Woolgoolga to Ballina Pacific Highway Upgrade

Moonimba Borrow Site

Air Quality Impact Assessment

Report Number 610.16962-R01

20 June 2017

Roads & Maritime Services
c/o Pacific Complete
21 Prince Street
GRAFTON NSW 2460

Version: v1.0

Woolgoolga to Ballina Pacific Highway Upgrade

Moonimba Borrow Site

Air Quality Impact Assessment

PREPARED BY:

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
2 Lincoln Street
Lane Cove NSW 2066 Australia
(PO Box 176 Lane Cove NSW 1595 Australia)
T: +61 2 9427 8100 F: +61 2 9427 8200
sydney@slrconsulting.com www.slrconsulting.com

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.16962-R01-v1.0	20 June 2017	Ali Naghizadeh	K Lawrence	K Lawrence
610.16962-R01-v0.1	01 June 2017	Ali Naghizadeh	K Lawrence	DRAFT

Table of Contents

Table of Contents

Table of Contents

TABLES

FIGURES

1 INTRODUCTION

Pacific Complete on behalf of Roads and Maritime Services (RMS) is preparing a modification report for the Woolgoolga to Ballina Pacific Highway Upgrade project (W2B) for the use of the Moonimba Quarry, known to the project as Moonimba Borrow Site (the project site), situated in Bungawalbin, NSW. This Air Quality Impact Assessment (AQIA) will form part of this modification report.

Pacific Complete is proposing to intensify the annual extraction rate at the site to one million tonnes (1,000,000 tonnes), which is equivalent to 400,000 m^3 of aggregate per annum, to provide sufficient material to complete the W2B project. The purpose of this AQIA is to predict the highest levels of identified air pollutants that could result from the added industrial activity at the project site and compare these predictions with those of the existing operations. Air quality impacts from the existing operations were assessed in the 2014 *Newman's Quarry Expansion Air Quality Impact Assessment* prepared by ENVIRON Australia Pty Ltd for Newman's Quarry and Landscaping Pty Ltd (hereafter, the 2014 AQIA). For the purpose of this study, it has been assumed that emissions from the existing operations are similar to what was predicted in the 2014 AQIA.

Moonimba Borrow Site is situated approximately 10 km south-west of Woodburn. It resides to the west of Portion C of the W2B project. Split between two pits, the site will operate with a total excavation area of 21 hectares (ha).

An Environmental Impact Statement (EIS) prepared by RMS for the Woolgoolga to Ballina Pacific Highway Upgrade (RMS, 2012), considered the potential air quality impact from the construction of the W2B project through a qualitative air quality assessment. This assessment did not identify air quality as a key issue for the W2B project and found that while there was potential for sensitive receptors to be affected by fugitive dust emissions, any negative impacts could be avoided through appropriate mitigation. These mitigation measures will be adopted for the proposed Moonimba Borrow Site.

It is noted that the Moonimba Borrow Site was not identified in the 2012 EIS as a borrow site to provide material for the construction of the project and was therefore not assessed at the time. The assessment criteria adopted by the 2012 EIS have also since been updated by the NSW Environment Protection Authority (EPA) (NSW EPA, 2017). This AQIA adopts the current assessment criteria.

This AQIA has been prepared in accordance with the EPA document '*Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*' (NSW EPA, 2017), hereafter referred to as 'The Approved Methods'. This assessment involves the modelling of local meteorology and the dispersion of potential emissions from the project site to predict the level of impact that may be experienced in the surrounding environment. The sections of this report where the requirements of the Approved Methods are met are as follows:

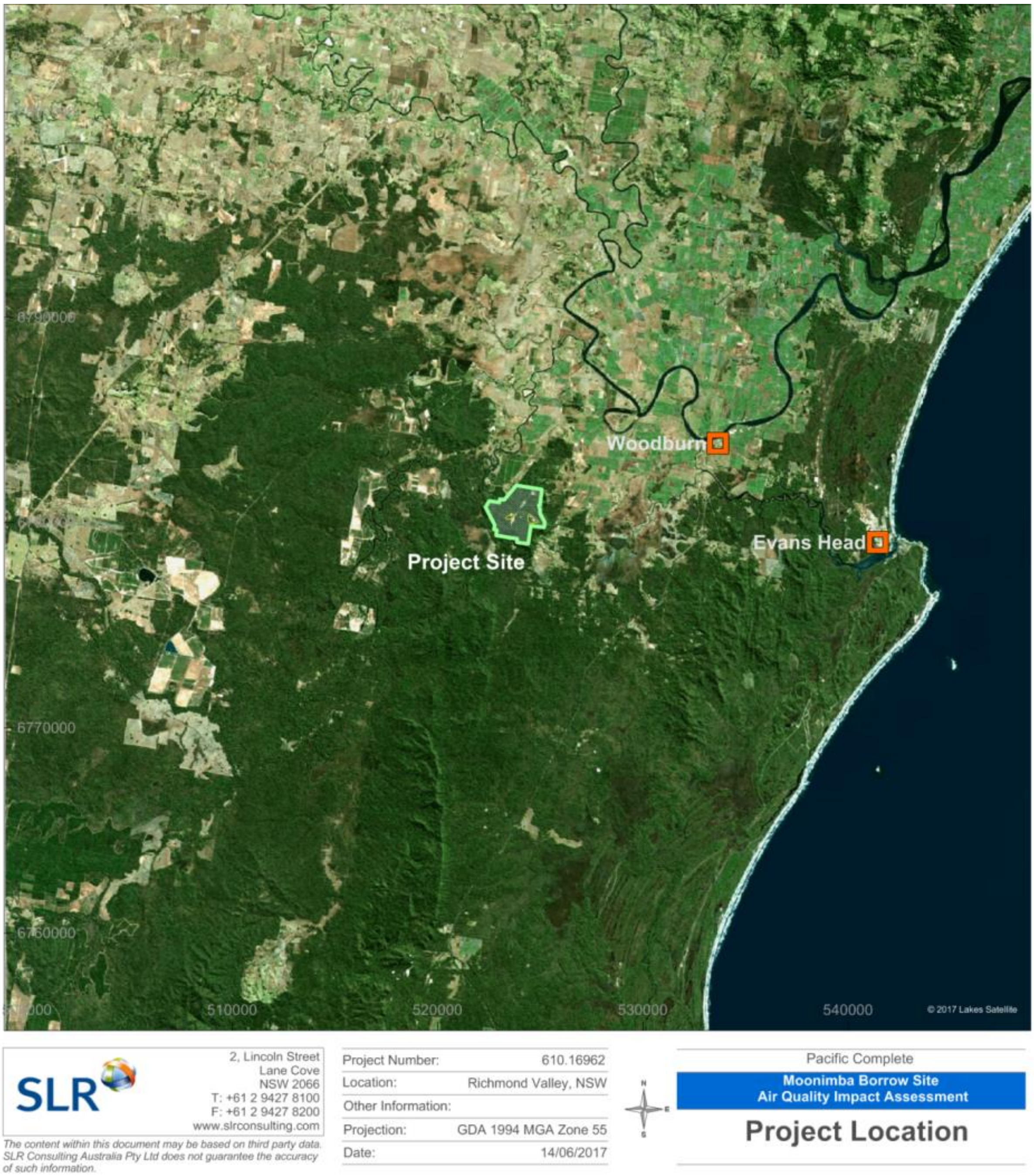
- Description of local topographic features and sensitive receptor locations (**Section 3**).
- Establishment of air quality assessment criteria (**Section 4**).
- Analysis of climate and dispersion meteorology for the region (**Section 5**).
- Description of existing air quality environment (**Section 6**).
- Compilation of a comprehensive emissions inventory for the existing and proposed activities (**Section 7**).
- Completion of atmospheric dispersion modelling and analysis of results (**Section 8**).
- Preparation of an air quality impact assessment report comprising the above.

2 PROJECT OVERVIEW

2.1 Project locality

The project site is situated in the Northern Rivers region of north-eastern New South Wales, located about 10 km south west of Woodburn, 5 km south of the Richmond River at Swan Bay and 17 km inland due east from the Pacific Ocean at Evans Head. It resides to the west of Portion C of the W2B project. **Figure 1** illustrates the location of the project site.

Figure 1 Location of the project site



2.2 Project description

The existing Borrow Site operation operates under Development Consent 127/1995 which allows a maximum extraction of 30,000 m^3 per annum. The Borrow Site operation extracts sand and sandstone by blasting and excavation. Pacific Complete is proposing to intensify the extraction rate at the site to 400,000 m^3 per annum to provide sufficient material to complete the W2B project. The project site consists of two pits namely the Eastern Pit and the Western Pit.

The operations on the project site will generally involve:

- Clearing of vegetation;
- Removal and stockpiling of topsoil and overburden;
- Off-site transport of overburden;
- Removal of raw material by drilling and blasting;
- Crushing and screening of raw material in mobile processing plants and stockpile products;
- Off-site transport of overburden; and
- Importation of fill for use in rehabilitation of the project site.

It is proposed to extract a total of 800,000 m^3 of aggregate in two years. In order to achieve this, it is proposed to open 21 hectares of land (total area of the two pits) and commence quarrying in the two pits as soon as approval is granted. As such, mobile processing plants will be used on-site and stockpiling of overburden and product will be carried out at various locations within the two pits.

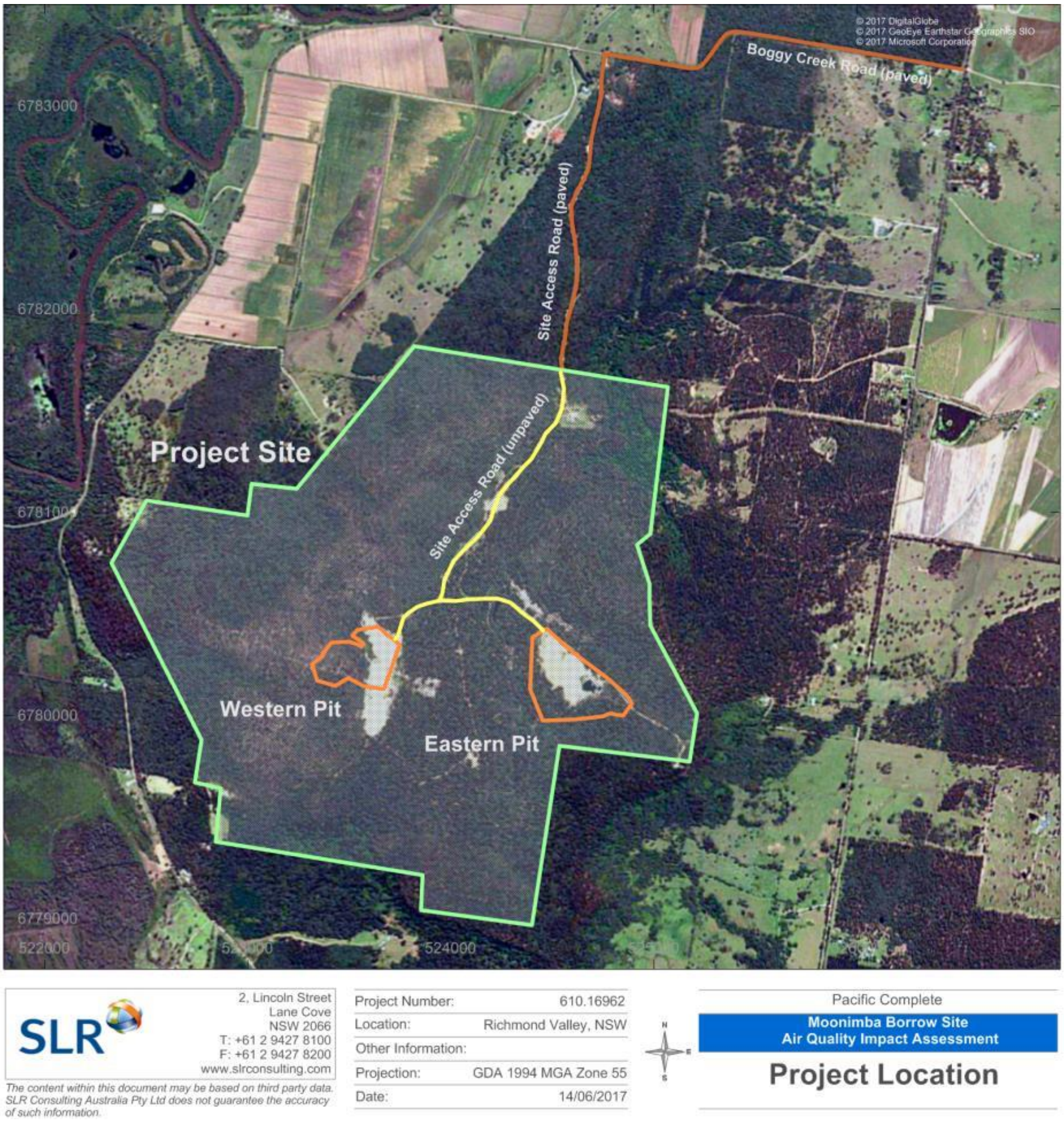
The project site is accessed from Boggy Creek Road via a 1.6 km dedicated paved road which has been constructed to Council's requirements pursuant to consent 127/95. The paved road ends at the boundary of the project site, from which point an unpaved access road continues south for 1.4 km to a fork from which one road heads to the Eastern Pit, and the other to the Western Pit.

A description of the activities for the first and second year of operation at the project site is presented in **Table 1**. **Figure 2** illustrates the layout of the project site.

Table 1 Description of operations at the project site

Description	Year 1	Year 2
Process	Removal of topsoil Placement of topsoil in extracted areas Removal of overburden Removal of raw material Drilling and Blasting Processing of raw material in mobile screening and crushing plants Loading of product and overburden to trucks for off-site transportation Importation of fill material	Removal of raw material Drilling and Blasting Processing of raw material in mobile screening and crushing plants Loading of product to trucks for off-site transportation Importation of fill material
Operating hours	7 am to 6 pm Monday to Friday 8 am to 5 pm Saturday	7 am to 6 pm Monday to Friday 8 am to 5 pm Saturday

Figure 2 Project site layout



3 PROJECT SETTING

3.1 Sensitive receptors

Sensitive receptors are locations where the general population can be adversely impacted by exposure to pollution from the atmospheric emissions. These locations include hospitals, schools, day care facilities and residential housing.

The project site is situated in a rural environment surrounded by farming properties and nature reserves. A number of non-project related residential dwellings are situated in the area surrounding the project site. A list of existing sensitive receptor points identified in the immediate vicinity of the project site is provided in **Table 2**, along with the respective distances of each of these receptor points to the site boundary and the proposed extraction boundary. **Figure 3** illustrates the location of the surrounding receptors in relation to the project site. Concentrations of particulate matter have been assessed at each of these receptors, for relevant averaging periods as discussed in **Section 4**. The identified sensitive receptors are the same as those identified in the 2014 AQIA. The numbering used in the 2014 AQIA has been used in this assessment in order to facilitate comparison between the predicted results of the proposed operations to the existing operations as presented in the 2014 AQIA. It is noted that sensitive receptor R36 is the owner/operator's dwelling.

Figure 3 Location of the identified sensitive receptors

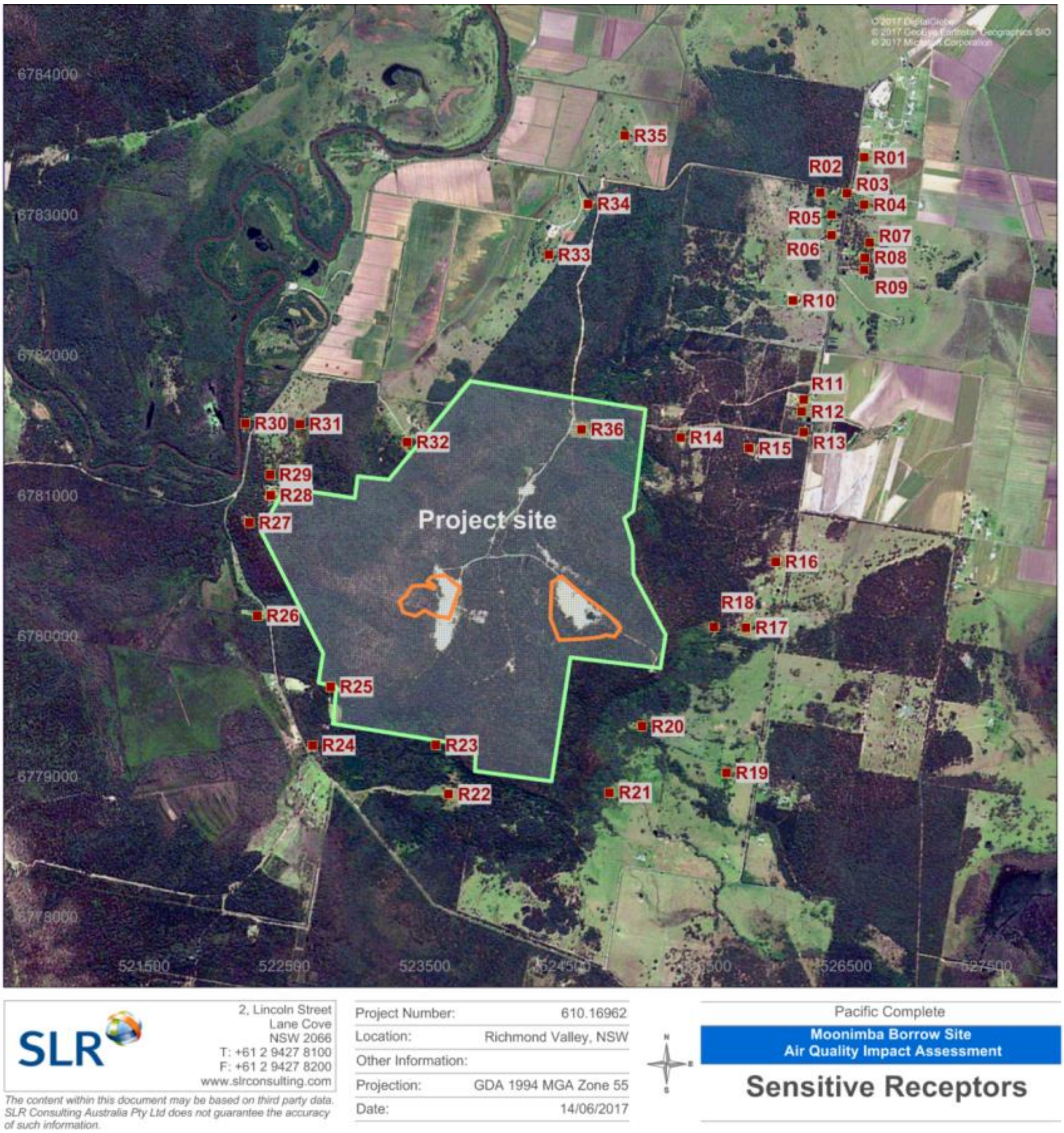


Table 2 Details of identified sensitive receptors

Receptor ID	Location (m, UTM)		Distance (m) from nearest proposed extraction boundary	Elevation (m, AHD)
	Easting	Northing		
R1	526,627	6,783,408	3,660 / NE	27
R2	526,316	6,783,160	3,285 / NE	26
R3	526,504	6,783,156	3,400 / NE	30
R4	526,627	6,783,073	3,400 / NE	19
R5	526,392	6,783,005	3,220 / NE	17
R6	526,394	6,782,855	3,090 / NE	11
R7	526,664	6,782,802	3,210 / NE	18
R8	526,631	6,782,697	3,120 / NE	18
R9	526,625	6,782,609	3,040 / NE	18
R10	526,121	6,782,390	2,550 / NE	9
R11	526,197	6,781,687	2,050 / NE	13
R12	526,183	6,781,599	2,000 / NE	12
R13	526,195	6,781,452	1,900 / NE	14
R14	525,319	6,781,416	1,290 / NE	65
R15	525,808	6,781,339	1,550 / NE	28
R16	525,997	6,780,531	1,200 / E	33
R17	525,785	6,780,062	885 / E	39
R18	525,555	6,780,067	660 / E	66
R19	525,645	6,779,028	1,250 / SE	40
R20	525,044	6,779,358	666 / SE	73
R21	524,812	6,778,888	1,100 / S	80
R22	523,667	6,778,875	1,230 / S	58
R23	523,577	6,779,225	885 / S	92
R24	522,700	6,779,224	1,140 / SW	27
R25	522,827	6,779,641	715 / SW	43
R26	522,303	6,780,147	1,005 / W	17
R27	522,248	6,780,808	1,185 / NW	45
R28	522,399	6,781,005	1,180 / NW	31
R29	522,394	6,781,150	1,270 / NW	30
R30	522,219	6,781,517	1,650 / NW	16
R31	522,607	6,781,512	1,410 / NW	7
R32	523,371	6,781,383	980 / N	26
R33	524,380	6,782,717	2,280 / N	11
R34	524,659	6,783,080	2,660 / N	15
R35	524,921	6,783,566	3,150 / N	13
R36*	524,613	6,781,474	1,050 / N	97

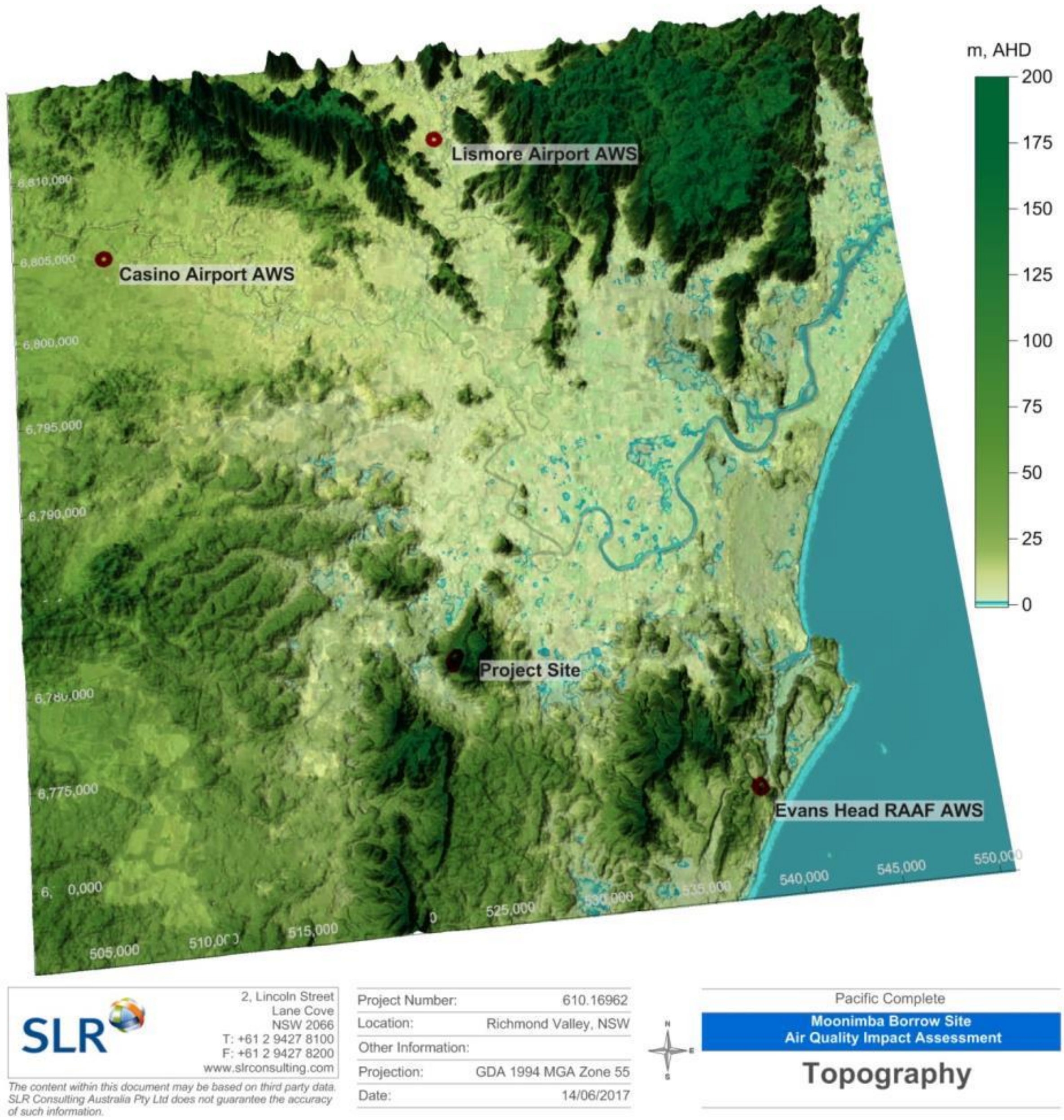
***** Owner/operator's dwelling

3.2 Surrounding topography

Topography is important in air quality studies as local atmospheric dispersion can be influenced by night-time katabatic (downhill) drainage flows from elevated terrain or channelling effects in valleys or gullies around the project site.

A three dimensional representation of the area is given in **Figure 4**. The topography of the local area within the model domain ranges from approximately 0 m to 200 m Australian Height Datum (AHD). The project site is located on the top of Moonimba Ridge, the highest parts of which reach an elevation of more than 188 m. There are extensive floodplains to the north and east of the project site with elevations generally between 0 and 10 m. The areas southwest and southeast of the project site are marked by elevated terrain with elevations generally similar to the project site.

Figure 4 Local topography surrounding the project site



Note: Vertical exaggeration applied

4 AIR QUALITY CRITERIA

4.1 Pollutants of interest

SLR Consulting has conducted a large number of assessments for quarry operations across Australia. The results of these assessments have indicated that the key pollutants for determining compliance with relevant air quality criteria from these types of operations are suspended particulate matter (TSP, PM_{10} and $PM_{2.5}$) and fugitive dust deposition.

While emissions of pollutants associated with the combustion of diesel fuel, including nitrogen oxides (NOx), sulphur dioxide (SO_2), carbon monoxide (CO) and Volatile Organic Compounds (VOCs), will be generated by the current and proposed operations at the project site, these emissions are unlikely to compromise air quality goals at the closest receptors, given the nature and scale of the operation.

4.2 Suspended particulate matter

Airborne contaminants that can be inhaled directly into the lungs can be classified on the basis of their physical properties as gases, vapours or particulate matter. In common usage, the terms "dust" and "particulates" are often used interchangeably. The health effects of particulate matter are strongly influenced by the size of the airborne particles. Smaller particles can penetrate further into the respiratory tract, with the smallest particles having a greater impact on human health as they penetrate to the gas exchange areas of the lungs. Larger particles primarily cause nuisance associated with coarse particles settling on surfaces.

The term "particulate matter" refers to a category of airborne particles, typically less than 30 microns (µm) in diameter and ranging down to 0.1 µm and is termed total suspended particulate (TSP). Particulate matter with an aerodynamic diameter of 10 microns or less is referred to as PM_{10}. The PM_{10} size fraction is sufficiently small to penetrate the large airways of the lungs, while $PM_{2.5}$ (2.5 microns or less) particulates are generally small enough to be drawn in and deposited into the deepest portions of the lungs. Potential adverse health impacts associated with exposure to PM_{10} and $PM_{2.5}$ include increased mortality from cardiovascular and respiratory diseases, chronic obstructive pulmonary disease and heart disease, and reduced lung capacity in asthmatic children.

The ambient air quality goals set by NSW EPA for suspended particulate matter are summarised in **Table 3**. These include updated PM_{10} and $PM_{2.5}$ air quality goals established by the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) (National Environment Protection Council, 2016), which were adopted by NSW EPA through an amendment to the Approved Methods in 2017.

Table 3 Suspended particulate air quality criteria used in this assessment

Pollutant	Averaging Time	Goal
TSP	Annual	90 µg/m^3
PM_{10}	24 Hours	50 µg/m^3
	Annual	25 µg/m^3
$PM_{2.5}$	24 Hours	25 µg/m^3
	Annual	8 µg/m^3

SOURCE: (NSW EPA, 2017)

4.3 Deposited particulate matter

The preceding section is largely concerned with the health impacts of particulate matter. Nuisance (amenity) impacts also need to be considered, mainly in relation to deposition of dust. In NSW, accepted practice regarding the nuisance impact of dust is that dust-related nuisance can be expected to impact on residential areas when annual average dust deposition levels exceed 4 grams per square metre per month (g/m^2/month).

Table 4 presents the EPA impact assessment goals for dust deposition, showing the allowable increase in dust deposition level over the ambient (background) level which would be acceptable so that dust nuisance could be avoided.

Table 4 Goals for allowable dust deposition

Averaging Period	Maximum Increase in Deposited Dust Level	Maximum Total Deposited Dust Level
Annual	2 g/m^2/month	4 g/m^2/month

Source: (NSW EPA, 2017)

4.4 Summary of project air quality goals

In view of the foregoing, the air quality goals adopted for this assessment, which conform to current EPA and Federal air quality criteria, are summarised in **Table 5**.

Table 5 Project air quality goals

Pollutant	Averaging Period	Criteria ($\mu g/m^3$)	Source
PM_{10}	24 hours	50	(NSW EPA, 2017)
	Annual	25	(NSW EPA, 2017)
$PM_{2.5}$	24 hours	25	(NSW EPA, 2017)
	Annual	8	(NSW EPA, 2017)
TSP	Annual	90	(NSW EPA, 2017)
		Criteria (g/m^2/month)	
Deposited dust	Annual	2 (maximum increase in deposited dust level) 4 (maximum total deposited dust level)	(NSW EPA, 2017)

5 CLIMATE AND METEOROLOGY

The nearest available meteorological monitoring stations collecting data suitable for use in a quantitative air dispersion modelling study operated by the Bureau of Meteorology (BoM) are located at Evans Head RAAF Bombing Range, Casino Airport and Lismore Airport.

The nearest station, at Evans Head RAAF Bombing Range (Station 58212, elevation 63 m), has data available from 1998 to 2017 for the following parameters:

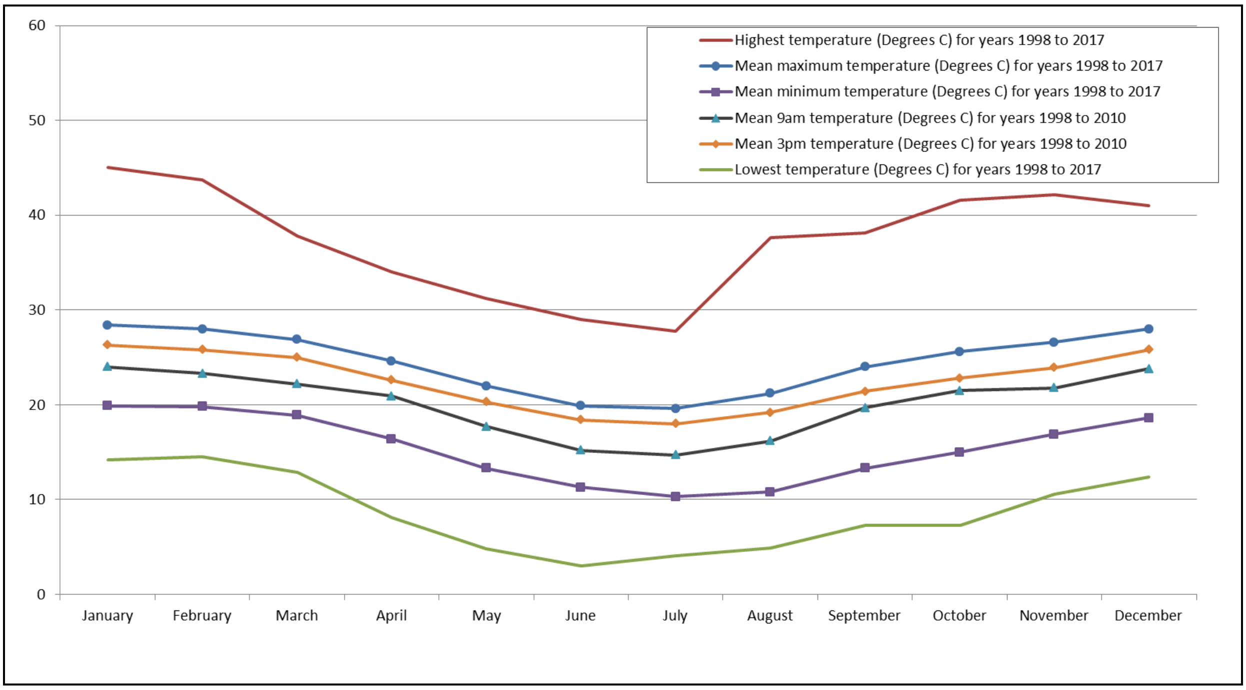
- Temperature (°C)
- Rainfall (mm)
- Relative humidity (%)
- Cloud cover
- Wind speed (m/s) and wind direction (degrees).

A review of the long term data collected by this station is provided in the following sections.

5.1 Temperature

Long-term temperature statistics for Evans Head RAAF Bombing Range are summarised in **Figure 5**. Mean maximum temperatures range from 19.6°C in winter to 28.4°C in summer, while mean minimum temperatures range from 10.3°C in winter to around 19.9°C in summer. Maximum temperatures above 40°C and minimum temperatures less than 5°C have been recorded.

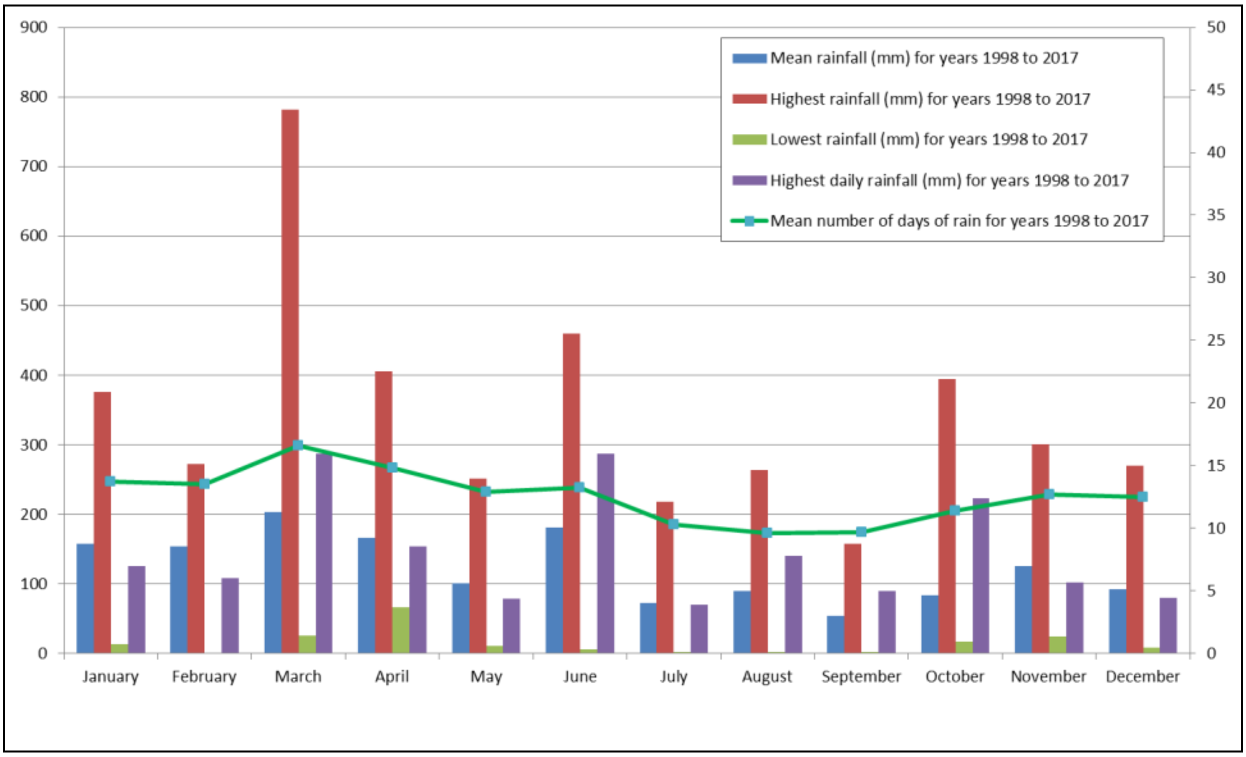
Figure 5 Long term temperature data for Evans Head RAAF Bombing Range



5.2 Rainfall

Long-term rainfall statistics for Evans Head RAAF Bombing Range are summarised in **Figure 6.** The average monthly rainfall is relatively high in summer and autumn, reducing from mid-winter to spring with the lowest average of 53.6 mm/month recorded during September. August and September recorded an average of less than ten days of rain days per month. The highest average monthly rainfall of 202.8 mm/month occurs in March, with an average of 16.6 rain days recorded in this month. The highest monthly rainfall recorded over the time period examined was 781.2 mm recorded in March 2017.

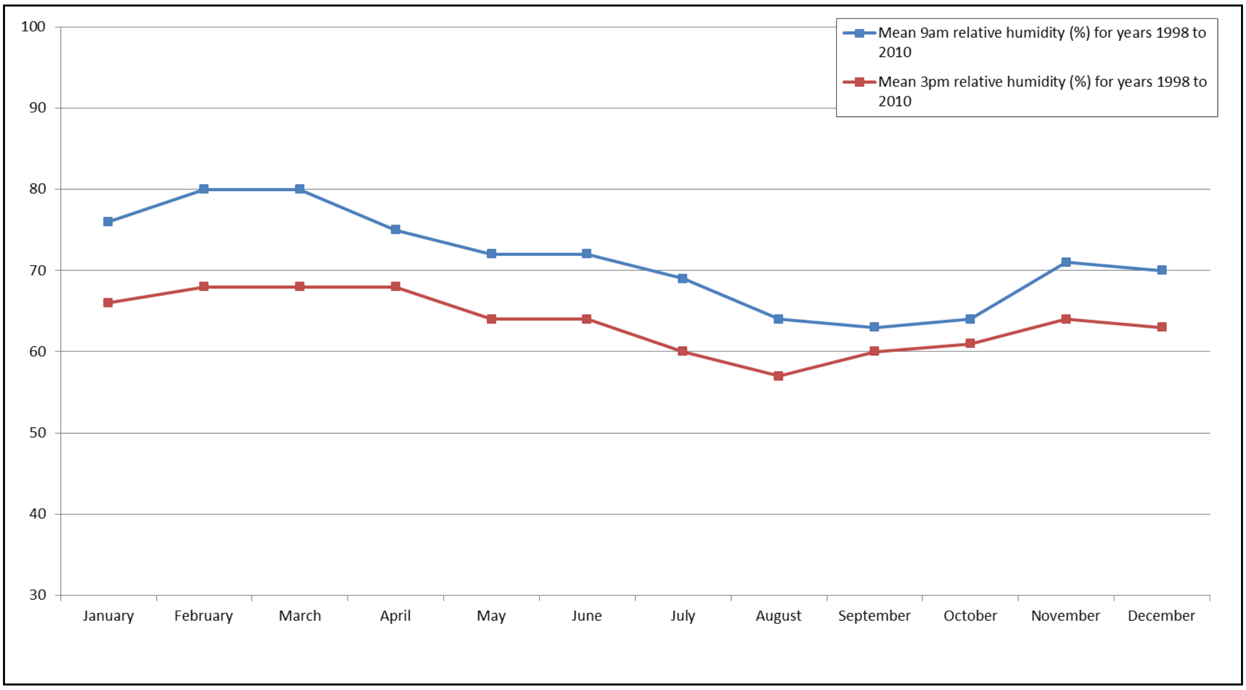
Figure 6 Long term monthly rainfall data for Evans Head RAAF Bombing Range



5.3 Relative humidity

Long-term humidity statistics (9 am and 3 pm monthly averages) for Evans Head RAAF Bombing Range are summarised in **Figure 7**. Morning humidity levels range from an average of around 80% in early winter to around 59% in mid-spring. Afternoon humidity levels are lower, at around 49% in summer and dropping to a low of 37% in mid of spring.

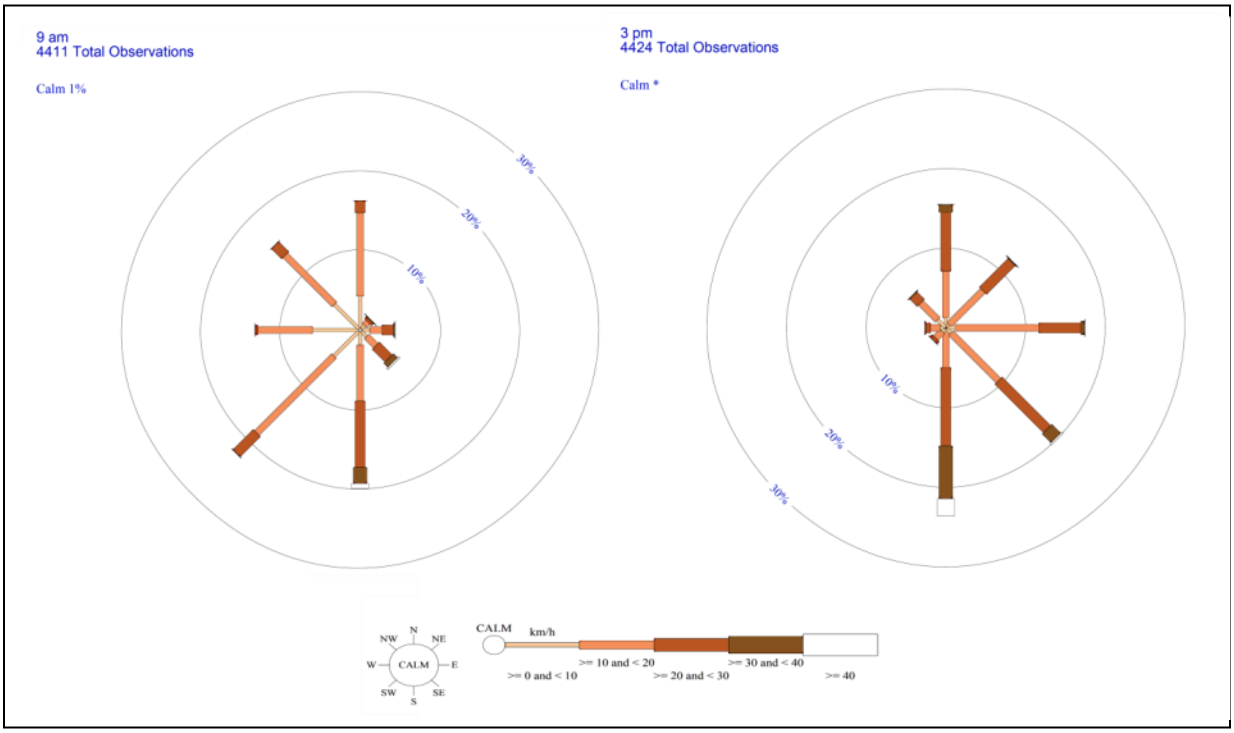
Figure 7 Long term humidity data for Evans Head RAAF Bombing Range



5.4 Wind speed and direction

Long term wind data (9 am and 3 pm) for Evans Head RAAF Bombing Range are presented as wind roses in **Figure 8**. The wind roses show a strong diurnal pattern, with winds from the northwest and southwest quadrants dominating during the morning and winds from the northeast and southeast quadrants dominating in the afternoon. Winds are also stronger in the afternoon than during the morning.

Figure 8 Rose of wind direction vs wind speed (km/hr) at Evans Head RAAF Bombing Range (1998 - 2010)



Note: An asterisk (*) indicates that the frequency of calms is less than 0.5%.

5.5 Selection of representative year for meteorological modelling

To identify an appropriate calendar year for use in the dispersion modelling study, observed wind, temperature and relative humidity data from Evans Head RAAF Bombing Range for five calendar years (2012 - 2016) were analysed and compared against the long term average wind data. Based on this long term meteorological data analysis, the 2016 calendar year was identified as a suitable representative year for use in this study.

6 EXISTING AIR QUALITY

The main focus of this report is the assessment of the potential impacts of the project site on the closest sensitive receptors, which include thirty six residences as identified in **Section 3.1**. The purpose of assessing background air quality is to determine the concentrations of air pollutants currently experienced at these residences, with the predicted concentrations from the modification added to these background concentrations to identify the likely future cumulative air quality impacts. It is therefore important to gain an understanding of the current background air quality at these residential locations.

6.1 Existing sources of air emissions in the region

The air quality in the region surrounding the project site will be influenced by emissions generated by a range of sources, originating from both within and outside the local area. Specifically, air quality will be influenced by traffic-generated pollution, wind generated dust emissions from exposed areas, dust and diesel emissions from agricultural activities, pollution transported into the area from more distant sources and pollution generated by the existing Moonimba Borrow Site itself. More remote and episodic sources including dust storms, bush fires and sea spray may also contribute to particulate levels in the region.

A desktop review of industrial sites in the area regulated by the NSW EPA and those that are required to report under the provisions of *Protection of the Environment (General) Regulation 2009* and with information stored in the National Pollutant Inventory (NPI) was carried out. Only three industrial sources of dust emissions which may potentially cause direct cumulative impacts with emissions from the project site were identified within a 20 km radius of the project site. These are:

- Coraki Quarry, 18 Petersons Quarry Rd, Coraki, NSW 2471
- Cape Byron Power Broadwater, 117 Pacific Highway, Broadwater, NSW 2472
- Broadwater Sugar Mill, 117 Pacific Highway, Broadwater, NSW 2472

To appropriately assess the *cumulative* impact of the proposed intensification of extraction at the project site, the incremental impact from the proposed operation needs to be added to a dataset which includes the influences of all other sources of particulate in the region, including those listed above, and is representative of the air quality likely to be experienced at sensitive receptor locations without the impact of the proposed operation.

6.2 Review of air quality monitoring data

There is limited information on existing air quality in the region surrounding the project site. No publicly available air quality monitoring data is available for the region surrounding the project site and no air quality monitoring has been carried out at the project site.

During the Environmental Assessment stage of the Pacific Highway upgrade between Sapphire and Woolgoolga, RMS monitored air quality at a site adjacent to the Pacific Highway at Korora between Korora Public School and the Korora Rural Fire Brigade, north of Coffs Harbour. According to the *Woolgoolga to Ballina Pacific Highway Upgrade Environmental Impact Statement* (RMS, 2012), this location is one of the most trafficked sections of the highway.

Monitoring was undertaken for a range of air quality parameters including PM_{10} and $PM_{2.5}$ from October 2005 to January 2006, which covers the holiday period when traffic emissions are likely to be higher than typical levels in the area. The results of this monitoring were published in Working Paper 8 of the *Environmental Assessment for the Sapphire to Woolgoolga Pacific Highway Upgrade* (RTA, 2007) and have been referenced in this assessment. Working Paper 8 states that:

"Due to the proximity of the monitoring site to the Pacific Highway, the concentrations of air quality parameters measured include traffic emissions. Therefore, the concentrations detected are likely to be higher than the background levels for the local area and will give a conservative indication of the air quality experienced on the NSW north coast."

Considering the lack of any significant source of emissions in the surrounding area of the project site and the conditions under which the Korora monitoring was conducted, the adoption of the Korora monitoring dataset will provide a conservative estimate of the background air quality likely to be found in the area surrounding the project site.

As part of the W2B project, dust deposition monitoring has also been performed at several locations along this section of the Pacific Highway since July 2016. The dust deposition monitoring network for this section of the highway currently consists of a total of 17 dust deposition gauges, eight of which are located within a 20 km radius of the project site. **Figure 9** illustrates the location of these eight dust deposition gauges which have been reviewed for the purpose of this assessment.

6.2.1 Suspended particulate matter

Table 6 presents a summary of the 24-hour PM_{10} and $PM_{2.5}$ concentrations recorded at Korora over the period October 2005 to January 2006.

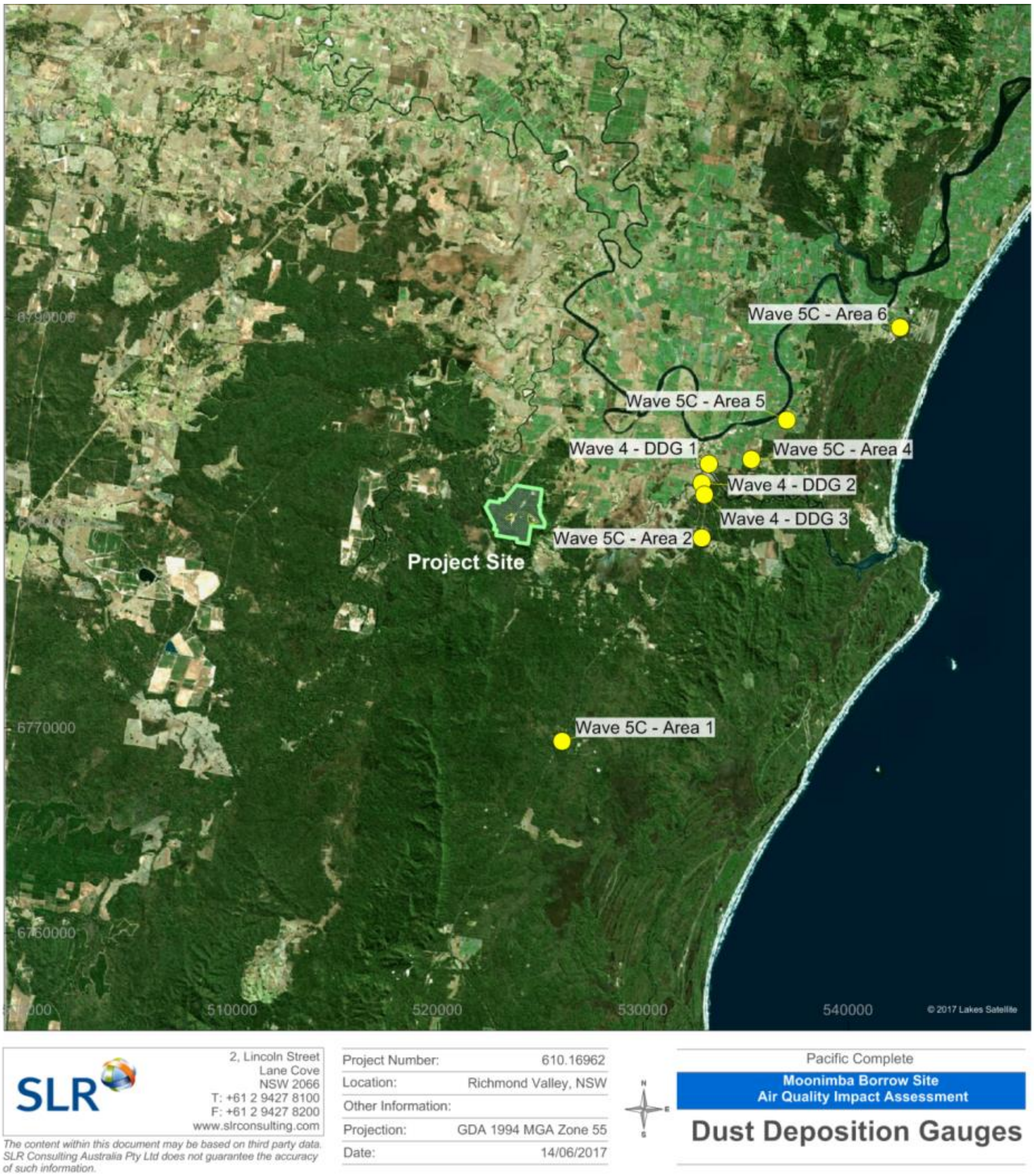
Table 6 Korora Monitoring Dataset Summary – October 2005 to January 2006

	Unit	PM_{10}	$PM_{2.5}$
Number of Measurements		98	80
Minimum	µg/m³	2.0	4.0
Maximum	µg/m³	37.0	15.0
Average	µg/m³	17.8	7.9

For the purpose of this AQIA, the maximum 24-hour average PM_{10} and $PM_{2.5}$ concentrations recorded at the Korora RTA site have been adopted as background levels to assess cumulative 24-hour average PM_{10} and $PM_{2.5}$ concentrations at each sensitive receptor. The average PM_{10} and $PM_{2.5}$ concentrations have been used to assess cumulative annual average concentrations at each sensitive receptor location.

TSP concentrations were not monitored at the Korora monitoring site. For the purpose of this assessment, the estimated TSP levels presented in the 2014 AQIA have been adopted as the background annual average TSP concentration. The 2014 AQIA used a baseline annual average TSP concentration of 43 $\mu g/m^3$, derived from the average PM_{10} concentration recorded at Korora (17 $\mu g/m^3$) and an assumed PM_{10}/TSP ratio of 40%.

Figure 9 W2B dust monitoring locations



6.2.2 Background dust deposition

A summary of the dust deposition rates recorded by the W2B deposition monitoring program from July 2016 to April 2017 is presented in **Table 7**.

Table 7 W2B dust deposition monitoring data (2016-2017)

Monitoring Location	Measured Dust Deposition Rate (g/m²/month)										Average Recorded Deposition Rate (g/m²/month)
	2016	2017									
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	
Wave 5C - Area 1	1.4	1.4	1.1	3.5	6.7	2.1	1.9	1.2	0.2	5.6	2.5
Wave 5C - Area 2	0.8	0.8	1.7	0.5	--	0.7	0.4	0.6	2.0	0.3	0.9
Wave 5C - Area 4	2.6	2.6	2.4	0.9	1.2	1.6	2.6	2.0	6.4	12.9	3.5
Wave 5C - Area 5	2.4	2.4	0.9	1.6	1.8	2.6	2.3	1.7	1.3	1.6	1.9
Wave 5C - Area 6	0.6	0.6	0.2	0.4	1.0	0.1	0.6	0.8	1.0	0.4	0.6
Wave 4 - DDG 1	0.9	2.1	1.6	1.1	1.5	2.5	1.2	3.4	1.0	1.0	1.6
Wave 4 - DDG 2	0.8	1.3	1.1	0.9	2.1	4.9	1.6	3.7	0.8	1.1	1.8
Wave 4 - DDG 3	1.9	1.9	2.3	1.1	1.6	0.8	1.0	1.6	1.1	0.9	1.4

Note: An unrealistically high dust deposition rate of 135.8 g/m²/month was recorded at Wave 5C - Area 2 for November 2016. It is most likely that this isolated high recording was due to sample contamination and has therefore not been included.

The average deposition rate recorded across the eight selected monitoring sites was 1.8 g/m²/month. Based on this, the background level of dust deposition for the area surrounding the project site is conservatively taken as 2.0 g/m²/month.

6.3 Adopted background levels

The adopted background levels assumed for each pollutant are presented in **Table 8**.

Table 8 Adopted background particulate levels

Air Quality Indicator	Value	Averaging Period
Deposited dust	2.0 g/m²/month	Annual
TSP	43 µg/m³	Annual
PM_{10}	37 µg/m³	24-hours
	17 µg/m³	1-year
$PM_{2.5}$	15 µg/m³	24-hours
	7.0 µg/m³	1-year

7 EMISSION ESTIMATION

7.1 Emission scenarios

In order to assess the potential variation in emissions over the two years of extraction at the project site, two emission inventories were compiled (namely year 1 and year 2). Emissions from each scenario were estimated and dispersion modelling was carried out for year 2, which was shown to be the year with the highest overall emissions.

7.2 Overview of emission estimation methodology

Particulate emissions for each operational scenario (year 1 and year 2) were estimated for various particle size fractions based on the relevant emission factors sourced from National Pollutant Inventory (NPI) *Emission Estimation Technique Manual for Mining* (hereafter, "EETMM"), and the USEPA's AP-42 Emission Factor Handbook. The estimated TSP emission rates were used to provide an indication of dust deposition rates.

Meteorological data, particularly wind speed is a critical parameter used in the emission estimation calculations (specifically, for the estimation of emissions from wind erosion and material handling). For the estimation of these emissions, the 2016 meteorological data extracted from CALMET were used.

As noted in **Section 4.1,** on the basis of low emissions intensity**,** emissions of pollutants associated with the combustion of diesel fuel including NOx, SO_2, CO and VOCs have not been assessed in this study.

7.3 Sources of operational emissions

Sources of particulate emissions associated with the project site include:

- Topsoil and overburden removal;
- Raw material extraction activities, including excavating, drilling and blasting;
- Vehicle entrainment of particulate matter during the haulage of material along the sealed and unsealed roads;
- Unloading of material to processing plants;
- Crushing and screening of extracted material at screening plants;
- Process plant operations including loading of product to stockpiles and stockpile management;
- Loading of products to delivery trucks;
- Unloading of imported fill to emplacement areas; and
- Wind erosion associated with material stockpiles, active pits and imported fill emplacement areas.

7.4 Emission factors

Potential particulate emissions from the current and proposed operations have been estimated based on the emission factors presented in the EETMM, Version 3.1 (Environment Australia, 2012). In some instances, the moisture content of materials at the project site is not adequately reflected within the default emission factors contained in the EETMM or the equations given in Table 1 of the EETMM document. USEPA AP-42 documentation was therefore used to derive representative emission factors in these instances. For wheel generated particulate emissions from haulage on unpaved roads, Australian-specific emission factors for PM_{10}, developed by Australian Coal Association Research Program (ACARP, 2015) were used. The PM_{10} emissions were scaled using USEPA AP-42 data in order to estimate TSP and $PM_{2.5}$ emissions. Details of the emission factor/equations used in estimating the potential emissions are presented in **Table 9**.

Table 9 Emission factor equations

Activity	Emission Factor Equation	Units	Source	Variables	Controls Applied*
Bulldozer	$EF = k \times \frac{s^{1.2}}{M^{1.3}}$	kg/h	NPI EETM v3.1 and USEPA AP42 Bulldozing on overburden	k = 2.6 (TSP) k = 2.6 × 0.75 (PM_{10}) k = 2.6 × 0.105 (PM_{10}) U = mean wind speed (m/s) M = Moisture content (%)	No Controls
Unpaved haul route wheel dust	$EF_{TSP} = 3.6 \times EF_{PM10}$ $EF_{PM10} = 0.26$ $EF_{PM2.5} = 0.10 \times EF_{PM10}$	kg/vehicle kilometres travelled (VKT)	ACARP 2015 and USEPA AP42 - Wheel Generated Dust from Unpaved Roads (2003)		Level 2 watering (>2 l/m^2/hr) - (75%)
Wheel generated dust from paved roads	$EF = k \times sL^{0.91} \times W^{1.02}$	kg/VKT	US EPA AP42 Section 13.2.1	k = 3.23 (TSP) k = 0.62 (PM_{10}) k = 0.15 ($PM_{2.5}$) sL = silt loading (g/m^2) W = average weight of the vehicles traveling the road (tonnes)	No Controls
Loading and unloading from stockpiles and processing plants,	$EF = \frac{k \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$	kg/t	NPI EETM v3.1	k = 0.74 (TSP) k = 0.35 (PM_{10}) k = 0.053 ($PM_{2.5}$) U = average wind speed (m/s) M = Moisture content (%)	No Controls
Crushing	$EF_{TSP} = 0.0027$ $EF_{PM10} = 0.0012$ $EF_{PM2.5} = 0.047 \times EF_{TSP}$	kg/t	USEPA AP-42 11.19.2 – Tertiary Crushing Factor		Water Sprays (50%)
Screening	$EF_{TSP} = 0.0125$ $EF_{PM10} = 0.0043$ $EF_{PM2.5} = 0.047 \times EF_{TSP}$	kg/t	USEPA AP42 11.19.2 - Screening Factor		No Controls
Wind erosion	$EF_{TSP} = 0.4$ $EF_{PM10} = 0.2$ $EF_{PM2.5} = 0.047 \times EF_{TSP}$	kg/ha/hr	NPI EETM v3.1		Water Sprays (50%)
Topsoil removal	$EF_{TSP} = 0.029$ $EF_{PM10} = 0.39 \times EF_{TSP}$ $EF_{PM2.5} = 0.047 \times EF_{TSP}$	kg/t	NPI EETM v3.1, USEPA AP42 Topsoil removal by scraper and SPCC(1986) data		No Controls

* Refer **Section 7.6**

7.5 Site parameters and activity rates

The site parameters and activity data used in the emission factor equations to estimate particulate emissions for the two years of operation are summarised in **Table 10**. Haulage distances for the two scenarios were calculated as outlined in **Table 11**.

Table 10 Parameters used for the estimation of particulate emissions from the project site

Description	Unit	Year 1	Year 2
Annual topsoil throughput	tonnes/annum	10,200	--
Annual overburden throughput – Eastern Pit	tonnes/annum	307,143	--
Annual overburden throughput – Western Pit	tonnes/annum	192,857	--
Annual sandstone throughput – Eastern Pit	tonnes/annum	307,143	614,286
Annual sandstone throughput – Western Pit	tonnes/annum	192,857	385,714
Annual fill import throughput	m^3/annum	30,000	30,000
Operating days per year		312	312
Operating hours - Monday to Friday	hours	0700 - 1800	0700 - 1800
Operating hours - Saturday	hours	0700 - 1700	0700 - 1700
Moisture content - Overburden	%	5 .0[a]	N/A
Moisture content – Raw Material	%	4.0 [a]	4.0 [a]
Silt content - Overburden	%	7.1 [a]	7.1 [a]
Silt content – Raw Material	%	10.0 [b]	10.0 [b]
Sealed road silt loading	g/m^2	0.6 [c]	0.6 [c]
Dozers	hours/annum	1,000	300
Drilling (total) – Eastern Pit	holes/blast	100	100
Blasting (total) – Eastern Pit	blasts/annum	29	29
Drilling (total) – Western Pit	holes/ blast	100	100
Blasting (total) – Western Pit	blasts/annum	19	19
Annual crushing and screening throughput	tonnes/annum	500,000	1,000,000
On-site dump trucks - Unloaded weight	tonnes	47.0	--
On-site dump trucks - Loaded weight	tonnes	112.0	--
On-site dump trucks – Number of return trips		159	--
Off-site transportation - Average unloaded weight	tonnes	13.0	13.0
Off-site transportation - Average loaded weight	tonnes	45.0	45.0
Off-site transportation – Number of return trips		32,844	32,844

[a] Assumed same as existing operations as presented in the 2014 AQIA
[b] Conservative assumption
[c] USEPA AP-42 Section 13.2.1, paved roads with average daily traffic of less than 500 vehicles per day

Table 11 Distances of haul routes

Haul Route	Return Distance (km)
Project site boundary to Western Pit	4.8
Project site boundary to Eastern Pit	4.2
Boggy Creek Road to project site boundary	3.2
Boggy Creek Road between quarry access road and Reardons Lane	3.6
Total	**15.8**

The areas of disturbance assumed for the two scenarios are presented in **Table 12**.

Table 12 Areas of active disturbance

Disturbance Area	Area (ha)	
	Year 1	Year 2
Eastern Pit	12.9	12.9
Western Pit	8.1	8.1
TOTAL	**21.0**	**21.0**

7.6 Emission controls

Emission controls have been applied to the sources as identified in **Table 9**. Specifically, emissions controls have been applied as follows, as per Table 4 of the EETMM (DSEWPC, 2012):

- Unpaved haul roads – 75% reduction in particulate emissions relating to Level 2 watering (>2 l/m^2/hour):
  - Eastern Pit to site boundary;
  - Western Pit to site boundary; and
  - All movements within the active pits.
- Wind erosion from pit, product stockpiles and overburden emplacement areas – 50% reduction in particulate emissions relating to use of water sprays.
- Processing of raw materials in mobile crushers - 50% reduction in particulate emissions relating to use of water sprays.
- Removal of topsoil - 50% reduction in particulate emissions relating to naturally or artificially moist soil.

7.7 Estimated emissions

Based on the emission factors detailed in **Section 7.4**, parameters detailed in **Section 7.5** and control measures outlined in **Section 7.6**, a particulate emissions inventory has been compiled for the two operational scenarios. **Table 13** and **Figure 10** present a summary of the total estimated TSP, PM_{10} and $PM_{2.5}$ emission rates for the two scenarios. Full details of the emission inventory are provided in **Appendix B**.

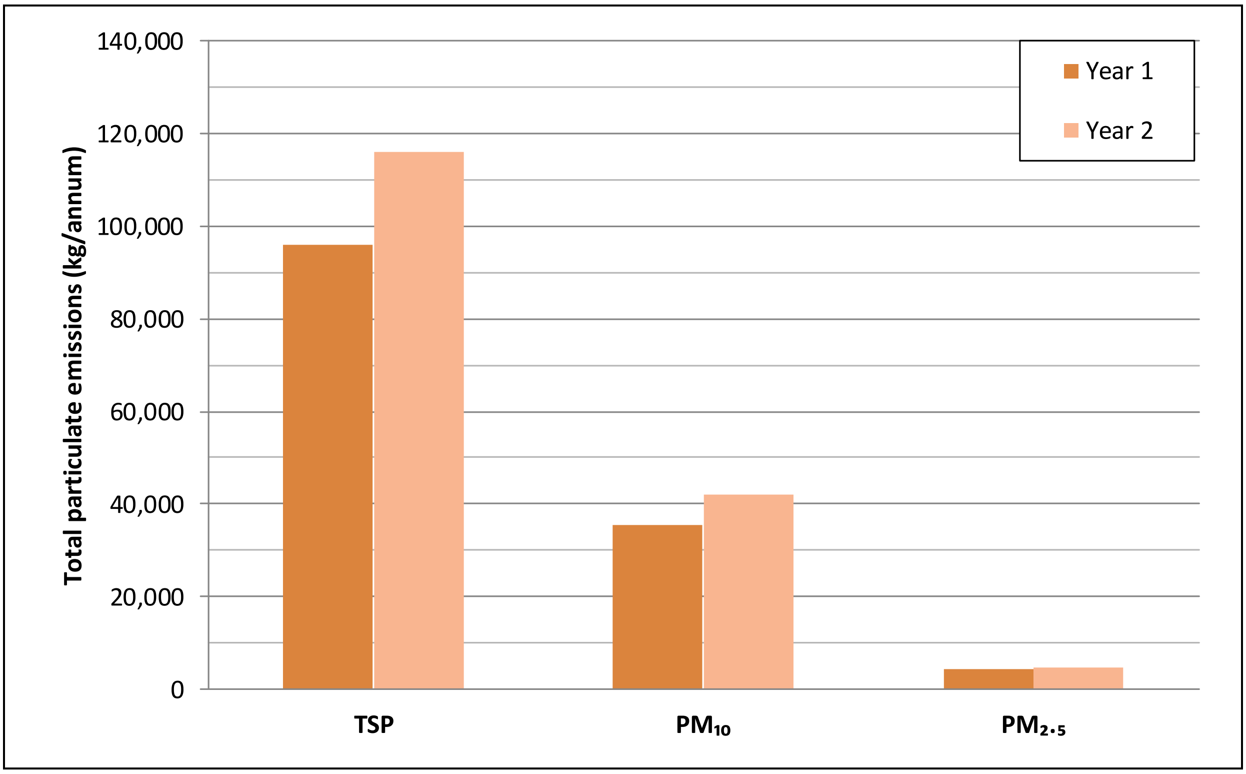
Year 2 was determined to have the worst case overall annual emissions and was therefore the year selected for the dispersion modelling. The most significant contribution to the estimated increase in emissions for the second year of operation at the project site is attributed to the higher levels of on-site crushing and screening. It is noted that for both years of operation, extraction and processing activities take place throughout the whole area of the two pits. Therefore, the estimated annual emissions calculated for each pit will be spread evenly across the pit. No sensitive receptor is therefore expected to be impacted more during the first year of operations due to changes in the source locations.

Table 13 Comparison of the estimated emission rates

Particulate Size Fraction	Unit	Year 1	Year 2	Difference[1]
TSP emission rate	kg/annum	95,988	116,225	21% increase
PM_{10} emission rate	kg/annum	35,518	41,925	18% increase
$PM_{2.5}$ emission rate	kg/annum	4,275	4,734	11% increase

[1]Difference between the year 1 and year 2 operations

Figure 10 Estimated annual TSP, PM_{10} and $PM_{2.5}$ emissions for year 1 and year 2



8 ATMOSPHERIC DISPERSION MODELLING METHODOLOGY

8.1 Model selection

Emissions from the project have been modelled using a combination of the TAPM, CALMET and CALPUFF models. CALPUFF is a transport and dispersion model that ejects “puffs” of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so it typically uses the fields generated by a meteorological pre-processor CALMET, discussed further below. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain either hourly concentration or hourly deposition fluxes evaluated at selected receptor locations. The CALPOST post-processor is then used to process these files, producing tabulations that summarise results of the simulation for user-selected averaging periods.

8.2 Meteorological modelling

8.2.1 Meteorological data availability

To adequately characterise the dispersion meteorology of the project site information is needed on the prevailing wind regime, atmospheric stability, mixing depth and other meteorological parameters. Hourly meteorological data from the following Automatic Weather Stations (AWSs) operated by BoM were used in the meteorological modelling study for the study area:

- Evans Head RAAF Bombing Range AWS (AWS Number 058212);
- Casino Airport AWS (AWS Number 058208);
- Lismore Airport AWS (AWS Number 058214);

The location of the AWSs listed above are summarised in **Table 14**.

Table 14 Meteorological monitoring station details

Station Name	Location (m, MGA)		Distance (km) / Direction From project site	Elevation (m, AHD)
	Easting	Northing		
Evans Head RAAF Bombing Range	538,541	6,771,674	16 km / SE	63
Casino Airport	506,026	6,805,042	30 km / NW	21
Lismore Airport	525,374	6,810,765	30 km / N	9

8.2.2 TAPM

The TAPM prognostic model, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was used to generate the upper air data required for CALMET modelling.

TAPM predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate one full year of hourly meteorological observations at user-defined levels within the atmosphere.

Additionally, the TAPM model may assimilate actual local wind observations so that they can optionally be included in a model solution. The wind speed and direction observations are used to realign the predicted solution towards the observation values. In this study, data from the BoM’s Evans Head RAAF Bombing Range, Casino Airport and Lismore Airport AWSs have been used to nudge (i.e. influence) the TAPM predictions. **Table 15** details the parameters used in the TAPM meteorological modelling for this assessment.

Table 15 Meteorological parameters used for this study - TAPM

TAPM (v 4.0)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km and 1 km)
Number of grid points	35 x 35 x 35
Year of analysis	2016
Centre of analysis	525,967 m E 6,789,215 S
Data assimilation	Evans Head RAAF Bombing Range, Casino Airport and Lismore Airport

8.2.3 CALMET

In the simplest terms, CALMET is a meteorological model that develops hourly wind and other meteorological fields on a three-dimensional gridded modelling domain that are required as inputs to the CALPUFF dispersion model. Associated two dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, sea breeze, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final hourly varying wind field thus reflects the influences of local topography and land uses.

CALMET modelling was conducted using the nested CALMET approach, where the final results from a coarse-grid run were used as the initial guess of a fine-grid run. This has the advantage that off-domain terrain features including slope flows, blocking effect can be allowed to take effect and the larger-scale wind flow provides a better start in the fine-grid run.

The outer domain was modelled with a resolution of 0.9 km. The TAPM-generated 3-dimensional meteorological data was used as the initial guess wind field and the local topography and available surface weather observations in the area were used to refine the wind field predetermined by TAPM. Hourly surface meteorological data from BOM stations located at Evans Head RAAF Bombing Range, Casino Airport and Lismore Airport were incorporated in the outer domain modelling.

The output from the outer domain CALMET modelling was then used as the initial guess field for the mid and inner domain CALMET modelling. Horizontal grid spacing of 0.3 km and 0.1 km were used in the mid and inner domain respectively to adequately represent the important local terrain features and land use. The finer scale local topography and land use data were used in the inner domain run to refine the wind field parameters given by the coarse CALMET runs. **Table 16** details the parameters used in the meteorological modelling to drive the CALMET model.

Table 16 Meteorological parameters used for this study – CALMET (v 6.1)

Outer Domain	
Meteorological grid	45 km × 45 km
Meteorological grid resolution	0.9 km
Surface station data	Evans Head RAAF Bombing Range, Casino Airport and Lismore Airport
Initial guess filed	3D output from TAPM modelling
Mid Domain	
Meteorological grid	15 km × 15 km
Meteorological grid resolution	0.3 km
Initial guess field	3D output from outer domain modelling
Inner Domain	
Meteorological grid	10 km × 10 km
Meteorological grid resolution	0.1 km
Initial guess field	3D output from mid domain modelling

8.3 Meteorological data used in modelling

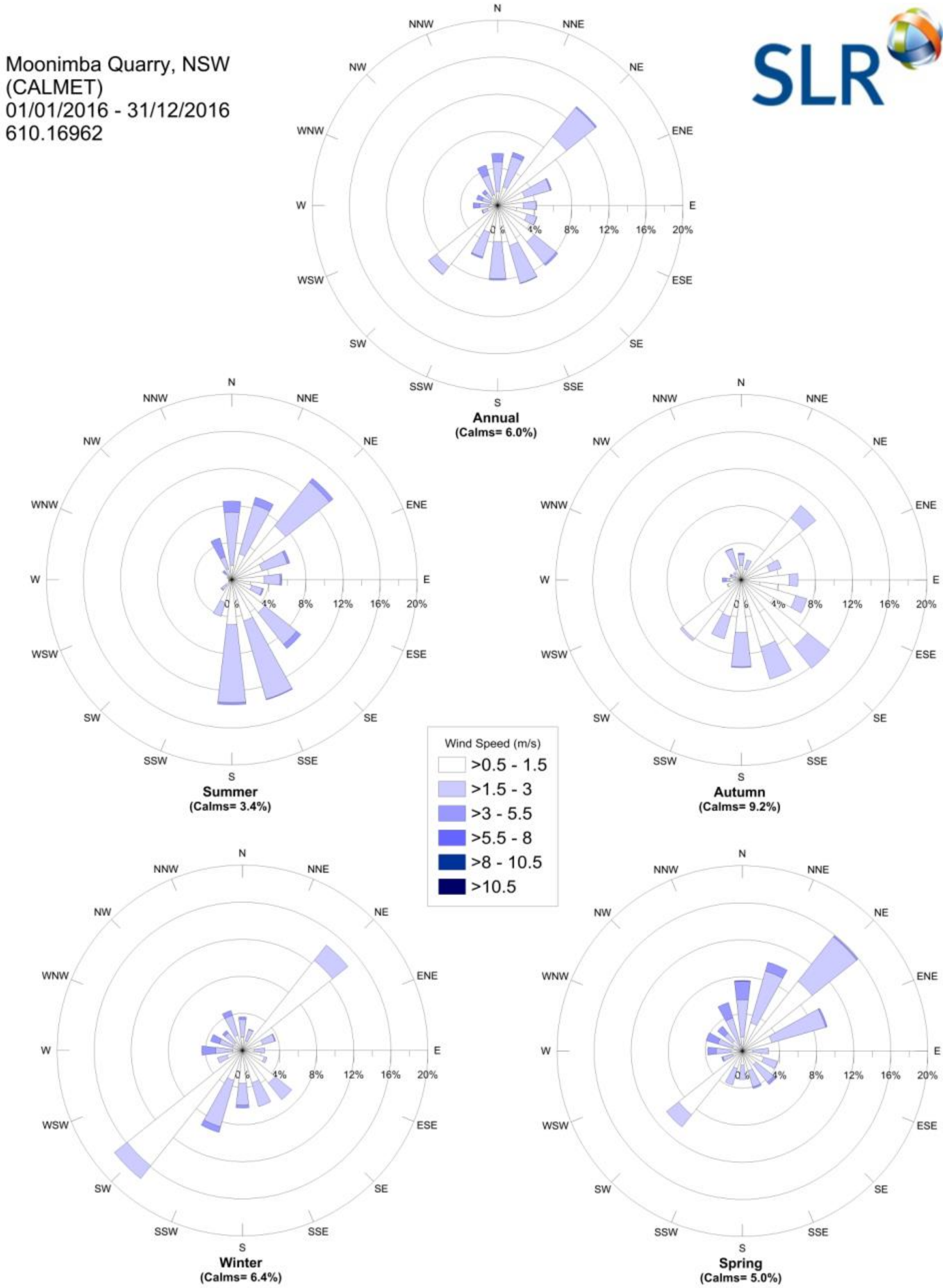
8.3.1 Wind speed and direction

A summary of the annual wind behaviour predicted by CALMET for the site is presented in **Figure 11, which** indicates that in 2016 the site experienced predominantly light to moderate winds (between 1.5 m/s and 8 m/s). Calm wind conditions (wind speed less than 0.5 m/s) were predicted to occur 6% of the time during 2016.

The seasonal wind roses indicate that:

- In summer, the winds are light to moderate (1.5 to 8 m/s) predominantly from the south and south-southeast (occurring about 25% of the time in total) and from the northeast (approximately 15% of the time).
- In autumn, the winds are light (1.5 to 3 m/s) predominantly from the south to south-southeast (approximately 30% of the time).
- In winter, winds are light (1.5 to 3 m/s) predominantly from the northeast (approximately 15% of the time) and southwest (approximately 18% of the time).
- In spring, winds are light to moderate (1.5 to 8 m/s) predominantly from the north-northeast to east-northeast (approximately 35% of the time).

Figure 11 CALMET predicted seasonal wind roses for the project site – 2016



8.3.2 Atmospheric stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Turner assignment scheme identifies six Stability Classes, A to F, to categorise the degree of atmospheric stability as follows:

- A = Extremely unstable conditions
- B = Moderately unstable conditions
- C = Slightly unstable conditions
- D = Neutral conditions
- E = Slightly stable conditions
- F = Moderately stable conditions

The meteorological conditions defining each Pasquill stability class are shown in **Table 17**.

Table 17 Meteorological conditions defining Pasquill stability classes

Surface wind speed (m/s)	Daytime insolation			Night-time conditions	
	Strong	Moderate	Slight	Thin overcast or > 4/8 low cloud	<= 4/8 cloudiness
< 2	A	A - B	B	E	F
2 - 3	A - B	B	C	E	F
3 - 5	B	B - C	C	D	E
5 - 6	C	C - D	D	D	D
> 6	C	D	D	D	D

Source: (Pasquill, 1961)

Notes:

1. Strong insolation corresponds to sunny midday in midsummer in England; slight insolation to similar conditions in midwinter.
2. Night refers to the period from 1 hour before sunset to 1 hour after sunrise.
3. The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

The frequency of each stability class at the project site during the modelled year (2016) as predicted by CALMET is shown in **Figure 12**. The results indicate a high frequency of conditions typical to Stability Class “F”. Stability Class “F” is indicative of moderately stable conditions, conducive to a low level of pollutant dispersion due to limited mechanical mixing.

8.3.3 Mixing height

Diurnal variations in maximum and average mixing depths predicted by CALMET at the project site during 2016 are illustrated in **Figure 13**. It can be seen that an increase in the mixing depth during the morning is apparent, arising due to the onset of vertical mixing following sunrise. The maximum average mixing heights occur in the early to mid-afternoon, due to the dissipation of ground-based temperature inversions and the growth of the convective mixing layer.

Figure 12 CALMET predicted annual stability class distributions for the project site during 2016

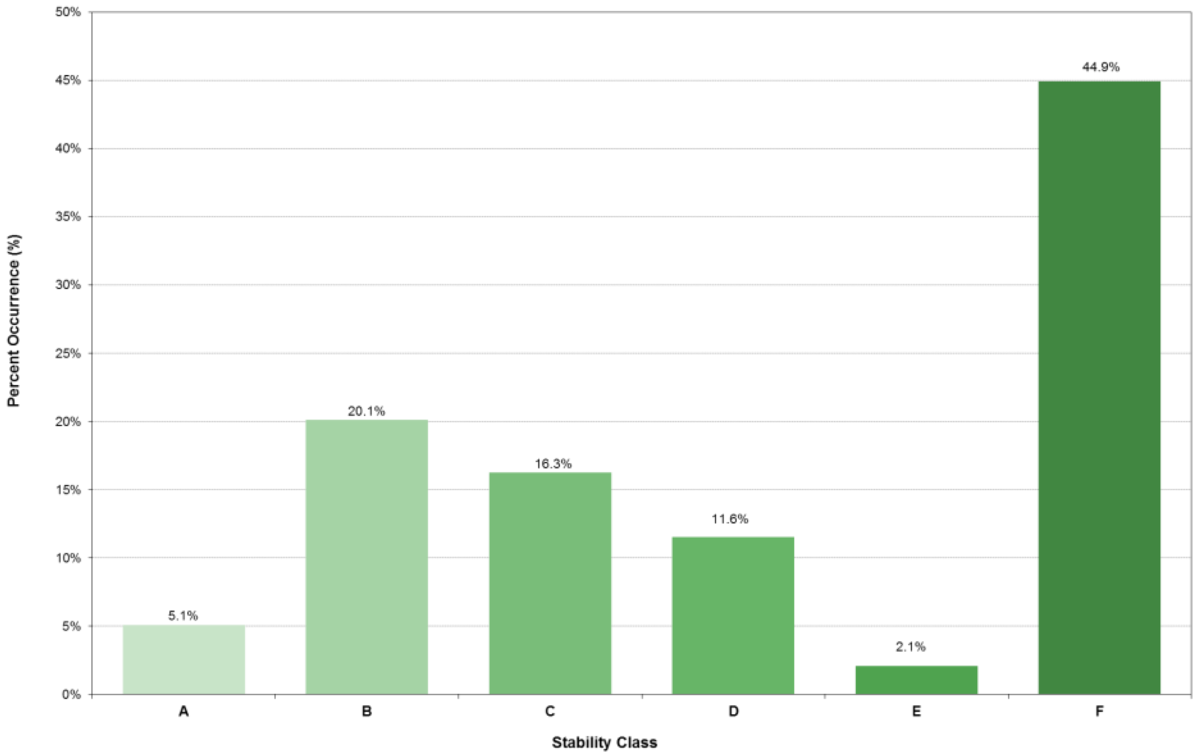
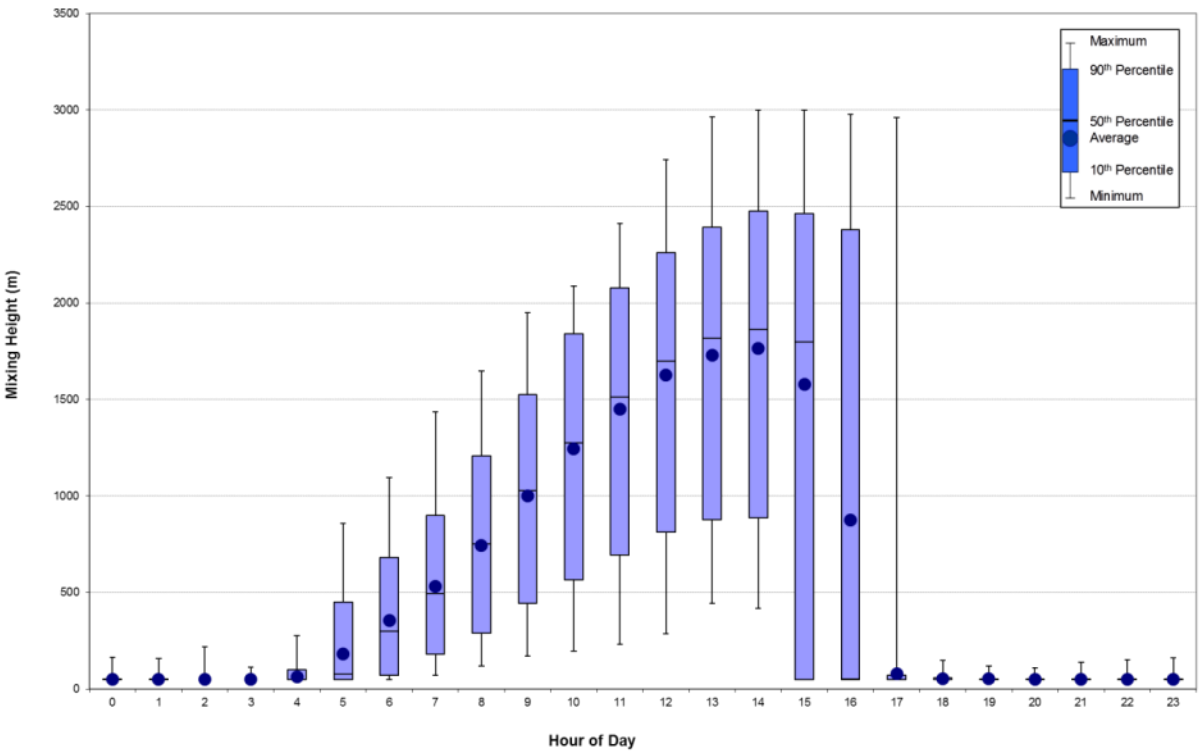


Figure 13 CALMET predicted diurnal variation in mixing depth for the project site during 2016



8.4 Dispersion model configuration

As discussed in **Section 8.1**, dispersion modelling was conducted using the CALPUFF dispersion model and three-dimensional meteorological data output from CALMET.

Emissions from the activities at the project site were represented by a series of volume sources, while wind erosion from exposed areas were represented by area sources.

The estimated particulate emissions were modelled as:

- Fine Particulates (FP < 2.5 µm),
- Course Matter (2.5 µm<CM<10 µm) and
- the Rest (RE>10 µm),

and then grouped using CALPOST to predict $PM_{2.5}$, PM_{10} and TSP concentrations at surrounding receptor locations. This approach provides the most realistic treatment of the differing size fractions, with the lighter, finer particulate matter being dispersed further than the heavier size fraction which settles out of the air more rapidly.

Based on the sensitivity of each activity to wind speed, an hourly varying emission file representing hourly FP, CM and RE emissions for each source was generated using the annual average emission rate estimated for each activity. Details of the algorithm used to generate the variable emission files are presented in **Appendix A**.

9 DISPERSION MODELLING RESULTS

The sections below present a summary of the air quality impacts predicted by the modelling at the sensitive receptors identified in **Section 3.1**. Dispersion modelling was performed for the year 2 operations at the project site, which is representative of the worst case impacts associated with the proposed future operations at the Moonimba Borrow Site.

The incremental and cumulative 24-hour and annual average $PM_{2.5}$ and PM_{10} concentrations predicted at surrounding sensitive receptors for year 2 operations are presented **Table 18** and **Table 19**. The predicted incremental and cumulative annual average TSP concentrations and maximum monthly dust deposition rates are presented in **Table 20**. The estimated background concentrations outlined in **Section 6.3** have been used to calculate the cumulative impacts at each sensitive receptor.

The modelling results presented in **Table 18**, **Table 19** and **Table 20** show that the cumulative $PM_{2.5}$, PM_{10} and TSP concentrations and dust deposition rates predicted at each surrounding sensitive receptor comply with the relevant ambient air quality criteria outlined in **Section 4.4**.

Contour plots showing the incremental impact predicted due to the project site's emissions (ie. excluding background levels) for each pollutant are presented in **Appendix C**. These plots do not represent the dispersion pattern for any individual time period, but rather illustrate the maximum concentration that was predicted to occur at each model calculation point given the range of meteorological conditions occurring over the 2016 modelling period.

Table 18 Predicted $PM_{2.5}$ concentrations – year 2 operations (worst case)

Receptor ID	Incremental $PM_{2.5}$ Concentrations (µg/m³)		Cumulative $PM_{2.5}$ Concentrations [1] (µg/m³)	
	24-Hour Average	Annual Average	24-Hour Average	Annual Average
R01	0.10	0.01	15.1	7.0
R02	0.50	0.11	15.5	7.1
R03	0.40	0.07	15.4	7.1
R04	0.10	0.02	15.1	7.0
R05	0.10	0.04	15.1	7.0
R06	0.10	0.02	15.1	7.0
R07	0.10	0.01	15.1	7.0
R08	0.10	0.01	15.1	7.0
R09	0.10	0.01	15.1	7.0
R10	0.10	0.02	15.1	7.0
R11	0.10	0.01	15.1	7.0
R12	0.10	0.01	15.1	7.0
R13	0.10	0.01	15.1	7.0
R14	0.30	0.03	15.3	7.0
R15	0.10	0.02	15.1	7.0
R16	0.20	0.02	15.2	7.0
R17	0.50	0.03	15.5	7.0
R18	0.80	0.04	15.8	7.0
R19	0.20	0.02	15.2	7.0
R20	0.50	0.06	15.5	7.1
R21	0.50	0.05	15.5	7.0
R22	0.30	0.04	15.3	7.0
R23	0.50	0.08	15.5	7.1
R24	0.20	0.02	15.2	7.0
R25	0.30	0.03	15.3	7.0
R26	0.20	0.02	15.2	7.0
R27	0.20	0.02	15.2	7.0
R28	0.20	0.02	15.2	7.0
R29	0.10	0.02	15.1	7.0
R30	0.10	0.02	15.1	7.0
R31	0.20	0.03	15.2	7.0
R32	0.20	0.04	15.2	7.0
R33	0.20	0.05	15.2	7.0
R34	0.50	0.14	15.5	7.1
R35	0.30	0.05	15.3	7.0
R36	1.20	0.24	16.2	7.2
Criteria			**25.0**	**8.0**

1 Includes assumed constant background values of 15.0 µg/m³ (24-hour average) and 7.0 µg/m³ (annual average).

Table 19 Predicted PM_{10} concentrations – year 2 operations (worst case)

Receptor ID	Incremental PM_{10} Concentrations (µg/m³)		Cumulative PM_{10} Concentrations [1] (µg/m³)	
	24-Hour Average	Annual Average	24-Hour Average	Annual Average
R01	0.7	0.1	37.7	17.1
R02	1.9	0.5	38.9	17.5
R03	1.8	0.3	38.8	17.3
R04	0.6	0.1	37.6	17.1
R05	0.6	0.2	37.6	17.2
R06	0.5	0.1	37.5	17.1
R07	0.5	0.1	37.5	17.1
R08	0.5	0.1	37.5	17.1
R09	0.5	0.1	37.5	17.1
R10	0.6	0.1	37.6	17.1
R11	0.7	0.1	37.7	17.1
R12	0.7	0.1	37.7	17.1
R13	0.7	0.1	37.7	17.1
R14	3.0	0.2	40.0	17.2
R15	0.9	0.1	37.9	17.1
R16	2.3	0.2	39.3	17.2
R17	5.5	0.3	42.5	17.3
R18	7.9	0.4	44.9	17.4
R19	2.5	0.2	39.5	17.2
R20	5.2	0.5	42.2	17.5
R21	5.0	0.4	42.0	17.4
R22	2.8	0.4	39.8	17.4
R23	4.8	0.7	41.8	17.7
R24	2.3	0.2	39.3	17.2
R25	2.8	0.3	39.8	17.3
R26	2.0	0.2	39.0	17.2
R27	1.5	0.2	38.5	17.2
R28	1.5	0.2	38.5	17.2
R29	1.4	0.2	38.4	17.2
R30	1.2	0.2	38.2	17.2
R31	1.6	0.2	38.6	17.2
R32	2.1	0.4	39.1	17.4
R33	1.7	0.3	38.7	17.3
R34	2.0	0.6	39.0	17.6
R35	1.8	0.2	38.8	17.2
R36	11.5	2.3	48.5	19.3
Criteria			**50.0**	**25.0**

1 Includes assumed constant background values of 37.0 µg/m³ (24-hour average) and 17.0 µg/m³ (annual average).

Table 20 Predicted TSP concentrations and dust deposition rates – year 2 operations (worst case)

Receptor ID	Annual Average TSP Concentrations (µg/m³)		Maximum Monthly Dust Deposition Rates (g/m²/month)	
	Increment	Cumulative	Increment	Cumulative
R01	0.2	43.2	0.01	2.0
R02	2.1	45.1	0.09	2.1
R03	1.3	44.3	0.06	2.1
R04	0.4	43.4	0.02	2.0
R05	0.6	43.6	0.03	2.0
R06	0.4	43.4	0.02	2.0
R07	0.2	43.2	0.01	2.0
R08	0.2	43.2	0.01	2.0
R09	0.2	43.2	0.01	2.0
R10	0.3	43.3	0.01	2.0
R11	0.2	43.2	0.01	2.0
R12	0.2	43.2	0.01	2.0
R13	0.2	43.2	0.01	2.0
R14	0.6	43.6	0.01	2.0
R15	0.3	43.3	0.01	2.0
R16	0.4	43.4	0.01	2.0
R17	0.6	43.6	0.02	2.0
R18	0.8	43.8	0.02	2.0
R19	0.4	43.4	0.01	2.0
R20	1.2	44.2	0.03	2.0
R21	0.9	43.9	0.03	2.0
R22	0.8	43.8	0.02	2.0
R23	1.5	44.5	0.03	2.0
R24	0.5	43.5	0.01	2.0
R25	0.7	43.7	0.02	2.0
R26	0.4	43.4	0.01	2.0
R27	0.4	43.4	0.01	2.0
R28	0.5	43.5	0.01	2.0
R29	0.5	43.5	0.01	2.0
R30	0.4	43.4	0.01	2.0
R31	0.5	43.5	0.02	2.0
R32	1.0	44.0	0.03	2.0
R33	0.9	43.9	0.03	2.0
R34	2.7	45.7	0.09	2.1
R35	0.8	43.8	0.03	2.0
R36	6.5	49.5	0.14	2.1
Criteria		**90.0**	**2.0**	**4.0**

1 Includes assumed constant background values of 43.0 µg/m³ (TSP) and 2.0 mg/m²/month (dust deposition)

10 DUST MITIGATION MEASURES

The results of the dispersion modelling indicate compliance for all modelled parameters. Nevertheless, in order to ensure that impacts on off-site air quality are minimised and within the scope permitted by the W2B planning approval, dust emissions from the project site will be managed in accordance with the W2B Construction Air Quality Management Plan (CAQMP).

The CAQMP covers all sources of emissions identified in **Section 7.3** of this AQIA, including wind erosion, wheel generated dust, blasting, extraction, material handling and processing of extracted material.

The contractor should review and apply all relevant mitigation measures from the CAQMP to the operation of the site. **Table 21** presents the key measures identified to be relevant for the operation of the Moonimba Borrow Site (but may not be limited to).

Table 21 Relevant mitigation measures from the W2B Construction Air Quality Management Plan

ID	Measure/Requirement
AQ1	Training will be provided to all project personnel, including relevant sub-contractors on sound air quality control practices and the requirements from this plan through inductions, toolboxes and targeted training.
AQ3	Vegetation clearing will be staged where possible to minimise the area and time that surfaces are exposed.
AQ4	Exposed surfaces with no scheduled work for two weeks will be treated to minimise dust generation. Exposed surfaces will be stabilised progressively using the most practical site specific methods, such as watering and geo-fabrics for short term exposure and emulation spray, spray grass, soil compaction and revegetation for longer term exposed areas or final finishes.
AQ5	Construction activities will be modified, reduced or controlled during high or unfavourable wind conditions if they have a potential to increase dust generation.
AQ6	Control measures including water carts, sprinklers, sprays, dust screens or the application of geo- binding agents will be utilised where applicable to control dust emissions. The frequency of use will be modified accommodate prevailing conditions. Dust control equipment will be maintained to ensure its operability.
AQ10	Stockpiles will be located in accordance with the criteria established in The Stockpile Management Protocol. Control measures including water carts, sprinklers, sprays, dust screens or the application of geo-binding agents will be utilised where applicable to control dust emissions. A suitable cover crop or provision of other covering over topsoil stockpiles will be established where stockpiles are in place for longer than 4 weeks.
AQ11	Temporary stockpiles that are planned to be in place for long periods will be temporarily seeded and stabilised.
AQ16	Disturbed areas will be progressively rehabilitated as soon as practical.
AQ17	Areas of disturbed material and access roads will be stabilised where possible by methods such as compaction. Compounds, ancillary facilities, administration access roads and standing areas will be hard surfaced.
AQ18	Measures implemented to minimise dust, soil or mud from being deposited from vehicles on public roads. This will be achieved by implementing mitigation measures such as rumble grids and large aggregate at entry/exit points. Manual cleaning will also be carried out where appropriate. In the event of any spillage or tracking, the spilt material will be removed within 24 hours.

ID	Measure/Requirement
	Management measures should include: • Watering of unsealed haul roads, as required • Visual checks of exhaust emissions.
AQ19	Hardstand areas and surrounding public roads will be cleaned, as required, using methods including brooms, bobcat attachments or street sweepers.
AQ20	Vehicle movement will be confined to designated haul roads and areas. These roads will have speed limits of 40 km/h in order to reduce dust generation. Reduced speed limit maybe implemented where dust generation persists.
AQ21	All loaded haulage trucks will be covered where there is a risk of release of dust or other materials and at all times on public roads.
AQ25	Dust suppression systems will be installed and used on crushing and screening plants and mulching equipment to minimise generation of dust from these activities.
AQ30	Where practical during blasting, a combination of the following mitigation measures will be used to suppress dust: • Weather reports checked prior to blasting minimise the potential for windblown dust reaching surrounding residents. • Controlled blasts to minimise dust produced.
AQ31	Crushers will be positioned in protected areas, where practical, to reduce wind dispersion of dust particles (eg within cuts). Water spraying will be utilised if necessary.
AQ33	Dust deposition gauges will be established at least one month prior to the commencement of construction to establish background dust levels. Monitoring equipment will remain in place until completion of the construction works and/or where ground conditions are stable. Results will be captured on a monthly basis and collected in accordance with DEC's "*Approved Methods for the Sampling and Analysis of Air Pollutants in NSW*" guidelines.
AQ34	An onsite weather station will be established to record weather data. Rainfall at the premises will be measured and recorded in millimetres per 24-hour period at the same time each day from the time that the site office is established.
AQ35	Public roads will be inspected each day at main entry and exit points to and from areas where construction activities are taking place including the project compound and site offices. Material tracked onto the road pavement will be removed in accordance with AQ18.
AQ36	Weather forecast will be reviewed on a daily basis and appropriate measures implemented where unfavourable weather conditions (dry weather, wind speed >10m/s) are anticipated. Measures to be implemented during unfavourable weather conditions are outlined in AQ5.
AQ37	Dust control and operational procedures will be reviewed and modified if results exceed the air quality criteria and are attributable to construction activities.

11 CONCLUSION

SLR Consulting was commissioned by Pacific Complete to conduct an AQIA for the proposed intensification of extraction at the Moonimba sand and sandstone borrow site situated in Bungawalbin, NSW. The site is currently operating an annual extraction rate of 30,000 m^3 per annum. Pacific Complete is proposing to intensify the extraction rate at the site to 400,000 m^3 per annum for two years to provide sufficient material to complete the W2B project. This AQIA has been prepared in accordance with The Approved Methods (NSW EPA, 2017).

Emissions of fugitive particulate matter from all on-site activities (both years of operation) were estimated using Environment Australia National Pollutant Inventory, ACARP and US EPA approved emission factors. Mitigation measures implemented at the site to minimise dust emissions, including on-site haul road watering and water spraying of exposed areas and stockpiles, were included in the emission calculations. year 2 was selected as the worst case scenario as it was estimated to give rise to the highest emission rates. The calculated emissions from year 2 were modelled using the CALMET/CALPUFF modelling software to investigate the transport of emitted pollutants (TSP and PM_{10} and $PM_{2.5}$) from the project site to predict the impact upon the nearest identified sensitive receptor locations.

Based on the modelling results, the following conclusions have been drawn for the proposed intensification of extraction at the Moonimba Borrow Site:

- The modelling of $PM_{2.5}$ emissions from all identified sources associated with the operations at the project site showed that maximum predicted annual and 24-hour average cumulative $PM_{2.5}$ concentrations at all nearby sensitive receptors would remain below the relevant ambient air quality criteria. The incremental impacts predicted by the modelling of $PM_{2.5}$ emissions are negligible.
- The modelling of PM_{10} emissions from all identified sources associated with the operations at the project site showed that maximum predicted annual and 24-hour average cumulative PM_{10} concentrations at all nearby sensitive receptors would remain below the relevant ambient air quality criteria.
- The modelling of TSP emissions from identified sources associated with the operations at the project site showed that these emissions have no potential to give rise to ground level exceedances of the ambient air quality criteria for annual average TSP concentrations and dust deposition rates.

No air quality constraints have therefore been identified for the proposed intensification of extraction at the Moonimba Borrow Site as a result of this air quality impact assessment.

12 REFERENCES

ACARP. (2015). *Development of Australia-Specific PM10 Emission Factors for Coal Mines.* Australian Coal Association Research Program.

DSEWPC. (2012). *National Pollutant Inventory, Emission Estimation Technique Manual for Mining, Version 3.1.* Commonwealth of Australia.

ENVIRON . (2014). *Newman's Quarry Expansion Air Quality Impact Assessment .* prepared by ENVIRON Australia Pty Ltd for Newman's Quarry and Landscaping Pty Ltd .

National Environment Protection Council. (2003). *Variation to the National Environment Protection (Ambient Air Quality) Measure.* Canberra: National Environment Protection Council.

National Environment Protection Council. (2016). *National Environment Protection (Ambient Air Quality) Measure.* Canberra: Department of the Environment.

NSW EPA. (2017, January). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. Prepared by NSW Environment Protection Authority, which is part of the NSW Office of Environment and Heritage (OEH).

Oke, T. R. (2002). *Boundary Layer Climates.* Routledge.

Pasquill. (1961). The estimation of the dispersion of windborne material. *The Meteorological Magazine, 90*(1063), 33-49.

RMS. (2012). *Woolgoolga to Ballina Pacific Highway Upgrade, Environmental Impact Statement.* NSW Roads and Maritime Services.

RTA. (2007). *Environmental Assessment for the Sapphire to Woolgoolga Pacific Highway Upgrade, Working Paper 8.* NSW Roads and Traffic Authority.

USEPA. (2006 and Updates). *Emission Factors & AP42, Compilation of Air Pollutant Emission Factors.* US Environmental Protection Agency.

A brief summary of the steps used in calculating the hourly varying emission rates for each source are presented below.

Step 1: Calculate annual average emission rate (kg/year) for FP, CM and RE

$FP_{annual} = PM_{2.5,\,annual}$	(FP) Fine Particulate – particulate of size less than 2.5 µm
$CM_{annual} = PM_{10,annual} – PM_{2.5,\,annual}$	(CM) Coarse Particulate – particulate of size between 10 µm and 2.5 µm
$RE_{annual} = TSP_{annual} - PM_{10,annual}$	(RE) Rest Particulate – particulate of size greater than 10 µm

Step 2: Identify the operating hours for each activity

Step 3: Classify the sensitivity of each type of activity to wind speed

- Wind insensitive: activities with emission factor that is independent of wind speed (e.g. blasting)
- Wind sensitive: activities with emission factor that is a function of $(\text{wind speed}/2.2)^{1.3}$ (e.g. loading)
- Wind erosion: emission from exposed areas/stockpiles

Step 4: Identify the number of sources associated with each activity

- Note that each wind erosion source is modelled as an independent source.

Step 5: Calculate the hourly average emission rate for each activity per source

<table>
<tr>
<td>

$$FP_{AC,i,h} = \frac{FP_{annual,i} \times 1000}{N_{days} \times OH_i \times 3600 \times N_{s,i}} \times WSFactor_{i,h}$$

$$CM_{AC,i,h} = \frac{CM_{annual,i} \times 1000}{N_{days} \times OH_i \times 3600 \times N_{s,i}} \times WSFactor_{i,h}$$

$$RE_{AC,i,h} = \frac{RE_{annual,i} \times 1000}{N_{days} \times OH_i \times 3600 \times N_{s,i}} \times WSFactor_{i,h}$$

For wind insensitive activities

$$WSFactor_{i,h} = 1$$

For wind sensitive activities

$$WSFactor_{i,h} = \frac{\left(\frac{WS_h}{2.2}\right)^{1.3}}{\frac{\sum_{j=1}^{n}\left(\frac{WS_j}{2.2}\right)^{1.3}}{n}}$$

For wind erosion activities

$$WSFactor_{i,h} = \frac{(WS_h)^3}{\frac{\sum_{j=1}^{n}(WS_j)^3}{n}}$$

</td>
<td>

Where:

$FP_{AC,i,h}$- Fine particulates emission rate for Activity i (g/s) at hour h

$CM_{AC,i,h}$- Fine particulates emission rate for Activity i (g/s) at hour h

$CM_{AC,i,h}$- Fine particulates emission rate for Activity i (g/s) at hour h

OH_i-daily Operating hours (1- 24) for Activity i

N_{days}-Number of days in the meteorological data file

$N_{s,i}$-Number of sources associated with Activity i

WS_h-Wind speed at the hour

n -number of hours in the meteorological data file

</td>
</tr>
</table>

Note: If the activity was modelled as area source, the equation on the left column of the table needs to be divided by the area of that activity.

Step 6: Calculate hourly average emission rate for each source

To calculate the emission rate for a particular source for a particular hour, add up the calculated emission rate for each activity associated with source.

For example, if Source 1 is associated with Activity 1, Activity 2 and Activity 3, then:

- $ER_{S1,h,FP} = FP_{AC,1,h} + FP_{AC,2,h} + FP_{AC,3,h}$
- $ER_{S1,h,CM} = CM_{AC,1,h} + CM_{AC,2,h} + CM_{AC,3,h}$
- $ER_{S1,h,RE} = RE_{AC,1,h} + RE_{AC,2,h} + RE_{AC,3,h}$

Table B1 Detailed emission estimation calculation for year 1 operations

ACTIVITY	Annual Average Emission Rate			Intensity	Units	TSP EF	PM_{10} EF	$PM_{2.5}$ EF	Units	Var 1	Units	Var 2	Units	Var 3	Units	Var 4	Units	Var 5	Units
	TSP emission (kg/y)	PM_{10} emission (kg/y)	$PM_{2.5}$ emission (kg/y)																
TS - West - Removal	62	24	3	4,293	tonnes/ year	0.0290	0.0113	0.0014	kg/t										
TS - West - Loading to Trucks	2	0	0	4,293	tonnes/ year	0.0004	0.0002	0.00003	kg/t	1.19	WS Factor	5	%MC						
TS - West - Emplacing at dump	2	1	0	4,293	tonnes/ year	0.0004	0.0002	0.00003	kg/t	1.19	WS Factor	5	%MC						
TS - West - Hauling on unpaved roads	16	4	0	66	VKT	0.943	0.260	0.026	kg/ VKT										
TS - East - Removal	86	34	4	5,950	tonnes/ year	0.0290	0.0113	0.0014	kg/t										
TS - East - Loading to Trucks	2	1	0	5,950	tonnes/ year	0.0004	0.0002	0.00003	kg/t	1.19	WS Factor	5	%MC						
TS - East - Emplacing at dump	2	1	0	5,950	tonnes/ year	0.0004	0.0002	0.00003	kg/t	1.19	WS Factor	5	%MC						
TS - East - Hauling on unpaved roads	20	5	1	83	VKT	0.943	0.260	0.026	kg/ VKT										
OB - West - Dozers	1,667	368	175	328	hours/ year	5.1	1.1	0.5	kg/h	10	%SC	5	%MC						
OB - West - Loading to truck	76	36	5	192,857	tonnes/ year	0.0004	0.0002	0.00003	kg/t	1.19	WS Factor	5	%MC						
OB - West - Hauling on unpaved roads to Site Boundary	10,865	2,995	299	46,071	VKT	0.943	0.260	0.026	kg/ VKT										
OB - East - Dozers	2,655	585	279	522	hours/ year	5.1	1.1	0.5	kg/h	10	%SC	5	%MC						
OB - East - Loading to truck	120	57	9	307,143	tonnes/ year	0.0004	0.0002	0.00003	kg/t	1.19	WS Factor	5	%MC						
OB - East - Hauling on unpaved roads to Site Boundary	5,969	1,645	165	25,313	VKT	0.943	0.260	0.026	kg/ VKT										

ACTIVITY	Annual Average Emission Rate TSP emission (kg/y)	PM10 emission (kg/y)	PM2.5 emission (kg/y)	Intensity	Units	TSP EF	PM10 EF	PM2.5 EF	Units	Var 1	Units	Var 2	Units	Var 3	Units	Var 4	Units	Var 5	Units
OB - Hauling on paved roads - Boundary to Reardons Lane	6,688	1,284	311	500,000	tonnes/ year	0.013	0.003	0.001	kg/t	32	tonnes/ load	29	Ave GMV	6.8	km/ return trip	0.1	kg/ VKT	0.6	SL
BL - West - Blasting	132	69	6	19	Blasts/ year	6.957	3.618	0.33	kg/blast	1000	area blasted (m2)								
DR - West - Drilling	1,121	583	52	1,900	holes/ year	0.590	0.31	0.03	kg/hole										
BL - East - Blasting	202	105	9	29	Blasts/ year	6.957	3.618	0.33	kg/blast	1000	area blasted (m2)								
DR - East - Drilling	1,711	890	80	2,900	holes/ year	0.590	0.31	0.03	kg/hole										
EM - West - Dozers	393	89	41	58	hours/ year	6.8	1.5	0.7	kg/h	10	%SC	4	%MC						
EM - West - Unloading to process plant	103	49	7	192,857	tonnes/ year	0.0005	0.0003	0.00004	kg/t	1.19	WS Factor	4	%MC						
EM - West - Crusher	260	116	12	192,857	tonnes/ year	0.0027	0.0012	0.0001	kg/t										
EM - West - Screener	2,411	829	113	192,857	tonnes/ year	0.0125	0.0043	0.0006	kg/t										
EM - East - Dozers	626	141	66	92	hours/ year	6.8	1.5	0.7	kg/h	10	%SC	4	%MC						
EM - East - Unloading to process plant	164	78	12	307,143	tonnes/ year	0.0005	0.0003	0.00004	kg/t	1.19	WS Factor	4	%MC						
EM - East - Crusher	415	184	19	307,143	tonnes/ year	0.0027	0.0012	0.0001	kg/t										
EM - East - Screener	3,839	1,321	180	307,143	tonnes/ year	0.0125	0.0043	0.0006	kg/t										
PR - West - Unloading to Stockpiles	103	49	7	192,857	tonnes/ year	0.0005	0.0003	0.00004	kg/t	1.19	WS Factor	4	%MC						
PR - West - Loading to customer trucks	103	49	7	192,857	tonnes/ year	0.0005	0.0003	0.00004	kg/t	1.19	WS Factor	4	%MC						
PR - West - Hauling on unpaved roads to Site Boundary	5,433	1,497	150	23,036	VKT	0.943	0.260	0.026	kg/VKT										
PR - East - Unloading to Stockpiles	164	78	12	307,143	tonnes/ year	0.0005	0.0003	0.00004	kg/t	1.19	WS Factor	4	%MC						

ACTIVITY	Annual Average Emission Rate			Intensity	Units	TSP EF	PM_{10} EF	$PM_{2.5}$ EF	Units	Var 1	Units	Var 2	Units	Var 3	Units	Var 4	Units	Var 5	Units
	TSP emission (kg/y)	PM_{10} emission (kg/y)	$PM_{2.5}$ emission (kg/y)																
PR - East - Loading to customer trucks	164	78	12	307,143	tonnes/ year	0.0005	0.0003	0.00004	kg/t	1.19	WS Factor	4	%MC						
PR - East - Hauling on unpaved roads to Site Boundary	4,753	1,310	131	20,156	VKT	0.943	0.260	0.026	kg/ VKT										
PR - Haulage on paved roads - Boundary to Reardons Lane	6,688	1,284	311	500,000	tonnes/ year	0.013	0.003	0.001	kg/t	32	tonnes/ load	29	Ave GMV	6.8	km/ return trip	0.1	kg/ VKT	0.6	SL
IF - Unloading	27	13	2	51,000	tonnes/ year	0.0005	0.0003	0.00004	kg/t	1.19	WS Factor	4	%MC						
IF - Haulage on unpaved roads from site boundary	1,466	404	40	6,216	VKT	0.943	0.260	0.026	kg/ VKT										
IF - Haulage on paved roads to site boundary	682	131	32	51,000	tonnes/ year	0.013	0.003	0.001	kg/t	32	tonnes/ load	29	Ave GMV	6.8	km / return trip	0.1	kg/ VKT	0.6	SL
WE - East Pit	22,601	11,752	1,058	13	ha	0.40	0.21	0.02	kg/ha/hour	8,760	hours								
WE - West Pit	14,191	7,379	664	8	ha	0.40	0.21	0.02	kg/ha/hour	8,760	hours								
Total (kg/yr)	**95,988**	**35,518**	**4,275**																

SC = Silt Content (%)
TS = Topsoil
EM = Extracted Materials
TS = Topsoil
MC = Moisture Content (%)
GVM = Gross Vehicle Mass
PR = Product
BL = Blasting
SL = g/m^2 silt loading
VKT = Vehicle kilometre travelled
OB = Overburden
IF = Imported Fill
WS Factor = average of $(\text{wind speed}/2.2)^{1.3}$ in m/s
WE = Wind erosion
DR = Drilling
EF = Emission Factor

Table B1 Detailed emission estimation calculation for year 2 operations

ACTIVITY	Annual Average Emission Rate			Intensity	Units	TSP EF	PM_{10} EF	$PM_{2.5}$ EF	Units	Var 1	Units	Var 2	Units	Var 3	Units	Var 4	Units	Var 5	Units
	TSP emission (kg/ y)	PM_{10} emission (kg/y)	$PM_{2.5}$ emission (kg/y)																
BL - West - Blasting	132	69	6	19	Blasts/ year	6.96	3.62	0.33	kg/blast	1000	area blasted (m2)								
DR - West - Drilling	1,121	583	52	1,900	holes/ year	0.59	0.31	0.03	kg/hole										
BL - East - Blasting	202	105	9	29	Blasts/ year	6.96	3.62	0.33	kg/blast	1000	area blasted (m2)								
DR - East - Drilling	1,711	890	80	2,900	holes/ year	0.59	0.31	0.03	kg/hole										
EM - West - Dozers	786	177	83	116	hours/ year	6.80	1.53	0.71	kg/h	10	%SC	4	%MC						
EM - West - Unloading to process plant	207	98	15	385,714	tonnes/ year	0.00054	0.00025	0.00004	kg/t	1.19	WS Factor	4	%MC						
EM - West - Crusher	521	231	24	385,714	tonnes/ year	0.0027	0.0012	0.0001	kg/t										
EM - West - Screener	4,821	1,659	226	385,714	tonnes/ year	0.013	0.004	0.001	kg/t										
EM - East - Dozers	1,253	282	132	184	hours/ year	6.8	1.5	0.7	kg/h	10	%SC	4	%MC						
EM - East - Unloading to process plant	329	156	24	614,286	tonnes/ year	0.00054	0.00025	0.00004	kg/t	1.19	WS Factor	4	%MC						
EM - East - Crusher	829	369	39	614,286	tonnes/ year	0.0027	0.0012	0.0001	kg/t										
EM - East - Screener	7,679	2,641	359	614,286	tonnes/ year	0.0125	0.0043	0.0006	kg/t										
PR - West - Unloading to Stockpiles	207	98	15	385,714	tonnes/ year	0.00054	0.00025	0.00004	kg/t	1.19	WS Factor	4	%MC						
PR - West - Loading to customer trucks	207	98	15	385,714	tonnes/ year	0.00054	0.00025	0.00004	kg/t	1.19	WS Factor	4	%MC						
PR - West - Hauling on unpaved roads to Site Boundary	13,645	3,761	376	57,857	VKT	0.94	0.26	0.03	kg/VKT										
PR - East - Unloading to Stockpiles	329	156	24	614,286	tonnes/ year	0.0005	0.0003	0.00004	kg/t	1.19	WS Factor	4	%MC						
PR - East - Loading to customer trucks	329	156	24	614,286	tonnes/ year	0.0005	0.0003	0.00004	kg/t	1.19	WS Factor	4	%MC						

ACTIVITY	Annual Average Emission Rate			Intensity	Units	TSP EF	PM_{10} EF	$PM_{2.5}$ EF	Units	Var 1	Units	Var 2	Units	Var 3	Units	Var 4	Units	Var 5	Units
	TSP emission (kg/ y)	PM_{10} emission (kg/y)	$PM_{2.5}$ emission (kg/y)																
PR - East - Hauling on unpaved roads to Site Boundary	19,014	5,241	524	80,625	VKT	0.943	0.260	0.03	kg/ VKT										
PR - Haulage on paved roads - Boundary to Reardons Lane	13,376	2,568	621	1,000,000	tonnes/ year	0.0134	0.0026	0.0006	kg/t	32	tonnes/ load	29	Ave GMV	6.8	km/ return trip	0.1	kg/ VKT	0.6	SL
IF - Unloading	27	13	2	51,000	tonnes/ year	0.0005	0.0003	0.00004	kg/t	1.19	WS Factor	4	%MC						
IF - Haulage on unpaved roads from site boundary	12,027	3,315	332	51,000	VKT	0.94	0.26	0.03	kg/ VKT										
IF - Haulage on paved roads to site boundary	682	131	32	51,000	tonnes/ year	0.0134	0.0026	0.0006	kg/t	32	tonnes/ load	29	Ave GMV	6.8	km/ return trip	0.062 9	kg/ VKT	0.6	SL
WE - East Pit	22,601	11,752	1,058	13	ha	0.40	0.21	0.02	kg/ha/ hour	8760	hours								
WE - West Pit	14,191	7,379	664	8	ha	0.40	0.21	0.02	kg/ha/ hour	8760	hours								
Total (kg/ yr)	**116,225**	**41,925**	**4,734**																

SC = Silt Content (%)
TS = Topsoil
EM = Extracted Materials
IF = Imported Fill
MC = Moisture Content (%)
GVM = Gross Vehicle Mass
PR = Product
EF = Emission Factor
SL = g/m^2 silt loading
VKT = Vehicle kilometre travelled
DR = Drilling
WS Factor = average of $(\text{wind speed}/2.2)^{1.3}$ in m/s
WE = Wind erosion
BL = Blasting

Figure C 1 Maximum predicted incremental 24-hour average $PM_{2.5}$ ($\mu g/m^3$) – proposed year 2 operations

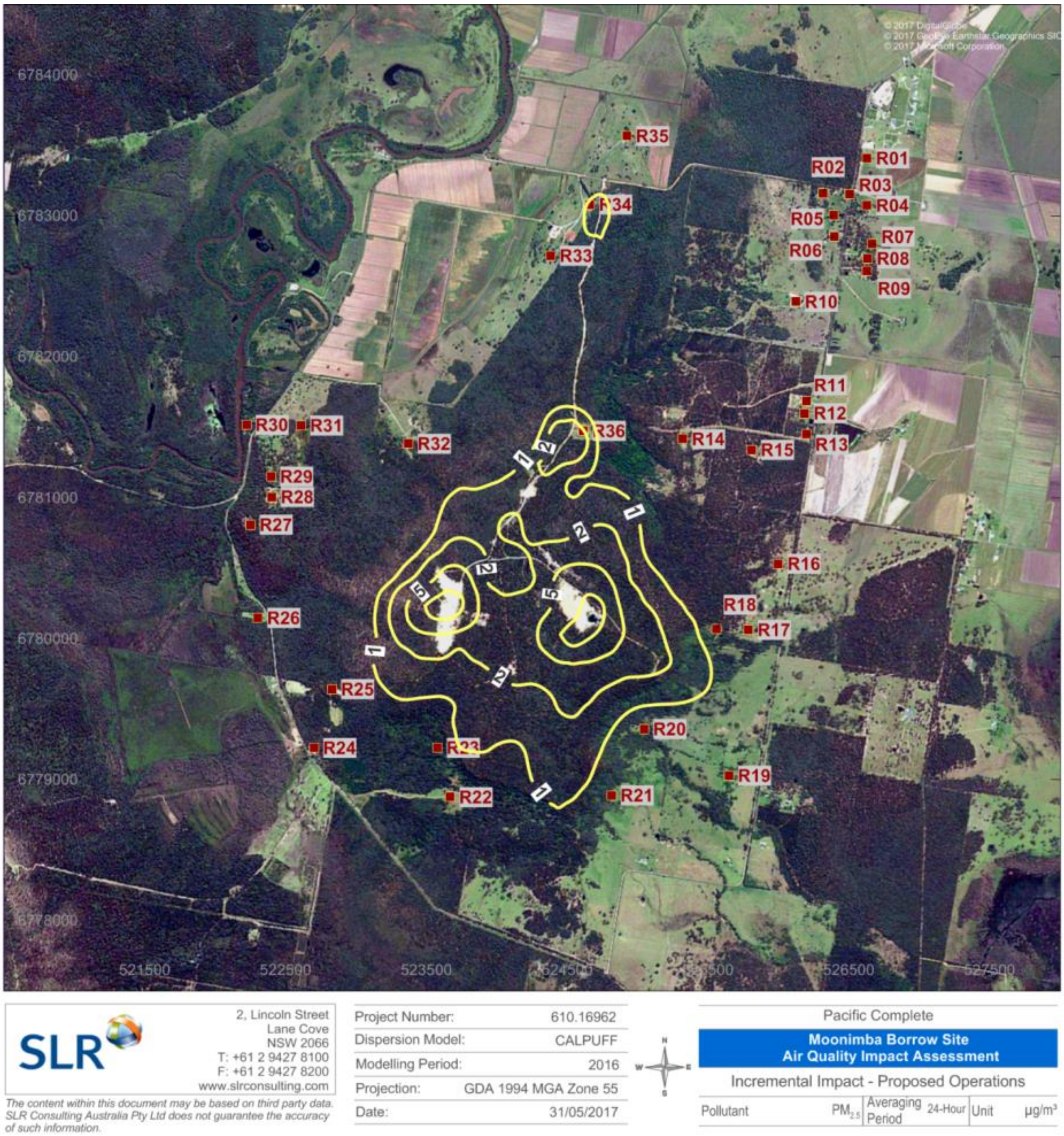


Figure C 2 Predicted incremental annual average $PM_{2.5}$ (µg/m^3) – proposed year 2 operations

SLR
2, Lincoln Street
Lane Cove
NSW 2066
T: +61 2 9427 8100
F: +61 2 9427 8200
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	610.16962
Dispersion Model:	CALPUFF
Modelling Period:	2016
Projection:	GDA 1994 MGA Zone 55
Date:	31/05/2017

Pacific Complete

Moonimba Borrow Site
Air Quality Impact Assessment

Incremental Impact - Proposed Operations

Pollutant	$PM_{2.5}$	Averaging Period	Annual	Unit	µg/m^3

Figure C 3 Maximum predicted incremental 24-hour average PM_{10} (µg/m³) – proposed year 2 operations

SLR
2, Lincoln Street
Lane Cove
NSW 2066
T: +61 2 9427 8100
F: +61 2 9427 8200
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	610.16962
Dispersion Model:	CALPUFF
Modelling Period:	2016
Projection:	GDA 1994 MGA Zone 55
Date:	31/05/2017

Pacific Complete
Moonimba Borrow Site
Air Quality Impact Assessment
Incremental Impact - Proposed Operations

Pollutant	PM_{10}	Averaging Period	24-Hour	Unit	µg/m³

Figure C 4 Predicted incremental annual average PM_{10} ($\mu g/m^3$) – proposed year 2 operations

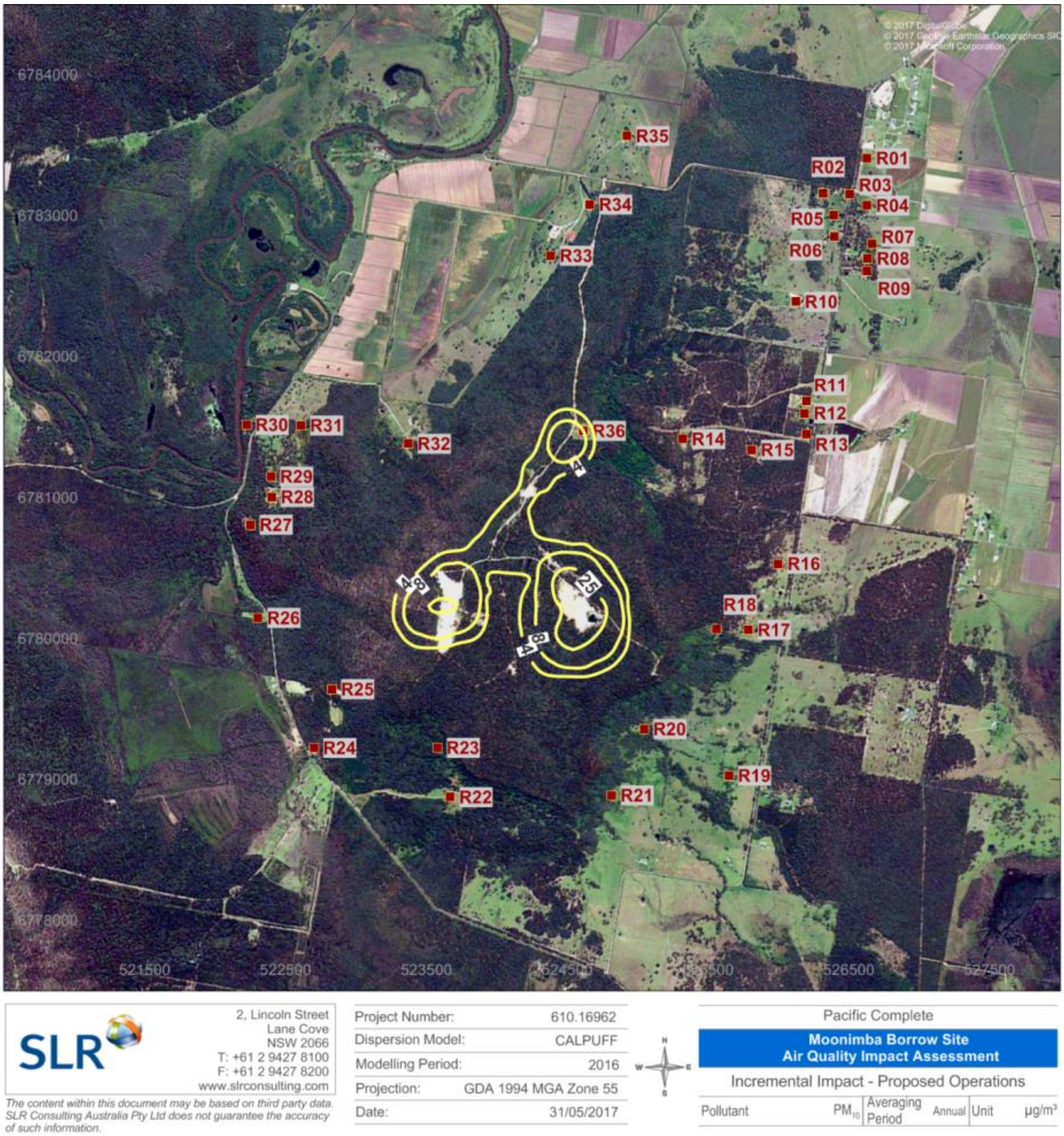


Figure C 5 Predicted incremental annual average TSP ($\mu g/m^3$) – proposed year 2 operations

SLR
2, Lincoln Street
Lane Cove
NSW 2066
T: +61 2 9427 8100
F: +61 2 9427 8200
www.slrconsulting.com

The content within this document may be based on third party data. SLR Consulting Australia Pty Ltd does not guarantee the accuracy of such information.

Project Number:	610.16962
Dispersion Model:	CALPUFF
Modelling Period:	2016
Projection:	GDA 1994 MGA Zone 55
Date:	31/05/2017

Pacific Complete
Moonimba Borrow Site
Air Quality Impact Assessment
Incremental Impact - Proposed Operations

Pollutant	TSP	Averaging Period	Annual	Unit	$\mu g/m^3$

Figure C 6 Predicted incremental annual average dust deposition rate (g/m^2/month) – proposed year 2 operations