# Sutton Forest Quarries Pty Ltd

ABN 66 158 999 994

# Air Quality and Greenhouse Gas Assessment

## Specialist Consultant Studies Compendium

### Volume 2, Part 8

*Prepared by*

**Pacific Environment Pty Ltd**

**March 2018**

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ABN 66 158 999 994

# Air Quality and Greenhouse Gas Assessment


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# EXECUTIVE SUMMARY

## Overview

Sutton Forest Quarries Pty Ltd (SFQ or "the Applicant") proposes to develop and operate a sand extraction and processing operation (the "Proposal") at 13302 Hume Highway, Sutton Forest (the "Site"). The proposed rate of sand production would average approximately 700,000 tonnes per annum (tpa) with a maximum of 860,000 tpa. The majority of the sand products would be distributed to the Sydney market.

An Air Quality and Greenhouse Gas Assessment has been prepared to form part of an Environmental Impact Statement (EIS) to support an application for Development Consent under Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to facilitate the State Significant Development.

## Existing Environment

Meteorological and air quality monitoring was established on the Site to determine the baseline air quality environment for the Proposal. The prevailing winds for the area are characterised by wind originating from the north, east and west.

SFQ installed five dust deposition gauges and a High Volume Air Sampler (HVAS) in November 2013. Dust deposition data are available for the period November 2013 to August 2014. HVAS data are available from November 2013 to January 2015. A review of these data indicates that ambient air quality for the area is generally good.

To supplement the data collected around the Site, reference is also made to monitoring data from the Lynwood Quarry, approximately 22km southwest of the Site.

From the monitoring data available, the following background concentrations were established:

- Annual average TSP of 32.3µg/m$^3$
- Annual average $PM_{10}$ of 12.9µg/m$^3$
- Annual average $PM_{2.5}$ of 5.2µg/m$^3$
- Annual average dust deposition of 1.6g/m$^2$/month
- 24-hour average $PM_{10}$ – daily varying
- 24-hour average $PM_{2.5}$ – daily varying

## Emissions and Modelling Assessment

Two operating scenarios over the life of the Proposal (Stage 2 and Stage 4) have been assessed to represent the potential worst case air quality impacts that the Proposal would have on private receptors surrounding the Site. Detailed emission inventories have been prepared for the two operating scenarios for TSP, $PM_{10}$, $PM_{2.5}$ and dust deposition.

Dispersion modelling was conducted to predict ground level concentrations of the air quality parameters of interest. Cumulative impacts were also considered where appropriate, taking into account the Proposal and other sources.

AERMOD was chosen as the most suitable dispersion model due to the source types, location of nearest receptors and nature of local topography. AERMOD is the US-EPA's recommended steady-state plume dispersion model for regulatory purposes and has been applied for many similar assessments in NSW in recent years.

The modelling results showed that during operation, the Proposal is predicted to comply with the air quality criteria for the relevant averaging periods for TSP, $PM_{10}$, $PM_{2.5}$, and dust deposition.

An assessment of cumulative 24-hour impact was completed using a statistical analysis (Monte Carlo simulation). This was used to determine the probability of exceeding the impact assessment criterion for cumulative $PM_{10}$ and $PM_{2.5}$ 24-hour averages at selected receptors located around the Site. Results indicate that there would be no additional days above the EPA assessment criteria of 50µg/m$^3$ ($PM_{10}$) or 25µg/m$^3$ ($PM_{2.5}$).

The potential for exceedances of air quality criteria during construction were assessed semi-quantitatively. Emissions from construction activities account for a relatively small component compared to the overall air emissions associated with the operation of the Proposal. Construction particulate matter emissions are considered short lived and able to be effectively managed.

**Greenhouse Gas Assessment**

A greenhouse gas assessment indicates that average annual Scope 1 and 2 emissions from the Proposal (0.029Mt $CO_2$-e) would represent approximately 0.005% of Australia's commitment under the Kyoto Protocol (591.5Mt $CO_2$-e) and a very small proportion of global greenhouse emissions.

# 1. INTRODUCTION

This report has been prepared by Pacific Environment Limited for R.W. Corkery & Co. Pty Limited (RWC) on behalf of Sutton Forest Quarries Pty Ltd (SFQ). The purpose of this study is to assess the likely air quality impacts of the proposed Sutton Forest Sand Quarry (hereafter referred to as the “Proposal”). The locality of the Proposal is shown in **Figure 1**.

Annual sales for the Proposal would average approximately 700,000 tonnes per annum (tpa) with a maximum production of 860,000tpa. The majority of the sand products would be distributed to the Sydney market. This assessment forms part of an Environmental Impact Statement (EIS) being prepared by RWC to support an application for Development Consent under Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to facilitate the State Significant Development.

This assessment generally 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*” (NSW EPA, 2016) (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.

The objectives of the air quality and greenhouse gas assessment are as follows.

- To understand meteorological conditions relevant to the Proposal.
- To characterise current air quality and baseline air quality issues.
- To estimate the emissions of particulate matter (PM) (as $PM_{10}$, $PM_{2.5}$, total suspended particulates (TSP) and depositional dust) for two representative worst case stages of the Proposal.
- To apply a regulatory dispersion model to predict future ambient air quality surrounding the Proposal, for two representative stages of the Proposal.
- To recommend air quality management measures.
- To estimate greenhouse gas emissions and evaluate the potential contribution of the Proposal to future climate change.

For the purposes of this document, the Proposal would be undertaken within an area referred to as “the Site” (see **Figure 2**). The Site incorporates the Quarry Operations Area, i.e. the area in which all extraction, processing and related activities would be undertaken. Access between the Quarry Operations Area and the Hume Highway would be via the Quarry Interchange and the Quarry Access Road.

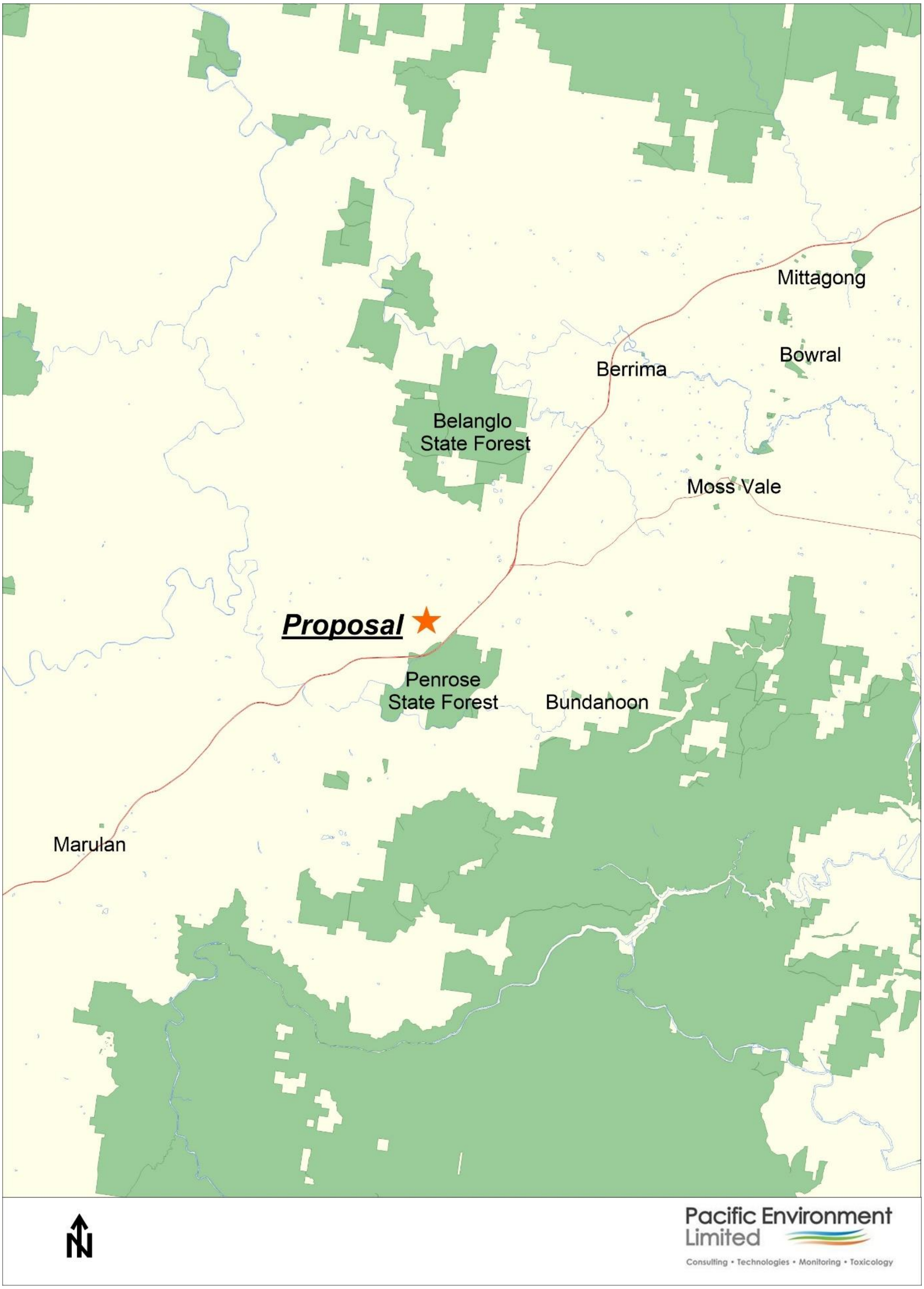


**Figure 1 Locality Plan**

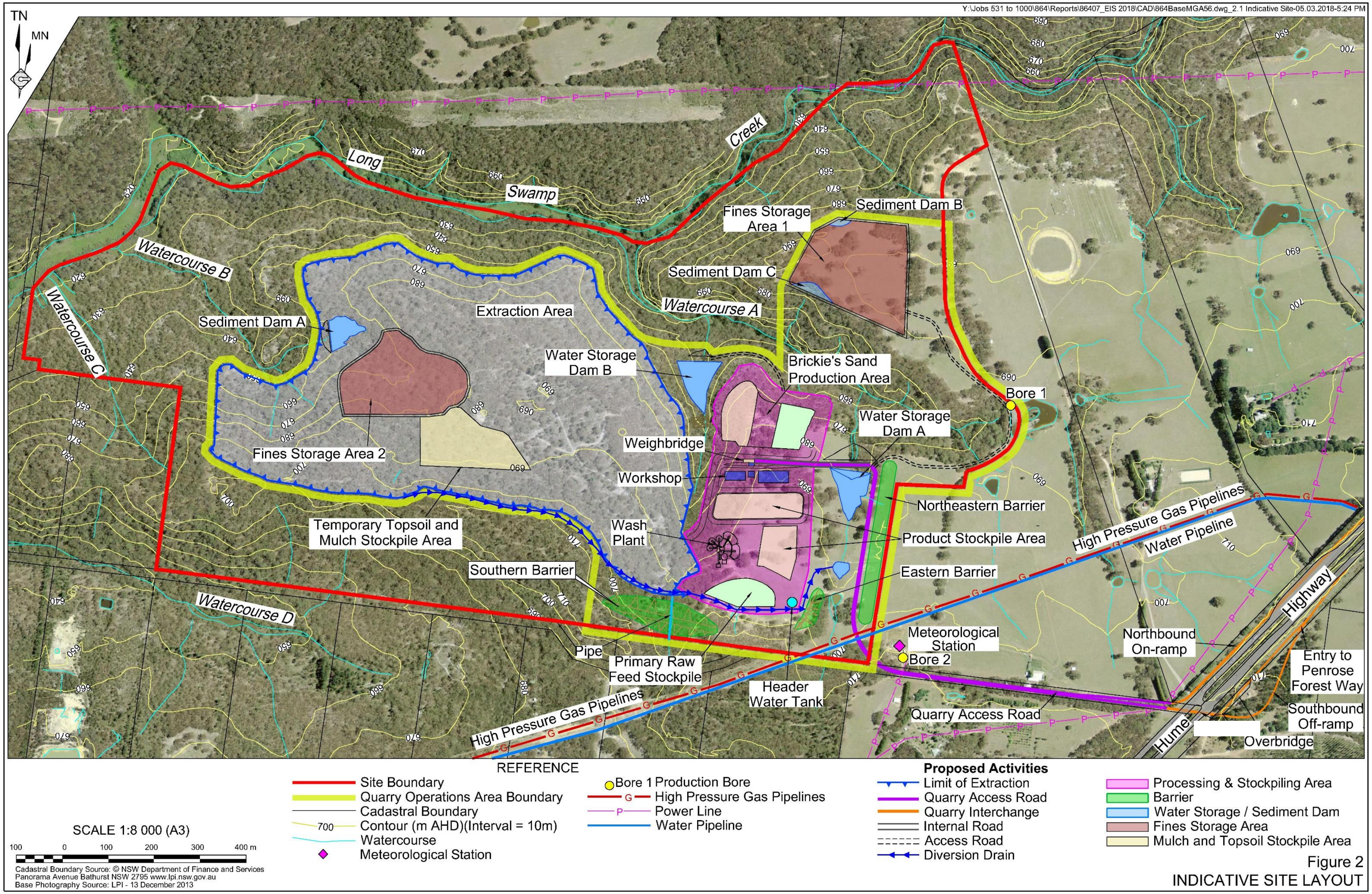


**Figure 2 Sutton Forest Sand Quarry Indicative Site Layout**

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## 2. STUDY REQUIREMENTS

This Air Quality and Greenhouse Gas Assessment has been prepared in accordance with the Director-General's Requirements (DGRs) for the Proposal dated 7 February 2014 and which the Department of Planning and Environment has advised (22 January 2018) that can still be relied upon for the assessment.

**Table 1** outlines the requirements relevant to the air quality and greenhouse gas assessment and where each is addressed in the report.

**Table 1**
**Coverage of DGR's and Issues raised by other Government Agencies**

Page 1 of 2

| Organisation | Paraphrased Requirement/Issue | Relevant Section(s) |
|---|---|---|
| **DIRECTOR-GENERAL'S REQUIREMENTS** | | |
| **AIR QUALITY** | | |
| The EIS must include a quantitative assessment of the potential:<br>• construction and operational impacts; | | Section 7.4 |
| • reasonable and feasible mitigation measures to minimise dust emissions; and | | Section 6.5 |
| • monitoring and management measures. | | Section 8 |
| **GREEN HOUSE GASES** | | |
| The EIS must include:<br>• a quantitative assessment of potential Scope 1, 2 and 3 greenhouse gas emissions;<br>• a qualitative assessment of the potential impacts of these emissions on the environment; and<br>• an assessment of reasonable and feasible measures to minimise greenhouse gas emissions and ensure energy efficiency. | | Section 9 |
| **ISSUES RAISED BY OTHER GOVERNMENT AGENCIES** | | |
| **AIR QUALITY** | | |
| EPA<br>(21/01/14) | Demonstrate that environmental outcomes for the project ensure:<br>• Unacceptable impacts do not occur on human health or the environment<br>• No offensive odours are caused or permitted from the premises<br>• Emissions of dust from the premises are prevented or minimised<br>• All relevant guidelines in regards to ambient air quality are satisfied; and<br>• Vehicular kilometres travelled are minimised | <br>Section 7<br>Section 6.1<br>Section 6.5<br>Section 7<br>Section 6.5 |
| | • Identify and describe all processes and sources (including odour and dust) that could result in air emissions and detail the characteristics and quantity of all emissions. | Section 6.6 and Appendix 1 |
| | • Describe any proposed mitigation and monitoring and management measures to ensure air quality outcomes are achieved. | Section 8 |
| | Demonstrate that emissions will be minimised to the maximum extent achievable for all emission sources | Section 6.5 |
| | Specify any proposed management protocols, pollution control equipment and emission control techniques/practices that will be employed as part of the project | Section 8 |

**Table 1**
**Coverage of DGR's and Issues raised by other Government Agencies (Cont'd)**

Page 2 of 2

| Organisation | Paraphrased Requirement/Issue | Relevant Section(s) |
|---|---|---|
| **ISSUES RAISED BY OTHER GOVERNMENT AGENCIES (Cont'd)** | | |
| EPA (21/01/14) (Cont'd) | Assess the risk associated with potential discharges of fugitive and point source emissions for all stages of the project, include air quality impact assessment in accordance with the *EPA's Approved Methods for the Modelling and assessment of Air Pollutants in NSW.* | Section 7 |
| | Justify the level of assessment undertaken on the basis of risk factors including proposal location, characteristics of the receiving environment and type and quantity of pollutants emitted. | Section 6 |
| DTIRIS – DRE (07/02/14) | Assess dust impacts, and proposed measures to minimise these impacts. | Section 7 |

# 3. PROPOSAL DESCRIPTION AND LOCAL SETTING

## 3.1 PROPOSAL DESCRIPTION

The proposed extraction and processing areas, as shown on **Figure 2**, have been defined based upon the occurrence of friable sandstone within the Quarry Operations Area, and taking advantage of the local topography that would provide long term protection to control the propagation of noise to the south and limit the visibility of operational areas from the adjoining properties and the Hume Highway. An estimated 34 million tonnes of friable sandstone has been defined within the proposed extraction area and the footprint of the processing and stockpiling area. This resource is capable of yielding approximately 29 million tonnes of high quality sand products. Negligible overburden is present within the proposed extraction area as the friable sandstone in a number of areas lies directly beneath the soil.

Extraction would be undertaken principally through the use of bulldozers ripping the friable sandstone although the Applicant proposes, when required, to blast the harder sandstone in the lower benches. All extracted friable sandstone would be hauled off-road haul trucks to the processing area.

A fixed wash plant and the mobile screening plants would be used to process the extracted raw sand to produce high quality sand products meeting nominated Australian standards and customers' individual specifications. The principal products produced would be various grades of washed concrete sand and mortar (brickies) sands. The fixed wash plant would be used to produce concrete sand and blended products whereas the mobile screening plants would be used to produce brickies sand products.

The sand extraction and processing operations have been designed to optimise the recovery of sand whilst satisfying both site and surrounding environmental constraints and progressively backfilling the extraction void with processing residues (oversize materials and processing fines) and VENM/ENM to create a final landform with features that would support the ongoing agricultural and nature conservation land uses.

**Figure 2** displays the principal components of the Proposal, including the Quarry Access Road, extraction area, processing area, fines storage areas, stockpiling area and dams.

The Applicant proposes to commence production at an initial extraction rate of approximately 250 000 tonnes per annum (tpa) (yielding approximately 220 000tpa of sand products) increasing to the maximum extraction rate of 1 Million tpa (Mtpa) that would yield approximately 860 000tpa of sand products.

The volume of the identified friable sandstone resource is such that the Applicant proposes to develop the Proposal in a staged manner over a sequence of 8 extraction stages (Stages 0 - 7) – see **Figure 3**. The development consent currently being sought is anticipated to enable extraction of the resource until Year 30. Assuming an average rate of extraction is maintained in the preceding years, Year 30 of the Proposal is represented by extraction Stage 5. Further development of the subsequent extraction stages (Stages 6 and 7) would be enabled by additional development consent being sought in the future.

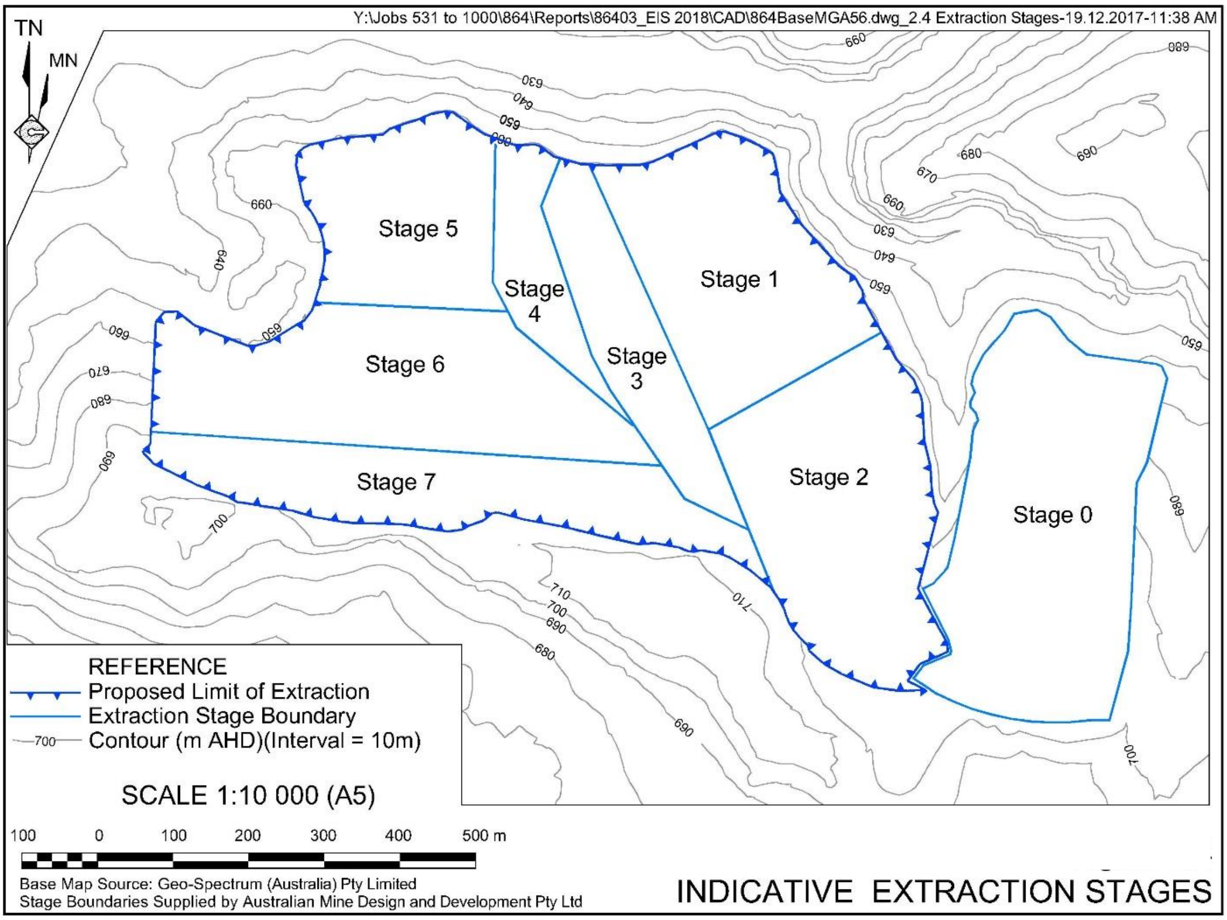



**Figure 3 Staged extraction areas for Sutton Forest Sand Quarry**

## 3.2 LOCAL SETTING

The Proposal is a greenfield development, and is located in the Southern Highlands of NSW, approximately 110km southwest of Sydney. The Site is located approximately 0.9km from the Hume Highway which carries approximately 21,000 vehicles per day, of which approximately one third are heavy vehicles (Transport and Urban Planning, 2018).

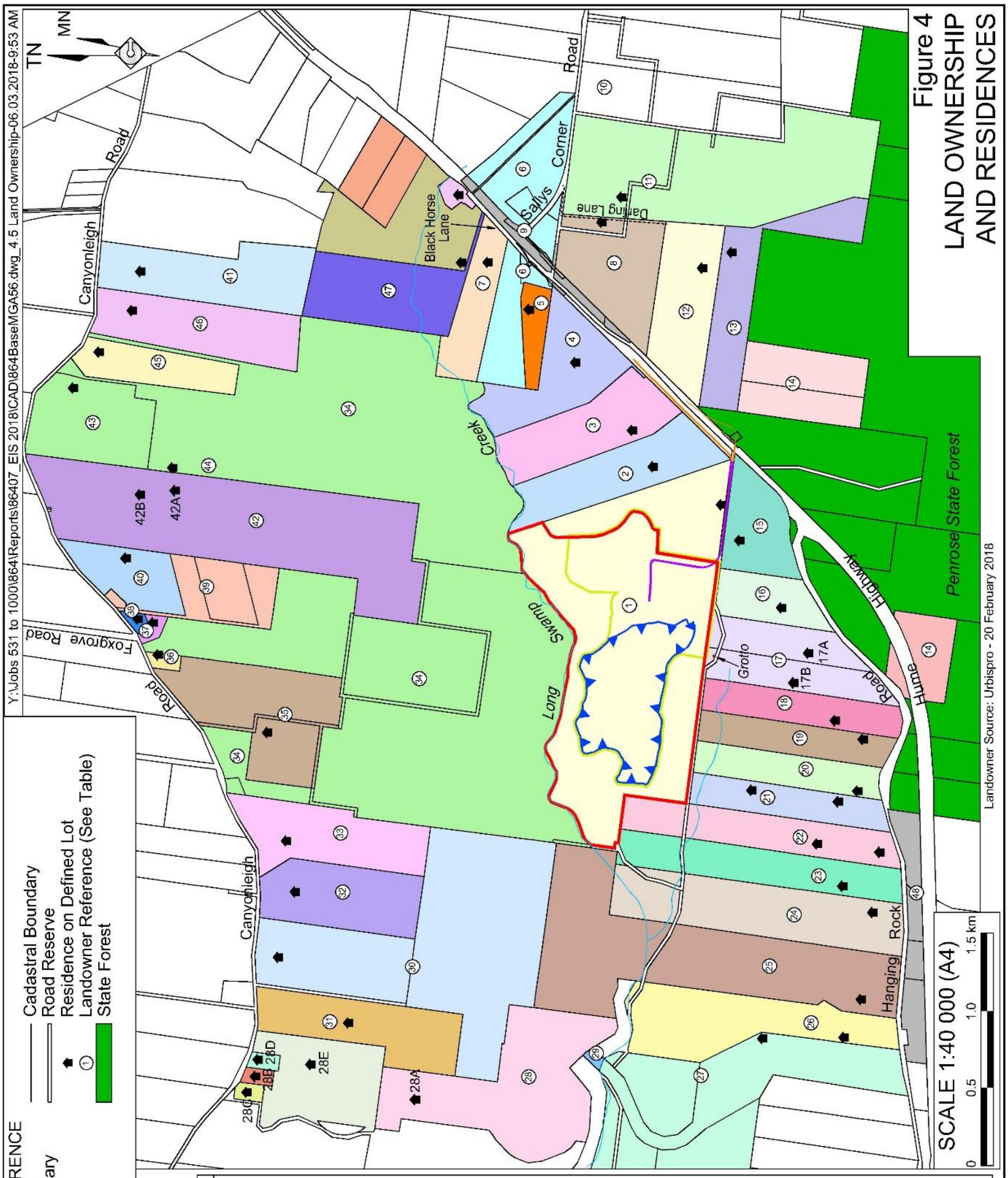
Significant features in the area include the Penrose State Forest to the south and Belanglo State Forest to the north of the Site. (See **Figure 1**)

There are also several quarries located near the Site which have the potential to contribute to particulate matter concentrations in the local airshed, including the existing Penrose Quarry approximately 2km to the southwest and the approved Green Valley Sand Quarry. The Green Valley Sand Quarry has not yet been developed. Intermittent, very low scale extraction occurs at one clay/shale and sand quarry south of the proposed extraction area. Quarry operations further afield include Peppertree Quarry (24km southwest) and Lynwood Quarry (22km southwest). Other potential sources of particulate matter include agriculture and smoke from domestic wood burning, particularly during the cooler months of the year. These sources are anticipated to have limited contributions to the air quality in the vicinity of the Site and any contributions would be captured in the baseline monitoring data.

A sensitive receptor is defined as a location where people are likely to work or reside, and may include a dwelling, school, hospital, office or public recreational area including places of worship in addition to known or likely future locations (NSW EPA, 2016). Private landholders are considered sensitive receptors and are located to the north, east and south of the Proposal boundary as shown in the land ownership map provided in **Figure 4**. In total, there are 33 sensitive receptors that were assessed as part of this study. The bulk of the receptors are residences located on either rural lifestyle blocks or rural properties. One property (No. 17) is a monastery run by the Pauline Fathers. Residences on properties No. 1 and No. 3 are considered as project-related residences as the owners of these properties have entered into commercial agreements with the Applicant regarding the operation of the Quarry. In order to ensure that amenity at these locations is considered, these residences have been included in the modelling and results summary.

The monastery is frequently used for both indoor and outdoor religious services. The monastery site contains a shrine church, accommodation facilities and over 40 small outdoor shrines and chapels located around the northern end of the property. The property is open to the public on a daily basis with regular masses held in either English or Polish. Major mass services attract large crowds (in excess of 3 000 people) to the monastery.

Topography is predominantly gently undulating across most of the Site and surrounding area with some areas exhibiting steep slopes and small near vertical cliffs. **Figure 5** shows a pseudo three dimensional representation of the local topography surrounding the Site. The locations of the on-site meteorological station and the automatic weather station (AWS) at Moss Vale are also displayed in **Figure 5**.




| Ref | Landowner |
|---|---|
| 1 | RL Henderson |
| 2 | VM Hofman |
| 3 | Tulla Resources Group Pty Limited |
| 4 | G Firriolo |
| 5 | S & S Leaning |
| 6 | Australian Property Syndicates Pty Limited |
| 7 | N & S Lo Russo |
| 8 | M Radovac |
| 9 | Roads and Traffic Authority of New South Wales |
| 10 | CE Dalton |
| 11 | SC & PF Samuel |
| 12 | NL & VM Ford |
| 13 | L & D Petkovski |
| 14 | His Most Gracious Majesty King George the Fifth for the Purpose of the Forestry Act, 1916 |
| 15 | The Commissioner for Main Roads as regards Lot 20 in DP255946 (Motorway) Birdram Proprietary Limited as regards Lot 15 in DP255946 |
| 16 | Latham Property Holdings Pty Limited |
| 17 | The Trustees of the Pauline Fathers and Brothers |
| 18 | DW & SL Hutton |
| 19 | A Beverley |
| 20 | TB Brown & KL Maher |
| 21 | CJ & KG Zelinsky |
| 22 | AJ & AP Palk |
| 23 | G & AB Bishop, SA Palk |
| 24 | R & J Kuhn |
| 25 | Coca-Cola Amatil (Aust) Pty Limited |
| 26 | Youth Off The Streets Limited |
| 27 | Tranteret Family Business Pty Ltd |
| 28A | E Kirk |
| 28B | MJ & & MD O'Dowd |
| 28C | TA Pall & M Adamson |
| 28D | JR & LM Murphy |
| 28E | DJ & SA Quartermaine |
| 29 | The State of New South Wales |
| 30 | Paul D Edwards Pty Limited |
| 31 | ML & SE Ridewood |
| 32 | CT Dunlea & CM Jeffery |
| 33 | SJ Kearney |
| 34 | Filetron Pty Limited |
| 35 | Warette Pastoral Company Pty Limited |
| 36 | SB Defina |
| 37 | CMH Laird, NF Clarke |
| 38 | JB O'Reilly, SA Lazzari |
| 39 | PGH Bricks |
| 40 | Shanti Mission Harmony Centres Ltd |
| 41 | GJ O'Donnell |
| 42 | Padella Pty Limited |
| 43 | Filetron Pty Limited |
| 44 | The Forestry Commission of NSW |
| 45 | S Robinson, RM Cook |
| 46 | S Lyle, N Turner, P Lyle |
| 47 | A & ME Clifford |
| 48 | The Commissioner for Main Roads |

**Figure 4 Land ownership in the vicinity of the Proposal**

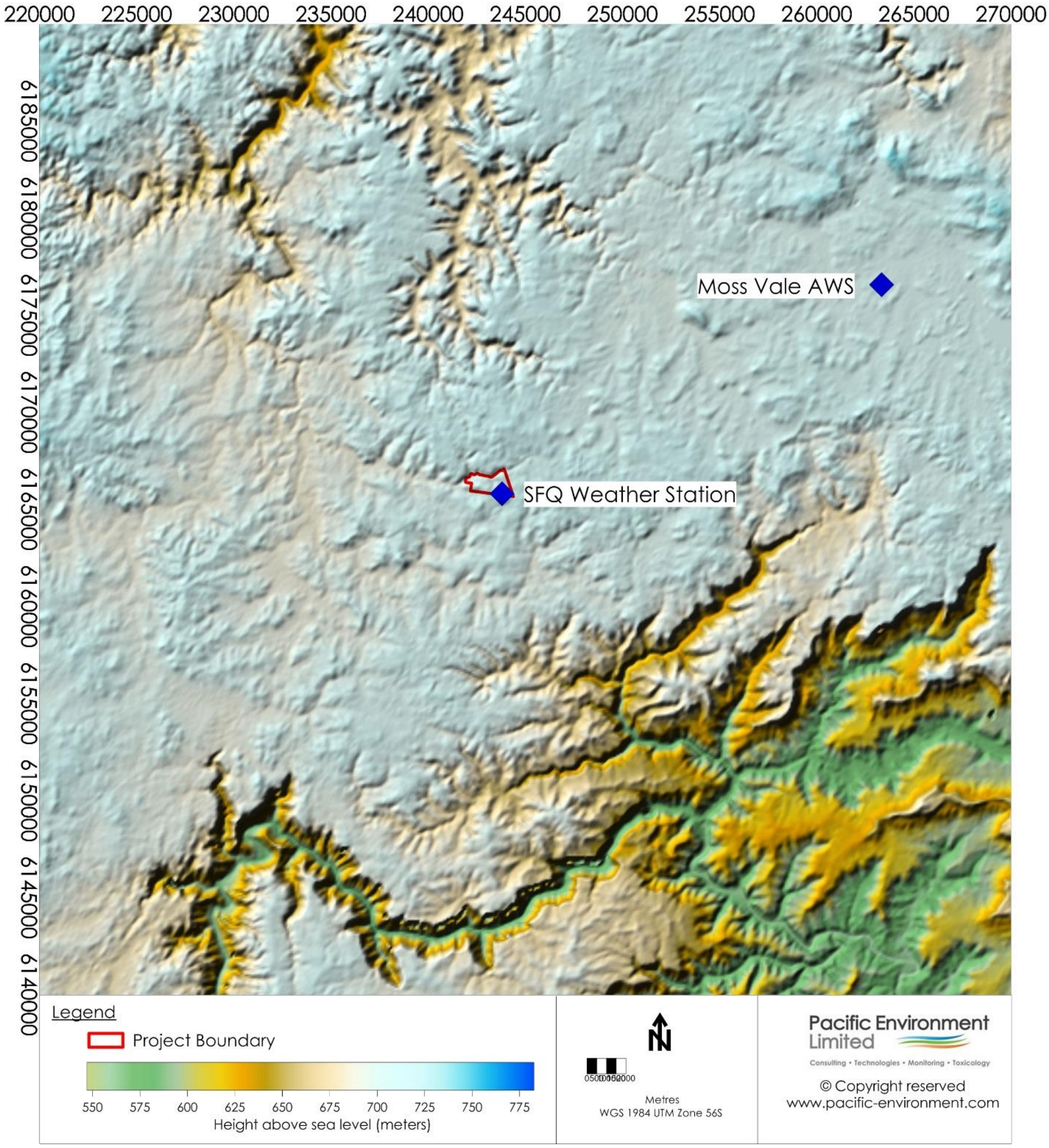



**Figure 5 Pseudo three-dimensional plot of the Site and surrounds**

# 4. AIR QUALITY CRITERIA

## 4.1 INTRODUCTION

The potential emissions to air from the Proposal are summarised as follows.

- Proposal activities described in Section 3.1 have the potential to generate fugitive particulate matter (PM) emissions, particularly from sand extraction (particularly ripping), periodic blasting, hauling, stockpiling, and wind erosion of exposed areas. Fugitive PM emissions can also be expected during construction, from vegetation stripping, earthworks and materials handling.

- Combustion of diesel due to the operation of extraction equipment and product trucks would result in emission of fine fractions of PM ($PM_{10}$ and $PM_{2.5}$), oxides of nitrogen ($NO_x$), carbon monoxide (CO), sulfur dioxide ($SO_2$) and organic compounds. The mobile earthmoving equipment associated with the Quarry would be relatively small and emissions from diesel-powered equipment during both construction and operation are unlikely to result in significant off-site concentrations of these compounds. As discussed in further detail in Section 4.4, it is noted that emissions of PM from diesel combustion are included in the emission factor equations used to estimate fugitive PM emissions for relevant sources (i.e. dozers), although the combustion derived PM is generally a small component of total PM from the activity. In comparison to the weekly emissions from vehicles travelling the Hume Highway, combustion emissions from the Proposal would be relatively small and therefore have not been considered further.

- Other emissions to air from the Proposal include greenhouse gases (GHG) such as carbon dioxide ($CO_2$) from the combustion of fuel in combustion engines, blasting, and indirect GHG emissions from the transportation of sand products from the Site. GHG emissions are assessed in Section 9.

The following sections provide information on the air quality criteria used to assess the impact of PM and other emissions to assist in interpreting the significance of predicted concentration and deposition levels, some background discussion is also provided.

## 4.2 HEALTH EFFECTS

Particulate matter has the capacity to affect health and to cause nuisance effects and is categorised by size and/or by chemical composition. The potential for harmful effects depends on both. The particulate size ranges are commonly described as:

- TSP –refers to all suspended particles in the air. In practice, the upper size range is typically 30µm to 50µm.
- $PM_{10}$ – 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 diameters less than 10 µm and with a unit density. $PM_{10}$ are a sub-component of TSP.

- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5μm diameter (a subset of $PM_{10}$). These are often referred to as the fine particles and are a sub-component of $PM_{10}$.
- $PM_{2.5-10}$ – defined as the difference between $PM_{10}$ and $PM_{2.5}$ mass concentrations. These are 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 (WHO, 2011). 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 approximately 10μm, while not able to affect health, can soil materials and generally degrade aesthetic elements of the environment. For this reason, air quality criteria 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 50μm settle out of the atmosphere too quickly to be regarded as air pollutants.

Both natural and anthropogenic processes contribute to the atmospheric load of particulate matter. Coarse particles ($PM_{2.5-10}$) and larger are derived primarily from mechanical processes resulting in the suspension of dust, soil, or other crustal[1] materials from roads, farming, mining, dust storms, and so forth. Coarse particles also include sea salts, pollen, mould, spores, and other plant parts. Dust generated by extraction operations is composed of predominantly coarse particulate matter (and larger).

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 aerosols from volatile organic compound emissions. $PM_{2.5}$ may penetrate beyond the larynx and into the thoracic respiratory tract and evidence suggests that particles in this size range are more harmful than the coarser component of $PM_{10}$.

The size of particles determines 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 6**, 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.

The health-based assessment criteria used by NSW EPA have, to a large extent, been developed by reference to epidemiological studies undertaken in urban areas with large populations where the primary pollutants are the products of combustion (NSW EPA, 1998; National Environment Protection Council [NEPC], 1998a; NEPC, 1998b). This means that, in contrast to dust of crustal origin, the particulate matter from urban areas would be composed of smaller particles and would generally contain acidic and carcinogenic substances that are associated with combustion.

Emissions of crystalline silica can also be associated with extractive industries such as sand quarrying. Section 4.6 presents more detailed discussion on these associated health issues.

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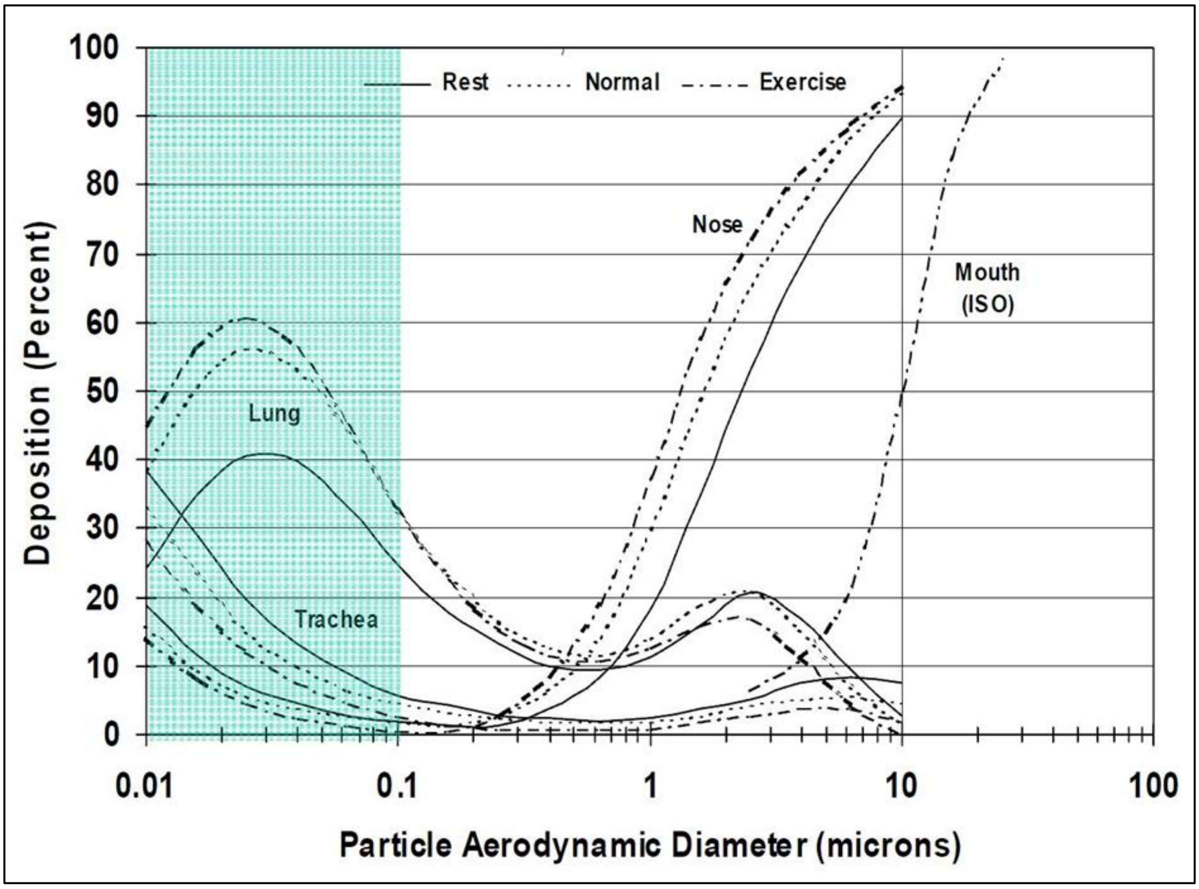
[1] Crustal dust refers to dust generated from materials derived from the earth's crust.




Source: Chow, 1995

**Figure 6 Particle Deposition within the Respiratory Track**

## 4.3 ASSESSMENT CRITERIA

### 4.3.1 NSW EPA Impact Assessment Criteria

The NSW EPA *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (NSW EPA, 2016) (hereafter referred to as 'the Approved Methods') specify air quality assessment criteria relevant for assessing impacts from air pollution. The air quality criteria relate to the total dust burden in the air and not just the dust from proposed activities such as sand extraction. In other words, consideration of background dust levels needs to be made when using these criteria to assess potential impacts. These criteria are health-based (i.e. they are set at levels to protect against health effects).

**Table 2** summarises the air quality criteria for concentrations of particulate matter that are relevant to this study.

These criteria are health-based (i.e. they are set at levels to protect against health effects) and for $PM_{10}$ and $PM_{2.5}$ are consistent with Amended National Environment Protection Measure for Ambient Air Quality (Ambient Air-NEPM) (NEPC, 2016). In addition, the Approved Methods include other measures of air quality, namely dust deposition and Total Suspended Particulates (TSP) which are not stated in the Ambient Air-NEPM. The Approved Methods were updated at the end of 2016 to align the annual average $PM_{10}$ criterion with the NEPM (25 $\mu g/m^3$), prior to this the Approved Methods criterion was 30 $\mu g/m^3$. The updated Approved Methods also introduced criteria for 24-hour average and annual average $PM_{2.5}$.

**Table 2**
**Air Quality Standards/Criteria for Particulate Matter Concentrations**

| Pollutant | Averaging period | Standard/Goal | Source |
|---|---|---|---|
| TSP | Annual mean | 90 $\mu g/m^3$ | NSW EPA (2016) (assessment criteria) |
| $PM_{10}$ | Maximum 24-hour average | 50 $\mu g/m^3$ | NSW EPA (2016) (assessment criteria) |
| | Annual mean | 25 $\mu g/m^3$ | |
| $PM_{2.5}$ | Annual Mean | 8 $\mu g/m^3$ | NSW EPA (2016) (assessment criteria) |
| | Maximum 24-hour average | 25 $\mu g/m^3$ | |
| Notes: $\mu g/m^3$ – micrograms per cubic metre. | | | |

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

**Table 3** shows 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 (NSW EPA, 2016).

**Table 3**
**EPA Criteria for Dust (Insoluble Solids) Fallout**

| Pollutant | Averaging period | Maximum increase in deposited dust level | Maximum total deposited dust level |
|---|---|---|---|
| Deposited dust | Annual | 2 $g/m^2$/month | 4 $g/m^2$/month |
| Notes: $g/m^2$/month – grams per square metre per month. | | | |

### 4.3.2 NSW Department of Planning and Environment Voluntary Land Acquisition and Mitigation Policy

In December 2014, NSW Department of Planning and Environment (DPE) released a policy relating to voluntary mitigation and land acquisition criteria (VLAMP) for air quality and noise (NSW Government, 2014). This is reflected in State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (the Mining SEPP) at Clause 12A.

The policy sets out voluntary mitigation and land acquisition rights where it is not possible to comply with the EPA impact assessment criteria even with the implementation of all reasonable and feasible avoidance and/or mitigation measures. This policy also applies to vacant land, considered to be the whole of a lot, including contiguous lots owned by the same landowner. Voluntary acquisition rights apply where a proposed development contributes to exceedances of the acquisition criteria at any residence or workplace on privately-owned land, or, on more than 25% of any privately-owned land, and a dwelling could be built on that land under existing planning controls.

The DPE voluntary mitigation and acquisition criteria are summarised in **Table 4** and **Table 5**, respectively. An updated version of the VLAMP is presently under consideration with a draft version released in November 2017 (NSW Government, 2017). This draft VLAMP proposes an annual average $PM_{10}$ criteria that is reduced to 25 µg/m$^3$. Whilst, this updated policy is still in draft form, for conservatism the Proposal has been assessed against these proposed criteria in addition to the EPA impact assessment criteria discussed in Section 4.3.

Table 4
DPE particulate matter mitigation criteria

| Pollutant | Criterion | Averaging Period | Application |
|---|---|---|---|
| TSP | 90 µg/m$^3$ | Annual mean | Total impact |
| $PM_{10}$ | 50 µg/m$^3$ | 24-hour average | Incremental impact[(a)] |
| | 25 µg/m$^3$ | Annual mean | Total impact |
| $PM_{2.5}$ | 25 µg/m$^3$ | 24-hour average | Incremental impact[(a)] |
| | 8 µg/m$^3$ | Annual mean | Total impact |
| Deposited dust | 2 g/m$^2$/month | Annual mean | Incremental impact[(a)] |
| | 4 g/m$^2$/month | Annual mean | Total impact |

Note:
(a) Zero allowable exceedances of the criterion over the life of the development.

**Table 5**
**DPE particulate matter acquisition criteria**

| Pollutant | Criterion | Averaging Period | Application[(a)] |
|---|---|---|---|
| TSP | 90 µg/m$^3$ | Annual mean | Total impact |
| $PM_{10}$ | 50 µg/m$^3$ | 24-hour average | Incremental impact[(b)] |
| | 25 µg/m$^3$ | Annual mean | Total impact |
| $PM_{2.5}$ | 25 µg/m$^3$ | 24-hour average | Incremental impact[(b)] |
| | 8 µg/m$^3$ | Annual mean | Total impact |
| Deposited dust | 2 g/m$^2$/month | Annual mean | Incremental impact[(b)] |
| | 4 g/m$^2$/month | Annual mean | Total impact |

Notes:
(a) Voluntary acquisition rights apply where the Proposal contributes to exceedances of the acquisition criteria at any residence or workplace on privately-owned land, or, on more than 25% of any privately-owned land, and a dwelling could be built on that land under existing planning controls.
(b) Up to five allowable exceedances of the criterion over the life of the development.

Total impact includes the impact of the Proposal and all other sources, whilst incremental impact refers to the impact of the Proposal considered in isolation.

At Clause 12AB(4), the Mining SEPP sets a non-discretionary development standard of cumulative annual average $PM_{10}$ concentration for private dwellings of 30 µg/m$^3$. This is also proposed to be amended to 25 µg/m$^3$ to align with the proposed amendments to VLAMP.

## 4.4 DIESEL FUMES

The US EPA AP-42 emission factors used in the particulate (TSP, $PM_{10}$ and $PM_{2.5}$) emissions inventories (see Section 6.6) include particulate matter emissions from both the mechanical processes (i.e. crustal material) and the diesel exhaust (combustion). These emission factors do not distinguish between these two sources, since the sampling method used to derive the original emission factors captured both mechanical and combustion particulate matter sources.

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

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

Discussions with Chatten Cowherd in the US, who was directly involved with the original work to determine these AP-42 emission factors several decades ago, support the NPI comments that vehicle exhaust emissions are captured to a large extent in these emission factors. While exhaust emissions from some equipment might have had sufficient buoyancy allowing a portion of those to rise above the downwind sampling tower under light wind conditions, Chatten Cowherd indicated that testing under such conditions was avoided.

It is further noted that the historical nature of the particulate matter emission factors referenced in the assessment means that the combustion component of the particulate matter emission would be reflective of both engines and fuels from several decades ago. Given the significant improvements in both of these aspects over this time period, the combustion particulate matter component within the aggregated emission factors may be regarded as highly conservative.

The Site is located approximately 0.9km from the Hume Highway which carries approximately 21,000 vehicles per day, of which almost 6,000 vehicles per day are heavy vehicles (Transport and Urban Planning, 2018). In comparison, at peak production, the Proposal is expected to reach a maximum of 166 laden trucks (332 vehicle movements). Therefore, the maximum traffic that would be generated by the Proposal is less than 6% of the heavy vehicles that travel daily on the Hume Highway. When combined with the fact that the majority of the sensitive receptors are located closer to the Hume Highway than they are to the Proposal, it is considered that any contribution of diesel fumes from traffic generated by the Proposal to the predicted air quality has been accounted for and as such no separate assessment of diesel emissions has been completed.

## 4.5 BLAST FUMES

Blasting also results in fugitive particulate matter emissions. Particulate matter emissions from mining equipment and blasting are included in the dispersion modelling results presented in Section 7 .

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

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

The Proposal would undertake a maximum of 12 blasts per year. Each blast would use a maximum of 200kg of ANFO, resulting in a total annual ANFO usage of 2.4t under the most conservative scenario. This represents less than 0.004% of the total ANFO usage during the ACARP study discussed above and given over 80% of these blast plumes did not show $NO_2$ levels above ambient levels, it is considered that there is minimal risk of any adverse $NO_2$ impacts due to blasting from the Proposal and as such no further assessment has been completed.

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

## 4.6 CRYSTALLINE SILICA

Silica ($SiO_2$) is a naturally occurring mineral composed of silicon and oxygen. It exists in crystalline and amorphous forms depending on the structural arrangement of the oxygen and silicon atoms. Whilst the crystalline forms are naturally known to be fibrogenic (causes the formation of fibres), the creation of fibres from amorphous forms may also occur via drilling or ripping. However, only the respirable particles (those which are capable of reaching the gas exchange region of the lungs) are considered in determining health effects of crystalline silica.

Human exposure to crystalline silica nearly always occurs during occupational activities that involve the working of materials containing crystalline silica products (e.g. masonry, concrete, sandstone) or use or manufacture of crystalline silica-containing products. Activities that involve cutting, grinding or breaking of these materials can result in the liberation of particles in multiple size ranges.

Crystalline silica dust is found everywhere in the environment (i.e. not in an occupational context) due to natural, industrial and agricultural activities as it comprises 12% of the earth's crust (EOG Resources, 2014).

Whilst the long term inhalation of silica dust may lead to the formation of scar tissue in the lungs, which can result in the serious lung disease silicosis, this is regarded exclusively as a work place exposure issue that is associated with long-term exposure to high levels of respirable crystalline silica (RCS).

The World Health Organization's Concise International Chemical Assessment Document on Crystalline Silica, Quartz (CICAD, 2000) states that "there are no known adverse health effects associated with the non-occupational exposure to quartz".

In addition, an Australian Government Senate Committee (2005) report identified that there are no reports in the international literature of individuals developing silicosis as a result of exposure to non-occupational levels (i.e. levels outside the work place) of silica dust, and an expert appearing before the committee confirmed the potential for such an occurrence as being very remote.

A literature review on the potential impacts to health from exposure to crustal material in Port Hedland, WA, states "exposure to airborne quartz carries the risk of silicosis, but only with prolonged exposure to concentrations greater than 200 µg/m$^3$" (Department of Health, 2007).

In Australia, the occupational exposure standards for respirable crystalline silica are defined by Safe Work Australia. The national exposure standard for respirable crystalline silica is 100 µg/m$^3$ (Time Weighted Average (TWA)). Although the occupational standard is not applicable to the assessment of the ambient air quality, the risk of silicosis among people living in areas surrounding activities such as sand quarries would therefore be considered minimal provided the concentration of respirable particles at the source was acceptable in terms of occupational safety.

The NSW EPA has not set any impact assessment criteria for crystalline silica. The Victorian EPA has adopted an ambient assessment criterion for mining and extractive industries of 3 µg/m$^3$ (annual average as $PM_{2.5}$) (VEPA, 2007). This has been derived from the Reference Exposure Level (REL) set by the California EPA Office of Environmental Health Hazard Assessment of 3 µg/m$^3$ (annual average as $PM_4$) (OEHHA, 2005), at or below which "no adverse effects are expected for indefinite exposure".

As presented in the air quality assessment (see Section 7.1), the annual average $PM_{10}$ concentration at the most affected residence due to the Proposal - only is predicted to be less than 2.3 µg/m$^3$. Given that crystalline silica would be a small fraction of $PM_{10}$ concentrations, any $PM_4$ crystalline silica levels would be significantly below levels that may be of concern. As a consequence, crystalline silica is not considered further in this assessment.

# 5. EXISTING ENVIRONMENT

## 5.1 METEOROLOGY

Air quality impacts are influenced by meteorological conditions, primarily in the form of gradient wind flow regimes, and by local conditions driven by topographical features. Wind speed, wind direction, temperature and relative humidity all affect the potential dispersion and transport of plumes and are basic input requirements for dispersion modelling. The local dispersion meteorology for the Proposal has been reviewed and is described in the following sub-sections.

### 5.1.1 Sutton Forest AWS

In October 2012, SFQ installed an automatic weather station (AWS), measuring wind speed, wind direction, temperature, humidity, air pressure and rainfall. Data are available from November 2012 to end of July 2016. However, there are some extended periods with missing or invalid data.

The most complete period of data available were from 1 March 2014 to 28 February 2015, which had data availability of 99% which meets the 90% capture rate required by the Approved Methods (NSW EPA, 2016).

The annual and seasonal data from the on-site AWS for the period 1 March 2014 to 28 February 2015 are presented in **Figure 7**. The wind rose shows that wind directions are quite variable with season, with very few winds from the south on an annual basis. Westerlies dominate in all seasons other than summer, while in summer, spring and autumn there are more winds from the northern and eastern quadrants which are very infrequent in winter. The annual average wind speed is 2.4 m/s with calms (winds less than 0.5 m/s) occurring approximately 3.6% of the time.

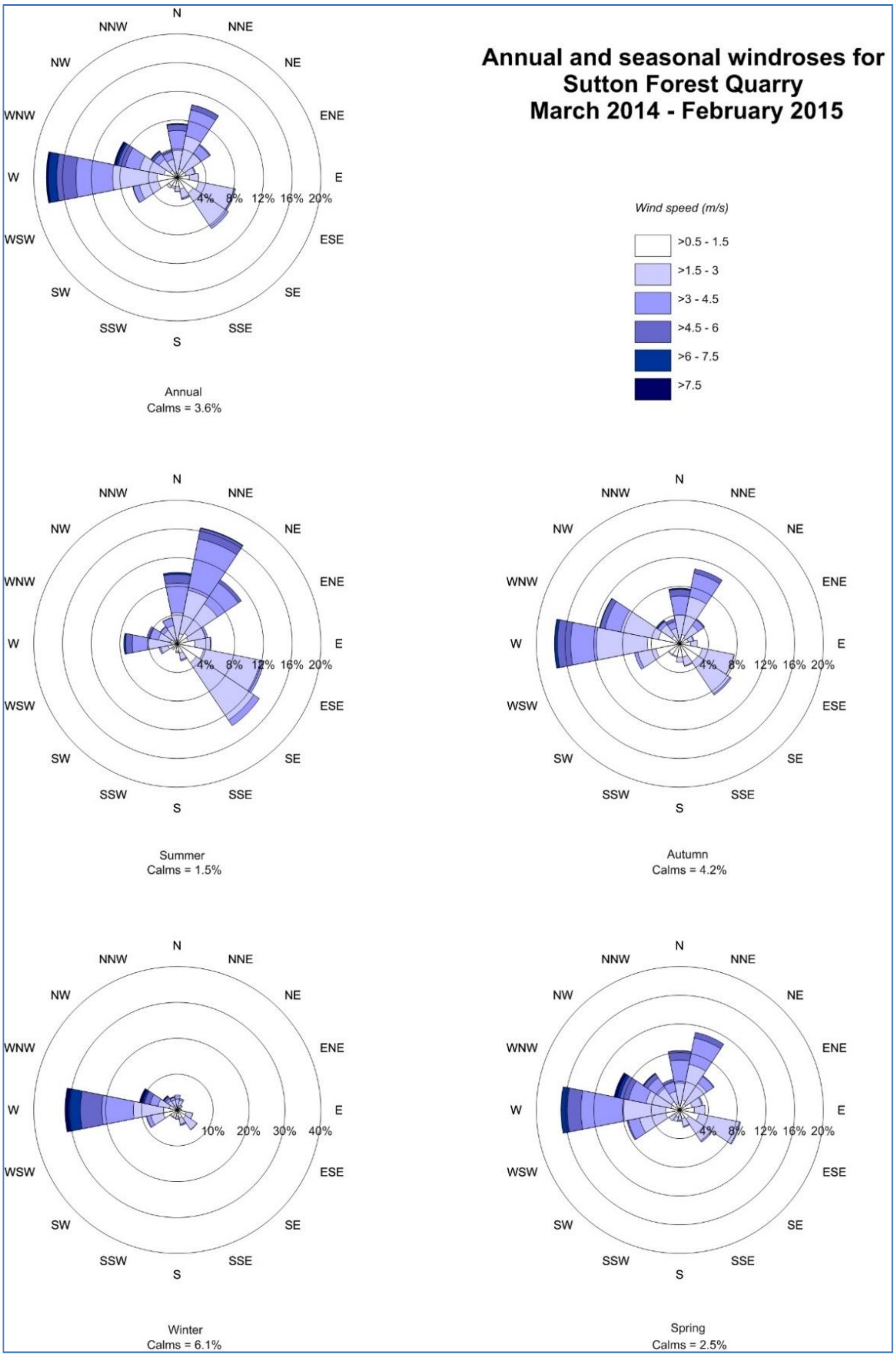



**Figure 7 Annual and seasonal wind roses for Sutton Forest AWS (March 2014 – February 2015)**

## 5.2 CLIMATE

Climate statistics for the BoM Moss Vale AWS are summarised in **Table 6**.

**Table 6**
**Climate Statistics for Moss Vale AWS BoM Station**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **9am Mean Temperature (ºC) and Relative Humidity (%)** | | | | | | | | | | | | | |
| Temp | 18.9 | 17.9 | 15.2 | 13.7 | 9.6 | 7.2 | 6.2 | 8.0 | 11.6 | 14.2 | 15.7 | 17.4 | 13.0 |
| Humidity | 70 | 80 | 83 | 79 | 83 | 83 | 81 | 73 | 67 | 63 | 70 | 67 | 75 |
| **3pm Mean Temperature (ºC) and Relative Humidity (%)** | | | | | | | | | | | | | |
| Temp | 24.2 | 22.7 | 20.6 | 17.7 | 14.2 | 11.6 | 10.6 | 12.2 | 15.2 | 17.5 | 19.9 | 22.0 | 17.4 |
| Humidity | 51 | 60 | 59 | 58 | 60 | 63 | 61 | 53 | 51 | 51 | 56 | 52 | 56 |
| **Daily Maximum Temperature (ºC)** | | | | | | | | | | | | | |
| Mean | 26.3 | 24.4 | 22.0 | 18.9 | 15.5 | 12.6 | 11.8 | 13.4 | 16.7 | 19.6 | 22.1 | 24.1 | 19.0 |
| **Daily Minimum Temperature (ºC)** | | | | | | | | | | | | | |
| Mean | 14.0 | 14.1 | 12.0 | 8.4 | 4.7 | 3.5 | 2.4 | 2.9 | 5.4 | 7.8 | 10.5 | 12.2 | 8.2 |
| **Rainfall (mm)** | | | | | | | | | | | | | |
| Monthly mean | 69.8 | 98.6 | 83.2 | 54.9 | 41.2 | 87.4 | 45.9 | 49.4 | 38.2 | 44.2 | 65.7 | 52.9 | 708.2 |
| **Rain days (Number)** | | | | | | | | | | | | | |
| Mean no. of rain days | 12.3 | 14.2 | 16.1 | 16.9 | 14.6 | 17.0 | 13.4 | 11.8 | 10.8 | 11.2 | 14.4 | 12.4 | 165.1 |
| Station number: 068239; Commenced 2001; Currently Operating; Elevation: 678m AHD; Latitude: 34.53S; Longitude: 150.42E | | | | | | | | | | | | | |
| Source: BoM (2018). | | | | | | | | | | | | | |

### 5.2.1 Temperature

January is typically the warmest month with a mean daily maximum temperature of 26.3°C. July is typically the coolest month with a mean daily minimum temperature of 2.4°C.

### 5.2.2 Relative humidity

Relative humidity is highest in March, May and June at 83% (observed at 9am), and the lowest in January, September and October at 51% (observed at 3pm).

### 5.2.3 Rainfall

February is the wettest month with a maximum mean monthly rainfall of 98.6 mm recorded at Moss Vale AWS recorded over 14.2 rain days. The minimum rainfall and number of rain days occurs in September.

## 5.3 EXISTING AIR QUALITY

### 5.3.1 Introduction

To assess impacts against all the relevant air quality criteria (detailed in Section 4) it is necessary to have information on existing PM concentrations and deposition levels in the vicinity of the Site.

SFQ installed five dust deposition gauges and a High Volume Air Sampler (HVAS) in November 2013. The air quality monitoring locations for the Proposal are shown in **Figure 8**. Data are available from November 2013 to October 2014.

As limited baseline air quality monitoring data are available for the Proposal, reference is also made to air quality monitoring data from the Lynwood Quarry, published on their website (Holcim, 2016). The Lynwood Quarry data include the measurement of dust deposition and dust concentration (as $PM_{10}$) from January 2013 to June 2016. Although Lynwood Quarry is located approximately 22km southwest of the Site, it is located in a similar rural environment. As the air quality data include the contribution from the operation of the Lynwood Quarry, the data are considered to provide a conservative estimate in assisting with characterising the local air quality environment for the Proposal.

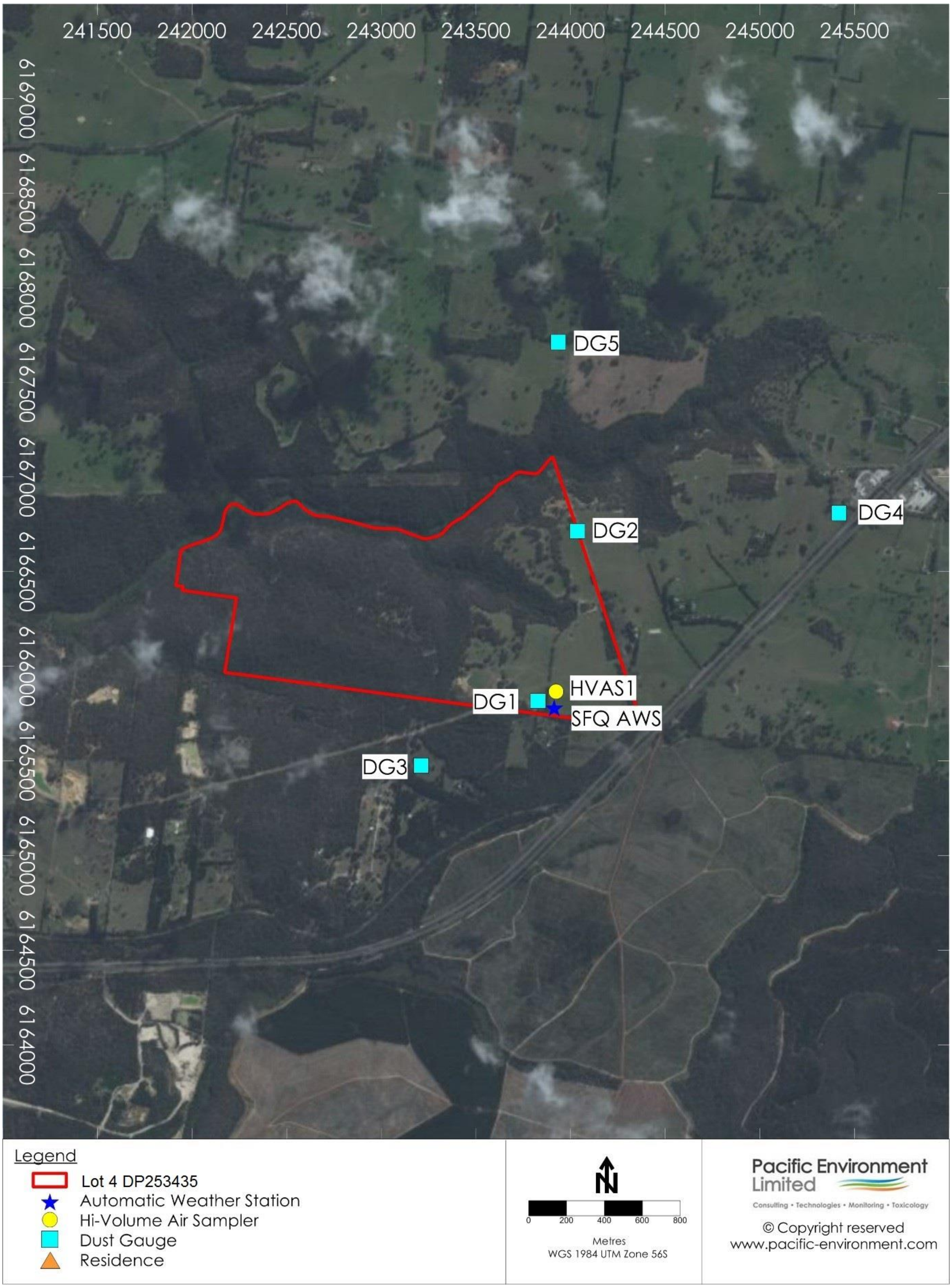



**Figure 8 Location of monitoring stations**

### 5.3.2 Dust Deposition

The results of the dust deposition recorded around the Site are shown in **Table 7**. The results provide deposited dust information collected during the recording period adjusted to provide an average over a 30 day period during the time that deposited dust was sampled. This was adjusted so that conditions were as close as is practical to those used to determine the impact assessment criteria. The highest monthly average was 7.3 g/m$^2$/month measured at DG3 in August 2014, located to the south of the Site at the Pauline Fathers Monastery. Field notes accompanying this monitoring event indicated that bugs and debris contributed to this result, and as such it is considered contaminated and is not included in the average at that site. The average deposited dust across all sites is 0.4 g/m$^2$/month.

**Table 7**
**Dust Deposition Data (November 2013 to August 2014)**

| **Period** | **Impact assessment criteria: 4g/m$^2$/month** | | | | |
|---|---|---|---|---|---|
| | **Insoluble solids (g/m$^2$/month)** | | | | |
| | **DG1** | **DG2** | **DG3** | **DG4** | **DG5** |
| Nov-13 | 0.6 | 0.4 | NR | 0.2 | 0.4 |
| Dec-13 | 0.4 | 0.3 | 0.1 | NR | 0.1 |
| Feb-14 | NR | 0.4 | 0.3 | 1.4 | 0.9 |
| Mar-14 | 0.1 | 0.1 | 0.3 | 0.2 | 0.5 |
| May-14 | 0.1 | 0.1 | 0.3 | 0.5 | 0.1 |
| Jun-14 | 0.9 | 0.1 | 0.4 | 0.1 | 0.1 |
| Jul-14 | 2.0 | 0.3 | 1.2 | 0.2 | 0.3 |
| Aug-14 | 0.3 | 1.0 | 7.3* | 0.3 | 0.2 |
| **Average** | **0.6** | **0.3** | **0.4** | **0.4** | **0.3** |
| **Average all** | **0.4** | | | | |

*NR = No Reading; * = contaminated reading and not included in the average*

Dust deposition is also monitored using dust deposition gauges at eight locations around the Lynwood Quarry site. The annual average dust deposition levels measured between 2013 and 2015 at the eight gauges are summarised in **Table 8**. Contaminated results (attributed to insects or bird droppings), or those that are considered outliers, have been removed from the annual averages. These measurements include the effects of all background sources relevant to the location.

The dust deposition data presented in **Table 8** indicate that deposited dust levels at all dust gauges (other than DD6 which is located within the Lynwood Quarry site boundary) lie below the impact assessment criterion of 4g/m$^2$/month, averaged annually.

**Table 8**
**Annual Average Dust Deposition Data for Lynwood Quarry (2013 to 2015)**

| Year | Impact assessment criterion: 4g/m$^2$/month | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Insoluble solids (g/m$^2$/month) | | | | | | | |
| | **DD1** | **DD2** | **DD3** | **DD4** | **DD5** | **DD6** | **DD7** | **DD8** |
| 2013 | 0.7 | 1.0 | 0.6 | 0.7 | 0.6 | 8.3* | 0.9 | 0.6 |
| 2014 | 2.3 | 2.6 | 1.5 | 1.5 | 3.0 | 1.9 | 1.1 | 1.3 |
| 2015 | 1.5 | 3.3 | 2.9 | 2.0 | 2.9 | 2.7 | 0.9 | 1.1 |

** DD6 was located within the site boundary and therefore not considered representative of off-site air quality.*

When excluding the non-representative 2013 data from DD6, the dust deposition data from Lynwood Quarry range from 0.6 g/m$^2$/month (annual average) to 3.3g/m$^2$/month, however this includes contribution from the existing quarry. The average dust deposition level is 1.6g/m$^2$/month and this is adopted as a conservative estimation of background dust deposition for this assessment.

### 5.3.3 $PM_{10}$ Concentration

$PM_{10}$ measurements recorded as part of the air quality monitoring network for the Proposal (on an approximately one-day-in-six basis) for the period November 2013 to January 2015 are shown in **Table 9**. After excluding erroneous records, the average of all records of 24-hour average $PM_{10}$ is 12.9µg/m$^3$. The records varied between 2.2µg/m$^3$ and 38.7µg/m$^3$.

$PM_{10}$ monitoring from further afield have also been reviewed. The Lynwood Quarry also measures $PM_{10}$ concentrations using two HVAS (referred to as HVAS1 and HVAS2), with each recording a 24-hour average sample, every six days.

A time series of the $PM_{10}$ concentration measurements from the Lynwood Quarry HVAS for the period January 2013 to June 2016, together with the Proposal data, is shown in **Figure 9**. The results indicate that the $PM_{10}$ concentrations in the area are relatively low. The maximum 24 hour average concentrations at HVAS1 and HVAS2 were 50.9µg/m$^3$ and 43.4µg/m$^3$, respectively. Whilst this shows one exceedance of the impact assessment criterion of 50µg/m$^3$, it is noted this was attributed to local road works.

The respective annual average $PM_{10}$ concentrations for the Lynwood Quarry HVAS were 10.1µg/m$^3$ and 8.7 µg/m$^3$, also below the annual average impact assessment criterion of 25µg/m$^3$.

The average $PM_{10}$ concentration recorded on Site is 12.9µg/m$^3$, slightly higher than measured at Lynwood Quarry, and this value has been conservatively assumed for the background.

Assuming that $PM_{10}$ constitutes ~40% of the TSP (NSW Minerals Council, 2000), an annual average background TSP level would be 32.3µg/m$^3$.

**Table 9**
**24-hour average $PM_{10}$ data for Sutton Forest Sand Quarry**

| Date | Impact assessment criterion: 50 µg/m³ | Date | Impact assessment criterion: 50 µg/m³ |
|---|---|---|---|
| | $PM_{10}$ concentration (µg/m³) | | $PM_{10}$ concentration (µg/m³) |
| 17/11/13 | 5.4 | 16/06/14 | 3.9 |
| 23/11/13 | 16.4 | 22/06/14 | 4.6 |
| 30/11/13 | 12.9 | 6/07/14# | 6.5 |
| 08/12/13 | 8.1 | 13/07/14 | 2.2 |
| 15/12/13 | 15.4 | 20/07/14 | 2.8 |
| 24/12/13 | 31.9 | 26/07/14 | 5.8 |
| 31/12/13 | 22.1 | 03/08/14 | 3.1 |
| 19/01/14# | 42.8 | 09/08/14 | 3.1 |
| 26/01/14 | 12.1 | 20/09/14# | 37.3 |
| 02/02/14 | 14.8 | 28/09/14 | 5.9 |
| 09/02/14 | 33.5 | 04/10/14 | 9.1 |
| 16/02/14 | 15.0 | 12/10/14 | 8.1 |
| 23/02/14 | 17.4 | 20/10/14 | 16.9 |
| 01/03/14 | 6.2 | 26/10/14 | 21.1 |
| 08/03/14 | 7.1 | 01/11/14 | 18.3 |
| 15/03/14 | 8.4 | 22/11/14# | 38.7 |
| 22/03/14 | 9.1 | 29/11/14 | 20.8 |
| 28/03/14 | 7.4 | 07/12/14 | 19.2 |
| 30/03/14 | 7.6 | 13/12/14 | 6.9 |
| 06/04/14 | 4.9 | 21/12/14 | 15.1 |
| 13/04/14 | 7.2 | 27/12/14 | 8.8 |
| 19/04/14 | 8.8 | 02/01/15 | 29.1 |
| 26/04/14 | 11.9 | 10/01/15 | 12.8 |
| 05/05/14 | 11.3 | 18/01/15 | 12.9 |
| 7/06/14* | 0.0 | | |
| **Average All Samples (excluding erroneous records)** | | | **12.9** |

High Volume Air Sampler calibrated to 1,600m³ per 24 hour sampling period.
# Filter envelope left in machine for 19 days and results considered erroneous. Not included in statistical analysis.
* No reading recorded for this period and therefore assumed to be erroneous. Not included in statistical analysis.

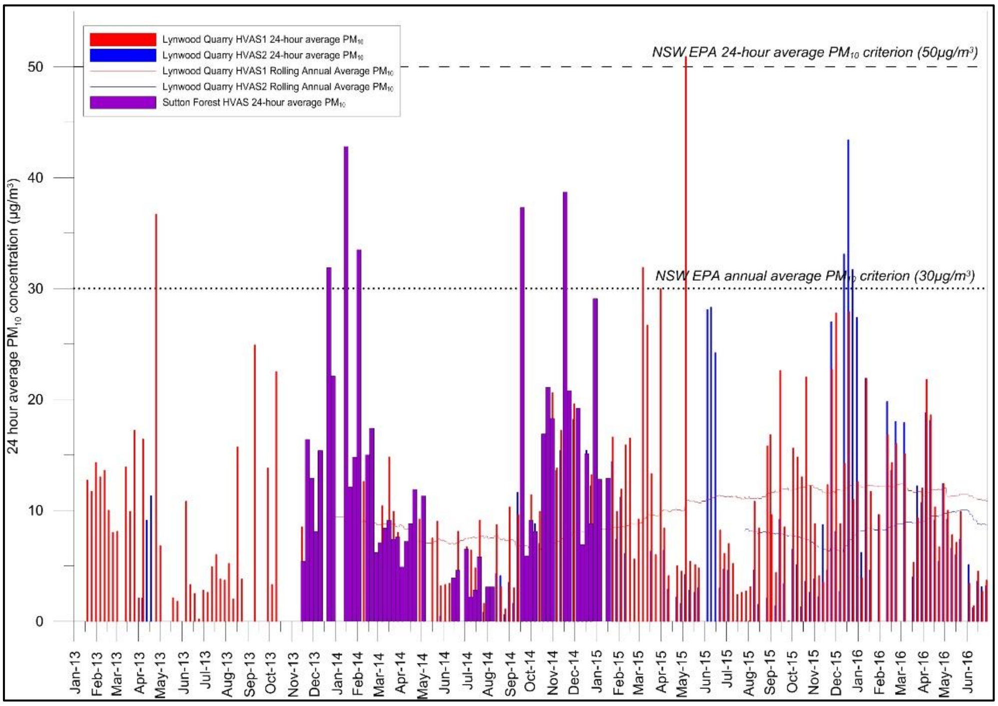



**Figure 9** **Lynwood Quarry and Proposal HVAS data (January 2013 to June 2016)**

### 5.3.4 $PM_{2.5}$ Concentration

The $PM_{10}$ data have also been extrapolated to provide an estimate of background $PM_{2.5}$ concentrations. A ratio of 0.4 has been applied to the $PM_{10}$ data to give an annual average $PM_{2.5}$ concentration of 5.2 µg/m$^3$. The adopted ratio is based on simultaneous measurements of $PM_{10}$ and $PM_{2.5}$ concentrations at a rural EPA monitoring site (Wagga Wagga North 2013 – 2015; NSW EPA, 2016).

The derived background, based on this ratio, is below the NSW EPA assessment criterion of 8 µg/m$^3$.

### 5.3.5 Adopted Background Concentrations

From the monitoring data available, it has been assumed that the following background concentrations apply at the nearest receptors surrounding the Site.

- Annual average TSP of 32.3 µg/m$^3$
- Annual average $PM_{10}$ of 12.9 µg/m$^3$
- Annual average $PM_{2.5}$ of 5.2 µg/m$^3$
- Annual average dust deposition of 1.6 g/m$^2$/month
- 24-hour average $PM_{10}$ – daily varying (see Section 7.3)
- 24-hour average $PM_{2.5}$ – daily varying (see Section 7.3)

# 6. APPROACH TO ASSESSMENT

## 6.1 INTRODUCTION

The overall approach to the assessment is based on a Level 2 assessment methodology as outlined in the Approved Methods. The Approved Methods specify how assessments based on the use of atmospheric dispersion models should be completed, including guidelines for the preparation of meteorological data to be used in dispersion models. There are no odorous activities taking place on Site and therefore no odour impact assessment is required for the Proposal.

## 6.2 MODELLING SYSTEM

The atmospheric dispersion modelling conducted for this assessment is based on the AERMET/AERMOD advanced modelling system. The NSW EPA has accepted AERMOD as a suitable atmospheric dispersion model for assessments of this kind and it has been used on numerous similar proposals.

AERMOD was chosen as the most suitable model due to the source types, location of nearest receptors and nature of local topography. AERMOD is the US-EPA's recommended steady-state plume dispersion model for regulatory purposes. AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the US in December 2006 as it incorporates more recent, and potentially more accurate, algorithms to represent both meteorological interactions and atmospheric dispersion. Ausplume, a steady state Gaussian plume dispersion model developed by the Victorian EPA and frequently used in Australia for simple near-field applications is based on ISC, Ausplume has also now been replaced in Victoria by AERMOD.

A significant feature of AERMOD is that the Pasquill-Gifford stability-based dispersion is replaced with a turbulence-based approach that uses the Monin-Obukhov length scale to account for the effects of atmospheric turbulence-based dispersion.

The AERMOD system includes AERMET, used for the preparation of meteorological input files and AERMAP, used for the preparation of terrain data. Terrain data were sourced from NASA's Shuttle Radar Topography Mission (SRTM) Data (1 arc second (~30m) resolution) and processed within AERMAP to create the necessary input files.

## 6.3 DISPERSION METEOROLOGY

AERMET requires surface and upper air meteorological data as input. Surface data were sourced from a combination of the available on site meteorological data (see Section 5.1) and supplemented with cloud data from the BoM Moss Vale AWS located approximately 22km northwest of the Site.

Annual and seasonal wind rose plots of the meteorological file used within the modelling are shown in **Figure 7**.

Appropriate values for three surface characteristics are required for AERMET as follows.

- Surface roughness, which is the height at which the mean horizontal wind speed approaches zero, based on a logarithmic profile.
- Albedo, which is an indicator of reflectivity of the surface.
- Bowen ratio, which is an indicator of surface moisture.

Values of surface roughness, Bowen ratio and albedo were determined based on a review of the land use (using aerial photography) for a radius of 3km centred on the Site. Default values for forested land and grassland were chosen for three separate sectors to represent the varying land use types in the surrounding area.

### 6.3.1 Atmospheric Stability

An important aspect of pollutant dispersion is the level of turbulence in the lowest 1 km or so of the atmosphere, known as the planetary boundary layer (PBL). Turbulence controls how effectively a plume is diffused into the surrounding air and hence diluted. It acts by increasing the cross-sectional area of the plume due to random motions. With stronger turbulence, the rate of plume diffusion increases. Weak turbulence limits diffusion and contributes to high plume concentrations downwind of a source.

Turbulence is generated by both thermal and mechanical effects to varying degrees. Thermally driven turbulence occurs when the surface is being heated, in turn transferring heat to the air above by convection. Mechanical turbulence is caused by the frictional effects of wind moving over the earth’s surface and depends on the roughness of the surface as well as the flow characteristics.

Turbulence in the boundary layer is influenced by the vertical temperature gradient, which is one of several indicators of stability. Plume models use indicators of atmospheric stability in conjunction with other meteorological data to estimate the dispersion conditions in the atmosphere.

Stability can be described across a spectrum ranging from highly unstable through neutral to highly stable. A highly unstable boundary layer is characterised by strong surface heating and relatively light winds, leading to intense convective turbulence and enhanced plume diffusion. At the other extreme, very stable conditions are often associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Neutral conditions are linked to windy and/or cloudy weather, and short periods around sunset and sunrise, when surface rates of heating or cooling are very low.

The stability of the atmosphere plays a large role in determining the dispersion of a plume and it is important to have it correctly represented in dispersion models. Current air quality dispersion models (such as AERMOD and CALPUFF) use the Monin-Obukhov Similarity Theory (MOST) to characterise turbulence and other processes in the PBL. One of the measures of the PBL is the Monin-Obukhov length (L), which approximates the height at which turbulence is generated equally by thermal and mechanical effects (Seinfeld and Pandis 2006). It is a measure of the relative importance of mechanical and thermal forcing on atmospheric turbulence.

Because values of L diverge to + and - infinity as stability approaches neutral from the stable and unstable sides, respectively, it is often more convenient to use the inverse of L (i.e., 1/L) when describing stability.

**Figure 10** shows the hourly averaged 1/L for the Site computed from all data in the AERMET surface file. Based on **Table 10** this plot indicates that the PBL is stable overnight and becomes unstable as radiation from the sun heats the surface layer of the atmosphere and drives convection. The changes from positive to negative occur at the shifts between day and night. This indicates that the diurnal patterns of stability are realistic.

**Table 10**
**Inverse of the Monin-Obukhov length L with respect to atmospheric stability**

| 1/L | Atmospheric Stability |
|---|---|
| Negative | Unstable |
| Zero | Neutral |
| Positive | Stable |

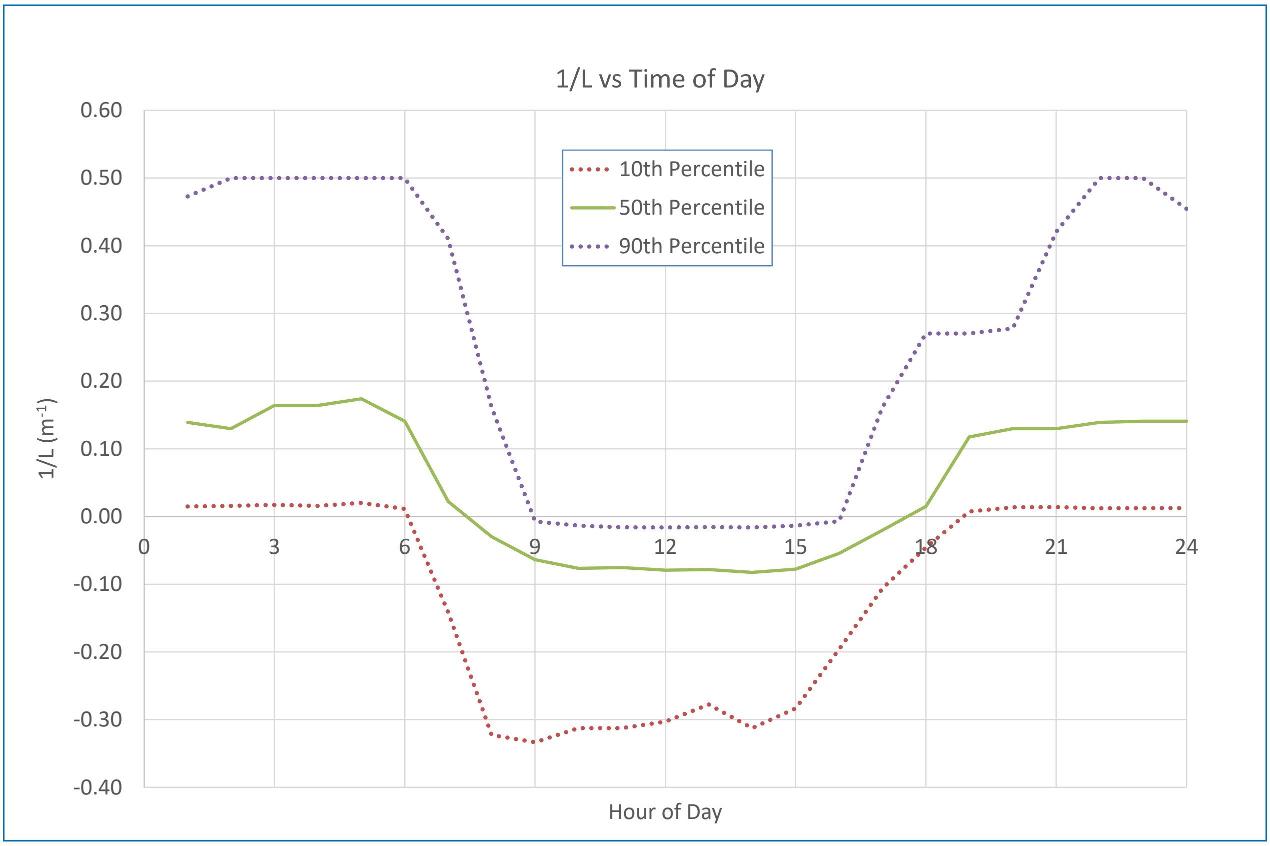



**Figure 10 Annual statistics for the Site of 1/L by hour of the day**

**Figure 11** shows the variations in atmospheric stability at the Site over the year by hour of the day, with reference to the widely known Pasquill-Gifford classes of stability. The relationship between L and stability classes is based on values derived by Golder (1972) set out in NSW EPA (2016). Note that the reference to stability classes here is only for convenience in describing stability. The model uses calculated values of L across a continuum.

**Figure 11** shows that stable and very stable conditions occur for about 60% of the time, which is typical for inland locations that regularly experience temperature inversions at night. Atmospheric instability increases during the day and reaches a peak around noon as solar-driven convective energy peaks. A stable atmosphere is prevalent during the night. These profiles indicate that pollutant dispersion is most effective during the daytime and least effective at night.

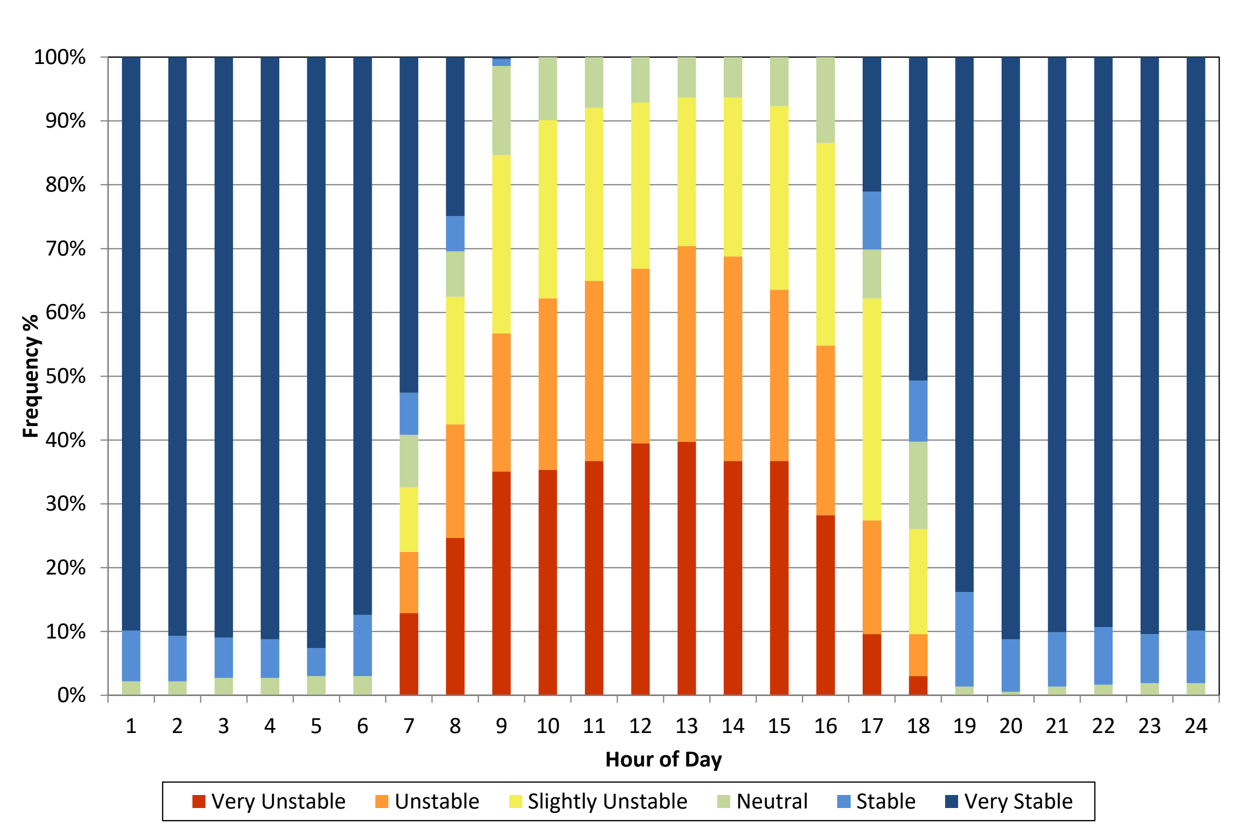



**Figure 11 Annual distribution of stability type by hour of the day**

## 6.4 MODELLING SCENARIOS

Two operational scenarios were chosen for quantitative dispersion modelling. The extraction stages modelled (Stage 2 and Stage 4) are based on a maximum sand extraction rate of 1 million tpa and represent when the Proposal would be operating in closest proximity to the nearby sensitive receptors.

The modelled scenarios for extraction Stages 2 and 4 are shown in **Figure 3** and **Figure 13** respectively.

## 6.5 BEST PRACTICE MITIGATION MEASURES

The Proposal would incorporate a number of best practice mitigation measures on Site to ensure that PM impacts are minimised. Recommended measures to be employed for the Proposal include the following.

- Use of a water truck to control emissions from internal haul roads.
- Enforcement of speed limits on site and on the Quarry Access Road.
- Training and implementation of standard operating procedures.
- Progressive rehabilitation of exposed areas.
- Minimising drop height of material during truck loading and unloading.
- Sheltering of stockpiles and transfer points where possible.
- Management of dust generating activities during unfavourable meteorological conditions, i.e. minimising or restricting such activities during hot, windy periods.

It is noted the material to be excavated has an inherent moisture content of approximately 10% that would minimise the dust-generating potential of the activities.

## 6.6 EMISSION ESTIMATES

During operations, the Proposal would result in emissions of PM, primarily from material handling and hauling in the extraction area and screening, crushing and stockpile loading in the processing area. The extraction method for the Proposal would involve ripping and occasional blasting and excavator/haul trucks.

As the maximum daily production rates can vary from week to week, using a daily average production rate based on the annual throughput could underestimate potential short term PM impacts. Therefore, a maximum daily extraction rate of 4,000 tonnes per day has been assessed for the 24-hour average periods for $PM_{10}$ and $PM_{2.5}$. Daily throughputs for the wash plant are 4,000 tonnes per day and the mortar (brickies) sand processing plant would operate at 800 tonnes per day using existing stockpiles.

Emission factors developed by the US EPA (US EPA, 1985 and updates) and locally by the National Pollution Inventory (NPI) (NPI, 2012) have been used to estimate the amount of PM produced by each activity. The emission estimates are based on the type of equipment to be used, volumes of material handled and locations of potential wind erosion areas and take into account information on the material properties such as the silt and moisture contents of various materials and active haul roads between the extraction area and the processing plant.

In estimating PM emissions, consideration has been given to best practice management and controls, including watering of haul roads (see Section 6.5).

With the exception of the wash plant, it has been conservatively assumed that extraction activities would take place between 5am and 10pm, seven days per week. All other all activities are assumed to occur 24 hours per day, seven days per week. Hence, these assumptions are conservative given activities at this intensity are likely to occur.

The air quality metrics that have been assessed quantitatively are as follows.

- TSP
- $PM_{10}$
- $PM_{2.5}$
- Dust deposition.

The estimated PM emissions for the Stage 2 and Stage 4 are presented in **Table 11** and **Table 12** respectively.

The source locations used in the modelling are provided in **Figure 12** and **Table 13** for Stage 2, and **Figure 13** and **Table 14** for stage 4. The detailed emissions inventories for all scenarios are provided in **Appendix 1**.

**Table 11**
**Estimated annual particulate matter emissions for Stage 2**

| Activity | TSP (kg/yr) | $PM_{10}$ (kg/yr) | | $PM_{2.5}$ (kg/yr) | |
|---|---|---|---|---|---|
| | Annual Maximum | Annual Maximum | Daily Maximum | Annual Maximum | Daily Maximum |
| Extraction Area/Processing - Dozers | 11,006 | 2,557 | 2,557 | 1,156 | 1,156 |
| Pit - drilling | 1,593 | 828 | 828 | 48 | 48 |
| Pit - blasting | 151 | 79 | 79 | 5 | 5 |
| Pit - loading material to trucks at pit | 147 | 70 | 99 | 11 | 15 |
| Pit - hauling material to dry screening plant (brickies sand) | 4,310 | 1,164 | 1,648 | 116 | 165 |
| Pit - hauling material from pit to processing area (for washed sand products) | 27,801 | 7,505 | 10,627 | 751 | 1,063 |
| Brickies sand screening plant - unloading to raw feed stockpile | 15 | 7 | 10 | 1 | 1 |
| Brickies sand screening plant - Loading to hopper from raw feeds stockpile | 15 | 7 | 10 | 1 | 1 |
| Brickies sand screening plant - Screening | 15,000 | 3,600 | 5,098 | 3,600 | 5,098 |
| Brickies sand screening plant - Relocating to product stockpile | 12 | 6 | 6 | 1 | 0.8 |
| Wash Plant - Unloading to raw feed stockpile | 133 | 63 | 89 | 9 | 13 |
| Wash Plant - Loading to hopper from raw feed stockpile | 133 | 63 | 89 | 9 | 13 |
| Wash Plant - Screening | 990 | 333 | 472 | 23 | 32 |
| Wash Plant - Primary Crusher | 108 | 49 | 49 | 9 | 9 |
| Wash Plant - Conveyor unloading | 133 | 63 | 89 | 9 | 13 |
| Wash Plant - Relocating to product stockpile | 235 | 111 | 111 | 17 | 17 |
| Waste - loading fines at processing area | 9 | 4 | 6 | 1 | 0.9 |
| Waste - loading oversized material | 4 | 2 | 28 | 0 | 4 |
| Waste - hauling fines to emplacement area | 4,346 | 1,173 | 1,661 | 117 | 166 |
| Waste - unloading fines at emplacement area | 9 | 4 | 6 | 1 | 0.9 |
| Waste - hauling oversized material | 970 | 262 | 3,493 | 26 | 349 |
| Waste - unloading oversized material | 6 | 3 | 38 | 0 | 6 |
| Product - loading washed sand product material to trucks | 235 | 111 | 111 | 17 | 17 |
| Product - loading Brickies product material to trucks | 16 | 8 | 8 | 1 | 1.2 |
| Product - hauling product material to off-site location (sealed road) | 2,721 | 522 | 522 | 126 | 126 |
| Wind Erosion - Extraction Area | 13,403 | 6,701 | 6,701 | 1,005 | 1,005 |
| Wind Erosion - Processing and Stockpiling Area | 10,512 | 5,256 | 5,256 | 788 | 788 |
| Wind Erosion - Fines Storage | 1,927 | 964 | 964 | 145 | 145 |
| Wind Erosion - Topsoil and Mulch Stockpiling Area | 1,533 | 767 | 767 | 115 | 115 |
| Grading unsealed roads | 2,048 | 716 | 716 | 63 | 63 |
| **Total (kg/yr)** | **99,521** | **32,996** | **42,135** | **8,172** | **10,438** |

**Table 12**
**Estimated annual particulate matter emissions for Stage 4**

| Activity | TSP | $PM_{10}$ (kg/yr) | | $PM_{2.5}$ (kg/yr) | |
|---|---|---|---|---|---|
| | Annual Maximum | Annual Maximum | Daily Maximum | Annual Maximum | Daily Maximum |
| Extraction Area/Processing - Dozers | 11,006 | 2,557 | 2,557 | 1,156 | 1,156 |
| Pit - drilling | 1,593 | 828 | 828 | 48 | 48 |
| Pit - blasting | 151 | 79 | 79 | 5 | 5 |
| Pit - loading material to trucks at pit | 147 | 70 | 99 | 11 | 15 |
| Pit - hauling material to dry screening plant (brickies sand) | 4,310 | 1,164 | 1,648 | 116 | 165 |
| Pit – hauling material from pit to processing area (for washed sand products) | 27,801 | 7,505 | 10,627 | 751 | 1,063 |
| Brickies sand screening plant - unloading to raw feed stockpile | 15 | 7 | 10 | 1 | 1 |
| Brickies sand screening plant - Loading to hopper from raw feeds stockpile | 15 | 7 | 10 | 1 | 1 |
| Brickies sand screening plant - Screening | 15,000 | 3,600 | 5,098 | 3,600 | 5,098 |
| Brickies sand screening plant - Relocating to product stockpile | 12 | 6 | 6 | 1 | 1 |
| Wash Plant - Unloading to raw feed stockpile | 133 | 63 | 89 | 9 | 13 |
| Wash Plant - Loading to hopper from raw feed stockpile | 133 | 63 | 89 | 9 | 13 |
| Wash Plant - Screening | 990 | 333 | 472 | 23 | 32 |
| Wash Plant - Primary Crusher | 270 | 122 | 122 | 23 | 23 |
| Wash Plant - Conveyor unloading | 133 | 63 | 89 | 9 | 13 |
| Wash Plant - Relocating to product stockpile | 235 | 111 | 111 | 17 | 17 |
| Waste - loading fines at processing area | 9 | 4 | 6 | 1 | 1 |
| Waste - loading oversized material | 4 | 2 | 28 | 0 | 4 |
| Waste - hauling fines to emplacement area | 4,346 | 1,173 | 1,661 | 117 | 166 |
| Waste - unloading fines at emplacement area | 9 | 4 | 6 | 1 | 1 |
| Waste - hauling oversized material | 970 | 262 | 3,493 | 26 | 349 |
| Waste - unloading oversized material | 6 | 3 | 38 | 0 | 6 |
| Product - loading washed sand product material to trucks | 235 | 111 | 111 | 17 | 17 |
| Product - loading Brickies product material to trucks | 16 | 8 | 8 | 1 | 1 |
| Product - hauling product material to off-site location (sealed road) | 2,721 | 522 | 522 | 126 | 126 |
| Wind Erosion - Extraction Area | 18,396 | 9,198 | 9,198 | 1,380 | 1,380 |
| Wind Erosion - Processing and Stockpiling Area | 10,512 | 5,256 | 5,256 | 788 | 788 |
| Wind Erosion - Fines Storage | 876 | 438 | 438 | 66 | 66 |
| Wind Erosion - Topsoil and Mulch Stockpiling Area | 1,533 | 767 | 767 | 115 | 115 |
| Grading unsealed roads[a] | 41,832 | 14,616 | 14,616 | 1,297 | 1,297 |
| **Total (kg/yr)** | **143,408** | **48,940** | **58,079** | **9,714** | **11,981** |

Note:
(a) Grader hours were overestimated in the emission calculations for Stage 4. Thus the estimated emissions and predicted impacts are conservative.

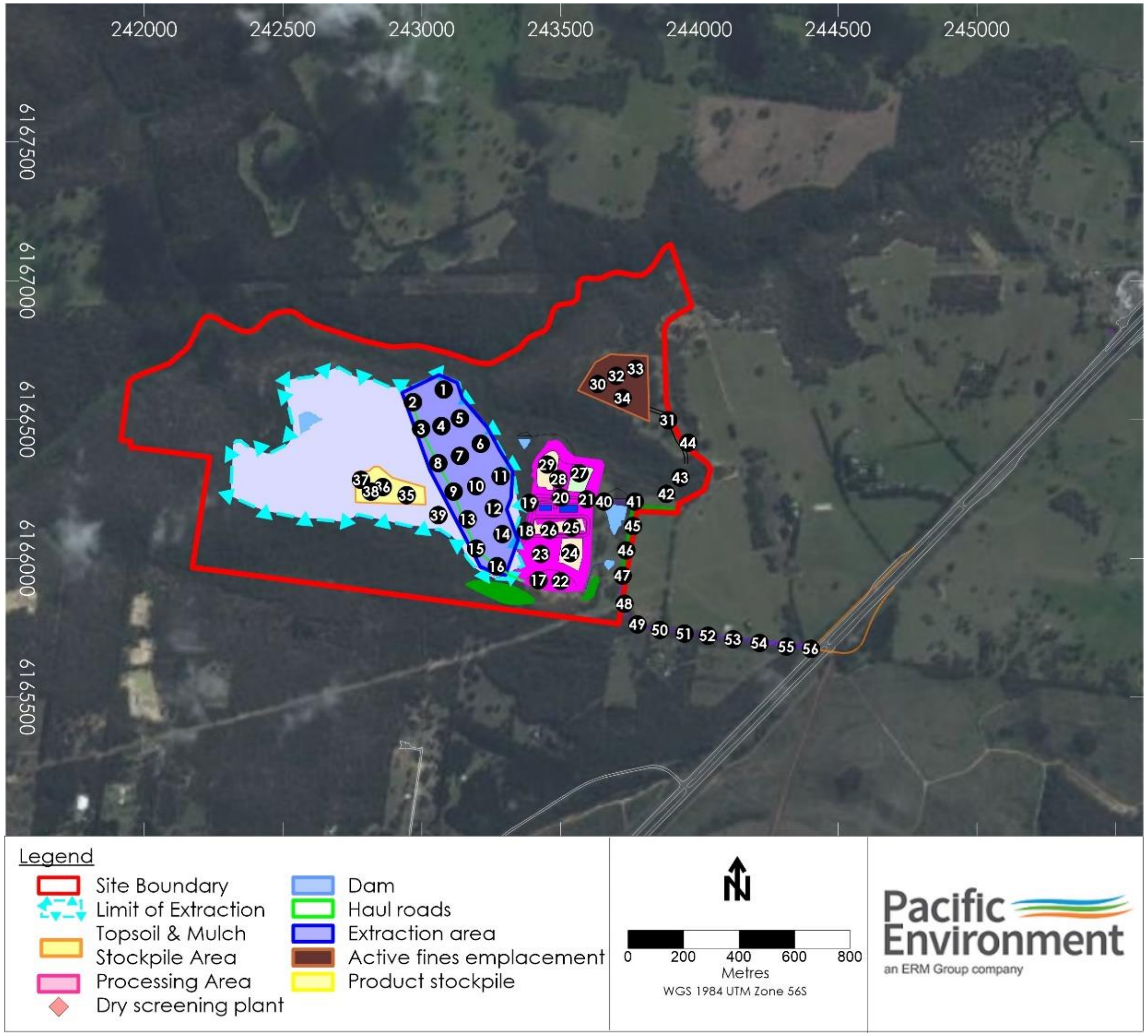



**Figure 12 Source locations adopted for Stage 2 modelling**

**Table 13**
**Source locations adopted for Stage 2 modelling**

| ACTIVITY | SOURCE LOCATIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 1 | 4 | 5 | 6 | 7 | 10 | 11 | 12 | 14 | | | | | | | |
| Pit - loading material to trucks at pit | 1 | 2 | 4 | 5 | 6 | 7 | | | | | | | | | | |
| Pit - hauling material to dry screening plant (brickies sand) | 1 | 2 | 4 | 5 | 6 | 7 | | | | | | | | | | |
| Pit - loading material to trucks at pit | 1 | 4 | 5 | 6 | 7 | 10 | 11 | 12 | 14 | | | | | | | |
| Pit - hauling material to dry screening plant (brickies sand) | 2 | 3 | 8 | 9 | 13 | 15 | 16 | 18 | 19 | 20 | 20 | | | | | |
| Pit – hauling material from pit to processing area (for washed sand products) | 2 | 3 | 8 | 9 | 13 | 15 | 16 | | | | | | | | | |
| Brickies sand screening plant - unloading to raw feed stockpile | 27 | | | | | | | | | | | | | | | |
| Brickies sand screening plant - Loading to hopper from raw feed stockpile | 28 | | | | | | | | | | | | | | | |
| Brickies sand screening plant - Screening | 28 | | | | | | | | | | | | | | | |
| Brickies sand screening plant - Relocating to product stockpile | 29 | | | | | | | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 17 | 22 | | | | | | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 23 | | | | | | | | | | | | | | | |
| Wash Plant - Screening | 23 | | | | | | | | | | | | | | | |
| Wash Plant - Primary Crusher | 23 | | | | | | | | | | | | | | | |
| Wash Plant - Conveyor | 23 | | | | | | | | | | | | | | | |
| Wash Plant - Relocating to product stockpile | 24 | 25 | 26 | | | | | | | | | | | | | |
| Waste - loading fines at processing area | 23 | | | | | | | | | | | | | | | |
| Waste - loading oversized material | 23 | | | | | | | | | | | | | | | |
| Waste - hauling fines to emplacement area | 18 | 19 | 20 | 21 | 31 | 40 | 41 | 42 | 43 | 44 | | | | | | |
| Waste - unloading fines at emplacement area | 30 | 32 | 33 | 34 | | | | | | | | | | | | |
| Waste - hauling oversized material | 13 | 15 | 16 | 35 | 39 | | | | | | | | | | | |
| Waste - unloading oversized material | 35 | 36 | | | | | | | | | | | | | | |
| Product - loading washed sand product material to trucks | 24 | 25 | 26 | | | | | | | | | | | | | |
| Product - loading Brickies product material to trucks | 29 | | | | | | | | | | | | | | | |
| Product - hauling product material to off-site location (sealed road) | 18-21 | | 40 | 41 | 45-56 | | | | | | | | | | | |
| Wind Erosion - Extraction Area | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Wind Erosion - Processing and Stockpiling Area | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | | | |
| Wind Erosion - Fines Storage | 30 | 32 | 33 | 34 | | | | | | | | | | | | |
| Wind Erosion - Topsoil and Mulch Stockpiling Area | 35 | 36 | 37 | 38 | | | | | | | | | | | | |
| Grading unsealed roads | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |

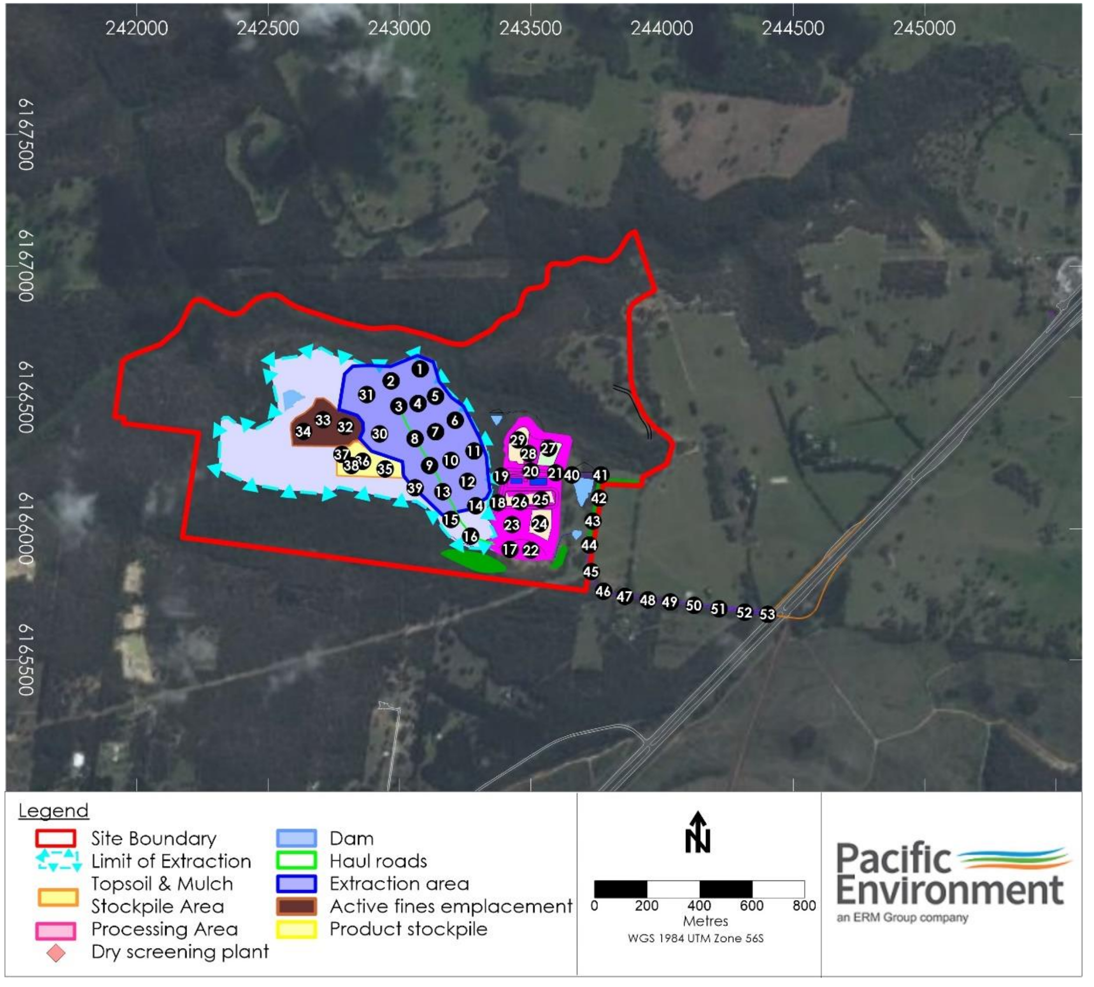



**Figure 13 Source locations adopted for Stage 4 modelling**

**Table 14**
**Source locations adopted for Stage 4 modelling**

| ACTIVITY | SOURCE LOCATIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 1 | 2 | 4 | 5 | 6 | 7 | 10 | 11 | 12 | 14 | 30 | | | | | |
| Pit - loading material to trucks at pit | 1 | 2 | 4 | 5 | 6 | 7 | 31 | | | | | | | | | |
| Pit - hauling material to dry screening plant (brickies sand) | 1 | 2 | 4 | 5 | 6 | 7 | 31 | | | | | | | | | |
| Pit - loading material to trucks at pit | 1 | 2 | 4 | 5 | 6 | 7 | 10 | 11 | 12 | 14 | | | | | | |
| Pit - hauling material to dry screening plant (brickies sand) | 3 | 8 | 9 | 13 | 15 | 16 | 18 | 19 | 20 | | | | | | | |
| Pit – hauling material from pit to processing area (for washed sand products) | 3 | 8 | 9 | 13 | 15 | 16 | | | | | | | | | | |
| Brickies sand screening plant - unloading to raw feed stockpile | 27 | | | | | | | | | | | | | | | |
| Brickies sand screening plant - Loading to hopper from raw feed stockpile | 28 | | | | | | | | | | | | | | | |
| Brickies sand screening plant - Screening | 28 | | | | | | | | | | | | | | | |
| Brickies sand screening plant - Unloading to product stockpile | 29 | | | | | | | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 17 | 22 | | | | | | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 23 | | | | | | | | | | | | | | | |
| Wash Plant - Screening | 23 | | | | | | | | | | | | | | | |
| Wash Plant - Primary Crusher | 23 | | | | | | | | | | | | | | | |
| Wash Plant - Conveyor | 23 | | | | | | | | | | | | | | | |
| Wash Plant - Unloading to product stockpile | 24 | 25 | 26 | | | | | | | | | | | | | |
| Waste - loading fines at processing area | 23 | | | | | | | | | | | | | | | |
| Waste - loading oversized material | 23 | | | | | | | | | | | | | | | |
| Waste - hauling fines to dump area | 15 | 16 | 18 | 19 | 20 | 30 | 32 | 39 | | | | | | | | |
| Waste - unloading fines at dump area | 32 | 33 | 34 | | | | | | | | | | | | | |
| Waste - hauling oversized material | 13 | 15 | 16 | 35 | 39 | | | | | | | | | | | |
| Waste - unloading oversized material | 35 | 36 | | | | | | | | | | | | | | |
| Product - loading washed sand product material to trucks | 24 | 25 | 26 | | | | | | | | | | | | | |
| Product - loading Brickies product material to trucks | 29 | | | | | | | | | | | | | | | |
| Product - hauling product material to off-site location (sealed road) | 18-21 | | 40-53 | | | | | | | | | | | | | |
| Wind Erosion - Extraction Area | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13-16 | | 30 | 31 |
| Wind Erosion - Processing and Stockpiling Area | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | | | |
| Wind Erosion - Fines Storage | 32 | 33 | 34 | | | | | | | | | | | | | |
| Wind Erosion - Topsoil and Mulch Stockpiling Area | 35 | 36 | 37 | 38 | | | | | | | | | | | | |
| Grading unsealed roads | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |

## 6.7 EMISSIONS FROM NEARBY SOURCES

As well as accounting for background dust levels around the Site the potential for cumulative impacts arising from operations at the Penrose Sand Quarry should also be considered. Penrose Sand Quarry is owned by Adelaide Brighton Limited and is located approximately 2 km southwest of the Site.

A dispersion modelling assessment was completed by Holmes Air Sciences (1997) which assessed the potential air quality impacts of the Penrose Sand Quarry. A different meteorology data set was used in the Penrose Sand Quarry assessment compared with the current assessment for the Proposal, therefore air quality impacts on nearby residents cannot be directly compared.

However, the dispersion modelling assessment for the Penrose Sand Quarry showed a maximum cumulative increment at the nearest sensitive receptor of no more than 5 µg/m$^3$ for annual average $PM_{10}$ and no more than 0.5 g/m$^2$/month for annual average dust deposition. When considered with the predicted impacts from the Proposal and existing background levels, the combined concentrations are still below the relevant impact assessment criteria.

# 7. IMPACT ASSESSMENT

Dust concentrations and deposition levels for the selected years of assessment are presented for Stage 2 and Stage 4 as contour plots showing the following.

- Predicted annual average TSP concentration.
- Predicted annual average $PM_{10}$ concentration.
- Predicted annual average $PM_{2.5}$ concentration.
- Predicted annual average monthly dust deposition.
- Predicted maximum 24-hour average $PM_{10}$ concentration.
- Predicted maximum 24-hour average $PM_{2.5}$ concentration.

Contour plots of PM concentrations and dust deposition rates show the areas that are predicted to experience increases in dust concentration and levels. It is important to note that the contour figures are presented to provide a visual representation of the predicted concentrations and levels. To produce the contours, it is necessary to make interpolations, and as a result the contours may not always match exactly with predicted impacts at a specific location. Results have also been summarised in tabular form for each scenario.

The following sections examine predicted maximum 24-hour average $PM_{10}$ and $PM_{2.5}$ and annual average $PM_{10}$, TSP and dust deposition impacts attributable to the Proposal alone as well as cumulatively. Additional cumulative assessment for 24-hour average $PM_{10}$ and $PM_{2.5}$ is provided in Section 7.2.

## 7.1 ANNUAL AVERAGE $PM_{10}$, TSP, DUST DEPOSITION AND $PM_{2.5}$ PREDICTIONS

### 7.1.1 Stage 2 Modelling Scenario

**Table 15** presents a summary of the predicted annual average concentrations at each of the nearby receptors, due to the operations of the Proposal alone and cumulatively i.e. when added to the existing background concentrations or levels.

Contour plots are presented in **Figure 14** to **Figure 21** for the Proposal alone and cumulatively.

Modelling results for Stage 2 show no exceedances of the relevant annual average TSP, $PM_{10}$, $PM_{2.5}$ and dust deposition impact assessment criteria at any sensitive receptors.

## Table 15
## Stage 2 – Predicted annual average $PM_{10}$ and TSP concentrations and dust deposition levels due to the Proposal alone and the Proposal and other sources

| ID | Stage 2 - Proposal-only | | | | Stage 2 - Cumulative | | | |
|---|---|---|---|---|---|---|---|---|
| | TSP ($\mu g/m^3$) | $PM_{10}$ ($\mu g/m^3$) | $PM_{2.5}$ ($\mu g/m^3$) | Dust deposition ($g/m^2$/month) | TSP ($\mu g/m^3$) | $PM_{10}$ ($\mu g/m^3$) | $PM_{2.5}$ ($\mu g/m^3$) | Dust deposition ($g/m^2$/month) |
| | *Assessment criteria* | | | | | | | |
| | *N/A* | *N/A* | *N/A* | *2* | *90* | *25* | *8* | *4* |
| **Residences** | | | | | | | | |
| 1 | 6.1 | 2.6 | 0.6 | 0.5 | 38.4 | 15.5 | 5.7 | 2.1 |
| 2 | 2.4 | 1.5 | 0.3 | 0.3 | 34.7 | 14.4 | 5.5 | 1.9 |
| 3 | 1.4 | 0.8 | 0.2 | 0.2 | 33.7 | 13.7 | 5.4 | 1.8 |
| 4 | 0.5 | 0.6 | 0.1 | 0.1 | 32.8 | 13.5 | 5.3 | 1.7 |
| 5 | 0.2 | 0.3 | 0.1 | 0.0 | 32.5 | 13.2 | 5.2 | 1.6 |
| 7 | 0.1 | 0.2 | 0.1 | 0.0 | 32.4 | 13.1 | 5.2 | 1.6 |
| 8 | 0.5 | 0.4 | 0.1 | 0.1 | 32.8 | 13.3 | 5.2 | 1.7 |
| 11 | 0.5 | 0.4 | 0.1 | 0.1 | 32.8 | 13.3 | 5.2 | 1.7 |
| 12 | 0.5 | 0.4 | 0.1 | 0.1 | 32.8 | 13.3 | 5.2 | 1.7 |
| 13 | 0.4 | 0.2 | 0.1 | 0.1 | 32.7 | 13.1 | 5.2 | 1.7 |
| 15 | 1.8 | 0.8 | 0.2 | 0.2 | 34.1 | 13.7 | 5.3 | 1.8 |
| 16 | 1.4 | 1.5 | 0.3 | 0.1 | 33.7 | 14.4 | 5.5 | 1.7 |
| 17a | 1.3 | 1.4 | 0.3 | 0.1 | 33.6 | 14.3 | 5.5 | 1.7 |
| 17b | 1.7 | 1.8 | 0.4 | 0.2 | 34.0 | 14.7 | 5.5 | 1.8 |
| 18 | 0.9 | 0.6 | 0.1 | 0.1 | 33.2 | 13.5 | 5.3 | 1.7 |
| 19 | 0.6 | 0.4 | 0.1 | 0.1 | 32.9 | 13.3 | 5.3 | 1.7 |
| 20 | 0.6 | 0.8 | 0.2 | 0.1 | 32.9 | 13.7 | 5.4 | 1.7 |
| 21 | 0.6 | 1.0 | 0.3 | 0.1 | 32.9 | 13.9 | 5.4 | 1.7 |
| 23 | 0.2 | 0.5 | 0.2 | 0.0 | 32.5 | 13.4 | 5.3 | 1.6 |
| 24 | 0.2 | 0.5 | 0.3 | 0.0 | 32.5 | 13.4 | 5.4 | 1.6 |
| 25 | 0.1 | 0.3 | 0.2 | 0.0 | 32.4 | 13.2 | 5.4 | 1.6 |
| 26 | 0.1 | 0.2 | 0.2 | 0.0 | 32.4 | 13.1 | 5.3 | 1.6 |
| 27 | 0.1 | 0.2 | 0.1 | 0.0 | 32.4 | 13.1 | 5.3 | 1.6 |
| 28A | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 28B | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 28C | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 30 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 31 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 33 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 35 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 36 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 38 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 41 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 42a | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 42b | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 43 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 45 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 46 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 50 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 51 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 52 | 0.0 | 0.1 | 0.1 | 0.0 | 32.3 | 13.0 | 5.3 | 1.6 |
| 53 | 0.0 | 0.1 | 0.0 | 0.0 | 32.3 | 13.0 | 5.2 | 1.6 |
| 54 | 0.0 | 0.1 | 0.0 | 0.0 | 32.3 | 13.0 | 5.2 | 1.6 |
| 55 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 56 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 57 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 58 | 0.3 | 0.4 | 0.1 | 0.0 | 32.6 | 13.3 | 5.3 | 1.6 |
| 59 | 0.2 | 0.2 | 0.0 | 0.0 | 32.5 | 13.1 | 5.2 | 1.6 |
| 61 | 0.2 | 0.2 | 0.0 | 0.0 | 32.5 | 13.1 | 5.2 | 1.6 |
| 62 | 0.2 | 0.2 | 0.0 | 0.0 | 32.5 | 13.1 | 5.2 | 1.6 |
| 63 | 0.0 | 0.1 | 0.1 | 0.0 | 32.3 | 13.0 | 5.3 | 1.6 |
| 64 | 0.0 | 0.1 | 0.0 | 0.0 | 32.3 | 13.0 | 5.2 | 1.6 |
| 65 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |

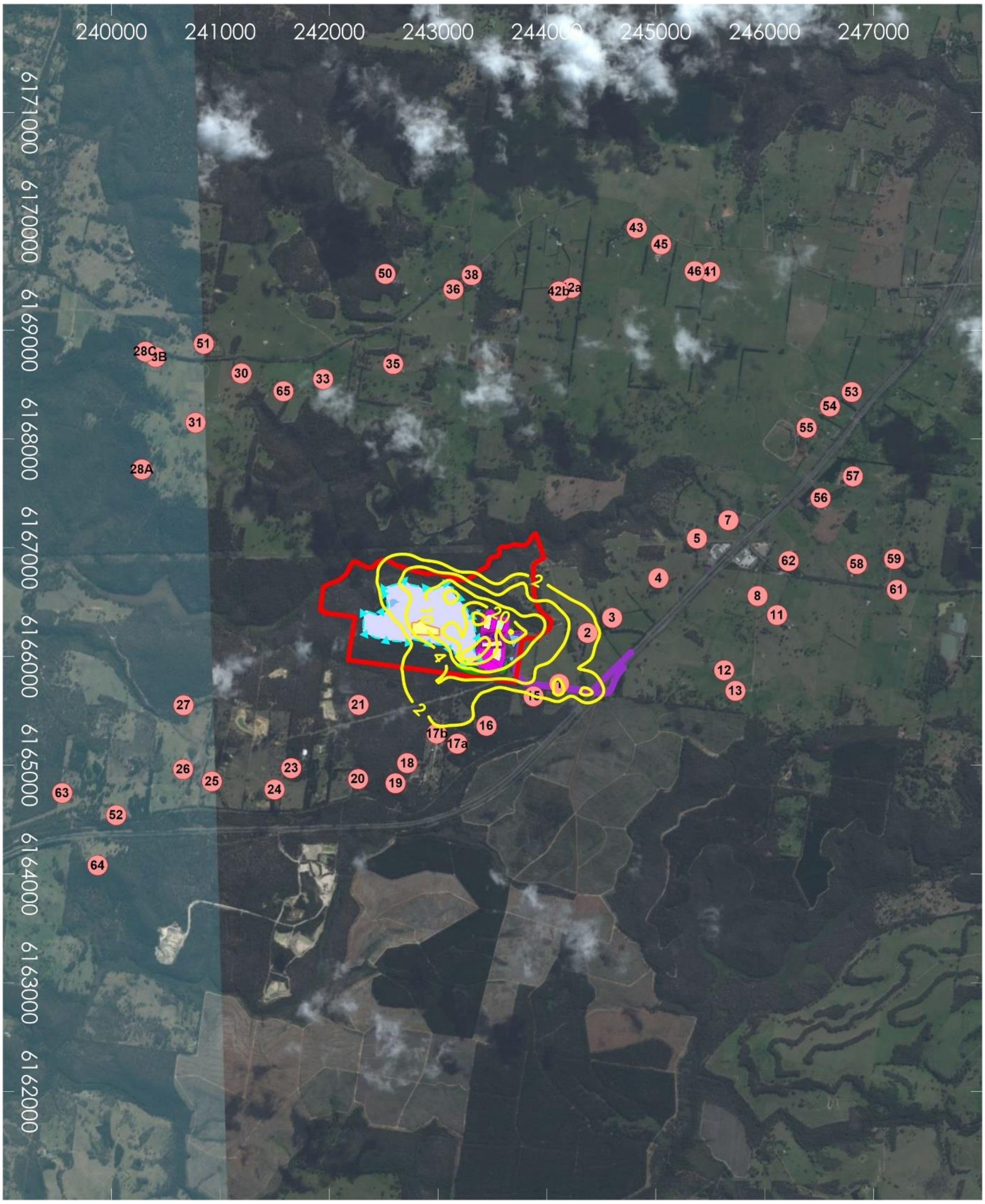



**Figure 14** **Predicted annual average TSP concentrations – Stage 2: Proposal alone**

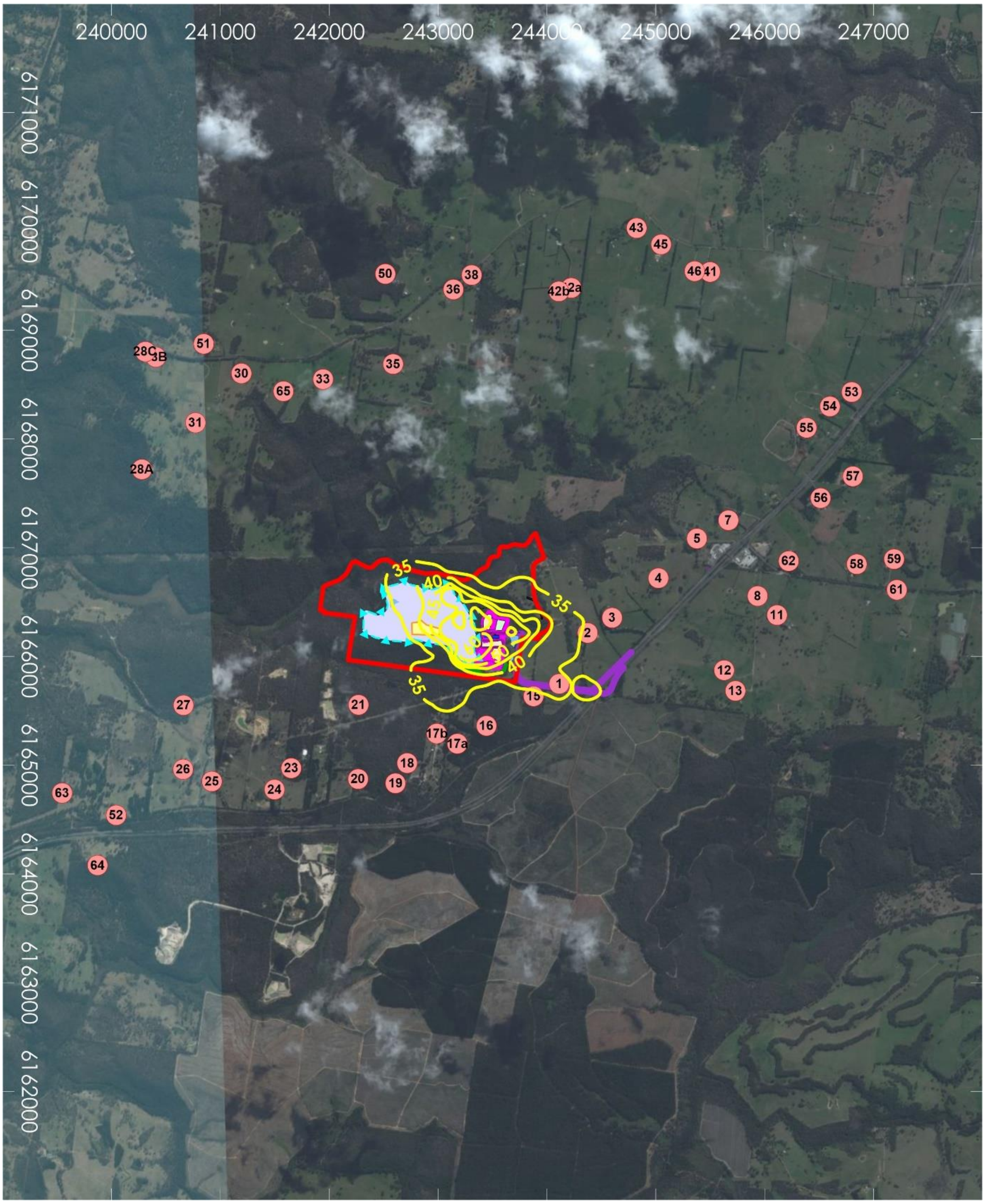



**Figure 15 Predicted annual average TSP concentrations – Stage 2: Cumulative**

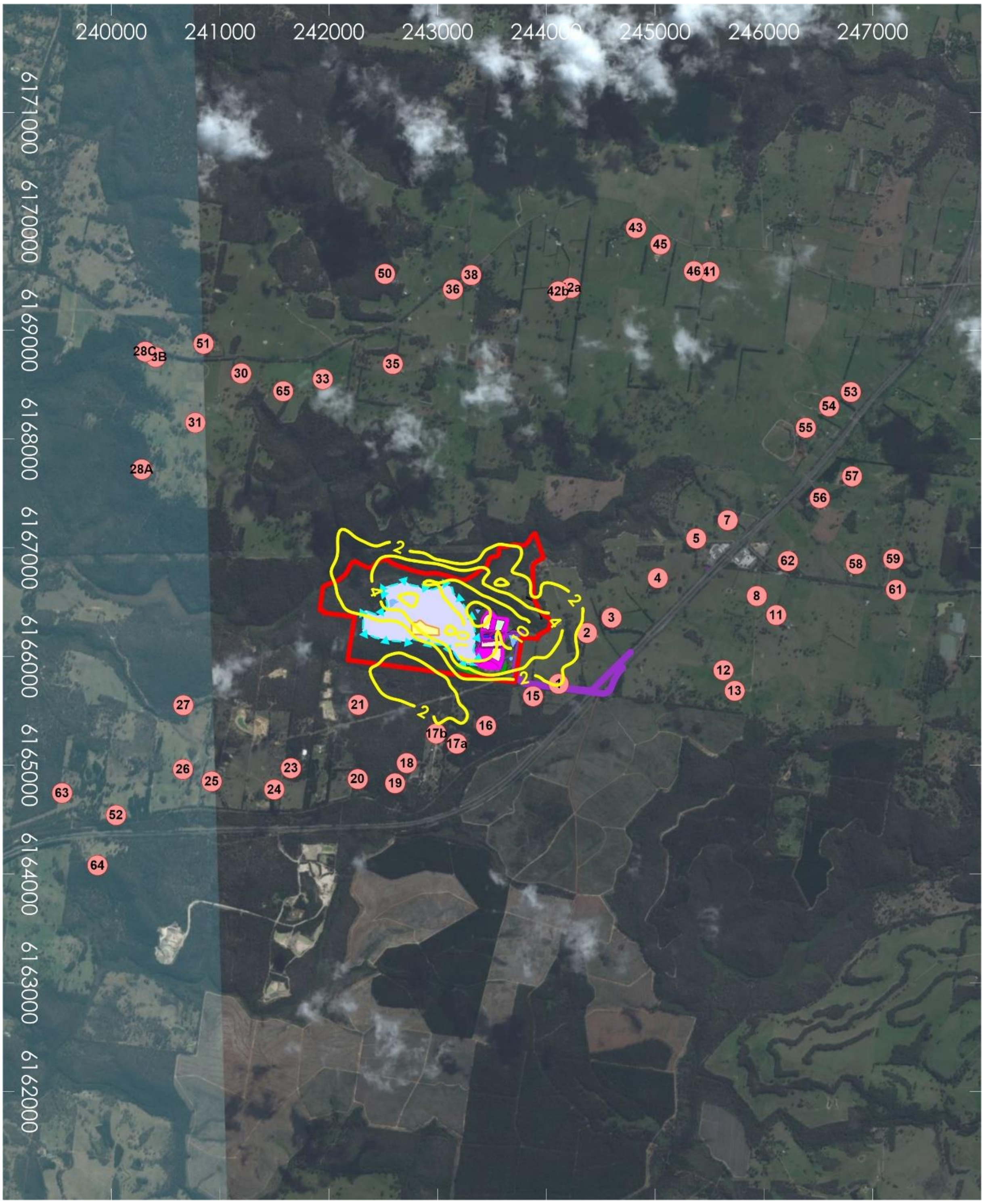



**Figure 16** **Predicted annual average $PM_{10}$ concentrations – Stage 2: Proposal alone**

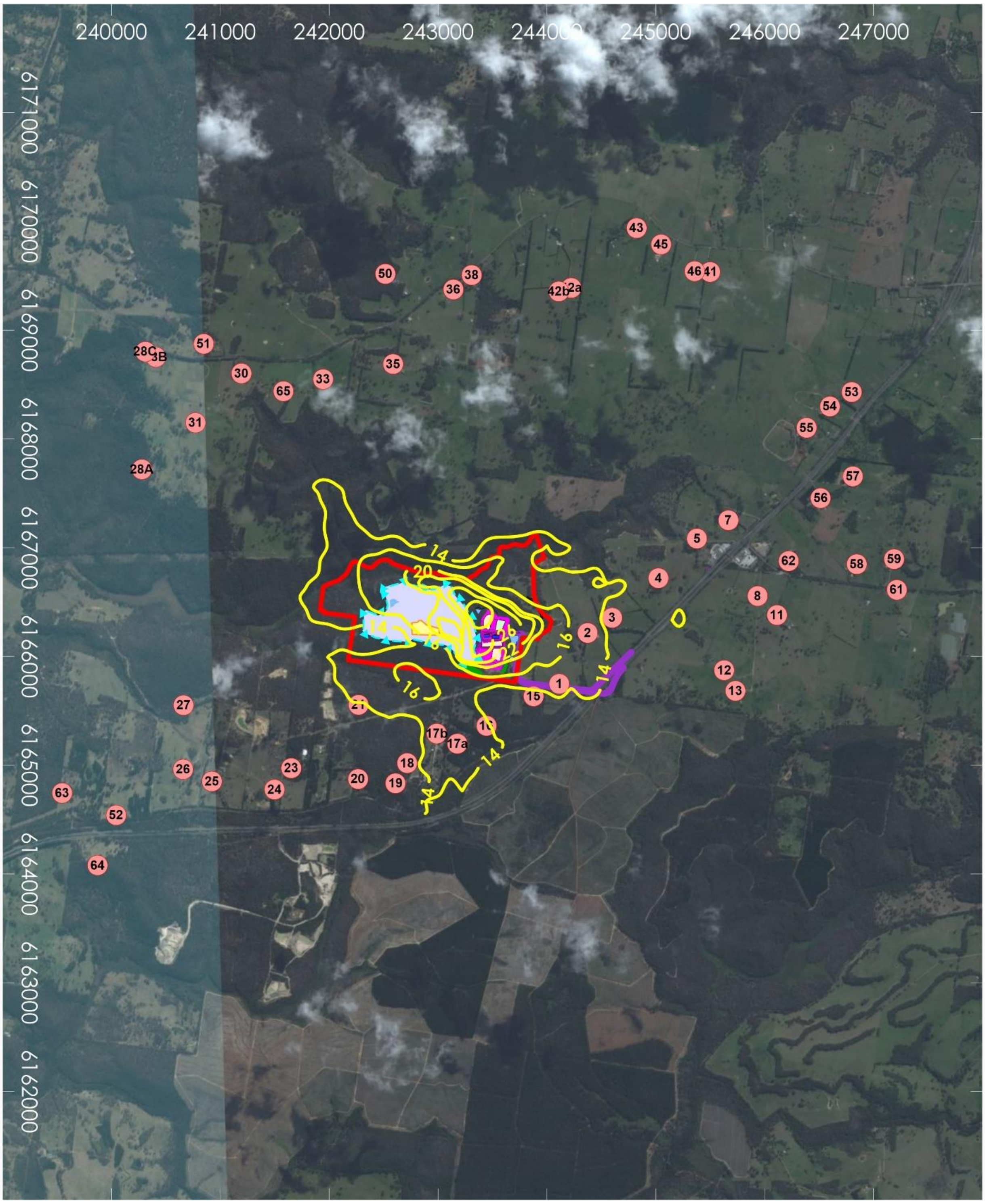



**Figure 17 Predicted annual average $PM_{10}$ concentrations – Stage 2: Cumulative**

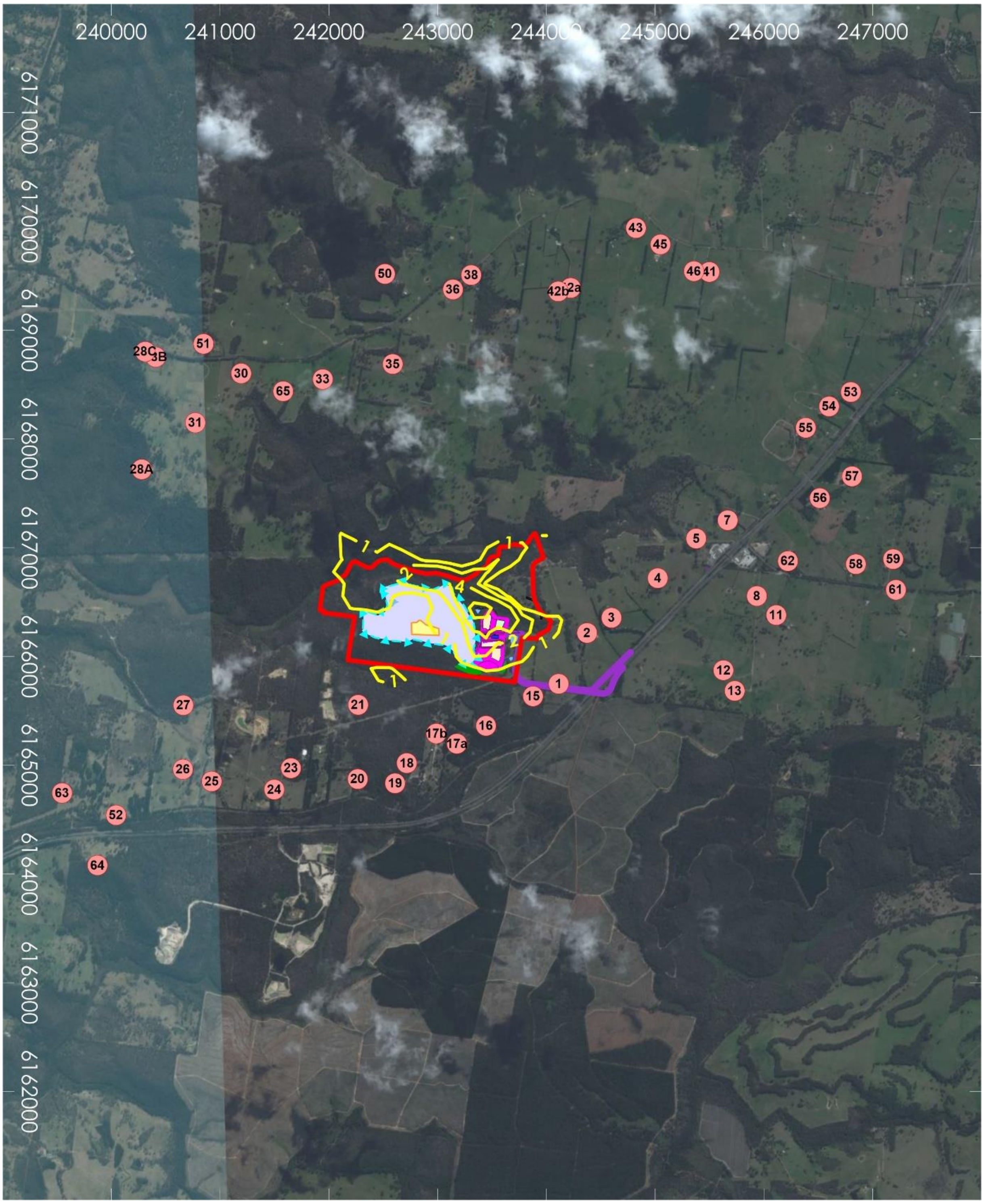



**Figure 18 Predicted annual average $PM_{2.5}$ concentrations – Stage 2: Proposal alone**

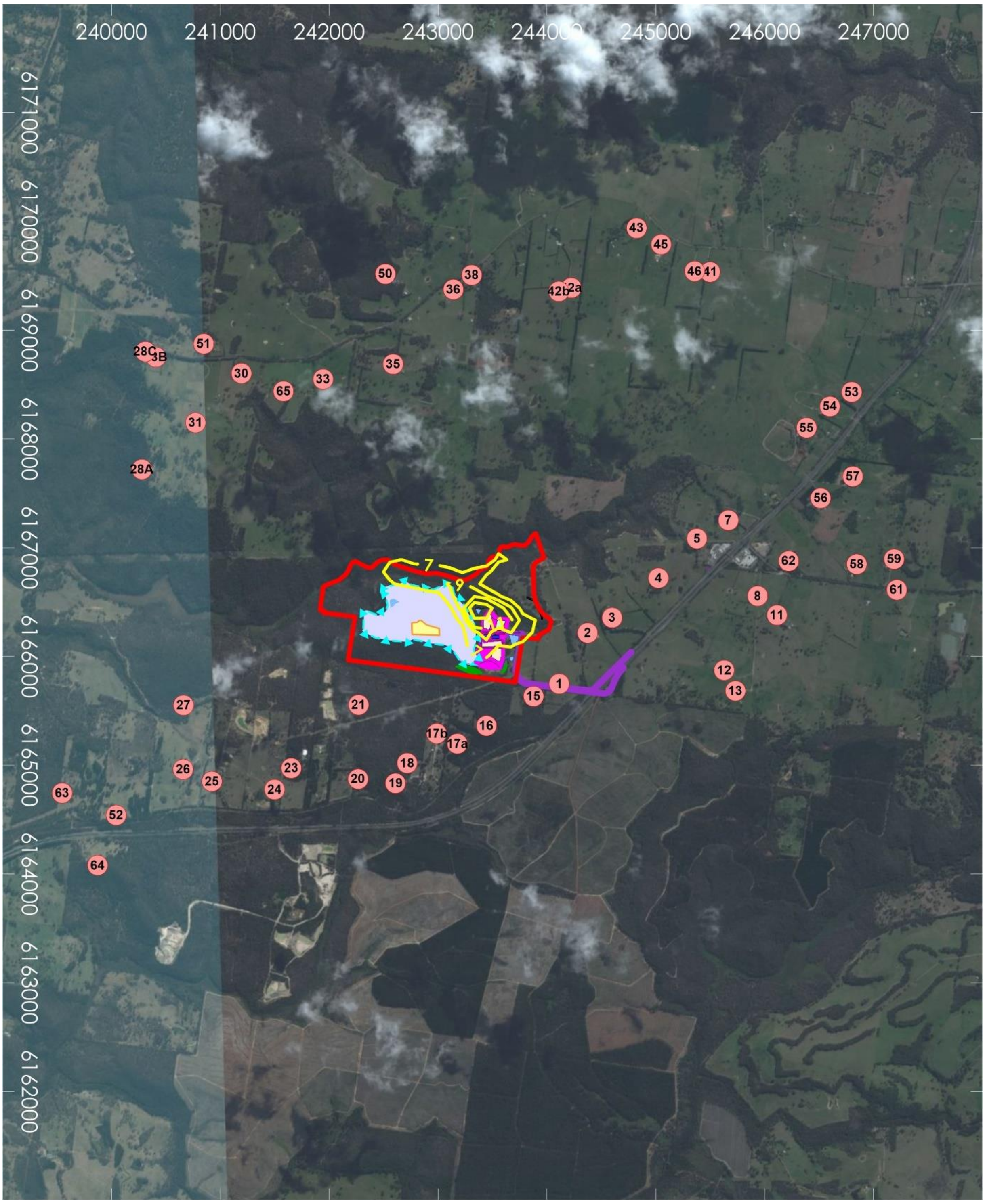



**Figure 19** **Predicted annual average $PM_{2.5}$ concentrations – Stage 2: Cumulative**

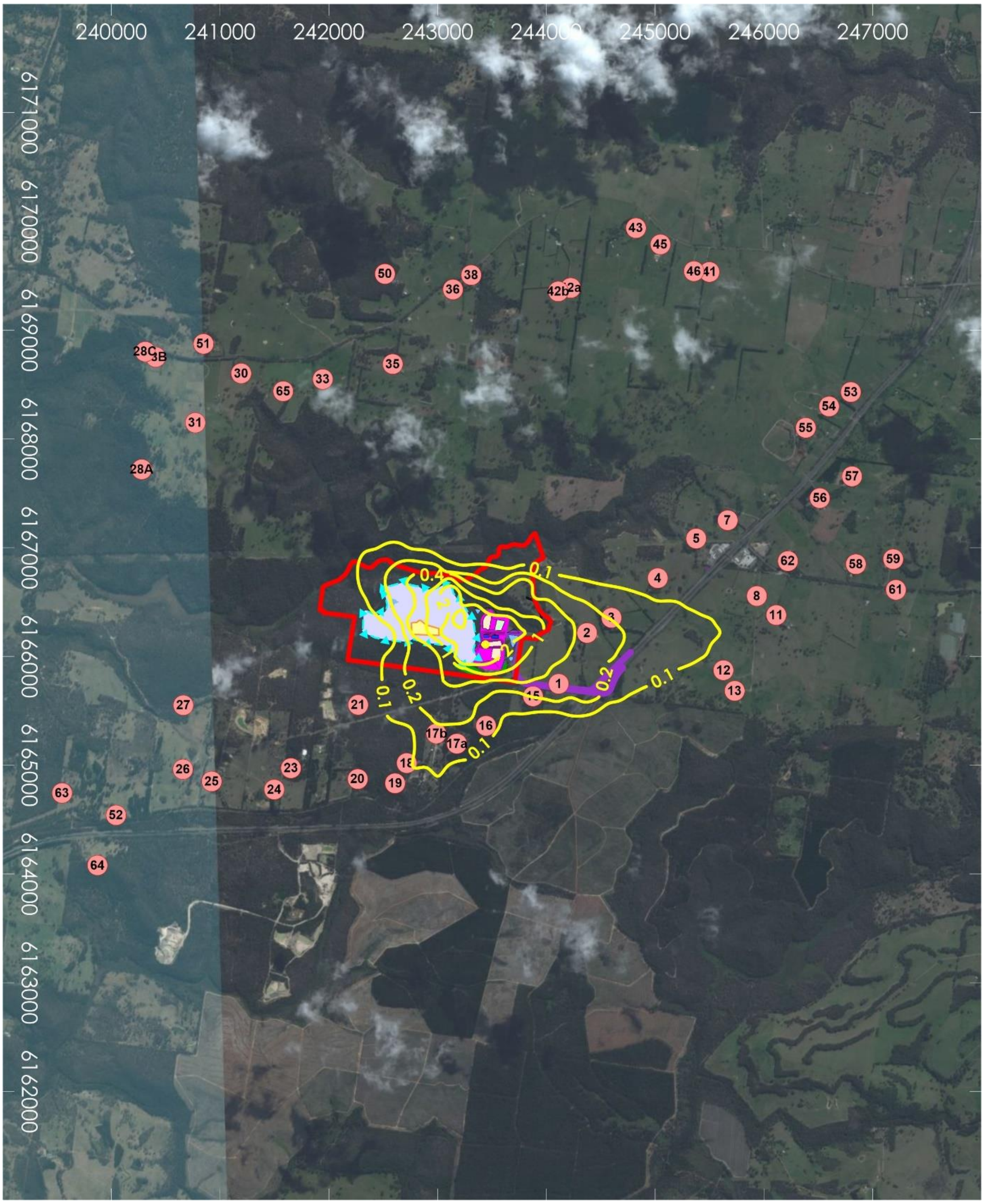



**Figure 20** **Predicted annual average dust deposition levels – Stage 2: Proposal alone**

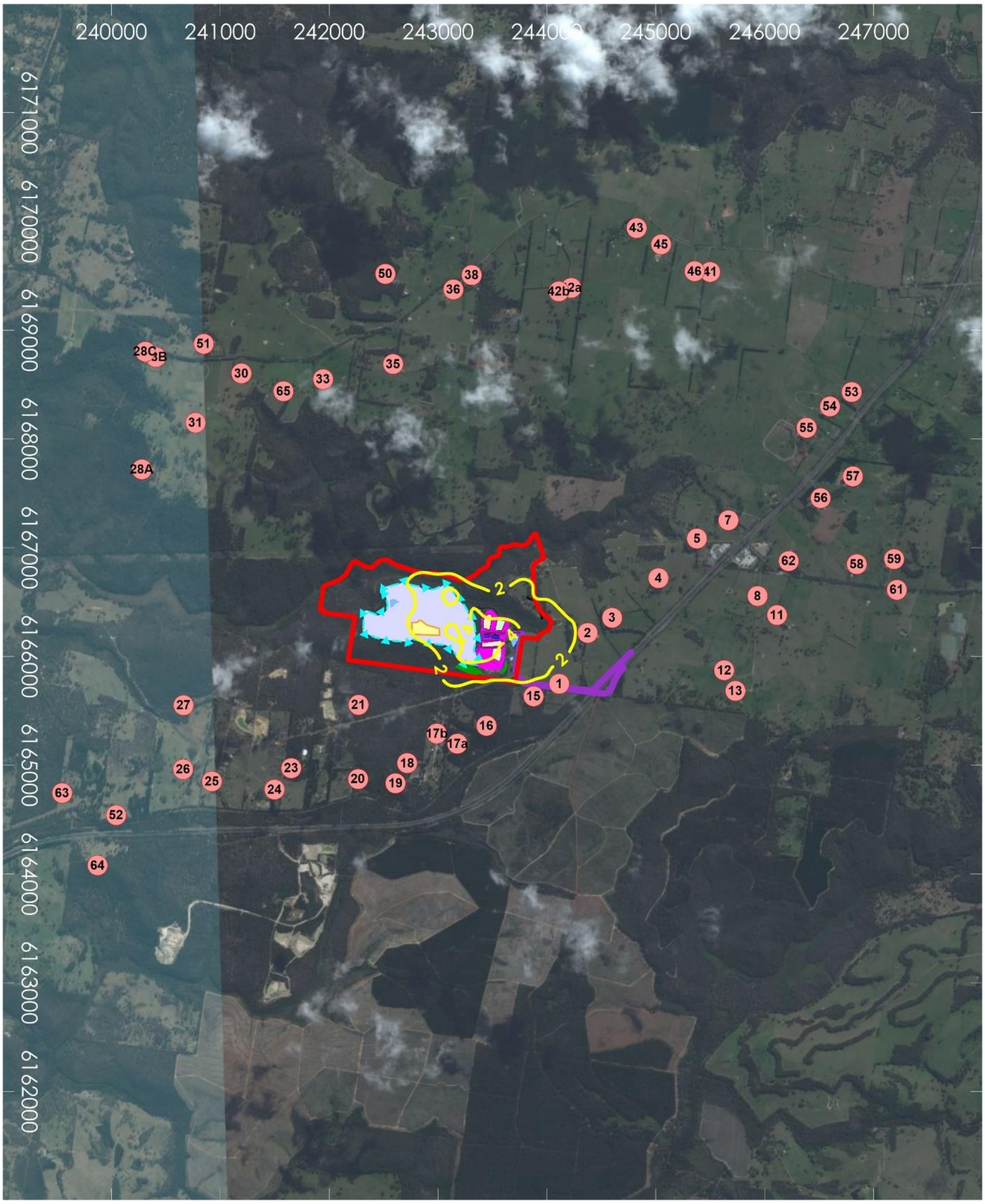



**Figure 21** **Predicted annual average dust deposition levels – Stage 2: Cumulative**

#### 7.1.2 Stage 4

**Table 16** presents a summary of the predicted annual average concentrations at each of the surrounding receptors, due to the operations of the Proposal alone and cumulatively i.e. when added to the existing background concentrations or levels.

Contour plots are presented in **Figure 22** to **Figure 29** for Proposal alone and cumulative impacts.

Modelling results for Stage 4 show no exceedances of the annual average TSP, $PM_{10}$, $PM_{2.5}$ and dust deposition impact assessment criteria at any sensitive receptors.

**Table 16**
**Stage 4 – Predicted annual average $PM_{10}$ and TSP concentrations and dust deposition levels due to the Proposal alone and the Proposal and existing sources**

| ID | Stage 4 - Proposal-only | | | | Stage 4 - Cumulative | | | |
|---|---|---|---|---|---|---|---|---|
| | TSP (µg/m³) | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | Dust deposition (g/m²/month) | TSP (µg/m³) | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | Dust deposition (g/m²/month) |
| | *Assessment criteria* | | | | | | | |
| | *N/A* | *N/A* | *N/A* | *2* | *90* | *25* | *8* | *4* |
| **Residences** | | | | | | | | |
| 1 | 6.4 | 2.8 | 0.6 | 0.5 | 38.7 | 15.7 | 5.7 | 2.1 |
| 2 | 2.7 | 1.7 | 0.3 | 0.4 | 35.0 | 14.6 | 5.5 | 2.0 |
| 3 | 1.6 | 1.0 | 0.2 | 0.2 | 33.9 | 13.9 | 5.4 | 1.8 |
| 4 | 0.6 | 0.6 | 0.1 | 0.1 | 32.9 | 13.5 | 5.3 | 1.7 |
| 5 | 0.2 | 0.3 | 0.1 | 0.0 | 32.5 | 13.2 | 5.2 | 1.6 |
| 7 | 0.1 | 0.2 | 0.1 | 0.0 | 32.4 | 13.1 | 5.2 | 1.6 |
| 8 | 0.6 | 0.5 | 0.1 | 0.1 | 32.9 | 13.4 | 5.2 | 1.7 |
| 11 | 0.6 | 0.4 | 0.1 | 0.1 | 32.9 | 13.3 | 5.3 | 1.7 |
| 12 | 0.7 | 0.4 | 0.1 | 0.1 | 33.0 | 13.3 | 5.3 | 1.7 |
| 13 | 0.5 | 0.3 | 0.1 | 0.1 | 32.8 | 13.2 | 5.2 | 1.7 |
| 15 | 2.1 | 0.9 | 0.2 | 0.2 | 34.4 | 13.8 | 5.3 | 1.8 |
| 16 | 1.6 | 1.6 | 0.3 | 0.2 | 33.9 | 14.5 | 5.4 | 1.8 |
| 17a | 1.5 | 1.6 | 0.3 | 0.2 | 33.8 | 14.5 | 5.5 | 1.8 |
| 17b | 2.3 | 2.3 | 0.4 | 0.2 | 34.6 | 15.2 | 5.5 | 1.8 |
| 18 | 1.1 | 0.7 | 0.1 | 0.1 | 33.4 | 13.6 | 5.3 | 1.7 |
| 19 | 0.8 | 0.5 | 0.1 | 0.1 | 33.1 | 13.4 | 5.3 | 1.7 |
| 20 | 0.8 | 1.0 | 0.2 | 0.1 | 33.1 | 13.9 | 5.4 | 1.7 |
| 21 | 0.8 | 1.3 | 0.3 | 0.1 | 33.1 | 14.2 | 5.4 | 1.7 |
| 23 | 0.3 | 0.6 | 0.2 | 0.0 | 32.6 | 13.5 | 5.3 | 1.6 |
| 24 | 0.3 | 0.6 | 0.3 | 0.0 | 32.6 | 13.5 | 5.4 | 1.6 |
| 25 | 0.2 | 0.4 | 0.2 | 0.0 | 32.5 | 13.3 | 5.4 | 1.6 |
| 26 | 0.1 | 0.3 | 0.2 | 0.0 | 32.4 | 13.2 | 5.3 | 1.6 |
| 27 | 0.1 | 0.3 | 0.1 | 0.0 | 32.4 | 13.2 | 5.3 | 1.6 |
| 28A | 0.2 | 0.2 | 0.0 | 0.0 | 32.5 | 13.1 | 5.2 | 1.6 |
| 28B | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 28C | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 30 | 0.2 | 0.1 | 0.0 | 0.0 | 32.5 | 13.0 | 5.2 | 1.6 |
| 31 | 0.2 | 0.2 | 0.0 | 0.0 | 32.5 | 13.1 | 5.2 | 1.6 |
| 33 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 35 | 0.1 | 0.0 | 0.0 | 0.0 | 32.4 | 12.9 | 5.2 | 1.6 |
| 36 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 38 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 41 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 42a | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 42b | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 43 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 45 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 46 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 50 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 51 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 52 | 0.1 | 0.2 | 0.1 | 0.0 | 32.4 | 13.1 | 5.3 | 1.6 |
| 53 | 0.0 | 0.1 | 0.0 | 0.0 | 32.3 | 13.0 | 5.2 | 1.6 |
| 54 | 0.0 | 0.1 | 0.0 | 0.0 | 32.3 | 13.0 | 5.2 | 1.6 |
| 55 | 0.0 | 0.0 | 0.0 | 0.0 | 32.3 | 12.9 | 5.2 | 1.6 |
| 56 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 57 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 58 | 0.3 | 0.4 | 0.1 | 0.0 | 32.6 | 13.3 | 5.3 | 1.6 |
| 59 | 0.2 | 0.2 | 0.0 | 0.0 | 32.5 | 13.1 | 5.2 | 1.6 |
| 61 | 0.3 | 0.3 | 0.0 | 0.0 | 32.6 | 13.2 | 5.2 | 1.6 |
| 62 | 0.3 | 0.2 | 0.0 | 0.0 | 32.6 | 13.1 | 5.2 | 1.6 |
| 63 | 0.1 | 0.2 | 0.1 | 0.0 | 32.4 | 13.1 | 5.3 | 1.6 |
| 64 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |
| 65 | 0.1 | 0.1 | 0.0 | 0.0 | 32.4 | 13.0 | 5.2 | 1.6 |

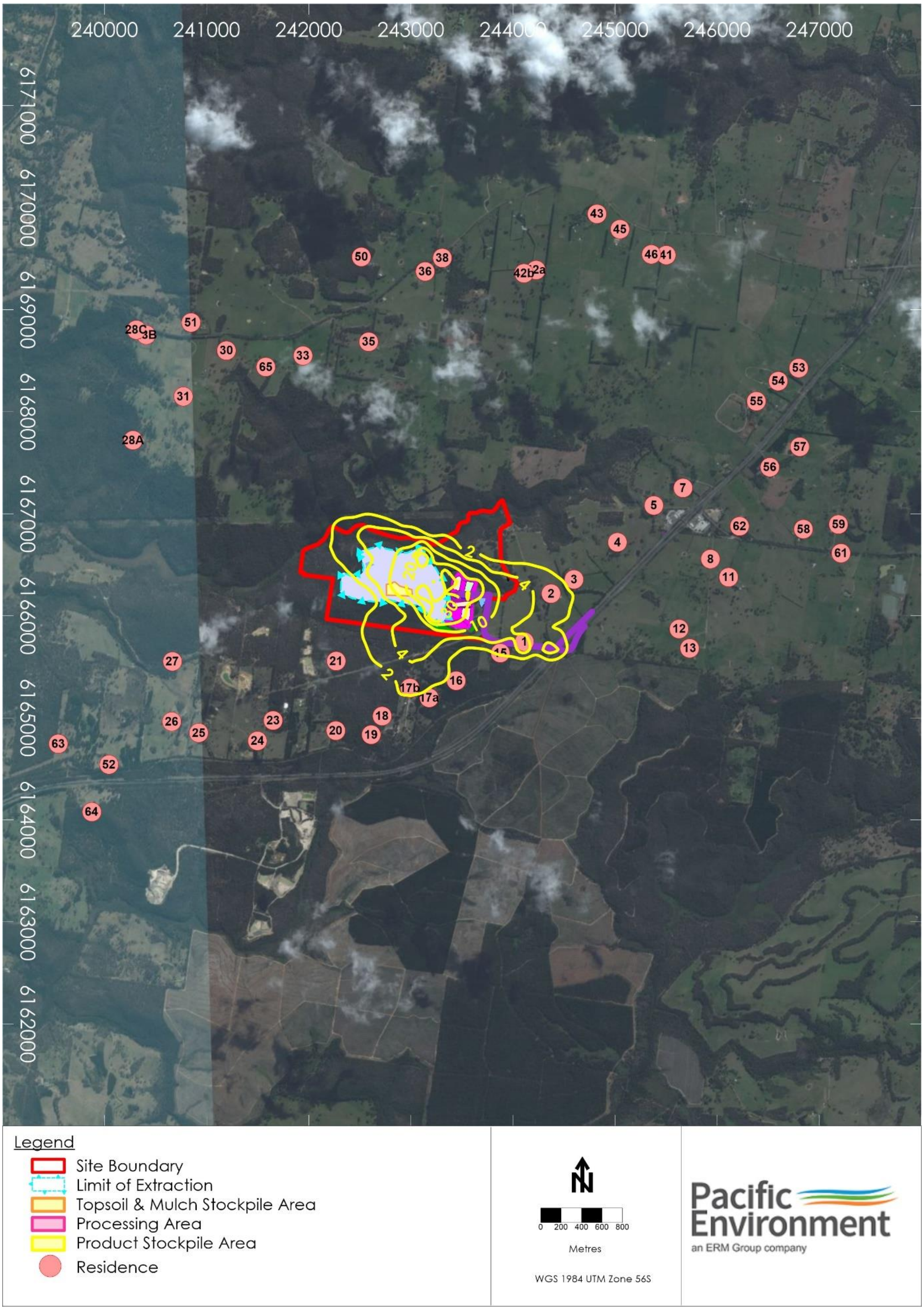



**Figure 22 Predicted annual average TSP concentrations – Stage 4: Proposal alone**

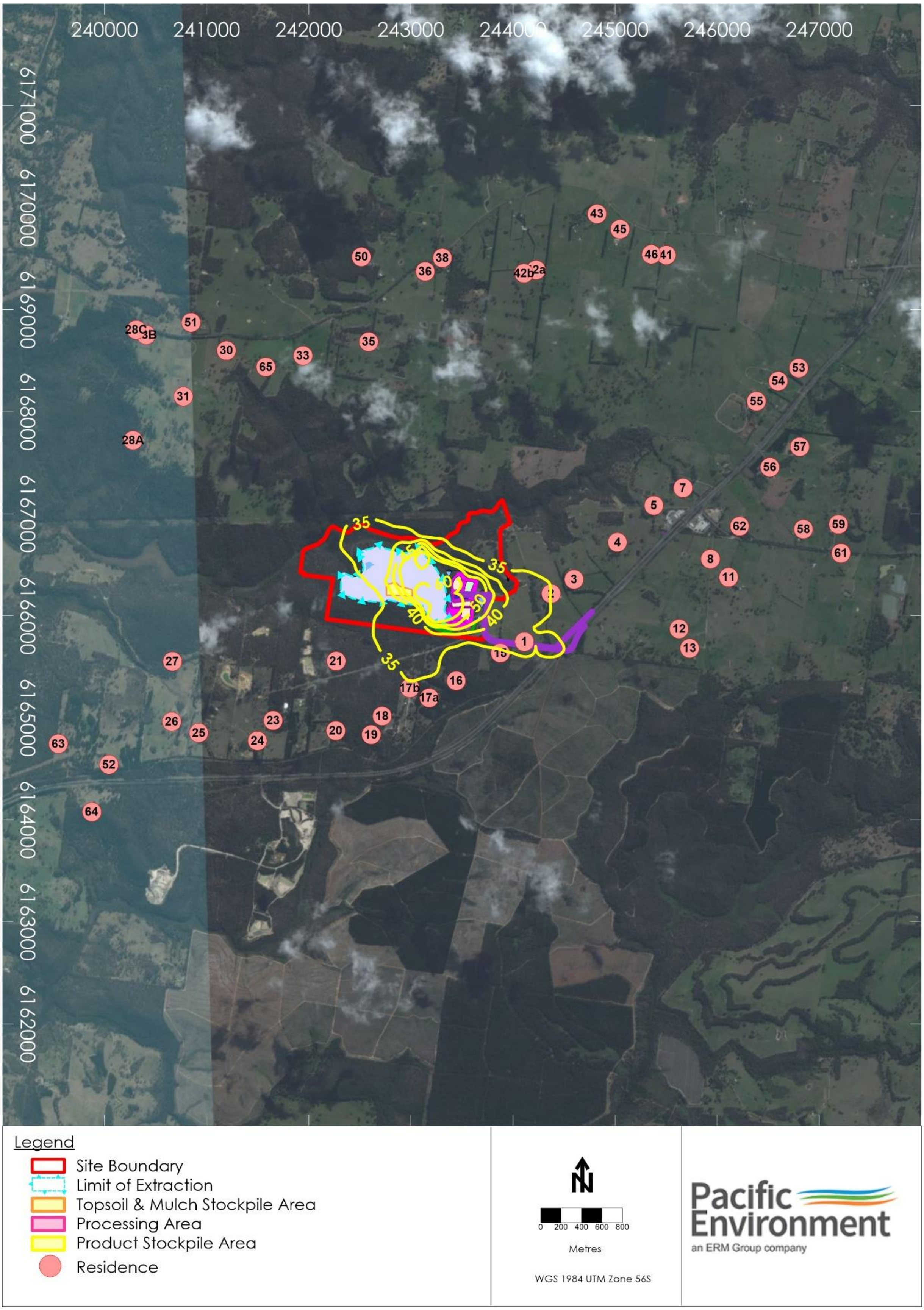



**Figure 23** **Predicted annual average TSP concentrations – Stage 4: Cumulative**

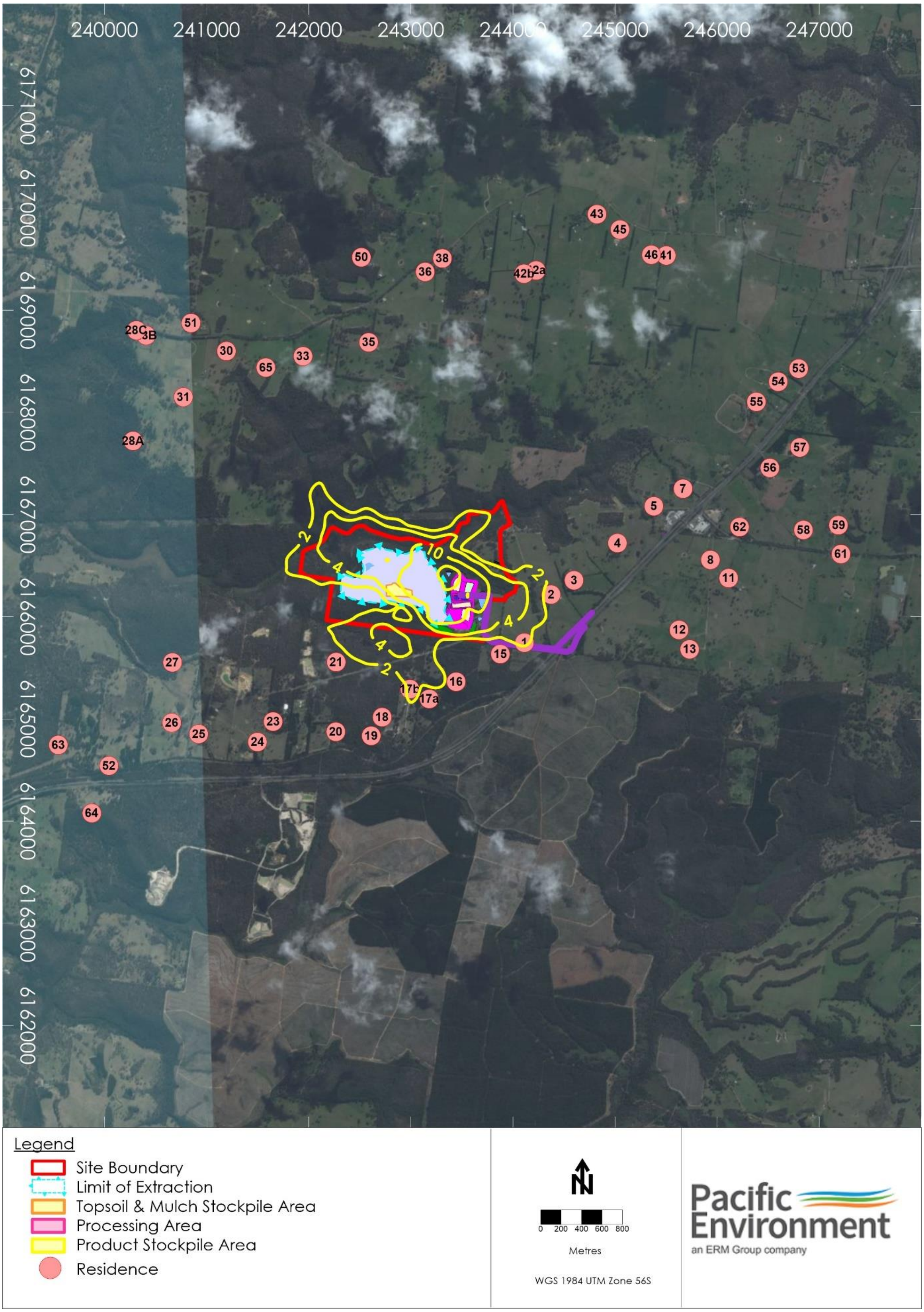



**Figure 24 Predicted annual average $PM_{10}$ concentrations – Stage 4: Proposal alone**

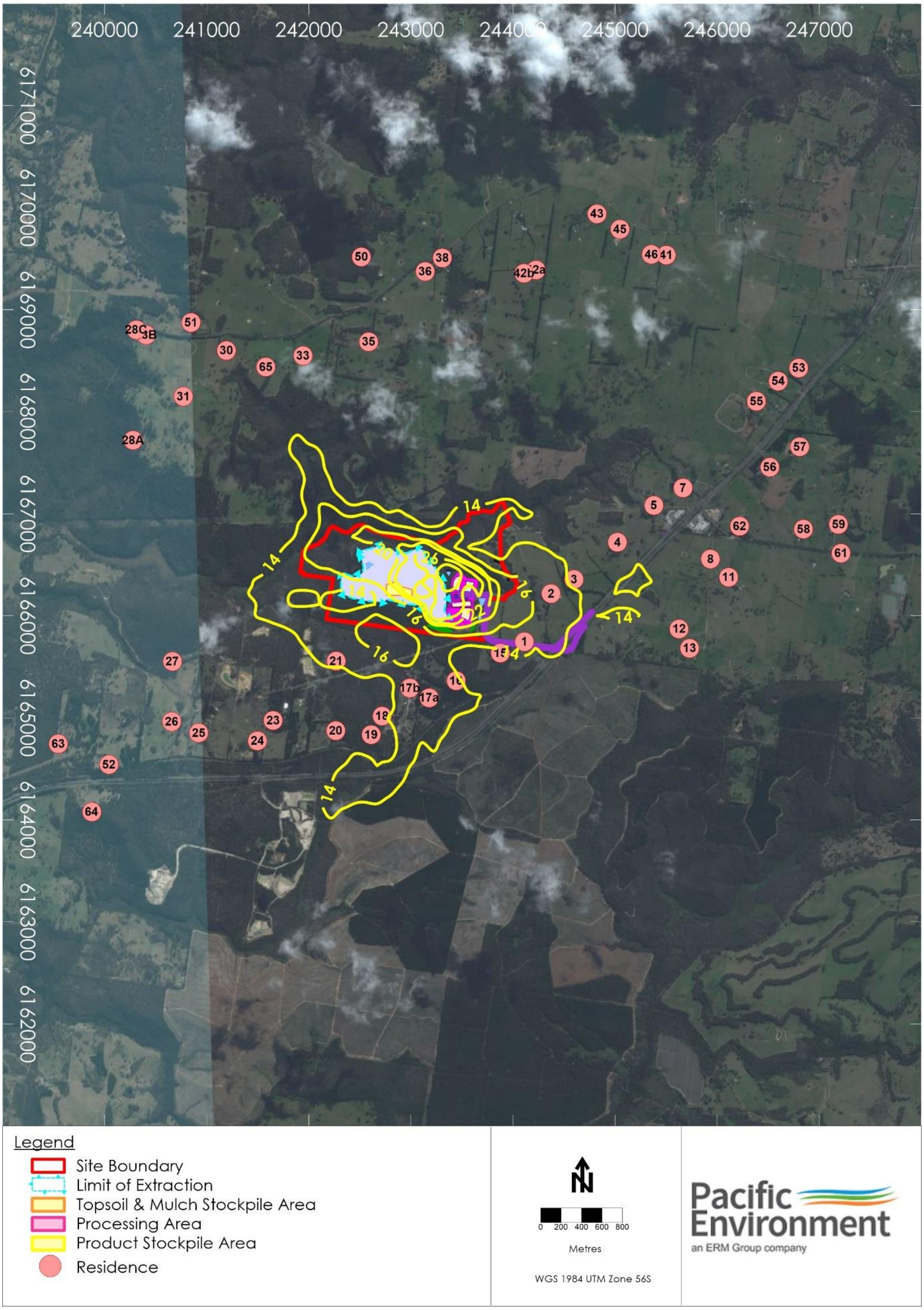



**Figure 25 Predicted annual average $PM_{10}$ concentrations – Stage 4: Cumulative**

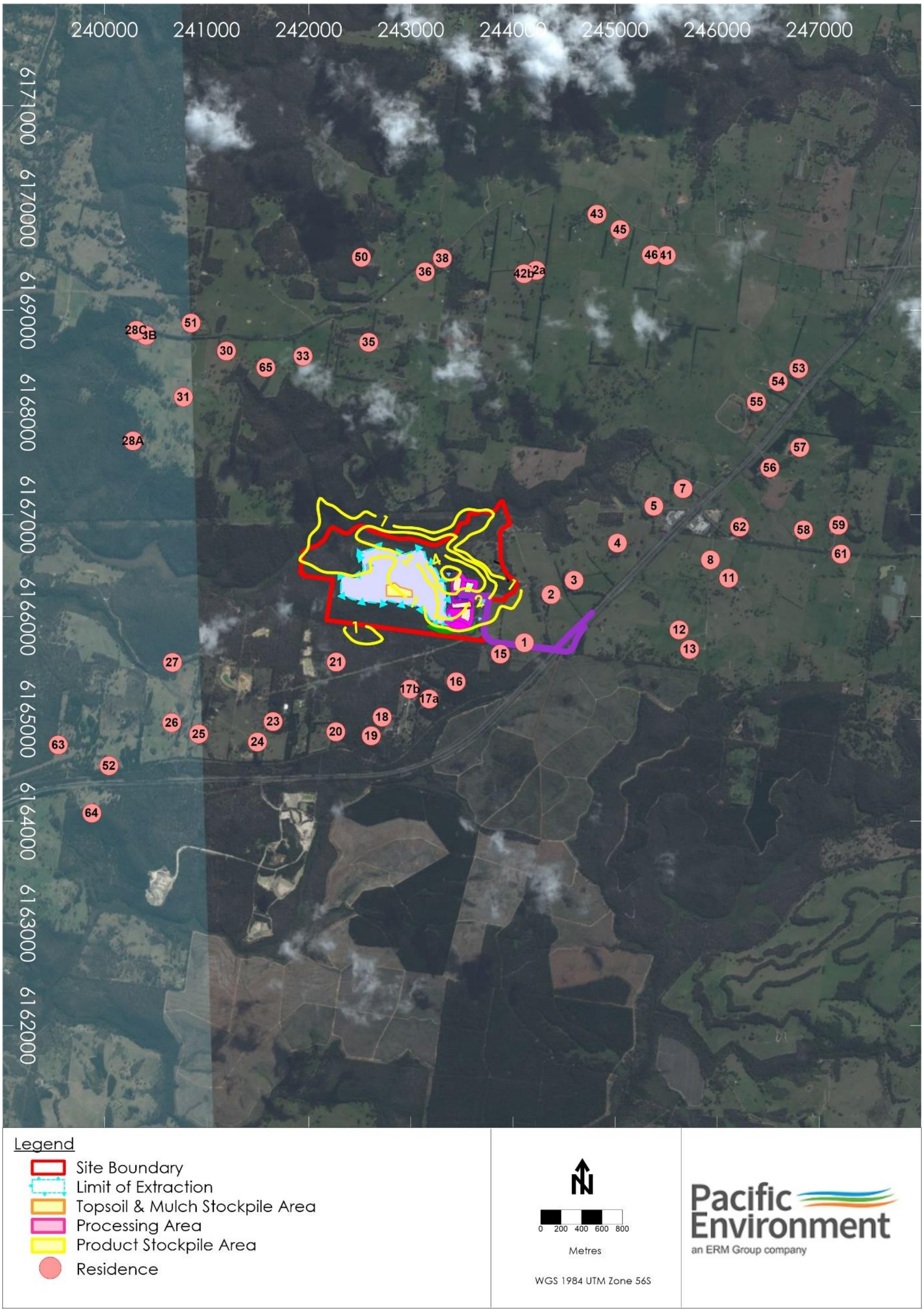



**Figure 26** **Predicted annual average $PM_{2.5}$ concentrations – Stage 4: Proposal alone**

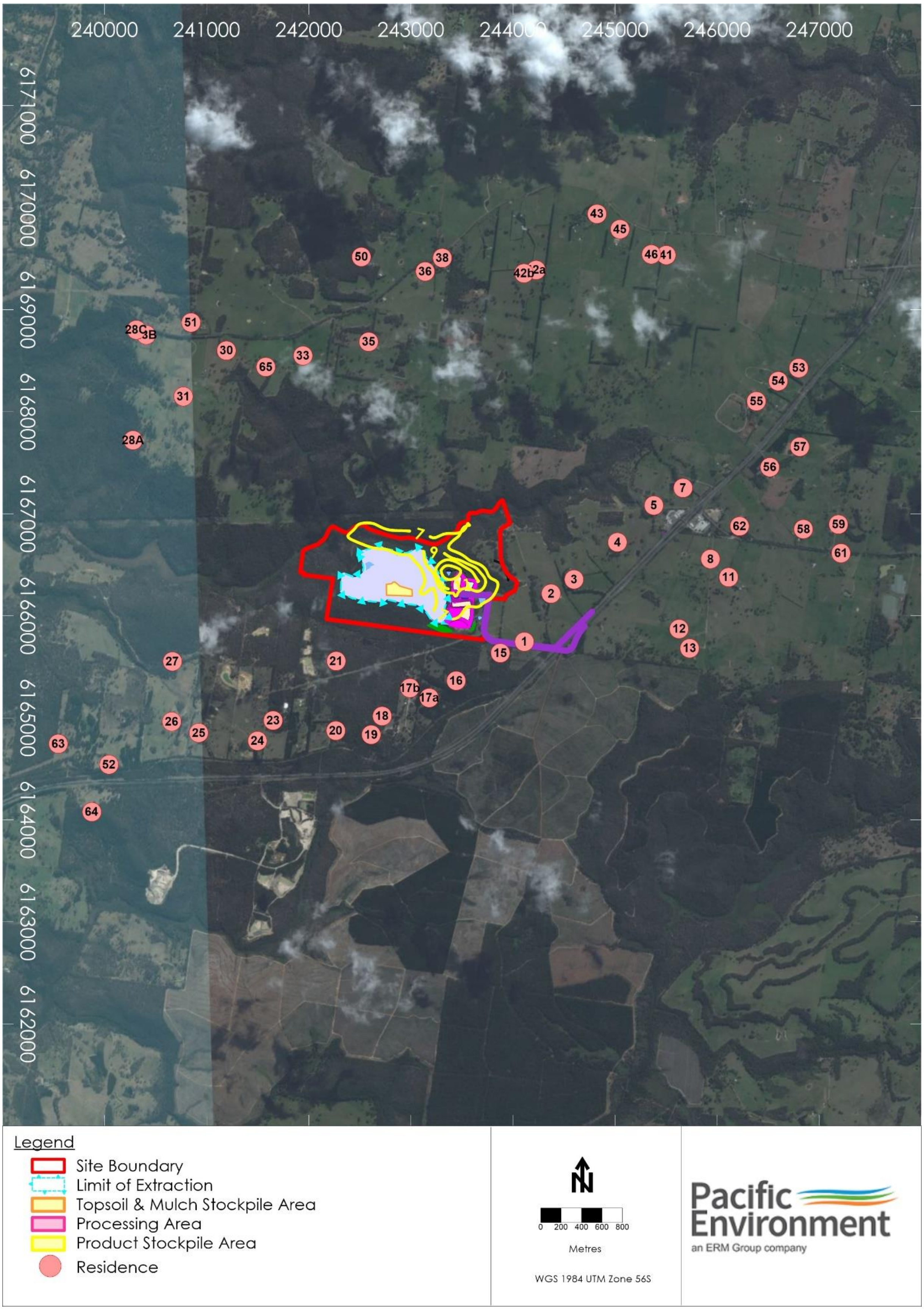



**Figure 27 Predicted annual average $PM_{2.5}$ concentrations – Stage 4: Cumulative**

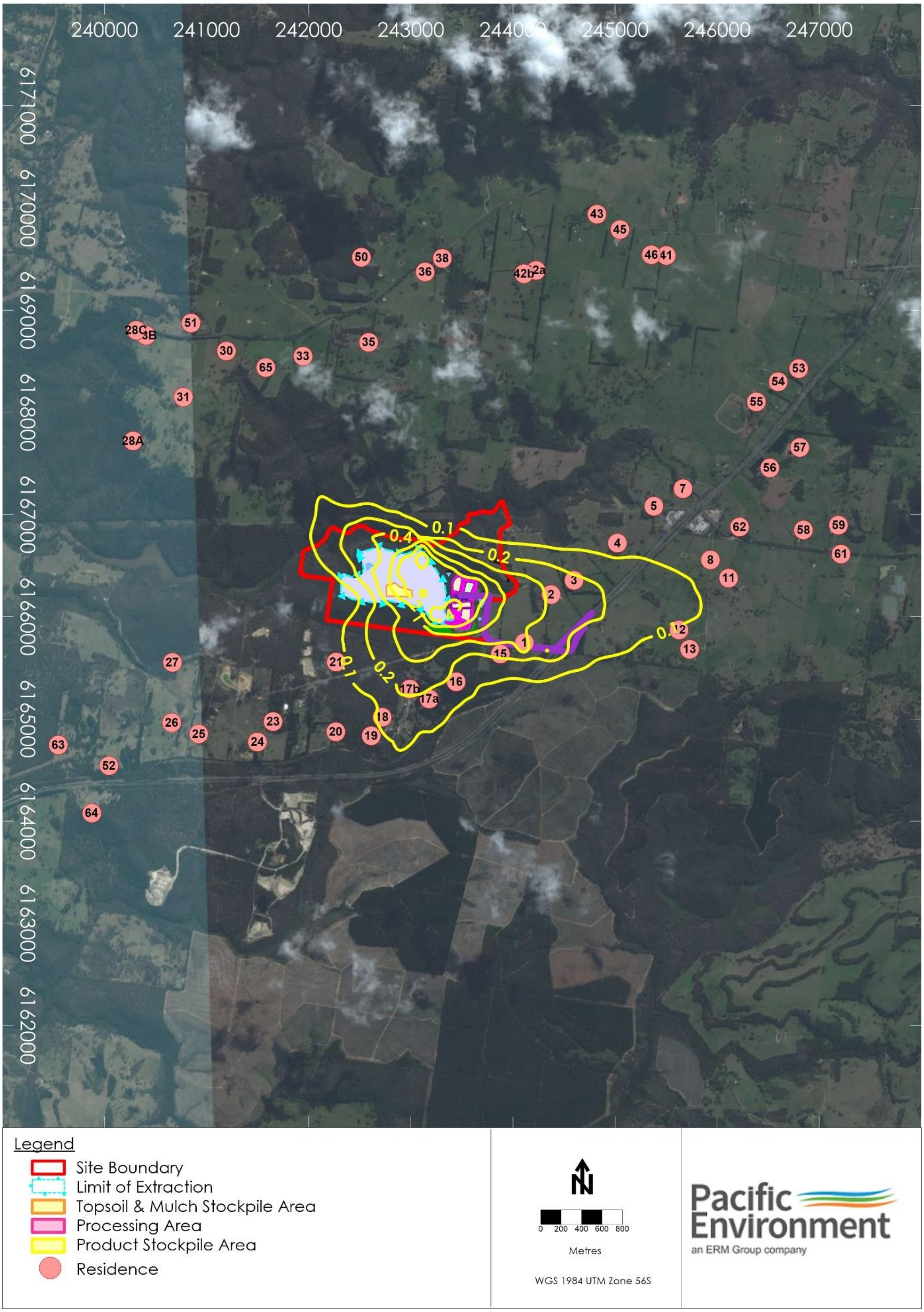



**Figure 28	Predicted annual average dust deposition levels – Stage 4: Proposal alone**

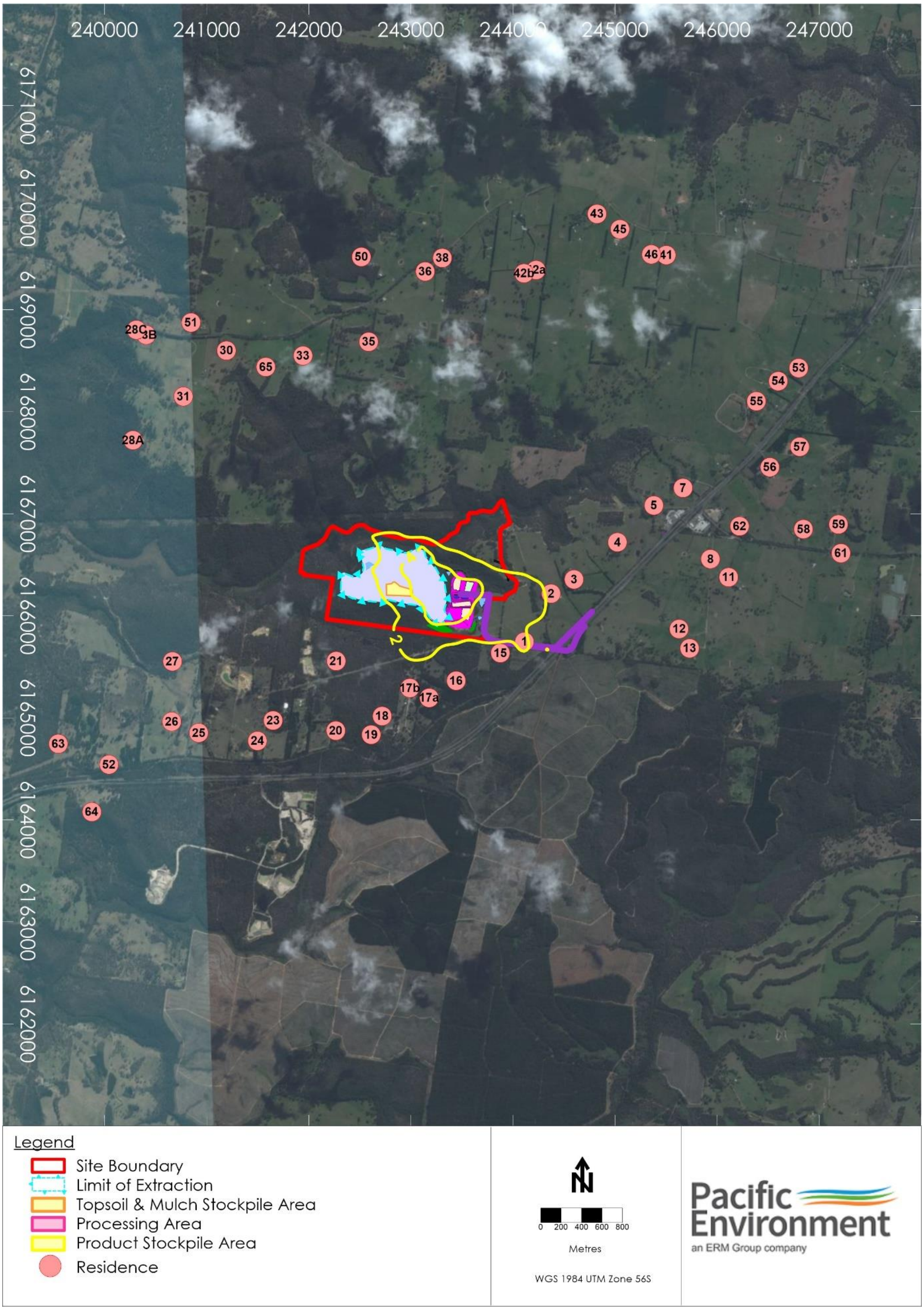



**Figure 29 Predicted annual average dust deposition levels – Stage 4: Cumulative**

## 7.2 24-HOUR AVERAGE $PM_{10}$ AND $PM_{2.5}$ CONCENTRATIONS

### 7.2.1 Proposal only $PM_{10}$ predictions

**Table 17** presents the predicted maximum 24-hour average $PM_{10}$ concentrations due to the Proposal alone at the sensitive receptors based on the maximum daily activities as discussed in Section 6.6. **Figure 30** and **Figure 31** show the corresponding contour plots for Stage 2 and Stage 4, respectively.

Modelling results show for both scenarios that due to the Proposal alone, all sensitive receptors are below the cumulative impact assessment criterion of 50 µg/m$^3$.

**Table 17**
**Summary of maximum predicted 24-hour average $PM_{10}$ concentrations from the Proposal alone for Stage 2 and Stage 4**

| ID | Stage 2 – Proposal alone | Stage 4 – Proposal alone | ID | Stage 2 – Proposal alone | Stage 4 – Proposal alone |
|---|---|---|---|---|---|
| | $PM_{10}$ (µg/m$^3$) | | | $PM_{10}$ (µg/m$^3$) | |
| | *Assessment criterion* | | | *Assessment criterion* | |
| | *N/A* | | | *N/A* | |
| **Receptors** | | | | | |
| 1 | 17 | 19 | 31 | 3 | 4 |
| 2 | 13 | 13 | 33 | 1 | 2 |
| 3 | 8 | 9 | 35 | 1 | 1 |
| 4 | 8 | 6 | 36 | 1 | 1 |
| 5 | 4 | 3 | 38 | 1 | 1 |
| 7 | 4 | 3 | 41 | 1 | 1 |
| 8 | 5 | 4 | 42a | 0 | 1 |
| 11 | 4 | 5 | 42b | 0 | 1 |
| 12 | 5 | 5 | 43 | 1 | 1 |
| 13 | 4 | 4 | 45 | 1 | 1 |
| 15 | 15 | 16 | 46 | 1 | 1 |
| 16 | 21 | 15 | 50 | 1 | 1 |
| 17a | 17 | 16 | 51 | 2 | 3 |
| 17b | 19 | 17 | 52 | 2 | 3 |
| 18 | 7 | 7 | 53 | 3 | 3 |
| 19 | 6 | 5 | 54 | 2 | 1 |
| 20 | 12 | 10 | 55 | 1 | 1 |
| 21 | 10 | 8 | 56 | 2 | 2 |
| 23 | 5 | 5 | 57 | 2 | 2 |
| 24 | 5 | 6 | 58 | 5 | 5 |
| 25 | 3 | 4 | 59 | 3 | 3 |
| 26 | 2 | 3 | 61 | 2 | 3 |
| 27 | 4 | 4 | 62 | 3 | 3 |
| 28A | 3 | 3 | 63 | 4 | 5 |
| 28B | 1 | 1 | 64 | 2 | 3 |
| 28C | 1 | 1 | 65 | 1 | 2 |
| 30 | 2 | 2 | | | |

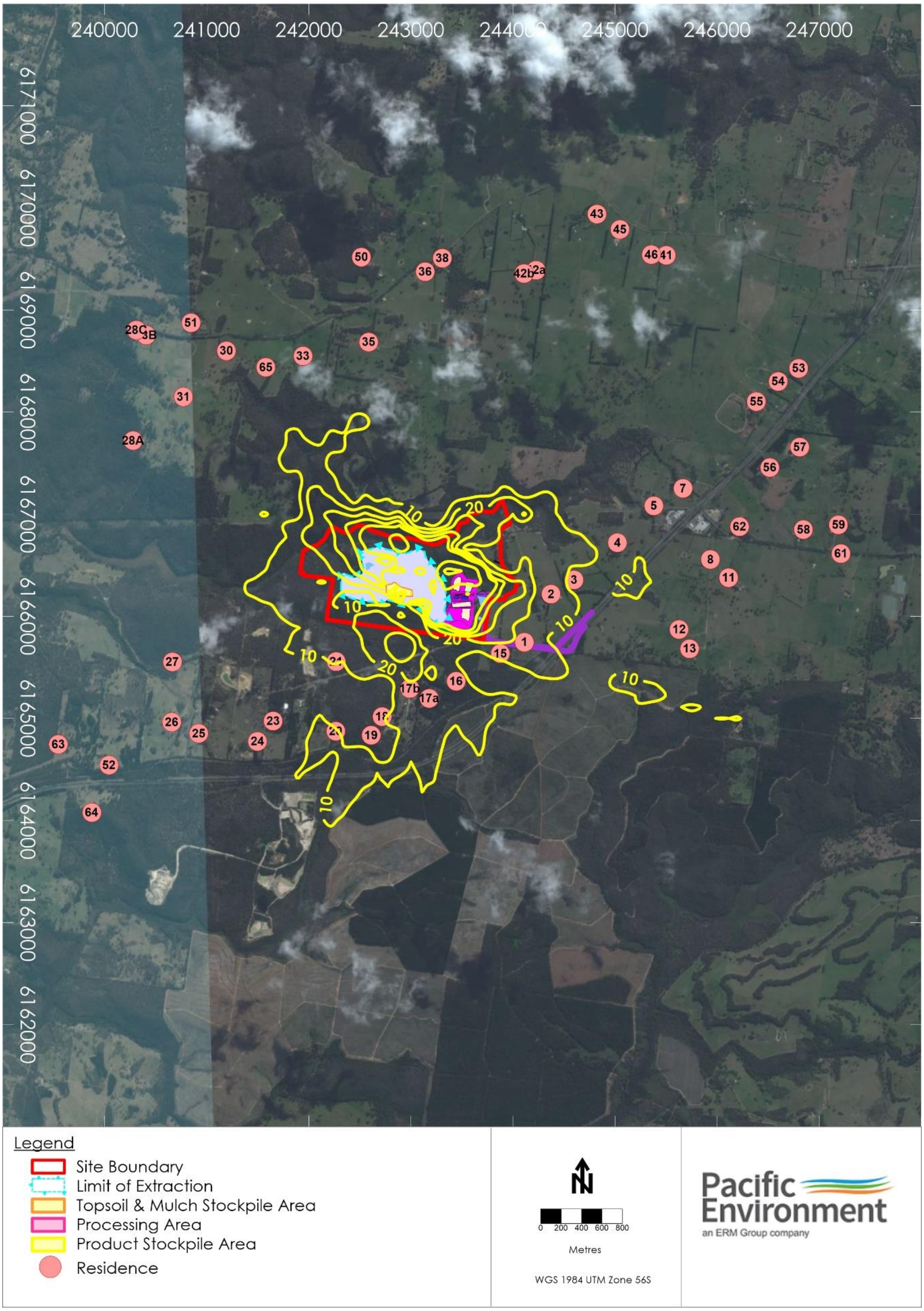



**Figure 30 Predicted maximum 24-hour average $PM_{10}$ concentrations – Stage 2: Proposal alone**

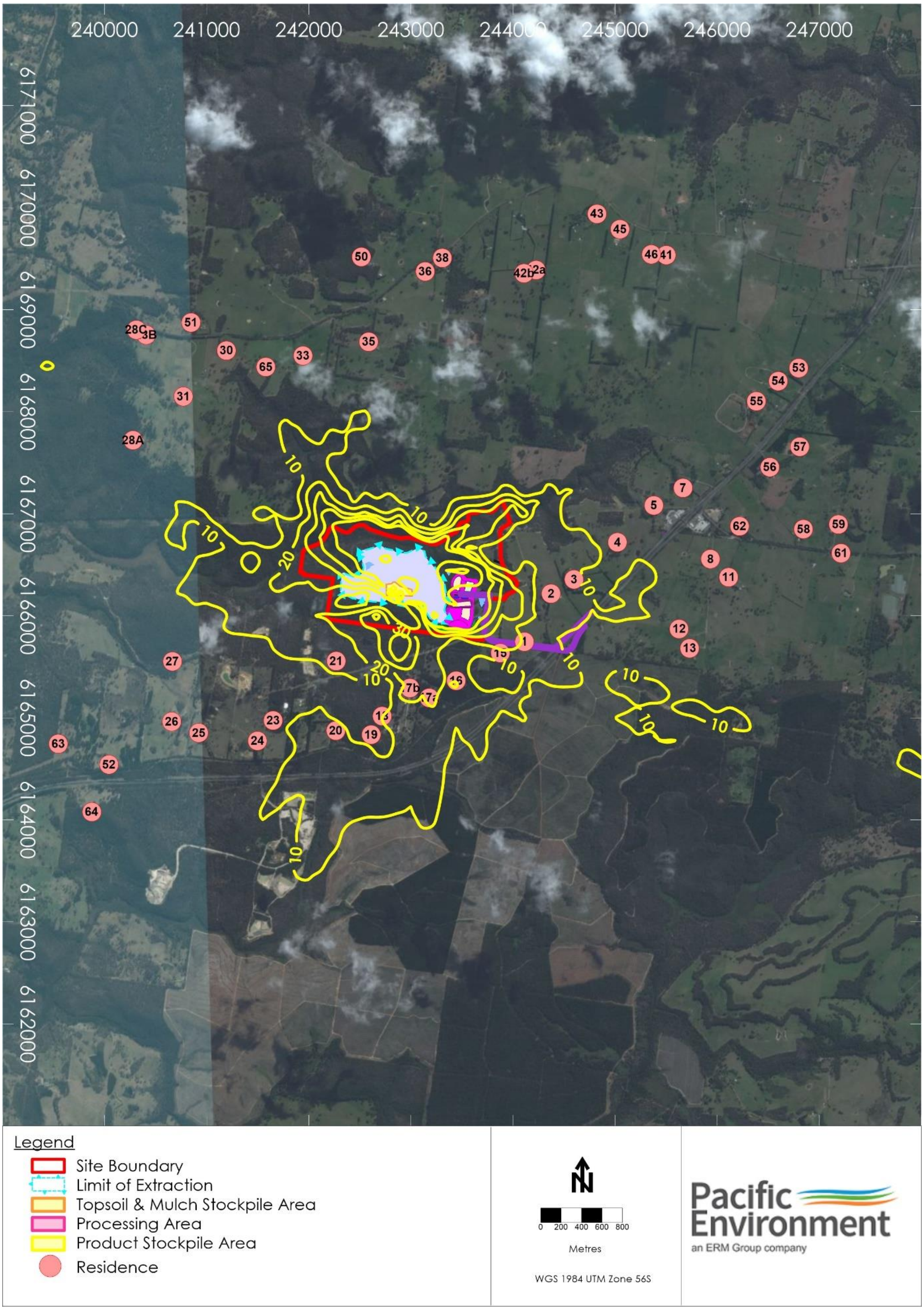



**Figure 31** **Predicted maximum 24-hour average $PM_{10}$ concentrations – Stage 4: Proposal alone**

### 7.2.2 Proposal only $PM_{2.5}$ predictions

**Table 18** presents the predicted maximum 24-hour $PM_{2.5}$ concentrations at the sensitive receptors due to the Proposal alone based on the maximum daily activities as discussed in Section 6.6. **Figure 32** and **Figure 33** show the corresponding contour plots for Stage 2 and Stage 4, respectively.

Modelling results show for both scenarios that all sensitive receptors are below the cumulative impact assessment criterion of 25 µg/m$^3$ due to the Proposal alone.

**Table 18**
**Summary of maximum predicted 24-hour average $PM_{2.5}$ concentrations from the Proposal alone for Stage 2 and Stage 4**

| ID | Stage 2 – Proposal alone | Stage 4 – Proposal alone | ID | Stage 2 – Proposal alone | Stage 4 – Proposal alone |
|---|---|---|---|---|---|
| | $PM_{2.5}$ | | | $PM_{2.5}$ | |
| | (µg/m$^3$) | | | (µg/m$^3$) | (µg/m$^3$) |
| | *Assessment criterion* | | | *Assessment criterion* | |
| | *N/A* | | | *N/A* | |
| **Receptors** | | | | | |
| 1 | 4 | 4 | 31 | 0 | 0 |
| 2 | 3 | 3 | 33 | 0 | 0 |
| 3 | 2 | 2 | 35 | 0 | 0 |
| 4 | 1 | 1 | 36 | 0 | 0 |
| 5 | 1 | 1 | 38 | 0 | 0 |
| 7 | 1 | 1 | 41 | 0 | 0 |
| 8 | 1 | 1 | 42a | 0 | 0 |
| 11 | 1 | 1 | 42b | 0 | 0 |
| 12 | 1 | 1 | 43 | 0 | 0 |
| 13 | 1 | 1 | 45 | 0 | 0 |
| 15 | 3 | 3 | 46 | 0 | 0 |
| 16 | 3 | 3 | 50 | 0 | 0 |
| 17a | 3 | 3 | 51 | 0 | 0 |
| 17b | 3 | 3 | 52 | 2 | 2 |
| 18 | 2 | 2 | 53 | 1 | 1 |
| 19 | 2 | 2 | 54 | 0 | 0 |
| 20 | 4 | 4 | 55 | 0 | 0 |
| 21 | 4 | 4 | 56 | 1 | 1 |
| 23 | 2 | 2 | 57 | 0 | 0 |
| 24 | 4 | 4 | 58 | 2 | 2 |
| 25 | 6 | 6 | 59 | 1 | 1 |
| 26 | 1 | 1 | 61 | 0 | 0 |
| 27 | 1 | 1 | 62 | 1 | 1 |
| 28A | 0 | 1 | 63 | 3 | 3 |
| 28B | 0 | 0 | 64 | 1 | 1 |
| 28C | 0 | 0 | 65 | 1 | 1 |
| 30 | 0 | 0 | | | |

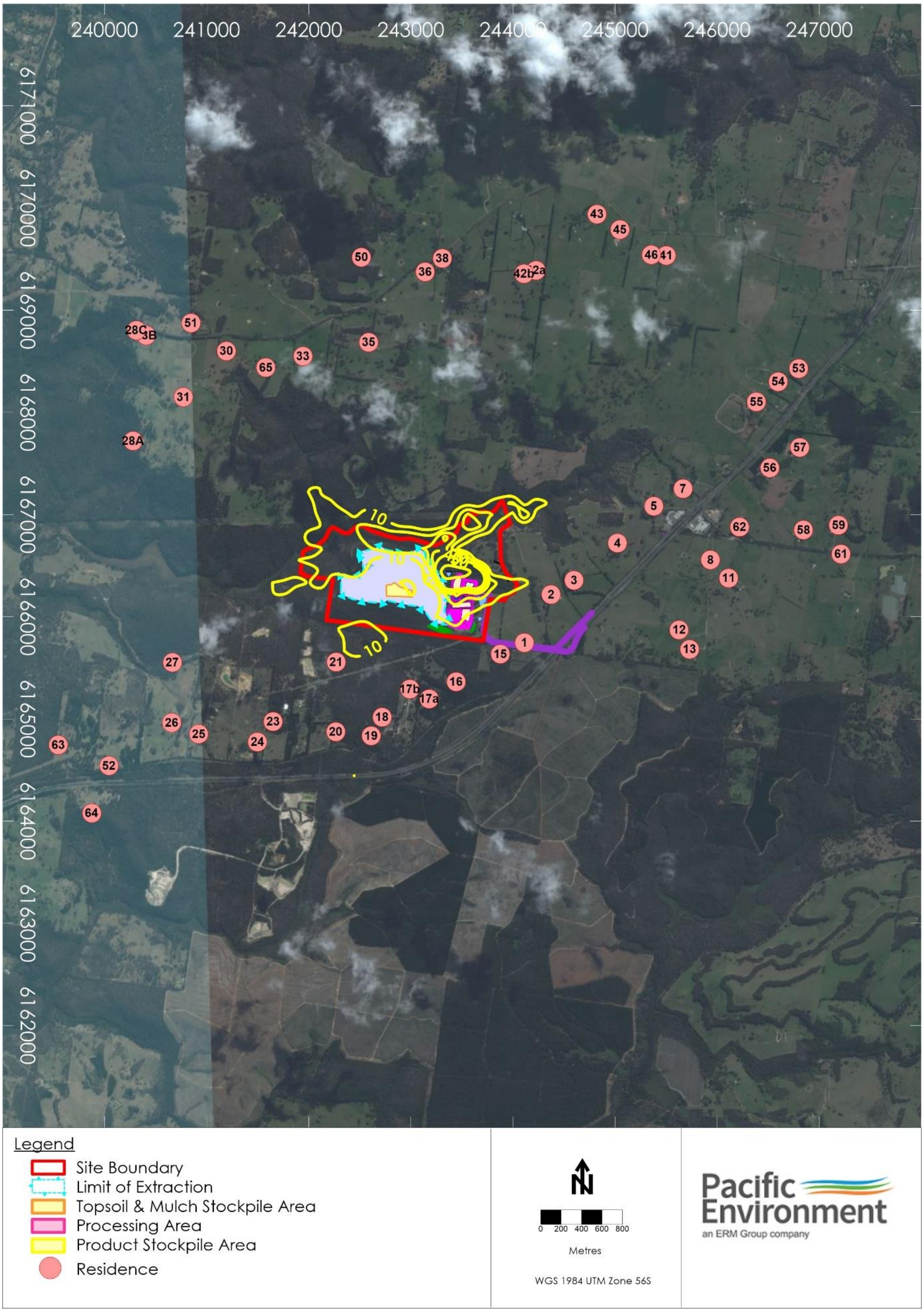



**Figure 32** **Predicted maximum 24-hour average $PM_{2.5}$ concentrations – Stage 2: Proposal alone**

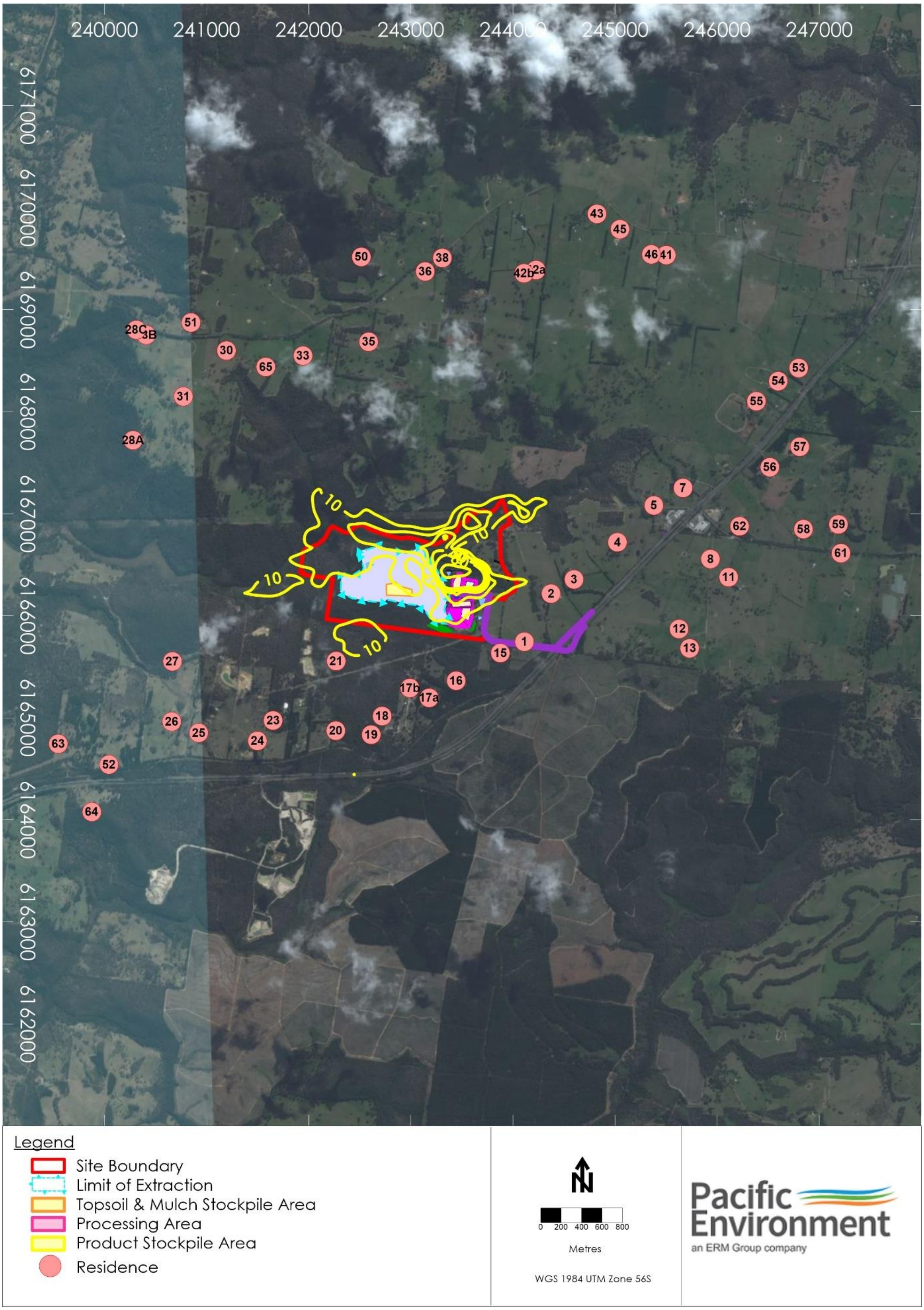



**Figure 33 Predicted maximum 24-hour average $PM_{2.5}$ concentrations – Stage 4: Proposal alone**

## 7.3 CUMULATIVE 24-HOUR PREDICTIONS

It is difficult to accurately predict cumulative 24-hour impacts due to the day to day variability in ambient PM levels and the spatial and temporal variation in any other anthropogenic activity e.g. agricultural activity, bush fires etc., in the future. Experience shows that the worst-case 24-hour $PM_{10}$ concentrations are often strongly influenced by sources such as bush fires and dust storms, which are unpredictable in nature. The variability in 24-hour average $PM_{10}$ concentrations can be clearly seen in the data collected at the HVAS monitors located at Lynwood Quarry and on site (see **Figure 9**).

Cumulative air quality impacts have been evaluated using a statistical approach known as a Monte Carlo Simulation. The Monte Carlo Simulation is a statistical modelling approach that combines the frequency distribution of one data set (in this case background 24-hour $PM_{10}$ and $PM_{2.5}$ concentrations) with the frequency distribution of another data set (in this case the Proposal's modelled impacts at a given point). This is achieved by repeatedly randomly sampling and combining values from the two data sets to create a third, 'cumulative' data set and associated frequency distribution.

This approach has been provided to achieve the objectives of a Level 2 Assessment (see Section 11.2 of [NSW EPA, 2016]). Monitored $PM_{10}$ 24-hour concentrations recorded at Lynwood Quarry and from the on-site HVAS were used to create a daily varying background data set which was then randomly added to model predictions made from the Proposal alone. The cumulative assessment focuses on the five sensitive receptors with the highest predicted contribution from the Proposal. For $PM_{10}$: sensitive receptor IDs 1, 15, 16, 17a and 17b; for $PM_{2.5}$: sensitive receptor IDs 1, 20, 21, 24 and 25. The locations of these sensitive receptors are shown in **Figure 4**.

The results of the simulation are shown in **Figure 34** to **Figure 37** for the selected representative receptors for $PM_{10}$ and $PM_{2.5}$ during Stage 2 and Stage 4.

The plots show the predicted frequency distribution of cumulative 24-hour average $PM_{10}$ and $PM_{2.5}$ concentration compared with the background (dashed red line). It is clear from that the addition of the Proposal would be unlikely to result in any additional days over the impact assessment criterion for $PM_{10}$ (50µg/m$^3$) and for $PM_{2.5}$ (25µg/m$^3$), as the statistical distribution of cumulative impacts are largely indistinguishable from background.

## 7.4 CONSIDERATION OF VACANT LAND

Vacant land is considered to be affected if it is predicted that the impact assessment criteria would be exceeded over greater than 25% of a property. Assessment criteria and the triggers for voluntary acquisition rights are provided in Section 4.3.2. Based on a review of the relevant air quality contours and land tenure information for the Proposal, no potential privately owned vacant land impacts have been identified for the Proposal, including land where a dwelling exists.

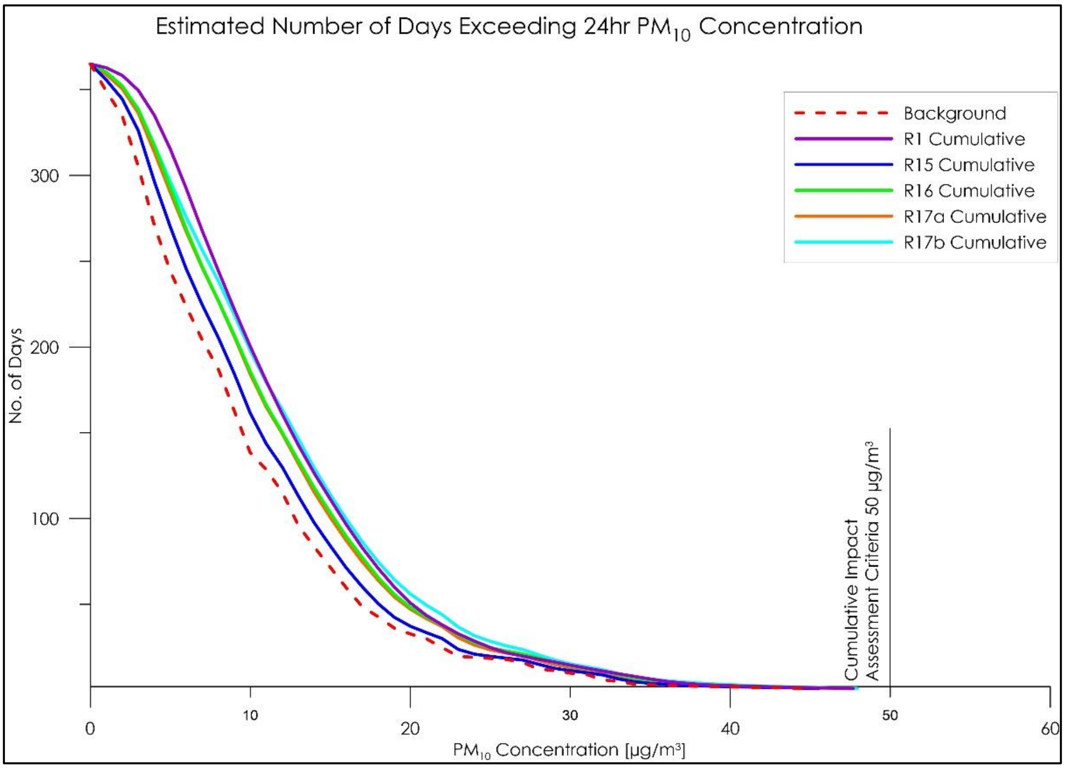



**Figure 34 Frequency distribution of cumulative 24-hr $PM_{10}$ concentration using Monte Carlo Simulation – Stage 2**

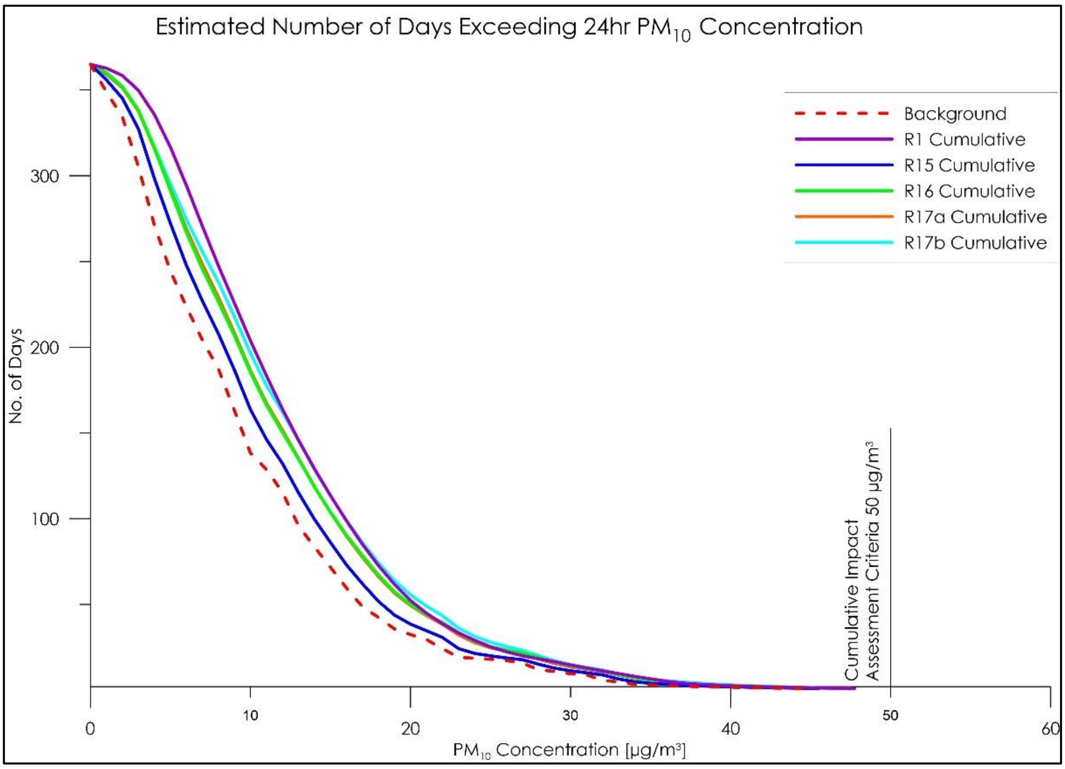



**Figure 35 Frequency distribution of cumulative 24-hr $PM_{10}$ concentration using Monte Carlo Simulation – Stage 4**

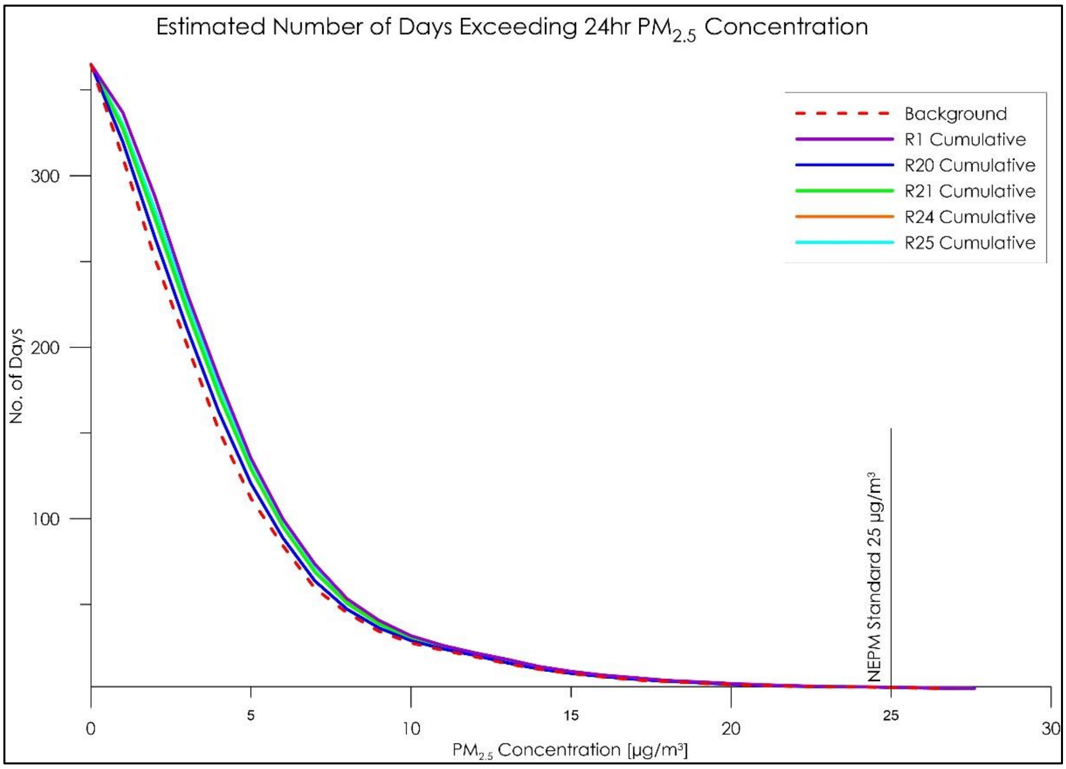



**Figure 36 Frequency distribution of cumulative 24-hr $PM_{2.5}$ concentration using Monte Carlo Simulation – Stage 2**

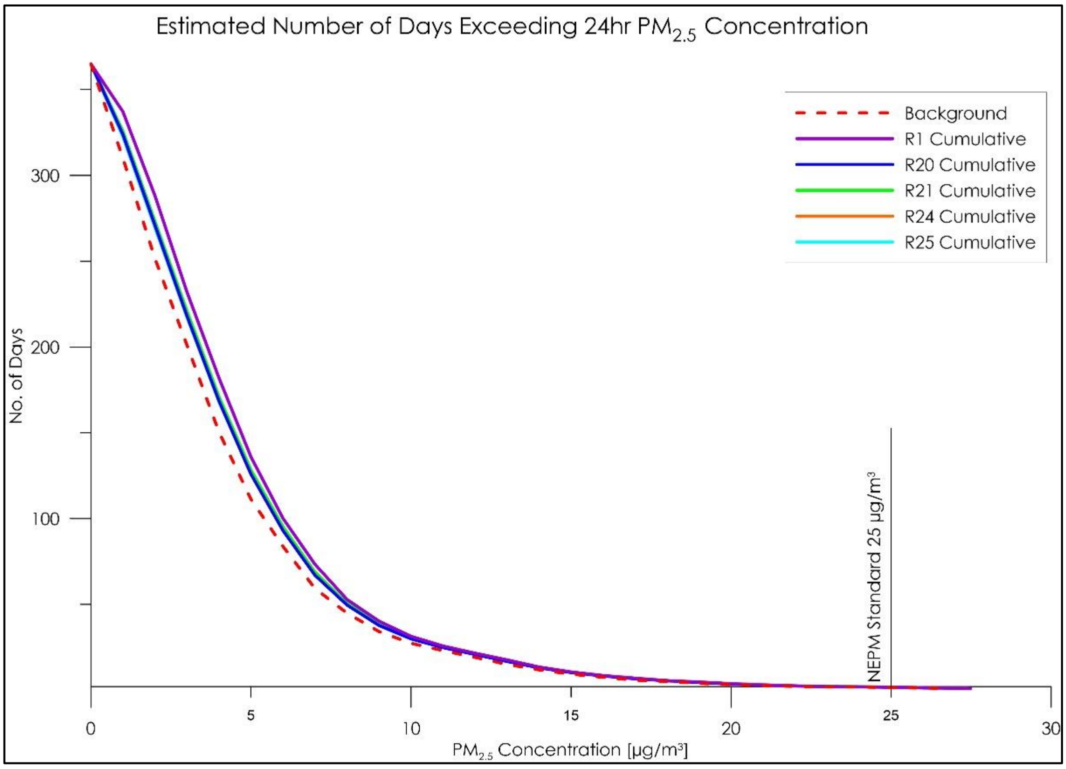



**Figure 37 Frequency distribution of cumulative 24-hr $PM_{2.5}$ concentration using Monte Carlo Simulation – Stage 4**

# 8. PROPOSED MANAGEMENT AND MONITORING MEASURES

## 8.1 CONSTRUCTION PHASE

The majority of construction activities would be undertaken over an approximate 12-month period prior to the commencement of sand production. Construction activities are proposed to occur between the hours of 6am to 10pm during Monday to Saturday. Construction activities for the Proposal would comprise the following.

- Marking out of all component areas to be disturbed during the site establishment stage.
- Vegetation clearing and stockpiling of soils to provide for buildings, roads, processing, internal roads, part of the processing and stockpiling area, Fines Storage Area 1, sediment dams and the water storage dam.
- Construction of the Quarry Access Road and construction of a new Quarry Interchange for access and egress to the Site from the Hume Highway.
- Extraction and stockpiling of sand from the footprint of the processing and stockpiling area.
- Construction of the processing plant.
- Construction of the water storage dams and northeastern, eastern and southern barriers.
- Construction of the site office, weighbridges and amenities.

Dust emissions during the construction phase of the Proposal would be considerably less than emissions during operations. Procedures for controlling dust impacts during construction would include, but not necessarily be limited to the following activities.

### 8.1.1 Clearing / Excavation

Emissions from vegetation stripping, topsoil clearing and excavation can occur, particularly during dry and windy conditions. Emissions can be effectively controlled by increasing the moisture content of the soil / surface. Other controls that would be considered are:

- Modify working practices by limiting excavation during periods of high winds (greater than 20 km/hour).
- Limiting the extent of clearing of vegetation and topsoil to the designated footprint required for construction during the appropriate stage of construction.

### 8.1.2 Haul Road and Quarry Access Road

The use of earth moving equipment can be significant sources of dust, and emissions should be controlled through the use of water sprays during the development of the internal haul road and the Quarry Access Road and Quarry Interchange construction. Where conditions are excessively dusty and windy, and fugitive dust can be seen leaving the Site, work practices should be modified to limit dust generating activity.

### 8.1.3 Haulage and Heavy Plant and Equipment

Vehicles travelling over paved or unpaved surfaces tend to produce wheel generated dust and can result in dirt track-out on paved surfaces surrounding the work areas.

- All vehicles on the Site should be confined to a designated route with speed limits enforced (20 km/hour).
- The number of vehicle trips and trip distances should be managed and reduced where possible, for example by coordinating delivery and removal of materials to avoid unnecessary trips.
- Dirt that has been tracked onto sealed roads should be removed as soon as practicable.
- When conditions are excessively dusty and windy, and dust can be seen leaving the Site, the use of a water truck (for water spraying of travel routes) should be used.

### 8.1.4 Wind Erosion

Wind erosion from exposed ground should be limited by avoiding unnecessary vegetation clearing and ensuring that rehabilitation occurs as quickly as possible. Wind erosion from temporary soil stockpiles can be limited by minimising the number of stockpiles on the Site and minimising the number of work faces on stockpiles.

## 8.2 OPERATIONAL PHASE

As detailed in Section 6.5, the Applicant would adopt a number of best practice mitigation measures on the Site to ensure that dust impacts are minimised. Measures to be employed throughout the life of the Proposal include:

- use of a water truck to control emissions from haul roads (unsealed);
- enforcement of speed limits on site;
- progressive rehabilitation of exposed areas;
- minimising drop height of material during truck loading and unloading where possible; and
- management of dust generating activities during unfavourable meteorological conditions.

It is noted there is extensive vegetation between the sensitive receptors to the south of the Site Boundary and the areas of Proposal related activities (see **Figure 2**) which may provide a small benefit in reducing the predicted PM concentrations at those sensitive receptors.

Due to their large leaf areas (relative to particulate matter) and aerodynamic roughness, trees are effective scavengers of both gaseous and particulate pollutants from the atmosphere. The use of vegetation for air pollution amelioration in urban areas was first actively promoted more than 40 years ago (Warren, 1973). Warren (1973) reported that for most heights and distances from a forest edge, PM concentrations were reduced 40-50% by particles released 2m above the ground.

More recently, an Environmental Information System for Planners (EIPs) has been developed in the UK to allow the effect of tree planting strategies on air quality to be quantified and considered within the planning process (Bealey et.al, 2007).

In rural areas, the use of vegetation as a windbreak / visual screen is common. In the US, the planting of vegetative environmental buffers around poultry farms to provide a visual screen, a vegetative filter (for odour and particulate matter) and a windbreak / shade is becoming increasingly common. For example, the states of Texas and Delaware provide explicit advice to industry relating to the selection of trees, windbreak design, and care and maintenance.

The air quality modelling assessment for the Proposal has not taken into account the screening impact of the vegetation that exists between the proposed operations and sensitive receptors, and this is one of the factors that lead to the conclusion that the predicted PM concentrations and deposition levels are conservative.

### 8.2.1 MONITORING MEASURES

It is recommended that monitoring of ambient air quality continues with a $PM_{10}$ HVAS and dust deposition gauges as detailed in Section 5.3. The results of the monitoring should be regularly reviewed and evaluated to establish the success of the proposed mitigation measures and the need to further monitor.

# 9. GREENHOUSE GAS ASSESSMENT

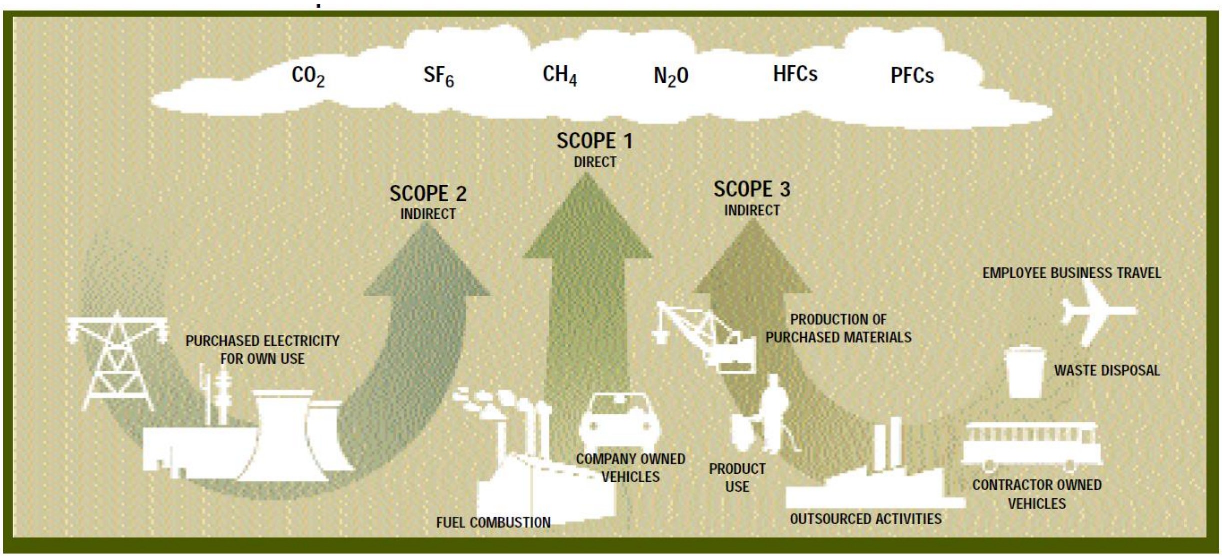
## 9.1 INTRODUCTION

Greenhouse gas (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* ("the GHG Protocol"; WRI/WBCSD, 2004).
- National Greenhouse and Energy Reporting (Measurement) Determination 2008.
- The Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) National Greenhouse Accounts (NGA) Factors August 2015 (DCCEE, 2015).

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Standard Organisation, endorsed by GHG initiatives (such as the Carbon Disclosure Proposal) 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 and summarised in **Figure 38**. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment.




Source: Figure 3, WRI/WBCSD, 2004

**Figure 38 Overview of Scopes and Emissions across a Reporting Entity**

## 9.2 METHODOLOGY

#### 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;
- Physical or chemical processing;
- Transportation of materials, products, waste and employees; and
- Fugitive emissions.

#### 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 the Proposal 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.

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.

As part of the assessment, an explanation of anticipated greenhouse gases from scope 3 emissions has been included.

## 9.3 GREENHOUSE GAS EMISSION ESTIMATES

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

Proposal-related GHG sources included in the assessment are as follows.

- Fuel consumption (diesel) during extraction and processing– scope 1.
- Indirect emissions associated with on-site electricity use – scope 2.
- Indirect emissions associated with the production of transport fuels – scope 3.

The operational phase of the Proposal is assumed to be 30 years. It is assumed that diesel and electricity usage would not vary significantly between years of operation.

Detailed information on the calculation of greenhouse gas emissions from the Proposal are provided in **Appendix 2**.

## 9.4 SUMMARY OF GHG EMISSIONS

A summary of the annual GHG emissions associated with the Proposal are presented in **Table 19**.

**Table 19**
**Summary of GHG Emissions** (**t $CO_{2-e}$ per year**)

| Type of fuel and activity | Scope 1 | Scope 2 | Scope 3 | Total Scope 1 and Scope 2 | Total All Scopes |
|---|---|---|---|---|---|
| Diesel - non-transport | 9,470 | 0 | 486 | 9,470 | 9,955 |
| Diesel - product transportation | 16,485 | 0 | 842 | 16,485 | 17,326 |
| Electricity usage | 0 | 2,752 | 393 | 2,752 | 3,145 |
| **Total** | **25,954** | **2,752** | **1,721** | **28,706** | **30,427** |

The Proposal’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 and scope 2 emissions from the Proposal (approximately 0.029 million tonnes [Mt] $CO_2$-e) would represent approximately 0.005% of Australia’s commitment for annual emissions under the Kyoto Protocol (591.5 Mt $CO_2$-e/annum) and a very small portion of global GHG emissions, given that Australia contributed approximately 1.15% of global GHG emissions in 2014 (PBL Netherlands Environmental Assessment Agency, 2015). Over 50% of these emissions are associated with the transportation of the quarry product to customers.

## 9.5 GREENHOUSE GAS MANAGEMENT

The following measures are recommended to minimise GHG emissions from the Proposal.

- Maximise energy efficiency as a key consideration in the development of the Proposal. For example, significant savings of GHG emissions (through increased energy efficiency) can be achieved by planning decisions which minimise haul distances and therefore fuel use;
- Continually improve energy use and efficiency;
- Consider the use of alternative fuels where economically and practically feasible;

- Review of extraction practices to minimise double handling of materials and ensuring that haulage is undertaken using the most efficient routes;
- Ongoing scheduled and preventative maintenance to ensure that diesel and electrically powered plants operate efficiently; and
- Development of targets for GHG emissions and energy use, and monitor and report against these.

# 10. CONCLUSIONS

Pacific Environment Limited has completed an air quality impact assessment for the construction and operation of the Sutton Forest Sand Quarry in the Southern Highlands of NSW.

Two operating scenarios have been assessed to represent the potential worst case air quality impacts on sensitive receptors in the vicinity of the Proposal.

Dispersion modelling was conducted to predict the ground level concentrations of TSP, $PM_{10}$, $PM_{2.5}$, and dust deposition for both operating scenarios. Cumulative impacts were also considered, taking into account existing background particulate matter concentrations and deposition rates.

The modelling results show that during its operation, the Proposal is predicted to comply with all of the impact assessment criteria for each relevant averaging period for TSP, $PM_{10}$, $PM_{2.5}$, and dust deposition.

Construction particulate matter emissions are considered short lived and able to be effectively managed.

A greenhouse gas assessment indicates that average annual scope 1 and 2 emissions from the Proposal (0.029Mt $CO_2$-e) would represent approximately 0.005% of Australia's commitment under the Kyoto Protocol (591.5 Mt $CO_2$-e) and a very small proportion of global greenhouse emissions.

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# *APPENDICES*

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# Appendix 1

## Emissions Estimates

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## Sutton Forest Sand Quarry

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

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

- Dozer activities.
- Drilling of blast holes (intermittent).
- Loading/unloading to trucks.
- Crushing and screening.
- Hauling.
- Wind erosion.
- Grading roads.

**Silt and moisture content**

Silt and moisture content values for in pit activities are based on values used in other assessments of similar facilities. Testing reports were provided for a number of product stockpiles and the highest moisture content of 2.7% was used for all stockpiling and loading of final products.

| Activity | Silt content (%) | Moisture content (%) |
|---|---|---|
| Extraction Area | 15 | 10 |
| Fines waste | - | 14 |
| Oversized materials waste | - | 10 |
| Sand product | - | 6 |
| Mortar product | - | 10 |

**Loading / transfer material dumping waste rock**

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

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

Where:

K = 0.74 for TSP, 0.35 for $PM_{10}$ and 0.105 for $PM_{2.5}$

U = wind speed (m/s)

M = moisture content (%)

**Hauling material on unsealed surfaces**

The emission estimate of wheel generated dust associated with hauling materials to or form the extraction area is based the US EPA AP42 emission equation for unpaved surfaces at industrial sites (US EPA, 1985 and updates) shown below:

$$E_{TSP}\ (kg/VKT) = 0.2819 \times 4.9 \times [\ \times (s/12)\text{^}0.7 \times ((W \times 1.1023)/3)\text{^}0.45]$$
$$E_{PM_{10}}\ (kg/VKT) = 0.2819 \times 1.5 \times [\ \times (s/12)\text{^}0.9 \times ((W \times 1.1023)/3)\text{^}0.45]$$
$$E_{PM_{2.5}}\ (kg/VKT) = 0.2819 \times 0.15 \times [\ \times (s/12)\text{^}0.9 \times ((W \times 1.1023)/3)\text{^}0.45]$$

Where:

s = silt content of road surface
W = mean vehicle weight (i.e. average of loaded and unloaded)

The silt content (s) for the haulage routes is assumed to be 6.4%.

The mean vehicle capacity of 50t for internal haul trucks and 30t for external haul trucks was provided by the Applicant.

**Crushing and Screening**

Whilst only primary crushing would occur, there are no emission factors available specifically for primary crushing, and as such the emission factor used for tertiary crushing have been taken from the US EPA emission factors (US EPA, 1985 and updates), which are shown in the table below:

| Activity | TSP | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|
| Tertiary crushing (controlled)* | 0.0006 | 0.00027 | 0.00005 |
| Fines crushing (controlled) | 0.0015 | 0.0006 | 0.000035 |
| Screening | 0.0018 | 0.0011 | 0.0011 |

*there are no emission factors for primary crushing activities

Primary crushing would occur at the wash plant and where the material would be sufficiently damp and therefore appropriate levels of control have been applied to the emission factors. No controls have been applied to screening and the mobile mortar and sand screening plant.

**Dozers**

Emissions from dozers have been calculated using the US EPA emission factor equation (US EPA, 1985 and updates).

$$E_{TSP}(kg/hr) = 2.6 \times \frac{s^{1.2}}{M^{1.3}}$$
$$E_{PM_{10}}(kg/hr) = 0.3375 \times \frac{s^{1.5}}{M^{1.4}}$$
$$E_{PM_{2.5}}(kg/hr) = 0.105 \times TSP$$

Where:

s = silt content

M = moisture content

**Wind Erosion**

The emission factor used for wind erosion has been taken to be 0.1 kg/ha for TSP, 0.05 kg/ha for $PM_{10}$ and 0.008kg/ha for $PM_{2.5}$.

**Grading roads**

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

$$E_{TSP} = 0.0034 \times S^{2.5}$$
$$E_{PM_{10}} = 0.00336 \times S^{2.0}$$
$$E_{PM_{2.5}} = 0.0001054 \times S^{2.5}$$

Where:

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

## Stage 2 – Annual TSP Emissions Based on Annual Maximum Activity

| ACTIVITY | TSP emission (kg/y) | Intensity | Units | Emission factor | Units | Variable 1 | Units | Variable 2 | Units | Variable 3 | Units | Variable 4 | Units | Variable 5 | Units | Control | Units | Controls Assumed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 11,006 | 3276 | h/y | 3.36 | kg/hr | 15 | Silt content | 10 | moisture content | | | | | | | 0 | % control | |
| Pit - drilling | 1,593 | 2700 | holes/y | 0.59 | kg/hole | | | | | | | | | | | | | |
| Pit - blasting | 151 | 9 | blasts/y | 16.80 | kg/blast | 1800 | Area of blast in square metres | 300 | holes/blast | | | | | | | | | |
| Pit - loading material to trucks at pit | 147 | 1,000,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Pit - hauling material to dry screening plant (brickies sand) | 4,310 | 100,000 | t/y | 0.172 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.40 | km/return trip | 3.59 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Pit - hauling material from pit to processing area (for washed sand products) | 27,801 | 900,000 | t/y | 0.124 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.72 | km/return trip | 3.59 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Brickies sand screening plant - unloading to raw feed stockpile | 15 | 100,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Loading to hopper from raw feeds stockpile | 15 | 100,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Screening | 15,000 | 100,000 | t/y | 0.15000 | kg/t | | | | | | | | | | | | | Dry screening |
| Brickie's sand screening plant - Relocating to product stockpile | 12 | 80,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 133 | 900,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 133 | 900,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Screening | 990 | 900,000 | t/y | 0.00110 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Primary Crusher | 108 | 180,000 | t/y | 0.00060 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Conveyor unloading | 133 | 900,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Relocating to product stockpile | 235 | 780,000 | t/y | 0.00030 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | | | |
| Waste - loading fines at processing area | 9 | 110,000 | t/y | 0.00008 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - loading oversized material | 4 | 30,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling fines to emplacement area | 4,346 | 110,000 | t/y | 0.15804 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.2 | km/return trip | 3.59 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading fines at emplacement area | 9 | 110,000 | t/y | 0.00008 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling oversized material | 970 | 30,000 | t/y | 0.12931 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.8 | km/return trip | 3.59 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading oversized material | 6 | 30,000 | t/y | 0.00020 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading washed sand product material to trucks | 235 | 780,000 | t/y | 0.00030 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading Brickie's product material to trucks | 16 | 80,000 | t/y | 0.00020 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - hauling product material to off-site location (sealed road) | 2,721 | 860,000 | t/y | 0.013 | kg/t | 30 | t/load | 50 | Mean vehicle mass (t) | 0.8 | km/return trip | 0.47 | kg/VKT | 3 | silt loading (g/m2) | 75 | % control | Level 2 watering |
| Wind Erosion - Extraction Area | 13,403 | 15.3 | ha | 0.10 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Processing and Stockpiling area | 10,512 | 12.0 | ha | 0.10 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Fines Storage | 1,927 | 2.2 | ha | 0.10 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Topsoil and Mulch Stockpile Area | 1,533 | 2.5 | ha | 0.10 | kg/ha/h | 8,760 | h/y | | | | | | | | | 30 | % control | Shelterbelt |
| Grading unsealed roads | 2,048 | 3,328 | km | 0.6 | kg/VKT | 8 | speed of graders in km/h | 416 | Hours per year | | | | | | | | | |
| **Total (kg/y)** | **99,521** | | | | | | | | | | | | | | | | | |

## Stage 2 – Annual $PM_{10}$ Emissions Based on Annual Maximum Activity

| ACTIVITY | $PM_{10}$ emission (kg/y) | Intensity | Units | Emission factor | Units | Variable 1 | Units | Variable 2 | Units | Variable 3 | Units | Variable 4 | Units | Variable 5 | Units | Control | Units | Controls Assumed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 2,557 | 3276 | h/y | 0.78 | kg/hr | 15 | Silt content | 10 | moisture content | | | | | | | 0 | % control | |
| Pit - drilling | 828 | 2700 | holes/y | 0.31 | kg/hole | | | | | | | | | | | | | |
| Pit - blasting | 79 | 9 | blasts/y | 8.74 | kg/blast | 1800 | Area of blast in square metres | 300 | holes/blast | | | | | | | | | |
| Pit - loading material to trucks at pit | 70 | 1,000,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Pit - hauling material to dry screening plant (brickies sand) | 1,164 | 100,000 | t/y | 0.047 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.40 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Pit - hauling material from pit to processing area (for washed sand products) | 7,505 | 900,000 | t/y | 0.033 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.72 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Brickies sand screening plant - unloading to raw feed stockpile | 7 | 100,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Loading to hopper from raw feeds stockpile | 7 | 100,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Screening | 3,600 | 100,000 | t/y | 0.03600 | kg/t | | | | | | | | | | | | | Dry screening |
| Brickie's sand screening plant - Relocating to product stockpile | 6 | 80,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 63 | 900,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 63 | 900,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Screening | 333 | 900,000 | t/y | 0.00037 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Primary Crusher | 49 | 180,000 | t/y | 0.00027 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Conveyor unloading | 63 | 900,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Relocating to product stockpile | 111 | 780,000 | t/y | 0.00014 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | | | |
| Waste - loading fines at processing area | 4 | 110,000 | t/y | 0.00004 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - loading oversized material | 2 | 30,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling fines to emplacement area | 1,173 | 110,000 | t/y | 0.04266 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.2 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading fines at emplacement area | 4 | 110,000 | t/y | 0.00004 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling oversized material | 262 | 30,000 | t/y | 0.03491 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.8 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading oversized material | 3 | 30,000 | t/y | 0.00010 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading washed sand product material to trucks | 111 | 780,000 | t/y | 0.00014 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading Brickie's product material to trucks | 8 | 80,000 | t/y | 0.00010 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - hauling product material to off-site location (sealed road) | 522 | 860,000 | t/y | 0.002 | kg/t | 30 | t/load | 50 | Mean vehicle mass (t) | 0.8 | km/return trip | 0.09 | kg/VKT | 3 | silt loading (g/m2) | 75 | % control | Level 2 watering |
| Wind Erosion - Extraction Area | 6,701 | 15.3 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Processing and Stockpiling area | 5,256 | 12.0 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Fines Storage | 964 | 2.2 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Topsoil and Mulch Stockpile Area | 767 | 2.5 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 30 | % control | Shelterbelt |
| Grading unsealed roads | 716 | 3,328 | km | 0.2 | kg/VKT | 8 | speed of graders in km/h | 416 | Hours per year | | | | | | | | | |
| **Total (kg/y)** | **32,996** | | | | | | | | | | | | | | | | | |

## Stage 2 – Annual $PM_{10}$ Emissions Based on Daily Maximum Activity

| ACTIVITY | $PM_{10}$ emission (kg/y) | Intensity | Units | Emission factor | Units | Variable 1 | Units | Variable 2 | Units | Variable 3 | Units | Variable 4 | Units | Variable 5 | Units | Control | Units | Controls Assumed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 2,557 | 3276 | h/y | 0.78 | kg/hr | 15 | Silt content | 10 | moisture content | | | | | | | 0 | % control | |
| Pit - drilling | 828 | 2700 | holes/y | 0.31 | kg/hole | | | | | | | | | | | | | |
| Pit - blasting | 79 | 9 | blasts/y | 8.74 | kg/blast | 1800 | Area of blast in square metres | 300 | holes/blast | | | | | | | | | |
| Pit - loading material to trucks at pit | 99 | 1,416,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Pit - hauling material to dry screening plant (brickies sand) | 1,648 | 141,600 | t/y | 0.047 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.40 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Pit - hauling material from pit to processing area (for washed sand products) | 10,627 | 1,274,400 | t/y | 0.033 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.72 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Brickies sand screening plant - unloading to raw feed stockpile | 10 | 141,600 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Loading to hopper from raw feeds stockpile | 10 | 141,600 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Screening | 5,098 | 141,600 | t/y | 0.03600 | kg/t | | | | | | | | | | | | | Dry screening |
| Brickie's sand screening plant - Relocating to product stockpile | 6 | 80,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 89 | 1,274,400 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 89 | 1,274,400 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Screening | 472 | 1,274,400 | t/y | 0.00037 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Primary Crusher | 49 | 180,000 | t/y | 0.00027 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Conveyor unloading | 89 | 1,274,400 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Relocating to product stockpile | 111 | 780,000 | t/y | 0.00014 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | | | |
| Waste - loading fines at processing area | 6 | 155,760 | t/y | 0.00004 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - loading oversized material | 28 | 400,240 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling fines to emplacement area | 1,661 | 155,760 | t/y | 0.04266 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.2 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading fines at emplacement area | 6 | 155,760 | t/y | 0.00004 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling oversized material | 3,493 | 400,240 | t/y | 0.03491 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.8 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading oversized material | 38 | 400,240 | t/y | 0.00010 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading washed sand product material to trucks | 111 | 780,000 | t/y | 0.00014 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading Brickie's product material to trucks | 8 | 80,000 | t/y | 0.00010 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - hauling product material to off-site location (sealed road) | 522 | 860,000 | t/y | 0.002 | kg/t | 30 | t/load | 50 | Mean vehicle mass (t) | 0.8 | km/return trip | 0.09 | kg/VKT | 3 | silt loading (g/m2) | 75 | % control | Level 2 watering |
| Wind Erosion - Extraction Area | 6,701 | 15.3 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Processing and Stockpiling area | 5,256 | 12.0 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Fines Storage | 964 | 2.2 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Topsoil and Mulch Stockpile Area | 767 | 2.5 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 30 | % control | Shelterbelt |
| Grading unsealed roads | 716 | 3,328 | km | 0.2 | kg/VKT | 8 | speed of graders in km/h | 416 | Hours per year | | | | | | | | | |
| **Total (kg/y)** | **42,135** | | | | | | | | | | | | | | | | | |

## Stage 2 – Annual $PM_{2.5}$ Emissions Based on Annual Maximum Activity

| ACTIVITY | $PM_{2.5}$ emission (kg/y) | Intensity | Units | Emission factor | Units | Variable 1 | Units | Variable 2 | Units | Variable 3 | Units | Variable 4 | Units | Variable 5 | Units | Control | Units | Controls Assumed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 1,156 | 3276 | h/y | 0.35 | kg/hr | 15 | Silt content | 10 | moisture content | | | | | | | 0 | % control | |
| Pit - drilling | 48 | 2700 | holes/y | 0.02 | kg/hole | | | | | | | | | | | | | |
| Pit - blasting | 5 | 9 | blasts/y | 0.50 | kg/blast | 1800 | Area of blast in square metres | 300 | holes/blast | | | | | | | | | |
| Pit - loading material to trucks at pit | 11 | 1,000,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Pit - hauling material to dry screening plant (brickies sand) | 116 | 100,000 | t/y | 0.005 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.40 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Pit - hauling material from pit to processing area (for washed sand products) | 751 | 900,000 | t/y | 0.003 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.72 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Brickies sand screening plant - unloading to raw feed stockpile | 1 | 100,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Loading to hopper from raw feeds stockpile | 1 | 100,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Screening | 3,600 | 100,000 | t/y | 0.03600 | kg/t | | | | | | | | | | | | | Dry screening |
| Brickie's sand screening plant - Relocating to product stockpile | 1 | 80,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 9 | 900,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 9 | 900,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Screening | 23 | 900,000 | t/y | 0.00003 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Primary Crusher | 9 | 180,000 | t/y | 0.00005 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Conveyor unloading | 9 | 900,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Relocating to product stockpile | 17 | 780,000 | t/y | 0.00002 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | | | |
| Waste - loading fines at processing area | 1 | 110,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - loading oversized material | 0 | 30,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling fines to emplacement area | 117 | 110,000 | t/y | 0.00427 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.2 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading fines at emplacement area | 1 | 110,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling oversized material | 26 | 30,000 | t/y | 0.00349 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.8 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading oversized material | 0 | 30,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading washed sand product material to trucks | 17 | 780,000 | t/y | 0.00002 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading Brickie's product material to trucks | 1 | 80,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - hauling product material to off-site location (sealed road) | 126 | 860,000 | t/y | 0.001 | kg/t | 30 | t/load | 50 | Mean vehicle mass (t) | 0.8 | km/return trip | 0.02 | kg/VKT | 3 | silt loading (g/m2) | 75 | % control | Level 2 watering |
| Wind Erosion - Extraction Area | 1,005 | 15.3 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Processing and Stockpiling area | 788 | 12.0 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Fines Storage | 145 | 2.2 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Topsoil and Mulch Stockpile Area | 115 | 2.5 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 30 | % control | Shelterbelt |
| Grading unsealed roads | 63 | 3,328 | km | 0.02 | kg/VKT | 8 | speed of graders in km/h | 416 | Hours per year | | | | | | | | | |
| **Total (kg/y)** | **8,172** | | | | | | | | | | | | | | | | | |

## Stage 2 – Annual $PM_{2.5}$ Emissions Based on Daily Maximum Activity

| ACTIVITY | $PM_{2.5}$ emission (kg/y) | Intensity | Units | Emission factor | Units | Variable 1 | Units | Variable 2 | Units | Variable 3 | Units | Variable 4 | Units | Variable 5 | Units | Control | Units | Controls Assumed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 1,156 | 3276 | h/y | 0.35 | kg/hr | 15 | Silt content | 10 | moisture content | | | | | | | 0 | % control | |
| Pit - drilling | 48 | 2700 | holes/y | 0.02 | kg/hole | | | | | | | | | | | | | |
| Pit - blasting | 5 | 9 | blasts/y | 0.50 | kg/blast | 1800 | Area of blast in square metres | 300 | holes/blast | | | | | | | | | |
| Pit - loading material to trucks at pit | 15 | 1,416,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Pit - hauling material to dry screening plant (brickies sand) | 165 | 141,600 | t/y | 0.005 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.40 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Pit - hauling material from pit to processing area (for washed sand products) | 1,063 | 1,274,400 | t/y | 0.003 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.72 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Brickies sand screening plant - unloading to raw feed stockpile | 1 | 141,600 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Loading to hopper from raw feeds stockpile | 1 | 141,600 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Screening | 5,098 | 141,600 | t/y | 0.03600 | kg/t | | | | | | | | | | | | | Dry screening |
| Brickie's sand screening plant - Relocating to product stockpile | 1 | 80,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 13 | 1,274,400 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 13 | 1,274,400 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Screening | 32 | 1,274,400 | t/y | 0.00003 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Primary Crusher | 9 | 180,000 | t/y | 0.00005 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Conveyor unloading | 13 | 1,274,400 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Relocating to product stockpile | 17 | 780,000 | t/y | 0.00002 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | | | |
| Waste - loading fines at processing area | 1 | 155,760 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - loading oversized material | 4 | 400,240 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling fines to emplacement area | 166 | 155,760 | t/y | 0.00427 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.2 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading fines at emplacement area | 1 | 155,760 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling oversized material | 349 | 400,240 | t/y | 0.00349 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.8 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading oversized material | 6 | 400,240 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading washed sand product material to trucks | 17 | 780,000 | t/y | 0.00002 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading Brickie's product material to trucks | 1 | 80,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - hauling product material to off-site location (sealed road) | 126 | 860,000 | t/y | 0.001 | kg/t | 30 | t/load | 50 | Mean vehicle mass (t) | 0.8 | km/return trip | 0.02 | kg/VKT | 3 | silt loading (g/m2) | 75 | % control | Level 2 watering |
| Wind Erosion - Extraction Area | 1,005 | 15.3 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Processing and Stockpiling area | 788 | 12.0 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Fines Storage | 145 | 2.2 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Topsoil and Mulch Stockpile Area | 115 | 2.5 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 30 | % control | Shelterbelt |
| Grading unsealed roads | 63 | 3,328 | km | 0.02 | kg/VKT | 8 | speed of graders in km/h | 416 | Hours per year | | | | | | | | | |
| **Total (kg/y)** | **10,438** | | | | | | | | | | | | | | | | | |

## Stage 4 – Annual TSP Emissions Based on Annual Maximum Activity

| ACTIVITY | TSP emission (kg/y) | Intensity | Units | Emission factor | Units | Variable 1 | Units | Variable 2 | Units | Variable 3 | Units | Variable 4 | Units | Variable 5 | Units | Control | Units | Controls Assumed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 11,006 | 3276 | h/y | 3.36 | kg/hr | 15 | Silt content | 10 | moisture content | | | | | | | 0 | % control | |
| Pit - drilling | 1,593 | 2700 | holes/y | 0.59 | kg/hole | | | | | | | | | | | | | |
| Pit - blasting | 151 | 9 | blasts/y | 16.80 | kg/blast | 1800 | Area of blast in square metres | 300 | holes/blast | | | | | | | | | |
| Pit - loading material to trucks at pit | 147 | 1,000,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Pit - hauling material to dry screening plant (brickies sand) | 4,310 | 100,000 | t/y | 0.172 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.40 | km/return trip | 3.59 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Pit - hauling material from pit to processing area (for washed sand products) | 27,801 | 900,000 | t/y | 0.124 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.72 | km/return trip | 3.59 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Brickies sand screening plant - unloading to raw feed stockpile | 15 | 100,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Loading to hopper from raw feeds stockpile | 15 | 100,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Screening | 15,000 | 100,000 | t/y | 0.15000 | kg/t | | | | | | | | | | | | | Dry screening |
| Brickie's sand screening plant - Relocating to product stockpile | 12 | 80,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 133 | 900,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 133 | 900,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Screening | 990 | 900,000 | t/y | 0.00110 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Primary Crusher | 270 | 450,000 | t/y | 0.00060 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Conveyor unloading | 133 | 900,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Relocating to product stockpile | 235 | 780,000 | t/y | 0.00030 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | | | |
| Waste - loading fines at processing area | 9 | 110,000 | t/y | 0.00008 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - loading oversized material | 4 | 30,000 | t/y | 0.00015 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling fines to emplacement area | 4,346 | 110,000 | t/y | 0.15804 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.2 | km/return trip | 3.59 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading fines at emplacement area | 9 | 110,000 | t/y | 0.00008 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling oversized material | 970 | 30,000 | t/y | 0.12931 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.8 | km/return trip | 3.59 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading oversized material | 6 | 30,000 | t/y | 0.00020 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading washed sand product material to trucks | 235 | 780,000 | t/y | 0.00030 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading Brickie's product material to trucks | 16 | 80,000 | t/y | 0.00020 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - hauling product material to off-site location (sealed road) | 2,721 | 860,000 | t/y | 0.013 | kg/t | 30 | t/load | 50 | Mean vehicle mass (t) | 0.8 | km/return trip | 0.47 | kg/VKT | 3 | silt loading (g/m2) | 75 | % control | Level 2 watering |
| Wind Erosion - Extraction Area | 18,396 | 21.0 | ha | 0.10 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Processing and Stockpiling area | 10,512 | 12.0 | ha | 0.10 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Fines Storage | 876 | 1.0 | ha | 0.10 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Topsoil and Mulch Stockpile Area | 1,533 | 2.5 | ha | 0.10 | kg/ha/h | 8,760 | h/y | | | | | | | | | 30 | % control | Shelterbelt |
| Grading unsealed roads | 41,832 | 67,968 | km | 0.6 | kg/VKT | 8 | speed of graders in km/h | 8,496 | Hours per year | | | | | | | | | |
| **Total (kg/y)** | **143,408** | | | | | | | | | | | | | | | | | |

## Stage 4 – Annual $PM_{10}$ Emissions Based on Annual Maximum Activity

| ACTIVITY | $PM_{10}$ emission (kg/y) | Intensity | Units | Emission factor | Units | Variable 1 | Units | Variable 2 | Units | Variable 3 | Units | Variable 4 | Units | Variable 5 | Units | Control | Units | Controls Assumed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 2,557 | 3276 | h/y | 0.78 | kg/hr | 15 | Silt content | 10 | moisture content | | | | | | | 0 | % control | |
| Pit - drilling | 828 | 2700 | holes/y | 0.31 | kg/hole | | | | | | | | | | | | | |
| Pit - blasting | 79 | 9 | blasts/y | 8.74 | kg/blast | 1800 | Area of blast in square metres | 300 | holes/blast | | | | | | | | | |
| Pit - loading material to trucks at pit | 70 | 1,000,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Pit - hauling material to dry screening plant (brickies sand) | 1,164 | 100,000 | t/y | 0.047 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.40 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Pit - hauling material from pit to processing area (for washed sand products) | 7,505 | 900,000 | t/y | 0.033 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.72 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Brickies sand screening plant - unloading to raw feed stockpile | 7 | 100,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Loading to hopper from raw feeds stockpile | 7 | 100,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Screening | 3,600 | 100,000 | t/y | 0.03600 | kg/t | | | | | | | | | | | | | Dry screening |
| Brickie's sand screening plant - Relocating to product stockpile | 6 | 80,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 63 | 900,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 63 | 900,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Screening | 333 | 900,000 | t/y | 0.00037 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Primary Crusher | 122 | 450,000 | t/y | 0.00027 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Conveyor unloading | 63 | 900,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Relocating to product stockpile | 111 | 780,000 | t/y | 0.00014 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | | | |
| Waste - loading fines at processing area | 4 | 110,000 | t/y | 0.00004 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - loading oversized material | 2 | 30,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling fines to emplacement area | 1,173 | 110,000 | t/y | 0.04266 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.2 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading fines at emplacement area | 4 | 110,000 | t/y | 0.00004 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling oversized material | 262 | 30,000 | t/y | 0.03491 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.8 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading oversized material | 3 | 30,000 | t/y | 0.00010 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading washed sand product material to trucks | 111 | 780,000 | t/y | 0.00014 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading Brickie's product material to trucks | 8 | 80,000 | t/y | 0.00010 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - hauling product material to off-site location (sealed road) | 522 | 860,000 | t/y | 0.002 | kg/t | 30 | t/load | 50 | Mean vehicle mass (t) | 0.8 | km/return trip | 0.09 | kg/VKT | 3 | silt loading (g/m2) | 75 | % control | Level 2 watering |
| Wind Erosion - Extraction Area | 9,198 | 21.0 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Processing and Stockpiling area | 5,256 | 12.0 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Fines Storage | 438 | 1.0 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Topsoil and Mulch Stockpile Area | 767 | 2.5 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 30 | % control | Shelterbelt |
| Grading unsealed roads | 14,616 | 67,968 | km | 0.2 | kg/VKT | 8 | speed of graders in km/h | 8,496 | Hours per year | | | | | | | | | |
| **Total (kg/y)** | **48,940** | | | | | | | | | | | | | | | | | |

## Stage 4 – Annual $PM_{10}$ Emissions Based on Daily Maximum Activity

| ACTIVITY | $PM_{10}$ emission (kg/y) | Intensity | Units | Emission factor | Units | Variable 1 | Units | Variable 2 | Units | Variable 3 | Units | Variable 4 | Units | Variable 5 | Units | Control | Units | Controls Assumed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 2,557 | 3276 | h/y | 0.78 | kg/hr | 15 | Silt content | 10 | moisture content | | | | | | | 0 | % control | |
| Pit - drilling | 828 | 2700 | holes/y | 0.31 | kg/hole | | | | | | | | | | | | | |
| Pit - blasting | 79 | 9 | blasts/y | 8.74 | kg/blast | 1800 | Area of blast in square metres | 300 | holes/blast | | | | | | | | | |
| Pit - loading material to trucks at pit | 99 | 1,416,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Pit - hauling material to dry screening plant (brickies sand) | 1,648 | 141,600 | t/y | 0.047 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.40 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Pit - hauling material from pit to processing area (for washed sand products) | 10,627 | 1,274,400 | t/y | 0.033 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.72 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Brickies sand screening plant - unloading to raw feed stockpile | 10 | 141,600 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Loading to hopper from raw feeds stockpile | 10 | 141,600 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Screening | 5,098 | 141,600 | t/y | 0.03600 | kg/t | | | | | | | | | | | | | Dry screening |
| Brickie's sand screening plant - Relocating to product stockpile | 6 | 80,000 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 89 | 1,274,400 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 89 | 1,274,400 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Screening | 472 | 1,274,400 | t/y | 0.00037 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Primary Crusher | 122 | 450,000 | t/y | 0.00027 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Conveyor unloading | 89 | 1,274,400 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Relocating to product stockpile | 111 | 780,000 | t/y | 0.00014 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | | | |
| Waste - loading fines at processing area | 6 | 155,760 | t/y | 0.00004 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - loading oversized material | 28 | 400,240 | t/y | 0.00007 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling fines to emplacement area | 1,661 | 155,760 | t/y | 0.04266 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.2 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading fines at emplacement area | 6 | 155,760 | t/y | 0.00004 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling oversized material | 3,493 | 400,240 | t/y | 0.03491 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.8 | km/return trip | 0.96964109 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading oversized material | 38 | 400,240 | t/y | 0.00010 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading washed sand product material to trucks | 111 | 780,000 | t/y | 0.00014 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading Brickie's product material to trucks | 8 | 80,000 | t/y | 0.00010 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - hauling product material to off-site location (sealed road) | 522 | 860,000 | t/y | 0.002 | kg/t | 30 | t/load | 50 | Mean vehicle mass (t) | 0.8 | km/return trip | 0.09 | kg/VKT | 3 | silt loading (g/m2) | 75 | % control | Level 2 watering |
| Wind Erosion - Extraction Area | 9,198 | 21.0 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Processing and Stockpiling area | 5,256 | 12.0 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Fines Storage | 438 | 1.0 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Topsoil and Mulch Stockpile Area | 767 | 2.5 | ha | 0.05 | kg/ha/h | 8,760 | h/y | | | | | | | | | 30 | % control | Shelterbelt |
| Grading unsealed roads | 14,616 | 67,968 | km | 0.2 | kg/VKT | 8 | speed of graders in km/h | 8,496 | Hours per year | | | | | | | | | |
| **Total (kg/y)** | **58,079** | | | | | | | | | | | | | | | | | |

## Stage 4 – Annual $PM_{2.5}$ Emissions Based on Annual Maximum Activity

| ACTIVITY | $PM_{2.5}$ emission (kg/y) | Intensity | Units | Emission factor | Units | Variable 1 | Units | Variable 2 | Units | Variable 3 | Units | Variable 4 | Units | Variable 5 | Units | Control | Units | Controls Assumed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 1,156 | 3276 | h/y | 0.35 | kg/hr | 15 | Silt content | 10 | moisture content | | | | | | | 0 | % control | |
| Pit - drilling | 48 | 2700 | holes/y | 0.02 | kg/hole | | | | | | | | | | | | | |
| Pit - blasting | 5 | 9 | blasts/y | 0.50 | kg/blast | 1800 | Area of blast in square metres | 300 | holes/blast | | | | | | | | | |
| Pit - loading material to trucks at pit | 11 | 1,000,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Pit - hauling material to dry screening plant (brickies sand) | 116 | 100,000 | t/y | 0.005 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.40 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Pit - hauling material from pit to processing area (for washed sand products) | 751 | 900,000 | t/y | 0.003 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.72 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Brickies sand screening plant - unloading to raw feed stockpile | 1 | 100,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Loading to hopper from raw feeds stockpile | 1 | 100,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Screening | 3,600 | 100,000 | t/y | 0.03600 | kg/t | | | | | | | | | | | | | Dry screening |
| Brickie's sand screening plant - Relocating to product stockpile | 1 | 80,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 9 | 900,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 9 | 900,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Screening | 23 | 900,000 | t/y | 0.00003 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Primary Crusher | 23 | 450,000 | t/y | 0.00005 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Conveyor unloading | 9 | 900,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Relocating to product stockpile | 17 | 780,000 | t/y | 0.00002 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | | | |
| Waste - loading fines at processing area | 1 | 110,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - loading oversized material | 0 | 30,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling fines to emplacement area | 117 | 110,000 | t/y | 0.00427 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.2 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading fines at emplacement area | 1 | 110,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling oversized material | 26 | 30,000 | t/y | 0.00349 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.8 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading oversized material | 0 | 30,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading washed sand product material to trucks | 17 | 780,000 | t/y | 0.00002 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading Brickie's product material to trucks | 1 | 80,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - hauling product material to off-site location (sealed road) | 126 | 860,000 | t/y | 0.001 | kg/t | 30 | t/load | 50 | Mean vehicle mass (t) | 0.8 | km/return trip | 0.02 | kg/VKT | 3 | silt loading (g/m2) | 75 | % control | Level 2 watering |
| Wind Erosion - Extraction Area | 1,380 | 21.0 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Processing and Stockpiling area | 788 | 12.0 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Fines Storage | 66 | 1.0 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Topsoil and Mulch Stockpile Area | 115 | 2.5 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 30 | % control | Shelterbelt |
| Grading unsealed roads | 1,297 | 67,968 | km | 0.02 | kg/VKT | 8 | speed of graders in km/h | 8,496 | Hours per year | | | | | | | | | |
| **Total (kg/y)** | **9,714** | | | | | | | | | | | | | | | | | |

## Stage 4 – Annual $PM_{2.5}$ Emissions Based on Daily Maximum Activity

| ACTIVITY | $PM_{2.5}$ emission (kg/y) | Intensity | Units | Emission factor | Units | Variable 1 | Units | Variable 2 | Units | Variable 3 | Units | Variable 4 | Units | Variable 5 | Units | Control | Units | Controls Assumed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraction Area/Processing - Dozers | 1,156 | 3276 | h/y | 0.35 | kg/hr | 15 | Silt content | 10 | moisture content | | | | | | | 0 | % control | |
| Pit - drilling | 48 | 2700 | holes/y | 0.02 | kg/hole | | | | | | | | | | | | | |
| Pit - blasting | 5 | 9 | blasts/y | 0.50 | kg/blast | 1800 | Area of blast in square metres | 300 | holes/blast | | | | | | | | | |
| Pit - loading material to trucks at pit | 15 | 1,416,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Pit - hauling material to dry screening plant (brickies sand) | 165 | 141,600 | t/y | 0.005 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.40 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Pit - hauling material from pit to processing area (for washed sand products) | 1,063 | 1,274,400 | t/y | 0.003 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.72 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Brickies sand screening plant - unloading to raw feed stockpile | 1 | 141,600 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Loading to hopper from raw feeds stockpile | 1 | 141,600 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Brickie's sand screening plant - Screening | 5,098 | 141,600 | t/y | 0.03600 | kg/t | | | | | | | | | | | | | Dry screening |
| Brickie's sand screening plant - Relocating to product stockpile | 1 | 80,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Unloading to raw feed stockpile | 13 | 1,274,400 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Loading to hopper from raw feed stockpile | 13 | 1,274,400 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | |
| Wash Plant - Screening | 32 | 1,274,400 | t/y | 0.00003 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Primary Crusher | 23 | 450,000 | t/y | 0.00005 | kg/t | | | | | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Conveyor unloading | 13 | 1,274,400 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | | | Emission factor assumes water application |
| Wash Plant - Relocating to product stockpile | 17 | 780,000 | t/y | 0.00002 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | | | |
| Waste - loading fines at processing area | 1 | 155,760 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - loading oversized material | 4 | 400,240 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 10 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling fines to emplacement area | 166 | 155,760 | t/y | 0.00427 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 2.2 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading fines at emplacement area | 1 | 155,760 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 15 | moisture content in % | | | | | | | 0 | % control | |
| Waste - hauling oversized material | 349 | 400,240 | t/y | 0.00349 | kg/t | 50 | t/load | 61 | Mean vehicle mass (t) | 1.8 | km/return trip | 0.10 | kg/VKT | 6.4 | % silt content | 75 | % control | Level 2 watering |
| Waste - unloading oversized material | 6 | 400,240 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading washed sand product material to trucks | 17 | 780,000 | t/y | 0.00002 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 6 | moisture content in % | | | | | | | 0 | % control | |
| Product - loading Brickie's product material to trucks | 1 | 80,000 | t/y | 0.00001 | kg/t | 1.18 | average of (wind speed/2.2)^1.3 in m/s | 8 | moisture content in % | | | | | | | 0 | % control | |
| Product - hauling product material to off-site location (sealed road) | 126 | 860,000 | t/y | 0.001 | kg/t | 30 | t/load | 50 | Mean vehicle mass (t) | 0.8 | km/return trip | 0.02 | kg/VKT | 3 | silt loading (g/m2) | 75 | % control | Level 2 watering |
| Wind Erosion - Extraction Area | 1,380 | 21.0 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Processing and Stockpiling area | 788 | 12.0 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Fines Storage | 66 | 1.0 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 0 | % control | |
| Wind Erosion - Topsoil and Mulch Stockpile Area | 115 | 2.5 | ha | 0.01 | kg/ha/h | 8,760 | h/y | | | | | | | | | 30 | % control | Shelterbelt |
| Grading unsealed roads | 1,297 | 67,968 | km | 0.02 | kg/VKT | 8 | speed of graders in km/h | 8,496 | Hours per year | | | | | | | | | |
| **Total (kg/y)** | **11,981** | | | | | | | | | | | | | | | | | |

# Appendix 2

## Greenhouse Gas Calculations

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**Diesel**

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) |
| Q | = | Estimated combustion of diesel | (GJ)[1] |
| EF | = | Emission factor (scope 1 or scope 3) for diesel combustion | (kg $CO_2$-e/GJ)[2] |

[1] GJ = giga joules
[2] kg $CO_2$-e/GJ = kilograms of carbon dioxide equivalents per gigajoule

The quantity of diesel consumed on site (approximately 3,500 kL/y as provided by the Applicant) was converted to GJ is 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, 2015). The estimated annual and Proposal total GHG emissions from diesel usage on site are presented in **Table 20**.

**Table 20**
**Estimated $CO_2$-e (tonnes) for Diesel Consumption – on site**

| Phase | Fuel Usage (kL) | Emission Factor (kg $CO_2$-e/GJ) | | Energy Content (GJ/kL) | Emissions (t CO2-e) | | |
|---|---|---|---|---|---|---|---|
| | | Scope 1 | Scope 3 | | Scope 1 | Scope 1 | Total |
| Annual | 3,495 | 70.2 | 3.6 | 38.6 | 9,470 | 486 | 9,955 |
| 30 years | 104,841 | 70.2 | 3.6 | 38.6 | 284,089 | 14,569 | 298,658 |

There would also be diesel consumption in the transport of the product sand to customers. The Applicant provided an estimate usage of 6.0ML/y. The estimated annual and Proposal total GHG emissions from diesel usage for transport are presented in **Table 21**.

**Table 21**
**Estimated $CO_2$-e (tonnes) for Diesel Consumption – transport**

| Phase | Fuel Usage (kL) | Emission Factor (kg $CO_2$-e/GJ) | | Energy Content (GJ/kL) | Emissions (t CO2-e) | | |
|---|---|---|---|---|---|---|---|
| | | Scope 1 | Scope 3 | | Scope 1 | Scope 3 | Total |
| Annual | 6,058 | 70.5 | 3.6 | 38.6 | 16,485 | 842 | 17,326 |
| 30 years | 181,729 | 70.5 | 3.6 | 38.6 | 494,540 | 25,253 | 519,793 |

**Electricity**

Greenhouse gas 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

Greenhouse gas emission factors were sourced from the NGA Factors (DCCEE, 2015). Annual usage of 3.276GWh per year was provided by the Applicant.

The estimated annual and Proposal total GHG emissions from electricity usage are presented in **Table 22**.

**Table 22**
**Estimated $CO_2$-e (tonnes) for Electricity Use**

| Time frame | Electricity Usage (kWh) | Emission Factor (kg $CO_2$-e/kWh) | | Emissions (t $CO_2$-e) | | |
|---|---|---|---|---|---|---|
| | | Scope 2 | Scope 3 | Scope 2 | Scope 3 | Total |
| Annual | 3,276,000 | 0.84 | 0.12 | 2,752 | 393 | 3,145 |
| 30 years | 98,280,000 | 0.84 | 0.12 | 82,555 | 11,794 | 94,349 |