LIDDELL COAL OPERATIONS

APPENDIX **L**

Air Quality and GHG Assessment

(Pacific Environment, 2013)

APPENDICES

4 September 2013

Nicole Armit
Principal – Environmental Management, Planning and Approvals
SLR Consulting Australia Pty Ltd
Level 1, 241 Denison Street
Broadmeadow NSW 2292

LIDDELL COAL OPERATIONS
MODIFICATION 5

In June 2013, Pacific Environment completed an air quality and greenhouse gas assessment for the Liddell Coal Operations – Modification 5 Project. The Department of Planning and Infrastructure (DoPI) have requested Pacific Environment respond to a number of issues raised by the NSW Environment Protection Authority (EPA) regarding the adequacy of the assessment.

The EPA's comments are listed as follows.

- Liddell Coal should provide additional information and clarification to justify the emission and operating scenarios assessed in the air quality assessment.
- Where site specific measurements/data exist, these values should be used in preference to generic or assumed input data sourced from literature.
- Where significant emission reductions have been achieved compared to those estimated in the Dust Stop report, the reduction muct be clearly justified.
- Revised dispersion modelling should be included in the assessment to reflect any changes to the project emissions inventory, based on the above.

This document addresses each of these points.

Pacific Environment Limited
Suite 1, Level 1, 146 Arthur Street, North Sydney, NSW 2060
(ASX: PEH) ABN: 43 692 285 758
www.pacific-environment.com
Ph: +61 2 9870 0900

Liddell Coal should provide additional information and clarification to justify the emission and operating scenarios assessed in the air quality assessment.

The years chosen for modelling were Year 2, Year 4 and Year 5. These years were considered representative of worst case for air quality at the nearest residential receivers. An indicative ROM coal and waste production schedule for the Project is provided in Table 1. The years highlighted were those chosen for modelling.

Table 1: Proposed production schedule for the Project

Project Year	Overburden mined (Mbcm)	ROM mined (Mtpa)
Year 1	39.1	7.2
Year 2	40.5	7.1
Year 3	39.5	7.0
Year 4	40.3	7.2
Year 5	39.7	7.0
Year 6	40.2	7.0
Year 7	40.2	7.0
Year 8	40.0	7.1
Year 9	29.9	5.3
Year 10	29.5	5.3
Year 11	30.5	4.3
Year 12	26.0	4.6
Year 13	12.8	2.0

These stages can be seen clearly in Figure 1, which presents the same information in graphical form. Year 2 represents one of the years of maximum combined (ROM and waste) extraction rates at the beginning of the Project, while operations are still towards the northwestern limits of the modification. This scenario was chosen to represent the worst case for the closest residences in the prevailing wind directions (along the NW/SE axis). While the production levels are not significantly greater than those in Year 1, the exposed pit and dump areas are potentially larger and Year 2 is therefore likely to present a worse case than in Year 1.

Year 4 represents the year of highest ROM production and therefore the maximum year of CHPP activity. Year 5 represents the period when extraction in the Entrance Pit begins to increase significantly and the exposed pit and dump areas are still near their peak. Production levels are slightly higher in Years 6, 7 and 8 than they are in Year 5, but Year 5 provides a worst case in terms of impacts for residences to the north and northwest.

Production and extraction levels drop off significantly from Year 9 onwards as the operations move further to the southeast and as such do not represent worst case scenarios in terms of air quality impact assessment at the nearest residences.

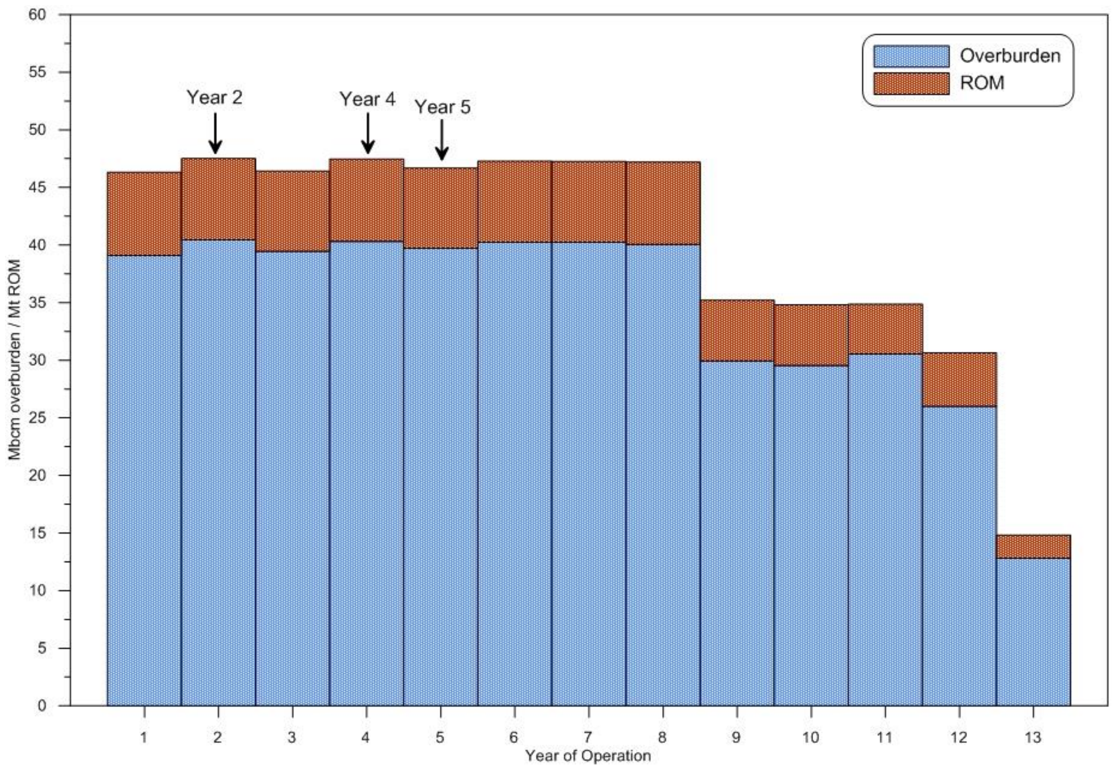

Figure 1: Proposed Waste (Mbcm) and ROM (Mt) Production rates throughout the Project

Where site specific measurements/data exist, these values should be used in preference to generic or assumed input data sourced from literature.

Many of the AP-42 emission factor equations used to calculate emissions from mining activities, require values for either silt or moisture content, or both in some cases. Some emission factor equations, blasting for example, do not require either of these parameters. For those that do include silt and moisture content, the total emission calculations are therefore sensitive to the values used in the equation, which should ideally be site-specific.

Site specific sampling was carried out at Liddell in December 2011 for the Dust Stop PRP process and these samples were analysed for both moisture and silt content. However, the analysis method used to determine silt content did not comply with the method prescribed in the AP-42, for which those specific equations were developed.

The laser diffraction method was used to determine the particle size distributions (PSD), and hence the silt content, of the Liddell samples. While this method may be more accurate for measuring particles in the micrometre range, the results are not suitable for use with these specific AP-42 equations. The dry sieving method which supports the AP-42, recognises the potential inaccuracies that may occur using this method. However, the equations have been developed using data collected in this way and to use values obtained via a different method would be inappropriate.

If a modified analysis method (such as laser diffraction) is to be used, the silt analysis results would have to be compared to those obtained by conventional dry sieving. If the comparison shows a significant but consistent difference in results, then it should be possible to develop an adjustment factor to correct the new results to what would have been obtained with the silt analysis method specified in AP-42. Only then it would be appropriate to use the alternative method results to support the AP-42 equations.

As no such comparison data were available at Liddell, and given that laser diffraction generally results in significantly higher silt contents than dry sieving, it was inappropriate to use these silt measurements for the purposes of an impact assessment. To use those values is likely to result in unrealistic overestimates of ground level concentrations.

In 2015, the predicted emissions from haulage on unsealed roads represented approximately 37% of the total PM_{10} emissions from the site. Given this activity is such a significant contributor to total emissions, it is overly conservative and unrealistic to use the much higher silt content determined by laser diffraction. A more realistic value of 3% was therefore used, the average value from a review of similar open cut mines as part of an ACARP research project (PAEHolmes, 2012). This is higher than the 2% measured at an adjacent mine.

Even though the value obtained using laser diffraction is not suitable for an air quality impact assessment, it could still reasonably have been used for the PRP, since that looked at emission estimates in relation to each other. The purpose of the PRP was to quantify existing emissions (using current controls), rank the dust generating activities, identify the top four emitters, identify further possible controls for those top four activities and then recalculate emissions to include those additional controls. Therefore, as long as the silt contents are consistent they remain relative to each other.

Where significant emission reductions have been achieved compared to those estimated in the Dust Stop report, the reduction must be clearly justified.

The total calculated PM_{10} emissions in the Liddell PRP were 3,218,880 kg/y in 2011. In the AQA, PM_{10} emissions in 2015 were calculated to be approximately 1,122,564 kg/y, significantly lower. ROM production rates were similar for both these scenarios, but there was considerably more waste proposed to be moved in 2015 (7.5 million tonnes more in 2015 than 2011). However, this alone would not account for the large difference in the emission estimates. Other contributors to this difference include the much higher silt contents (discussed above) and also the lower control factor used on haul roads in the PRP. A control factor of 75% was used in the PRP, while the AQA used 85%. Discussion for the justification of this factor can be found in Section 6.1 of the AQA.

When the increased silt contents and the reduced haul road control factor are applied to the AQA emission estimates for 2015, the total emissions are very similar to those calculated in the PRP, as shown in Table 1.

Table 1: Comparison of emission estimates

Liddell PRP (2011)	Mod 5 AQA (2015)	AQA adjusted for silt and haul control (2015)
3,218,880 kg	1,122,564 kg	3,085,811 kg

The remaining difference 133,069 kg can most likely be attributed to such things as differences in haul road lengths and exposed areas which will occur from year to year. It should be remembered that this is comparing two different mining years and as such emissions would not be expected to be the same.

In summary, the reduced emissions in the AQA were due to a combination of lower silt contents used for haul roads, topsoil and overburden, as well as the increased control factor on haul roads. As described above, the on-site silt content results determined by the laser diffraction method were not appropriate for use with the AP-42 emission factor equations. Using these would have led to potentially overestimating emissions from the site and unrealistically conservative predicted ground level concentrations.

Revised dispersion modelling should be included in the assessment to reflect any changes to the project emissions inventory, based on the above.

Given the discussion above, the emissions inventory presented in the AQA is sufficient and further modelling is not required. However to provide an indication of the difference the increase in silt content on haul roads would make to predicted annual average PM_{10} ground level concentrations, the model was run for the worst case year (Year 2) with an updated emission inventory. The results are presented in Figure 1 and show that the adjustment for silt makes little or no difference to predictions over the majority of the modelling domain where emissions from other nearby mines dominate. There is however, an increase to the northwest, but the nearest residences remain well below the annual cumulative PM_{10} criterion of 30 µg/m^3.

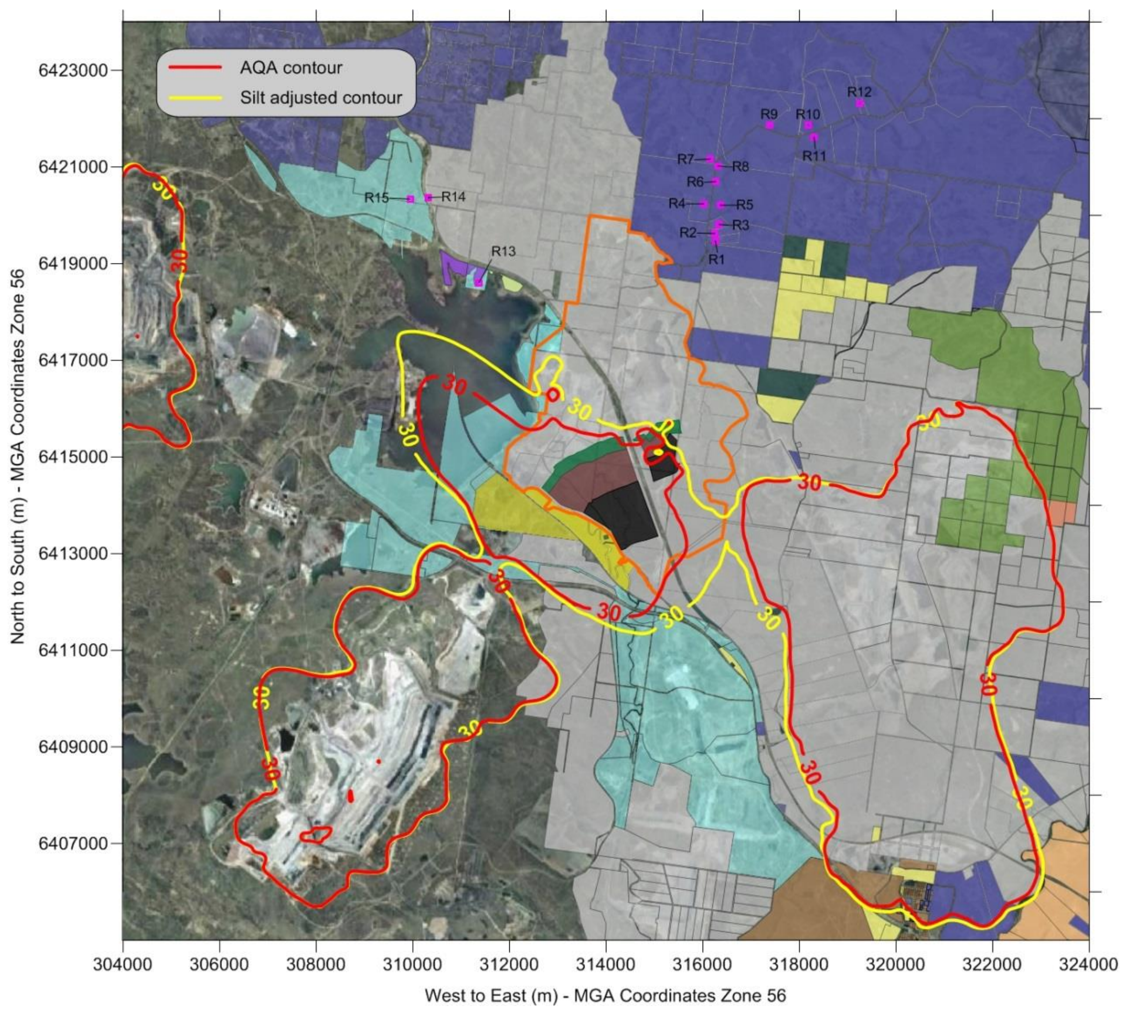

Figure 1: Comparison of predicted annual average PM_{10} concentrations – 2015 (µg/m^3)

I trust this information is sufficient for your response to the DP&I. Please do not hesitate to contact me if there is anything else you require.

Kind regards,

Jane Barnett
Principal Consultant – Air Quality

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Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

REPORT

AIR QUALITY AND GREENHOUSE GAS ASSESSMENT – LIDDELL COAL OPERATIONS MODIFICATION 5

GSS Environmental

Job No: **5347**

20 February 2013

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Pacific Environment Operations Pty ABN 86 127 101 642

BRISBANE
Level 1, 59 Melbourne Street, South Brisbane QLD 4101
PO Box 3306, South Brisbane QLD 4101
Ph: +61 7 3004 6400
Fax: +61 7 3844 5858

Unit 1, 22 Varley Street
Yeerongpilly, Qld 4105
Ph: +61 7 3004 6460

ADELAIDE
35 Edward Street, Norwood SA 5067
PO Box 3187, Norwood SA 5067
Ph: +61 8 8332 0960
Fax: +61 7 3844 5858

PERTH
Level 1, Suite 3
34 Queen Street, Perth WA 6000
Ph: +61 8 9481 4961
Fax: +61 7 3844 5858

SYDNEY
Suite 1, Level 1, 146 Arthur Street
North Sydney, NSW 2060
Ph: +61 2 9870 0900
Fax: +61 2 9870 0999

MELBOURNE
Suite 62, 63 Turner Street, Port Melbourne VIC 3207
PO Box 23293, Docklands VIC 8012
Ph: +61 3 9681 8551
Fax: +61 3 9646 3408

GLADSTONE
Suite 2, 36 Herbert Street, Gladstone QLD 4680
Ph: +61 7 4972 7313
Fax: +61 7 3844 5858

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1 INTRODUCTION

This report has been prepared by Pacific Environment (formerly PAEHolmes) for on behalf of GSS Environmental for Xstrata Coal NSW (XCN). The report assesses the likely air quality impacts of the proposed modification to Liddell Coal Operations (LCO), located approximately 25 kilometres (km) northwest of Singleton in the Upper Hunter Valley of New South Wales (NSW).

The assessment is based on the use of a computer-based dispersion model to predict ground-level dust concentrations and deposition levels in the vicinity of the mine. To assess the effect that the dust emissions would have on existing air quality, the dispersion model predictions have been compared to relevant air quality criteria.

The assessment follows the procedures outlined by the NSW Environment Protection Authority (EPA) in their document titled "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (**EPA, 2005**) (hereafter referred to as the "Approved Methods"). The Approved Methods specify how assessments based on the use of air dispersion models should be undertaken. They include guidelines for the preparation of meteorological data, emissions data and relevant air quality criteria.

This assessment also fulfils the Director-General Requirements (DGRs) for the Project relating to air quality and greenhouse gas. **Table 1.1** summarises the DGRs and the relevant sections of the report where these are addressed.

Table 1.1: Director-General's Requirements

Discipline	Requirement	Report Section
Air Quality	➢ Including a detailed consideration of the potential construction and operational impacts on the local air shed, in conjunction with air impacts from other sources, including surrounding mines and other operations at the mine.	Sections 6 and 7
Greenhouse Gas	➢ Including: o a quantitative assessment of the potential Scope 1, 2 and 3 greenhouse gas emissions from the Project o a qualitative assessment of the potential impacts of these emissions on the environment o a detailed description of the measures that would be implemented to minimise, reuse, recycle and dispose of any waste produced on site to ensure that the project is energy efficient	Section 8

In summary, the report provides information on the following:

- The way in which mining is to be undertaken with a focus on describing those aspects that will affect air quality.
- Air quality criteria that need to be met to protect the air quality environment.
- Meteorological and climatic conditions in the area.
- A discussion as to the likely existing air quality conditions in the area.

- The methods used to estimate dust emissions and the way in which dust emissions from the proposal would disperse and fallout.
- The expected dispersion and dust fallout patterns due to emissions from the Project incorporating the proposed modification and a comparison between the predicted dust concentration and fallout levels and the relevant air quality criteria.
- Control methods which can be used to reduce dust impacts.
- The estimated emissions of greenhouse gases from the Project (incorporating the incremental changes associated with the proposed Modification).

2 PROJECT DESCRIPTION

2.1 Overview

The Life of Mine planning process at LCO has identified the opportunity to maximise the recovery of coal resources within the existing development consent boundary and mining lease via the extension of open cut mining activities. In addition, LCO currently has approval to conduct mining operations until the end of 2023 within an approved mining footprint. However open cut mining activities will reach this approved boundary in 2014.

LCO are therefore seeking approval to modify DA 305-11-01 (Mod 5) to allow for this extension of mining activities (referred to as the Project). The primary objectives of the Project are to:

- Develop the on-going open cut mining operations with a focus on maximising resource recovery within the existing development consent and mining lease boundaries;
- Maintain continuity of coal production, and subsequently secure on-going employment opportunities and socio-economic flow-on benefits; and
- Continue to conduct mining at LCO in an environmentally responsible manner to minimise the potential for adverse impacts.

The proposed mining area progresses southward through the areas of both the South Pit and the Entrance Pit, as shown in **Figure 2.1**. Over this time, areas at the northern edges of both pits will be gradually rehabilitated. Excavation of the southernmost end of the Entrance Pit is scheduled to begin in approximately 2014 (Year 1 of the Project). From approximately Year 6 onwards, the area over which active mining is anticipated to occur begins to reduce gradually. In approximately Year 8, it is anticipated that mining activities will only occur in the Entrance Pit. Scenarios for specific modelling years are detailed in **Section 6** and represent mining activities in approximately Year 2, Year 4 and Year 5. It is anticipated that these years represent worst case conditions with respect to air quality, due to the volumes of material removed, transferred and processed on site.

The main activities associated with the modification would include:

- **Expansion of the open cut mining footprint** - Extension of the South and Entrance Pits to the south east, and, upon completion of mining in these pits, the mining of coal resources under the Mine Infrastructure Area (MIA) during which the MIA will be relocated to temporary facility. The extension will enable the recovery of an additional approximate 38 million tonnes (Mt) of Run of Mine (ROM) coal.

- **Extension to the Life of Mine** – The extension of open cut mining activities will lead to an associated extension of the life of mine at LCO from 2023 to 2028.

- **Additional Tailings Emplacement Areas** – A tailings emplacement area will be constructed within the final void of the South Pit to dispose of the additional tailings associated with the extension of open cut mining activities.

- **Coal Processing** – Coal will continue to be processed at the LCO CHPP at the approved rate of up to 8 Mtpa. Coal will however no longer be received from, or sent to, the Cumnock CHPP for processing as currently approved under DA 305-11-01, as this CHPP has been demolished following the cessation of mining operations at Cumnock No. 1 Colliery. LCO seeks to maintain a contingency for coal processing by delivery of up to 1.5 Mtpa of ROM coal to Ravensworth Central Coal Processing facility (RCCP) for washing via a new connection to the existing overland conveyor or by road transport route to RCCP. In addition, up to 2 Mtpa may be received from Mt Owen Complex for processing via the same existing overland conveyor.
- **Minor additional infrastructure**:
  - Construction and commissioning of a transfer point and conveyor connected to the existing Mt Owen/Glendell/Macquarie Generation conveyor, and
  - Infrastructure and auxiliary surface disturbance to support the new mining areas will be required, including but not limited to, powerlines, water management infrastructure and haul roads.

The proposed works lie wholly within both the existing development consent boundary and the mining lease ML 1597 boundary, shown in **Figure 2.1**. No further changes are proposed to that already approved by DA 305-11-01 including operating hours, coal handling techniques and mining methods.

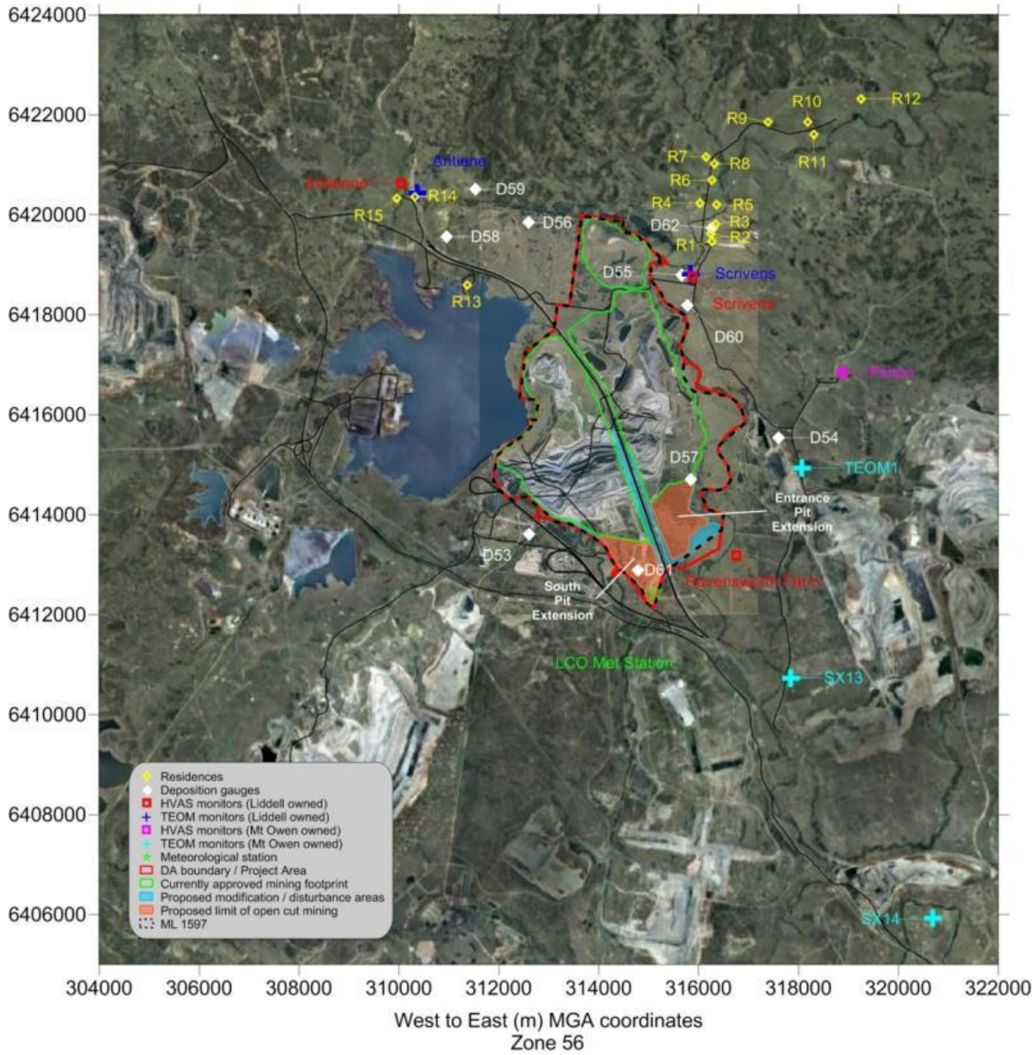


Figure 2.1: Project Site and Nearest Residential Properties

3 AIR QUALITY CRITERIA

3.1 Introduction

Extraction of coal requires the clearing of land and excavation of overburden material to recover the coal by heavy earth moving equipment. These activities generate fugitive dust emissions in the form of particulate matter described as total suspended particulate matter (TSP)[a], particulate matter with equivalent aerodynamic diameters 10 µm or less (PM_{10})[b] and particles with equivalent aerodynamic diameters of 2.5 µm and less ($PM_{2.5}$).

In practice, emissions of carbon monoxide (CO), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) will occur from diesel-powered equipment and vehicle exhausts. Emissions at open cut mines are comparatively small and too widely dispersed to give rise to significant off-site concentrations. For this reason these pollutants are not considered further in this report.

This section provides information on the air quality criteria used to assess the predicted impacts of the Project under the various agreed mining scenarios, with a focus on likely worst case. The assessment criteria provide benchmarks, which are intended to protect the community against the adverse effects of air pollutants. These criteria generally reflect current Australian standards for the protection of health and protection against nuisance effects. To assist in interpreting the significance of predicted concentration and deposition levels, some background discussion on the potential harmful effects of dust is provided below.

3.2 Particulate Matter and Health

The key air quality issue for mining operations is the emission of dust and particulate matter (PM). Mining generates PM from numerous activities including excavating, handling of material, hauling by heavy vehicles, and wind erosion from stockpiles and exposed surfaces. PM is formed when particulate becomes entrained in the atmosphere by the turbulent action of wind, by the mechanical disturbance of materials, or through the release of particulate-rich gaseous emissions from combustion sources.

Suspended PM can be defined by its size, chemical composition and source. Particle size is an important factor influencing its dispersion and transport in the atmosphere and its potential effects on human health. Typically, the size of suspended particles ranges from approximately 0.005 to 100 micrometres (µm) and is often described by the aerodynamic diameter of the particle.

The particulate size ranges are commonly described as:

- TSP – total suspended particulate matter refers to all suspended particles in the air. In practice, the upper size range is typically 30 µm – 50 µm.
- PM_{10} – refers to all particles with equivalent aerodynamic diameters of less than 10 µm, that is, all particles that behave aerodynamically in the same way as spherical particles with a unit density.
- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5 µm diameter (a subset of PM_{10}). Often referred to as the fine particles.
- $PM_{2.5-10}$ – defined as the difference between PM_{10} and $PM_{2.5}$ mass concentrations. Often referred to as coarse particles.

Evidence suggests that health effects from exposure to airborne particulate matter are predominantly related to the respiratory and cardiovascular systems. The human respiratory system has in-built defensive systems that prevent larger particles from reaching the more sensitive parts of the respiratory system. Particles larger than 10 µm, while not able to affect health, can soil materials and generally

[a] TSP refers to all particles suspended in air. In practice, the upper size range is typically 30 µm.

[b] PM_{10} refers to all particles with equivalent aerodynamic diameters of less than 10µm, that is, all particles that behave aerodynamically in the same way as spherical particles with a unit density.

degrade aesthetic elements of the environment. For this reason air quality goals make reference to measures of the total mass of all particles suspended in the air, this is referred to as TSP. In practice particles larger than 30 to 50 μm settle out of the atmosphere too quickly to be regarded as air pollutants. The upper size range for TSP is usually taken to be 30 μm.

Both natural and anthropogenic processes contribute to the atmospheric load of particulate matter. Coarse particles ($PM_{2.5-10}$) are derived primarily from mechanical processes resulting in the suspension of dust, soil, or other crustal[c] materials from roads, farming, mining, dust storms, and so forth. Coarse particles also include sea salts, pollen, mould, spores, and other plant parts.

Fine particles or $PM_{2.5}$ are derived primarily from combustion processes, such as vehicle emissions, wood burning, coal burning for power generation, and natural processes, such as bush fires. Fine particles also consist of transformation products, including sulphate and nitrate particles, and secondary organic aerosol from volatile organic compound emissions. Mining dust is likely to be composed of predominantly coarse particulate matter (and larger). As noted in Section 3.3 the $PM_{2.5}$ advisory reporting standards are not impact assessment criteria and are not specifically assessed in this report.

The size of particles determine their behaviour in the respiratory system, including how far the particles are able to penetrate, where they deposit, and how effective the body's clearance mechanisms are in removing them. This is demonstrated in **Figure 3.1** which shows the relative deposition by particle size within various regions of the respiratory tract. Additionally, particle size is an important parameter in determining the residence time and spatial distribution of particles in ambient air, key considerations in assessing exposure.

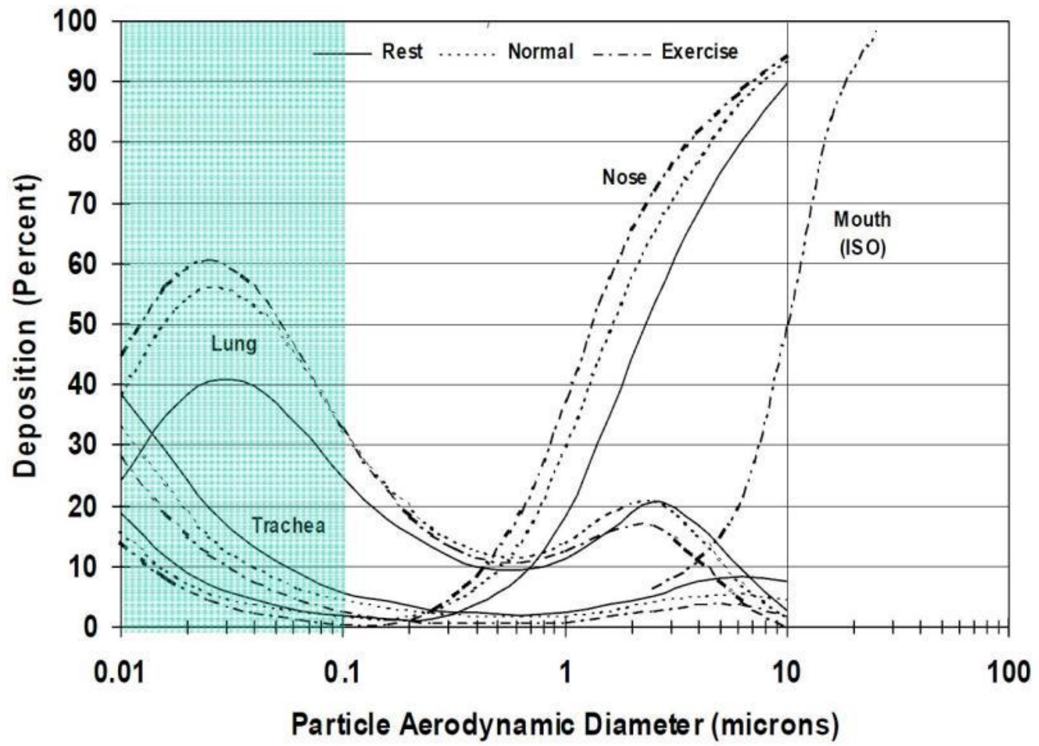


Figure 3.1: Particle Deposition within the Respiratory Tract (Source: Chow, 1995)

[c] Crustal dust refers to dust generated from materials derived from the earth's crust.

3.3 EPA Criteria

The Approved Methods specifies air quality assessment criteria relevant for assessing impacts from air pollution (**EPA, 2005**). The air quality goals relate to the total dust burden in the air and not just the dust from the Project. In other words, consideration of background dust levels needs to be made when using these goals to assess potential impacts. These criteria are health-based (i.e. they are set at levels to protect against health effects) and are consistent with the *National Environment Protection Measure for Ambient Air Quality* (referred to as the Ambient Air-NEPM) (**NEPC, 1998a**). However, the EPA's criteria include averaging periods, which are not included in the Ambient Air-NEPM, and also reference other measures of air quality, namely dust deposition and TSP.

In May 2003, the NEPC released a variation to the Ambient Air-NEPM (**NEPC, 2003**) to include advisory reporting standards for particulate matter with an equivalent aerodynamic diameter of 2.5 µm or less ($PM_{2.5}$). The purpose of the variation was to gather sufficient data nationally to facilitate the review of the Ambient Air-NEPM, which is currently underway. The variation includes a protocol setting out monitoring and reporting requirements for $PM_{2.5}$ particles. It is noted that the Ambient Air-NEPM $PM_{2.5}$ advisory reporting standards are not impact assessment criteria. However, for completeness, 24-hour and annual average $PM_{2.5}$ concentrations have been predicted at each of the 15 residential receptors shown in **Figure 2.1**, and compared to the advisory reporting standards. The results are presented in **Section 7.5**.

Table 3.1 summarises the air quality goals for pollutants that are relevant to this study.

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

Pollutant	Standard	Averaging Period	Source
TSP	90 µg/m³	Annual	NSW EPA (2005) (assessment criteria)
PM_{10}	50 µg/m³	24-Hour	NSW EPA (2005) (assessment criteria)
	30 µg/m³	Annual	NSW EPA (2005) (assessment criteria)
	50 µg/m³	24-Hour	NEPM (allows five exceedances per year)
$PM_{2.5}$	25 µg/m³	24-Hour	NEPM Advisory Reporting Standard
	8 µg/m³	Annual	NEPM Advisory Reporting Standard

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 fallout relatively close to source. Dust fallout can soil materials and generally degrade aesthetic elements of the environment, and are assessed for nuisance or amenity impacts.

Table 3.2 shows the total and the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust fallout levels are set to protect against nuisance impacts (**EPA, 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/m²/month	4 g/m²/month

Notes: g/m²/month – grams per square metre per month.

4 EXISTING ENVIRONMENT

4.1 Existing Air Quality

4.1.1 Introduction

Air quality standards and goals refer to pollutant levels that include the contribution from specific projects and existing sources. To fully assess impacts against all the relevant air quality standards and goals (see **Section 3**) 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. It is also important to note that the existing air quality conditions (that is, background conditions) will be influenced to some degree by the existing mining operations and other sources.

The current monitoring network consists of High Volume Air Samplers (HVAS), Tapered Element Oscillating Microbalance (TEOM) monitors and dust deposition gauges. HVAS measure both PM_{10} and TSP on a 6-day cycle while TEOMs measure 1-hour PM_{10} concentrations continuously. Deposition gauges measure the amount of deposited insoluble solids on a monthly basis to determine an annual average which can then be compared to air quality criteria.

The dust monitoring network is shown in **Figure 2.1** and comprises:

- Six HVAS monitors (three each for PM_{10} and TSP)
- Two TEOM monitors (measuring PM_{10})
- Ten dust deposition gauges
- One meteorological station

4.1.2 Dust Concentration

The monitoring results include all emission sources in the vicinity of the Project, including any contribution from surrounding mines and localised activities. Sources of particulate matter in the area would include mining activities, traffic on unsealed roads, local building and construction activities, farming, and animal grazing and to a lesser extent traffic from the other local roads and other sources such as wood-burning fires.

A summary of the annual average PM_{10} concentration from 2002 to 2011 is shown in **Table 4.1**. **Figure 4.1** shows the past three years of monitoring data in more detail, while the 24-hour average and rolling annual average PM_{10} concentration is shown in **Figure 4.2**.

Table 4.1: Annual average PM_{10} concentrations measured at each site (µg/m³)

	Picton (PM_{10}/1[a])	Ravensworth Farm (PM_{10}/4)	Scrivens (PM_{10}/12[b])	Aniene (PM_{10}/21)	Mt Owen TEOM SX13	Mt Owen TEOM SX14
Criterion	***30***	***30***	***30***	***30***	***30***	***30***
2002	-	26	-	-	-	-
2003	-	25	-	-	-	-
2004	16	23	-	-	-	-
2005	21	25	-	-	-	-
2006	17	22	-	-	-	-
2007	21	25	17	-	-	-
2008	24	25	15	-	-	-
2009	28	28	18	-	25	30
2010	22	22	12	11	18	23
2011	20	26	12	16	18	20

[a] *Monitoring commenced May 2004*
[b] *Data for 27 Sept 2009, 8 Dec 2009 and 13 Jan 2010 have been omitted due to widespread elevated dust conditions (**Environment NSW, 2012, BOM 2012b**). 26 Nov 2009 has also been omitted due to bushfire activity (**Emergency NSW, 2012**).*

From **Table 4.1** it can be seen that all of the annual average PM_{10} concentrations for each monitoring station comply with the EPA criteria of 30 µg/m³. In addition to these monitors, the Scrivens and Antiene TEOMs had measured for just over 12 months, resulting in PM_{10} annual averages of approximately 10 µg/m³ and 13 µg/m³, respectively, well below the air quality criteria.

These monitoring data are also plotted in **Figure 4.1** and **Figure 4.2** and show a seasonal trend in the 24-hour average PM_{10} concentrations at all PM_{10} monitoring locations. In general, the highest PM_{10} concentrations are experienced during summer and the lowest during winter. The measured 24-hour average PM_{10} concentrations have been above the 50 µg/m³ criterion on a number of occasions at all sites, particularly in the later part of 2009 when there were severe and widespread dust storms across eastern Australia and a number of bushfires in NSW.

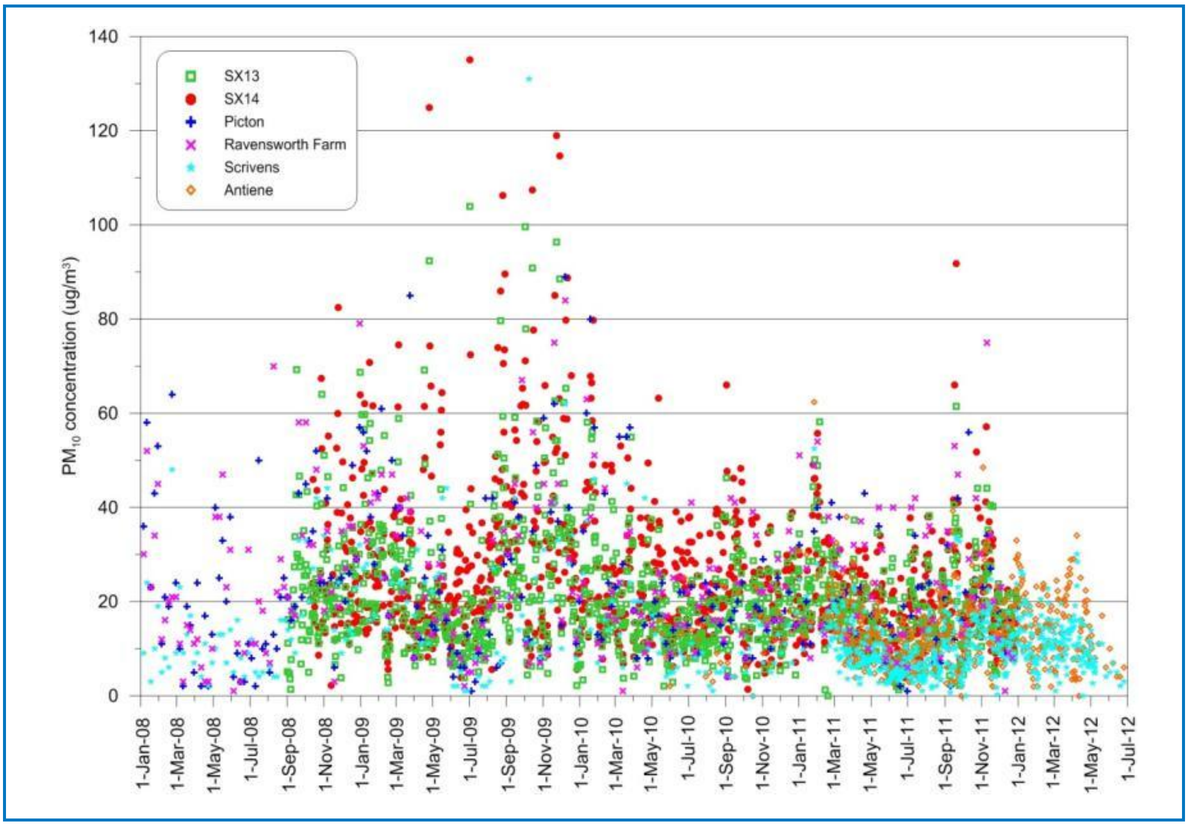


Figure 4.1: 24-hour average PM_{10} monitoring data for 2008 – 2011

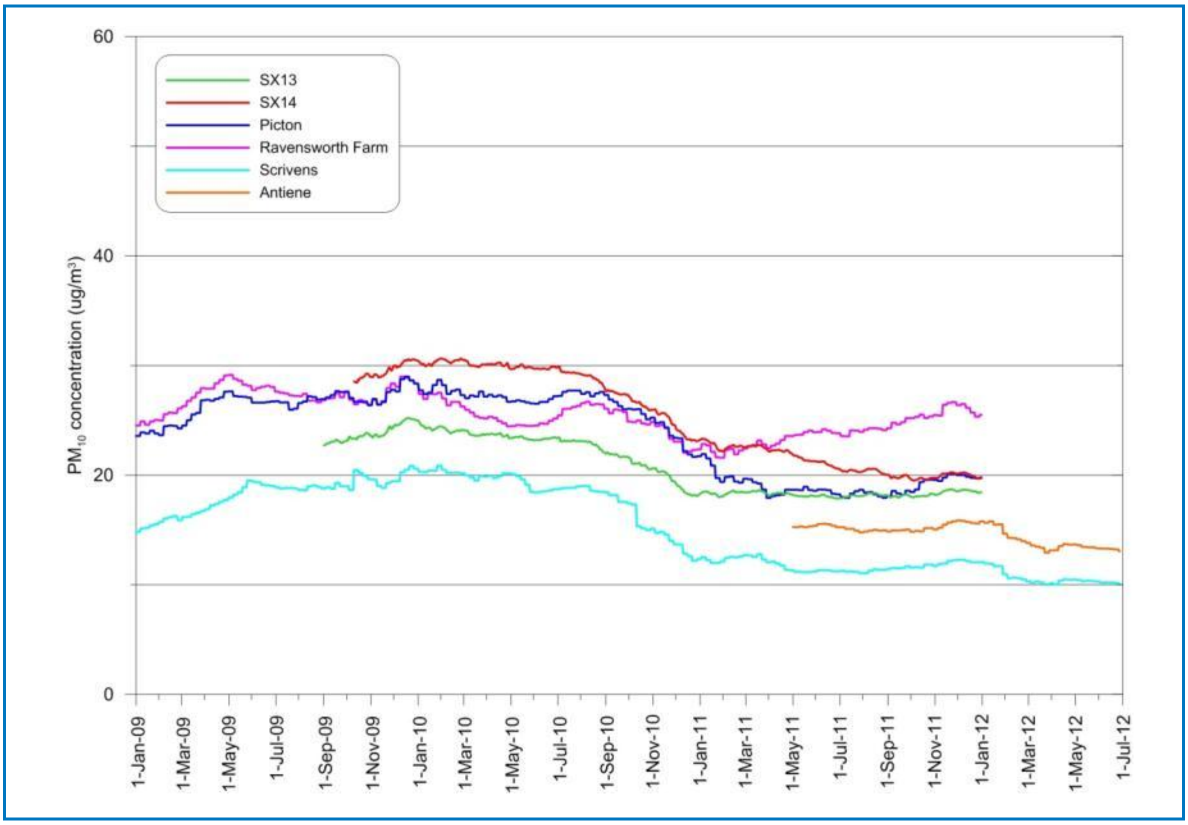


Figure 4.2: Annual average PM_{10} monitoring data for 2008 – 2011

A summary of the annual average TSP monitoring results for each of the five TSP HVAS monitors are presented in **Table 4.2**. The annual average TSP concentrations have remained below the EPA criterion of 90 µg/m³ for all years, except at TSP/3 in 2009. Values at all sites are higher in 2009. This is likely to be due to a series of bushfires and dust storms in that year, which came at the end of one of the most severe and prolonged droughts in NSW's history.

Table 4.2: Annual average TSP concentrations at HVAS sites - µg/m³

	Picton (TSP/1)	Ravensworth Farm (TSP/3ᵃ)	Scrivens (TSP/12)	Antiene (TSP/21)
Criterion	***90***	***90***	***90***	***90***
2002	79	-	-	-
2003	70	-	-	-
2004	47	-	-	-
2005	50	-	-	-
2006	50	74	38	-
2007	64	79	46	-
2008	63	73	41	-
2009	80	**91**	51	-
2010	62	83	32	39
2011	62	86	33	45

*NOTE: Exceedances of the Air Quality criterion shown in **bold**.*

*[a] Data for 27 Sept 2009, 20 Nov 2009, 8 Dec 2009 and 13 Jan 2010 have been omitted due to widespread elevated dust conditions and/or bushfire activity (**Environment NSW, 2012, BOM 2012b, Emergency NSW, 2012**).*

4.1.3 Dust Deposition

Table 4.3 presents the annual average dust deposition levels as measured at each gauge. Annual average dust deposition levels at all sites except D53, D57 and D61 are below the EPA assessment criterion of 4 g/m²/month. It should be noted however, that these sites are on mine owned land close to operations and are likely to experience levels more elevated than at other locations. Despite some exceedances, the average overall for all sites were below 4 g/m²/month.

Table 4.3: Annual average dust deposition levels for each monitoring site (g/m²/month)

Year	D53	D54	D55	D56	D57	D58	D59	D60	D61	D62
1999	2.5	1.4	1.4	1.3	1.9	1.3	1.2	1.3	1.3	-
2000	2.1	1.6	2.1	1.2	1.9	1.2	1.3	1.3	1.5	-
2001	2.8	2.1	1.5	-	2.2	1.7	1.8	1.2	2.8	-
2002	-	-	-	-	-	-	-	-	-	-
2003	2.5	2.3	1.5	1.6	2.4	1.4	1.0	1.5	1.9	1.7
2004	2.2	2.3	2.4	1.5	3.3	1.7	1.3	1.6	1.7	1.3
2005	2.1	2.7	1.5	1.2	3.4	1.5	1.8	1.4	2.2	1.9
2006	1.5	2.9	1.8	1.2	2.1	1.7	2.0	1.6	1.3	1.3
2007	-	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-	-
2009	**4.1**	3.8	1.7	2.7	**6.7**	2.0	1.7	2.4	**6.0**	2.6
2010	3.5	3.2	1.9	1.4	**5.2**	1.8	1.1	2.5	**4.3**	2.2
2011	3.2	2.4	1.5	1.1	**5.4**	1.5	1.9	2.5	**4.6**	2.2
Average	**2.7**	**2.5**	**1.7**	**1.5**	**3.5**	**1.6**	**1.5**	**1.7**	**2.8**	**1.9**

4.2 Meteorology

4.2.1 Wind Speed and Direction

Data from a meteorological station operated by LCO have been used to assess meteorological conditions at the mine (the location of the station is shown on **Figure 2.1**). The station measures 10-minute averages of wind speed, wind direction, temperature and sigma-theta. Data from 2010 were selected as the most appropriate for use in dispersion modelling.

Annual and seasonal windroses for the LCO meteorological station for the period January to December 2010 are shown in **Figure 4.3**.

On an annual basis, winds from the Project Site are predominantly from the east-southeast and west-northwest which is reflected to varying degrees in all seasons. The winter windroses show a higher percentage of winds from the west-northwest and summer shows a high percentage from the east-southeast. The annual percentage of calms (winds less than 0.5 m/s) is 14.8%. The annual average wind speed for 2010 is 3.1 m/s.

Meteorological data are also collected at the Mt Owen Complex with two meteorological stations both located within 4 km of the Project site (see **Figure 2.1**). Data from these sites have been made available for use in dispersion modelling for the Project.

Figure 4.4 presents annual and seasonal windroses for the meteorological stations located at Mt Owen Complex (named SX8 and SX13) for 2010. On an annual basis, winds from the SX8 site are predominantly from the east and west which is reflected to varying degrees in all seasons. Summer and autumn windroses show dominant easterly patterns while the winter windrose shows dominant westerly winds. The spring windrose is the most similar to the annual windrose with winds more equally spread across the eastern and western quadrants. The annual percentage of calms (winds less than 0.5 m/s) is 8.3%. The annual average wind speed for SX8 in 2010 is 2.5 m/s.

On an annual basis, winds from the SX13 site are predominantly from the northwest and southeast quadrants. The winter windrose shows dominant north-northwesterly winds. The spring and autumn windroses are the most similar in pattern to the annual windrose. In summer, winds from the southeast quadrant dominate. The annual percentage of calms (winds less than 0.5 m/s) is 3.3%. The annual average wind speed for SX8 in 2010 is 2.9 m/s.

The differences in wind patterns between the LCO and the Mt Owen sites may be explained by varying topography surrounding the stations. For example, the Mt Owen SX13 site is located within a shallow valley which is represented in the north/southerly wind patterns as shown in **Figure 4.4**. The LCO and Mt Owen SX8 sites are located to the east of elevated terrain features which are represented by the dominant winds from the west shown in each set of windroses.

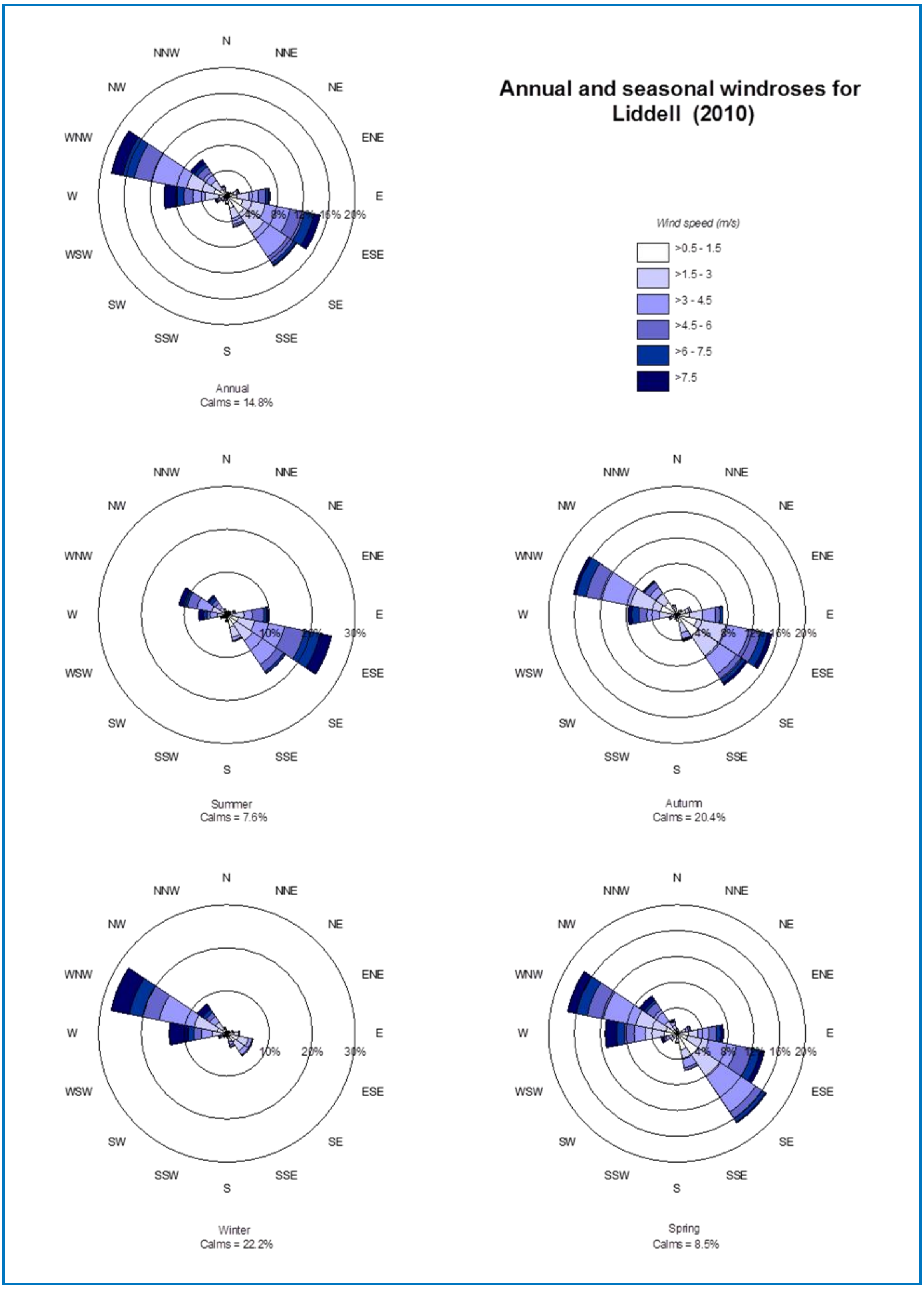


Figure 4.3: Annual and seasonal windroses for the LCO meteorological station (January to December 2010)

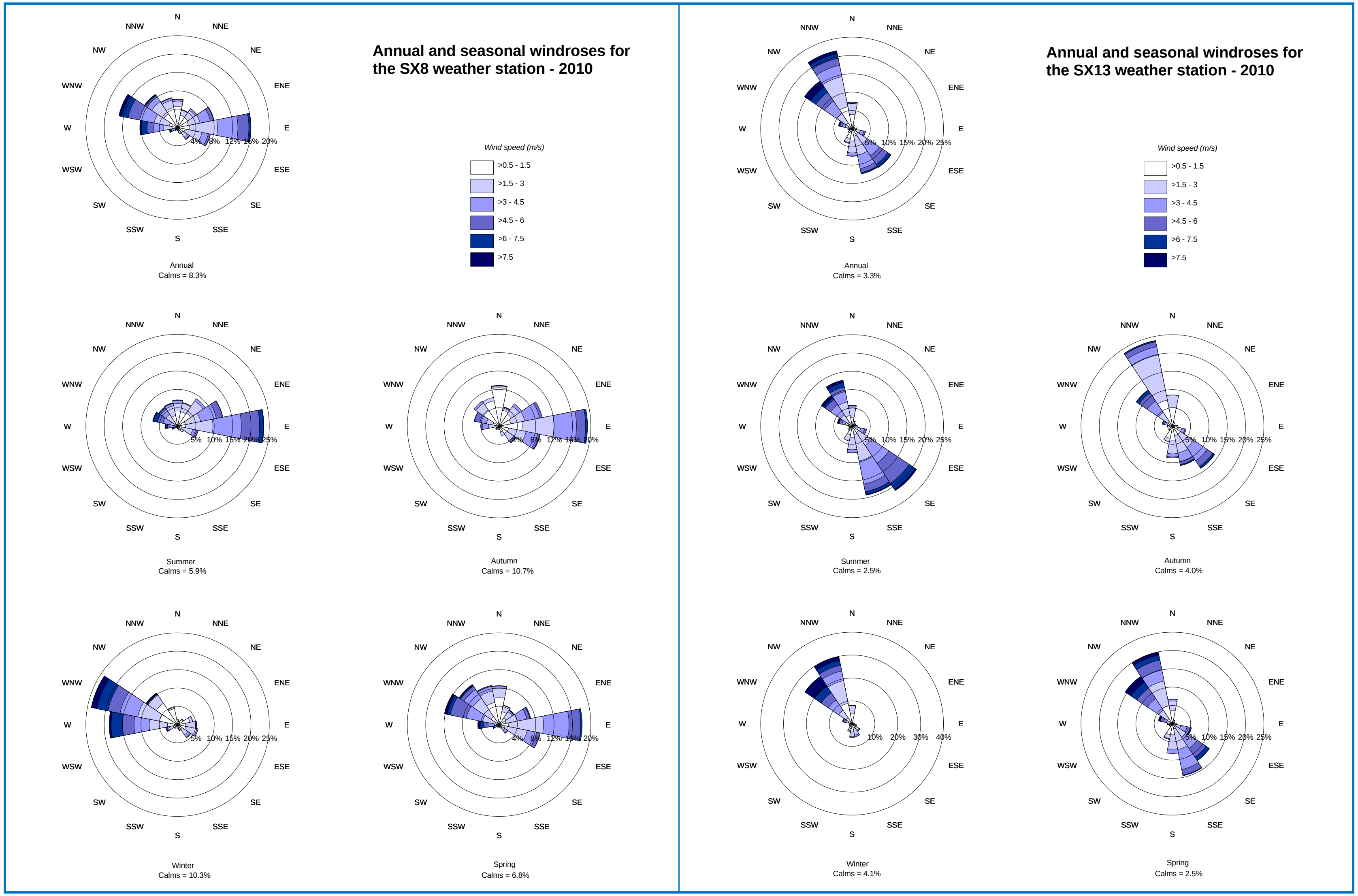


Figure 4.4: Annual and seasonal windroses for Mt Owen meteorological stations SX8 and SX13 (January to December 2010)

4.2.2 Local Climatic Conditions

The BoM collects climatic information in the vicinity of the study area. A range of climatic information collected from Jerry's Plains (Post Office, located approximately 14 km from the Project), are presented in **Table 4.4** (**BoM, 2012**). Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures experienced at Jerrys Plains are 25.2°C and 10.6°C, respectively. On average January is the hottest month, with an average maximum temperature of 31.7°C. July is the coldest month, with average minimum temperature of 3.8°C.

The annual average relative humidity reading collected at 9 am from the Jerry's Plains site is 70% and at 3 pm the annual average is 47%. The month with the highest relative humidity on average is June with a 9 am average of 80%. The months with the lowest relative humidity are October, November and December with a 3 pm average of 42%.

Rainfall data collected at Jerry's Plains shows that January is the wettest month, with an average rainfall of 76.7 mm over 7.9 rain days. The average annual rainfall is 645 mm with an average of 87.2 rain days.

Table 4.4: Climate Information for Jerry's Plains Post Office

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Maximum Temperature (°C)													
Max temperature (°C)	31.7	30.9	28.9	25.3	21.3	18	17.4	19.4	22.9	26.2	29.1	31.3	25.2
Mean Minimum Temperature (°C)													
Min temperature (°C)	17.1	17.1	15	11	7.5	5.3	3.8	4.4	7	10.3	13.2	15.7	10.6
Mean Rainfall Events													
Mean rainfall (mm)	76.7	72.8	58.4	44.5	40.9	48.1	43.5	36.5	42	52.2	61.1	67.9	645
Mean number of days of rain	7.9	7.5	7.4	6.4	6.6	7.7	7.1	7	6.6	7.6	7.7	7.7	87.2
9 am Mean Dry-bulb and Wet-bulb Temperatures (°C)[1] and Relative Humidity (%)													
Temperature (°C)	23.4	22.7	21.2	18	13.6	10.6	9.4	11.4	15.3	19	21.1	23	17.4
9am wet bulb temperature (°C)	19.3	19.3	17.9	15	11.6	9	7.7	9	11.9	14.5	16.3	18.1	14.1
9am relative humidity (%)	67	72	72	72	77	80	78	71	65	59	60	61	70
3 pm Mean Dry-bulb and Wet-bulb Temperatures (°C)[1] and Relative Humidity (%)													
3pm temperature (°C)	29.8	28.9	27.2	24.1	20.1	17.1	16.4	18.2	21.2	24.2	26.9	29	23.6
3pm wet bulb temperature (°C)	21.1	21.1	19.6	17.1	14.6	12.2	11.2	12.1	14.1	16.2	18	19.7	16.4
3pm relative humidity (%)	47	50	49	49	52	54	51	45	43	42	42	42	47

Source: BOM (2012)
Climate averages for Station: 061086; Commenced: 1884, Last record: 2012; Latitude: 32.50 °S; Longitude: 150.91 °E, elevation 90m.

5 MODELLING APPROACH

The assessment follows a conventional approach commonly used for air quality assessment in Australia and outlined in the Approved Methods (**EPA, 2005**).

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 three-dimensional 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 completed with consideration of these guidelines.

5.2 Model Set-up

CALMET was initially run for a coarse outer grid domain of 120 km x 120 km with a 2.5 km resolution.

Observed hourly surface data were incorporated into the modelling from meteorological stations including:

- LCO on-site weather station
- SX8 (Xstrata Mt Owen)
- SX13 (Xstrata Mt Owen)
- BoM Williamtown RAAF
- BoM Patterson (Tocal Automatic Weather Station (AWS))
- BoM Cessnock Airport AWS
- BoM Scone Airport AWS

Meteorological parameters such as wind speed, wind direction, temperature and relative humidity were sourced from all of the above stations. Cloud amount and cloud height data were sourced from the BoM Williamtown AWS station. Upper air information was incorporated through the use of prognostic 3-dimensional (3D) data extracted from TAPM[d].

The CALMET generated meteorological parameters from the outer grid were then used as input into a finer resolution inner grid domain of 30 km x 20 km with a 200 m resolution, centred on the Project site. Observed surface data from the LCO and SX8, SX13 sites were again incorporated into the inner modelling domain with any gaps in the data supplemented by TAPM. Detailed mine plan terrain data was incorporated into the modelling as the terrain of the site will vary over time, and a separate CALMET wind field generated for each mine plan scenario.

Table 5.1 summarises the inputs used for both the TAPM and CALMET models.

[d] The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. A detailed description of the TAPM model and its performance is provided elsewhere, (**Hurley, 2005**, **Hurley *et al*., 2005**).

Table 5.1: Meteorological Parameters used for TAPM and CALMET

TAPM (v 4.0.4)	
Number of grids (spacing)	3 (30 km, 10 km, 3 km)
Number of grid points	45 x 45 x 35
Year of analysis	January to December 2010
Centre of analysis	Liddell Coal Operations
	(32°21.5' S, 151°18' E)
CALMET (v. 6.327)	
Meteorological inner grid domain	30 km x 20 km
Meteorological inner grid resolution	0.20 km (fine resolution)
Surface meteorological stations	Liddell (LCO) Meteorological Station - Wind speed - Wind direction - Temperature - Relative humidity - Sea Level Pressure (SLP) SX8 (Mt Owen Mine) Meteorological Station - Wind speed - Wind direction - Temperature SX13 (Mt Owen Mine) Meteorological Station - Wind speed - Wind direction - Temperature - Relative Humidity BoM Williamtown RAAF AWS - Wind speed - Wind direction - Temperature - Relative humidity - Cloud Amount - Cloud Height - Sea Level Pressure BoM Patterson (Tocal) AWS - Wind speed - Wind direction - Temperature - Relative humidity BoM Cessnock Airport AWS - Wind speed - Wind direction - Temperature - Relative humidity - Sea Level Pressure BoM Scone Airport AWS - Wind speed - Wind direction - Temperature - Relative humidity - Sea Level Pressure
Upper air	Prognostic 3D.dat extracted from TAPM at the 3 km grid

5.3 Dispersion Meteorology

The CALMET generated winds are compared with the measured data from the LCO meteorological station and are presented as windroses in **Figure 5.1**.

The CALMET windroses are extracted for a single point at the approximate location of the LCO meteorological station.

The CALMET windroses for display very similar characteristics to the measured data from the LCO site with dominant winds from the west-northwest and east-southeast. The average wind speed from both the on-site data and CALMET is 3.1 m/s. The percentage occurrence of calm conditions (defined as wind speeds <0.5 m/s) are similar with 14.8% recorded at the LCO station compared with 13% from CALMET.

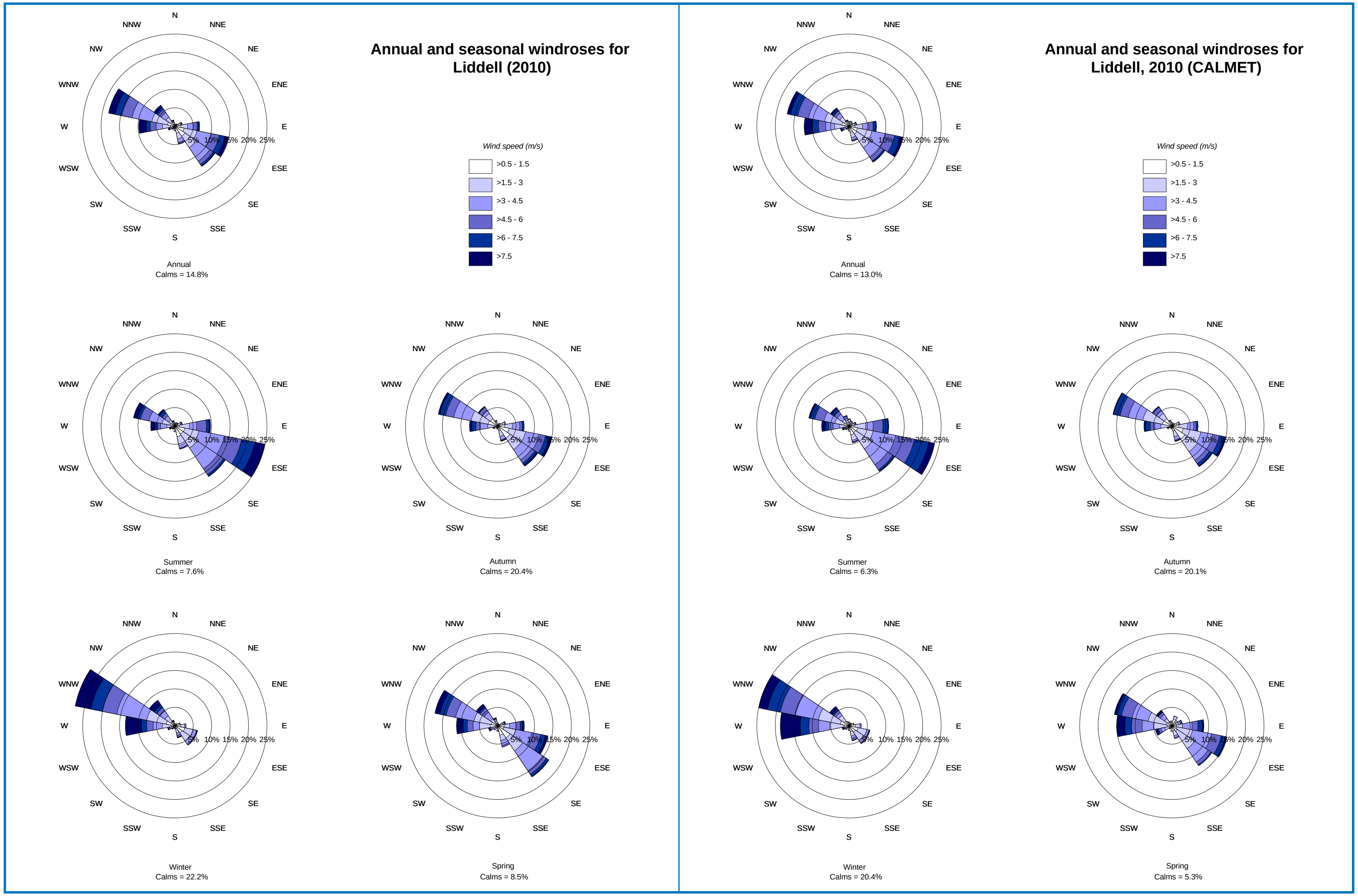


Figure 5.1: Annual and seasonal windroses for the LCO meteorological station and CALMET

6 EMISSIONS TO AIR

The operation of the Project has been analysed and estimates of dust emissions for the key dust generating activities have been made. Emission factors developed both locally, and by the US EPA (**US EPA, 2005**) have been applied to estimate the amount of dust produced by each activity. The emission factors applied are considered to be the most reliable, contemporary methods for determining dust generation rates.

The mining plans for the Project have been analysed and detailed emissions inventories have been prepared for three key operating scenarios, being Project Years Year 2, Year 4 and Year 5. These modelled years are considered to be representative of worst-case operations, for example where coal and waste production are highest, where extraction or wind erosion areas are largest or where operations are located closest to receivers.

6.1 Dust Control on Haul Roads

Preliminary emissions estimations indicated that of the potential dust sources on-site, emissions from the hauling of overburden and ROM coal contributes more than any other source group to short-term PM_{10} impacts at the closest residential receivers. Typically, modelling assessments for mine sites apply a haul road control level of 75% (representing control via > Level 2 watering). In accordance with the modelling scenarios presented in this report, an additional level of control on hauling (85% control) has been applied to emissions estimations.

This 85% control level is supported by **Sinclair Knight Merz (2005)** who derived an equation that shows control benefits for increased watering up to 95%. This finding is confirmed by **Buonicore and Davis (1992)** who state that a level of control of 90% is expected to be achieved by increasing the application rate of water and/or through the use of dust suppressants. The study states that 90% control can only be maintained provided the moisture content of the surface material is approximately 8% (refer to **Figure 6.1**).

The above observations are further reinforced within **US EPA, 2006**. **Figure 6.2** (after **US EPA, 2006**) presents the relationship between the instantaneous control efficiency due to watering and the resulting increase in surface moisture. The moisture ratio M (shown on the x-axis) is calculated by dividing the surface moisture content of the watered road by the surface moisture content of the uncontrolled road.

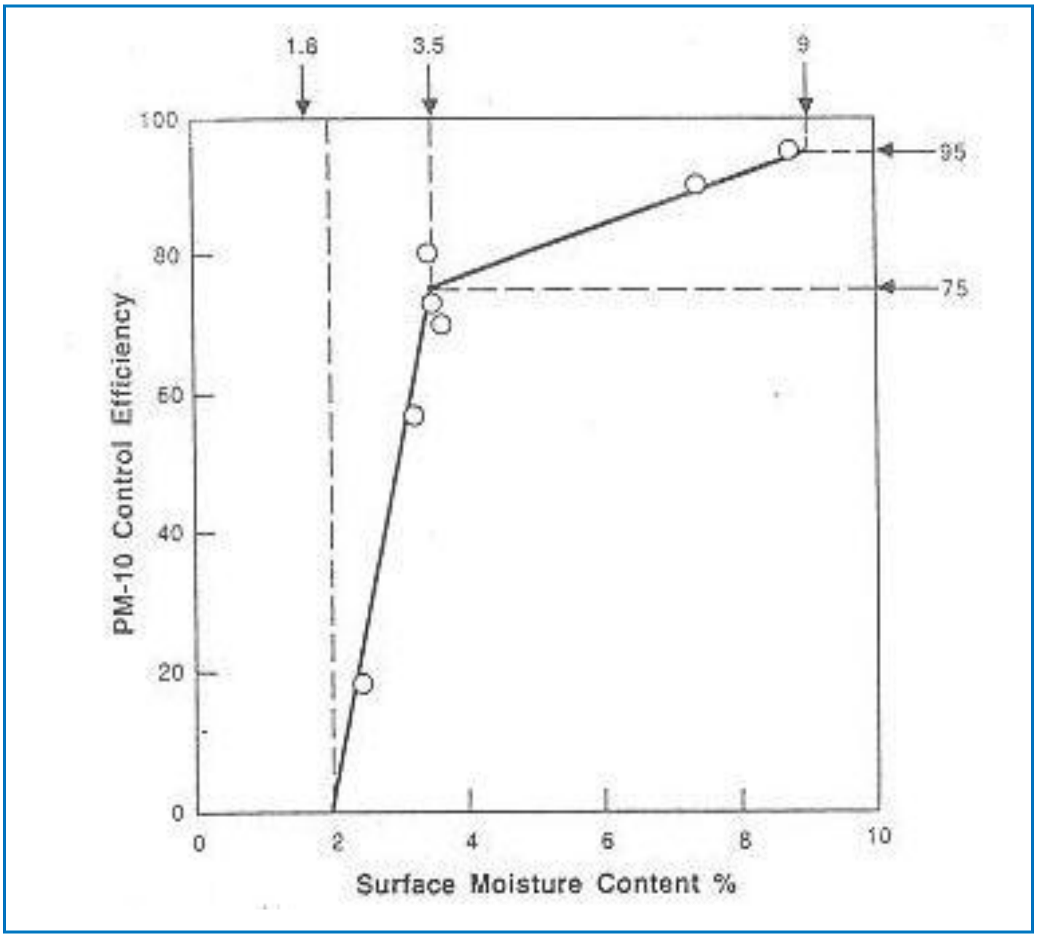


Figure 6.1: Watering Control Effectiveness for Unpaved Roads (Buonicore and Davis, 1992)

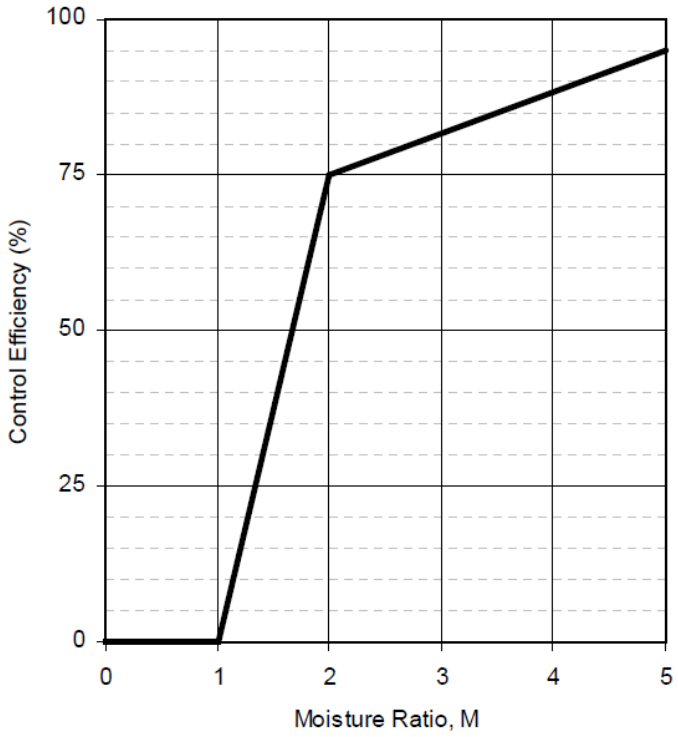


Figure 6.2: Watering Control Effectiveness for Unpaved Travel Surfaces (US EPA, 2006)

US EPA, 2006 states that as the watered surface dries, both the ratio M, and the predicted instantaneous control efficiency (shown on the y-axis), decrease. The figure shows that between the uncontrolled surface moisture content and a value twice as large, a small increase in moisture content results in a large increase in control efficiency. Beyond that, control efficiency grows slowly with increased moisture content. For example, if the uncontrolled surface moisture content was 2%, and the addition of water increased this to 4%, a 75% reduction in emissions could be expected. However, increasing the surface moisture content further to 6% would only result in an additional 5% control.

Notwithstanding the above, it is clear from **Figure 6.2**, that while returns diminish beyond 75% control, theoretical control efficiencies from the application of water alone may reach up to 95%. In the absence of any site specific testing at the Project site, a conservative assumption of 85% has been made, rather than assuming the full 95%.

6.2 Site Specific Measurements

As part of the Dust Stop Pollution Reduction Program (PRP) included in LCO's EPL in 2011, a monitoring program was undertaken to site specific measurements of silt and moisture contents of various dust generating materials. These values are listed in the subsequent PRP report (**Xstrata, 2012a**). These moisture values have been used, but there was uncertainty about the method used to obtain silt content measurements so measurements from similar nearby operations were used. In the case of unsealed haul roads a value of 3% was used. A recent review of silt content measurements on unsealed haul roads on open cut coal mines, has shown an average of approximately 3% (**PAEHolmes, 2012**). This value was used as it was more conservative than the 2% measured at the nearby Mt Owen operations.

6.3 Emission Estimates for the Project

Estimates of emissions for each source were developed on an hourly time step taking into account the activities that would take place at that location. Thus, for each source, for each hour, an emission rate was determined which depended upon the level of activity and the wind speed. Dust generating activities were represented by a series of volume sources situated according to the location of activities for the modelled scenarios.

To model the effect of pit retention for emissions within the open cut pits and the effects of other mine landforms, detailed mine terrain has been incorporated into the modelling for each modelled mine year.

For each stage of the mine shown in **Figure 6.3** to **Figure 6.5**, a corresponding emissions inventory has been developed. The information used for developing the inventories has been based on the operational descriptions and mine plan drawings and used to determine haul road distances and routes, stockpile and pit areas, activity operating hours, truck sizes and other details that are necessary to estimate dust emissions.

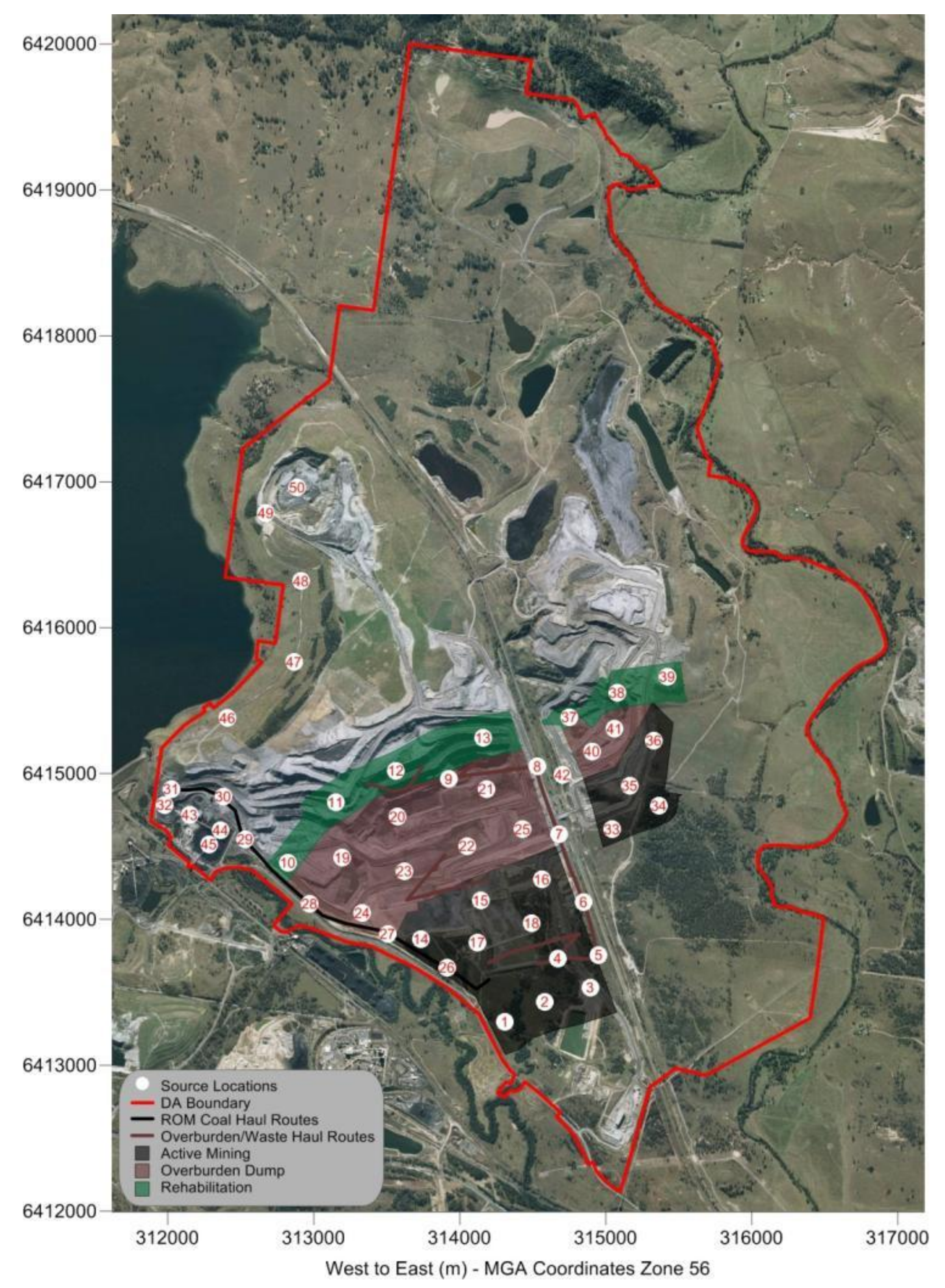


Figure 6.3: Year 2 (approximately 2015) Modelling Source Locations

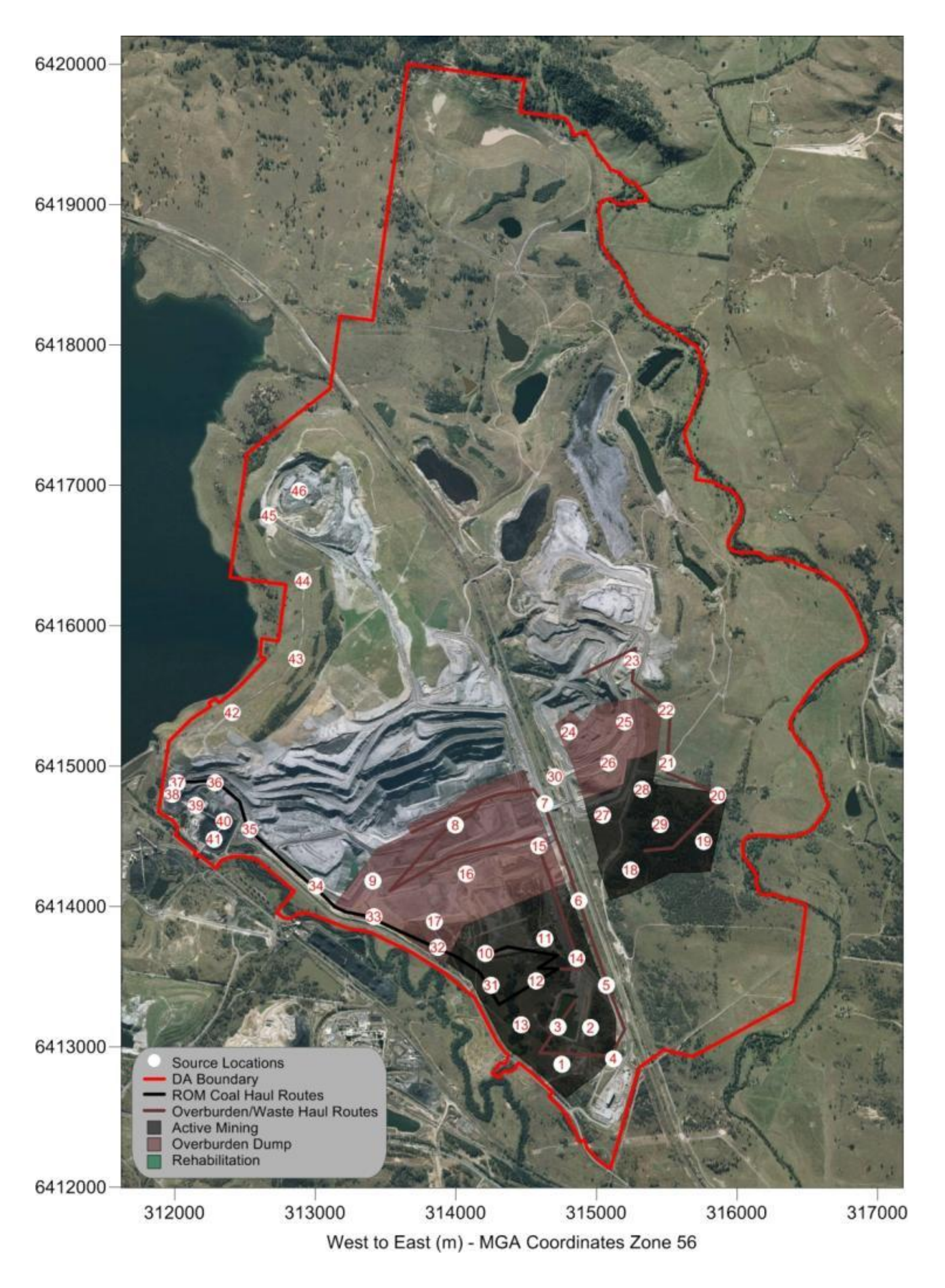


Figure 6.4: Year 4 (approximately 2017) Modelling Source Locations

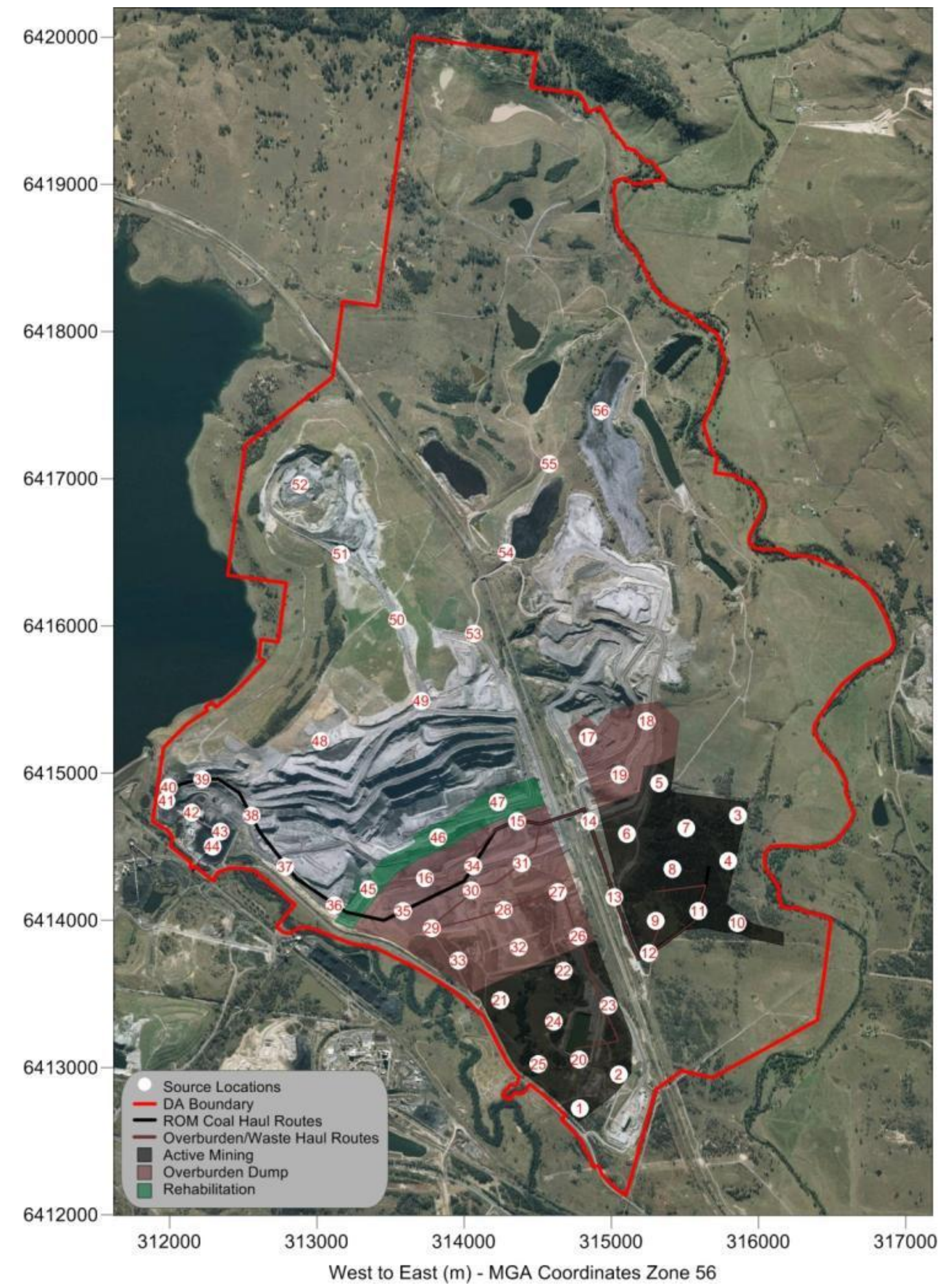


Figure 6.5: Year 5 (approximately 2018) Modelling Source Locations

Table 6.1 summarises the quantities of PM_{10} estimated to be released by each activity of the Project. Further details of emission rates are provided in **Appendix A**.

Table 6.1: Estimated annual PM_{10} emissions for the Project (kg/y)

ACTIVITY	Year 2	Year 4	Year 5
Dozers on topsoil	3,539	3,539	3,539
Loading topsoil	38	38	38
Hauling topsoil (to rehab), watering used on haul road	117	117	117
Unloading topsoil	38	38	38
Drilling overburden in Entrance Pit	166	166	2,386
Blasting overburden in Entrance Pit	1,051	1,051	15,132
Dozers on overburden in Entrance Pit	2,437	3,656	49,962
FEL loading overburden to haul truck in Entrance Pit	2,015	3,043	42,149
Hauling overburden to waste dump Entrance Pit	6,029	12,251	128,392
Unloading overburden at waste dump Entrance Pit	2,015	3,043	42,149
Dozers on waste dumps Entrance Pit	1,219	1,828	24,981
Drilling overburden in South Pit	5,633	5,633	3,413
Blasting overburden in South Pit	35,728	35,728	21,647
Dozers on overburden in South Pit	119,422	118,203	71,897
FEL loading overburden to haul truck in South Pit	98,751	98,405	60,654
Hauling overburden to waste dump South pit	295,437	396,101	184,759
Unloading overburden at waste dump South Pit	98,751	98,405	60,654
Dozers on waste dumps South Pit	59,711	59,101	35,948
Drilling ROM coal in Entrance Pit	-	-	-
Blasting ROM coal in Entrance Pit	-	-	-
Dozers ripping coal in Entrance Pit	1,386	-	14,324
Loading ROM to trucks in Entrance Pit	1,439	-	14,998
Hauling ROM to CHPP from Entrance Pit	874	-	17,891
Drilling ROM coal in South Pit	-	-	-
Blasting ROM coal in South Pit	-	-	-
Dozers ripping coal in South Pit	44,821	46,208	31,883
Loading ROM to trucks in South Pit	46,539	47,947	33,382
Hauling ROM to CHPP from South Pit	125	135	94
Dozers on rehab	10,617	10,617	10,617
Dozers pushing coal at ROM pad	23,104	23,104	23,104
FELs Loading ROM to ROM pad or hopper	23,989	23,973	24,190
Crushing ROM coal at the CHPP	4,185	4,182	4,220
Loading product to stockpiles	206	206	208
Hauling rejects to Durham Pit	4,553	4,550	6,978
Hauling rejects to South Pit dump (Year 2/4) or Antienne North (Year 5)	5,099	5,096	5,142
Wind erosion on active waste dump area - Entrance	7,096	14,410	14,410
Wind erosion on active waste dump area - South	55,538	50,370	52,210
Wind erosion on exposed pit area - Entrance	15,330	27,712	38,018
Wind erosion on exposed pit area - South	51,903	46,770	33,945
Wind erosion on active rehab area	30,660	21,900	10,950
Wind erosion and maintenance on product stockpiles	59,130	59,130	59,130
Graders	3,871	3,871	3,871
TOTAL	**1,122,564**	**1,230,525**	**1,147,421**

6.4 Emissions from Neighbouring Mines

For those modelling scenarios which include contributions from other nearby mining operations, estimated emissions have been taken from publicly available documents for those mines in each of the corresponding modelling years.

It should be noted that only those mines which are currently approved to be operating in each of the modelled years have been included in this assessment. This includes the following mines;

- Mount Arthur Coal Mine (**PAEHolmes, 2009a**)
- Drayton Coal Mine (**PAEHolmes, 2007a**)
- Drayton South Proposed Coal Mine (**PAEHolmes, 2007b** and **Hansen Bailey, 2011**)
- Ashton Coal surface facilities for underground operations (**PAEHolmes, 2009b**)
- Hunter Valley Operations (HVO) North Mine (West Pit) (**PAEHolmes, 2010**)
- Glendell Mine (**PAEHolmes, 2007b**)
- Mount Owen Mine (**PAEHolmes, 2003**)
- Ravensworth East Mine (**PAEHolmes, 2009b**)

Other mines which exist in the greater surrounds of the Project include Bengalla, HVO South, Integra and Rixs Creek. Ashton South East Open Cut was also recently been approved but is the subject of further court proceedings. These mines are located further than 10-15 km from the Project site, and as such are expected to have little cumulative effects when considered with the Project.

Each mine as listed above has been treated as a number of volume sources. These have been located at the apparent points of major emission, as estimated from the locations of pits, dumps and other major dust sources shown in each of the corresponding AQIAs.

Sources have been considered in three classes covering all dust emission sources for which there are emission factor equations for open cut mines. These classes are:

- Wind erosion sources where emissions vary with the hourly average wind speed according to the cube of the wind speed;
- Loading and dumping operations where emissions vary with the wind speed raised to the power of 1.3; and
- All other sources where emissions are assumed to be independent of wind speed.

For neighbouring mines, the proportion of emissions in each of these categories has been assumed to be:

- 0.732 for emissions independent of wind speed;
- 0.135 for emissions that depend on wind speed (such as loading and dumping); and
- 0.133 for wind erosion sources.

These factors are based on a detailed analysis of mine dust inventories undertaken as part of the Mt Arthur North EA (**URS, 2000**).

Table 6.2 presents the TSP emission estimates for other mines included in the cumulative assessment. Where data were unavailable for the exact LCO model year, the closest year of estimated emissions from the corresponding AQIA was selected. Unlike those estimates made for the Project, information on individual activities was not available for each of the neighbouring mines. It was therefore not possible to make specific estimates of PM_{10} emissions, as it was for LCO. The ratio of TSP:PM_{10} at each co-located HVAS monitor was therefore calculated for data over all years of monitoring and the average of these values taken to represent the average ratio of TSP:PM_{10} across the modelling domain. This ratio was then applied to the TSP modelling results from nearby mines to determine the PM_{10} concentrations.

Table 6.2: Estimated TSP emissions from nearby mining operations (kg/year)

Mine	Year 2	Year 4	Year 5
Mount Arthur	25,933,139	25,933,139	25,933,139
Drayton	3,225,173	3,225,173	-
Drayton South	-	6,640,000	6,640,000
Ashton Underground (surface facilities)	72,075	72,075	72,075
HVO North (West Pit)	9,081,154	9,081,154	9,081,154
Glendell	3,713,715	3,570,338	3,060,737
Mount Owen	4,410,474	4,931,814	4,931,814
Ravensworth East	4,967,410	4,967,410	4,967,410

6.5 Estimated Emissions from Distant Mines and Other Sources

In addition to the mines identified in **Section 6.3**, distant mines and other sources will contribute to PM_{10} and TSP concentrations and to dust deposition in the area surrounding the Project Site. Estimating the background allowance for distant mines and other sources (collectively referred to as non-modelled) is difficult and depends on local land use and the associated emission sources, as well as climate, soil type etc.

In previous assessments, the approach taken has been to compare the predicted impacts due to the Project and other mines at nearby monitoring locations. From this an estimate of the contribution by non-modelled sources was made and a single figure estimate of annual average background PM_{10} and TSP concentrations was added to all the predicted impacts.

However, it is recognised that there is in reality, spatial variation in the contribution that non-modelled sources make to the ambient concentrations of annual average PM_{10} and TSP where open cut mining and other emission sources (e.g. residential roads, power stations) are located compared with areas where open cut mining is not active.

For this assessment, a grid of annual average PM_{10} and TSP concentrations due to non-modelled sources has been created to make allowance for the spatial variability that occurs in the PM_{10} and TSP concentrations due to sources that are not explicitly included in the modelling.

The approach taken was to model the actual operations that took place at LCO, as well as other nearby mines in 2010 (see **Appendix B** for a summary of these emissions) in combination with the meteorological data for the same year. Annual average PM_{10} and TSP predictions were made at the HVAS and TEOM monitoring sites, as discussed in detail in **Section 4.1**.

- PM_{10}/1-TSP/1 – Picton (Mt Owen)
- PM_{10}/4-TSP/3 – Ravensworth Farm
- PM_{10}/12-TSP12 – Scrivens (HVAS 12)
- PM_{10}/21-TSP21 – Antienne (HVAS 21)
- SX13 (TEOM)
- SX14 (TEOM)

The difference between the predicted and measured annual average concentrations was taken to be the contribution of any distant mines and other sources which were not included explicitly in the model. This difference is then taken to represent the background level to add to the predicted impacts due to the operations for the Project and nearby mines.

Table 6.3 and **Table 6.4** present the measured, predicted and background annual average PM_{10} and TSP concentrations, respectively.

Table 6.3: Predicted and measured PM_{10} concentrations for 2010

Monitor ID	Measured concns (µg/m³)	Predicted concns (µg/m³)	Background concns (µg/m³) (measured – predicted)
PM_{10}/1	22	6	16
PM_{10}/4	22	37	-15[a]
PM_{10}/12	12	7	5
PM_{10}/21	11	9	2
SX13	18	27	-9[a]
SX14	30	18	12

[a] These values are negative due to the model over-predicting close to mining operations and indicate that there is likely to be very little contribution from other sources at those locations. They have been assigned a nominal value of 1 for assessment purposes.

Table 6.4: Predicted and measured TSP concentrations for 2010

Monitor ID	Measured concns (µg/m³)	Predicted concns (µg/m³)	Background concns (µg/m³) (i.e. measured – predicted)
TSP/1	62	19	43
TSP/3	84	65	19
TSP/12	32	10	22
TSP/21	39	15	24

The monitoring locations are sparsely located so in order to create a grid of spatially varying concentrations to add to the predicted impacts due to combined operations at the Project and other nearby mines, it was assumed that the annual average PM_{10} concentrations are 15 µg/m³ in the northeast and southwest corners where there will be little contribution from distant mines. Values of 2 µg/m³ have been assumed very close to neighbouring mines that have been included in the modelling, and about 10 µg/m³ in areas away from neighbouring mines. Corresponding values for TSP at those locations have been assumed as 15 µg/m³, 17 µg/m³ and 25 µg/m³.

Figure 6.6 and **Figure 6.7** show the grids created for PM_{10} and TSP. These demonstrate that closer to the mine the majority of the measured PM_{10} and TSP concentrations are due to the operations at those mines, with small contributions from other more distant mines and non-mining sources. Further away from these operations, this contribution to the total measured concentrations increases and the contribution from the mine decreases, as would be expected.

The approach taken for deposited dust has not been revised. The annual average quantity of deposited dust contributed by these other sources has been set conservatively at 1 g/m²/month.

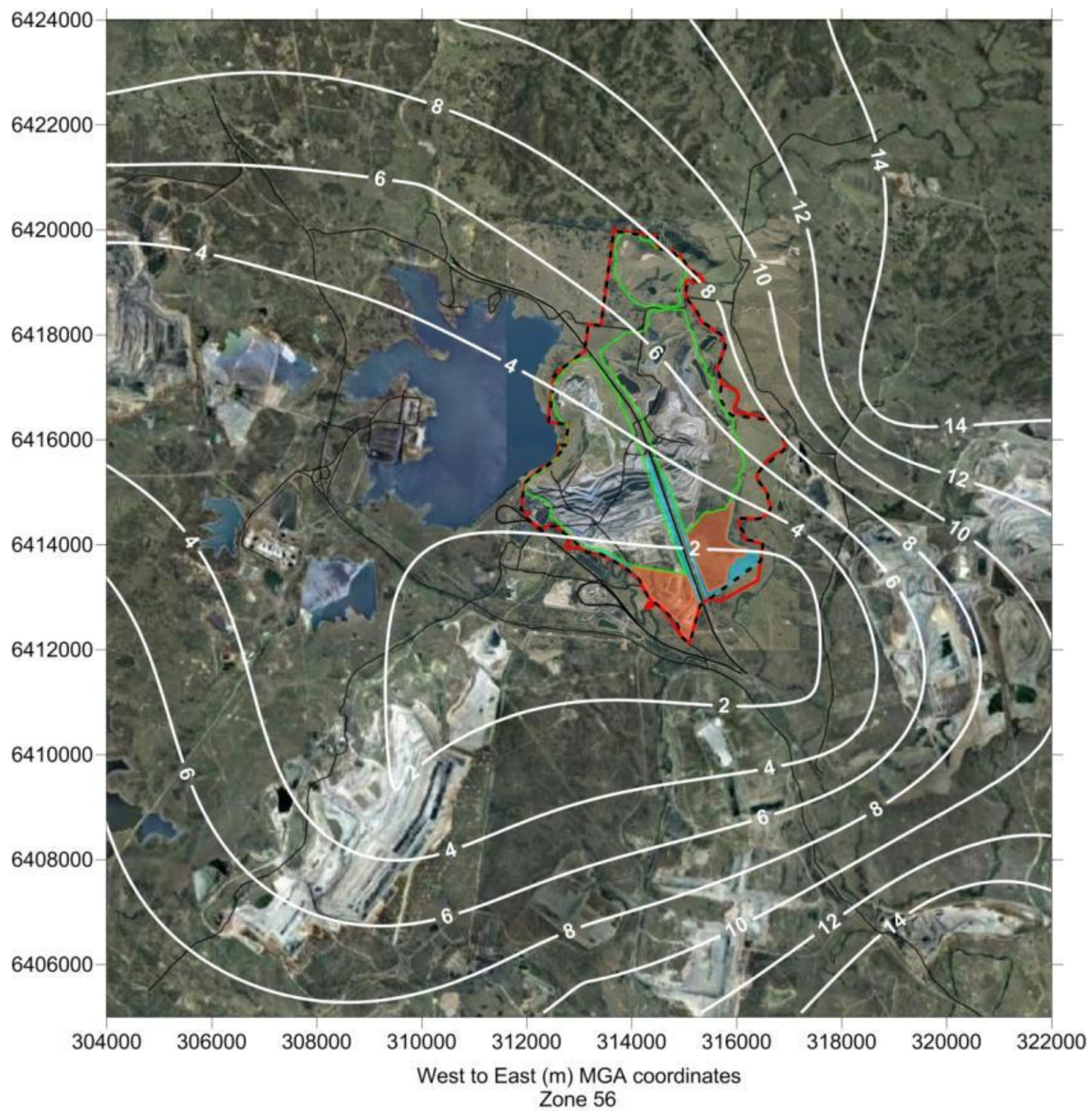


Figure 6.6: Estimated annual average PM_{10} concentrations due to non-modelled sources

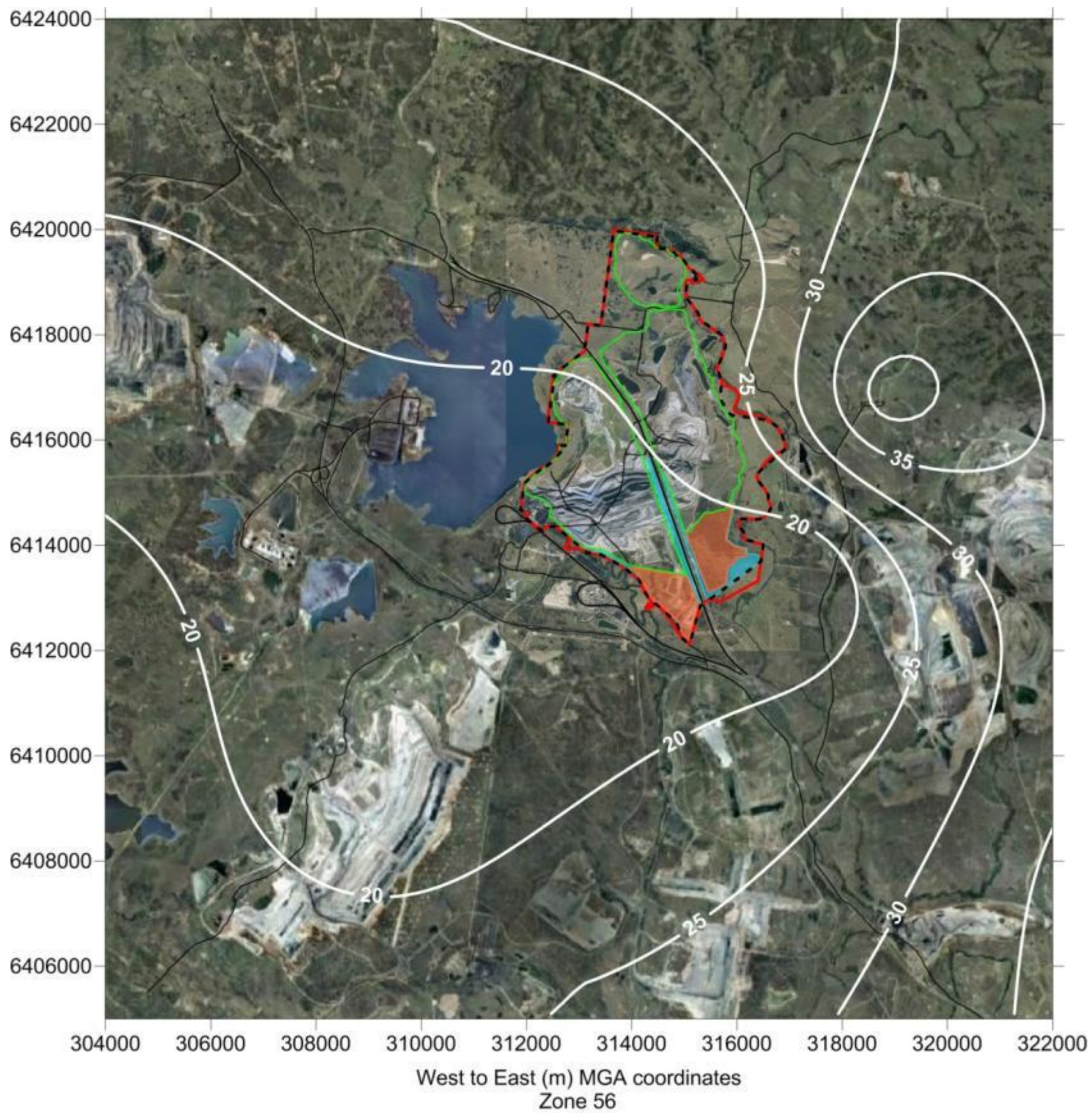


Figure 6.7: Estimated annual average TSP concentrations due to non-modelled sources

7 ASSESSMENT OF IMPACTS

7.1 Introduction

The air quality criteria used for identifying which properties are likely to experience air quality impacts are those specified in EPA's guidance document titled *"Approved Methods for the Modelling and Assessment of Air Pollutants in NSW"* (**Section 3**). These have been applied in the assessment process following the practices used in contemporary approvals for mining projects in NSW. It should be noted that these criteria apply to the cumulative impacts resulting from emissions from the Project together with surrounding approved mines and non-modelled sources. Cumulative results are discussed in **Sections 7.3** and **7.4**.

Results for Year 2, Year 4 and Year 5 are presented and discussed in **Sections 7.2**, and relate to the Project alone. The annual average cumulative results (**Section 7.3**) include both neighbouring and distant mines, using the spatially-varying background grid as described in **Section 6.5**. This approach also accounts for non-modelled sources using monitoring information and results can therefore be compared directly to air quality criteria.

Results for the 24-hour average cumulative impact assessment are assessed differently and are discussed in **Section 7.4**.

The contours are overlayed on base maps showing the relevant operational areas for each year, nearest private residences and land ownership information. **Figure 7.1** shows the various land ownership details in the project area.

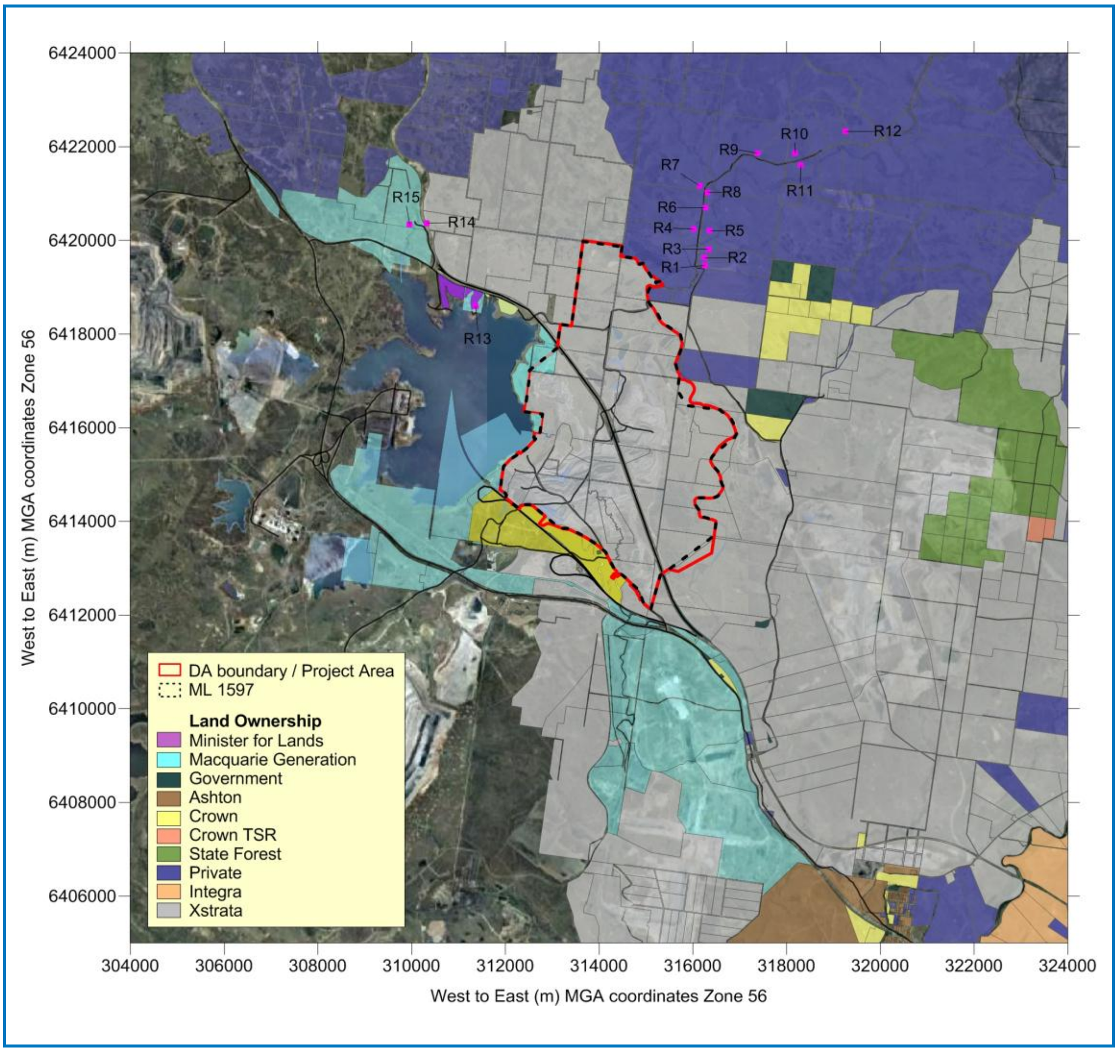


Figure 7.1: Land ownership details

7.2 Project Only Impacts

Dispersion model predictions have been made for Years 2, 4 and 5 of the proposed extension Project. Contour plots of particulate concentrations and deposition levels show the areas that are predicted to be affected by dust at different levels. It is important to note that the isopleth figures are presented to provide a visual representation of the predicted impacts. To produce the isopleths it is necessary to make interpolations, and as a result the isopleths will not always match exactly with predicted impacts at any specific location.

The actual predicted particulate concentrations/levels at nearby receivers are presented in tabular form, with those that are predicted to experience levels above the EPA's impact assessment criteria highlighted in bold.

7.2.1 Year 2

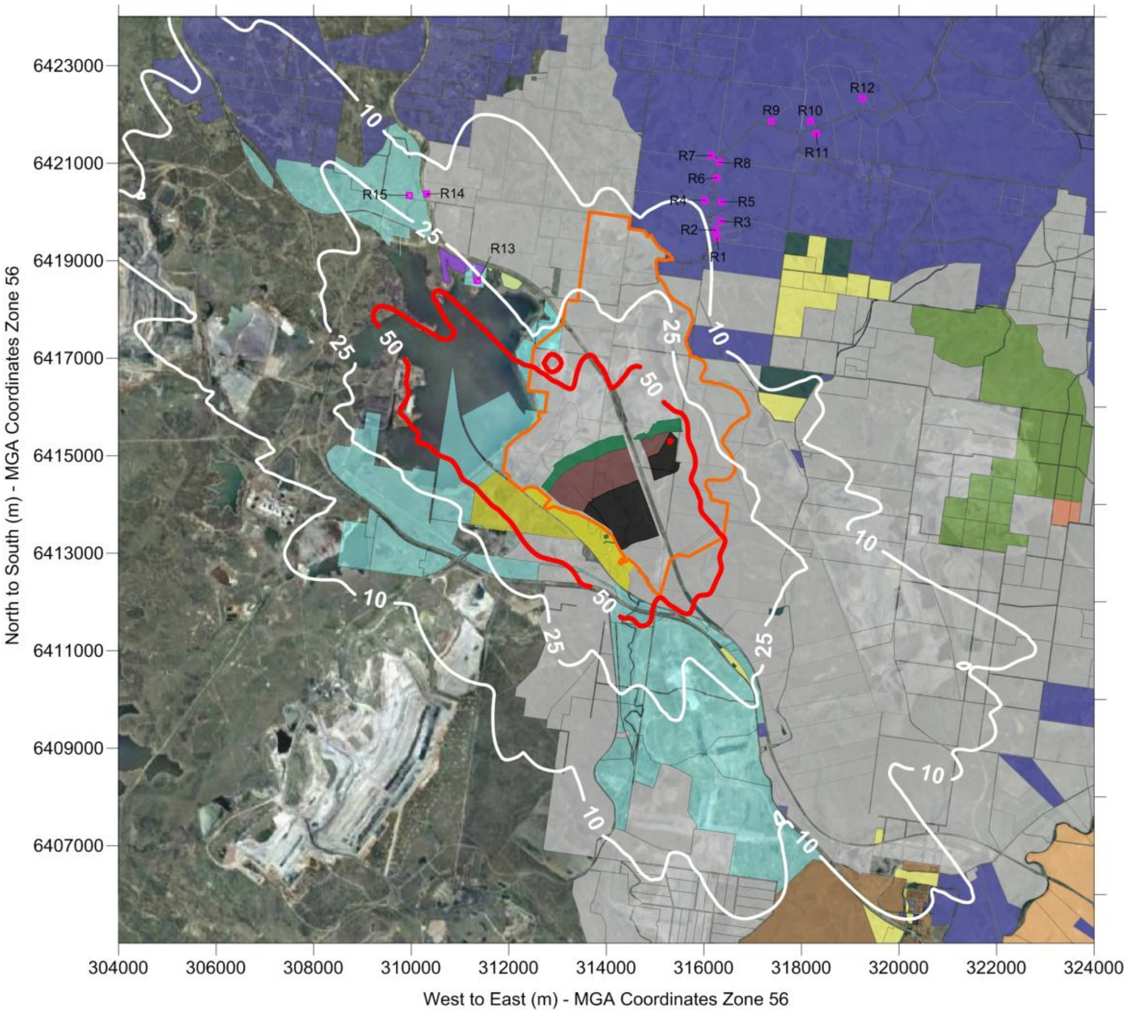
A summary of the predicted particulate concentrations at each of the individual residences for Year 2 is provided in **Table 7.1**. There are no residences that are predicted to experience 24-hour average PM_{10} concentrations above the assessment criteria, due to emissions from the Project-only. The highest 24-hour average PM_{10} prediction is approximately 28 µg/m^3 at R13.

Figure 7.2 to **Figure 7.5** present contour plots for the predicted maximum 24-hour average PM_{10}, annual average PM_{10} and TSP concentrations and dust deposition levels for the Project-only for Year 2. The bold red contour line in these figures represents the relevant air quality criterion.

The 24-hour PM_{10} contours presented do not represent a single worst case day, but rather the potential worst case 24-hour average PM_{10} concentration that could be reached at any particular location across the entire modelling year.

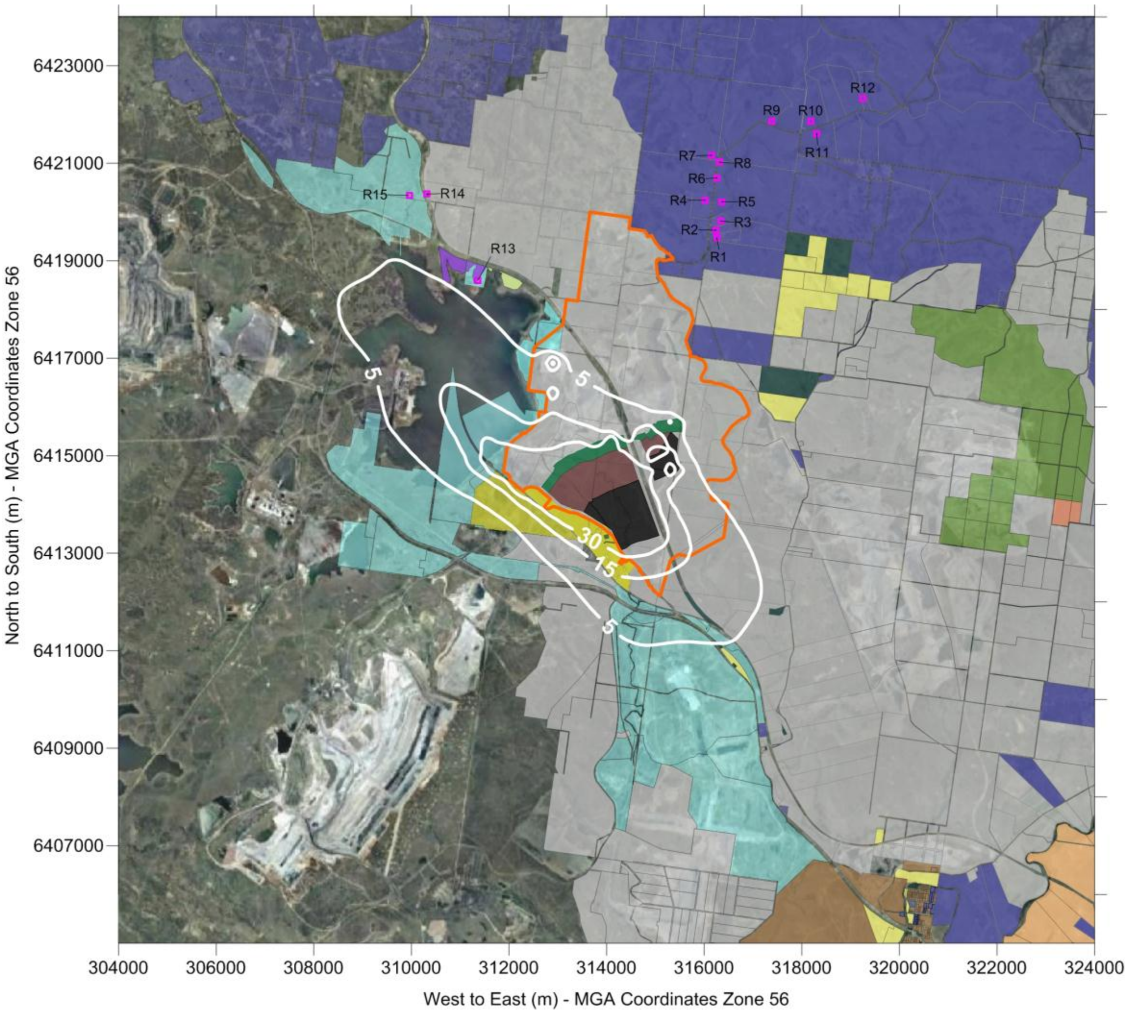
Table 7.1: Summary of predicted concentrations due to LCO only – Year 2

Residence	24-hour average PM_{10} (µg/m³)	Annual average PM_{10} (µg/m³)	Annual average TSP (µg/m³)	Annual average dust deposition (g/m²/month)
R1	9	0.3	0.7	<0.1
R2	9	0.3	0.7	<0.1
R3	8	0.3	0.6	<0.1
R4	9	0.3	0.6	<0.1
R5	8	0.2	0.6	<0.1
R6	8	0.2	0.5	<0.1
R7	7	0.2	0.5	<0.1
R8	7	0.2	0.5	<0.1
R9	4	0.1	0.3	<0.1
R10	2	0.1	0.2	<0.1
R11	2	0.1	0.2	<0.1
R12	1	0.1	0.2	<0.1
R13	28	3.1	8.5	0.1
R14	13	1.3	3.3	0.1
R15	18	1.7	4.2	0.1



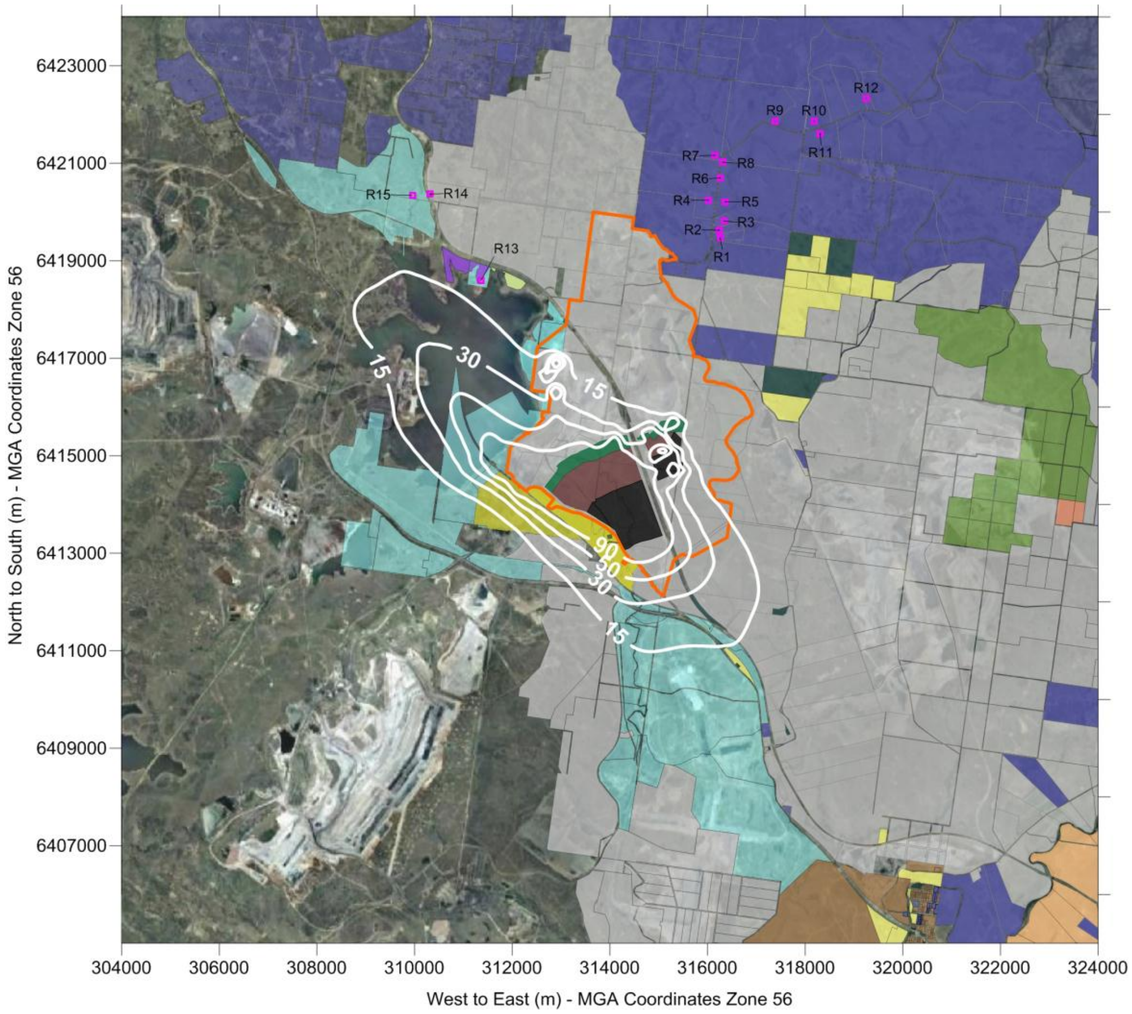
Species: PM10	**Location:** LCO	**Scenario:** Year 2 (Project only)	**Percentile:** N/A	**Averaging Time:** 24-hour
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 50 (for acquisition)	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.2: Predicted 24-hour average PM_{10} concentration due to emissions from the Project only – Year 2



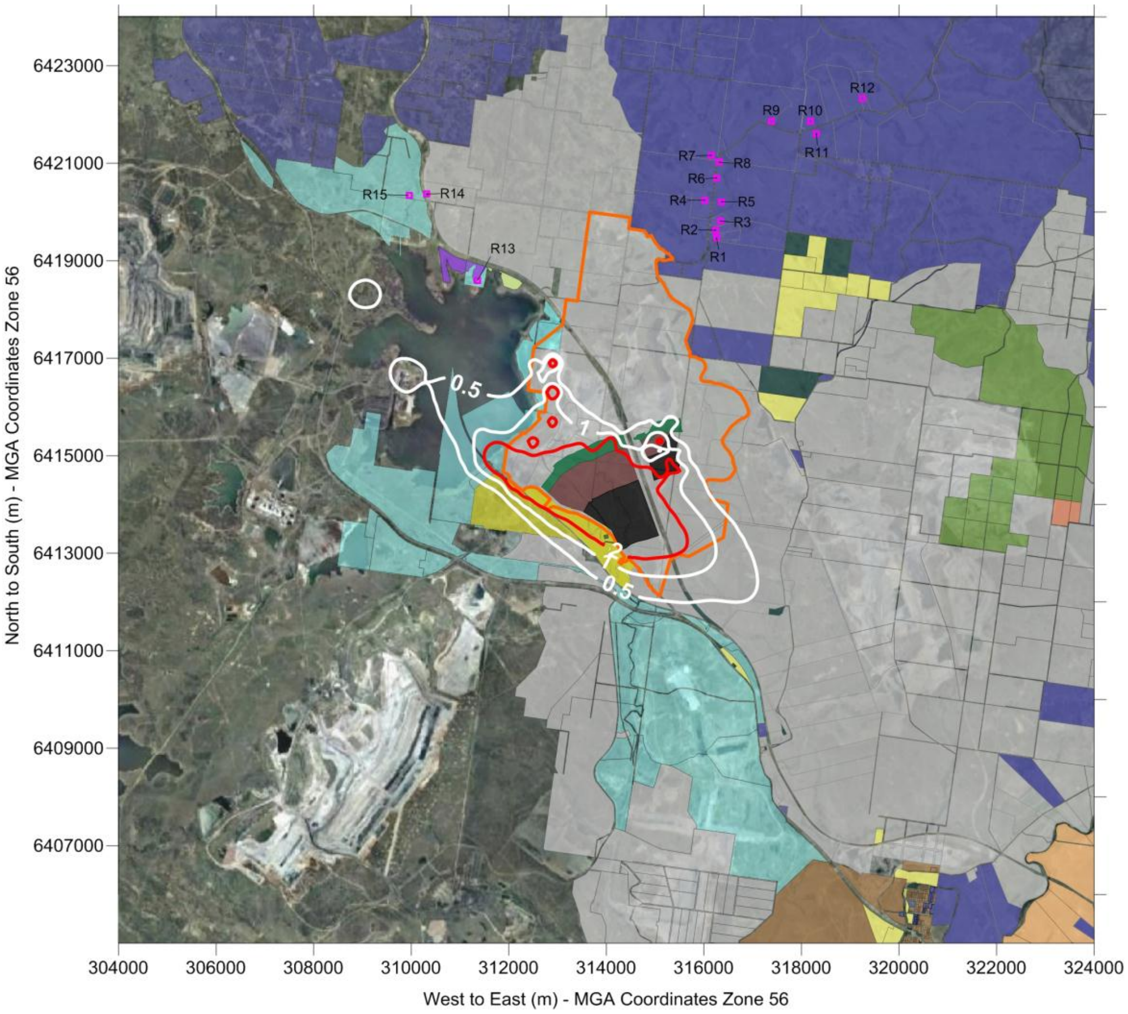
Species: PM10	Location: LCO	Scenario: Year 2 (Project only)	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.3: Predicted annual average PM_{10} concentration due to emissions from the Project only – Year 2



Species: TSP	Location: LCO	Scenario: Year 2 (Project only)	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.4: Predicted annual average TSP concentration due to emissions from the Project only – Year 2



Species: Dust Deposition	Location: LCO	Scenario: Year 2 (Project only)	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** g/m²/month	**Guideline:** 2 (Project only)	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.5: Predicted annual average deposition due to emissions from the Project only – Year 2

7.2.2 Year 4

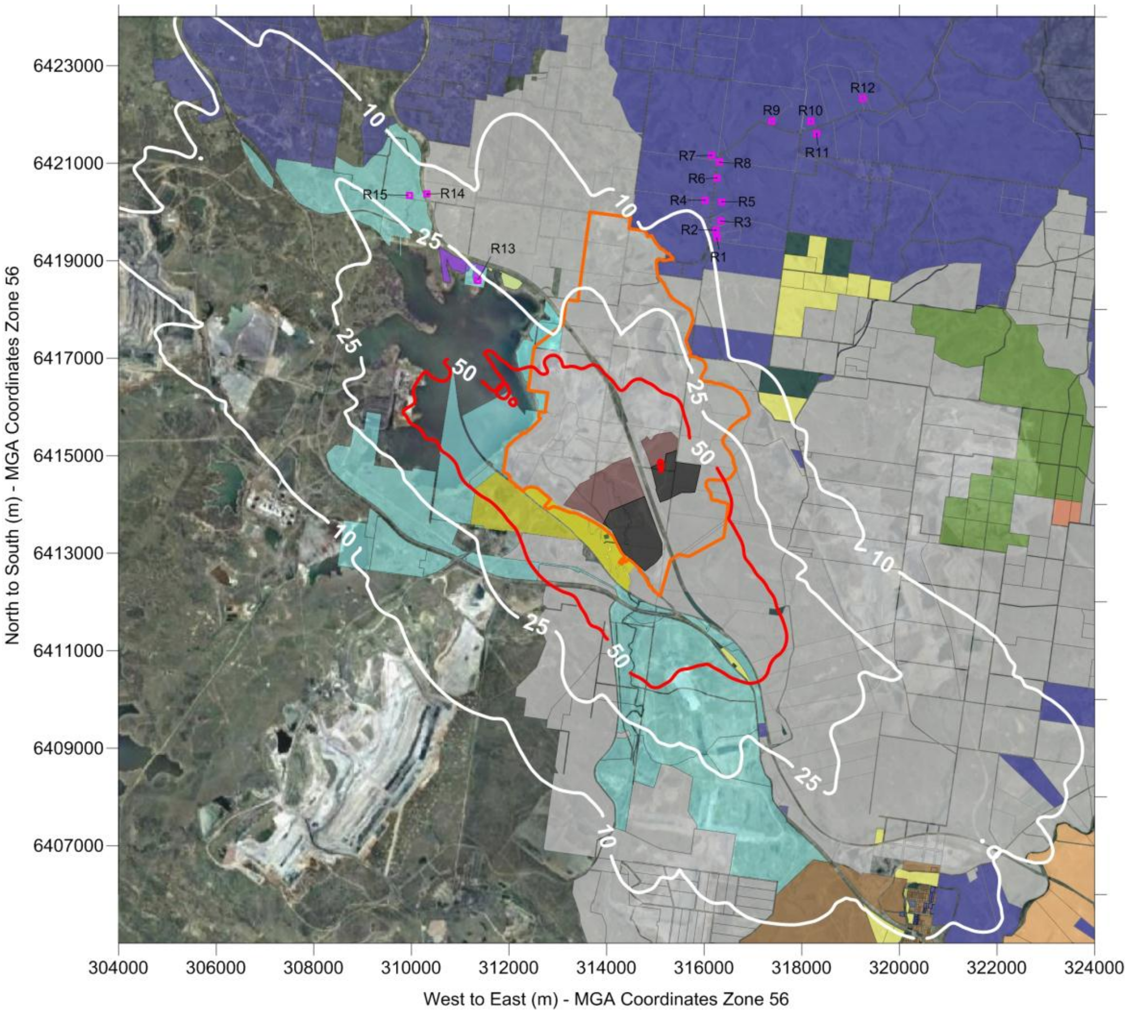
A summary of the predicted particulate concentrations at each of the individual residences for year 4 (approximately 2017) is provided in **Table 7.2**. There are no residences that are predicted to experience 24-hour average PM_{10} concentrations above the assessment criteria, due to emissions from the Project-only. The highest 24-hour average PM_{10} prediction is approximately 29 µg/m³ at R13.

Figure 7.6 to **Figure 7.9** present contour plots for the predicted maximum 24-hour average PM_{10}, annual average PM_{10} and TSP concentrations and dust deposition levels for the Project-only for Year 4.

The 24-hour average PM_{10} contours presented do not represent a single worst case day, but rather the potential worst case 24-hour PM_{10} concentration that could be reached at any particular location across the entire modelling year.

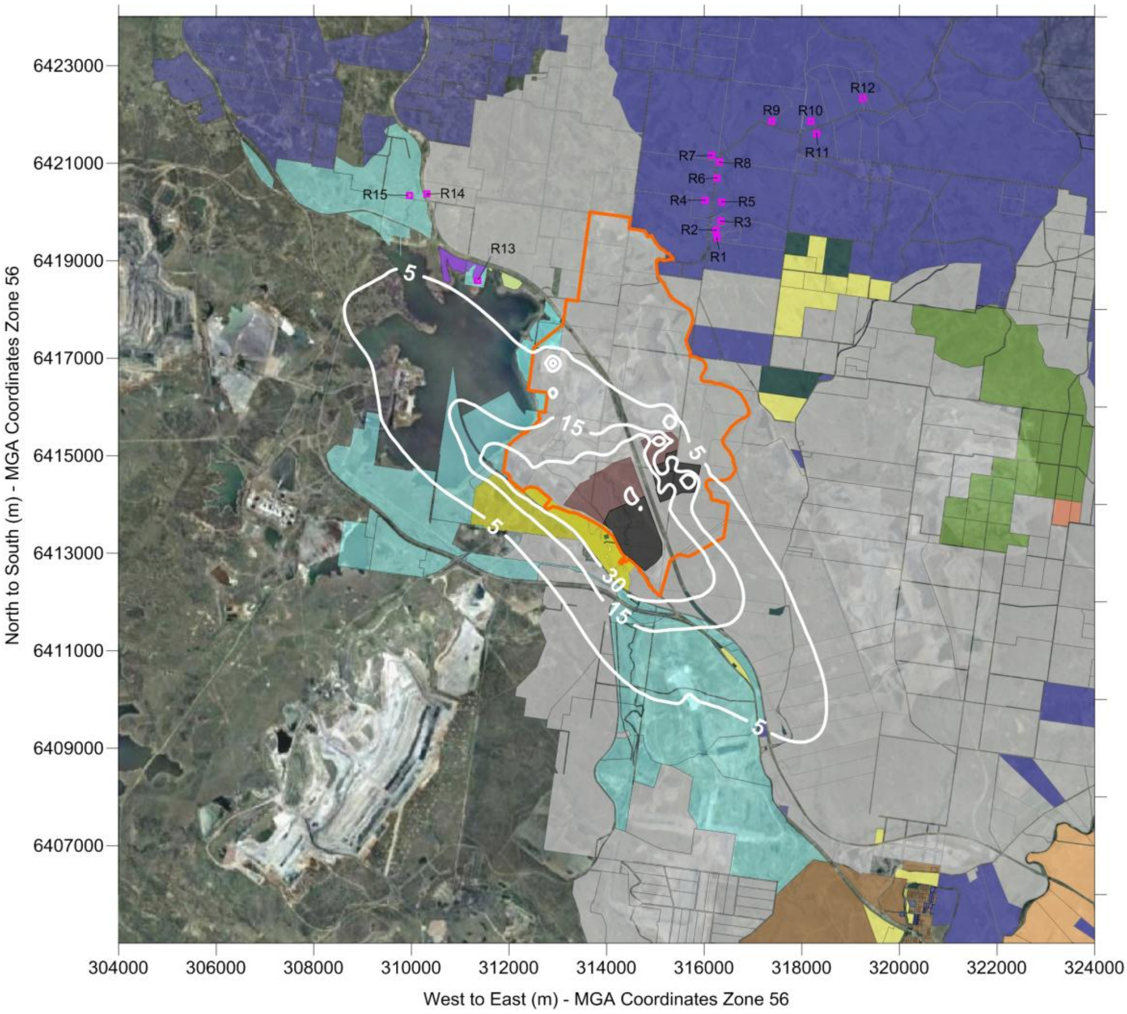
Table 7.2: Summary of predicted concentrations due to LCO only – Year 4

Residence	24-hour average PM_{10} (µg/m³)	Annual average PM_{10} (µg/m³)	Annual average TSP (µg/m³)	Annual average dust deposition (g/m²/month)
R1	9	0.3	0.8	<0.1
R2	9	0.3	0.8	<0.1
R3	8	0.3	0.7	<0.1
R4	10	0.3	0.7	<0.1
R5	8	0.3	0.7	<0.1
R6	8	0.2	0.6	<0.1
R7	8	0.2	0.5	<0.1
R8	8	0.2	0.5	<0.1
R9	4	0.2	0.4	<0.1
R10	3	0.1	0.3	<0.1
R11	2	0.1	0.3	<0.1
R12	2	0.1	0.2	<0.1
R13	30	3.3	9.2	0.1
R14	15	1.4	3.7	0.1
R15	19	1.8	4.6	0.1



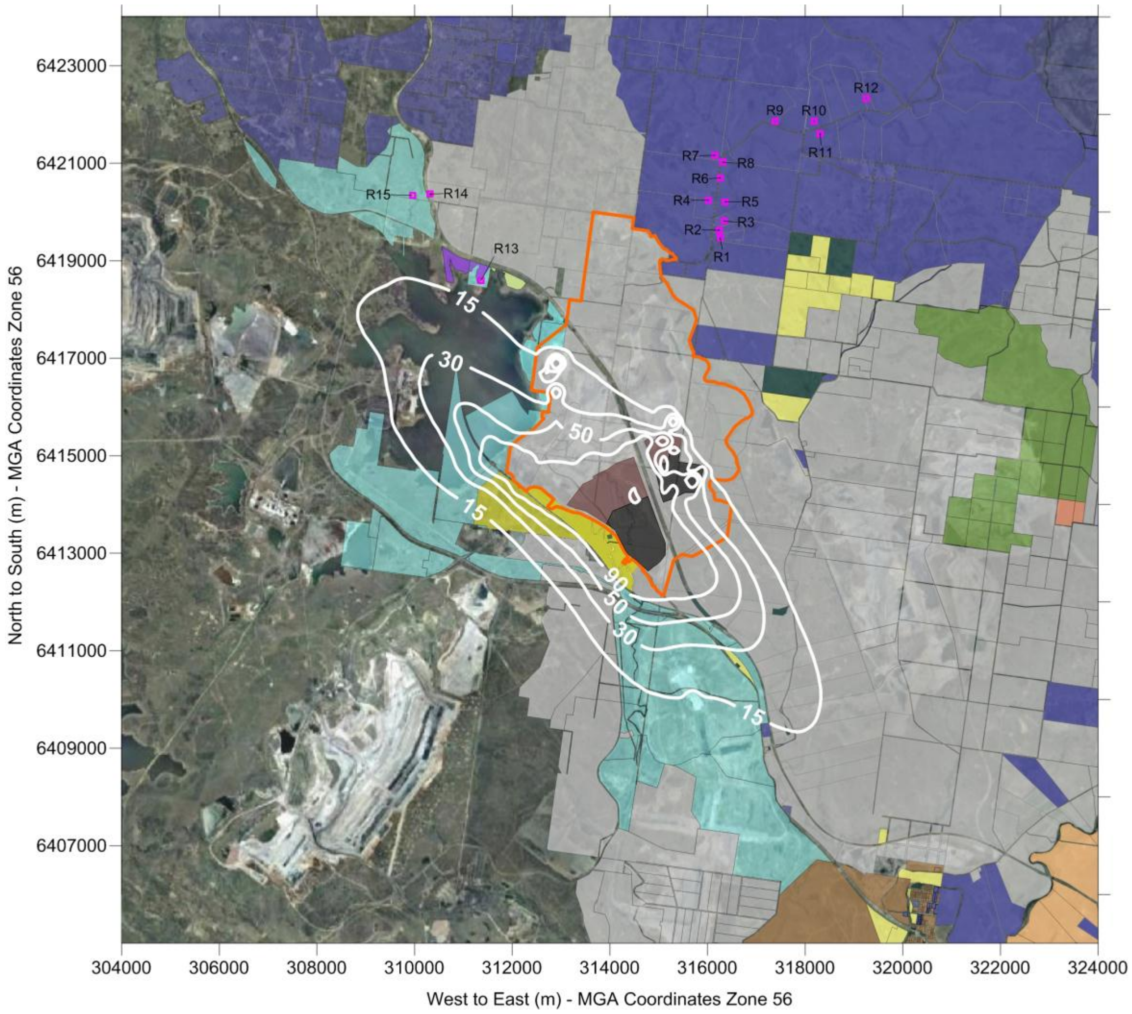
Species: PM10	Location: LCO	Scenario: Year 4 (Project only)	Percentile: N/A	Averaging Time: 24-hour
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 50 (for acquisition)	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.6: Predicted 24-hour average PM_{10} concentration due to emissions from the Project only – Year 4



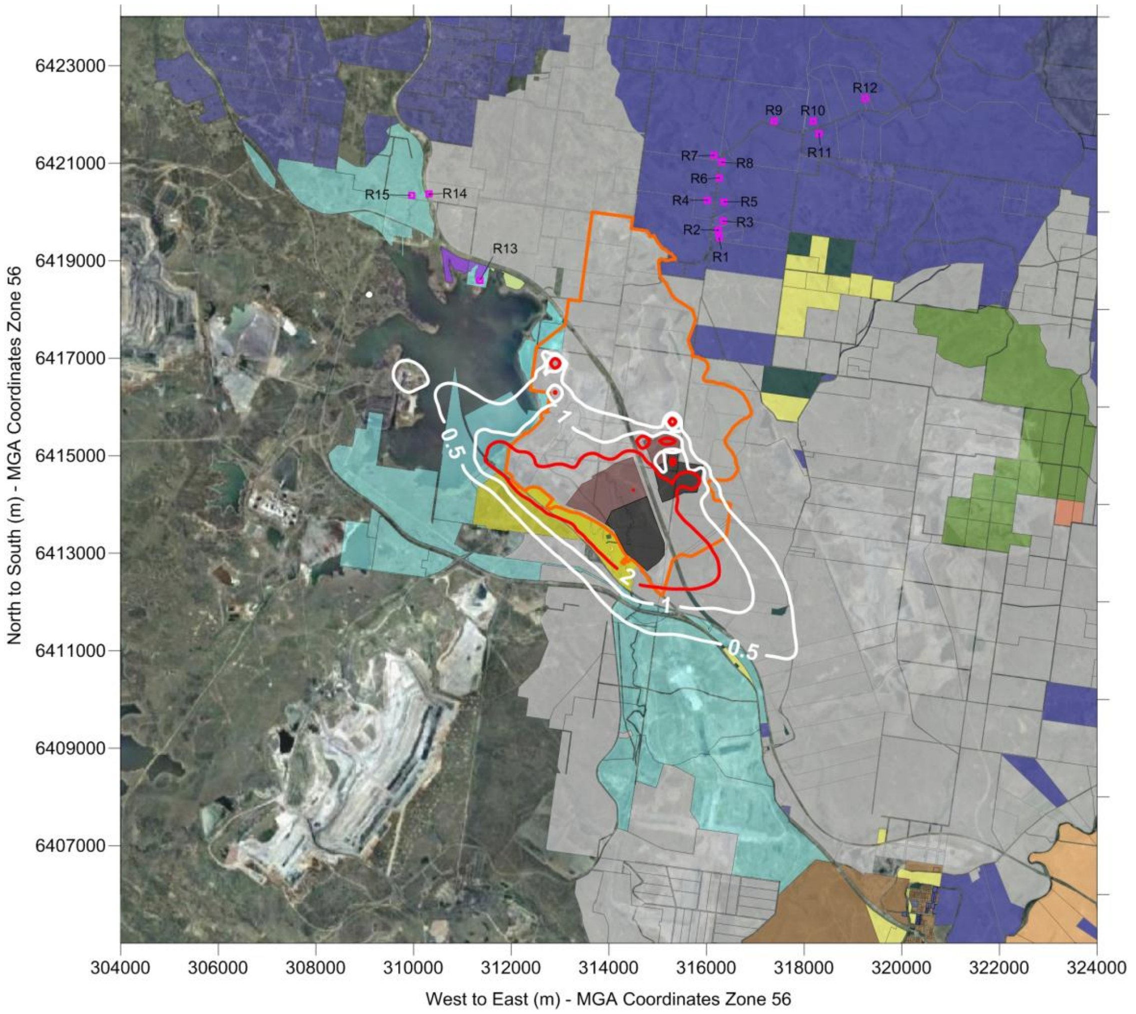
Species: PM10	Location: LCO	Scenario: Year 4 (Project only)	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.7: Predicted annual average PM_{10} concentration due to emissions from the Project only – Year 4



Species: TSP	Location: LCO	Scenario: Year 4 (Project only)	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.8: Predicted annual average TSP concentration due to emissions from the Project only – Year 4



Species: Dust Deposition	Location: LCO	Scenario: Year 4 (Project only)	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** g/m²/month	**Guideline:** 2 (Project only)	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.9: Predicted annual average TSP concentration due to emissions from the Project only – Year 4

7.2.3 Year 5

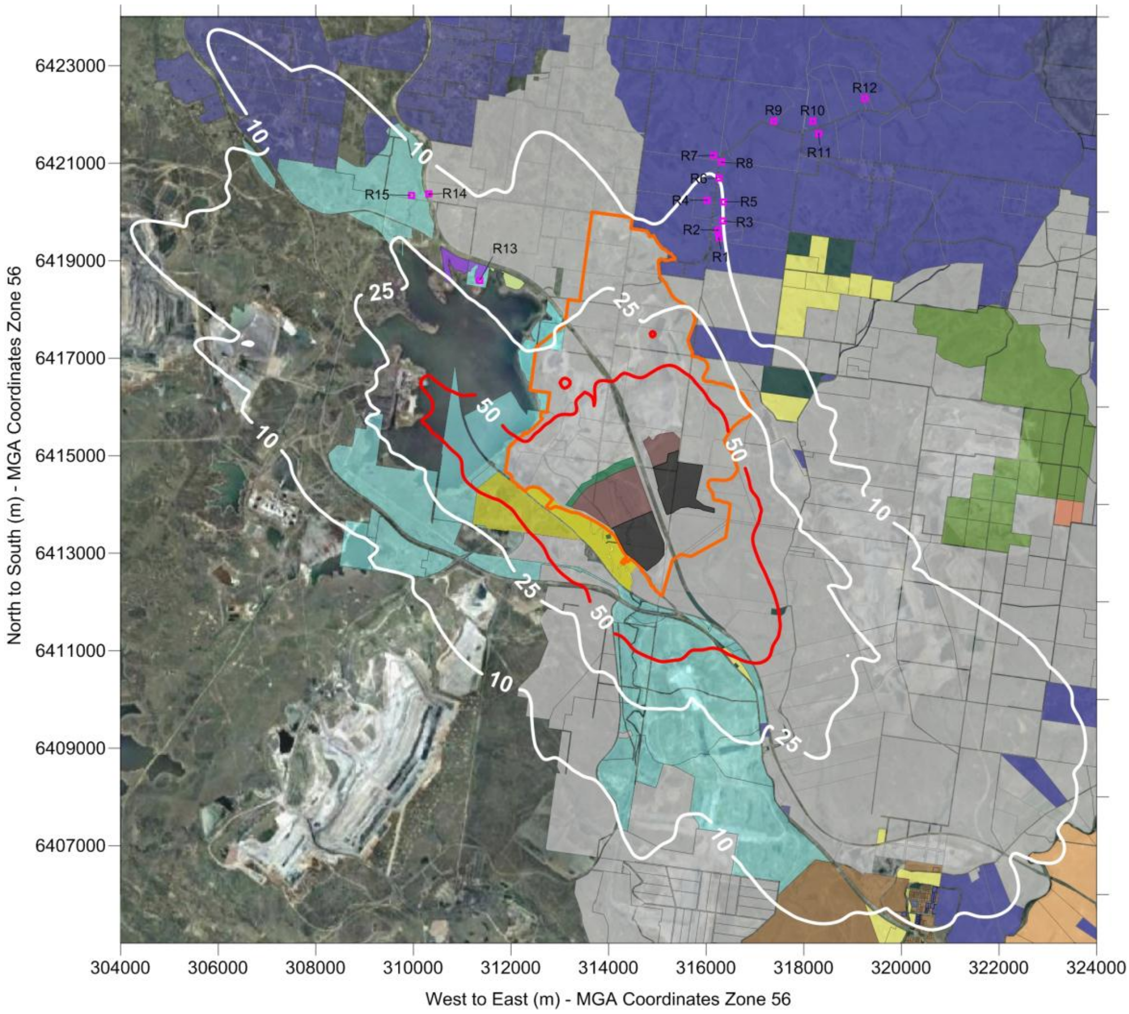
A summary of the predicted particulate concentrations at each of the individual residences for Year 5 (approximately 2018) is provided in **Table 7.3**. There are no residences that are predicted to experience 24-hour average PM_{10} concentrations above the assessment criteria, due to emissions from the Project-only. The highest 24-hour average PM_{10} prediction is approximately 20 µg/m³ at R13.

Figure 7.10 to **Figure 7.13** present contour plots for the predicted maximum 24-hour average PM_{10}, annual average PM_{10} and TSP concentrations and dust deposition levels for the Project-only for Year 5.

The 24-hour average PM_{10} contours presented do not represent a single worst case day, but rather the potential worst case 24-hour PM_{10} concentration that could be reached at any particular location across the entire modelling year.

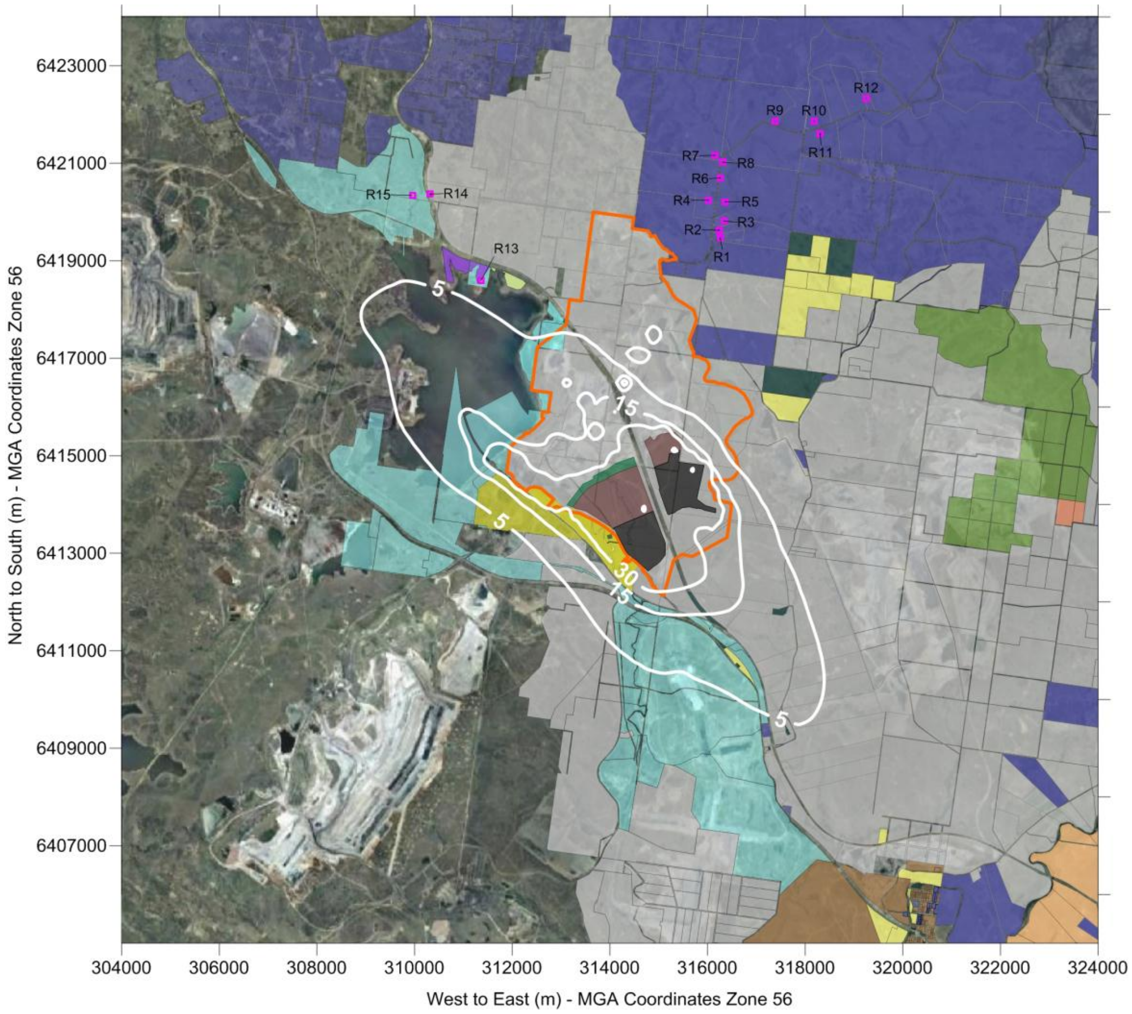
Table 7.3: Summary of predicted concentrations due to LCO only – Year 5

Residence	24-hour average PM_{10} (µg/m³)	Annual average PM_{10} (µg/m³)	Annual average TSP (µg/m³)	Annual average dust deposition (g/m²/month)
R1	11	0.4	0.9	<0.1
R2	11	0.4	0.9	<0.1
R3	10	0.3	0.8	<0.1
R4	11	0.3	0.8	<0.1
R5	10	0.3	0.7	<0.1
R6	10	0.3	0.7	<0.1
R7	9	0.2	0.6	<0.1
R8	9	0.3	0.6	<0.1
R9	5	0.2	0.4	<0.1
R10	3	0.1	0.3	<0.1
R11	3	0.1	0.3	<0.1
R12	2	0.1	0.2	<0.1
R13	21	3.6	9.9	0.2
R14	14	1.6	4.0	0.1
R15	15	1.8	4.6	0.2



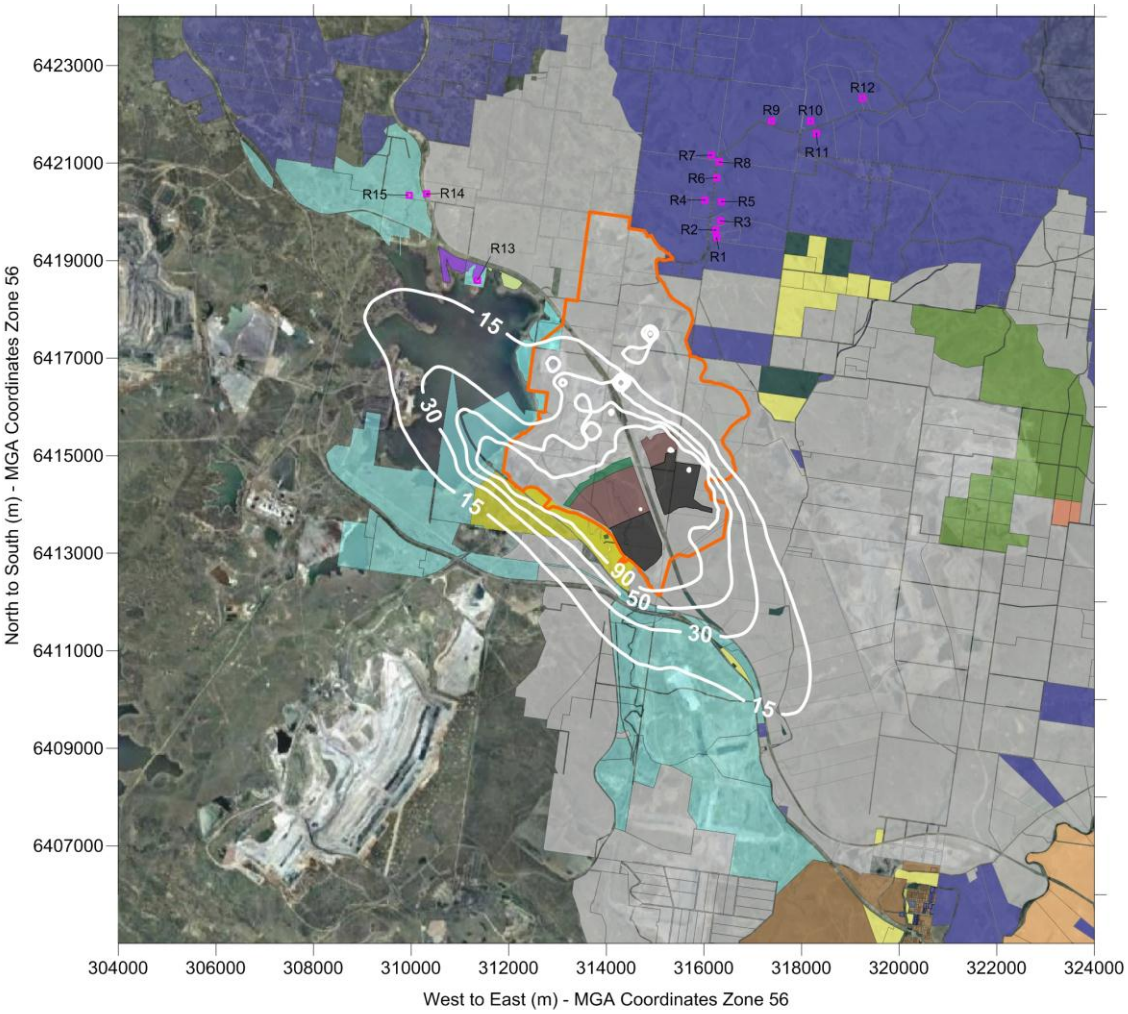
Species: PM10	Location: LCO	Scenario: Year 5 (Project only)	Percentile: N/A	Averaging Time: 24-hour
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 50 (for acquisition)	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.10: Predicted 24-hour average PM_{10} concentration due to emissions from the Project only – Year 5



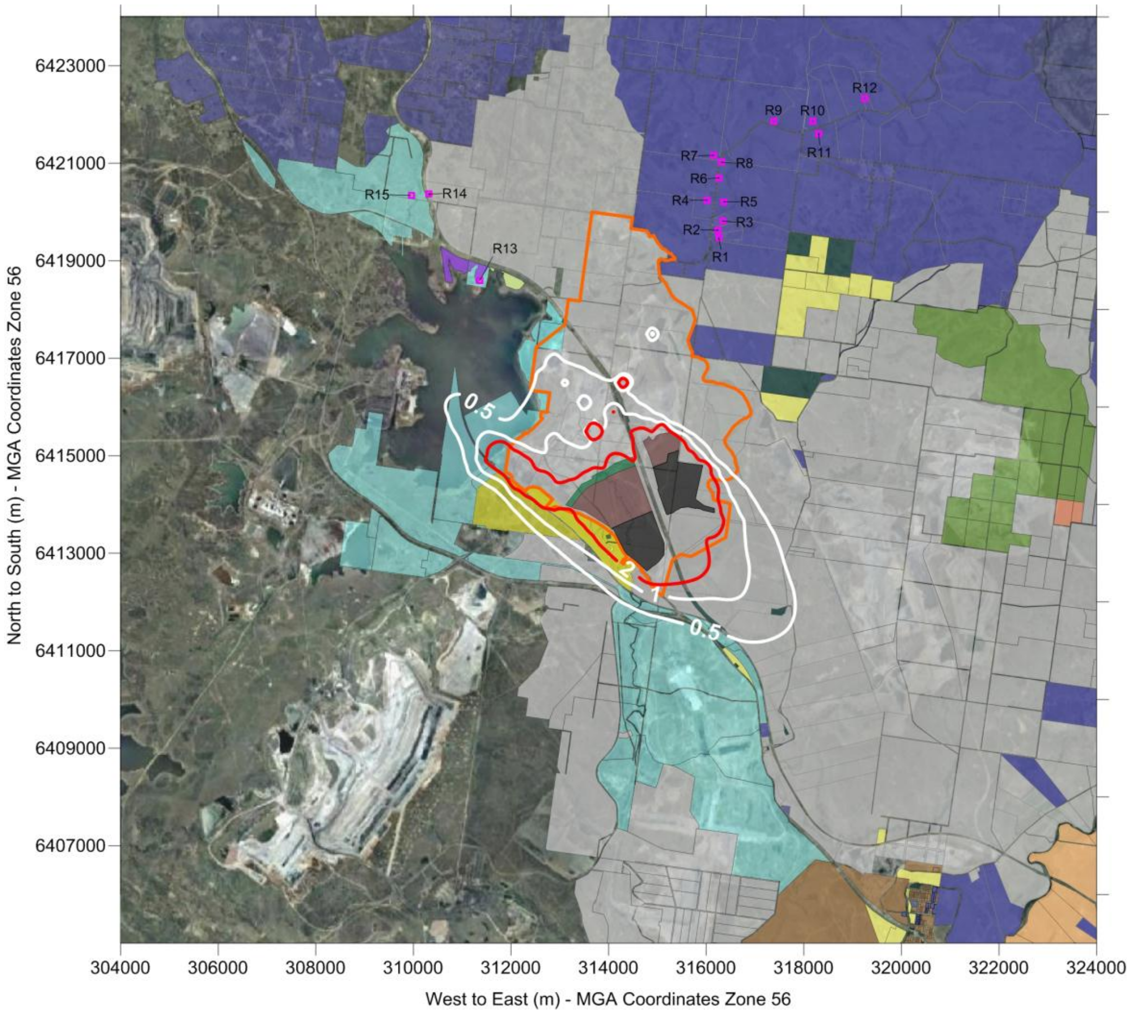
Species: PM10	Location: LCO	Scenario: Year 5 (Project only)	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.11: Predicted annual average PM_{10} concentration due to emissions from the Project only – Year 5



Species: TSP	Location: LCO	Scenario: Year 5 (Project only)	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.12: Predicted annual average TSP concentration due to emissions from the Project only – Year 5



Species: Dust Deposition	**Location:** LCO	**Scenario:** Year 5 (Project only)	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** g/m²/month	**Guideline:** 2 (Project only)	**Met Data:** CALMET	**Plot:** J. Barnett

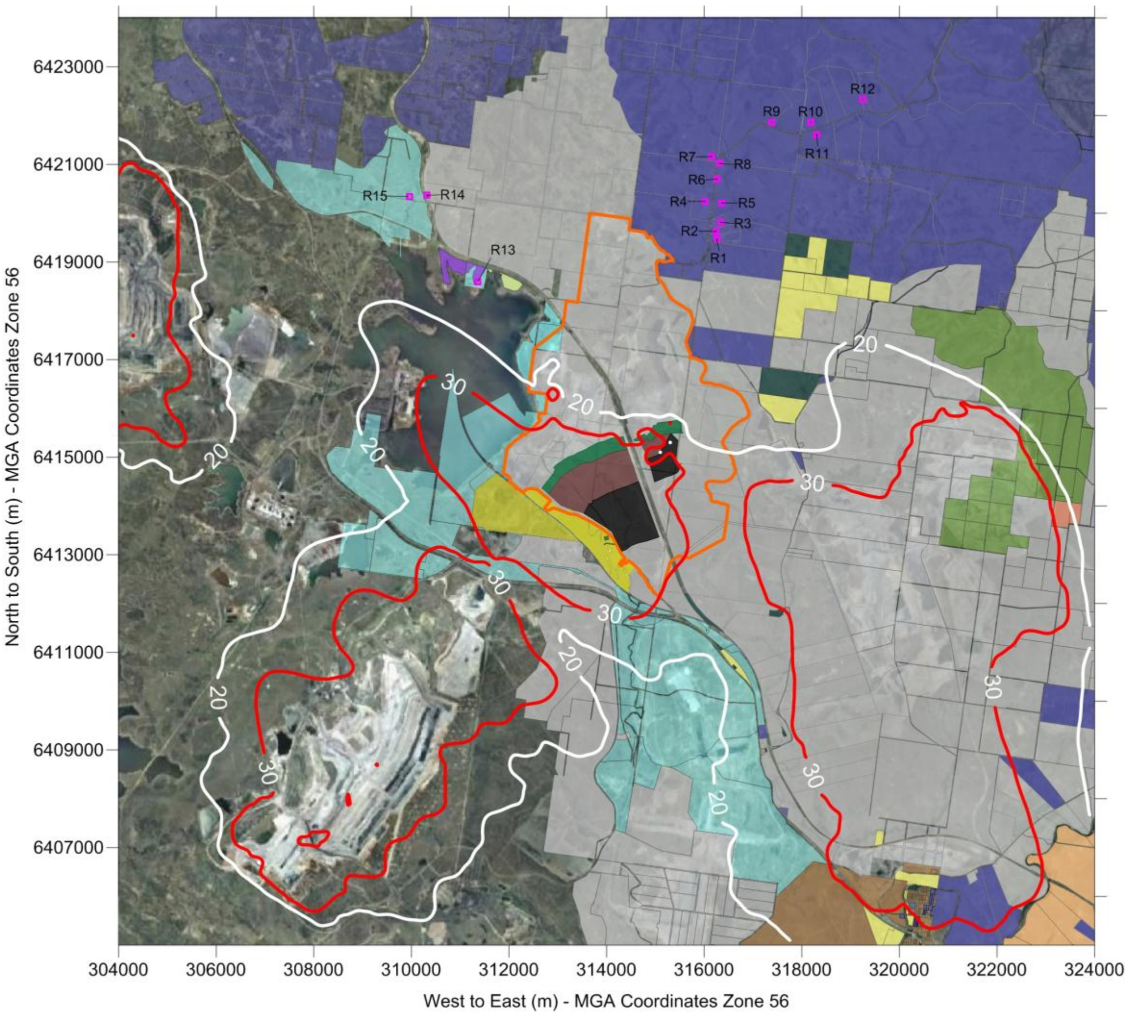
Figure 7.13: Predicted annual average dust deposition due to emissions from the Project only – Year 5

7.3 Cumulative Annual Average Impacts

7.3.1 Year 2

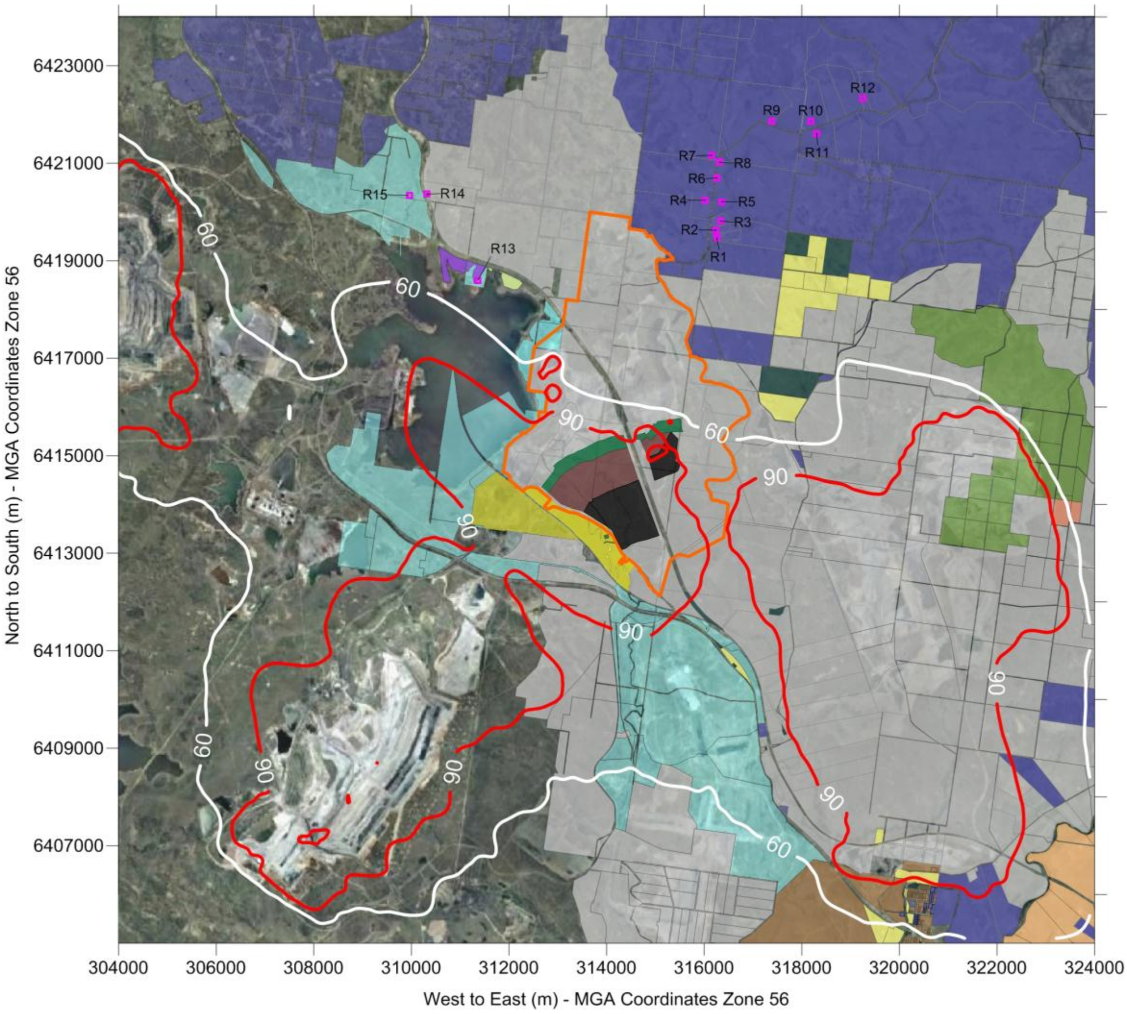
Figure 7.14 to **Figure 7.16** presents contour plots for the predicted cumulative annual average PM_{10} and TSP concentrations and dust deposition levels in Year 2. These results include contributions from the proposed LCO modification, nearby and distant mines, as well as other non-mining sources.

The bold red contour line represents the relevant air quality criterion. It can be seen that none of the fifteen residences identified to the north of LCO are predicted to be cumulatively impacted on an annual basis. There is some privately owned land in the southeast of the modelling domain, but it is clear from comparing these plots with the "Project Only" results in **Section 7.2.1**, that the proposed LCO Modification does not contribute in any significant way to these levels.



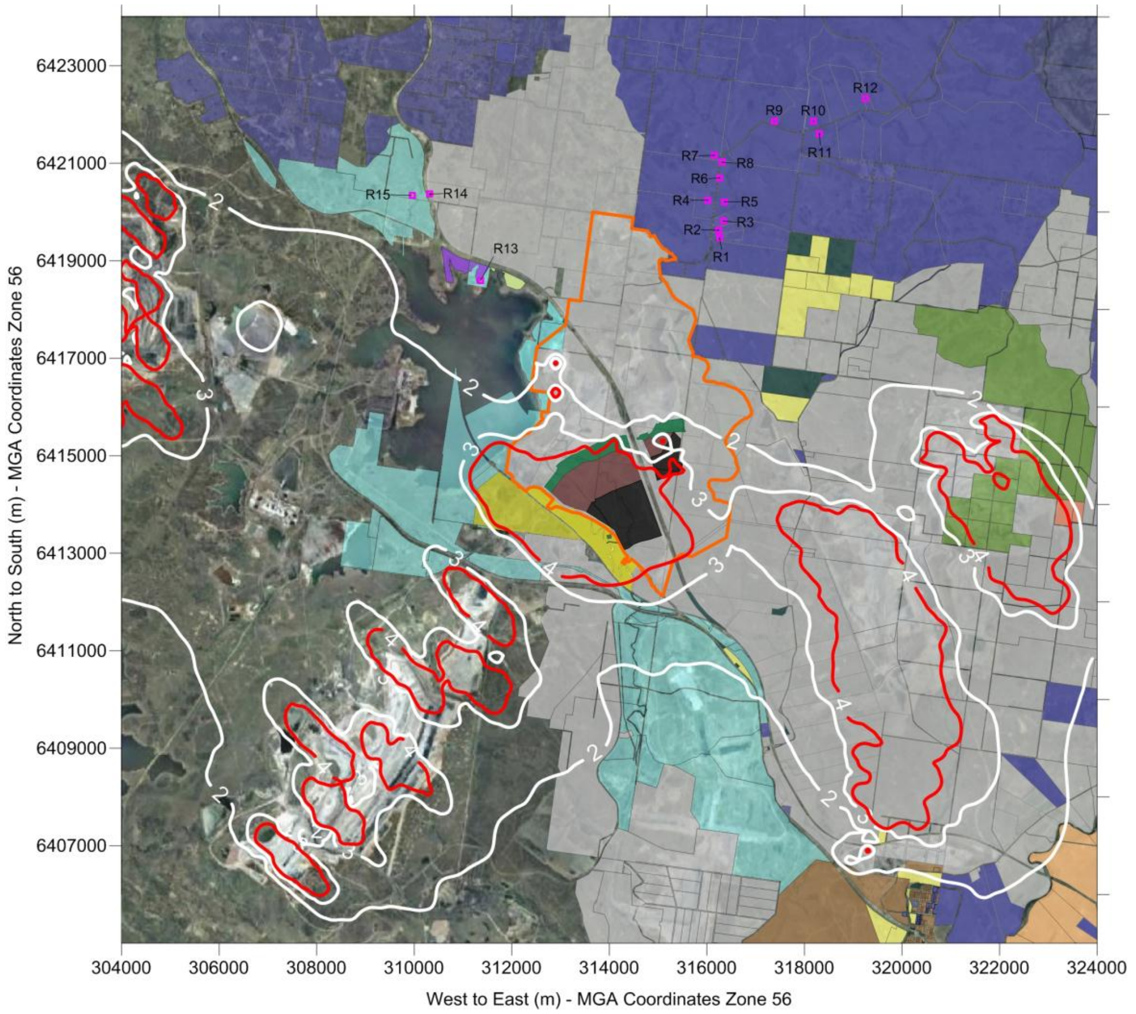
Species: PM_{10}	Location: LCO	Scenario: Year 2 cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 50	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.14: Predicted annual average PM_{10} concentration due to emissions from the Project, nearby mines and other sources – Year 2



Species: TSP	Location: LCO	Scenario: Year 2 cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 90	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.15: Predicted annual average cumulative TSP concentration due to emissions from the Project, nearby mines and other sources – Year 2



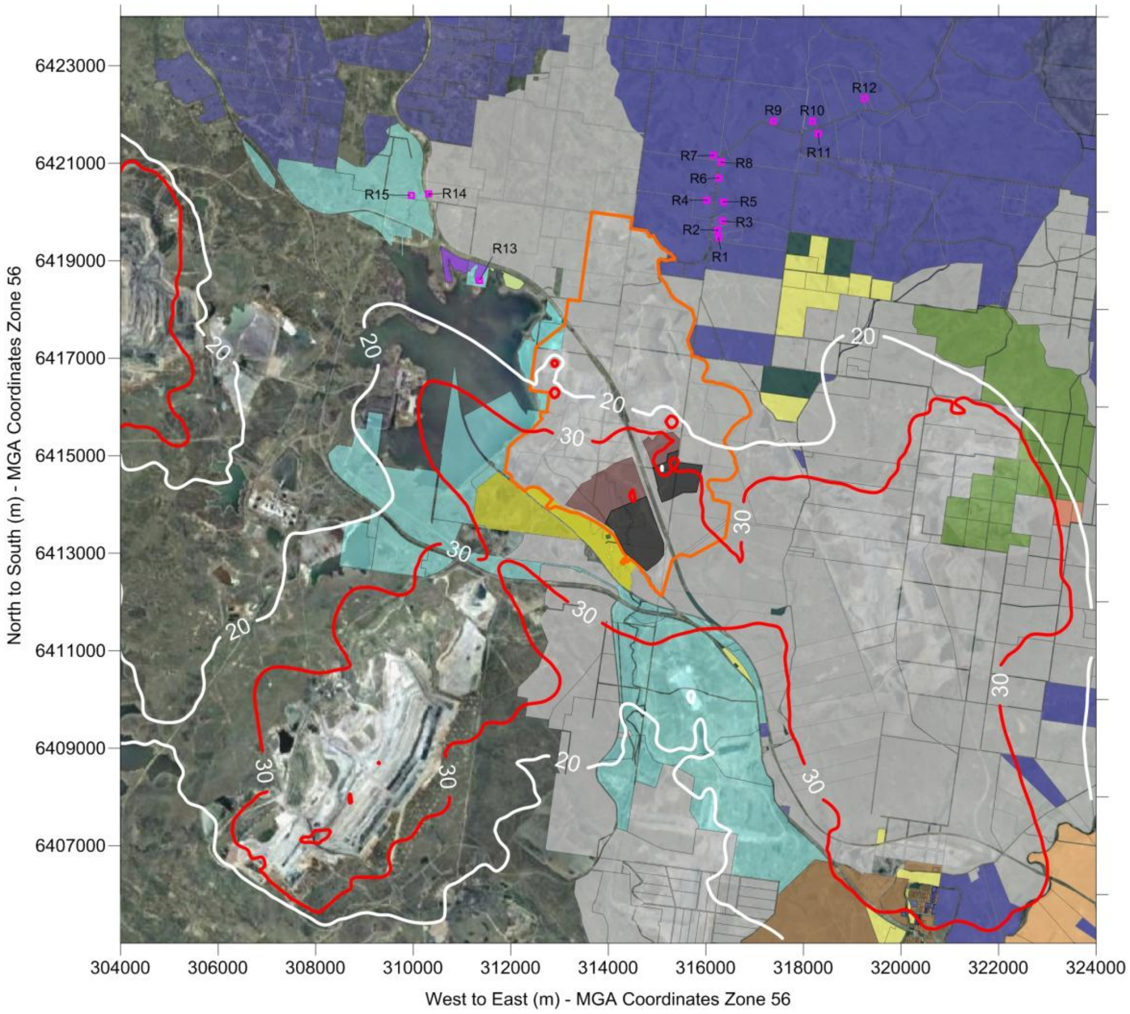
Species: Dust Deposition	Location: LCO	Scenario: Year 2 cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** g/m²/month	**Guideline:** 4	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.16: Predicted annual average dust deposition due to emissions from the Project, nearby mines and other sources – Year 2

7.3.2 Year 4

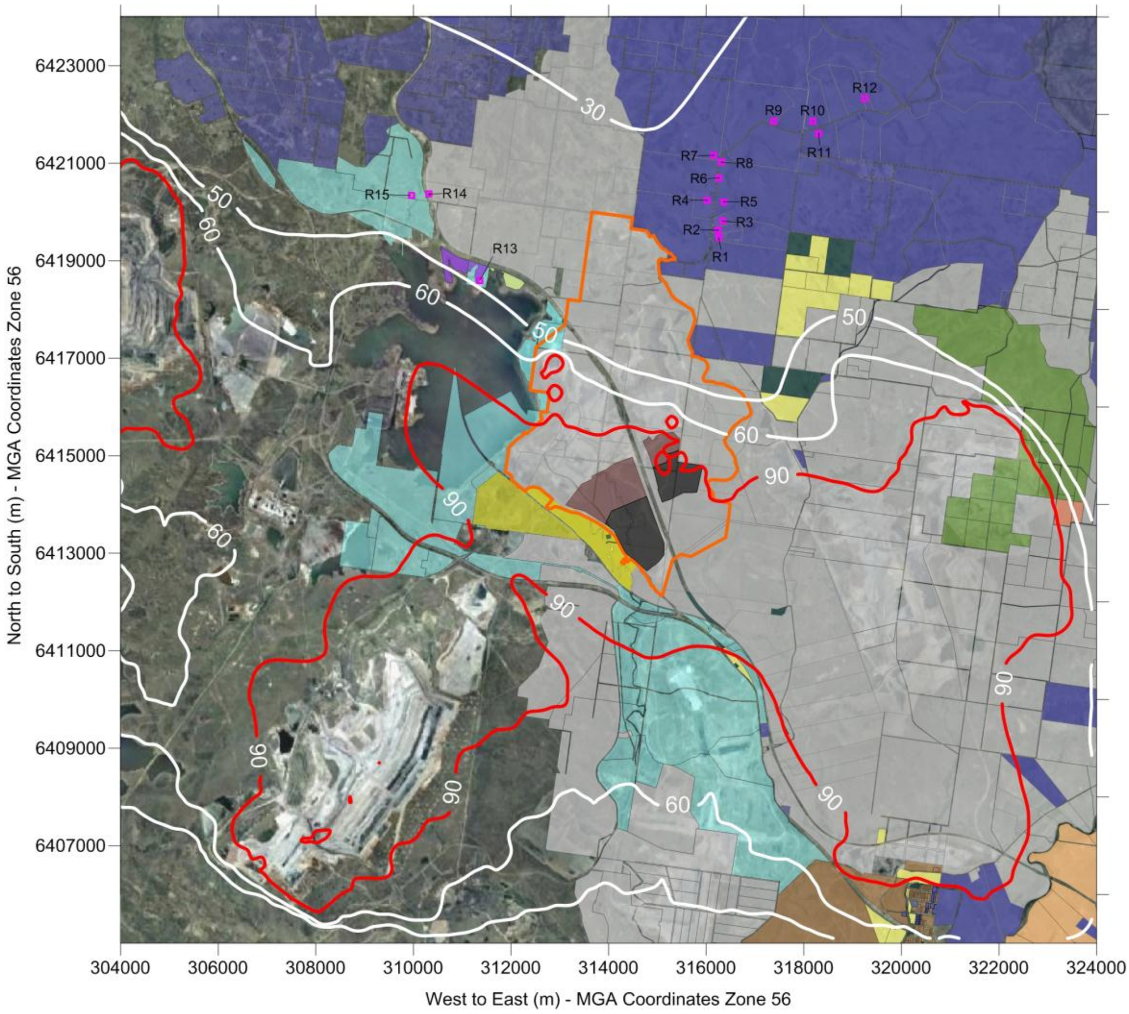
Figure 7.17 to **Figure 7.19** presents contour plots for the predicted cumulative annual average PM_{10} and TSP concentrations and dust deposition levels in Year 4. These results include contributions from the proposed LCO modification, nearby and distant mines, as well as other non-mining sources.

The bold red contour line represents the relevant air quality criterion. It can be seen that none of the fifteen residences identified to the north of LCO are predicted to be cumulatively impacted on an annual basis. There is some privately owned land in the southeast of the modelling domain, but it is clear from comparing these plots with the "Project Only" results in **Section 7.2.2**, that the proposed LCO Modification does not contribute in any significant way to these levels.



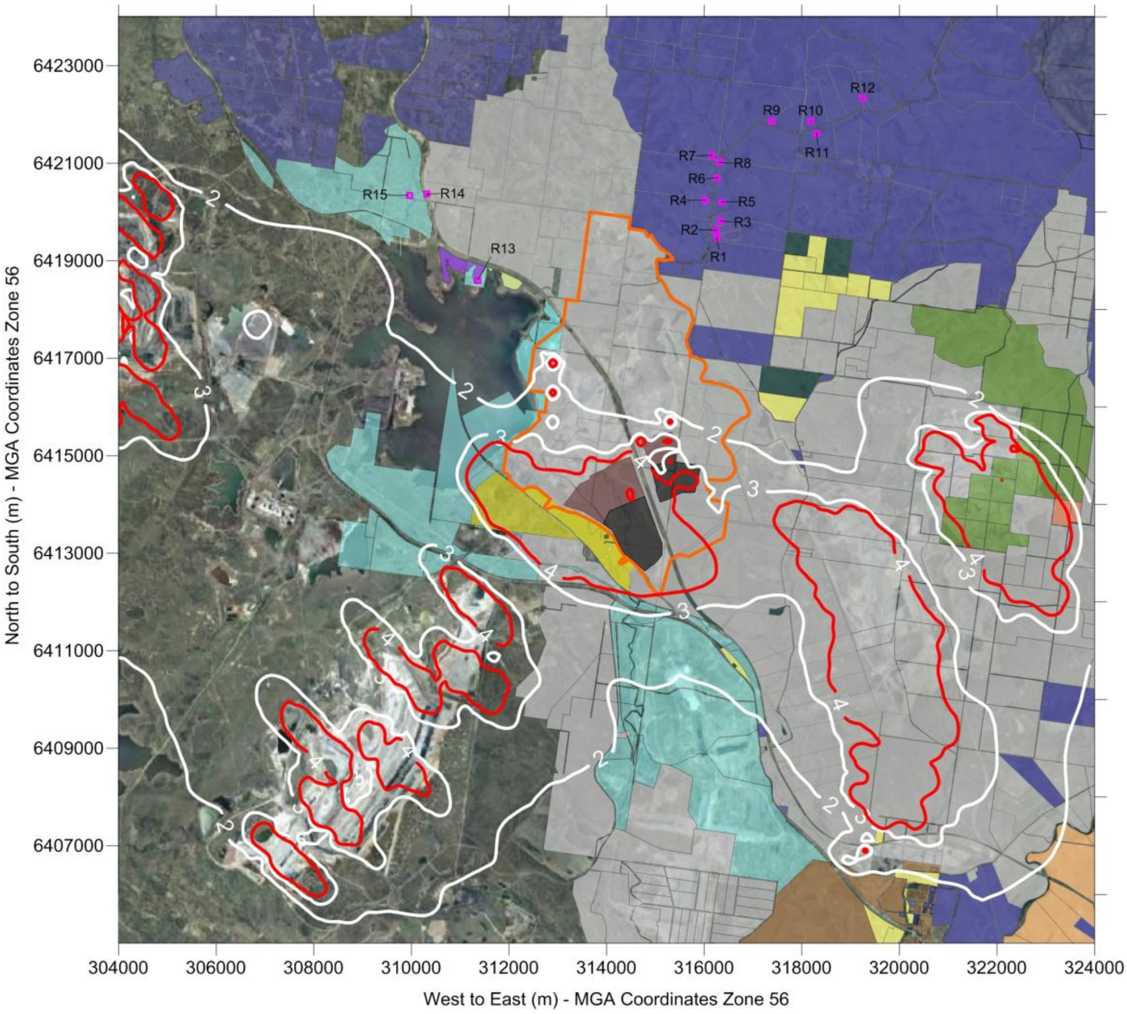
Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
PM_{10}	LCO	Year 4 cumulative	N/A	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF	µg/m³	50	CALMET	J. Barnett

Figure 7.17: Predicted annual average PM_{10} concentration due to emissions from the Project, nearby mines and other sources – Year 4



Species: TSP	Location: LCO	Scenario: Year 4 cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 90	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.18: Predicted annual average cumulative TSP concentration due to emissions from the Project, nearby mines and other sources – Year 4



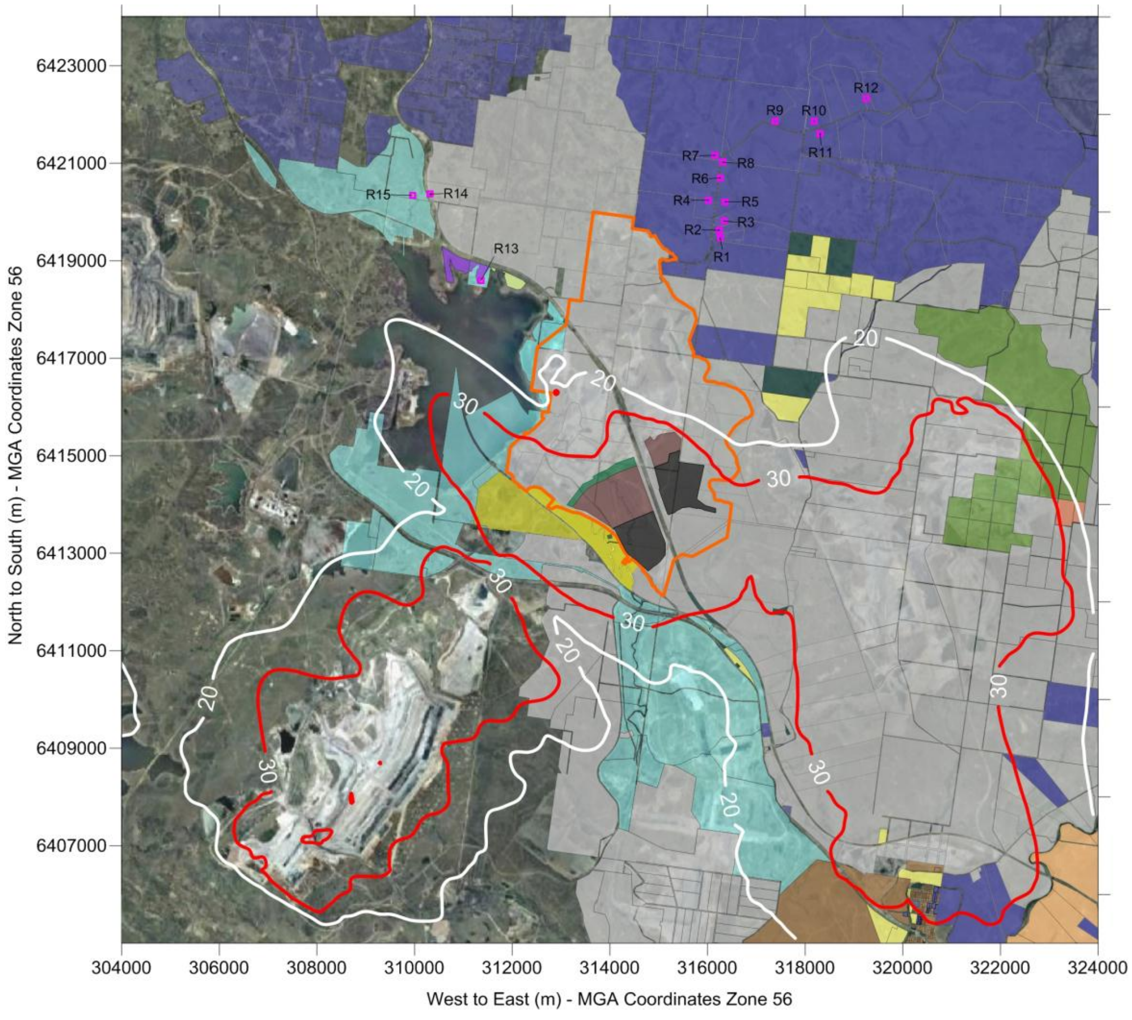
Species: Dust Deposition	Location: LCO	Scenario: Year 4 cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** g/m²/month	**Guideline:** 4	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.19: Predicted annual average dust deposition due to emissions from the Project, nearby mines and other sources – Year 4

7.3.3 Year 5

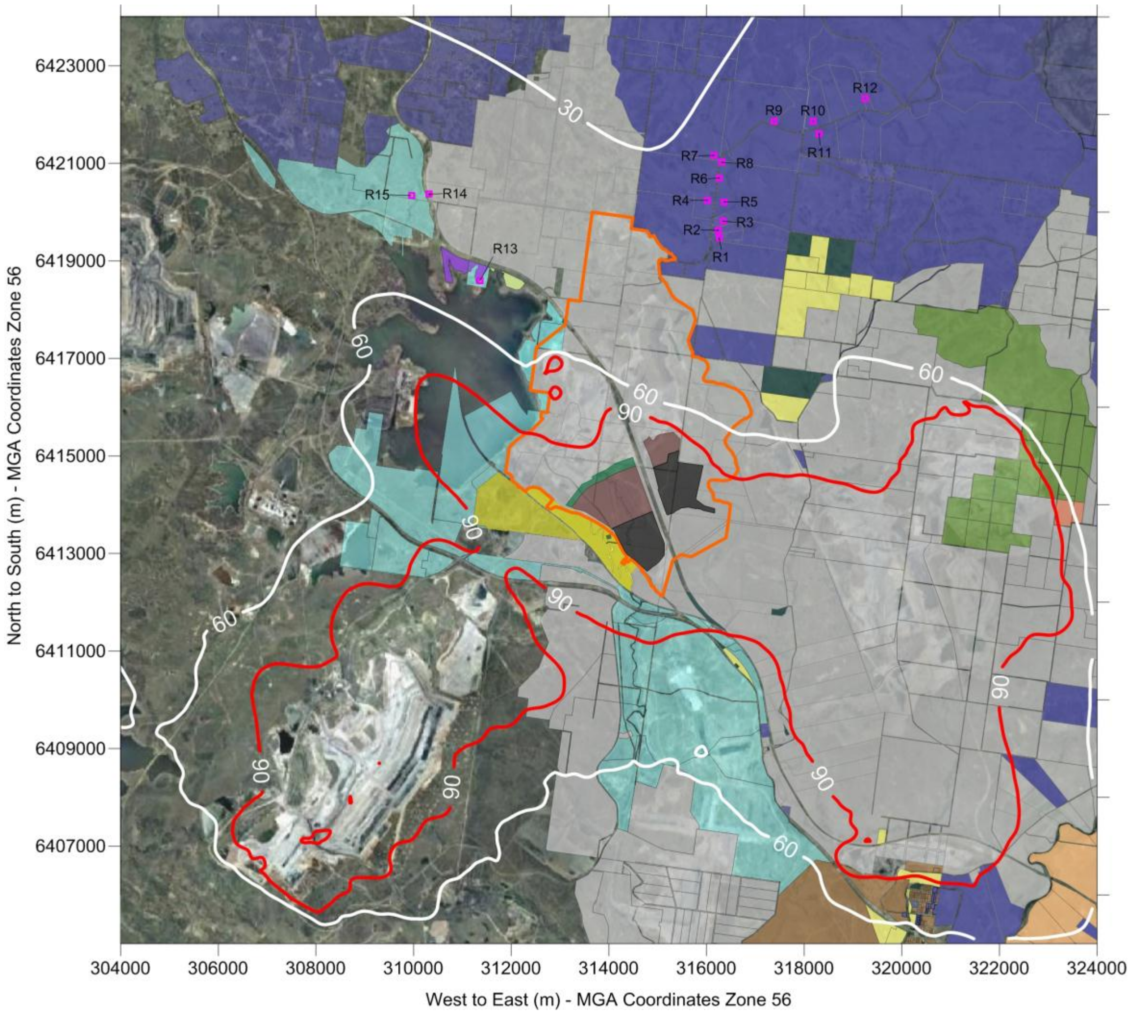
Figure 7.20 to **Figure 7.22** presents contour plots for the predicted cumulative annual average PM_{10} and TSP concentrations and dust deposition levels in Year 5. These results include contributions from the proposed LCO modification, nearby and distant mines, as well as other non-mining sources.

The bold red contour line represents the relevant air quality criterion. It can be seen that none of the fifteen residences identified to the north of LCO are predicted to be cumulatively impacted on an annual basis. There is some privately owned land in the southeast of the modelling domain, but it is clear from comparing these plots with the "Project Only" results in **Section 7.2.3**, that the proposed LCO Modification does not contribute in any significant way to these levels.



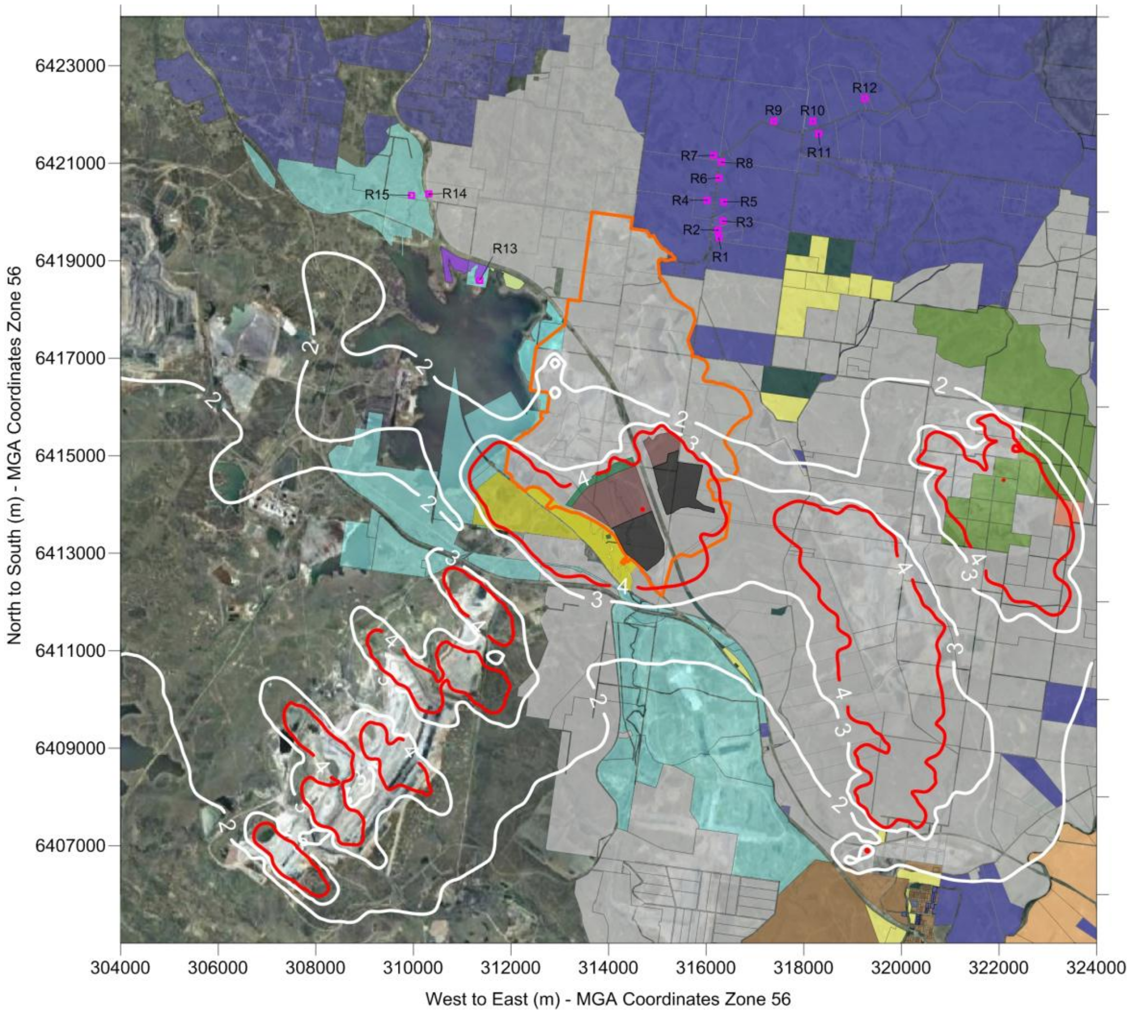
Species: PM_{10}	**Location:** LCO	**Scenario:** Year 5 cumulative	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 50	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.20: Predicted annual average PM_{10} concentration due to emissions from the Project, nearby mines and other sources – Year 5



Species: TSP	Location: LCO	Scenario: Year 5 cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 90	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.21: Predicted annual average cumulative TSP concentration due to emissions from the Project, nearby mines and other sources – Year 5



Species: Dust Deposition	Location: LCO	Scenario: Year 5 cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** g/m²/month	**Guideline:** 4	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.22: Predicted annual average dust deposition due to emissions from the Project, nearby mines and other sources – Year 5

7.4 Cumulative 24-hour Average PM_{10} Impacts

7.4.1 Introduction

It is difficult to accurately predict the cumulative 24-hour average PM_{10} concentrations using dispersion modelling due to the difficulties in resolving (on a day to day basis) the varying intensity, duration and precise locations of activities at mine sites, the weather conditions at the time of the activity, or combination of activities.

The difficulties in predicting cumulative 24-hour average impacts are compounded by the day to day variability in ambient dust levels and the spatial and temporal variation in any other anthropogenic activity e.g. agricultural activity, bushfires etc., including mining in the future. Experience shows that the worst-case 24-hour average PM_{10} concentrations are strongly influenced by other sources in the area, such as bushfires and dust storms, which are essentially unpredictable. The variability in 24-hour average PM_{10} concentrations can be clearly seen in the data collected at the TEOM and HVAS monitors located surrounding the mine (see **Section 4.1.2**).

Cumulative air quality impacts have been evaluated using a statistical approach (known as a Monte Carlo Simulation). This approach has been provided to achieve the objectives of a Level 2 Assessment (see Section 11.2 of **EPA, 2005**). The cumulative assessment focuses on representative receptors in key areas in the vicinity of the mine.

7.4.2 Cumulative assessment based on Monte Carlo

The Monte Carlo Simulation is a statistical approach that combines the frequency distribution of one data set (in this case background 24-hour average PM_{10} concentrations) with the frequency distribution of another data set (modelled impacts at a given receptor). This is achieved by repeatedly randomly sampling and combining values within the two data sets to create a third, 'cumulative' data set and associated frequency distribution.

Receptors (residence numbers) R1, R2, R13, R14 and R15 were chosen to represent those residences closest to LCO. Data from the SX13 TEOM were used to represent background values.

Individual 24-hour average predictions for the Project are added to a random value from the above data sets. This process is repeated many thousands of times yielding the 'cumulative' data set, which is then presented as a frequency distribution.

The process assumes that a randomly selected background value would have a chance equal to that of any other background value from the data set of occurring on the given 'modelled day'. Over sufficient repetitions, this yields a good statistical estimate of the combined and independent effects of varying background and the Project (plus nearby mines) contributions to total PM_{10}.

To generate greater confidence in the statistical robustness of the results, the Monte Carlo Simulation was repeated 250,000 times for each of the five receptors. In other words, the same 1-year set of predicted (modelled) 24-hour PM_{10} concentrations due to the Project were added to 250,000 variations of the randomly selected background concentrations at each receptor (a different random background concentration is selected each time).

The results of this analysis are presented graphically in **Figure 7.23**, **Figure 7.24** and **Figure 7.25**. The plots shows the statistically estimated number of days that 24-hour average PM_{10} concentrations might exceed 50 $\mu g/m^3$ and also compares the cumulative probability with the measured background.

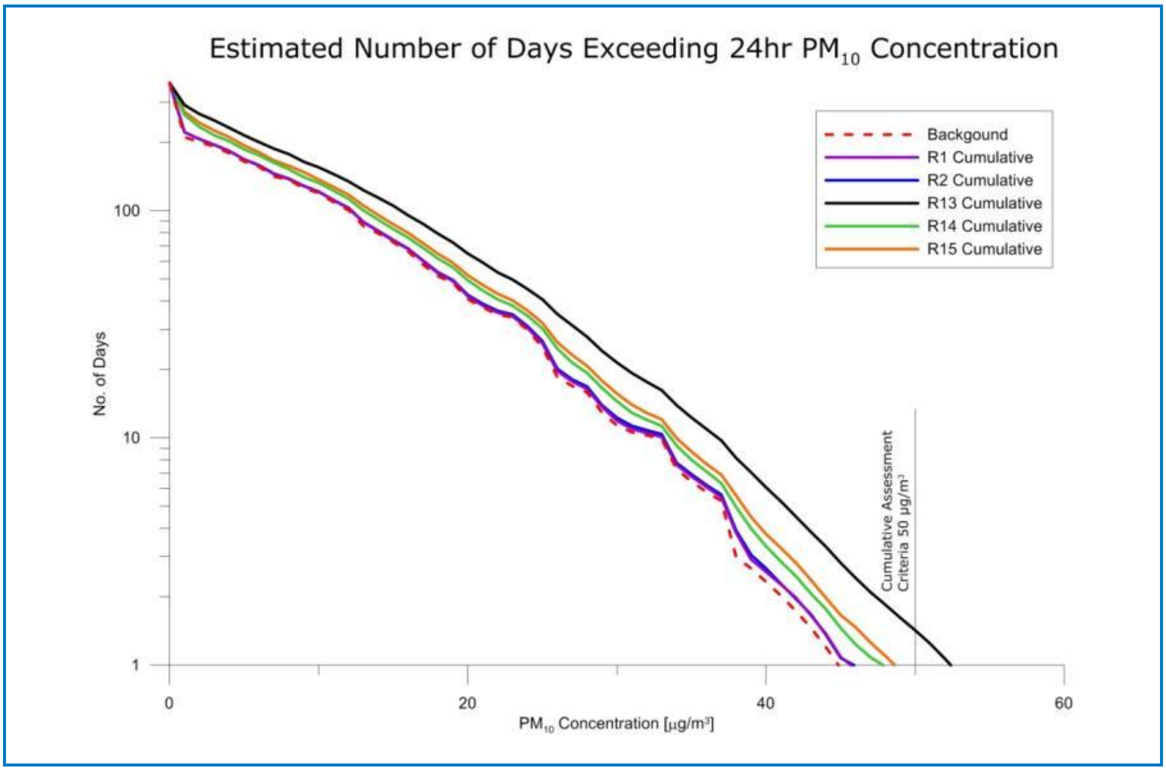


Figure 7.23: Receptors R1, R2, R13, R14 and R15 – statistical estimate of number of days exceeding 24-hr PM_{10} concentrations following Monte Carlo simulation for Year 2

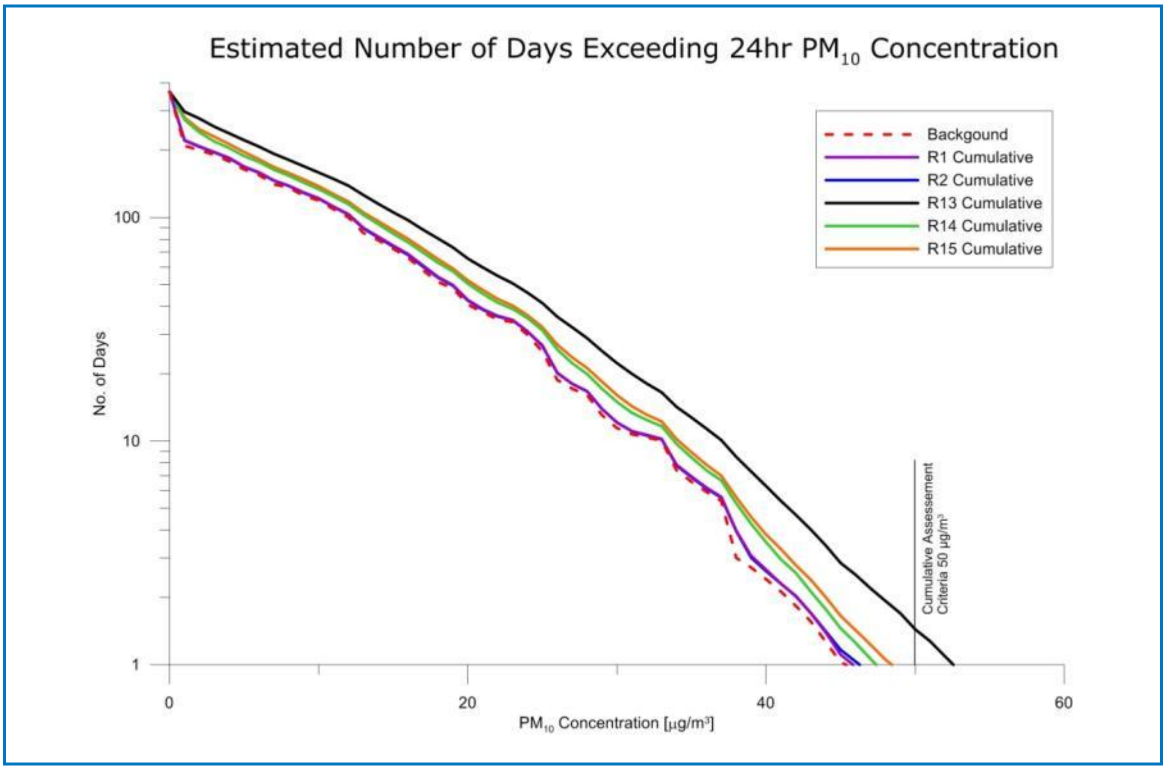


Figure 7.24: Receptors R1, R2, R13, R14 and R15 – statistical estimate of number of days exceeding 24-hr PM_{10} concentrations following Monte Carlo simulation for Year 4

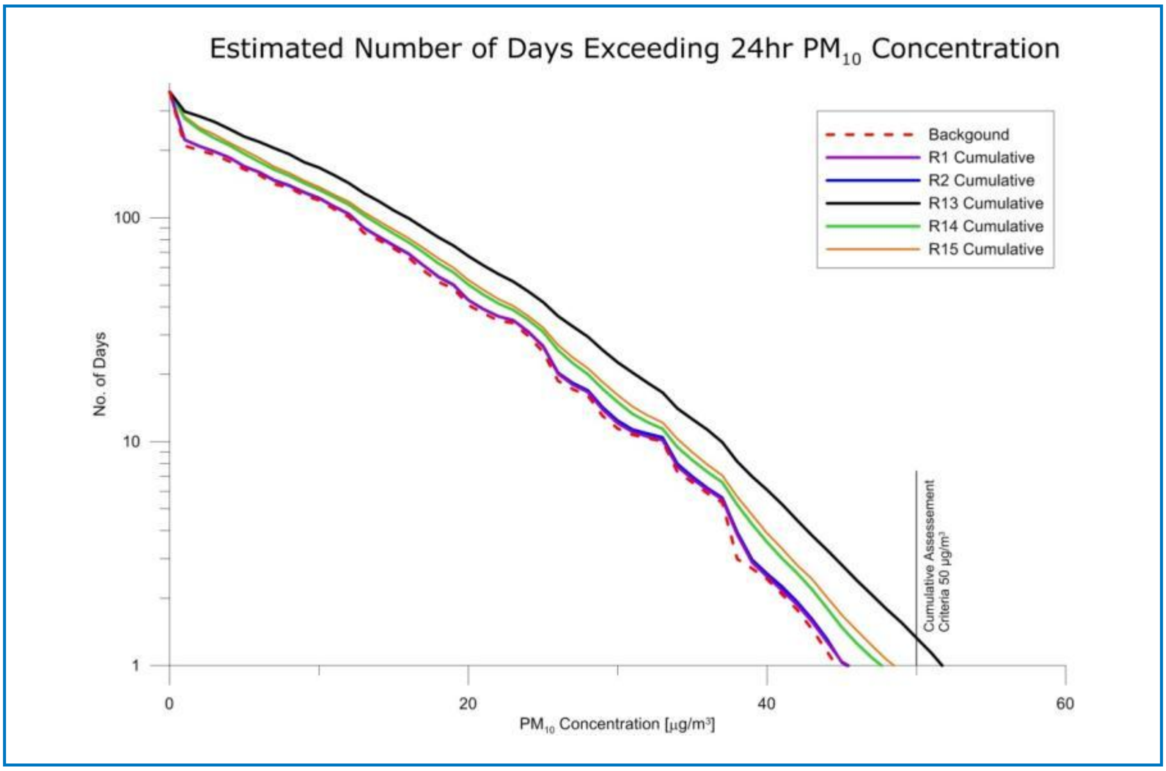


Figure 7.25: Receptors R1, R2, R13, R14 and R15 – statistical estimate of number of days exceeding 24-hr PM_{10} concentrations following Monte Carlo simulation for Year 5

Figure 7.23 to **Figure 7.25** show that existing activities in the area, rather than the Project, are the main contributors to PM_{10} concentrations. These levels will be due, in part, to existing mining operations in the region, but also other sources such as farming and regional dust events all of which are captured in the TEOM monitoring data. The Monte Carlo analysis has shown that due to the proposed LCO Modification, there is potentially only 1 day (at R13) when 50 µg/m³ may be exceeded. This is the case for all three modelled scenarios, although the probability becomes less as the mine progresses to the southeast.

Another way of interpreting these results is that the probability of the cumulative levels exceeding 50 µg/m³, is 0.3% for receptor R13. For the remaining fourteen receptors, this probability will be lower.

As the cumulative results are created from random pairings of background and modelled concentrations, it is not possible to determine meteorological conditions on particular days of exceedance.

7.5 $PM_{2.5}$ Predictions

Predictions of 24-hour and annual average $PM_{2.5}$ concentrations have been made for Years 2, 4 and 5 of the proposed extension Project. The predicted concentrations at the 15 nearest receptors are presented in **Table 7.4**.

The modelling results show that the levels predicted are well below the relative advisory standards for both 24-hour and annual averaging periods. Predicted annual average $PM_{2.5}$ concentrations are all below 1 µg/m³, and in most cases the levels are below the level which could be detected by monitoring.

The NSW EPA operates a $PM_{2.5}$ monitoring site in Muswellbrook, but data are only available from 2011. There are also $PM_{2.5}$ monitoring data available for Muswellbrook since 2005 from the Australian Nuclear

Science and Technology Organisation (ANSTO). These data show annual averages of the order of 6 μg/m³, between 2005 and 2011, and an average of the maximum 24-hour averages of 18.7 μg/m³ for the same period. The predicted concentrations at the most affected residence (R13) will still remain below the advisory reporting standards for each modelling year.

Table 7.4: Summary of predicted $PM_{2.5}$ results LCO only

Residence	24-hour average $PM_{2.5}$ (μg/m³)			Annual average $PM_{2.5}$ (μg/m³)		
	Year 2	Year 4	Year 5	Year 2	Year 4	Year 5
	Advisory reporting standard – 25 μg/m³			*Advisory reporting standard – 8 μg/m³*		
R1	3	3	4	0.1	0.1	0.1
R2	3	3	4	0.1	0.1	0.1
R3	3	3	4	0.1	0.1	0.1
R4	3	3	4	0.1	0.1	0.1
R5	3	3	4	0.1	0.1	0.1
R6	3	3	4	0.1	0.1	0.1
R7	3	3	3	0.1	0.1	0.1
R8	3	3	4	0.1	0.1	0.1
R9	2	1	2	0.0	0.1	0.1
R10	1	1	1	0.0	0.0	0.1
R11	1	1	1	0.0	0.0	0.1
R12	1	1	1	0.0	0.0	0.0
R13	6	6	4	0.7	0.8	0.9
R14	3	3	3	0.3	0.4	0.4
R15	4	4	3	0.4	0.5	0.5

7.6 Post-Blast Fume

Blasting activities have the potential to result in particulate matter emissions and fume which may include oxides of nitrogen, ammonia, nitric acid, carbon monoxide and carbon dioxide. Particulate matter emissions from blasting are included in dispersion modelling results and are controlled by adequate stemming of the blast.

Post blast fume is a product of (incomplete) combustion from a blast. Post blast fume is composed of toxic gases including NO_x which is visible as a reddish brown colour. Measures to minimise or avoid post blast fume would be implemented in accordance with Liddell's Post Blast Fume Procedure that was developed in consideration of the Code of Good Practice: Prevention and Management of Blast Generated NOx Gases in Surface Blasting (**Australian Explosives Industry and Safety Group Inc., 2011**).

The NSW Department of Planning and Infrastructure (DP&I) has requested that from 2 July 2012, all blasts be recorded, rated and reported upon request. The LCO Post Blast Fume Procedure outlines the procedures involved in preventing/mitigating, managing, recording and reporting each blast in accordance with the DP&I requirements. This document also outlines some measures taken to identify the case of post-blast fume, to be used in educating those responsible for surface blasts and minimising the likelihood of these events occurring. The document will also outline steps to be taken should an employee be exposed to these fumes and outlines the roles and accountabilities of management and other staff.

Managing fumes from blasting would involve, but not be limited to, the following measures:

- Selection of appropriate explosive products in consideration of local aspects surrounding the blast location.
- Reviewing geological conditions in the formulation of blast designs.
- Reviewing ground conditions (e.g. presence of clay or loose/broken ground).
- Minimising the time between drilling and loading, and loading and shooting of the blast.
- Consideration of meteorological conditions in blast scheduling.

7.7 Spontaneous Combustion

Spontaneous combustion occurs when coal and other carbonaceous materials undergo natural oxidation and heat up. Under the right conditions, the heat from the oxidation reaction can build up to a point where the coal will ignite and burn. For self-heating to occur, the composition of the coal must be such that low temperature oxidation can occur. Further, the material must be confined in such a way that heat from the oxidation is trapped, allowing the temperature to build up, but not so confined as to preclude the ingress of oxygen to the combustible material at a rate sufficient to promote the combustion and release of heat energy.

Once the coal reaches a high enough temperature it will liberate smoke, steam and volatile organic compounds (VOCs), some of which are odorous and can be harmful.

LCO manage spontaneous combustion in accordance with the LCO Spontaneous Combustion Management Plan (SCMP). The SCMP is a shared system between Mining Operations and the Coal Handling Preparation Plant (CHPP).

Historically, spontaneous combustion is primarily only encountered in or adjacent to the Liddell Seam, although care is taken when disposing all carbonaceous material. To that end, LCO have a number of key documents that outline controls when mining in or adjacent to spontaneous combustion areas. These documents include:

- Mining and Handling of Hot Material
- Handling of Hot Coal on the ROM
- Loading in Spontaneous Combustion and Reactive Sulphide Areas ("Hot and Reactive Zones")
- Spontaneous Combustion and Gas Detection
- Reactive Ground Procedure
- Mining above Underground Workings
- Gas Exposure Monitoring

LCO have also reviewed and updated, where necessary, existing procedures to include controls for spontaneous combustion. The Spontaneous Combustion Management Plan (**Xstrata, 2012b**) outlines a hierarchy of controls applied at LCO. These are listed as follows:

- Removal – identification of areas prone to spontaneous combustion and change of mining and spoil stockpiling to prevent outbreaks of spontaneous combustion or fire,
- Reduction – where removal of the spontaneous combustion hazard is not possible (eg in ROM stockpiles or where mining blocks have been previously created), the spontaneous combustion heated coal is cooled, stacked separately; subjected to trials of "novel" mitigating measures; or blended with other material,
- Engineering barriers – controls that minimise the impact of hot coal (such as FRAS belting); control the result of the spontaneous combustion (sprays for dust, fans for fumes) or isolation of personnel using Fit for Purpose machinery cabins,
- Procedures – are identified and prepared that are directed at: early identification of spontaneous combustion; dealing with heated materials; provision of protective or first response capacity; and preparing for / cleaning up after spontaneous combustion campaigns,
- Personnel skills and training – are documented in this Safety System and are directed at ensuring that personnel actively support the controls for spontaneous combustion at Liddell Coal Operations, and
- PPE – including gas monitors, masks, respirators and eye protection are required when directly exposed to spontaneous combustion effects.

7.8 Rail Transport

There has been much recent discussion both in the upper Hunter Valley and Newcastle concerning the potential health impacts due to dust emissions from coal wagons. These concerns have ranged from nuisance impacts to more serious impacts on human health.

The potential for health effects from coal dust emissions from rail transport has recently been studied extensively in Queensland. Queensland Rail (QR) commissioned an environmental evaluation of coal dust emissions from rolling stock in the Central Queensland Coal Industry (**Connell Hatch, 2008**). The purpose of this study was to determine the extent of the issue and identify any potential environmental harm caused by fugitive dust from coal wagons, in the context of nuisance and health impacts and to identify the potential reasonable and feasible measures that could reduce any environmental harm.

In terms of impacts on human health, the QR study concluded that there appears to be minimal risk of adverse impacts due to fugitive coal emissions from trains throughout the network, based on results of monitoring and modelling predictions (**Connell Hatch, 2008**). In terms of impacts on amenity, the results of monitoring and modelling indicate that fugitive coal dust at the edge of the rail corridor are below levels that are known to cause adverse impacts on amenity (**Connell Hatch, 2008**).

A recent report was prepared for the Australian Rail Track Corporation, which assessed particulate emissions from coal trains (**Environ, 2012**). The study compared particulate matter (PM) emissions from coal trains (loaded and unloaded) with passenger trains and freight trains. The study found that at one site there were no statistical differences in concentrations across all particulate size fractions for all train types. At the other site, it was concluded that concentrations coinciding with loaded and unloaded coal train passes are statistically higher for PM_{10} than concentrations recorded during passenger train passes. There was no statistical difference between loaded coal trains and unloaded coal trains. It is noted that PM concentrations were recorded at 3 m from the track and for short averaging periods to coincide train passes, therefore no assessment of impact can be inferred from the study.

8 GREENHOUSE GAS ASSESSMENT

8.1 Introduction

GHG 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 Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) *National Greenhouse Accounts* (NGA) *Factors 2012* (**DCCEE, 2012**).

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; CH_4 emissions from coal mines and venting); hydroflurocarbon 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 coal 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.

In the case of the Project, scope 3 emissions will include emissions associated with the extraction, processing and transport of diesel, and the transportation and combustion of product coal. 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 CO_2 and CH_4 would be the most significant GHGs for the Project. These gases are formed and released during the combustion of fuels used on-site and from fugitive emissions occurring during the mining process, due to the liberation of CH_4 from coal seams.

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 CO_2 equivalent (CO_2-e) emissions by applying the relevant global warming potential. The GHG assessment has been conducted using the NGA Factors, published by the **DCCEE (2012)**.

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

- Fuel consumption (diesel) during mining operations – scope 1;
- Release of fugitive CH_4 during mining – scope 1;
- Explosives consumption (ANFO, Heavy ANFO & Emulsion) during mining operations – 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 coal transportation – scope 3; and
- Emissions from the use of the product coal – scope 3.

A summary of the annual GHG emissions is provided in **Table 8.1**. Given that production levels remain fairly constant to those for existing operations, the GHG emissions are unlikely to change significantly (on an annual basis) to those already produced. Detailed emission calculations are provided in **Appendix C**.

Emissions from the shipping of product coal are not included in this assessment due to the uncertainties in emission estimates, including uncertainty in future export destinations and limited data on emission factors and/or fuel consumption for ocean going vessels.

It is noted that the default NGA Factor for fugitive CH_4 has been used in the GHG calculations. LCO have completed borehole sampling for the South Pit only and have provided an indication of estimated GHG emissions for the Life of Mine (LOM) for this pit. There are no data available however for the Entrance Pit. Using the NGA default factor is likely to be a conservative approach as site-specific data is often much lower than the default.

Table 8.1: Summary of Estimated CO_2-e (tonnes) – All Scopes

Year	Scope 1 Emissions (t CO_2-e)				Scope 2 Emissions (t CO_2-e)	Scope 3 Emissions (t CO_2-e)					
	Diesel	Fugitive Methane	Blasting (all types)	*Total*	Electricity	Diesel	Electricity	Energy Production	Transport via Rail	Transport via truck	*Total*
2014	119,956	317,546	4,214	*441,717*	15,920	9,095	3,256	11,219,879	10,702	31,958	*11,274,891*
2015	118,563	313,859	4,165	*436,588*	15,735	8,990	3,219	11,089,597	10,578	31,958	*11,144,341*
2016	121,722	322,222	4,276	*448,221*	16,155	9,229	3,304	11,385,081	10,860	31,958	*11,440,432*
2017	118,484	313,648	4,163	*436,295*	15,725	8,984	3,216	11,082,153	10,571	31,958	*11,136,882*
2018	119,555	316,484	4,200	*440,238*	15,867	9,065	3,246	11,182,325	10,666	31,958	*11,237,260*
2019	119,198	315,540	4,188	*438,926*	15,820	9,038	3,236	11,148,998	10,635	31,958	*11,203,864*
2020	121,583	321,853	4,271	*447,707*	16,136	9,219	3,301	11,372,028	10,847	31,958	*11,427,353*
2021	89,748	237,581	3,153	*330,482*	11,911	6,805	2,436	8,394,442	8,007	31,958	*8,443,649*
2022	89,500	236,924	3,144	*329,569*	11,878	6,786	2,430	8,371,252	7,985	31,958	*8,420,411*
2023	73,490	194,543	2,582	*270,615*	9,753	5,572	1,995	6,873,779	6,557	31,958	*6,919,861*
2024	78,910	208,889	2,772	*290,570*	10,473	5,983	2,142	7,380,667	7,040	31,958	*7,427,790*
2025	34,360	90,957	1,207	*126,524*	4,560	2,605	933	3,213,779	3,066	31,958	*3,252,341*
Total	**1,205,069**	**3,190,045**	**42,336**	**4,437,450**	**159,934**	**91,371**	**32,714**	**112,713,981**	**107,514**	**383,493**	**113,329,074**

8.3 Impacts on the Environment

According to the Intergovernmental Panel of Climate Change's (IPCC) Fourth Assessment Report, global surface temperature has increased 0.74 ± 0.18°C during the 100 years ending 2005 (**IPCC, 2007a**). The IPCC has determined "*most of the observed increase in globally averaged temperatures since the mid-twentieth century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations*". "Very likely" is defined by the IPCC as greater than 90% probability of occurrence (**IPCC, 2007b**).

Climate change projections specific to Australia have been determined by the CSIRO, based on the following global emissions scenarios predicted by the IPCC (**CSIRO, 2007**):

- A1F1 (high emissions scenario) – assumes very rapid economic growth, a global population that peaks in mid-century and technological change that is fossil fuel intensive.
- A1B (mid emissions scenario) – assumes the same economic and population growth as A1F1, with a balance between fossil and non-fossil fuel intensive technological changes.
- B1 (low emissions scenario) – assumes the same economic and population growth as A1F1, with a rapid change towards clean and resource efficient technologies.

For the global emissions scenarios described above, the projected changes in annual temperature relative to 1990 levels for Australian cities for 2030 and 2070 are presented in **Table 8.2** as determined by the **CSIRO (2007)**. The towns/cities presented in **Table 8.2** are those closest to the Project for which results are available.

Table 8.2: Projected Changes in Annual Temperature (relative to 1990)

Location	2030 - A1B (mid-range emissions scenario)	2070 - B1 (low emissions scenario)	2070 - A1F1 (high emissions scenario)
	Temperature (°C)		
Brisbane	0.7 - 1.4	1.1 - 2.3	2.1 - 4.4
Dubbo	0.7 - 1.5	1.2 - 2.5	2.2 - 4.8
St George (Queensland)	0.7 - 1.6	1.2 - 2.7	2.4 - 5.2
Sydney	0.6 - 1.3	1.1 - 2.2	2.1 - 4.3

Notes: Range of values represents the 10th and 90th percentile results.
For 2030, only A1B results are shown as there is little variation in projected results for the global emission scenarios A1B, B1 and A1F1 (**CSIRO, 2007**).

Source: **CSIRO (2007)** *Climate Change in Australia – Technical Report 2007*, Commonwealth Scientific and Industrial Research Organisation.

The CSIRO also details projected changes to other meteorological parameters (for example rainfall, potential evaporation, wind speed, relative humidity and solar radiation) and the predicted changes to the prevalence of extreme weather events (for example droughts, bush fires and cyclones).

The potential social and economic impacts of climate change to Australia are detailed in the Garnaut Climate Change Review (**Garnaut, 2008**), which draws on IPCC assessment work and the CSIRO climate projections. The Garnaut review details the negative and positive impacts associated with predicted climate change with respect to:

- Agricultural productivity
- Water supply infrastructure
- Urban water supplies
- Buildings in coastal settlements
- Temperature related deaths
- Ecosystems and biodiversity
- Geopolitical stability and the Asia-Pacific region

The Project's contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global GHG emissions. Average annual scope 1 emissions from the

Project (0.4 million tonnes [Mt] CO_2-e) would represent approximately 0.06% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global GHG emissions, given that Australia contributed approximately 1.5% of global GHG emissions in 2005 (**Commonwealth of Australia, 2011**).

A comparison of predicted annual GHG emissions from the Project with global, Australian and NSW emissions inventories are presented in **Table 8.3**.

Table 8.3: Comparison of Greenhouse Gas Emissions

Geographic coverage	Source coverage	Timescale	Emission Mt CO_2-e	Reference
Project	Scope 1 only	Average annual	0.4	This report.
Global	Consumption of fossil fuels	Total since industrialisation 1750 - 1994	865,000	IPCC (2007a). Figure 7.3 converted from Carbon unit basis to CO_2 basis. Error is stated greater than ±20%.
Global	CO_2-e emissions	2005	35,000	Based on Australia representing 1.5% of global emissions (Commonwealth of Australia, 2011). Australian National Greenhouse Gas Inventory (2005) taken from http://www.ageis.greenhouse.gov.au/
Global	CO_2-e emission increase 2004 to 2005	2005	733	IPCC (2007a). From tabulated data presented in Table 7.1 on the basis of an additional 733 Mt/a. Data converted from Carbon unit basis to CO_2 basis.
Australia	1990 Base	1990	547.7	Taken from the National Greenhouse Gas Inventory (2009) http://www.ageis.greenhouse.gov.au/
Australia	Kyoto target	Average annual 2008 - 2012	591.5	Based on 1990 net emissions multiplied by 108% Australia's Kyoto emissions target.
Australia	Total	2009	564.5	Taken from the National Greenhouse Gas Inventory (2009) http://www.ageis.greenhouse.gov.au/
NSW	Total	2009	160.5	Taken from the National Greenhouse Gas Inventory (2009) http://www.ageis.greenhouse.gov.au/

The commitment from the Australian Government to reduce GHG emissions is proposed to be achieved through the introduction of the Australian Government's proposed carbon pricing mechanisms which came into effect on 1 July 2012. This will involve a fixed price on GHG emissions, with no cap on Australia's GHG emissions, or emissions from individual facilities **(Commonwealth of Australia, 2011)**.

From 1 July 2015 an emissions trading scheme is proposed to be implemented. As such, Australia's GHG emissions, inclusive of emissions associated with the Project, would be capped at a level specified by the Australian Government. Under the emissions trading scheme, there will specifically be no limit on the level of GHG emissions from individual facilities, with the incentive for facilities to reduce their GHG emissions driven by the carbon pricing mechanism **(Commonwealth of Australia, 2011)**.

It is expected that the Project would exceed the facility threshold of 25,000 t CO_2-e per annum for participation in the carbon pricing mechanisms, and as such scope 1 GHG emissions from the Project would be subject to the carbon pricing mechanism. As such, LCO would directly contribute to the revenue generated by the carbon pricing mechanism, which is to be used to fund the following initiatives designed to reduce Australia's GHG emissions **(Commonwealth of Australia, 2011)**:

- $1.2 billion Clean Technology Program to improve energy efficiency in manufacturing industries and support research and development in low-pollution technologies.
- $10 billion Clean Energy Finance Corporation to invest in renewable energy, low-pollution and energy efficiency technologies.
- $946 million Biodiversity Fund (over the first six years) to protect biodiverse carbon stores and secure environmental outcomes from carbon farming.

In addition to contributing to these initiatives, LCO would implement Project-specific GHG mitigation measures, as described in **Section 8.5**.

8.4 Greenhouse Gas Emissions Intensity

The estimated GHG emissions intensity of the Project is approximately 0.11 t CO_2-e/t saleable coal (this includes all scope 1 emissions) (**Figure 8.1**).

The largest source of scope 1 GHG emissions are fugitive methane emissions (72%) (refer **Table 8.1**).

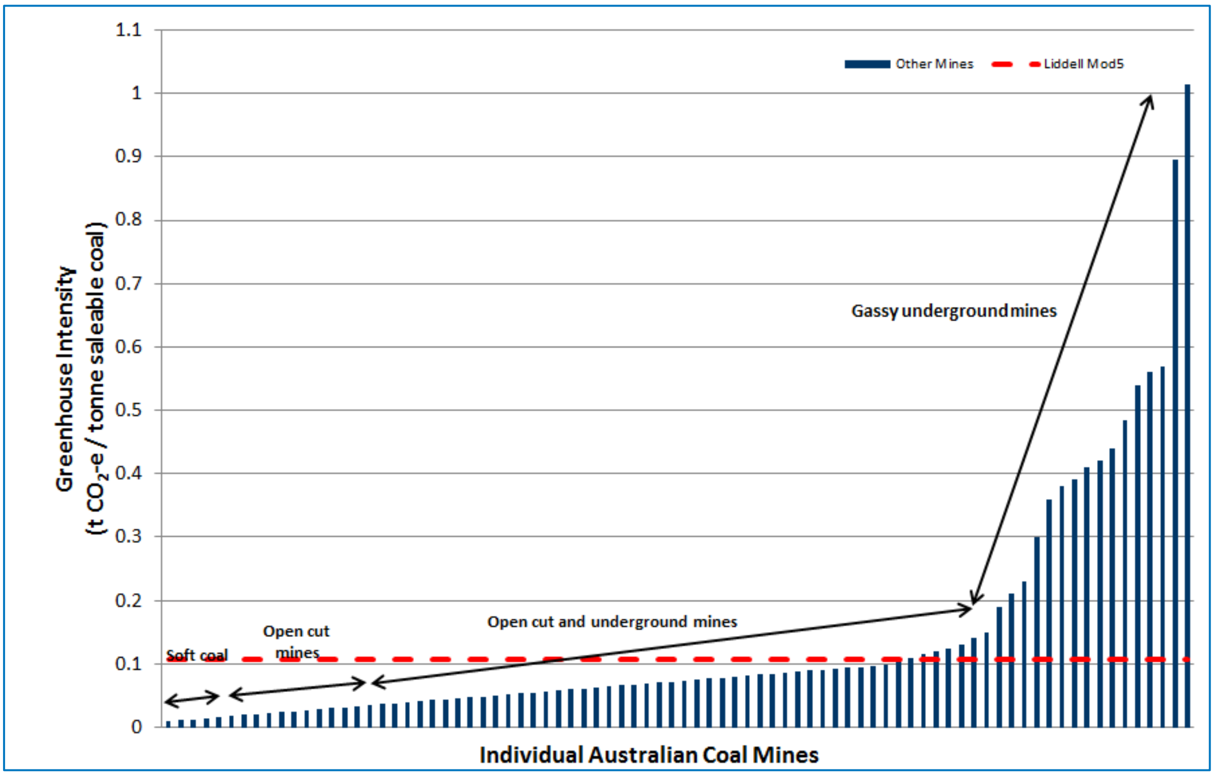


Figure 8.1: Greenhouse Gas Intensity Comparison

8.5 Greenhouse Gas Management

LCO have committed to implementing a number of reasonable and feasible measures to minimise GHG emissions from the Project. General energy saving commitments include:

- Improving energy use and efficiency and reducing GHG emissions from the mining, processing and use of coal
- Consideration of the use of alternative fuels where economically and practically feasible
- Review of mining practices to minimise double handling of materials and ensuring that coal and overburden haulage is undertaken using the most efficient routes
- Ongoing scheduled and preventative maintenance to ensure that diesel and electrically powered plants operate efficiently

- Develop targets for greenhouse gas emissions and energy use on-site and monitor and report against these

The effectiveness of these measures to reduce GHG emissions (and energy consumption) will be monitored, as LCO annually estimate GHG emissions and energy consumption in accordance with National Greenhouse and Energy Reporting and Energy Efficiency Operations requirements.

Site specific commitments have been made in the form of Energy Management Actions and Projects, and the identification of new Energy Savings Opportunities, outlined in Xstrata's *Energy Efficiency Review Workshop Outcomes Report: Liddell* (**Xstrata Coal NSW, 2011**). These measures are summarised below:

- LCO have adopted the Xstrata corporate commitment energy policy
- LCO adopts Xstrata's energy standards for purchase of new motors
- Timers installed on air conditioning units
- Sensors installed at the water fill point to operate pump on demand
- Funds will be allocated to energy management projects in the 2013 budget
- New lights and controls installed at the CHPP
- Annual review of energy projects
- Conduct a baseline study of energy use
- Reduce truck and machinery idle times
- Review lighting plant efficiency
- Reclaim system upgrade

9 CONCLUSIONS

Pacific Environment has completed an Air Quality and Greenhouse Gas Assessment for the proposed modification of mining operations at LCO. The assessment was prepared in accordance with the relevant regulatory requirements.

The proposed mining sequence for the Project has been analysed and detailed emissions inventories have been prepared for three key scenarios representative of worst-case operations. Dispersion modelling was conducted for each scenario to predict the ground level concentrations for all relevant particulate matter and deposited dust emissions.

Cumulative impacts were also considered including other nearby mining operations as well as other non-mining sources.

The modelling indicates that there are not predicted to be any exceedances of the annual average PM_{10}, TSP or dust deposition criteria either for the Project alone or cumulatively, for any of the three scenarios modelled.

A Monte Carlo analysis of the 24-hour average cumulative PM_{10} modelling results, has shown that there is a very minor chance of the levels at Residence 13 exceeding the 50 µg/m^3 criterion. The probability of this occurring is less than 0.3% or 1 day per year.

A GHG assessment for the Project indicates that average annual direct emissions from the Project (0.4 Mt CO_2-e) would represent approximately 0.06% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global greenhouse emissions.

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Appendix A Emissions Inventories

Table A1: TSP emissions inventory for the Liddell Modification Project – Year 2

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	Variable 6	units
Topsoil - Dozers on topsoil	14,785	1,000	h/y	14.8	kg/h	2.2	moisture content in %	10	silt content								
Topsoil - loading	80	50,000	t/y	0.0016	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
Topsoil - haulage (to rehab), watering used on haul road	504	50,000	t/y	0.067	kg/t	70	payload (tonnes)	77	Average vehicle mass in tonnes	2.0	km/return trip	2.35	kg/VKT	3	% silt content	85	% control
Topsoil - unloading	80	50,000	t/y	0.0016	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
OB - Drilling in Entrance Pit	319	1,800	holes/y	0.59	kg/hole											70	% control
OB - Blasting in Entrance Pit	2,021	5	blasts/y	404	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in Entrance Pit	9,923	480	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in Entrance Pit	4,261	1,854,012	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump Entrance Pit	25,967	1,854,012	t/y	0.093	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	5.5	km/return trip	4.86	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump Entrance Pit	4,261	1,854,012	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps Entrance Pit	4,961	240	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
OB - Drilling in South Pit	10,832	61,200	holes/y	0.59	kg/hole											70	% control
OB - Blasting in South Pit	68,708	170	blasts/y	404	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in South Pit	486,214	23,520	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in South Pit	208,789	90,846,608	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump South pit	1,272,393	90,846,608	t/y	0.093	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	5.5	km/return trip	4.86	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump South Pit	208,789	90,846,608	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps South Pit	243,107	11,760	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
CL - Drilling in Entrance Pit	0	0	holes/y	0.10	kg/hole											70	% control
CL - Blasting in Entrance Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in Entrance Pit	5,922	360	h/y	16.5	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in Entrance Pit	10,008	209,239	t/y	0.04783	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from Entrance Pit	3,765	209,239	t/y	0.120	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.6	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
CL - Drilling in South Pit	0	0	holes/y	0.10	kg/hole											70	% control
CL - Blasting in South Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in South Pit	191,492	11,640	h/y	16.5	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in South Pit	323,604	6,765,407	t/y	0.04783	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from South Pit	121,728	6,765,407	t/y	0.120	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.6	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
Dozers on rehab	44,355	3,000	h/y	14.8	kg/h	2.2	moisture content in %	10	silt content								
Dozers pushing coal at ROM pad	98,707	6,000	h/y	16.5	kg/h	8	moisture content in %	5	silt content								
FELs Loading ROM to ROM pad or hopper	166,806	6,974,647	t/y	0.04783	kg/t	8	moisture content in %									50	% control
Crushing ROM coal at the CHPP	9,416	6,974,647	t/y	0.00270	kg/t											50	% control
Loading product to stockpiles	206	4,533,520	t/y	0.00009	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	10.0	moisture content in %							50	% control
Hauling tailings to Durham Pit	19,608	1,220,563	t/y	0.107	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.0	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
Hauling rejects to South Pit dump	21,961	1,220,563	t/y	0.120	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.6	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
Wind erosion on active waste dump area - Entrance	14,191	16.2	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on active waste dump area - South	111,077	126.8	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - Entrance	30,660	35.0	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - South	103,806	118.5	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on active rehab area	61,320	70.0	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion and maintenance on product stockpiles	118,260	5.0	ha	5.4	kg/ha/h	8,760	h/y	3	m/s							50	% control
Graders	11,078	18,000	h/y	0.6	kg/h	8	Speed of grader km/h	3	graders								

Table A2: PM_{10} emissions inventory for the Liddell Modification Project – Year 2

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	Variable 6	units
Topsoil - Dozers on topsoil	3,539	1,000	h/y	3.5	kg/h	2.2	moisture content in %	10	silt content								
Topsoil - loading	38	50,000	t/y	0.0008	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
Topsoil - haulage (to rehab), watering used on haul road	117	50,000	t/y	0.016	kg/t	70	payload (tonnes)	77	Average vehicle mass in tonnes	2.0	km/return trip	0.55	kg/VKT	3	% silt content	85	% control
Topsoil - unloading	38	50,000	t/y	0.0008	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
OB - Drilling in Entrance Pit	166	1,800	holes/y	0.31	kg/hole											70	% control
OB - Blasting in Entrance Pit	1,051	5	blasts/y	210	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in Entrance Pit	2,437	480	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in Entrance Pit	2,015	1,854,012	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump Entrance Pit	6,029	1,854,012	t/y	0.022	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	5.5	km/return trip	1.13	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump Entrance Pit	2,015	1,854,012	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps Entrance Pit	1,219	240	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
OB - Drilling in South Pit	5,633	61,200	holes/y	0.31	kg/hole											70	% control
OB - Blasting in South Pit	35,728	170	blasts/y	210	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in South Pit	119,422	23,520	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in South Pit	98,751	90,846,608	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump South pit	295,437	90,846,608	t/y	0.022	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	5.5	km/return trip	1.13	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump South Pit	98,751	90,846,608	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps South Pit	59,711	11,760	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
CL - Drilling in Entrance Pit	0	0	holes/y	0.31	kg/hole											70	% control
CL - Blasting in Entrance Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in Entrance Pit	1,386	360	h/y	3.9	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in Entrance Pit	1,439	209,239	t/y	0.00688	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from Entrance Pit	874	209,239	t/y	0.028	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.6	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
CL - Drilling in South Pit	0	0	holes/y	0.31	kg/hole											70	% control
CL - Blasting in South Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in South Pit	44,821	11,640	h/y	3.9	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in South Pit	46,539	6,765,407	t/y	0.00688	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from South Pit	125	6,422,292	t/y	0.0001	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.6	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
Dozers on rehab	10,617	3,000	h/y	3.5	kg/h	2.2	moisture content in %	10	silt content								
Dozers pushing coal at ROM pad	23,104	6,000	h/y	3.9	kg/h	8	moisture content in %	5	silt content								
FELs Loading ROM to ROM pad or hopper	23,989	6,974,647	t/y	0.00688	kg/t	8	moisture content in %									50	% control
Crushing ROM coal at the CHPP	4,185	6,974,647	t/y	0.00120	kg/t											50	% control
Loading product to stockpiles	206	4,533,520	t/y	0.00009	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	10.0	moisture content in %							50	% control
Hauling rejects to Durham Pit	4,553	1,220,563	t/y	0.025	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.0	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
Hauling rejects to South Pit dump	5,099	1,220,563	t/y	0.028	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.6	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
Wind erosion on active waste dump area - Entrance	7,096	16.2	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on active waste dump area - South	55,538	126.8	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - Entrance	15,330	35.0	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - South	51,903	118.5	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on active rehab area	30,660	70.0	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion and maintenance on product stockpiles	59,130	5.0	ha	2.7	kg/ha/h	8,760	h/y	3	m/s							50	% control
Graders	3,871	18,000	h/y	0.2	kg/h	8	Speed of grader km/h	3	graders								

Table A3: TSP emissions inventory for the Liddell Modification Project – Year 4

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	Variable 6	units
Topsoil - Dozers on topsoil	14,785	1,000	h/y	14.8	kg/h	2.2	moisture content in %	10	silt content								
Topsoil - loading	80	50,000	t/y	0.0016	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
Topsoil - haulage (to rehab), watering used on haul road	504	50,000	t/y	0.067	kg/t	70	payload (tonnes)	77	Average vehicle mass in tonnes	2.0	km/return trip	2.35	kg/VKT	3	% silt content	85	% control
Topsoil - unloading	80	50,000	t/y	0.0016	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
OB - Drilling in Entrance Pit	319	1,800	holes/y	0.59	kg/hole											70	% control
OB - Blasting in Entrance Pit	2,021	5	blasts/y	404	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in Entrance Pit	14,884	720	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in Entrance Pit	6,435	2,799,821	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump Entrance Pit	52,761	2,799,821	t/y	0.126	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	7.4	km/return trip	4.86	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump Entrance Pit	6,435	2,799,821	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps Entrance Pit	7,442	360	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
OB - Drilling in South Pit	10,832	61,200	holes/y	0.59	kg/hole											70	% control
OB - Blasting in South Pit	68,708	170	blasts/y	404	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in South Pit	481,252	23,280	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in South Pit	208,055	90,527,560	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump South pit	1,705,935	90,527,560	t/y	0.126	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	7.4	km/return trip	4.86	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump South Pit	208,055	90,527,560	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps South Pit	240,626	11,640	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
CL - Drilling in Entrance Pit	0	0	holes/y	0.10	kg/hole											70	% control
CL - Blasting in Entrance Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in Entrance Pit	0	0	h/y	16.5	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in Entrance Pit	0	0	t/y	0.04783	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from Entrance Pit	0	0	t/y	0.000	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	0.0	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
CL - Drilling in South Pit	0	0	holes/y	0.10	kg/hole											70	% control
CL - Blasting in South Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in South Pit	197,414	12,000	h/y	16.5	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in South Pit	333,388	6,969,965	t/y	0.04783	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from South Pit	190,353	6,969,965	t/y	0.182	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	8.5	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
Dozers on rehab	44,355	3,000	h/y	14.8	kg/h	2.2	moisture content in %	10	silt content								
Dozers pushing coal at ROM pad	98,707	6,000	h/y	16.5	kg/h	8	moisture content in %	5	silt content								
FELs Loading ROM to ROM pad or hopper	166,694	6,969,965	t/y	0.04783	kg/t	8	moisture content in %									50	% control
Crushing ROM coal at the CHPP	9,409	6,969,965	t/y	0.00270	kg/t											50	% control
Loading product to stockpiles	206	4,530,477	t/y	0.00009	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	10.0	moisture content in %							50	% control
Hauling talings to Durham Pit	19,595	1,219,744	t/y	0.107	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.0	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
Hauling rejcts to South Pit dump	21,947	1,219,744	t/y	0.120	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.6	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
Wind erosion on active waste dump area - Entrance	28,820	32.9	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on active waste dump area - South	100,740	115.0	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - Entrance	55,425	63.3	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - South	93,539	106.8	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on active rehab area	43,800	50.0	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion and maintenance on product stockpiles	118,260	5.0	ha	5.4	kg/ha/h	8,760	h/y	3	m/s							50	% control
Graders	11,078	18,000	h/y	0.6	kg/h	8	Speed of grader km/h	3	graders								

Table A4: PM_{10} emissions inventory for the Liddell Modification Project – Year 4

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	Variable 6	units
Topsoil - Dozers on topsoil	3,539	1,000	h/y	3.5	kg/h	2.2	moisture content in %	10	silt content								
Topsoil - loading	38	50,000	t/y	0.0008	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
Topsoil - haulage (to rehab), watering used on haul road	117	50,000	t/y	0.016	kg/t	70	payload (tonnes)	77	Average vehicle mass in tonnes	2.0	km/return trip	0.55	kg/VKT	3	% silt content	85	% control
Topsoil - unloading	38	50,000	t/y	0.0008	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
OB - Drilling in Entrance Pit	166	1,800	holes/y	0.31	kg/hole											70	% control
OB - Blasting in Entrance Pit	1,051	5	blasts/y	210	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in Entrance Pit	3,656	720	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in Entrance Pit	3,043	2,799,821	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump Entrance Pit	12,251	2,799,821	t/y	0.029	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	7.4	km/return trip	1.13	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump Entrance Pit	3,043	2,799,821	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps Entrance Pit	1,828	360	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
OB - Drilling in South Pit	5,633	61,200	holes/y	0.31	kg/hole											70	% control
OB - Blasting in South Pit	35,728	170	blasts/y	210	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in South Pit	118,203	23,280	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in South Pit	98,405	90,527,560	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump South pit	396,101	90,527,560	t/y	0.029	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	7.4	km/return trip	1.13	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump South Pit	98,405	90,527,560	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps South Pit	59,101	11,640	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
CL - Drilling in Entrance Pit	0	0	holes/y	0.31	kg/hole											70	% control
CL - Blasting in Entrance Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in Entrance Pit	0	0	h/y	3.9	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in Entrance Pit	0	0	t/y	0.00688	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from Entrance Pit	0	0	t/y	0.000	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	0.0	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
CL - Drilling in South Pit	0	0	holes/y	0.31	kg/hole											70	% control
CL - Blasting in South Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in South Pit	46,208	12,000	h/y	3.9	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in South Pit	47,947	6,969,965	t/y	0.00688	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from South Pit	135	6,969,965	t/y	0.0001	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	8.5	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
Dozers on rehab	10,617	3,000	h/y	3.5	kg/h	2.2	moisture content in %	10	silt content								
Dozers pushing coal at ROM pad	23,104	6,000	h/y	3.9	kg/h	8	moisture content in %	5	silt content								
FELs Loading ROM to ROM pad or hopper	23,973	6,969,965	t/y	0.00688	kg/t	8	moisture content in %									50	% control
Crushing ROM coal at the CHPP	4,182	6,969,965	t/y	0.00120	kg/t											50	% control
Loading product to stockpiles	206	4,530,477	t/y	0.00009	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	10.0	moisture content in %							50	% control
Hauling talings to Durham Pit	4,550	1,219,744	t/y	0.025	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.0	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
Hauling rejcts to South Pit dump	5,096	1,219,744	t/y	0.028	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.6	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
Wind erosion on active waste dump area - Entrance	14,410	32.9	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on active waste dump area - South	50,370	115.0	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - Entrance	27,712	63.3	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - South	46,770	106.8	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on active rehab area	21,900	50.0	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion and maintenance on product stockpiles	59,130	5.0	ha	2.7	kg/ha/h	8,760	h/y	3	m/s							50	% control
Graders	3,871	18,000	h/y	0.2	kg/h	8	Speed of grader km/h	3	graders								

Table A5: TSP emissions inventory for the Liddell Modification Project – Year 5

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	Variable 6	units
Topsoil - Dozers on topsoil	14,785	1,000	h/y	14.8	kg/h	2.2	moisture content in %	10	silt content								
Topsoil - loading	80	50,000	t/y	0.0016	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
Topsoil - haulage (to rehab), watering used on haul road	504	50,000	t/y	0.067	kg/t	70	payload (tonnes)	77	Average vehicle mass in tonnes	2.0	km/return trip	2.35	kg/VKT	3	% silt content	85	% control
Topsoil - unloading	80	50,000	t/y	0.0016	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
OB - Drilling in Entrance Pit	4,588	25,920	holes/y	0.59	kg/hole											70	% control
OB - Blasting in Entrance Pit	29,100	72	blasts/y	404	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in Entrance Pit	203,416	9,840	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in Entrance Pit	89,116	38,775,372	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump Entrance Pit	552,960	38,775,372	t/y	0.095	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	5.6	km/return trip	4.86	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump Entrance Pit	89,116	38,775,372	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps Entrance Pit	101,708	4,920	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
OB - Drilling in South Pit	6,563	37,080	holes/y	0.59	kg/hole											70	% control
OB - Blasting in South Pit	41,629	103	blasts/y	404	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in South Pit	292,720	14,160	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in South Pit	128,240	55,798,706	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump South pit	795,723	55,798,706	t/y	0.095	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	5.6	km/return trip	4.86	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump South Pit	128,240	55,798,706	t/y	0.0023	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps South Pit	146,360	7,080	h/y	20.7	kg/h	1.7	moisture content in %	10	silt content								
CL - Drilling in Entrance Pit	0	0	holes/y	0.10	kg/hole											70	% control
CL - Blasting in Entrance Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in Entrance Pit	61,198	3,720	h/y	16.5	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in Entrance Pit	104,285	2,180,220	t/y	0.04783	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from Entrance Pit	77,055	2,180,220	t/y	0.236	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	11.0	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
CL - Drilling in South Pit	0	0	holes/y	0.10	kg/hole											70	% control
CL - Blasting in South Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in South Pit	136,216	8,280	h/y	16.5	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in South Pit	232,117	4,852,747	t/y	0.04783	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from South Pit	171,510	4,852,747	t/y	0.236	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	11.0	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
Dozers on rehab	44,355	3,000	h/y	14.8	kg/h	2.2	moisture content in %	10	silt content								
Dozers pushing coal at ROM pad	98,707	6,000	h/y	16.5	kg/h	8	moisture content in %	5	silt content								
FELs Loading ROM to ROM pad or hopper	168,201	7,032,967	t/y	0.04783	kg/t	8	moisture content in %									50	% control
Crushing ROM coal at the CHPP	9,495	7,032,967	t/y	0.00270	kg/t											50	% control
Loading product to stockpiles	208	4,571,429	t/y	0.00009	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	10.0	moisture content in %							50	% control
Hauling tailings to Antiene North	30,054	1,230,769	t/y	0.163	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	7.6	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
Hauling Rejects to South Pit dump	22,145	1,230,769	t/y	0.120	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.6	km/return trip	3.88	kg/VKT	3	% silt content	85	% control
Wind erosion on active waste dump area - Entrance	28,820	32.9	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on active waste dump area - South	104,419	119.2	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - Entrance	76,037	86.8	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - South	67,890	77.5	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion on active rehab area	21,900	25.0	ha	0.1	kg/ha/h	8,760	h/y										
Wind erosion and maintenance on product stockpiles	118,260	5.0	ha	5.4	kg/ha/h	8,760	h/y	3	m/s							50	% control
Graders	11,078	18,000	h/y	0.6	kg/h	8	Speed of grader km/h	3	graders								

Table A6: PM_{10} emissions inventory for the Liddell Modification Project – Year 5

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	Variable 6	units
Topsoil - Dozers on topsoil	3,539	1,000	h/y	3.5	kg/h	2.2	moisture content in %	10	silt content								
Topsoil - loading	38	50,000	t/y	0.0008	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
Topsoil - haulage (to rehab), watering used on haul road	117	50,000	t/y	0.016	kg/t	70	payload (tonnes)	77	Average vehicle mass in tonnes	2.0	km/return trip	0.55	kg/VKT	3	% silt content	85	% control
Topsoil - unloading	38	50,000	t/y	0.0008	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	2.2	moisture content in %								
OB - Drilling in Entrance Pit	2,386	25,920	holes/y	0.31	kg/hole											70	% control
OB - Blasting in Entrance Pit	15,132	72	blasts/y	210	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in Entrance Pit	49,962	9,840	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in Entrance Pit	42,149	38,775,372	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump Entrance Pit	128,392	38,775,372	t/y	0.022	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	5.6	km/return trip	1.13	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump Entrance Pit	42,149	38,775,372	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps Entrance Pit	24,981	4,920	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
OB - Drilling in South Pit	3,413	37,080	holes/y	0.31	kg/hole											70	% control
OB - Blasting in South Pit	21,647	103	blasts/y	210	kg/blast	15,000	Area of blast in square metres										
OB - Dozers on overburden in South Pit	71,897	14,160	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck in South Pit	60,654	55,798,706	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Hauling to waste dump South pit	184,759	55,798,706	t/y	0.022	kg/t	286	payload (tonnes)	385	Average vehicle mass in tonnes	5.6	km/return trip	1.13	kg/VKT	3	% silt content	85	% control
OB - Unloading at waste dump South Pit	60,654	55,798,706	t/y	0.0011	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	1.7	moisture content in %								
OB - Dozers on waste dumps South Pit	35,948	7,080	h/y	5.1	kg/h	1.7	moisture content in %	10	silt content								
CL - Drilling in Entrance Pit	0	0	holes/y	0.31	kg/hole											70	% control
CL - Blasting in Entrance Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in Entrance Pit	14,324	3,720	h/y	3.9	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in Entrance Pit	14,998	2,180,220	t/y	0.00688	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from Entrance Pit	17,891	2,180,220	t/y	0.055	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	11.0	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
CL - Drilling in South Pit	0	0	holes/y	0.31	kg/hole											70	% control
CL - Blasting in South Pit	0	0	blasts/y	0	kg/blast	0	Area of blast in square metres										
CL - Dozers ripping coal in South Pit	31,883	8,280	h/y	3.9	kg/h	8	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks in South Pit	33,382	4,852,747	t/y	0.00688	kg/t	8	moisture content in %										
CL - Hauling ROM to CHPP from South Pit	94	4,852,747	t/y	0.0001	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	11.0	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
Dozers on rehab	10,617	3,000	h/y	3.5	kg/h	2.2	moisture content in %	10	silt content								
Dozers pushing coal at ROM pad	23,104	6,000	h/y	3.9	kg/h	8	moisture content in %	5	silt content								
FELs Loading ROM to ROM pad or hopper	24,190	7,032,967	t/y	0.00688	kg/t	8	moisture content in %									50	% control
Crushing ROM coal at the CHPP	4,220	7,032,967	t/y	0.00120	kg/t											50	% control
Loading product to stockpiles	208	4,571,429	t/y	0.00009	kg/t	1.546	average of (wind speed/2.2)^1.3 in m/s	10.0	moisture content in %							50	% control
Hauling tailings to Antiene North	6,978	1,230,769	t/y	0.038	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	7.6	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
Hauling Rejects to South Pit dump	5,142	1,230,769	t/y	0.028	kg/t	181	payload (tonnes)	234	Average vehicle mass in tonnes	5.6	km/return trip	0.90	kg/VKT	3	% silt content	85	% control
Wind erosion on active waste dump area - Entrance	14,410	32.9	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on active waste dump area - South	52,210	119.2	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - Entrance	38,018	86.8	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on exposed pit area - South	33,945	77.5	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion on active rehab area	10,950	25.0	ha	0.05	kg/ha/h	8,760	h/y										
Wind erosion and maintenance on product stockpiles	59,130	5.0	ha	2.7	kg/ha/h	8,760	h/y	3	m/s							50	% control
Graders	3,871	18,000	h/y	0.2	kg/h	8	Speed of grader km/h	3	graders								

Appendix B 2010 Emission Estimates For Neighbouring Mines

Emission estimates for LCO and nearby mines – 2010

Detailed information was available on the mining operations at LCO for 2010. With this information it was possible to model these and nearby mining 2010 operations and compare those results with contemporaneous monitoring data, in order to estimate the contributions from non-modelled sources, as described in **Section 6.5**.

LCO operations

The Mt Owen, Glendell and Ravensworth East mining operations for 2010 were analysed and detailed emissions inventories were prepared for that year. These estimates are listed by activity in **Table B1**.

Table B1: Summary of estimated TSP emissions from 2010 operations (kg/y)

Activity	LCO
Topsoil - Dozers on topsoil	14,785
Topsoil - loading	80
Topsoil - haulage (to rehab), watering used on haul road	504
Topsoil - unloading	80
OB - Drilling in Entrance Pit	127
OB - Blasting in Entrance Pit	808
OB - Dozers on overburden in Entrance Pit	4,961
OB - FEL loading OB to haul truck in Entrance Pit	2,096
OB - Hauling to waste dump Entrance Pit	12,774
OB - Unloading at waste dump Entrance Pit	2,096
OB - Dozers on waste dumps Entrance Pit	3,760
OB - Drilling in South Pit	10,832
OB - Blasting in South Pit	68,708
OB - Dozers on overburden in South Pit	491,175
OB - FEL loading OB to haul truck in South Pit	207,515
OB - Hauling to waste dump South pit	1,264,634
OB - Unloading at waste dump South Pit	207,515
OB - Dozers on waste dumps South Pit	245,587
CL - Drilling in Entrance Pit	-
CL - Blasting in Entrance Pit	-
CL - Dozers ripping coal in Entrance Pit	1,974
CL - FELs Loading ROM to trucks in Entrance Pit	2,659
CL - Hauling ROM to CHPP from Entrance Pit	1,000
CL - Drilling in South Pit	-
CL - Blasting in South Pit	-
CL - Dozers ripping coal in South Pit	195,440
CL - FELs Loading ROM to trucks in South Pit	263,239
CL - Hauling ROM to CHPP from South Pit	99,021
Dozers on rehab	44,355
Dozers pushing coal at ROM pad	98,707
FELs Loading ROM to ROM pad or hopper	132,949
Crushing ROM coal at the CHPP	7,505
Loading product to stockpiles	214
Hauling rejects to onsite landfill	13,799
Unloading rejects to landfill	8,411
Topsoil - Dozers on topsoil	14,785
Topsoil - loading	80
Topsoil - haulage (to rehab), watering used on haul road	504
Topsoil - unloading	80
Wind erosion on active waste dump area - Entrance	65,437
Wind erosion on active waste dump area - South	136,919
Wind erosion on exposed pit area - Entrance	13,841
Wind erosion on exposed pit area - South	97,832
Wind erosion on active rehab area	3,592
Wind erosion and maintenance on product stockpiles	118,260
Graders	11,078
TOTAL (kg/y)	3,854,272

Other Neighbouring mines

Mining production rates as well as pit, dump and haulage locations for 2010 were also analysed for each of the nearby mines operating at that time. These mines/pits included Mount Arthur, Drayton, Ravensworth Narama, Ashton NE Open Cut, HVO North (West Pit), Glendell, Mount Owen and Ravensworth East. Emission estimates for these nearby mines were obtained from the estimates made in their individual EAs, and are summarised in **Table B2**.

Modelling sources for these mines have been located at the apparent points of major emission, as estimated from the locations of major dust sources shown in the EAs.

Table B2: Estimated TSP emissions from nearby modelled mines in 2010

Mine/Pit	TSP emissions for 2010 (kg/y)
Mount Arthur	18,591,695
Drayton	6,463,544
Ravensworth Narama	2,479,647
Ashton NEOC	268,074
HVO North (West Pit)	8,758,647
Glendell	2,509,447
Mount Owen	4,762,555
Ravensworth East	5,325,762

Appendix C Estimation of GHG Emissions

C.1 Fuel Consumption

Greenhouse gas (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 is based on a diesel intensity rate (kL diesel/tpa production), derived from the 2010 diesel consumption (35,023 kL) and a ROM coal rate of 5.6 Mtpa. 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).

Greenhouse gas emission factors and energy content for diesel were sourced from the NGA Factors (**DCCEE, 2012**). The estimated annual and Project total GHG emissions from diesel usage are presented in the table below.

Table C.1: Estimated CO_2-e (tonnes) for Diesel Consumption

Year	ROM (Mtpa)	Emission Factor (kg CO_2-e/GJ		Energy Content (GJ/kL)	Emissions (t CO_2-e)		Total
		Scope 1	Scope 3		Scope 1	Scope 3	
2014	7.1	69.9	5.3	38.6	119,956	9,095	129,051
2015	7.0	69.9	5.3	38.6	118,563	8,990	127,553
2016	7.2	69.9	5.3	38.6	121,722	9,229	130,952
2017	7.0	69.9	5.3	38.6	118,484	8,984	127,467
2018	7.0	69.9	5.3	38.6	119,555	9,065	128,620
2019	7.0	69.9	5.3	38.6	119,198	9,038	128,236
2020	7.2	69.9	5.3	38.6	121,583	9,219	130,802
2021	5.3	69.9	5.3	38.6	89,748	6,805	96,553
2022	5.3	69.9	5.3	38.6	89,500	6,786	96,286
2023	4.3	69.9	5.3	38.6	73,490	5,572	79,062
2024	4.6	69.9	5.3	38.6	78,910	5,983	84,893
2025	2.0	69.9	5.3	38.6	34,360	2,605	36,965
Total	**70.9**				**1,205,069**	**91,371**	**1,296,440**

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 greenhouse gases 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 is based on an intensity rate (kWh/tpa product coal) derived from the 2009 electricity use (14,251,803 kWh) and ROM coal rate of 5.6 Mtpa. Greenhouse gas emission factors were sourced from the NGA Factors (**DCCEE, 2012**). The estimated annual and project total GHG emissions from electricity usage are presented in the table below.

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

Year	ROM (Mtpa)	Emission Factor (kg CO_2-e/kWh)		Emissions (t CO_2-e)		Total
		Scope 2	Scope 3	Scope 2	Scope 3	
2014	7.1	0.88	0.18	15,920	3,256	19,177
2015	7.0	0.88	0.18	15,735	3,219	18,954
2016	7.2	0.88	0.18	16,155	3,304	19,459
2017	7.0	0.88	0.18	15,725	3,216	18,941
2018	7.0	0.88	0.18	15,867	3,246	19,113
2019	7.0	0.88	0.18	15,820	3,236	19,056
2020	7.2	0.88	0.18	16,136	3,301	19,437
2021	5.3	0.88	0.18	11,911	2,436	14,348
2022	5.3	0.88	0.18	11,878	2,430	14,308
2023	4.3	0.88	0.18	9,753	1,995	11,749
2024	4.6	0.88	0.18	10,473	2,142	12,615
2025	2.0	0.88	0.18	4,560	933	5,493
Total	**70.9**			**159,934**	**32,714**	**192,648**

C.3 Fugitive Methane

Emissions from fugitive CH_4 were estimated based on the using the following equation:

$$E_{co2-e} = Q \times EF$$

where:

E_{CO2-e}	=	Emissions of greenhouse gases from fugitive CH_4	(t CO_2-e/annum)
Q	=	ROM coal extracted during the year	(t)
EF	=	Project Specific Emission Factor	(t CO_2-e/tonne)

The default emission factor for fugitive emissions from open cut mines was sourced from the NGA Factors (**DCCEE, 2012**). The estimated annual and Project total GHG emissions from fugitive methane are presented in the table below.

Table C3: Estimated CO_2-e (tonnes) for Fugitive Methane

Year	ROM (Mtpa)	Site Specific EF (t CO_2-e/t)	Scope 1 Total Emission (t CO_2-e)
2014	7.1	0.045	317,546
2015	7.0	0.045	313,859
2016	7.2	0.045	322,222
2017	7.0	0.045	313,648
2018	7.0	0.045	316,484
2019	7.0	0.045	315,540
2020	7.2	0.045	321,853
2021	5.3	0.045	237,581
2022	5.3	0.045	236,924
2023	4.3	0.045	194,543
2024	4.6	0.045	208,889
2025	2.0	0.045	90,957
Total	**70.9**		**3,190,045**

C.4 Explosives Use

Emissions from explosive usage were estimated based on the using the following equation:

$$E_{co2-e} = Q \times EF$$

where:

E_{CO2-e}	=	Emissions of greenhouse gases from explosives	(tCO_2-e/annum)
Q	=	Quantity of explosive used (assumed ANFO)	(t)
EF	=	Scope 1 emission factor	(tCO_2-e/tonne explosive)

Greenhouse gas emission factors were sourced from the NGA Factors February 2008. It is noted that the AGO Factors and Methods were replaced by the NGA Factors (**DCCEE, 2012**), however the emission factor for explosives was excluded from the latest version. Emissions from explosives do not have to be reported under NGERS.

The quantity of diesel consumed (Q) in each year is based on a diesel intensity rate (kL diesel/tpa production), derived from the 2010 diesel consumption (35,023 kL) and a product coal rate of 4.7 Mtpa. 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). The estimated annual and project total GHG emissions from explosive usage are presented in the table below.

Table C.4: Estimated CO_2-e (tonnes) for Explosives

Year	ROM (Mtpa)	Emission Factor (t CO_2-e/tonne product)			Emissions (t CO_2-e)			Total (t CO_2-e)
		ANFO	Heavy ANFO	Emulsion	Scope 1 Emissions from ANFO	Scope 1 Emissions from Heavy ANFO	Scope 1 Emissions from Emulsion	
2014	7.1	0.17	0.18	0.17	122	2,704	1,388	4,214
2015	7.0	0.17	0.18	0.17	120	2,673	1,372	4,165
2016	7.2	0.17	0.18	0.17	123	2,744	1,409	4,276
2017	7.0	0.17	0.18	0.17	120	2,671	1,371	4,163
2018	7.0	0.17	0.18	0.17	121	2,695	1,384	4,200
2019	7.0	0.17	0.18	0.17	121	2,687	1,380	4,188
2020	7.2	0.17	0.18	0.17	123	2,741	1,407	4,271
2021	5.3	0.17	0.18	0.17	91	2,023	1,039	3,153
2022	5.3	0.17	0.18	0.17	91	2,018	1,036	3,144
2023	4.3	0.17	0.18	0.17	75	1,657	851	2,582
2024	4.6	0.17	0.18	0.17	80	1,779	913	2,772
2025	2.0	0.17	0.18	0.17	35	775	398	1,207
Total	**70.9**				**1,222**	**27,166**	**13,948**	**42,336**

C.5 COAL TRANSPORTATION

C.5.1 COAL TRANSPORTATION VIA RAIL TO NEWCASTLE

The scope 3 emissions associated with product coal transportation have been estimated based on all product coal being transported to Newcastle for export by rail. Emissions associated with product coal transportation have been estimated based on an emission factor for loaded trains of 12.3 grams per net tonne per kilometre (**Queensland Rail Network Access, 2002**).

Emission factors were not available for unloaded trains so the factor for loaded trains is conservatively applied for the return trip. The return rail trip from the Project to the port of Newcastle is estimated to be 188 km.

The total estimated GHG emissions from rail transport of product coal are provided in the table below.

Table C.5.1: Estimated CO_2-e (tonnes) for Coal Transportation by Rail

Year	Product Coal (Mtpa)	Scope 3 Emissions (t CO_2-e)
2014	4.63	10,702
2015	4.57	10,578
2016	4.70	10,860
2017	4.57	10,571
2018	4.61	10,666
2019	4.60	10,635
2020	4.69	10,847
2021	3.46	8,007
2022	3.45	7,985
2023	2.84	6,557
2024	3.04	7,040
2025	1.33	3,066
Total	**46.49**	**107,514**

C.5.2 COAL TRANSPORTATION VIA TRUCK TO RAVENSWORTH COAL MINE

LCO have indicated that they may in any year wish to transport 1.5 Mtpa of the total product coal to the Ravensworth Mine located approximately 3 km south of the Project. The coal would be transported by truck and then railed to the Port of Newcastle with the remaining to be railed straight from the Project site as per normal.

Scope 3 emissions associated with 1.5 Mt of product coal transportation to the Ravensworth Mine have been estimated for every year of the Project. This provides a very conservative approach as this is not likely to occur for every year of the Project and it would not be an additional 1.5 Mt but instead 1.5 Mt of the total product amount for that year.

The quantity of diesel consumed (Q) in each year is based on a diesel intensity rate (kL diesel/tpa production), derived from the 2010 diesel consumption (35,023 kL) and a product coal rate of 4.7 Mtpa. 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).

Greenhouse gas emission factors and energy content for diesel were sourced from the NGA Factors (**DCCEE, 2012**). The estimated annual and Project total GHG emissions from diesel usage are presented in Table C.5.2.

Table C.5.2: Estimated CO_2-e (tonnes) for Coal Transportation by Truck

Year	Product Coal (Mtpa)	Scope 3 Emissions (t CO_2-e)
2014	1.5	31,958
2015	1.5	31,958
2016	1.5	31,958
2017	1.5	31,958
2018	1.5	31,958
2019	1.5	31,958
2020	1.5	31,958
2021	1.5	31,958
2022	1.5	31,958
2023	1.5	31,958
2024	1.5	31,958
2025	1.5	31,958
Total	**18.0**	**383,493**

C.6 ENERGY PRODUCTION – USE OF PRODUCT COAL

Based on data provided by the client, it is assumed that the majority of the product coal would be sold as thermal coal, with a small fraction (approximately 11% over the life of the Project) sold as semi-soft coal. The scope 3 emissions associated with the combustion of product coal were estimated using the following equation:

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

Where:

E_{CO2-e}	=	Emissions of GHG from coal combustion	(t CO_2-e)
Q	=	Quantity of product coal burnt	(GJ)
EC	=	Energy Content Factor for black / coking coal	(GJ/t)[1]
EF	=	Emission factor for black / coking coal combustion	(kg CO_2-e/GJ)

[1] GJ/t = gigajoules per tonne

The quantity of thermal coal burnt in Mtpa is converted to GJ using an energy content factor for black coal of 27 GJ/t. The quantity of semi-soft coal burnt in Mtpa is converted to GJ using an energy content factor of 30 GJ/t. Note that this is the factor used for coking coal but it has been used here as a conservative estimate for coal that is not specifically sold as thermal coal.

The greenhouse gas emission factor and energy content for coal were sourced from the NGA Factors (**DCCEE, 2012**). The emissions associated with the use of the product coal are presented in the table.

Table C.6: Estimated CO_2-e (tonnes) for Energy Production

Year	Product Coal Mtpa		Scope 3 Emissions (t CO_{2-e})		
	Thermal	Semi-soft	Thermal	Semi-soft	Total
2014	4.10	0.53	9,781,825	1,438,054	11,219,879
2015	4.05	0.53	9,668,242	1,421,355	11,089,597
2016	4.16	0.54	9,925,853	1,459,228	11,385,081
2017	4.05	0.52	9,661,752	1,420,401	11,082,153
2018	4.08	0.53	9,749,085	1,433,240	11,182,325
2019	4.07	0.53	9,720,029	1,428,969	11,148,998
2020	4.15	0.54	9,914,474	1,457,555	11,372,028
2021	3.07	0.40	7,318,525	1,075,917	8,394,442
2022	3.06	0.40	7,298,308	1,072,945	8,371,252
2023	2.51	0.33	5,992,765	881,013	6,873,779
2024	2.70	0.35	6,434,685	945,981	7,380,667
2025	1.17	0.15	2,801,869	411,911	3,213,779
Total	**41.16**	**5.34**	**98,267,412**	**14,446,569**	**112,713,981**