williamtown AWS shows that June is the wettest month, with an average rainfall of 120.9 mm over 12.7 rain days. The average annual rainfall is 1,123.5 mm with an average of 138.7 rain days.

Table 4.1: Climate Averages for the Williamtown AWS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
9am Mean Dry-bulb and Wet-bulb Temperatures (°C) and Relative Humidity (%)													
Dry-bulb	23.0	22.5	21.2	18.2	14.3	11.6	10.5	12.2	15.7	18.8	20.5	22.2	17.6
Humidity	72.0	76.0	77.0	76.0	79.0	80.0	77.0	71.0	66.0	64.0	66.0	68.0	73.0
3pm Mean Dry-bulb and Wet-bulb Temperatures (°C) and Relative Humidity (%)													
Dry-bulb	26.5	26.1	24.9	22.5	19.3	16.8	16.2	17.6	20.0	21.9	23.8	25.6	21.8
Humidity	59.0	62.0	61.0	59.0	60.0	60.0	55.0	50.0	50.0	54.0	55.0	56.0	57.0
Daily Maximum Temperature (°C)													
Mean	28.1	27.6	26.3	23.6	20.3	17.7	17.1	18.7	21.4	23.7	25.5	27.2	23.1
Daily Minimum Temperature (°C)													
Mean	18.0	18.1	16.3	13.2	10.1	7.9	6.4	6.9	9.1	11.9	14.4	16.5	12.4
Rainfall (mm)													
Mean	96.9	120.5	119.3	111.3	113.7	120.9	72.8	74.6	60.5	72.7	83.4	79.2	1123.5
Rain days (Number)													
Mean	12.0	12.0	12.9	11.6	12.7	12.7	10.5	10.2	9.6	11.4	11.9	11.2	138.7

Source: BOM (2015) Climate averages for Station: 061078; Commenced: 1942; Latitude: 32.79 °S; Longitude: 151.84 °E

4.1.2 Local Wind Data

No onsite meteorological data are available for Project and the closest BoM AWS is located at Williamtown RAAF, approximately 12 km south of the site. The windroses for Williamtown RAAF AWS are presented in **Figure 4.1**. Wind speeds will be higher at Williamtown compared to the Project site, due their relative location from the coast. The dominant annual winds at Williamtown are from the west-northwest and the percentage calms (defined as wind speeds less than 0.5 m/s) are around 10%. These

west-northwest winds dominate through autumn, winter and spring, while summer experiences a range between northeast to south.

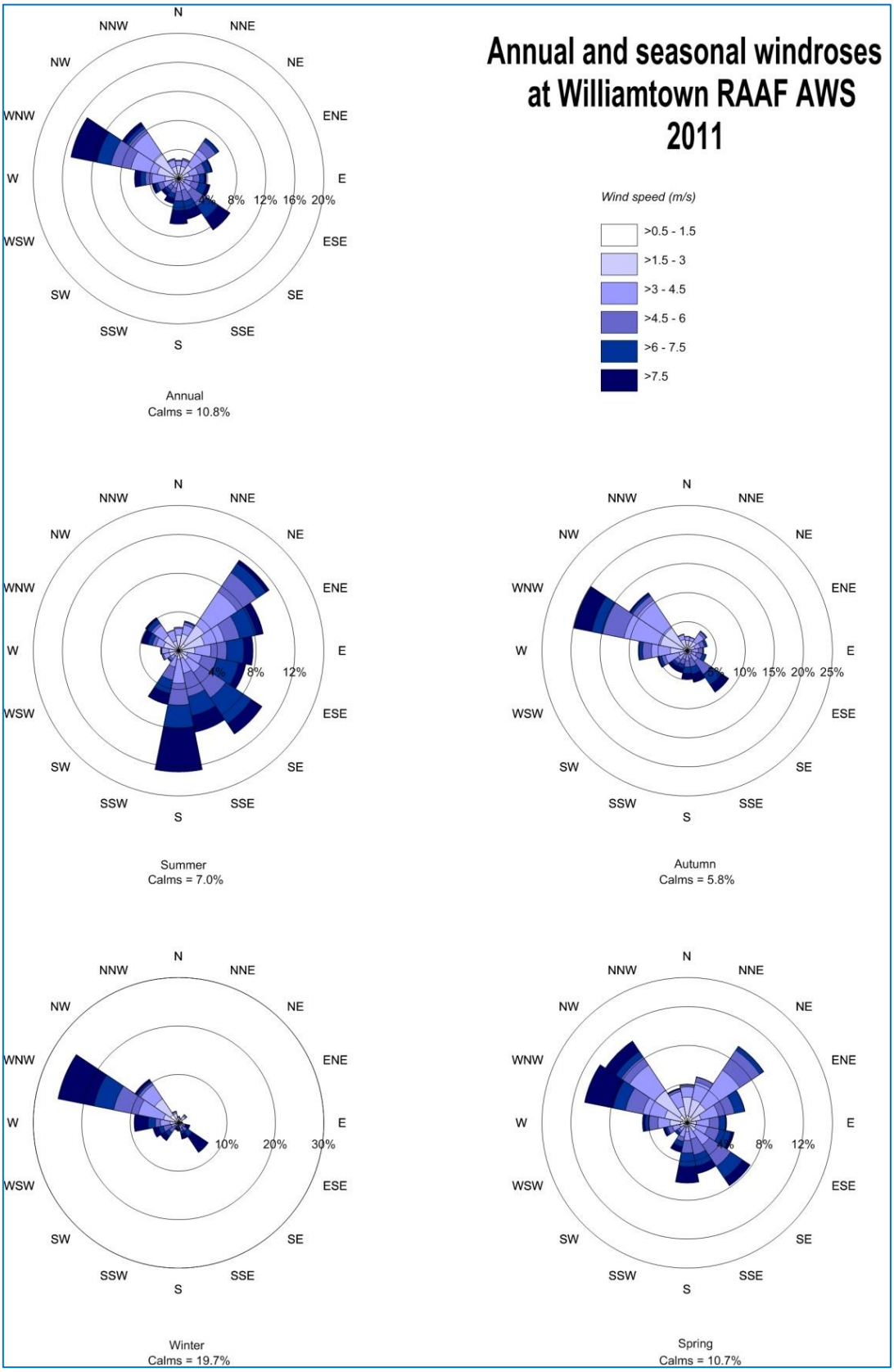


Figure 4.1: Windroses for Williamtown RAAF AWS - 061078

4.2 Existing Ambient Air Quality

Air quality standards and goals refer to pollutant levels which include the contribution from proposed projects as well as other sources. To fully assess impacts against all the relevant air quality standards and goals it is necessary to have information or estimates on existing dust concentration and deposition levels in the area in which the Project is likely to contribute to these levels.

4.2.1 PM_{10} Concentrations

There are no onsite monitoring data for PM_{10}, $PM_{2.5}$, TSP or dust deposition. The closest publicly available PM_{10} data are from the OEH site at Beresfield, which is approximately 17 km southwest of the proposed site. There are an additional two OEH monitoring sites located approximately 25-27 km to the south at Wallsend and Beresfield. A summary of the data from these monitoring sites are presented in **Table 4.2.**

The maximum 24-hour average PM_{10} concentrations occurred in April and September 2009 and are associated with regional dust storms that affected a widespread area of NSW (April 2009) and the eastern coast of Australia (September 2009). There are is also an exceedance at all three sites on May 6th 2015 which can likely be attributed to a dust storm experienced in Victoria and western NSW (**OEH, 2015**). Other exceedances may be attributed to bushfires, high winds or other local events. Generally the 24-hour average PM_{10} concentrations remain below the relevant air quality criteria.

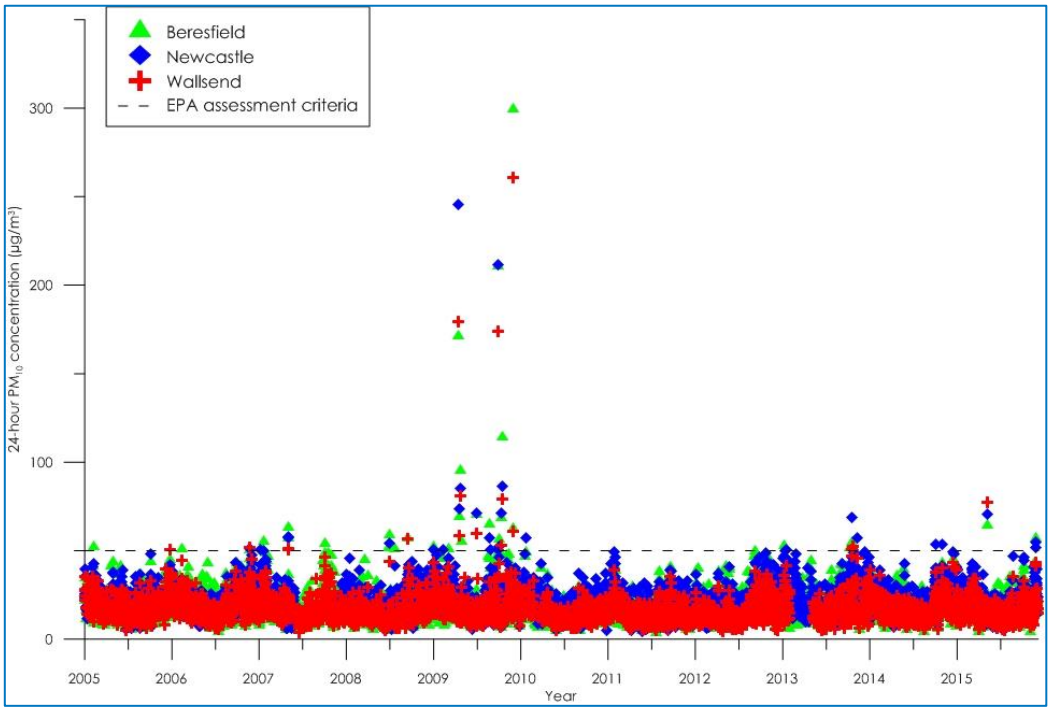


Figure 4.2: 24-hour average PM_{10} concentrations for Jan 2005 to Dec 2015

Annual average concentrations of PM_{10} are generally below the relevant air quality goals for the monitoring period, with the exception of Newcastle in 2009 (refer **Table 4.2**). Much of NSW experienced elevated average annual PM_{10} concentrations during 2009 as a result of generally drier and hotter conditions, and a number of significant dust storm events. The average annual PM_{10} at the closest monitoring site (Beresfield) is 20 µg/m^3. Due to the surrounding residential and industrial sites in Beresfield, this is a highly conservative estimate of PM_{10} concentrations at the project site. Furthermore, for conservatism all exceedances have been maintained in the values used as background PM_{10} concentrations.

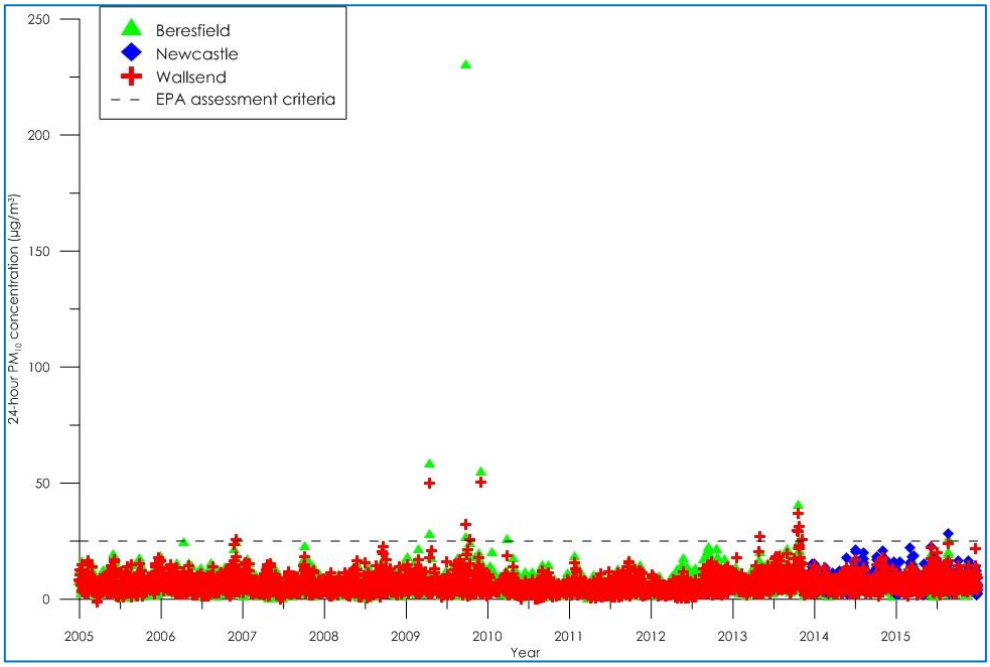
Table 4.2: Summary of annual average PM_{10} from closest EPA monitoring sites

Date	Annual average PM_{10} (µg/m³)		
	Wallsend	Newcastle	Beresfield
EPA Impact Assessment Criteria= 30 µg/m³			
2005	18.2	21.7	20.3
2006	18.6	21.1	21.2
2007	17.4	22.8	20.4
2008	15.7	20.5	18.4
2009	26.9	**31.9**	28.9
2010	14.7	18.6	16.6
2011	14.2	19.1	17.2
2012	14.9	20.6	21.3
2013	17.4	22.7	21.4
2014	16.9	21.4	19.4
2015	16.7	21.4	18.8
Average	**17.4**	**21.9**	**20.4**

4.2.2 $PM_{2.5}$ Concentrations

The closest publicly available $PM_{2.5}$ data are also from the OEH site at Beresfield. A summary of the Beresfield, Wallsend and Newcastle OEH data are presented in **Figure 4.3** and **Table 4.3.**

The maximum 24-hour average $PM_{2.5}$ concentrations occurred in April and September 2009 and are associated with regional dust storms that affected a widespread area of NSW (April 2009) and the eastern coast of Australia (September 2009). There are is also an exceedance at all three sites on May 6th 2015 which can likely be attributed to a dust storm experienced in Victoria and western NSW (**OEH, 2015**). Any other exceedances such as those measured in 2013 might be caused by bushfires or other local events. Generally the 24-hour average $PM_{2.5}$ concentrations remain below the relevant air quality criteria.



Note: $PM_{2.5}$ data from Newcastle monitoring station only available from 20/12/2013.

Figure 4.3: 24-hour average $PM_{2.5}$ concentrations for Jan 2005 to Dec 2015

Annual average concentrations of $PM_{2.5}$ are generally below the relevant air quality goals for the monitoring period, with a few exceedances in 2009, 2013 and 2014 (refer **Table 4.2**). Much of NSW experienced elevated average annual $PM_{2.5}$ concentrations during 2009 for the reasons previous discussed. The 2013 and 2014 exceedances may be due to major bushfire events and hazard reduction burns, or wood heater emissions. The average annual $PM_{2.5}$ at the closest monitoring site (Beresfield) is 7 µg/m³. For the purposes of this report the Beresfield average will be used, however as with the PM_{10} concentration adopted as background, this value is extremely conservative and all exceedances have been included for conservatism.

Table 4.3: Summary of annual average PM_{10} from closest EPA monitoring sites

	Annual average $PM_{2.5}$ (µg/m³)		
Date	**Wallsend**	**Newcastle**	**Beresfield**
EPA Criteria	**8 µg/m³**		
2005	6.5	-	6.8
2006	6.4	-	6.8
2007	5.8	-	6.3
2008	5.9	-	6.0
2009	**8.1**	**-**	**8.5**
2010	4.6	-	6.0
2011	4.8	-	5.5
2012	5.1	-	7.9
2013	7.7	**8.8**	**8.2**
2014	6.7	**8.1**	7.5
2015	7.3	7.8	7.3
Average	**6.2**	**8.0**	**7.0**

The Beresfield EPA site is the closest available data and has therefore been used as the background value for $PM_{2.5}$. This value is considered conservative as the data are influenced by local industrial activity and vehicle emissions.

4.2.3 TSP Concentrations

No TSP concentration data are available in the vicinity of the Project. However, annual average TSP concentrations can be estimated from the PM_{10} measurements by assuming that 40% of the TSP is PM_{10}. This relationship was obtained from data collected by co-located TSP and PM_{10} monitors operated for long periods of time in the Hunter Valley (**NSW Minerals Council, 2000**). Use of this relationship on the adopted PM_{10} annual average of 20 µg/m³ gives an existing annual average TSP concentration is approximately 50 µg/m³.

4.2.4 Dust deposition

Background values for dust deposition near the Project are not available. The Boral quarry located on Italia Road, Balickera received their Environmental Protection Licence (EPL 3956) on 1 July 2007. They are licenced to process 500,000 - 2,000,000 tonnes of material per annum (tpa). A review of their EPL indicates that they do not have any conditions requiring them to monitor dust. An extensive search of the internet, including the Boral company website, DP&E website, and Port Stephens Council website, has been unsuccessful in locating any information on the operations at the site, or any monitoring data collected in the vicinity of the operations. As no local data that characterised this location were available, data from Lynwood quarry were used. Annual averages from 8 dust deposition gauges around the proposed Lynwood Quarry are shown in **Table 4.4** (**Pacific Environment, 2015**).

Table 4.4: Dust deposition at Lynwood Quarry around Marulan, NSW

Year	Insoluble Solids (g/m²/month)							
	D1	D2	D3	D4	D5	D6	D7	D8
2004	1.0	2.2	0.9	0.9	0.9	3.2	0.7	0.9
2005	1.4	3.7	1.3	1.2	1.4	5.9	1.2	1.5
2006	1.0	4.8	1.5	2.0	1.3	11.7	1.5	1.1
2007	2.4	2.6	1.2	1.0	1.9	6.4	1.4	1.1
2008	2.0	7.7	1.8	1.6	1.6	14.0	1.4	2.4
2009	3.3	4.4	3.3	2.3	2.3	9.8	1.3	1.0
2010	1.7	1.6	1.4	1.2	1.2	10.8	1.1	1.6
2011	4.5	2.1	-	8.8	3.9	-	2.6	0.4
2012	2.2	3.6	3.1	2.4	1.8	11.2	1.4	1.3
2013	0.7	0.9	3.8	0.7	0.6	7.2	0.8	0.6
Average	**2.0**	**3.4**	**1.9**	**2.2**	**1.7**	**8.7**	**1.3**	**1.2**

The data in **Table 4.4** show that seven of the eight sites reported average levels below the EPA annual average 4 g/m²/month dust fallout criterion. In terms of estimating an existing background deposition level the values for D3, D4 and D7 are furthest removed from the quarry and are more likely to be less influenced by the operations there. The average across these three gauges is approximately 1.8 g/m²/month over the entire 10 year monitoring period. The average background dust deposition level for the project has therefore been estimated at 1.8 g/m²/month.

4.2.5 Existing Air Quality for Assessment Purposes

In summary, for the purposes of assessing potential air quality impacts, the following existing air quality levels are assumed.

- annual average PM_{10} concentration of 20 µg/m³,
- 24-hour PM_{10} concentrations – daily varying,
- annual average $PM_{2.5}$ concentration of 7 µg/m³,
- 24-hour $PM_{2.5}$ concentrations – daily varying,
- annual average TSP concentration of 50 µg/m³,
- annual average dust deposition of 1.8 g/m²/month.

5 MODELLING APPROACH

This Air Quality Assessment has been conducted in accordance with the Approved Methods (**NSW EPA, 2005**) and the approach is described in the following sections.

5.1 Modelling System

The CALMET/CALPUFF modelling system was chosen for this study. CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the 3-D meteorological fields that are utilised in the CALPUFF dispersion model. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict gridded meteorological fields for the region. CALPUFF is a multi-layer, multi-species non-steady state puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal (**Scire *et al.*, 2000**). The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer-range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across the puff and takes into account the complex arrangement of emissions from point, area, volume, and line sources.

In March 2011 the NSW EPA published generic guidance and optional settings for the CALPUFF modelling system for inclusion in the Approved Methods (**TRC, 2011**). The model set up for this study has been conducted in consideration of these guidelines.

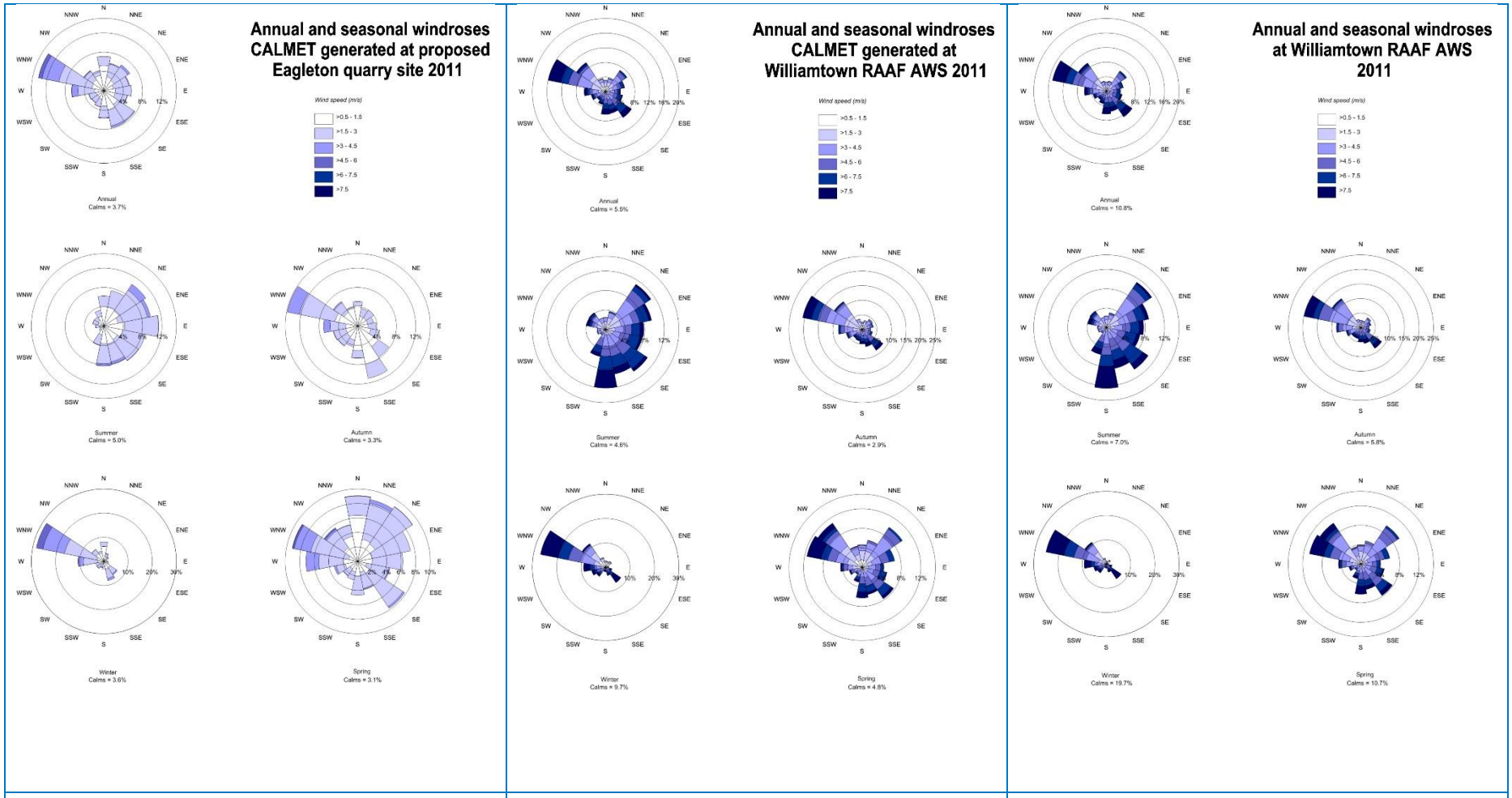
5.2 Model Set Up

CALMET was run for a domain of 40 km x 60 km with a 250 m resolution, covering the closest four BoM AWS sites. Observed hourly surface data were incorporated into the domain modelling, including the BoM data from Patterson (located 16.7 km north), Newcastle (located 24.6 km southeast), Cessnock (located 39.6 km southwest) and Williamtown RAAF (located 13 km southeast). Cloud amount and cloud heights were sourced from observations at Williamtown RAAF base. Further details on model set up are provided in **Appendix A**.

5.3 Dispersion Meteorology

A CALMET windrose extracted at the project site is shown in **Figure 5.1**. Also shown is a CALMET extract for the approximate location of the Williamtown RAAF Base AWS and compared with the measured data at this site.

The general dispersion patterns at the site are very similar to the measured data at Williamtown with dominant winds from north-northwest. However the magnitude of wind speeds are lower, as expected, with the project site located further inland and less exposed. The CALMET windrose extracted at the approximate location of the Williamtown AWS shows very similar characteristics to the measured data at Williamtown AWS indicating the model is performing reasonably well.



CALMET Extract Project Site	CALMET Extract at Williamtown RAAF Base	Measured winds at Williamtown RAAF

Figure 5.1: CALMET windrose extracted for the Project site, Williamtown RAAF and Measured Data

6 EMISSIONS TO AIR FROM CONSTRUCTION ACTIVITY

This chapter deals with the potential impacts of the construction phase of the Project. The main air pollution and amenity issues at construction sites are:

- Annoyance due to dust deposition (soiling of surfaces) and visible dust plumes.
- Elevated PM_{10} concentrations due to dust-generating activities.
- Exhaust emissions from diesel-powered construction equipment[¤].

Very high levels of soiling can also damage plants and affect the diversity of ecosystems.

The principal emissions from the construction phase of the Project will be dust and particulate matter, occurring from the following activities:

- Vegetation clearing and earthmoving during site preparation and access road construction;
- Excavation and stockpiling of excavated material;
- Movement of heavy plant and machinery within the site;
- Graders / scrapers working access road construction; and
- Wind erosion from exposed surfaces.

It is anticipated that dust emissions during the construction phase of the project will be considerably less than emissions during operation of the quarry (as described in **Section 6**). These impacts have therefore been assessed semi-quantitatively.

Dust emissions can occur during the preparation of the land (e.g. demolition and earth moving) and during construction itself, and can vary substantially from day to day depending on the level of activity, the specific operations being undertaken, and the weather conditions. A significant portion of the emissions results from quarry site and road vehicles moving over roads and open ground. If mud is allowed to get onto local public roads, dust emissions can occur at some distance from the construction site **(IAQM, 2014)**.

The risk of dust impacts from a demolition/construction site causing loss of amenity and/or health or ecological impacts is related to the following **(IAQM, 2014)**:

- The nature of the activities being undertaken.
- The duration of the activities.
- The size of the site.
- The meteorological conditions (wind speed, direction and rainfall). Adverse impacts are more likely to occur downwind of the site and during drier periods.
- The proximity of receptors to the activities.
- The sensitivity of the receptors to dust.
- The adequacy of the mitigation measures applied to reduce or eliminate dust.

It is very difficult to quantify dust emissions from construction activities. Due to the variability of the weather it is impossible to predict what the weather conditions would be when specific construction activities are undertaken. Any effects of construction on airborne particle concentrations would also

¤ Exhaust emissions from on-site plant and site traffic are unlikely to have a significant impact on local air quality, and in the majority of cases they will not need to be quantitatively assessed **(IAQM, 2014)**.

generally be temporary and relatively short-lived. Moreover, mitigation should be straightforward, as most of the necessary measures are routinely employed as 'good practice' on construction sites. It is therefore usual to provide a qualitative assessment of potential construction dust impacts. A largely qualitative approach has also been used here, and the impacts of construction have not been specifically modelled. The approach used for the Project was based on that described by **IAQM (2014)**. The aim is to identify risks and to recommend appropriate mitigation measures.

The IAQM guidance is designed primarily for use in the UK, although it may be applied elsewhere. Here, the guidance has been adapted for use in NSW, taking into account factors such as the assessment criteria for ambient PM_{10} concentrations.

6.1 Construction activities at the Project

A wide range of demolition and construction equipment is likely to be used for the quarry and the associated infrastructure. This includes:

- Excavators
- Heavy vehicles
- Scrapers
- Graders
- Concrete trucks

The principal emissions from the construction phase of the Project will be dust and particulate matter, occurring from the following activities:

- Vegetation clearing and earthmoving during site preparation and access road construction;
- Excavation and stockpiling of excavated material;
- Movement of heavy plant and machinery within the site;
- Graders / scrapers working access road construction; and
- Wind erosion from exposed surfaces.

It is anticipated that dust emissions during the construction phase of the project will be considerably less than emissions during operation of the quarry.

6.2 Assessment procedure

The IAQM assessment procedure for assessing risk is shown in **Figure 6.1**. Professional judgement is required in some steps, and where justification cannot be given a precautionary approach should be adopted.

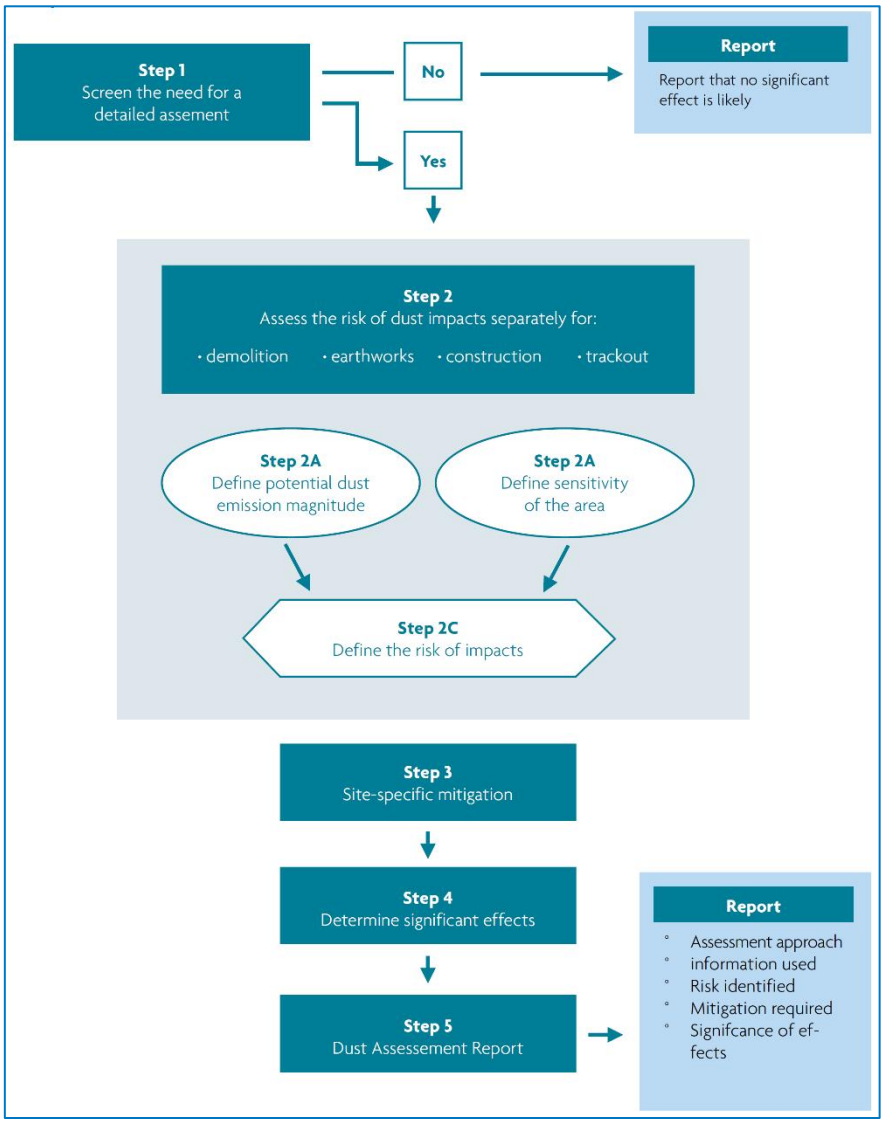


Figure 6.1: Steps in an assessment of construction dust (IAQM, 2014)

Activities on construction sites can be divided into four types to reflect their different potential impacts, and the potential for dust emissions is assessed for each activity that is likely to take place. These activities are:

- *Demolition*. Demolition is any activity that involves the removal of existing structures. This may also be referred to as de-construction, specifically when a building is to be removed a small part at a time.
- *Earthworks*. This covers the processes of soil stripping, ground levelling, excavation and landscaping. Earthworks will primarily involve excavating material, haulage, tipping and stockpiling.
- *Construction*. Construction is any activity that involves the provision of new structures, modification or refurbishment. A structure will include a residential dwelling, office building, retail outlet, road, *etc*.
- *Track-out*. This involves the transport of dust and dirt by HDVs from the construction/demolition site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network.

The assessment methodology considers three separate dust impacts:

- Annoyance due to dust soiling.
- The risk of health effects due to an increase in exposure to PM_{10}.
- Harm to ecological receptors

The assessment is used to define appropriate mitigation measures to ensure that there will be no significant effect.

The assessment steps, as they were applied to the Project, are summarised in the following Sections.

6.3 Step 1: Screening

Step 1 is a screening assessment. A construction dust assessment will normally be required where:

- There are human receptors within 350 m of the boundary of the site and/or within 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s).
- There are ecological receptors within 50 m of the boundary of the site and/or within 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s).

A 'human receptor', refers to any location where a person or property may experience the adverse effects of airborne dust or dust soiling, or exposure to PM_{10} over a time period relevant to air quality standards and goals. In terms of annoyance effects, this will most commonly relate to dwellings, but may also refer to other premises such as buildings housing cultural heritage collections (e.g. museums and galleries), vehicle showrooms, food manufacturers, electronics manufacturers, amenity areas and horticultural operations (e.g. salad or soft-fruit production). An 'ecological receptor' refers to any sensitive habitat affected by dust soiling. This includes the direct impacts on vegetation or aquatic ecosystems of dust deposition, and the indirect impacts on fauna (e.g. on foraging habitats) **(IAQM, 2014)**.

Construction activities would occur both at the quarry site and on Italia road and the intersection of Italia Road and Pacific Highway. Construction activities would occur at least 800 m from any residential receptors to the south-west of the site along Six Mile Road. These receptors are therefore unlikely to be impacted by construction dust. It is noted however that a property is located within 30 m of Italia road in the vicinity of the construction activities. Additionally a landscape supplies business and associated dwelling is also located in the north-eastern corner of the site as well as a motorcycle riding complex to the east of the site. These three receptors would potentially be impacted by construction dust.

In addition to these human receptors, the quarry is located nearby to ecological receptor Seven Mike Creek.

Due to potential construction impacts on these identified receptors, a step two risk assessment has been performed in **Section 6.4** below.

6.4 Step 2: Risk assessment

In Step 2 the risk of dust arising in sufficient quantities to cause annoyance and/or health effects was determined separately for each scenario and each of the four activities (demolition, earthworks, construction, and track-out). Risk categories were assigned to the site based on two factors:

- The scale and nature of the works, which determines the magnitude of potential dust emissions. This is assessed in Step 2A.
- The sensitivity of the area. The proximity of sensitive receptors (*i.e.* the potential for effects). This is assessed in Step 2B.

These factors are combined in Step 2C to give the risk of dust impacts. Risks are described in terms of there being a low, medium or high risk of dust impacts for each of the four separate potential activities. Where there is risk of an impact, then site-specific mitigation will be required in proportion to the level of risk.

6.4.1 Step 2A: Potential for dust emissions

The criteria for assessing the potential scale of emissions based on the scale and nature of the works are shown in **Table 6.1**. Based on these criteria, the appropriate categories for the Project are shown in **Table 6.2**.

Table 6.1: Site categories (scale of works) (from IAQM, 2014)

Type of activity	Site category		
	Large	Medium	Small
Demolition	Building volume >50,000 m^3, potentially dusty construction material (e.g. concrete), on-site crushing and screening, demolition activities >20 m above ground level.	Building volume 20,000–50,000m^3, potentially dusty construction material, demolition activities 10-20 m above ground level.	Building volume <20,000 m^3, construction material with low potential for dust release (e.g. metal cladding, timber), demolition activities <10 m above ground and during wetter months.
Earthworks	Site area >10,000 m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size), >10 heavy earth-moving vehicles active at any one time, formation of bunds>8 m in height, total material moved >100,000 tonnes.	Site area 2,500-10,000 m^2, moderately dusty soil type (e.g. silt), 5-10 heavy earth moving vehicles active at any one time, formation of bunds 4-8 m in height, total material moved 20,000-100,000 tonnes.	Site area <2,500 m^2, soil type with large grain size (e.g. sand), <5 heavy earth moving vehicles active at any one time, formation of bunds <4 m in height, total material moved <20,000 tonnes, earthworks during wetter months.
Construction	Total building volume >100,000 m^3, piling, on site concrete batching; sandblasting	Building volume 25,000-100,000 m^3, potentially dusty construction material (e.g. concrete), piling, on site concrete batching.	Total building volume <25,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber).
Track-out	>50 HDV (>3.5t) OUTWARD movements in any one day, potentially dusty surface material (e.g. high clay content), unpaved road length >100 m.	10-50 HDV (>3.5t) OUTWARD movements in any one day, moderately dusty surface material (e.g. high clay content), unpaved road length 50–100 m.	<10 HDV (>3.5t) OUTWARD movements in any one day, surface material with low potential for dust release, unpaved road length <50 m.

Table 6.2: Site categories for Eagleton Quarry

Type of activity	Construction phase category
Demolition	N/A (no demolition)
Earthworks	Large
Construction	Small
Track-out	Medium

6.4.2 Step 2B: Sensitivity of area

The sensitivity of the area takes into account the specific sensitivities of local receptors, the proximity and number of the receptors, and the local background PM_{10} concentration. Dust soiling and health impacts are treated separately.

6.4.2.1 Sensitivity of area to dust soiling effects on people and property

The criteria for determining the sensitivity of an area to dust soiling effects are shown in **Table 6.3**. Based on the IAQM guidance[b] the receptor sensitivity was assumed to be 'low' as no human receptors are located within 350m from the site.

Table 6.3: Criteria for sensitivity of area to dust soiling effects (from IAQM, 2014)

Receptor sensitivity	Number of receptors	Distance from source (m)			
		<20	<50	<100	<350
High	>100	High	High	Medium	Low
	10-100	High	Medium	Low	Low
	1-10	Medium	Low	Low	Low
Medium	>1	Medium	Low	Low	Low
Low	>1	Low	Low	Low	Low

The number of receptors in each distance band were estimated from an aerial photograph of the site. The exact counting of the number of 'human receptors' is not required by the IAQM guidance. Instead it is recommended that judgement is used to determine the approximate number of receptors within each distance band.

The numbers of receptors for each scenario and activity, and the resulting outcomes are shown in **Table 6.4**.

Table 6.4: Results - sensitivity to dust soiling effects of people and property

Scenario	Activity	Receptor sensitivity	Number of receptors by distance from source				Sensitivity of area
			<20 m	20-50 m	50-100 m	100-350 m	
Construction	Demolition	N/A	N/A	N/A	N/A	N/A	Low
	Earthworks	High	0	**3**	0	0	Low
	Construction	High	0	**3**	0	0	Low
	Track-out	High	0	**3**	0	0	Low

[b] Professional judgement is used to identify where on the spectrum between high and low sensitivity a receptor lies. High sensitivity receptors can reasonably expect enjoyment of a high level of amenity. The appearance, aesthetics or value of their properties would be diminished by soiling, and the people or properties would reasonably be expected to be present continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. Indicative examples include dwellings, museums and other culturally important collections, medium and long term car parks and car showrooms.

6.4.2.2 Sensitivity of area to human health impacts

The criteria for determining the sensitivity of an area to health impacts are shown in **Table 6.5.** Based on the IAQM guidance[c] the receptor sensitivity was assumed to be 'high'. The numbers of receptors for each scenario and activity, and the resulting outcomes are shown in **Table 6.6**.

Table 6.5: Criteria for sensitivity of area to health impacts (from IAQM, 2014)

Receptor sensitivity	Annual mean PM_{10} conc. ($\mu g/m^3$)(a)	Number of receptors	Distance from source (m)				
			<20	<50	<100	<200	<350
High	>24	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	21-24	>100	High	High	Medium	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	18-21	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<18	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	-	>10	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
Low	-	>1	Low	Low	Low	Low	Low

(a) Scaled to Sydney according to the ratio of NSW and UK annual mean standards (30 µgm/^{3} and 40 µgm/^{3} respectively).

Table 6.6: Results - sensitivity to health impacts

Activity	Receptor sensitivity	Annual mean PM_{10} conc. ($\mu g/m^3$)	Number of receptors by distance from source					Sensitivity of area
			<20 m	20-50 m	50-100 m	100-200 m	100-350 m	
Demolition	High	21-24	N/A	N/A	N/A	N/A	N/A	Low
Earthworks	High	21-24	0	3	0	0	0	Medium
Construction	High	21-24	0	3	0	0	0	Medium
Track-out	High	21-24	0	3	0	0	0	Medium

6.4.3 Step 2C: Risk of dust impacts

The dust emission potential determined in Step 2A is combined with the sensitivity of the area determined in Step 2B to give the risk of impacts with no mitigation applied. The criteria are shown in **Table 6.7**.

[c] The sensitivity of people to the health effects of PM_{10} is based on exposure to elevated concentrations over a 24-hour period. High sensitivity receptors relate to locations where members of the public are exposed over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day). Indicative examples include residential properties. Hospitals, schools and residential care homes should also be considered as having equal sensitivity to residential areas for the purposes of this assessment.

Table 6.7: Criteria for sensitivity of area to health impacts (from IAQM, 2014)

Type of activity	Sensitivity of area	Dust emission potential		
		Large	Medium	Small
Demolition	High	High Risk	Medium Risk	Medium Risk
	Medium	High Risk	Medium Risk	Low Risk
	Low	Medium Risk	Low Risk	Negligible
Earthworks	High	High Risk	Medium Risk	Low Risk
	Medium	Medium Risk	Medium Risk	Low Risk
	Low	Low Risk	Low Risk	Negligible
Construction	High	High Risk	Medium Risk	Low Risk
	Medium	Medium Risk	Medium Risk	Low Risk
	Low	Low Risk	Low Risk	Negligible
Track-out	High	High Risk	Medium Risk	Low Risk
	Medium	Medium Risk	Low Risk	Negligible
	Low	Low Risk	Low Risk	Negligible

The final results for the Step 2 risk assessment are provided in **Table 6.8**. As there is no demolition to occur, air quality impacts are not applicable to this activity. The area is assessed as having medium sensitivity to dust soiling, human health and ecological impacts caused by earthworks, construction and track-out. The risk of these impacts during earthworks are assessed as being medium. Impacts caused by construction and track-out are considered to be low.

Table 6.8: Summary of risk assessment for the three construction scenarios

Type of activity	Step 2A: Potential for dust emissions	Step 2B: Sensitivity of area			Step 2C: Risk of dust impacts		
		Dust soiling	Human health	Ecological	Dust soiling	Human health	Ecological
Demolition	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Earthworks	Large	Medium	Medium	Medium	Medium	Medium	Medium
Construction	Small	Medium	Medium	Medium	Low	Low	Low
Track-out	Medium	Medium	Medium	Medium	Low	Low	Low

6.5 Step 3: Mitigation

Step 3 involved determining mitigation measures for each of the four potential activities in Step 2. This was based on the risk of dust impacts identified in Step 2C.

The results are shown in **Table 6.9** to **Table 6.13**. Most of the recommended measures are routinely employed as 'good practice' on construction sites. At Eagleton Quarry, particular attention should be paid to controlling dust generated by earthworks due to the risk level of this activity compared to construction and track-out risks.

A Dust Management Plan should be produced to cover the construction of Eagleton Quarry. This should contain details of the site-specific mitigation measures to be applied. Additional guidance on the control of dust at construction sites in NSW is provided as part of the NSW EPA Local Government Air

Quality Toolkit[d]. Detailed guidance is also available from the UK **(GLA, 2006)** and the United States **(Countess Environmental, 2006)**.

Table 6.9: Mitigation for all sites: Communications

	Mitigation measure	Action for site risk
1	Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.	Highly recommended
2	Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the site manager.	Highly recommended
3	Display the head or regional office contact information	Highly recommended

Table 6.10: Mitigation for all sites: Dust management

	Mitigation measure	Action for site risk
4	Develop and implement a Dust Management Plan (DMP), which may include measures to control other emissions, approved by the local authority. The level of detail will depend on the risk, and should include as a minimum the highly recommended measures in this document. The desirable measures should be included as appropriate for the site. The DMP may include monitoring of dust deposition, dust flux, real time PM_{10} continuous monitoring and/or visual inspections.	Highly recommended
Site management		
5	Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.	Highly recommended
6	Make the complaints log available to the local authority when asked.	Highly recommended
7	Record any exceptional incidents that cause dust and/or air emissions, either on- or offsite, and the action taken to resolve the situation in the log book.	Highly recommended
8	Hold regular liaison meetings with other high risk construction sites within 500m of the site boundary, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised. It is important to understand the interactions of the off-site transport/deliveries which might be using the same strategic road network routes.	Not required
Monitoring		
9	Undertake daily on-site and off-site inspection, where receptors (including roads) are nearby, to monitor dust, record inspection results, and make the log available to the local authority when asked. This should include regular dust soiling checks of surfaces such as street furniture, cars and window sills within 100m of site boundary, with cleaning to be provided if necessary.	Desirable
10	Carry out regular site inspections to monitor compliance with the DMP, record inspection results, and make an inspection log available to the local authority when asked	Highly recommended
11	Increase the frequency of site inspections by the person accountable for air quality and dust issues on site when activities with a high potential to produce dust are being out and during prolonged dry or windy conditions.	Highly recommended
12	Agree dust deposition, dust flux, or real-time PM_{10} continuous monitoring locations with the local authority. Where possible commence baseline monitoring at least three months before work commences on site or, if it a large site, before work on a phase commences.	Highly recommended

[d] http://www.epa.nsw.gov.au/air/lgaqt.htm

	Mitigation measure	Action for site risk
Preparing and maintaining the site		
13	Plan site layout so that machinery and dust causing activities are located away from receptors, as far as is possible.	Highly recommended
14	Erect solid screens or barriers around dusty activities or the site boundary that are at least as high as any stockpiles on site.	Highly recommended
15	Fully enclose site or specific operations where there is a high potential for dust production and the site is actives for an extensive period	Highly recommended
16	Avoid site runoff of water or mud.	Highly recommended
17	Keep site fencing, barriers and scaffolding clean using wet methods.	Highly recommended
18	Remove materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site cover as described below.	Highly recommended
19	Cover, seed or fence stockpiles to prevent wind whipping.	Highly recommended
Operating vehicle/machinery and sustainable travel		
20	Ensure all on-road vehicles comply with the requirements of the London Low Emission Zone and the London NRMM standards, where applicable	Highly recommended
21	Ensure all vehicles switch off engines when stationary - no idling vehicles.	Highly recommended
22	Avoid the use of diesel or petrol powered generators and use mains electricity or battery powered equipment where practicable.	Highly recommended
23	Impose and signpost a maximum-speed-limit of 15 mph on surfaced and 10 mph on unsurfaced haul roads and work areas (if long haul routes are required these speeds may be increased with suitable additional control measures provided, subject to the approval of the nominated undertaker and with the agreement of the local authority, where appropriate)	Desirable
24	Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials.	Highly recommended
25	Implement a Travel Plan that supports and encourages sustainable travel (public transport, cycling, walking, and car-sharing)	Desirable
Operations		
26	Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems.	Highly recommended
27	Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.	Highly recommended
28	Use enclosed chutes and conveyors and covered skips.	Highly recommended
29	Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.	Highly recommended
30	Ensure equipment is readily available on site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods.	Highly recommended
Waste management		
31	Avoid bonfires and burning of waste materials	Highly recommended

Table 6.11: Mitigation specific to earthworks

	Mitigation measure	Action for site risk
36	Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable.	Desirable
37	Use Hessian, mulches or trackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.	Desirable
38	Only remove the cover in small areas during work and not all at once.	Desirable

Table 6.12: Mitigation specific to construction

	Mitigation measure	Action for site risk
39	Avoid scabbling (roughening of concrete surfaces) if possible.	Desirable
40	Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place.	Desirable
41	Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery.	Not required
42	For smaller supplies of fine power materials ensure bags are sealed after use and stored appropriately to prevent dust.	Not required

Table 6.13: Mitigation specific to track-out

	Mitigation measure	Action for site
43	Use water-assisted dust sweeper(s) on the access and local roads, to remove, as necessary, any material tracked out of the site. This may require the sweeper being continuously in use.	Desirable
44	Avoid dry sweeping of large areas.	Desirable
45	Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.	Desirable
46	Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.	Not required
47	Record all inspections of haul routes and any subsequent action in a site log book.	Desirable
48	Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and regularly cleaned.	Not required
49	Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable).	Desirable
50	Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits.	Not required
51	Access gates to be located at least 10m from receptors where possible.	Not required

6.6 Step 4: Significance of risks

Once the risk of dust impacts has been determined in Step 2C and the appropriate dust mitigation measures identified in Step 3, the final step is to determine whether there are residual significant effects arising from the construction phase of a proposed development. For almost all construction activity, the aim should be to prevent significant effects on receptors through the use of effective mitigation. Experience shows that this is normally possible. Hence the residual effect will normally be 'not significant' **(IAQM, 2014)**.

However, even with a rigorous Dust Management Plan in place, it is not possible to guarantee that the dust mitigation measures will be effective all the time. There is the risk that the on-site office buildings as well as the small number of residential properties and businesses in the immediate vicinity of the site boundary might experience some occasional dust soiling impacts. This does not imply that impacts are likely, or that if they did occur, that they would be frequent or persistent. Given the distances between the construction sites and the receptors, overall construction dust is unlikely to represent a serious ongoing problem. Any effects would be temporary and relatively short-lived, and would only arise during dry weather with the wind blowing towards a receptor, at a time when dust is being generated and mitigation measures are not being fully effective. The likely scale of this would not normally be considered sufficient to change the conclusion that with mitigation the effects will be 'not significant'.

7 EMISSIONS TO AIR FROM OPERATIONS

7.1 Operational Phase

This chapter discusses emissions to air during the operational phase. An assessment of impacts during the construction phase is detailed in **Section 6**. During operations, the Project will result in emissions of particulate matter, primarily from wind erosion, drilling, blasting, material handling and hauling in the extraction area. In the processing area emissions will primarily occur from screening, crushing, stockpile loading and wind erosion of product stockpiles. Dust emissions during operations have been estimated by analysing the activities taking place for the Project. Emission estimates are presented for a maximum operational production scenario of 600 ktpa of product. **Section 7.2** discusses emissions from diesel equipment and blast fumes.

The estimated dust emissions for the maximum operational scenario of the quarry are presented in **Table 7.1**. In estimating dust emissions, consideration has been given to best practice management and controls, including watering on haul roads, dump pads and stockpiles, as well as the use of fabric filters and partially enclosed conveyors. The hauling of product from the site to Italia Road has also been included in the emissions inventory. Detailed emission inventories are provided in **Appendix B**.

Table 7.1: Estimated Annual Dust Emission (600 ktpa Throughput)

ACTIVITY	TSP (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)
Extraction Area			
Drilling rock	1,328	690	40
Blasting rock	1,304	678	39
Excavator loading	622	294	45
Hauling to Processing area	24,818	6,377	638
Processing Area			
Unloading at processing area	311	147	22
Rehandle rock to hopper	311	147	22
Primary Crushing (controlled)	360	162	30
Screening (controlled)	660	222	15
Secondary Crushing (controlled_	360	162	30
Tertiary Crushing (controlled)	360	162	30
Crushing (Fines) (controlled)	900	360	21
Fines Screening (controlled)	1,080	660	660
Pug Mill	180	110	110
Stacking stockpiles - aggregate	311	147	22
FEL loading trucks - aggregate	622	294	45
Hauling product to site boundary (unsealed road)	12,409	3,188	319
Hauling product to Italia Road (sealed road)	36,370	6,981	1,689
Grading roads	1,412	1,412	1,412
Wind Erosion			
WE - Extraction Area	26,798	13,399	2,010
WE- from conveyors	27	14	2
WE - Processing Area (stockpiles)	416	208	31
Total	**110959**	**35816**	**7232**

* Dozers no longer required under new project

Aside from wind erosion, activities and emissions will occur between the hours of 7am and 6pm Monday to Friday and 7am to 3pm on Saturdays, with no operations on Sundays or public holidays. Due to limitations within the modelling, it has been conservatively assumed that operations will occur 7 days per week between the maximum daily operating hours of 7am to 6pm. TSP, PM_{10} and $PM_{2.5}$ emission rates were calculated using emission factors derived from **US EPA (1995)** and **NERDDC (1988)** work (see **Appendix A**)

7.1.1 Best Practice mitigation measures

The Project will employ a number of best practice mitigation measures on-site to ensure that dust impacts are minimised. Recommended measures to be employed for the Project include:

- Use of water carts/trucks to control emissions from haul roads.
- Enforcement of speed limits onsite and on right of way.
- Progressive rehabilitation of exposed areas.
- Application of water at the crusher and on conveyor transfer points.
- Minimising drop height of material during truck loading and unloading.
- Use of water sprays when drilling.
- Sheltering of stockpiles and transfer points where possible.
- Proper blast design.
- Management of dust generating activities during unfavourable meteorological conditions.

7.2 Diesel Emissions

The US EPA AP-42 emission factors used in the particulate (TSP, PM_{10} and $PM_{2.5}$) emissions inventories (see **Appendix B**) include particulate matter emissions from both the mechanical processes (i.e. crustal material) and the diesel exhaust (combustion). These emission factors do not distinguish between these two sources, since the sampling method used to derive the original emission factors captured both mechanical and combustion particulate matter sources.

The following text from Version 2.3 of the National Pollutant Inventory (NPI) Emission Estimation Technique Manual for Mining supports this (**NPI, 2001**):

> *"It should be noted that the emission factors for mining activities in Tables 1 and 2 have been derived from measurements that cover all PM_{10} emissions associated with a unit operation, including exhaust emissions. To add the exhaust PM_{10} emissions to the fugitive emissions would involve some measure of double counting for those activities."*

The Project is located less than 2 km from the A1 (Pacific Highway) which carries approximately 15,400 vehicles per day, of which approximately 15% (2,310) are heavy vehicles (**GHD, 2016**). In comparison, the Proposal is expected to reach a maximum of 192 vehicle movements daily. Therefore the maximum traffic that would be generated by the Proposal is less than 8% of the heavy vehicles that travel daily on the Pacific Highway. It is therefore considered that any contribution of diesel fumes to the predicted air quality has been accounted for and as such no separate assessment of diesel emissions has been completed.

7.3 Blast Fume Emissions

Blasting also results in fugitive particulate matter emissions. Particulate matter emissions from mining equipment and blasting are included in the dispersion modelling results presented in **Section 7.5**.

Nitrogen oxide emissions (NO_x) are emitted from blast fume as a result of the chemical reaction of ammonium nitrate explosives during the blasting process. NO_x principally comprise nitric oxide (NO) and nitrogen dioxide (NO_2). Typically, at the point of emission (e.g. in diesel powered equipment), NO_x would consist of approximately 90-95% NO and 5-10% NO_2. Ultimately, all nitric oxides emitted into the atmosphere are oxidised to NO_2 and to other higher oxides of nitrogen. The rate at which this oxidation takes place depends on prevailing atmospheric conditions including temperature, humidity and the presence of other substances in the atmosphere such as ozone (O_3). It can vary from a few minutes to many hours. The rate of conversion is quite important because from the point of emission to the point of maximum ground level concentration there will be an interval of time during which some oxidation will take place. If the dispersion is sufficient to have diluted the plume to the point where the concentration is very low, it is unimportant that the oxidation has taken place. However, if the oxidation is rapid then high concentrations of NO_2 can occur when inadequate dispersion / dilution conditions exist. Generally, for plumes close to the source, the time interval for oxidation is not sufficient to have converted a large proportion of the plume to NO_2.

This is supported by a study CSIRO completed for an ACARP monitoring study in 2013 that assessed emissions from blasting from open cut coal mines (**Day et.al, 2013**). Continuous monitoring of NO_2 concentrations was conducted for 18 months near the fence line of a large open-cut coal mine in the Hunter Valley. During the monitoring period, about 70,000t of ANFO explosive was consumed in almost 500 individual blasts. About 73% of these blasts were assigned fume ratings of zero suggesting that there was little to no NO_2 produced during these explosions. Only one blast was assigned a fume rating of four (equating to a frequency of approximately 0.2% of blasts). NO_2 plumes from only six blasts were detected at the monitoring sites adjacent to the particular coal mine. Two other events with elevated NO_2 levels, which were probably blast fumes, were also detected. The maximum concentration of NO_2 measured in these plumes was 343ppb. This compares with the workplace 80-hour exposure limit of 3ppm (3,000ppb). About 80% of the blast plumes that passed over the monitors did not show NO_2 levels above the ambient levels.

The Project will use a maximum of 210 t of ANFO per year which represents less than 0.3% of the total ANFO usage during the ACARP study discussed above. As over 80% of these blast plumes did not show NO_2 levels above existing ambient levels, it is considered that there is minimal risk of any adverse NO_2 impacts due to blasting from the Project and as such no further assessment has been completed.

Blast fume management would be included in a Noise and Blasting Management Plan to be prepared and submitted to DPE three months prior to operations commencing.

7.4 Emissions from nearby sources

Consistent with the previous assessment, emissions from the nearby Gardenland landscaping supplies facility have been included in this assessment. Sources considered include loading and unloading of raw material and product, screening of material and wheel generated dust and emissions were estimated using US EPA emission factors. The predicted ground level concentration (glcs) of dust were minor, however they are included in the cumulative assessment for completeness.

The other nearby dust source is an off-road motor cycle track to the northeast of the site off Italia road. This facility is only operational on weekends so dust impacts are expected to be minor and as with the previous assessment, have not been considered further.

7.5 Impact Assessment

The modelling predictions for the Project are presented in the sections below. The contour plots are indicative of the concentrations that could potentially be reached under the new conditions modelled. A summary of the predicted pollutant concentrations (due to the Project alone) at each of the assessment locations is presented in **Table 7.2**. An assessment of cumulative impacts is presented in **Section 7.5.5**.

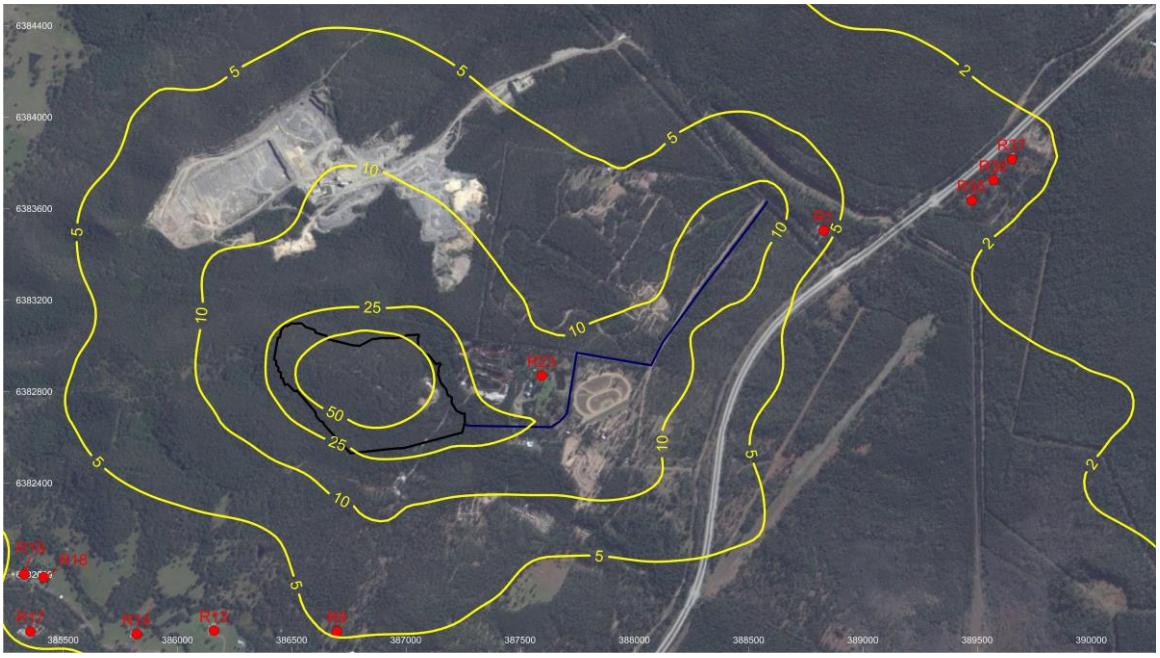
Table 7.2: Predicted Incremental Ground Level Concentrations at Receptor Locations

Receptor ID	PM_{10} 24-hour µg/m³	PM_{10} Annual µg/m³	$PM_{2.5}$ 24-hour µg/m³	$PM_{2.5}$ Annual µg/m³	TSP Annual µg/m³	Dust Deposition Annual g/m²/month
Criteria	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**2**
R1	5.5	0.4	1.3	0.1	1.0	0.10
R2	1.7	0.1	0.4	0.0	0.2	0.02
R3	1.9	0.1	0.5	0.0	0.2	0.02
R4	1.9	0.1	0.5	0.0	0.2	0.01
R5	3.4	0.2	0.8	0.1	0.4	0.03
R6	4.1	0.3	1.0	0.1	0.4	0.03
R7	4.4	0.3	1.0	0.1	0.5	0.03
R8	5.2	0.4	1.1	0.1	0.6	0.04
R9	4.2	0.3	0.9	0.1	0.5	0.03
R10	2.8	0.3	0.7	0.1	0.5	0.04
R11	2.8	0.2	0.6	0.1	0.4	0.03
R12	2.5	0.2	0.5	0.0	0.3	0.02
R13	2.4	0.3	0.5	0.1	0.5	0.04
R14	2.4	0.3	0.5	0.1	0.4	0.04
R15	2.0	0.2	0.4	0.1	0.4	0.03
R16	1.9	0.2	0.4	0.0	0.3	0.02
R17	2.1	0.2	0.4	0.1	0.3	0.03
R18	2.4	0.3	0.4	0.1	0.4	0.03
R19	2.2	0.2	0.4	0.1	0.3	0.03
R20	1.5	0.1	0.4	0.0	0.2	0.02
R21	1.3	0.1	0.3	0.0	0.2	0.01
R22	1.3	0.1	0.3	0.0	0.2	0.02
R23	11.0	4.2	2.7	1.0	14.9	0.62
R24	1.7	0.2	0.4	0.0	0.3	0.02
R25	2.4	0.2	0.4	0.0	0.2	0.02
R26	1.0	0.1	0.2	0.0	0.1	0.00
R27	1.1	0.1	0.2	0.0	0.1	0.00
R28	1.3	0.1	0.2	0.0	0.2	0.01
R29	1.0	0.1	0.2	0.0	0.1	0.01
R30	1.5	0.1	0.3	0.0	0.2	0.02
R31	1.4	0.1	0.3	0.0	0.2	0.02
R32	1.4	0.2	0.3	0.0	0.2	0.02
R33	0.8	0.1	0.2	0.0	0.1	0.01
R34	1.4	0.1	0.3	0.0	0.2	0.01
R35	2.7	0.1	0.7	0.0	0.2	0.02
R36	2.6	0.1	0.6	0.0	0.2	0.01
R37	2.4	0.1	0.6	0.0	0.2	0.01
R38	1.2	0.1	0.3	0.0	0.1	0.01
R39	1.1	0.0	0.3	0.0	0.1	0.00
R40	1.0	0.1	0.2	0.0	0.1	0.01

7.5.1 Incremental Ground Level PM_{10} Concentrations

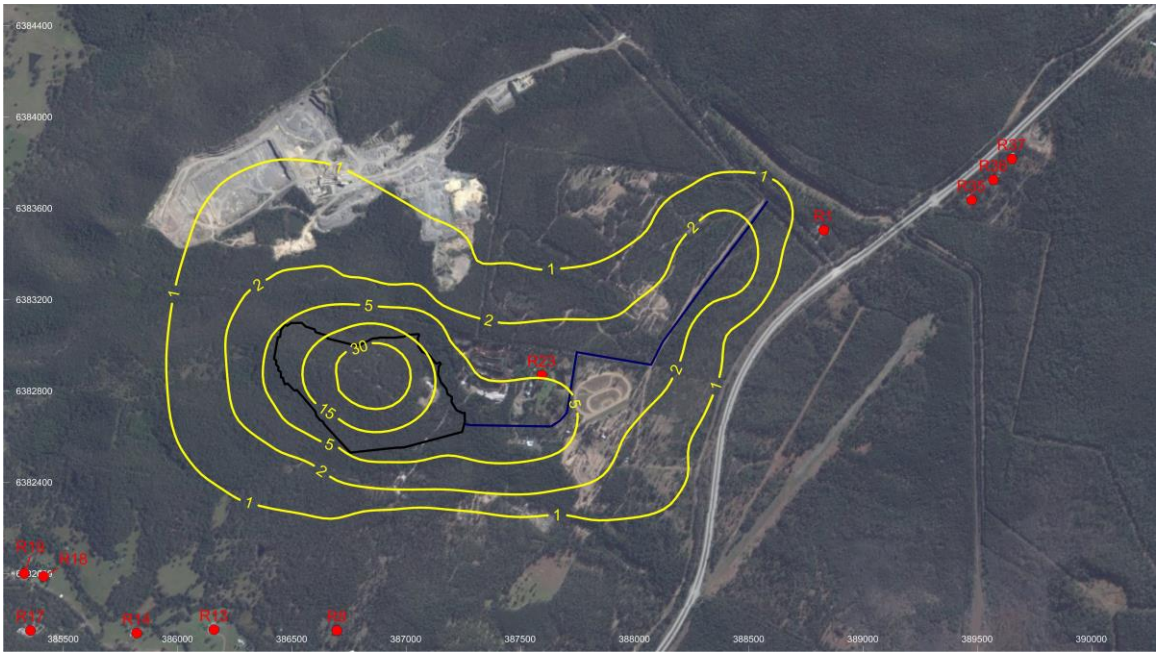
Contour plots for the predicted (glcs) of PM_{10} are presented in **Figure 7.1** and **Figure 7.2**. Predicted 24-hour average and annual average PM_{10} are presented for the maximum throughput (600Ktpa).

There are no privately owned receivers that are predicted to experience glcs of PM_{10} above the assessment criteria due to emissions from the Project only. The highest predicted glcs occur at the R23. At this location, the predicted incremental 24-hour average PM_{10} concentration is 11.0 µg/m^3. The predicted annual average PM_{10} concentration at this receiver is 4.2 µg/m^3.



Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Eagleton	600 ktpa throughput	Maximum	24-Hour
Model Used:	**Units:**	**Assessment criteria:**	**Met Data:**	**Plot:**
CALPUFF v. 6.333	µg/m^3	N/A	CALMET	J. Cox

Figure 7.1: Incremental maximum 24-Hour average PM_{10} Concentration – 600 ktpa throughput



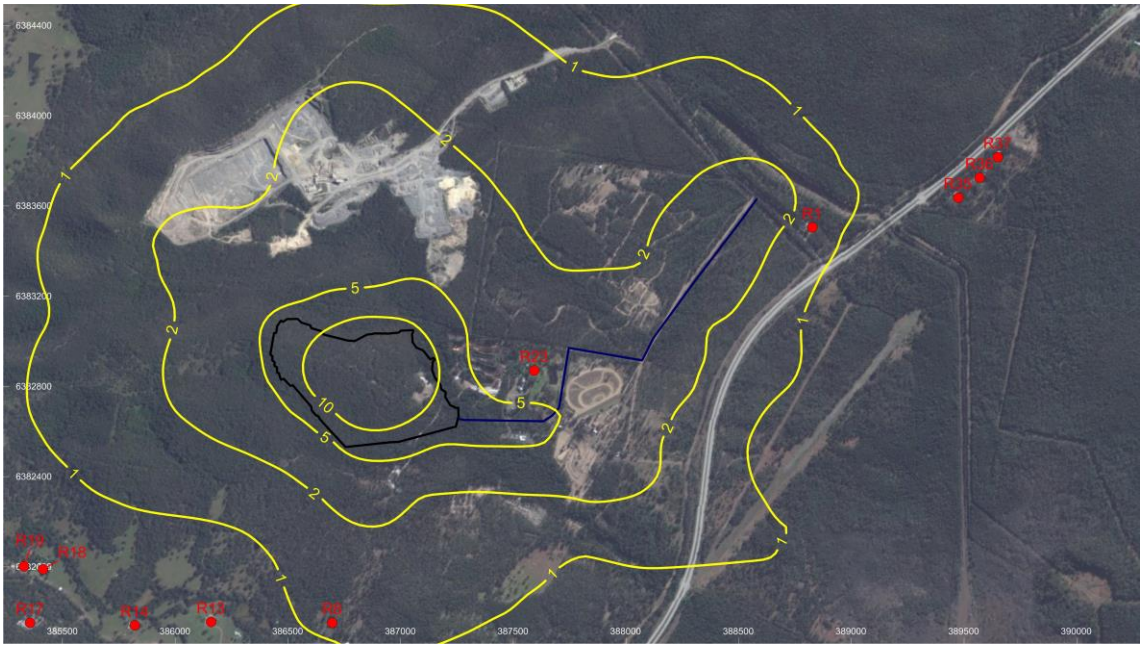
Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Eagleton	600Ktpa throughput	N/A	Annual
Model Used:	**Units:**	**Assessment criteria:**	**Met Data:**	**Plot:**
CALPUFF v. 6.333	$\mu g/m^3$	N/A	CALMET	J. Cox

Figure 7.2: Incremental Annual Average PM_{10} Concentration – 600 ktpa throughput

7.5.1 Incremental Ground Level $PM_{2.5}$ Concentrations

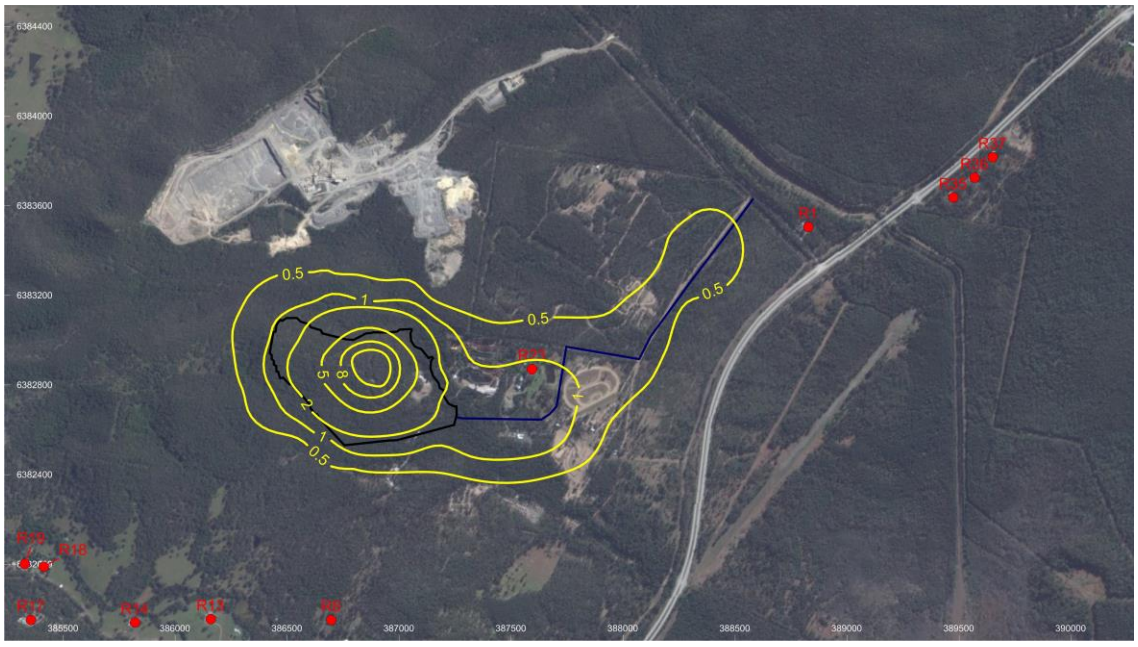
Contour plots for the predicted glcs of $PM_{2.5}$ are presented in **Figure 7.3** and **Figure 7.4**. There are no exceedances of the relevant 24-hour and annual average criteria beyond the site boundaries due to the Project alone. There are no privately owned receivers that are predicted to experience glcs of $PM_{2.5}$ above the assessment criteria, due to emissions from the Project only.

The highest predicted glcs occur at R23. At this location, the predicted incremental 24-hour $PM_{2.5}$ concentration is 2.7 $\mu g/m^3$. The predicted annual average $PM_{2.5}$ concentration at this residence is 1.0 $\mu g/m^3$.



Species:	Location:	Scenario:	Percentile:	Averaging Time:
$PM_{2.5}$	Eagleton	600Ktpa throughput	N/A	24-h
Model Used:	**Units:**	**Assessment criteria:**	**Met Data:**	**Plot:**
CALPUFF v. 6.333	µg/m³	N/A	CALMET	J. Cox

Figure 7.3: Incremental maximum 24-Hour average $PM_{2.5}$ Concentration – 600 ktpa throughput



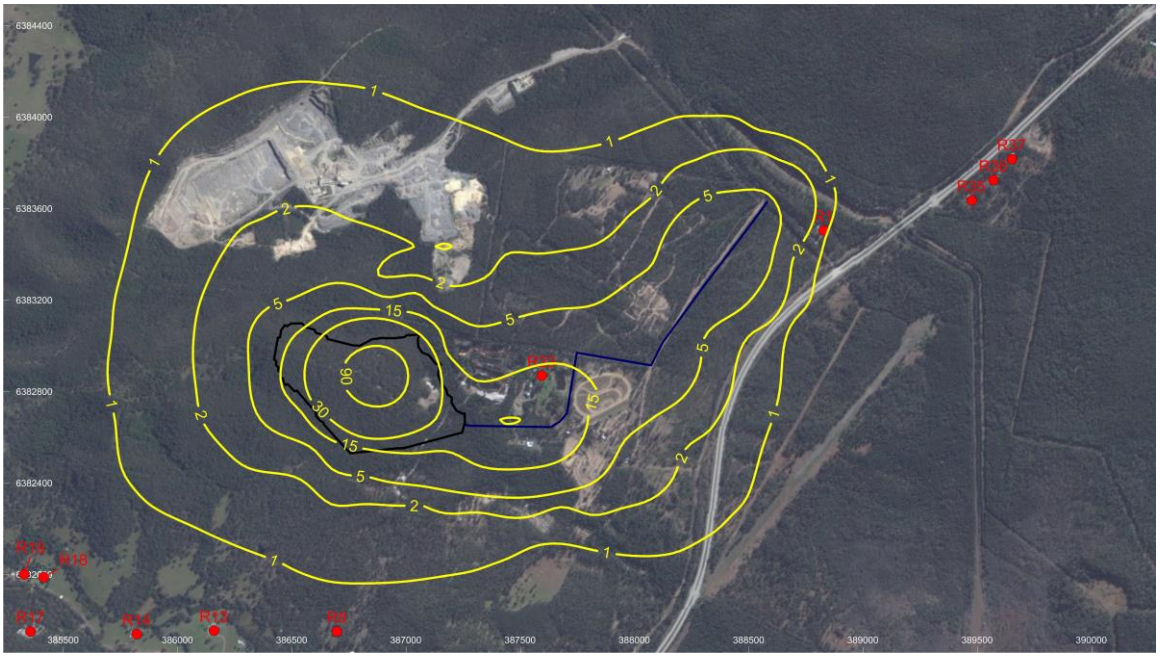
Species:	Location:	Scenario:	Percentile:	Averaging Time:
$PM_{2.5}$	Eagleton	600Ktpa throughput	N/A	Annual
Model Used:	**Units:**	**Assessment criteria:**	**Met Data:**	**Plot:**
CALPUFF v. 6.333	µg/m³	N/A	CALMET	J. Cox

Figure 7.4: Incremental Annual Average $PM_{2.5}$ Concentration – 600 ktpa throughput

7.5.2 Incremental Ground Level TSP Concentrations

A contour plots for the predicted glcs of TSP are presented in **Figure 7.5**. The relevant impact assessment criterion is shown by the red contour line.

There are no privately owned receivers that are predicted to experience glcs of TSP above the assessment criteria, due to emissions from the Project only. The highest predicted glcs occur at R23. At this location, the predicted incremental annual average TSP concentration is 14.9 µg/m^3.



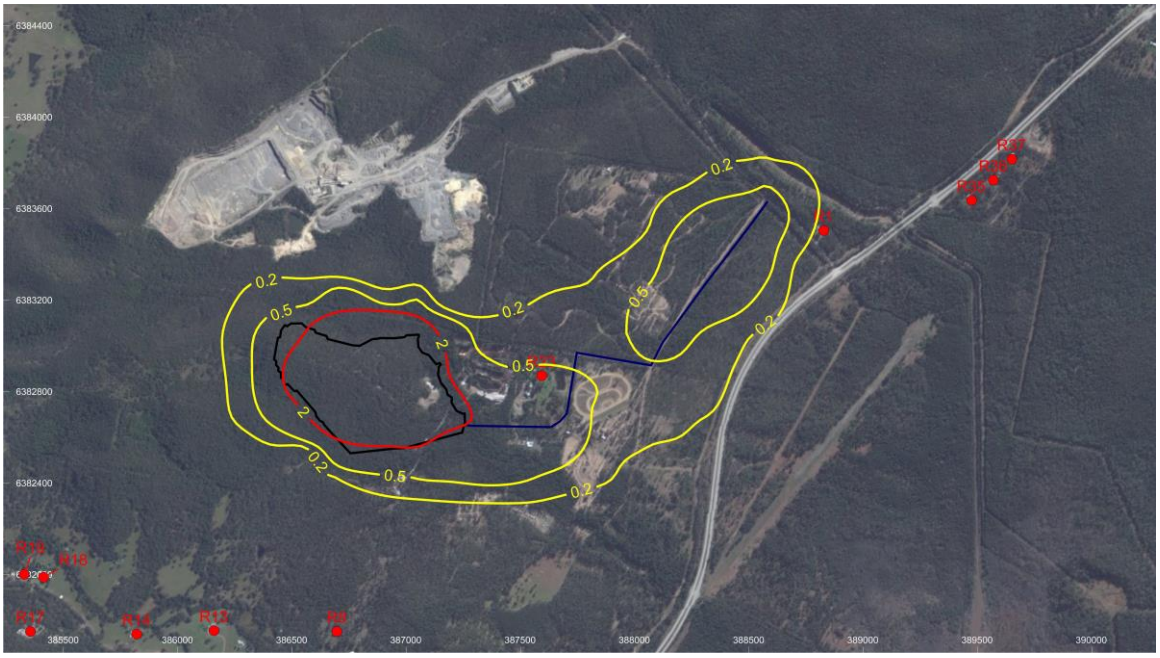
Species:	Location:	Scenario:	Percentile:	Averaging Time:
TSP	Eagleton	600Ktpa throughput	N/A	Annual
Model Used:	**Units:**	**Assessment criteria:**	**Met Data:**	**Plot:**
CALPUFF v. 6.333	µg/m^3	N/A	CALMET	J. Cox

Figure 7.5: Incremental Annual Average TSP Concentration – 600 ktpa throughput

7.5.3 Incremental Ground Level Dust Deposition Level

Contour plots for the predicted dust deposition levels are presented in **Figure 7.6**. The relevant impact assessment criterion is shown by the red contour line.

There are no privately owned receivers that are predicted to experience dust deposition above the assessment criteria, due to emissions from the Project only. The highest predicted levels occur at R23. At this location, the predicted incremental annual average dust deposition is 0.6 g/m^2/month.



Species:	Location:	Scenario:	Percentile:	Averaging Time:
Deposited Dust	Eagleton	600Ktpa throughput	N/A	Annual
Model Used:	**Units:**	**Assessment criteria:**	**Met Data:**	**Plot:**
CALPUFF v. 6.333	g/m^2/month	2 g/m^2/month	CALMET	J. COX

Figure 7.6: Incremental Annual Average Dust Deposition – 600 ktpa throughput

7.5.4 Potential Impacts on Proposed Kings Hill Area

In May 2012, land at Kings Hill, located approximately 4 km south of the Project, was approved for up to 4,500 residences.

Based on the modelling results presented in the sections above, it is not anticipated that the proposed rezoning would result in any significant impact for future residential dwellings as part of the subdivision. This area is located at least 1 km further south than the residences presented in **Table 7.2** and therefore glcs at these locations due to the Project would be expected to be lower.

7.5.5 Cumulative Impact Assessment

For 24-hour average concentrations, the cumulative concentrations are assumed to be the sum of the 24-hour average OEH Beresfield monitoring station data, the modelled contribution due to the Gardenland activities and the contribution due to the Project. The assessment has been completed for the five most impacted receivers as a result of the Project (i.e. R23, R1, R8, R7, and R9).

For background annual average concentrations, the assumptions detailed in **Section 4.2.5** are applied.

7.5.5.1 24-Hour average PM_{10}

The cumulative assessments of PM_{10} concentrations at the worst impacted receptors are shown in **Figure 7.7**, **Figure 7.8**, **Figure 7.9**, **Figure 7.10** and **Figure 7.11**. The plots show the cumulative 24-hour average PM_{10} concentration compared with the assumed background. It is clear from these plots that the addition of the project would be unlikely to result in any days over the impact assessment criteria at the 50 µg/m^3 level, and that the project has a very minimal impact on current PM_{10} concentrations

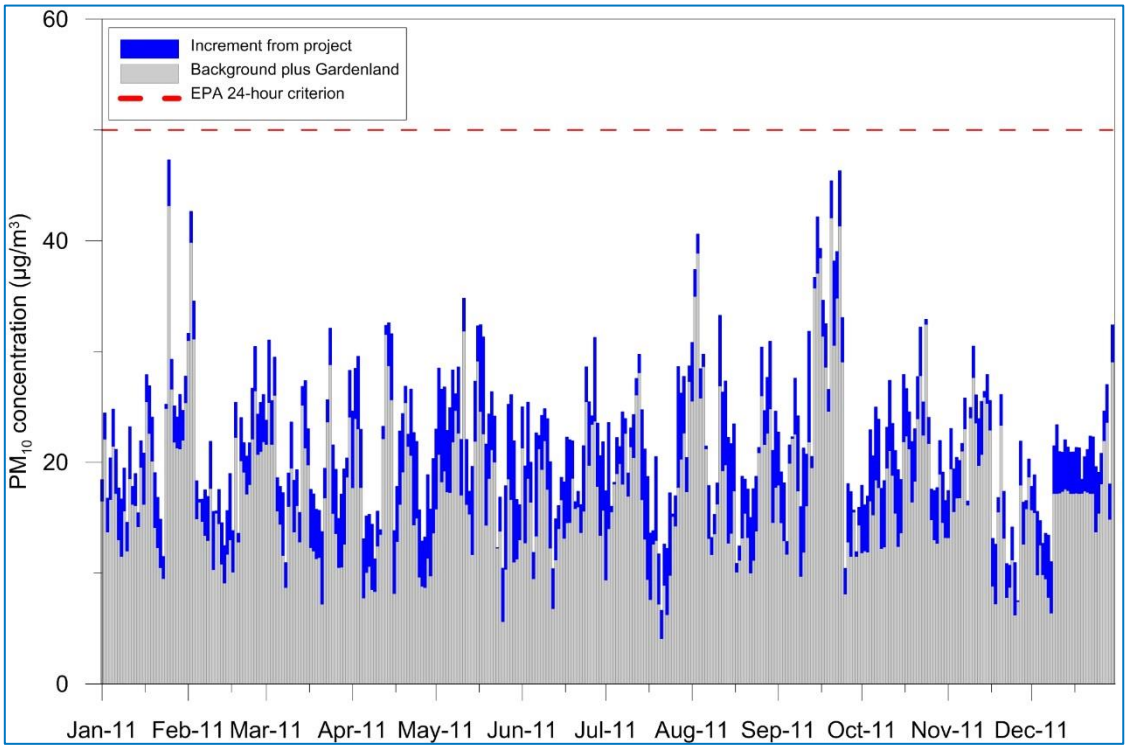


Figure 7.7: PM_{10} concentration time-series at R23

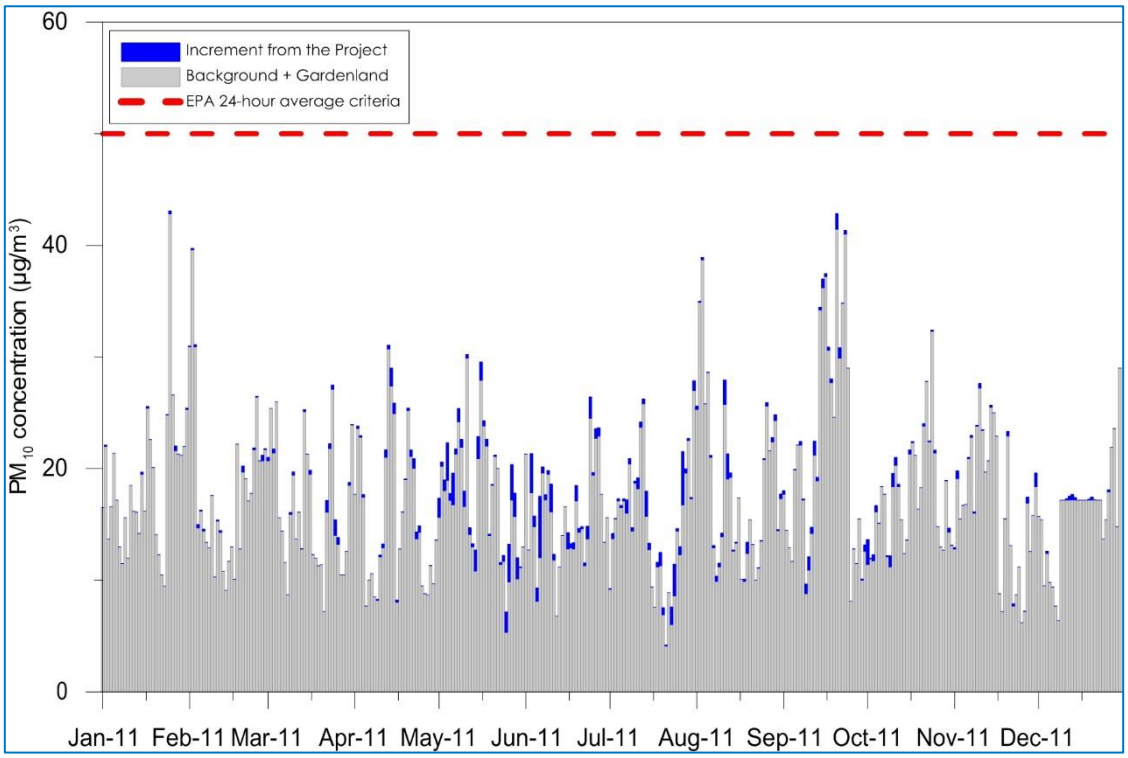


Figure 7.8: PM_{10} concentration time-series at R1

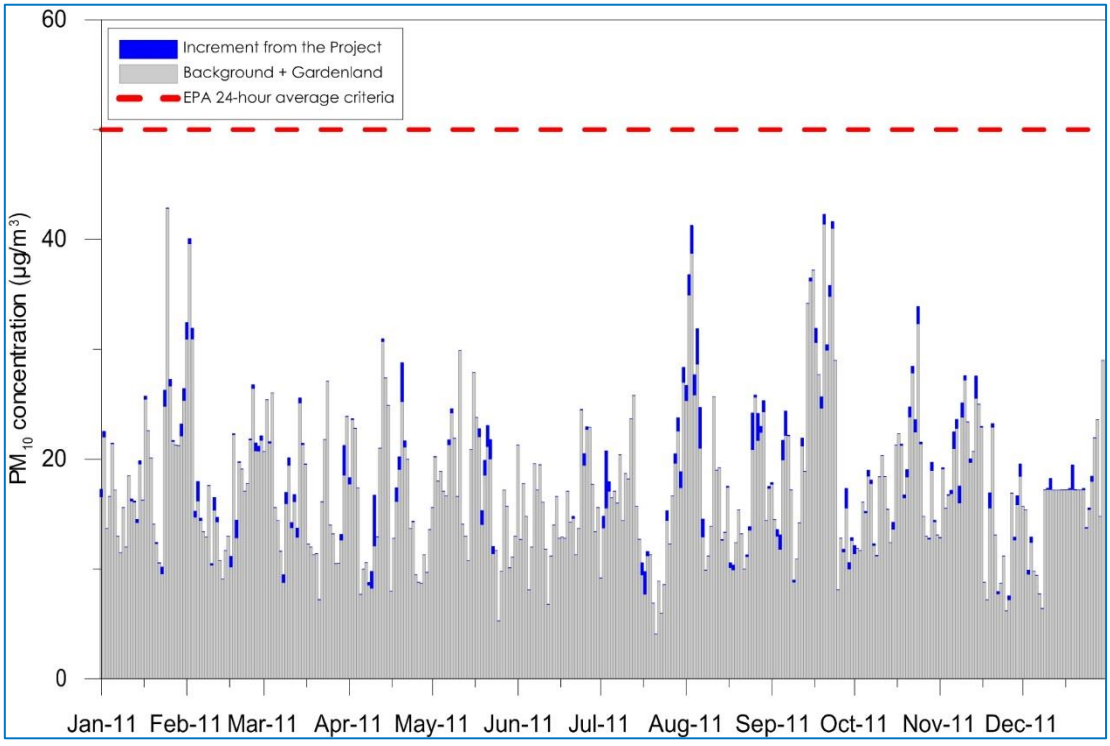


Figure 7.9: PM_{10} concentration time-series at R8

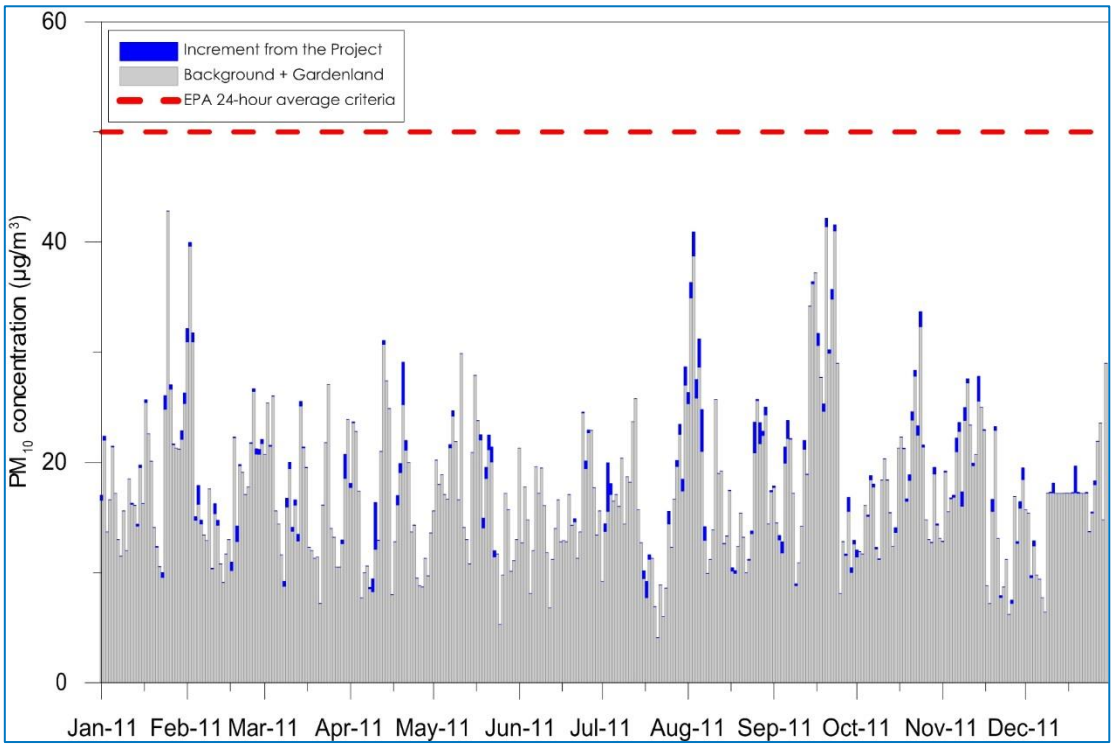


Figure 7.10: PM_{10} concentration time-series at R7

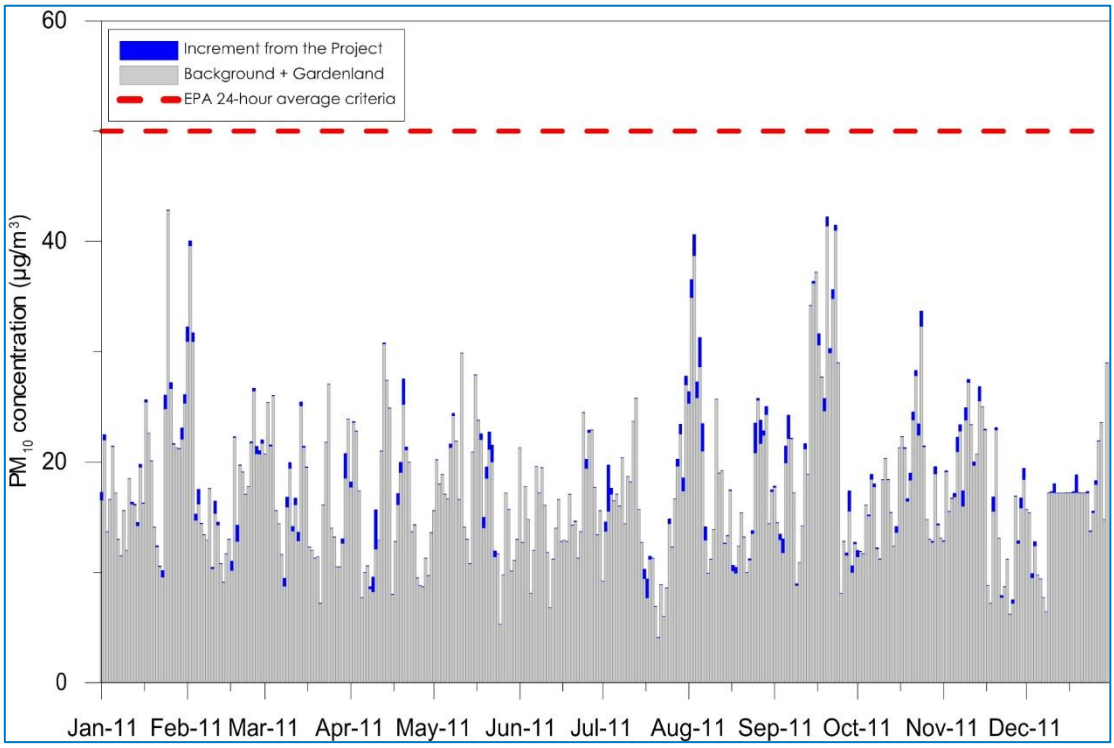


Figure 7.11: PM_{10} concentration time-series at R9

7.5.5.2 24-Hour average $PM_{2.5}$

The results of the cumulative assessment for 24-hour average $PM_{2.5}$ are shown in **Figure 7.12**, **Figure 7.13**, **Figure 7.14**, **Figure 7.15**, and **Figure 7.16** for the five worst impacted assessment locations. The plots show time-series of cumulative 24-hour $PM_{2.5}$ concentration compared with the assumed background (Beresfield $PM_{2.5}$ concentrations plus modelled Gardenland $PM_{2.5}$ concentrations). It is clear from these plots that the addition of the project would be unlikely to result in any days over the impact assessment criteria at the 25 µg/m^3 level, and that as with PM_{10}, the project has a very minimal impact on current $PM_{2.5}$ concentrations.

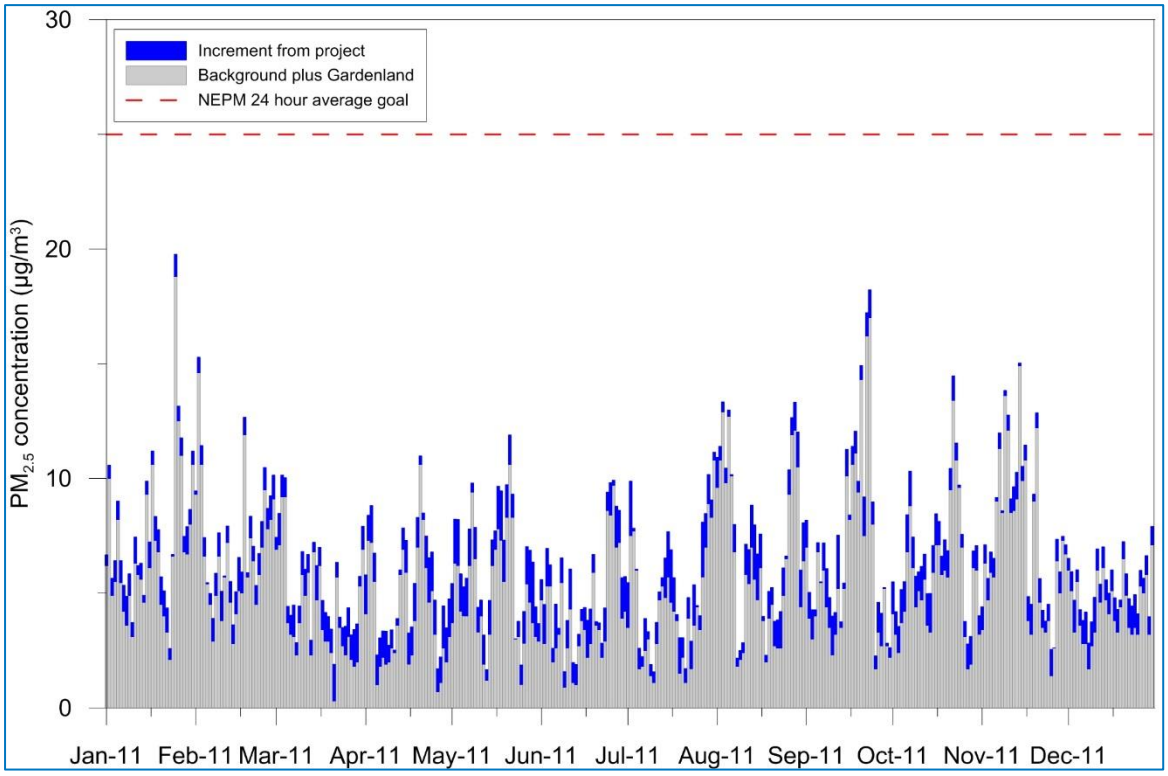


Figure 7.12: $PM_{2.5}$ concentration time-series at R23

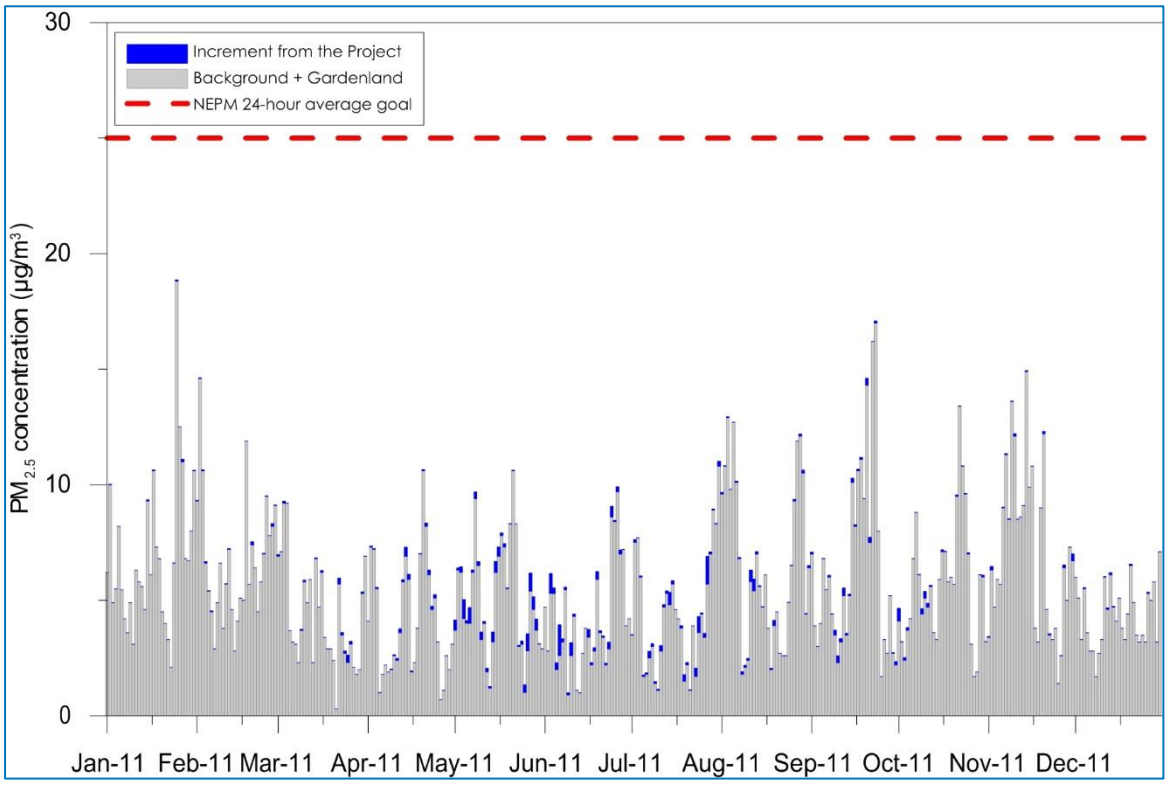


Figure 7.13: $PM_{2.5}$ concentration time-series at R1

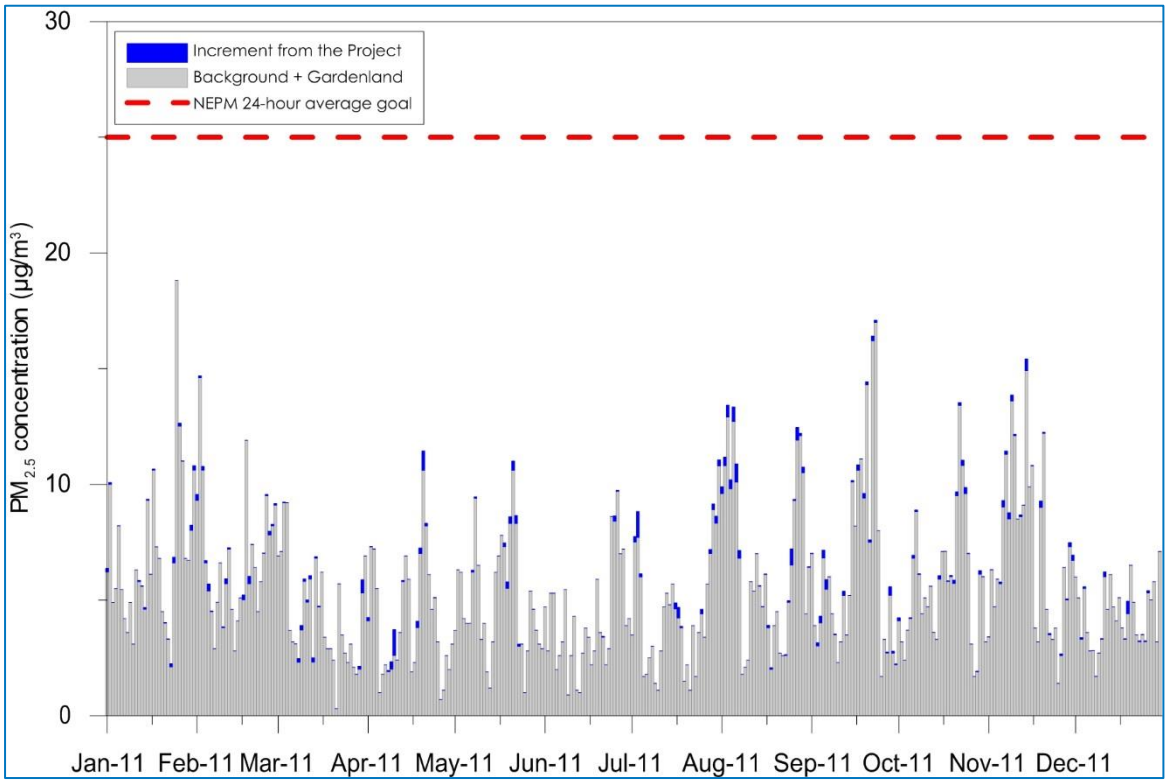


Figure 7.14: $PM_{2.5}$ concentration time-series at R8

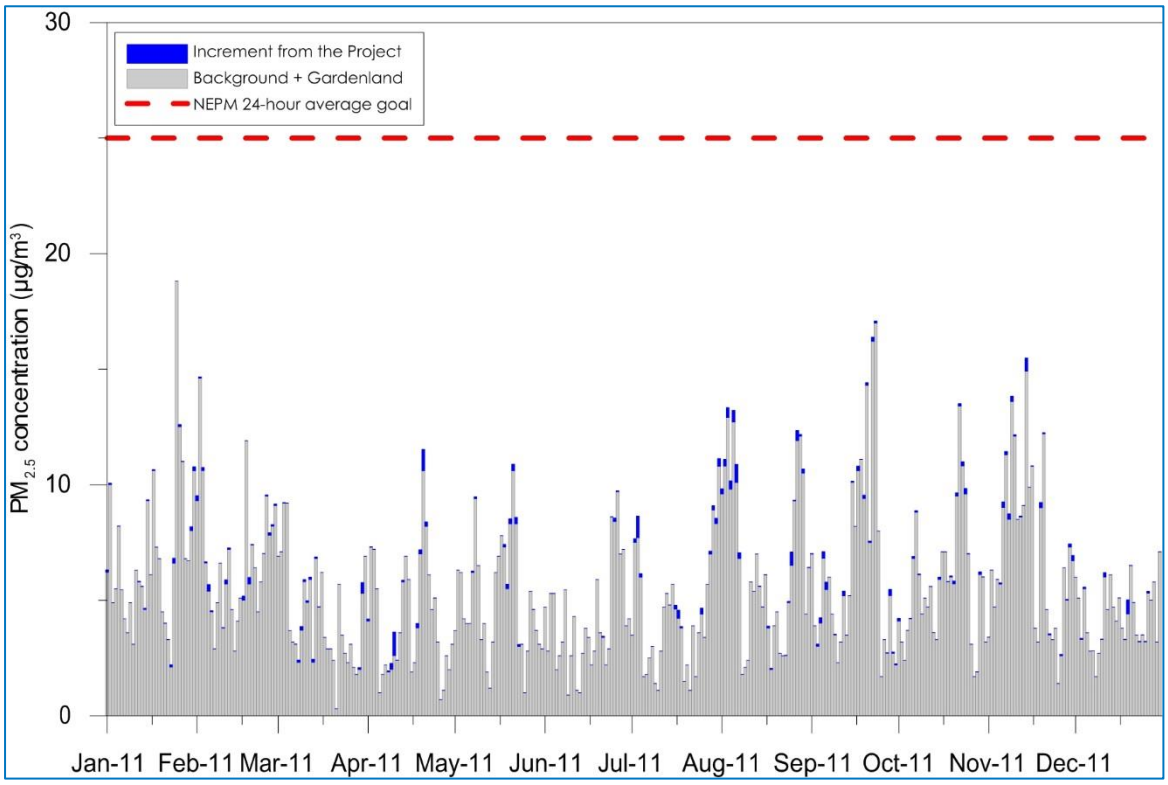


Figure 7.15: $PM_{2.5}$ concentration time-series at R7

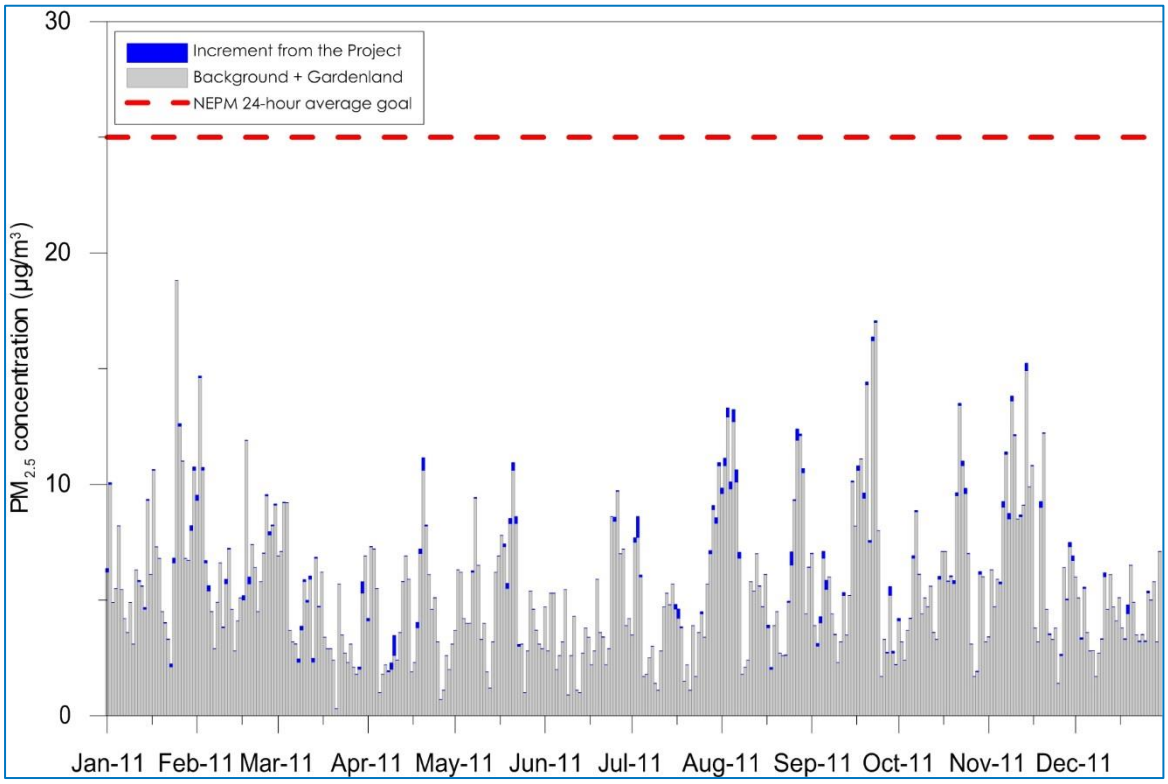


Figure 7.16: $PM_{2.5}$ concentration time-series at R9

7.5.5.3 Annual Average

The predicted pollutant concentrations, including the emissions from Gardenland, at each of the sensitive receptors are added to the adopted background levels and presented in **Table 7.3**. There are no privately owned receivers that are predicted to exceed the annual average assessment criteria when existing background concentrations are included.

Table 7.3: Predicted Cumulative Annual Average PM_{10}, $PM_{2.5}$, TSP and Dust Deposition concentrations at Receptor Locations

Receptor ID	PM_{10}	$PM_{2.5}$	TSP	DD
	Annual	Annual	Annual	Annual
	µg/m³	µg/m³	µg/m³	g/m²/month
Criteria	**30**	**25**	**90**	**4**
Background	***20***	***7***	***50***	***1.8***
R1	20.4	7.09	51	1.9
R2	20.1	7.03	50	1.8
R3	20.1	7.03	50	1.8
R4	20.1	7.03	50	1.8
R5	20.2	7.05	50	1.8
R6	20.3	7.06	50	1.8
R7	20.3	7.07	51	1.8
R8	20.4	7.08	51	1.8
R9	20.3	7.07	51	1.8
R10	20.3	7.07	50	1.8
R11	20.3	7.05	50	1.8
R12	20.2	7.04	50	1.8
R13	20.3	7.07	51	1.8
R14	20.3	7.06	50	1.8
R15	20.3	7.05	50	1.8
R16	20.2	7.05	50	1.8
R17	20.2	7.05	50	1.8
R18	20.3	7.06	50	1.8
R19	20.2	7.05	50	1.8
R20	20.1	7.03	50	1.8
R21	20.1	7.03	50	1.8
R22	20.2	7.03	50	1.8
R23	24.2	7.99	64.9	2.4
R24	20.2	7.04	50	1.8
R25	20.2	7.04	50	1.8
R26	20.1	7.02	50	1.8
R27	20.1	7.02	50	1.8
R28	20.1	7.03	50	1.8
R29	20.1	7.02	50	1.8
R30	20.2	7.03	50	1.8
R31	20.1	7.03	50	1.8
R32	20.2	7.04	50	1.8
R33	20.1	7.02	50	1.8
R34	20.1	7.03	50	1.8
R35	20.1	7.03	50	1.8
R36	20.1	7.02	50	1.8
R37	20.1	7.02	50	1.8
R38	20.1	7.01	50	1.8
R39	20	7.01	50	1.8
R40	20.1	7.02	50	1.8

7.5.6 Monitoring and Mitigation Measures

As discussed in the original air quality assessment, the Project employs a number of best practice mitigation measures on-site to ensure that dust impacts are minimised. These measures include:

- Use of water carts/trucks to control emissions from haul roads.
- Enforcement of speed limits onsite and on right of way.
- Progressive rehabilitation of exposed areas.
- Application of water at the crusher and on conveyor transfer points.
- Minimising drop height of material during truck loading and unloading.
- Use of water sprays when drilling.
- Sheltering of stockpiles and transfer points where possible.
- Proper blast design.
- Management of dust generating activities during unfavourable meteorological conditions.

In addition to these measures above the proponent will commit to the installation of an air quality monitor (High Volume Air Sampler (HVAS) or Tapered Element Oscillating Microbalance (TEOM)) at a location representative of nearby receptors.

Fumes from blasting will be managed, in accordance with *Code of Good Practice: Prevention and Management of Blast Generated NO_x Gases in Surface Blasting* (**Australian Explosives Industry and Safety Group Inc., 2011**). In summary they include measures to:

- Restrict blasting to between 9am and 5pm (EST) (9am and 6pm (EST)) Monday to Saturday, when winds are not blowing from the north and northeast.
- Restrict blast frequency to two blasts per day.
- Assess meteorological conditions such as wind speed and direction immediately prior to each blast to identify the blast exclusion arc.
- Restrict blasting to suitable atmospheric and meteorological conditions.
- Advise nearby private landholders of blasting times.
- Document and video record each blast to determine fume generation for a minimum of 1-minute duration while following the blast until the fume has dissipated.

Although theoretically there is potential for NO_2 from blast fumes to exceed the 1-hour average criterion under certain meteorological conditions, blasts will continue to be designed not to cause exceedances.

8 GREENHOUSE GAS ASSESSMENT

8.1 Introduction

As with the original Greenhouse gas (GHG) assessment, emissions have been estimated based on the methods outlined in the following documents:

- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) Greenhouse Gas Protocol *The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition* **(WRI/WBCSD, 2004)**;
- National Greenhouse and Energy Reporting (Measurement) Determination 2008; and
- The Department of the Environment *National Greenhouse Accounts* (NGA) *Factors 2015* **(DOE, 2015)**.

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Standard Organisation, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes.

Three 'scopes' of emissions (scope 1, scope 2 and scope 3) are defined for GHG accounting and reporting purposes, as described below. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment. The 'scope' of an emission is relative to the reporting entity. Indirect scope 2 and scope 3 emissions will be reportable as direct scope 1 emissions from another facility.

1) Scope 1: Direct Greenhouse Gas Emissions

Direct GHG emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct GHG emissions are those emissions that are principally the result of the following types of activities undertaken by an entity:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources.
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials (e.g. the manufacture of cement, aluminium, etc.).
- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources (e.g. trucks, trains, ships, aeroplanes, buses and cars).
- Fugitive emissions. These emissions result from intentional or unintentional releases (e.g. equipment leaks from joints, seals, packing and gaskets; methane (CH_4) emissions from coal mines and venting); hydrofluorocarbon (HFC) emissions during the use of refrigeration and air conditioning equipment; and CH_4 leakages from gas transport.

2) Scope 2: Energy Product Use Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that account for GHG emissions from the generation of purchased energy products (principally, electricity, steam/heat and reduction materials used for smelting) by the entity. Scope 2 in relation to mines typically covers purchased electricity, defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity.

3) Scope 3: Other Indirect Greenhouse Gas Emissions

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

For consistency with the previous assessment, scope 3 emissions will not be assessed. The GHG Protocol provides that reporting scope 3 emissions is optional. If an organisation believes that scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with scope 1 and scope 2. However, the GHG Protocol notes that reporting scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult because reporting is voluntary. Double counting needs to be avoided when compiling national (country) inventories under the Kyoto Protocol. The GHG Protocol also recognises that compliance regimes are more likely to focus on the "point of release" of emissions (i.e. direct emissions) and/or indirect emissions from the purchase of electricity.

8.2 Greenhouse Gas Emission Estimates

Emissions of carbon dioxide (CO_2) would be the most significant GHGs for the Project. These gases are formed and released during the combustion of fuels used on site.

Inventories of GHG emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as global warming potentials) and emission factors take into account the global warming potentials of the gases created during combustion. The estimated emissions are referred to in terms of carbon dioxide equivalent (CO_2-e) emissions by applying the relevant global warming potential. The GHG assessment has been conducted using the National Greenhouse Account (NGA) Factors, published by the **DOE (2015)**.

Project-related GHG sources included in the assessment are as follows:

- fuel consumption (diesel) during quarrying operations and construction – scope 1.
- indirect emissions associated with on-site electricity use – scope 2.
- indirect emissions associated with the production and transport of fuels – scope 3.
- emissions from transportation – scope 3.

A summary of the annual GHG emissions is provided in **Table 8.1**. It is acknowledged that there is likely to be a switch from a diesel powered processing plant to an electricity powered processing plant after the quarry begins operating. Due to uncertainty regarding when this is likely to happen, the GHG assessment provides results for the maximum diesel usage under a 100% diesel powered plant for the entire quarry life, as well as the maximum electricity usage under a 100% electricity powered plant for the entire quarry life. This assessment is therefore highly conservative. Further details for the calculations are provided in **Appendix C**.

Average annual scope 1 emissions from the Project (0.04 Mt CO_2-e) would represent approximately 0.0003% of Australia's annual average commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global greenhouse emissions, given that Australia contributed approximately 1.5% of global GHG emissions in 2005 **(Commonwealth of Australia, 2011)**. In reality these emissions will be lower as the plant will not be operating entirely on 100% diesel and 100% electricity at the same time.

Table 8.1: Summary of Annual Greenhouse Gas Emissions

Year	Scope 1 Emissions (t CO_2-e)	Scope 2 Emissions (t CO_2-e)	Scope 3 Emissions (t CO_2-e)		
	Diesel	Electricity	Diesel	Electricity	*Total*
Year 1	620	1,260.0	32	180.0	*212*
Year 2	802	1,260.0	41	180.0	*221*
Year 3	923	1,260.0	47	180.0	*227*
Year 4	1,104	1,260.0	56	180.0	*236*
Year 5	1,344	1,260.0	69	180.0	*249*
Year 6	1,527	1,260.0	78	180.0	*258*
Year 7	1,527	1,260.0	78	180.0	*258*
Year 8	1,527	1,260.0	78	180.0	*258*
Year 9	1,527	1,260.0	78	180.0	*258*
Year 10	1,527	1,260.0	78	180.0	*258*
Year 11	1,527	1,260.0	78	180.0	*258*
Year 12	1,527	1,260.0	78	180.0	*258*
Year 13	1,527	1,260.0	78	180.0	*258*
Year 14	1,527	1,260.0	78	180.0	*258*
Year 15	1,527	1,260.0	78	180.0	*258*
Year 16	1,527	1,260.0	78	180.0	*258*
Year 17	1,527	1,260.0	78	180.0	*258*
Year 18	1,527	1,260.0	78	180.0	*258*
Year 19	1,527	1,260.0	78	180.0	*258*
Year 20	1,527	1,260.0	78	180.0	*258*
Year 21	1,527	1,260.0	78	180.0	*258*
Year 22	1,527	1,260.0	78	180.0	*258*

Year	Scope 1 Emissions (t CO_{2}-e)	Scope 2 Emissions (t CO_{2}-e)	Scope 3 Emissions (t CO_{2}-e)		
	Diesel	Electricity	Diesel	Electricity	*Total*
Year 23	1,527	1,260.0	78	180.0	*258*
Year 24	1,527	1,260.0	78	180.0	*258*
Year 25	1,527	1,260.0	78	180.0	*258*
Year 26	1,527	1,260.0	78	180.0	*258*
Year 27	1,527	1,260.0	78	180.0	*258*
Year 28	1,527	1,260.0	78	180.0	*258*
Year 29	1,527	1,260.0	78	180.0	*258*
Year 30	1,527	1,260.0	78	180.0	*258*
Total	**42,959**	**37,800**	**2,194**	**5,400**	**7,594**
Annual Average	1,520	1,260	78	180	258

9 CONCLUSION

This report updates a previous Air Quality and Greenhouse Gas Assessment for the Project, in accordance with the Director General Requirements for Environmental Assessment. It reflects impacts associated with an increase in production output from a maximum of 500 ktpa to a maximum of 600 ktpa.

One worst-case operational scenario was assessed based on maximum annual production at 600 ktpa. Dispersion modelling was conducted for both scenarios to predict the ground level concentrations for all relevant pollutants.

The results of the modelling indicate that the predicted incremental PM_{10}, TSP and dust deposition at the closest residential receptors are all below the impact assessment criteria, even at a worst-case maximum production rate. The highest predicted glcs occur at R23 that is located adjacent to Gardenland, however these predicted glcs comply with the relevant assessment criteria.

A cumulative assessment, incorporating existing background levels, indicates that the Project is unlikely to result in any exceedances of relevant impact assessment criteria at the neighbouring receivers.

A re-assessment of the GHG emissions associated with revised Project data indicates that average annual scope 1 emissions would represent approximately 0.0003% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_{2}-e).

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Appendix A MODEL SETUP

Model Set Up

TAPM (v 4.0.4)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grid points	50 x 50 x 35
Year of analysis	2011
Centre of analysis (local coordinates)	368200, 6379200
CALMET (v. 6.333)	
Meteorological grid domain	60 km x 40 km
Meteorological grid resolution	250 m
Input data	Surface station data from Williamtown, Cessnock, Patterson and Newcastle. Prognostic 3D.dat extracted from TAPM at 3 km grid

CALMET Model Options used

Flag	Descriptor	Default	Value Used
IEXTRP	Extrapolate surface wind observations to upper layers	Similarity theory	Similarity theory
BIAS (NZ)	Relative weight given to vertically extrapolated surface observations versus upper air data	NZ * 0	-1, -0.5, -0.25, 0, 0, 0, 0
TERRAD	Radius of influence of terrain	No default (typically 5- 15km)	5 km
RMAX1 and RMAX2	Maximum radius of influence over land for observations in layer 1 and aloft	No Default	2.5 km
R1 and R2	Distance from observations in layer 1 and aloft at which observations and Step 1 wind fields are weighted equally	No Default	1.25 km

CALPUFF Model Options used

Flag	Flag Descriptor	Value Used	Value Description
MCHEM	Chemical Transformation	0	Not modelled
MDRY	Dry Deposition	1	Yes for PM
MTRANS	Transitional plume rise allowed?	1	Yes
MTIP	Stack tip downwash?	1	Yes
MRISE	Method to compute plume rise	1	Briggs plume rise
MSHEAR	Vertical wind Shear	0	Vertical wind shear not modelled
MPARTL	Partial plume penetration of elevated inversion?	1	Yes
MSPLIT	Puff Splitting	0	No puff splitting
MSLUG	Near field modelled as slugs	0	Not used
MDISP	Dispersion Coefficients	2	Based on micrometeorology
MPDF	Probability density function used for dispersion under convective conditions	0	No
MROUGH	PG sigma y,z adjusted for z	0	No
MCTADJ	Terrain adjustment method	3	Partial Plume Adjustment
MBDW	Method for building downwash	1	ISC method

Appendix B ESTIMATED EMISSIONS

Eagleton Hard Rock Quarry

Estimated emissions are presented for all significant dust generating activities associated with the operation of the Project.

Fugitive dust emissions can be expected during operation from the following activities:

- Drilling and blasting
- Loading/unloading to trucks;
- Crushing and screening – primary/secondary/tertiary;
- Hauling
- wind erosion; and
- Grading roads

Loading / transfer material dumping waste rock

Each tonne of material loaded will generate a quantity of particulate matter that will depend on the wind speed and the moisture content according to the US EPA emission factor equation (**US EPA, 1985 and updates**) shown below:

$$E\ (kg/t) = k\ \times 0.0016\ \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$$

Where:

K = 0.74 for TSP, 0.35 for PM_{10} and 0.053 for $PM_{2.5}$

U – wind speed (m/s)

M – moisture content (%)

The moisture content of waste material is assumed to be 2% and the wind speed is taken from the CALMET generated wind at the project site.

Hauling material on unsealed surfaces

The emission estimate of wheel generated dust associated with hauling at the pit top areas (i.e. for hauling of waste rock material during construction is based the US EPA AP42 emission equation for unpaved surfaces at industrial sites (**US EPA, 1985 and updates**) shown below:

$$E\ \ (kg/VKT) = 0.2819 \times k \times [\ \times (s/12)\text{^}0.7 \times ((W \times 1.1023)/3)\text{^}0.45]$$

Where:

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

s = silt content of road surface

W = mean vehicle weight

The silt content (s) for the haulage routes is assumed to be 5%.

The mean vehicle weight used in the emissions estimates is an average of the loaded and unloaded gross vehicle mass, to account for one empty trip and one loaded trip. Haul trucks carrying waste during construction are assumed to have a payload of 33 t and a gross vehicle mass of 47.3 t.

Drilling

The emission factor used for drilling has been taken to be 0.59 kg/hole (**US EPA, 1985 and updates**).

Blasting

TSP emissions from blasting were estimated using the **US EPA (1985 and updates)** emission factor equation below:

$$E_{TSP} = k \times A^{1.5} \ (kg|blast)$$

Where:
k = 0.00022 for TSP, 0.000114 for PM_{10} and 0.000066 for $PM_{2.5}$
E_{TSP} = TSP emissions
A = Area to be blasted in m^2

The area blasted is 6,250 m^2.

Crushing and Screening

The emission factor used for crushing have been taken to from the US EPA emission factors (**US EPA, 1985 and updates**), which are shown in the table below:

Activity	TSP	PM_{10}	$PM_{2.5}$
Tertiary crushing (controlled)	0.0006	0.00027	0.00005
Fines crushing (controlled)	0.0015	0.0006	0.000035
Screening (controlled)	0.0011	0.00037	0.000025
Fine screening (controlled)	0.0018	0.0011	0.0011

Wind Erosion

The emission factor used for wind erosion has been taken from the US EPA emission factors (**US EPA, 1985 and updates**) for wind erosion of overburden and exposed areas. These emission factors are 0.1 kg/VKT for TSP, 0.5 x TSP for PM_{10} and 0.075 x TSP for $PM_{2.5}$.

Grading roads

Estimates of TSP emissions from grading roads have been made using the **US EPA (1985 and updates)** emission factor equation (Equation 8).

$$E_{TSP} = 0.0034 \times S^{2.5}$$

Where:
S = speed of the grader in km/h (taken to be 8 km/h)

Estimated emissions of TSP

ACTIVITY	TSP emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Controls Assumed
Extraction Area																		
Drilling rock	1327.5	7500	holes/y	0.59	kg/hole											70	% control	Water injection
Blasting rock	1304	12	blasts/y	108.70	kg/blast	6250	Area of blast in square metres	625	holes/blast									
Excavator loading	622	600,000	t/y	0.00104	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %									
Hauling to Processing area	24818	600000	t/y	0.165	kg/t	33	t/load	47.32	Vehicle gross mass (t)	2	km/return trip	2.71	kg/VKT	5	% silt content	75	% control	Watering Level 2
Processing Area																		
Unloading at processing area	311	600000	t/y	0.00104	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							50	% control	Water sprays
Rehandle rock to hopper	311	600000	t/y	0.00104	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							50	% control	Water sprays
Primary Crushing (controlled)	360	600,000	t/y	0.0006	kg/t													Water application
Screening (controlled)	660	600,000	t/y	0.0011	kg/t													Water application
Secondary Crushing (controlled_	360	600,000	t/y	0.0006	kg/t													Water application
Tertiary Crushing (controlled)	360	600,000	t/y	0.0006	kg/t													Water application
Crushing (Fines) (controlled)	900	600,000	t/y	0.0015	kg/t													Water application
Fines Screening (controlled)	1,080	600,000	t/y	0.0018	kg/t													Water application
Pug Mill	180	100,000	t/y	0.0018	kg/t													Water application
Stacking stockpiles - aggregate	311	600,000	t/y	0.00104	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							50	% control	Water sprays
FEL loading trucks - aggregate	622	600,000	t/y	0.00104	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %									
Hauling product to site boundary (unseal	12,409	600,000	t/y	0.083	kg/t	33	t/load	47.32	Vehicle gross mass (t)	1	km/return trip	2.71	kg/VKT	5	% silt content	75	% control	Watering Level 2
Hauling product to Italia Road (sealed ro	36,370	600,000	t/y	0.061	kg/t	33	t/load	47.32	Vehicle gross mass (t)	4	km/return trip	0.50	kg/VKT	3.0	g/m2 silt loading			
Grading roads	1,412	2,294	km	0.615	kg/VKT	8	speed of graders in km/h	287	Grader hours									
Wind Erosion																		
WE - Extraction Area	26798	30.59	ha	0.1	kg/ha/h	8760	h/y											
WE- from conveyors	27	0.05	ha	0.1	kg/ha/y	8760	h/y									40	% Control	Wind shielding - si
WE - Processing Area (stockpiles)	416	0.95	ha	0.1	kg/ha/h	8760	h/y									50	% Control	Water sprays
Total (kg/y)	110,959																	

Estimated emissions of PM_{10}

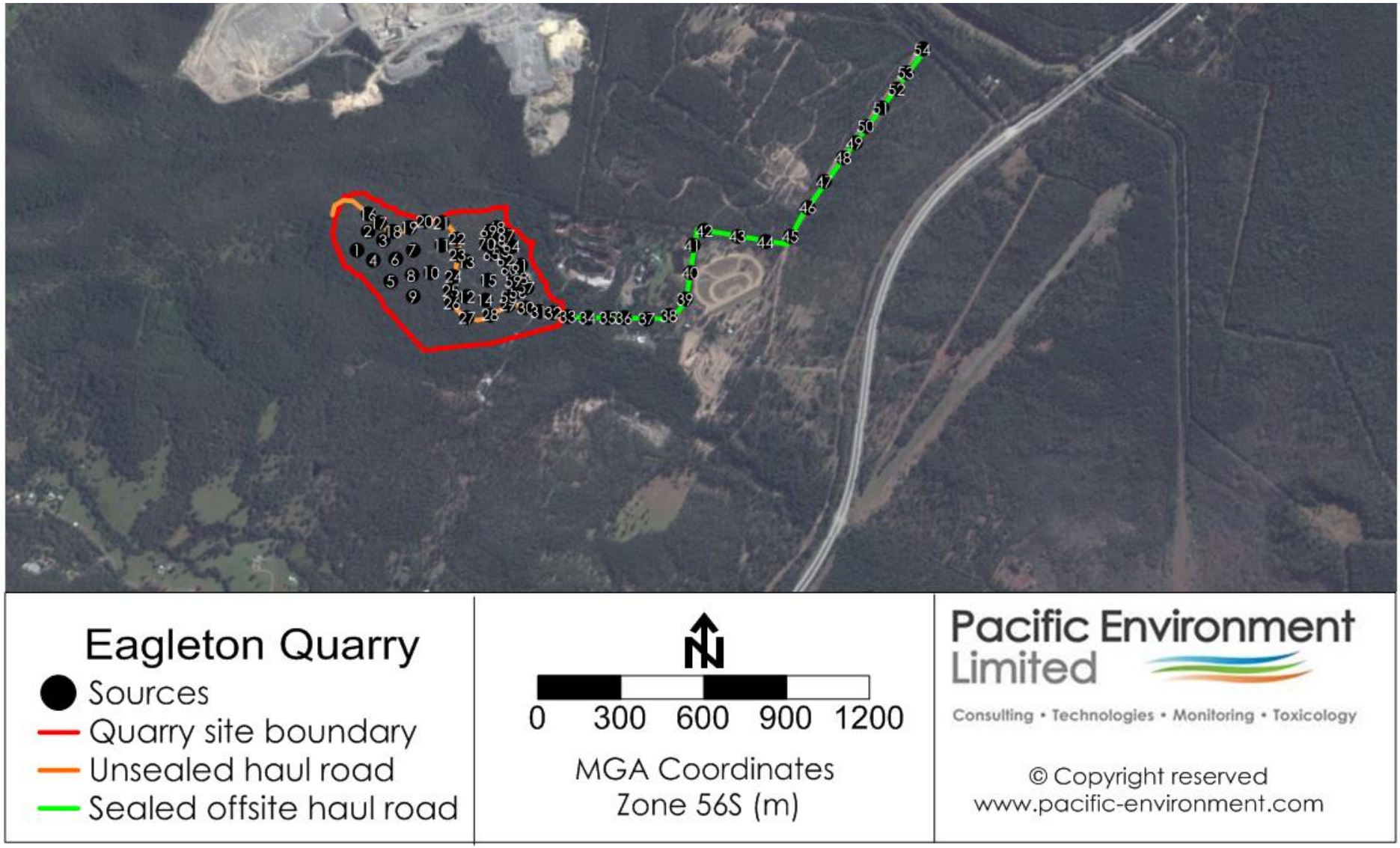
ACTIVITY	PM10 emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Controls Assumed
Extraction Area																		
Drilling rock	690.3	7500	holes/y	0.3068	kg/hole											70	% control	Water injection
Blasting rock	678	12	blasts/y	56.525713	kg/blast	6250	Area of blast in square metres	625	holes/blast									
Excavator loading	294	600,000	t/y	0.0004906	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %									
Hauling to Processing area	6377	600000	t/y	0.0425128	kg/t	32.7	t/load	47.32	Vehicle gross mass (t)	2	km/return trip	0.6950846	kg/VKT	5	% silt content	75	% control	Watering Level 2
Processing Area																		
Unloading at processing area	147	600000	t/y	0.0004906	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							50	% control	Water sprays
Rehandle rock to hopper	147	600000	t/y	0.0004906	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							50	% control	Water sprays
Primary Crushing (controlled)	162	600,000	t/y	0.00027	kg/t													Water application
Screening (controlled)	222	600,000	t/y	0.00037	kg/t													Water application
Secondary Crushing (controlled_	162	600,000	t/y	0.00027	kg/t													Water application
Tertiary Crushing (controlled)	162	600,000	t/y	0.00027	kg/t													Water application
Crushing (Fines) (controlled)	360	600,000	t/y	0.0006	kg/t													Water application
Fines Screening (controlled)	660	600,000	t/y	0.0011	kg/t													Water application
Pug Mill	110	100,000	t/y	0.0011	kg/t													Water application
Stacking stockpiles - aggregate	147	600,000	t/y	0.0004906	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							50	% control	Water sprays
FEL loading trucks - aggregate	294	600,000	t/y	0.0004906	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %									
Hauling product to site boundary (unseal	3,188	600,000	t/y	0.0212564	kg/t	33	t/load	47.32	Vehicle gross mass (t)	1	km/return trip	0.6950846	kg/VKT	5	% silt content	75	% control	Watering Level 2
Hauling product to Italia Road (sealed ro	6,981	600,000	t/y	0.0116352	kg/t	33	t/load	47.32	Vehicle gross mass (t)	4	km/return trip	0.0951182	kg/VKT	3.0	g/m2 silt loading			
Grading roads	1,412	2,294	km	0.615	kg/VKT	8	speed of graders in km/h	287	Grader hours									
Wind Erosion																		
WE - Extraction Area	13399	30.59	ha	0.05	kg/ha/h	8760	h/y											
WE- from conveyors	14	0.05	ha	0.05	kg/ha/y	8760	h/y									40	% Control	Wind shielding - si
WE - Processing Area (stockpiles)	208	0.95	ha	0.05	kg/ha/h	8760	h/y									50	% Control	Water sprays
Total (kg/y)	35,816																	

Estimated emissions $PM_{2.5}$

ACTIVITY	PM2.5 emission (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Controls Assumed
Extraction Area																		
Drilling rock	39.825	7500	holes/y	0.0177	kg/hole											70	% control	Water injection
Blasting rock	39	12	blasts/y	3.26	kg/blast	6250	Area of blast in square metres	625	holes/blast									
Excavator loading	45	600,000	t/y	0.00007	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %									
Hauling to Processing area	638	600000	t/y	0.004	kg/t	33	t/load	47.32	Vehicle gross mass (t)	2	km/return trip	0.07	kg/VKT	5	% silt content	75	% control	Watering Level 2
Processing Area																		
Unloading at processing area	22	600000	t/y	0.00007	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							50	% control	Water sprays
Rehandle rock to hopper	22	600000	t/y	0.00007	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							50	% control	Water sprays
Primary Crushing (controlled)	30	600,000	t/y	0.0001	kg/t													Water application
Screening (controlled)	15	600,000	t/y	0.0000	kg/t													Water application
Secondary Crushing (controlled_	30	600,000	t/y	0.0001	kg/t													Water application
Tertiary Crushing (controlled)	30	600,000	t/y	0.0001	kg/t													Water application
Crushing (Fines) (controlled)	21	600,000	t/y	0.0000	kg/t													Water application
Fines Screening (controlled)	660	600,000	t/y	0.0011	kg/t													Water application
Pug Mill	110	100,000	t/y	0.0011	kg/t													Water application
Stacking stockpiles - aggregate	22	600,000	t/y	0.00007	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							50	% control	Water sprays
FEL loading trucks - aggregate	45	600,000	t/y	0.00007	kg/t	0.876	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %									
Hauling product to site boundary (unseal	319	600,000	t/y	0.002	kg/t	33	t/load	47.32	Vehicle gross mass (t)	1	km/return trip	0.07	kg/VKT	5	% silt content	75	% control	Watering Level 2
Hauling product to Italia Road (sealed ro	1,689	600,000	t/y	0.003	kg/t	33	t/load	47.32	Vehicle gross mass (t)	4	km/return trip	0.02	kg/VKT	3.0	g/m2 silt loading			
Grading roads	1,412	2,294	km	0.615	kg/VKT	8	speed of graders in km/h	287	Grader hours									
Wind Erosion																		
WE - Extraction Area	2010	30.59	ha	0.01	kg/ha/h	8760	h/y											
WE- from conveyors	2	0.05	ha	0.01	kg/ha/y	8760	h/y									40	% Control	Wind shielding - si
WE - Processing Area (stockpiles)	31	0.95	ha	0.01	kg/ha/h	8760	h/y									50	% Control	Water sprays
Total (kg/y)	7,232																	

Estimated emissions of TSP, PM_{10} and $PM_{2.5}$ from Port Stephens Gardenland

ACTIVITY	TSP emission (kg/y)	PM10 emission (kg/y)	PM2.5 emission (kg/y)
Turning - FEL	6	3	0
Loading - FEL	6	3	0
Hauling	49	37	37
Unloading - FEL	6	3	0
Screening			
Crushing (hammer mill)	21	8	0
Screening	15	5	0
Wind erosion			
WE total	634	317	48
Hauling product to Italia Rd	228	44	11
Total	**965**	**420**	**97**



Modelled Quarry plan

Appendix C ESTIMATION OF GREENHOUSE GAS EMISSIONS

C.1 FUEL CONSUMPTION

GHG emissions from diesel consumption were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

E_{CO2-e}	=	Emissions of GHG from diesel combustion	(t CO_2-e)[1]
Q	=	Estimated combustion of diesel	(GJ)[2]
EF	=	Emission factor (scope 1 or scope 3) for diesel combustion	(kg CO_2-e/GJ)[3]

1 tCO_2-e = tonnes of carbon dioxide equivalent.

2 GJ = gigajoules.

3 kg CO_2-e/GJ = kilograms of carbon dioxide equivalents per gigajoule.

The quantity of diesel consumed (Q) in each year has been provided by the proponent. The quantity of diesel consumed in gigajoules (GJ) (Q) is then calculated using an energy content factor for diesel of 38.6 gigajoules per kilolitre (GJ/kL).

GHG emission factors and energy content for diesel were sourced from the NGA Factors (**DoE, 2015**). The estimated annual and Project total GHG emissions from diesel usage are presented in **Table C.1**.

Table C.1: Estimated CO_{2-e} (tonnes) for diesel consumption

Year	Diesel (kL)	Emissions (t CO_{2-e})		
		Scope 1	Scope 3	Total
Year 1	228	620	32	652
Year 2	295	802	41	843
Year 3	339	923	47	970
Year 4	406	1,104	56	1,160
Year 5	494	1,344	69	1,413
Year 6	561	1,527	78	1,605
Year 7	561	1,527	78	1,605
Year 8	561	1,527	78	1,605
Year 9	561	1,527	78	1,605
Year 10	561	1,527	78	1,605
Year 11	561	1,527	78	1,605
Year 12	561	1,527	78	1,605
Year 13	561	1,527	78	1,605
Year 14	561	1,527	78	1,605
Year 15	561	1,527	78	1,605
Year 16	561	1,527	78	1,605
Year 17	561	1,527	78	1,605
Year 18	561	1,527	78	1,605
Year 19	561	1,527	78	1,605
Year 20	561	1,527	78	1,605
Year 21	561	1,527	78	1,605
Year 22	561	1,527	78	1,605
Year 23	561	1,527	78	1,605
Year 24	561	1,527	78	1,605
Year 25	561	1,527	78	1,605
Year 26	561	1,527	78	1,605
Year 27	561	1,527	78	1,605
Year 28	561	1,527	78	1,605
Year 29	561	1,527	78	1,605
Year 30	561	1,527	78	1,605
Total	**15,786**	**42,959**	**2,194**	**45,152**

C.2 ELECTRICITY

GHG emissions from electricity usage were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

E_{CO2-e}	=	Emissions of GHG from electricity usage	(tCO_2-e/annum)
Q	=	Estimated electricity usage	(kWh/annum)[1]
EF	=	Emission factor (Scope 2 or Scope 3) for electricity usage	($kgCO_2$-e/kWh)[2]

[1] kWh/annum = kilowatt hours per annum

[2] $kgCO_2$-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour

The quantity of electricity used each year was provided by the proponent and assumed to be 750kW/h. GHG emission factors were sourced from the NGA Factors (**DoE, 2015**). The estimated annual and Project total GHG emissions from electricity usage are presented in **Table C.2**.

Table C.2: Estimated CO_2-e (tonnes) for electricity

Year	Electricity (kWhr)	Emissions (t CO_2-e)		
		Scope 2	Scope 3	Total
Year 1	1,500,000	1,260	180	1,440
Year 2	1,500,000	1,260	180	1,440
Year 3	1,500,000	1,260	180	1,440
Year 4	1,500,000	1,260	180	1,440
Year 5	1,500,000	1,260	180	1,440
Year 6	1,500,000	1,260	180	1,440
Year 7	1,500,000	1,260	180	1,440
Year 8	1,500,000	1,260	180	1,440
Year 9	1,500,000	1,260	180	1,440
Year 10	1,500,000	1,260	180	1,440
Year 11	1,500,000	1,260	180	1,440
Year 12	1,500,000	1,260	180	1,440
Year 13	1,500,000	1,260	180	1,440
Year 14	1,500,000	1,260	180	1,440
Year 15	1,500,000	1,260	180	1,440
Year 16	1,500,000	1,260	180	1,440
Year 17	1,500,000	1,260	180	1,440
Year 18	1,500,000	1,260	180	1,440
Year 19	1,500,000	1,260	180	1,440
Year 20	1,500,000	1,260	180	1,440
Year 21	1,500,000	1,260	180	1,440
Year 22	1,500,000	1,260	180	1,440
Year 23	1,500,000	1,260	180	1,440
Year 24	1,500,000	1,260	180	1,440
Year 25	1,500,000	1,260	180	1,440
Year 26	1,500,000	1,260	180	1,440
Year 27	1,500,000	1,260	180	1,440
Year 28	1,500,000	1,260	180	1,440
Year 29	1,500,000	1,260	180	1,440
Year 30	1,500,000	1,260	180	1,440
Total	**45,000,000**	**37,800**	**5,400**	**43,200**