Air Noise Environment
Environmental Monitoring and Assessment

Air Quality Assessment - White Rock Quarry - MOP Review

Groundwork Plus

Date of Issue: 12 December 2022

Prepared by:
Air Noise Environment

ABN: 13 081 834 513



This document has been prepared and issued by Air Noise Environment Pty Ltd in accordance with our Quality Assurance procedures. Authorship, copyright details and legal provisions relating to this document are provided on the following page. Should you have any queries regarding the contents of this document, please contact your nearest Air Noise Environment office:

Brisbane Office

A: Leve 3, 43 Peel Street

South Brisbane, QLD, 4101

T: 07 3255 3355

E: qld@ane.com.au

DOCUMENT CONTROL SHEET

Document Details

Project Reference: 207402.0043.R01V01_final.odt

Document Title: Air Quality Assessment - White Rock Quarry - MOP Review

Client: Groundwork Plus

Revision History

Version:	Issue Date:	Author:	Description:	Approved by:
01	07/12/2022	Hector Machado	Final	Samuel Wong
02				
03				
04				
Revision:	**Issue Date:**	**Author:**	**Details of Revision:**	

Disclaimer:

This document has been prepared with all due care and attention by professional environmental practitioners according to accepted practices and techniques. This document is issued in confidence and is relevant only to the issues pertinent to the subject matter contained herein. Air Noise Environment Pty Ltd holds no responsibility for misapplication or misinterpretation by third parties of the contents of this document. If the revision history does not state that a Final version of the document has been issued, then it remains a draft. Draft versions of this document should not be relied upon for any purpose by the client, regulatory agencies or other interested parties.

Where site inspections, testing or fieldwork have taken place, the report is based on the information made available by the client or their nominees during the visit, visual observations and any subsequent discussions with regulatory authorities. It is further assumed that normal activities were being undertaken at the site on the day of the site visit(s).

The validity and comprehensiveness of supplied information has not been independently verified and, for the purposes of this report, it is assumed that the information provided to Air Noise Environment Pty Ltd for the purposes of this project is both complete and accurate.

Executive Summary

Hanson Construction Materials Pty Ltd (Hanson) are undertaking a Mine Operations Plan (MOP) review of their White Rock Quarry located at Horsnells Gully Road, Horsnell Gully. The review will involve additional extraction areas over 4 stages. For the purpose of this assessment, Stages 1, 2, 3 and 3A have been considered. Operations at the site are currently approved and proposed to occur 24 hours per day, 7 days a week however activities specific to crushing and screening are proposed to occur between the hours of 6 AM and 6 PM. Air Noise Environment was commissioned by Groundwork Plus (SA) Pty Ltd (Groundwork Plus) on behalf of Hanson to assess potential changes in air quality in the surrounding area as a result of the proposal.

Key air emission sources for the quarry development include extraction activity, wind erosion over exposed surfaces/stockpiles, haul routes, a concrete batching plant and processing plant. Particulate matter ($PM_{2.5}$, PM_{10}, TSP and deposited dust) is considered to be the main indicator for these air emission sources. Residential receptors are located to the north and north east at Norton Summit and to the west at Skye. In order to minimise potential dust impacts on nearby sensitive receptors, water spraying is proposed on unsealed haul routes and at the mobile processing plant.

To assess the potential for air quality impacts as a result of the quarry development, computational air dispersion modelling was undertaken using the CALPUFF modelling system. The modelling has utilised meteorological data derived from CALMET, and emission rates estimated from published emission factors (e.g. NPI Mining Manual, US EPA AP 42) and proposed operational data (e.g. throughputs, air emission controls). CALMET was run with observations only using Bureau of Meteorology data from the Mount Lofty and Adelaide (Kent Town) surface stations and upper air data from the Adelaide Airport station. The year 2009 was adopted based on advice from the South Australia Environmental Protection Authority. Comparison of predicted wind roses with those derived from the Bureau of Meteorology monitoring data for the years 2009 - 2014 indicates that the CALMET model is predicting local wind fields accurately.

To understand the variation in potential air quality impacts as well as to assess a worst-case scenarios, various modelling scenarios have been considered (Stage 1, 2, 3 and 3A).

The results of the modelling demonstrate compliance with the air quality criteria for all the stages of the proposed development. This takes into account Level 1 watering on unsealed haul routes and a mobile processing plant with water sprays. It is also essential that sealed access roads are cleaned regularly and maintained at all times to ensure silt loading minimised.

Overall, the proposed quarry operations are expected to result in increased particulate concentrations in the surrounding area, however, the potential for dust impacts can be effectively managed to achieve the relevant air quality goals with the above measures are in place.

Table of Contents

Index of Tables

Index of Figures

1 Introduction

1.1 Scope of Study

Groundwork Plus (SA) Pty Ltd (Groundwork Plus) commissioned Air Noise Environment on behalf of Hanson to undertake an air quality assessment for the proposed White Rock quarry MOP (Mine Operations Plan) review at Horsnell Gully, South Australia. The proposed development includes additional extractive areas over four stages with an in-pit mobile processing plant.

The study considers the potential impacts of the proposed development on nearby sensitive receptors in accordance with the requirements of the South Australia Environmental Protection Authority. Computational modelling has been undertaken for assessing potential air quality impacts and results have been compared to criteria defined in the South Australia Environmental Protection (Air Quality) Policy 2016.

1.2 This Report

This report presents the methodology, results and recommendations of the air quality assessment. Report sections are summarised below:

- Section 2 Site Operations
- Section 3 Existing Environment
- Section 4 Assessment Criteria
- Section 5 Modelling Approach
- Section 6 Meteorological Modelling
- Section 7 Air Emissions Data
- Section 8 Air Dispersion Modelling
- Section 9 Predicted Results
- Section 10 Crystalline Silica Review
- Section 11 Conclusion

A glossary of terms is provided in Appendix A to assist the reader.

2 Site Operations

2.1 Site Location

The subject site is located at Horsnells Gully Road, Horsnell Gully, and covers land parcels identified as F130081 A27, F130079 A25, F130094 A40, F130063 A9, F130671 Q9, F130945 QP1, F130062 A8 and F130945 QP2. The site is currently zoned as Hills Face under the Planning and Design Code (South Australia). The surroundings are zoned as Hills Face and Conservation zones under the Adelaide Hills Council Development Plan 2017.

The nearest sensitive receptors includes rural residential dwellings located to the north and north-east at the Norton Summit township. Residential dwellings are also located in close proximity at Skye, to the south-west and west, as follows:

- 30 m from the northern property boundary to the rural residential dwellings to the north.
- 225 m from the eastern property boundary to the rural residential dwellings to the north east, Norton Summit.
- 50 m from the western boundary of the property to residential dwellings to the west, Skye.
- 105 m from the sediment basins to an existing dwelling, owned by Hanson.

Figure 2.1 presents an aerial photo identifying the site location and surrounding land uses. Figure 2.1 also identifies potential residential dwellings identified through a review of aerial photography.

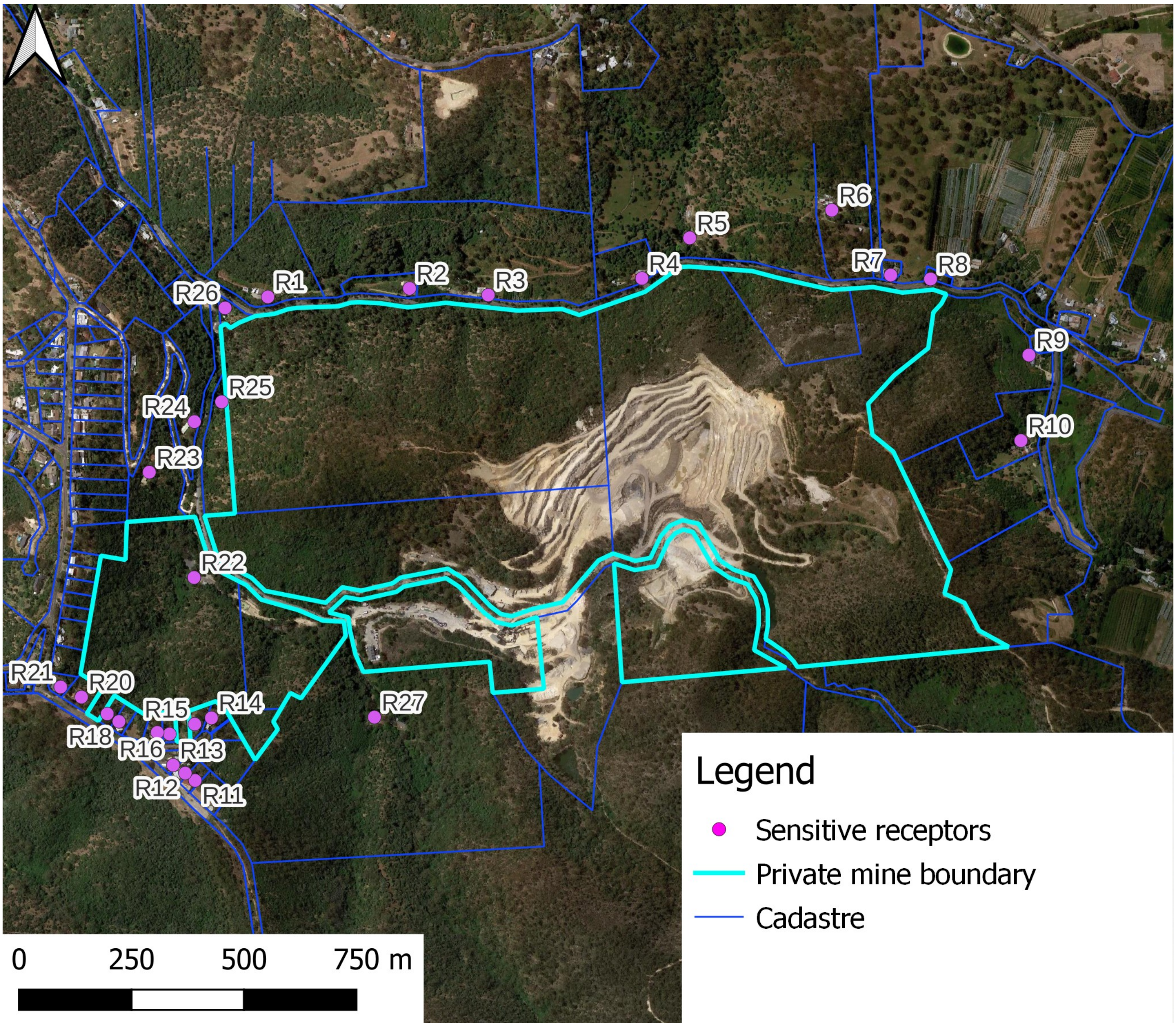


Figure 2.1 - Site Location and Surrounding Land Uses

2.2 Proposed Operations

The proposal is to increase the extraction area over stages 1, 2, 3 and 3a which will be associated with an increased throughput from the current average throughput of 300 ktpa up to a worst case estimated annual throughput of 500 ktpa.

Blasting is expected to occur 1-2 times a week during the early stages. The frequency of blasting is expected to be reduced to 1-2 times per fortnight as the quarry develops.

Mobile crushing equipment will be implemented in the pit floor. A typical mobile equipment train will be comprised of a jaw crusher, a re-claimer, a cone crusher, a screen deck and a return stacker, as per Figure 2.2. Water sprays will be used to wet down ROM material and at transfer points.

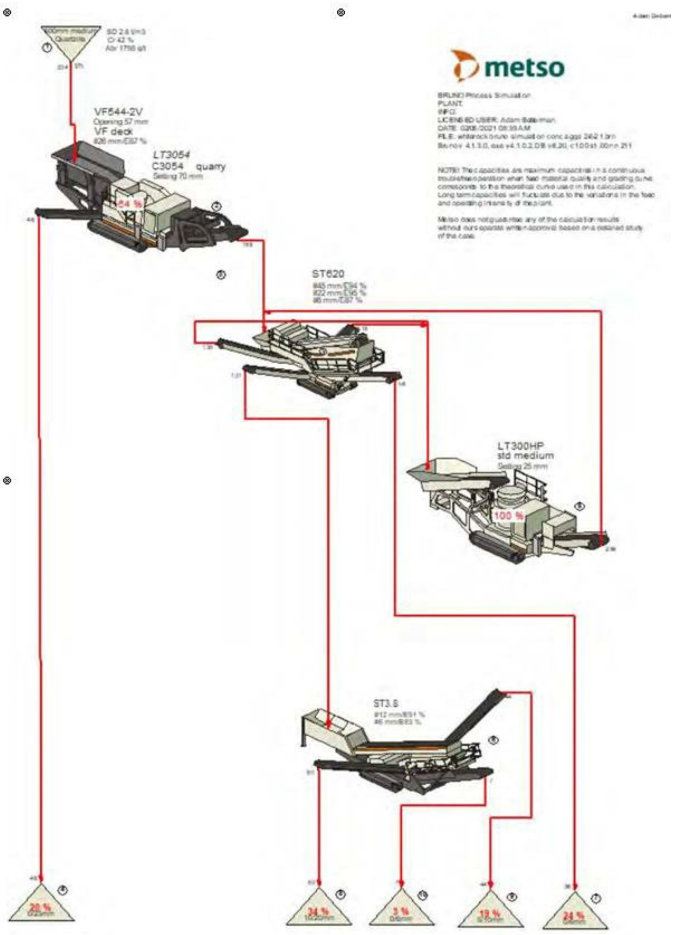


Figure 2.2 - Mobile plant layout

Appendix D presents figures of the proposed quarry stages.

2.3 Air Emission Sources

Particulate matter ($PM_{2.5}$, PM_{10}, TSP and deposited dust) is considered to be the main indicator for assessing potential air quality impacts for the site. On-site haul routes and wind blown dust from large exposed surface areas are likely to be the main contributor to air emissions from the site operation. The proposed mobile processing plant will have a water spraying system at transfer points, minimising dust emissions from this source. A summary of key air emission sources is listed below:

Extraction Area

- Drill and blasting;
- Extraction of overburden and rock; and
- Wind erosion over exposed extraction areas and material stockpiles.

- Concrete Batching Plant
  - Material handling including aggregate loading, weigh hopper loading, truck loading and cement deliveries; and
  - Wind erosion over material stockpiles.

Proposed Processing Plant

- Crushing;
- Screening; and
- Transfer Points.

Material Stockpile Area

- Wind erosion over material stockpile area.

Haul Route

- On-site haul trucks between extraction area and processing plant (in pit);
- Haul trucks between the processing area (in pit) to the stockpiles;
- Product trucks between stockpiles and site exit/entry; and
- Concrete trucks between concrete batching plant and site exit/entry.

3 Existing Environment

3.1 Topography

The subject site is located on the western face of the Adelaide Hills. The Adelaide Hills region is defined by significant variation in topography within the Western Mount Lofty Ranges. A number of valleys exist in the area associated with creeks and gullies. The ground height of the development site is in the range of 215 to 461 metres above sea level. Figure 3.1 presents ground contours of the site and surrounding area.

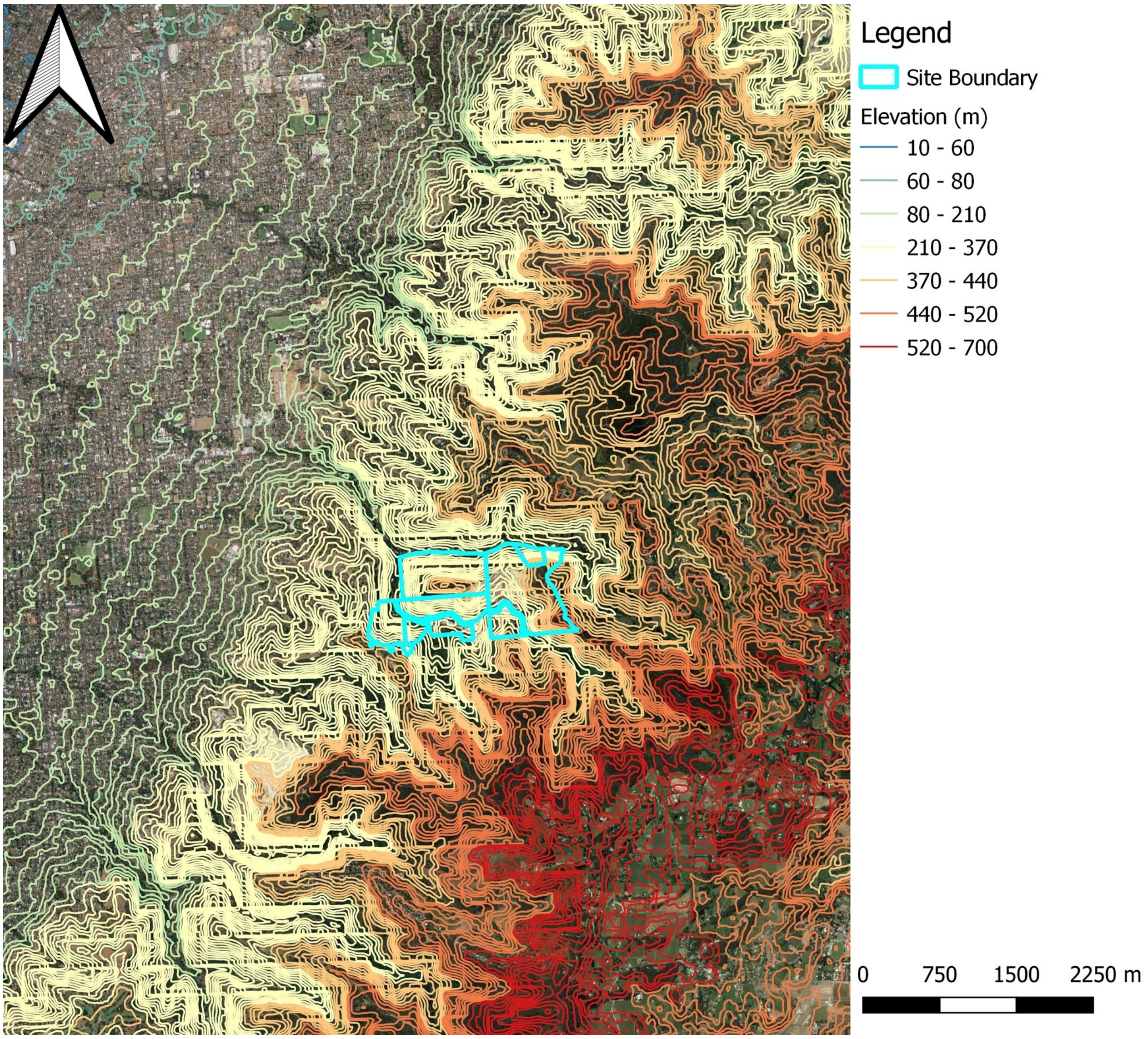


Figure 3.1 - Site Topography

3.2 Meteorology

The Adelaide Hills area is characterised as having a Mediterranean climate. Based on the nearest Bureau of Meteorology station at Mount Lofty (5.9 km south east of the proposed development site), historical temperatures range from 5.2 - 9.4 °C in winter to 12.0 – 21.7 °C in summer, and the mean annual rainfall is 989 mm.

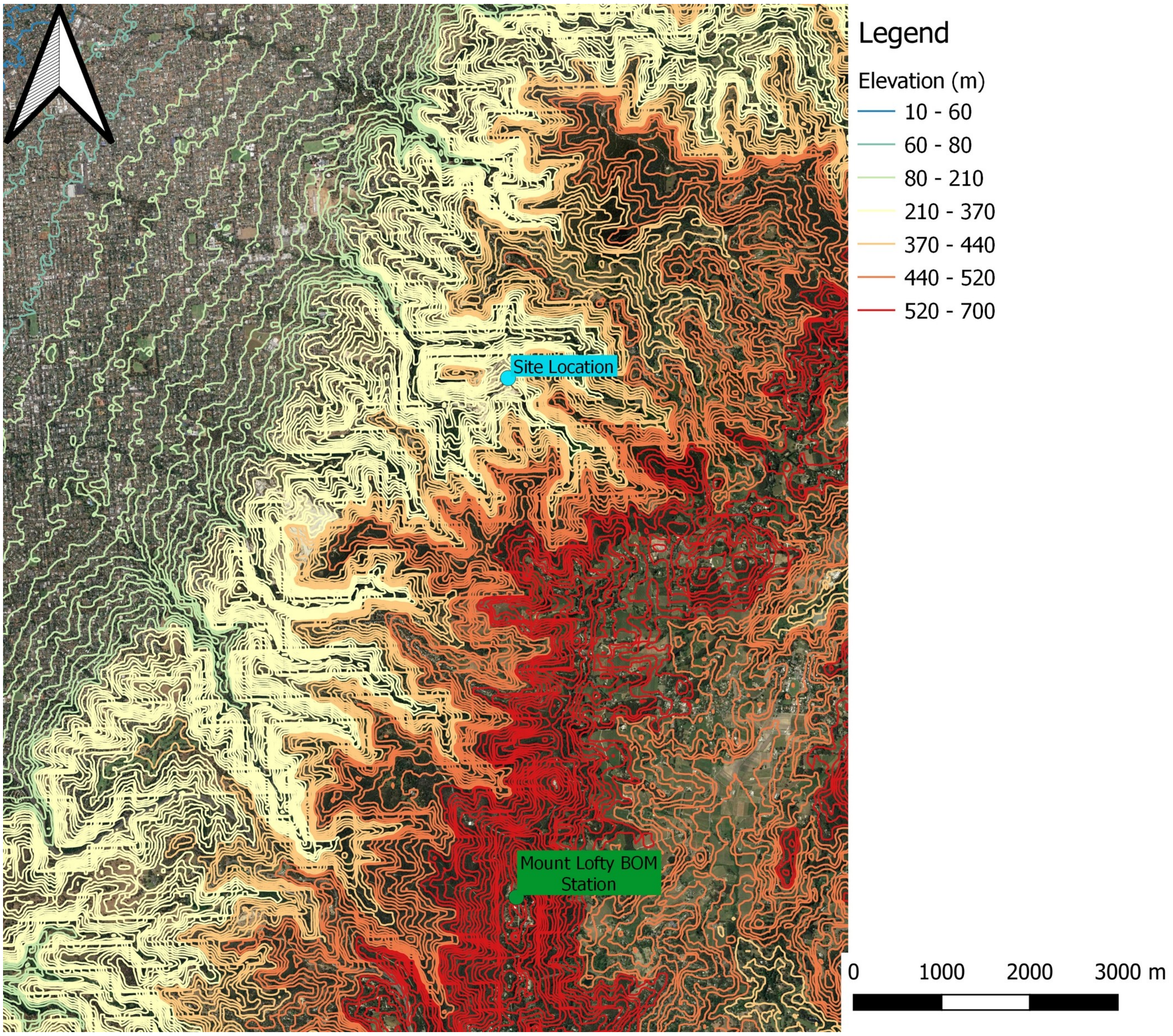


Figure 3.2 - Site location and nearby Bureau of Meteorology station

With regards to wind conditions, the Mount Lofty stations shows that the area is dominated by westerly and easterly winds. North easterly and south westerly winds are noted to be minimal.

Average wind speeds for Mount Lofty are 3.3 m/s. Calms are not considered to be a major feature of the area, with the proportion of calms being 1.1%.

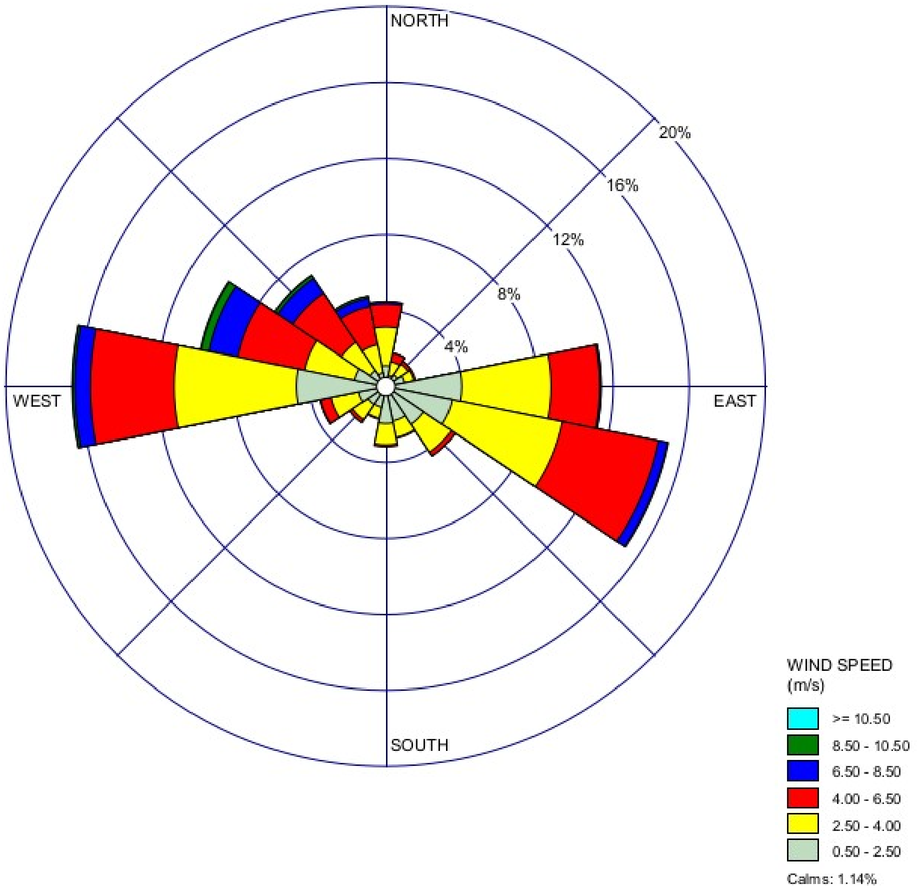


Figure 3.3 - 2009 - 2014 Mount Lofty BoM Station Wind Rose

3.3 Background Particulate Monitoring

Besides contribution from the White Rock Quarry, ambient particulate concentrations in the Adelaide Hills area are defined by local traffic and the Stonyfell Quarry where sandstone and quartzite are extracted (located 1.9 km from the nearest emission sources of the White Rock Quarry). Besides these sources, there are no other major anthropogenic dust emission sources in the area. To allow for the assessment of cumulative pollutant concentrations, the assessment has considered ambient concentrations from the South Australia Environmental Protection Authority air quality monitoring stations at Christie Downs, Elizabeth Downs, Kensington Gardens, Netley, Adelaide CBD, Le Fevre 1 and Le Fevre 2.

The location of the South Australia EPA monitoring stations are presented in Figure 3.4.

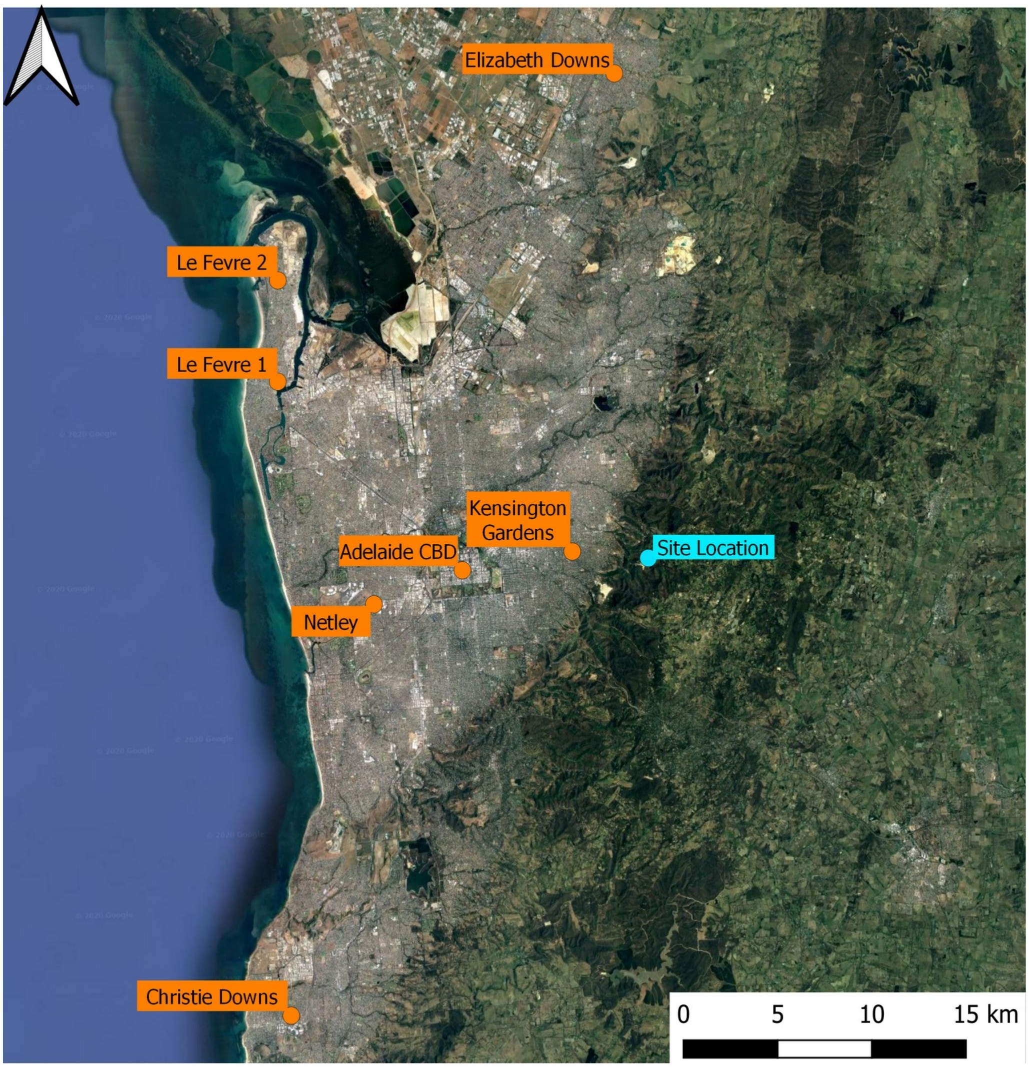


Figure 3.4 - SA EPA Monitoring Station Locations

Table 3.1 presents the ambient monitoring data from the nearby SA EPA monitoring stations for the year 2019.

Table 3.1 - PM_{10} and $PM_{2.5}$ Data – SA EPA Monitoring Stations

Monitoring Station	Measured Concentration (µg/m³)			
	$PM_{2.5}$	$PM_{2.5}$	PM_{10}	PM_{10}
	24-hour, 70th Percentile	Annual Average	24-hour, 70th Percentile	Annual Average
Adelaide CBD	6.6	6.1	18.7	17.4

Monitoring Station	Measured Concentration (µg/m³)			
	$PM_{2.5}$	$PM_{2.5}$	PM_{10}	PM_{10}
	24-hour, 70th Percentile	Annual Average	24-hour, 70th Percentile	Annual Average
Netley	6.8	6.2	29.6	28.3
Le Fevre 1	6.9	6.3	23.9	22.2
Le Fevre 2	6.7	6.5	23.9	22.2
Elizabeth Downs	6.5	6.1	22.6	21.4
Kensington Gardens			16.1	15.3
Christie Downs			20.0	17.9
Adopted Background	**6.5**	**6.1**	**16.1**	**15.3**

To provide an assessment of cumulative PM_{10} impacts, data from the Kensington Garden air quality monitoring station has been adopted. The Kensington Gardens Air Quality Monitoring station is noted be located 3.5 km from the White Rock Quarry.

It is noted that TSP is not measured at the South Australia EPA monitoring stations. In order to assess cumulative TSP impacts, a TSP/PM_{10} ratio has been derived for a typical residential area (i.e. Cannon Hill (Queensland Department of Environment and Science) station data). This ratio was then applied to the Kensington Gardens PM_{10} 24-hour 70th percentile and annual average to derive the TSP 24-hour and annual background concentrations.

Table 3.2 - Adopted TSP Background

TSP/PM_{10} ratio (DES Cannon Hill station)	TSP 24-hour (µg/m³)	TSP annual average (µg/m³)
2.1	34.5	32.6

4 Assessment Criteria

The results of the modelling have been compared to ambient air quality goals defined in the *South Australia Environment Protection (Air Quality) Policy 2016 (SA Air Quality EPP)* and *National Environment Protection (Ambient Air Quality) Measure 2016 (NEPM Air).*

The air quality goals for $PM_{2.5}$ and PM_{10} are based on 24-hour and annual average concentrations, and are related to the protection of human health. The SA EPA has also identified a suggested TSP target limit of 120 µg/m^3 as a 24 hour average to prevent nuisance impacts. It is noted that other states reference an annual average 90 µg/m^3 goal for TSP. Reference has also been made to a commonly adopted dust deposition limit of 4 g/m^2/month (e.g. NSW EPA).

The air quality criteria are applicable at the nearest sensitive receptors, which are defined as a 'fixed location such as a house, building, other premises or open area where health, property or amenity is affected by emissions that increase the concentration of the emitted parameter above background levels' in the SA EPA Ambient Air Quality Assessment (August 2016) guideline.

Table 4.1 summarises the air quality criteria.

Table 4.1 - Air Quality Criteria

Compound	Air Quality Criteria (µg/m^3)	Averaging Period	Source
TSP	120	24-hour	SA EPA advice
	90	Annual	Other Australian states
PM_{10}	50	24-hour	SA Air Quality EPP
	25	Annual	NEPM
$PM_{2.5}$	25	24-hour	SA Air Quality EPP, NEPM
	8	Annual	SA Air Quality EPP, NEPM
Deposited Dust	4 g/m^2/month	Month	Other Australian states

In addition to the above, SA EPA is currently adopting an interim air quality goal of 3 µg/m^3 ambient air quality for crystalline silica (as PM_{10})[1].

1 SA EPA, 26 September 2022, Respirable crystalline silica (RCS) monitoring and analysis, https://engage.epa.sa.gov.au/white-rock-quarry-hanson/news_feed/granting-of-the-licence

5 Modelling Approach

To assess the potential for air quality impacts, air dispersion modelling has been undertaken to predict pollutant concentrations at the nearest sensitive receptors based on the proposed operational details of the quarry.

Atmospheric dispersion modelling involves the mathematical simulation of the dispersion of air contaminants in the environment. The modelling utilises a range of information to estimate the dispersion of pollutants released from a source including:

- meteorological data for surface and upper air winds, temperature and pressure profiles, as well as humidity, rainfall, cloud cover and ceiling height information;
- emissions parameters including source location and height, source dimensions and physical parameters (e.g. exit velocity and temperature) along with pollutant mass emission rates;
- terrain elevations and land use both at the source and throughout the surrounding region;
- the location, height and width of any obstructions (such as buildings or other structures) that could significantly impact on the dispersion of the plume; and
- sensitive receptor locations and heights.

The CALPUFF modelling system has been adopted for the dispersion modelling. The CALPUFF modelling system comprises of three components, including CALMET for meteorological predictions, CALPUFF for air dispersion modelling and CALPOST for results analysis.

CALPUFF treats emissions as a series of puffs. These puffs are then dispersed throughout the modelling area and allowed to grow and bend with spatial variations in meteorology. In doing so, the model is able to retain a memory of the plume's movement throughout a single hour and from one hour to the next while continuing to better approximate the effects of complex air flows.

CALPUFF utilises the meteorological processing and prediction model CALMET to provide three dimensional wind field predictions for the area of interest. The final wind field developed by the model (for consideration by CALPUFF) includes an approximation of the effects of local topography, the effects of varying surface temperatures (as is observed in land and sea bodies) and surface roughness (resulting from varied land uses and vegetation cover in an area). The CALPUFF model is able to resolve complex terrain influences on local wind fields including consideration of katabatic flows and terrain blocking.

Post processing of modelled emissions is undertaken using the CALPOST package. This allows the rigorous analysis of pollutant predictions generated by the CALPUFF system. In particular CALPOST is able to provide an analysis of predicted pollutant concentrations for a range of averaging periods from 1 hour to 1 year.

For the purpose of the assessment, the meteorological year 2009 has been selected based on previous discussions with the SA EPA. Meteorological predictions have been reviewed to confirm the suitability of the model year.

A total of 4 modelling scenarios have been completed as follows:

- Stage 1
- Stage 2
- Stage 3
- Stage 3A

The following sections present the methodology, assumptions and outcomes of the meteorological and air dispersion modelling (Section 6 Meteorological Modelling, Section 7 Air Emissions Data and Section 8 Air Dispersion Modelling).

6 Meteorological Modelling

6.1 Overview

CALMET has been run to predict meteorological data for the year 2009 based on advice from the SA EPA. CALMET has been run in No-OBS mode with a prognostic data set developed using TAPM. CALMET was originally run with a TAPM-developed 3D prognostic data set with no observations included. The results of the CALMET run with no observations did not accurately represent the wind conditions of Adelaide Airport. Given the CALMET predicted dataset was not an accurate representation of the existing environment, CALMET was run with observations only, utilising measured Bureau of Meteorology surface station data from the Adelaide (Kent Town) and Mount Lofty and measured Bureau of Meteorology upper air data from the Adelaide Airport station.

The following sections provide an overview of the data utilised in the CALMET modelling, along with details of some of the key parameters selected to establish calculation limits within CALMET.

6.2 Vertical Stations

For the purposes of the modelling, CALMET was initialised with a total of 10 vertical layers with layer boundaries at 20 m, 40 m, 80 m, 160 m, 320 m, 640 m, 1,200 m, 2,000 m, 3,000 m and 4,000 m respectively. The vertical levels used in the modelling were selected to provide the model with the ability to predict atmospheric conditions at a range of heights. A greater resolution of vertical heights has been adopted nearer to the ground, given the ground level sources considered in the assessment.

6.3 Terrain and Land Use Data

Terrain data for the area surrounding the development was obtained from the Shuttle Radar Topography Mission (SRTM) 1-arc-second dataset. Data for a 20 km x 20 km area (0.2 km spacing) has been extracted for use in the modelling.

The TERRAD value in CALMET is used to determine the radius of influence for terrain features within the model domain. The TERRAD value has been calculated based on the rule 'ridge-to-ridge divided by 2, rounded up' recommended by the NSW Office of Environment and Heritage[2]. A TERRAD value of 6 km has been adopted after review of the surrounding terrain features.

Land use data was also created based from the USGS and satellite imagery and incorporated into the CALMET model. Where land use categories do not correspond with the CALMET land use input file categories, satellite imagery has been reviewed to determine the most appropriate land use category. Figures 6.1 and 6.2 presents the modelled terrain and land use in CALMET.

2 TRC Environmental Corporation (March 2011) 'Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia' prepared on behalf of the NSW Office of Environment and Heritage.

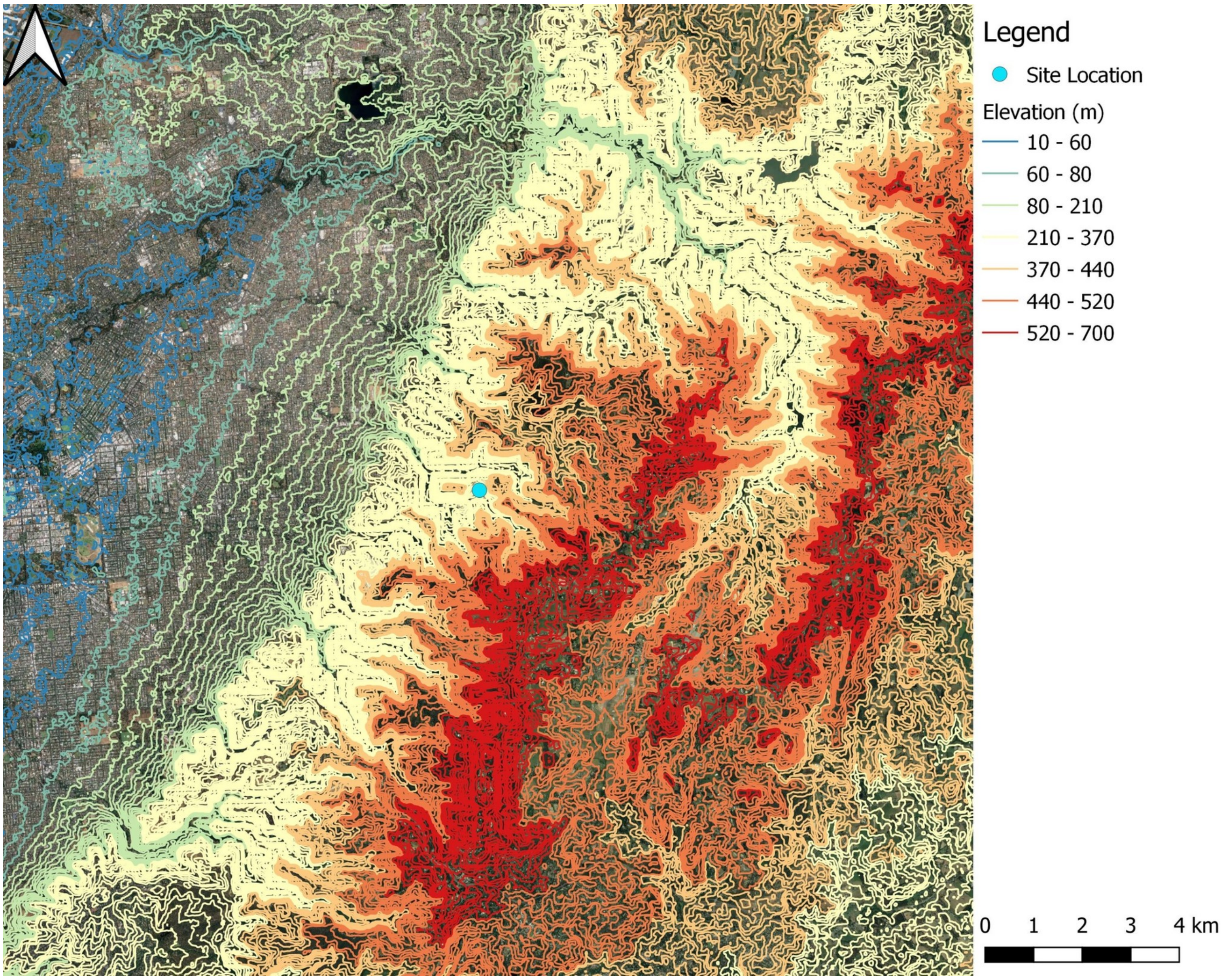


Figure 6.1 - Modelled Terrain

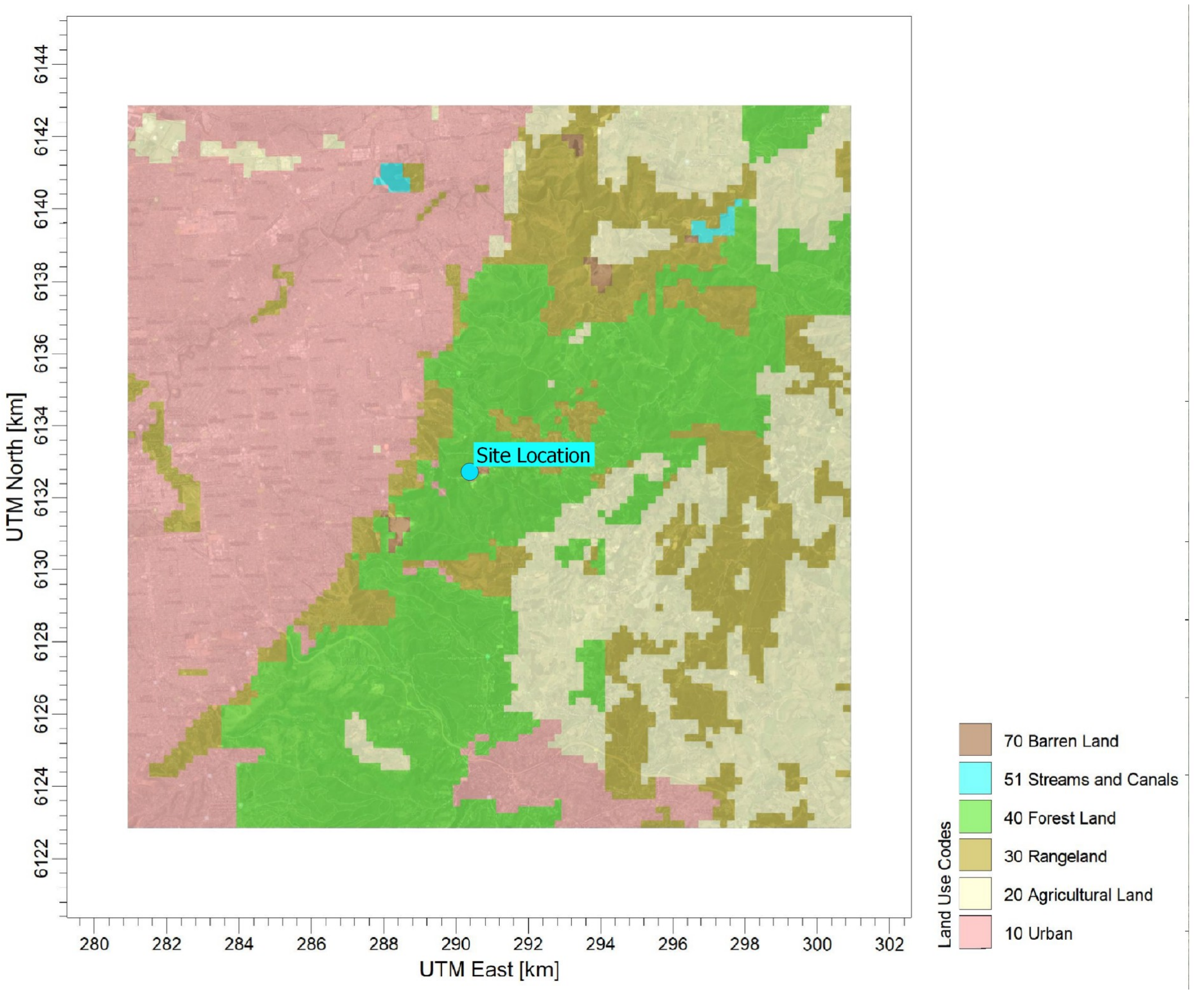


Figure 6.2 - Modelled Land Use

6.4 Observational Data

Observational data has been included in the CALMET modelling in order to ensure the accuracy of the predicted CALMET dataset. A number of Bureau of Meteorology stations are present in the surrounding area, Figure 6.3 presents the location of the nearby BoM observational data sites and the South Australia EPA air quality monitoring sites along with the site location.

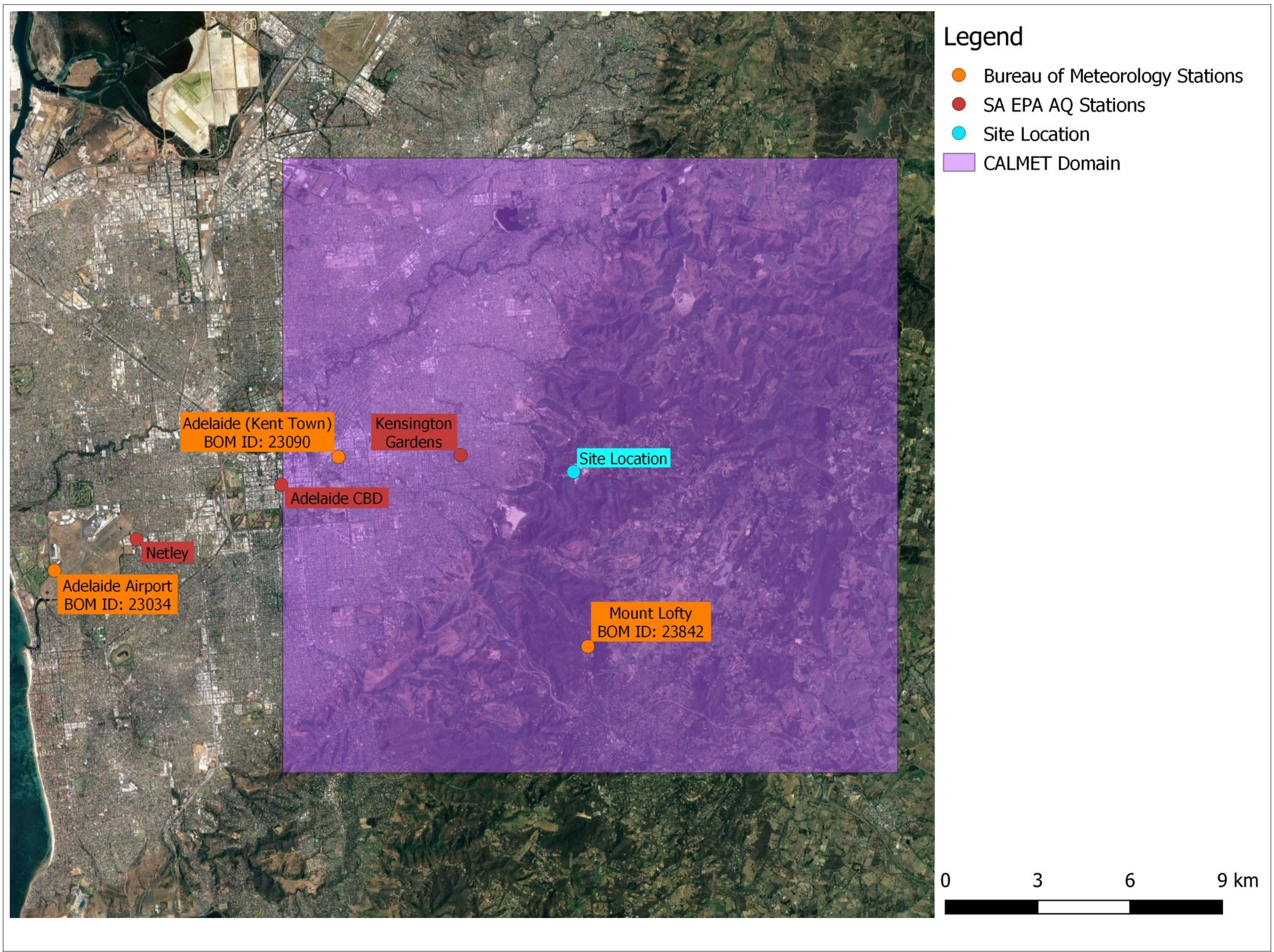


Figure 6.3 - CALMET Domain Available Meteorological Stations

Surface data from the Adelaide (Kent Town) and Mount Lofty BoM stations are considered appropriate for inclusion in the CALMET modelling due to their close proximity to the site. It is noted that meteorological data is also measured at the Netley, Adelaide CBD and Kensington Gardens stations however, data was not publicly available at the time of the assessment (based on a review of the SA Government online data portal). These stations are located in close proximity to the BoM stations – the Kensington Gardens and Adelaide CBD stations are both located within 4 km of the Adelaide (Kent Town) station. The Netley station is located well outside that CALMET domain. Hence, adopting the data from either EPA or BoM stations is considered appropriate.

In order to determine the appropriateness for inclusion in CALMET, the completeness of the required CALMET parameters were reviewed. CALMET requires observational data for the following parameters wind speed (m/s), wind direction (°), temperature (°C), pressure (hPa), cloud cover (Tenths) and relative humidity (%).

Table 6.1 presents the availability of data required by CALMET for 2009.

Table 6.1 - Data availability of BoM observational data

BoM Station	Parameter	Data Availability (%)
Adelaide (Kent Town)	Temperature	99.9%
	Pressure	99.9%
	Wind Speed	99.9%
	Wind Direction	99.9%
	Relative Humidity	99.9%
	Cloud Cover	0%
Mount Lofty	Temperature	99.7%
	Pressure	0%
	Wind Speed	61.6%
	Wind Direction	61.6%
	Relative Humidity	99.7%
	Cloud Cover	0%

There are minimal gaps in the data from the Adelaide (Kent Town) BoM station for all parameters aside from cloud cover which are not recorded at Adelaide Kent Town. Wind direction and wind speed data is noted to be unavailable at the Mount Lofty station from January 1 2009 until 21 May 2009. There are minimal gaps in the relative humidity and temperature parameters for the Mount Lofty Dataset. It is noted that data is unavailable for cloud cover at both the Mount Lofty and Adelaide (Kent Town) stations. In the absence of observed cloud cover data, the MCLOUD option in CALMET has been set to the gridded cloud cover from prognostic relative humidity at 850mb (Teixera).

Pressure is noted only to be recorded at the Adelaide (Kent Town) station. For CALMET to run, at least one station must have a value for all parameters for any given hour. Where gaps exist in the data for both stations, gap filling has been undertaken in accordance with the US EPA Meteorological Monitoring Guidance for Regulatory Modelling Applications[3]. Gaps in the data which overlap between the Mount Lofty and Adelaide (Kent Town) data sets have been linearly interpolated. The US EPA suggests caution be used when gaps in data persist for longer than several hours and when gaps occur during day/night transition periods. Gaps in the overlapping data sets for 2009 are noted to persist no longer than 2 hours and do not occur during day/night transition periods.

Adelaide Airport is noted to be the only nearby BoM station to record upper air data. A review of the upper air data from the Adelaide Airport for 2009 has concluded that the data available is appropriate for use in the CALMET modelling. CALMET requires data from two soundings per day for the modelling period at intervals of 14 hours or less. Analysis of the available 2009 upper data from Adelaide Airport indicates that, during the two years, a number of soundings are missing or inappropriate for use (missing both wind speed and wind direction for top cell face level). Where sounding data is unavailable, TAPM upper air data has been used to supplement the missing

3 United States Environmental Protection Agency (February 2000), 'Meteorological Monitoring Guidance for Regulatory Modelling Applications'.

sounding. Consecutive missing sounding data is noted to occur for no more than 3 consecutive soundings

An R1 and RMAX1 value of 3 km and 5 km have been adopted given the nearest ridges to the BoM station (5 km to the north).

6.5 CALPUFF Dispersion Modelling

The CALPUFF modelling system treats emissions as a series of puffs. These puffs are then dispersed throughout the modelling area and allowed to grow and bend with spatial variations in meteorology. In doing so, the model is able to retain a memory of the plume's movement throughout a single hour and from one hour to the next while continuing to better approximate the effects of complex air flows.

CALPUFF utilises the meteorological processing and prediction model CALMET to provide three dimensional wind field predictions for the area of interest. The final wind field developed by the model (for consideration by CALPUFF) includes an approximation of the effects of local topography, the effects of varying surface temperatures (as is observed in land and sea bodies) and surface roughness (resulting from varied land uses and vegetation cover in an area). The CALPUFF model is able to resolve complex terrain influences on local wind fields including consideration of katabatic flows and terrain blocking.

6.6 CALPOST

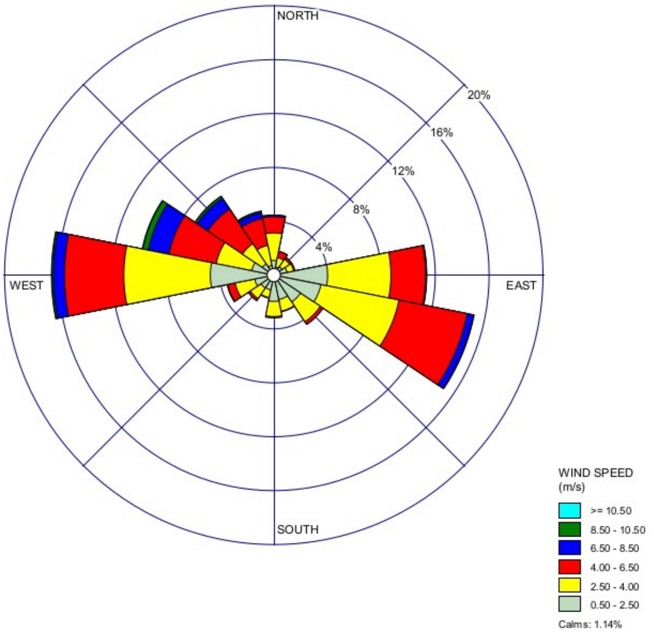
Post processing of modelled emissions is undertaken using the CALPOST package. This allows the rigorous analysis of pollutant predictions generated by the CALPUFF system. In particular CALPOST is able to provide an analysis of predicted pollutant concentrations for a range of averaging periods from 1 hour to 1 year.

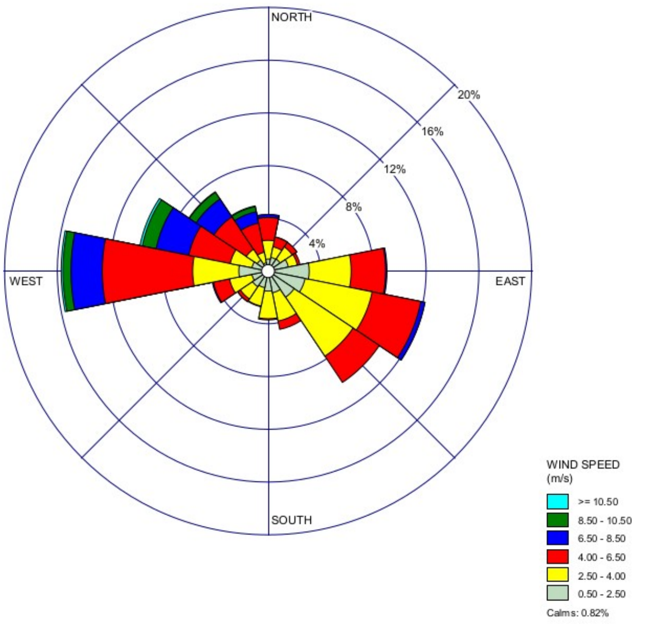
6.7 Meteorological Predictions

6.7.1 Wind Predictions

For the purpose of verifying the accuracy of the CALMET modelling, predicted wind roses for the year 2009 have been compared to the available wind monitoring data at the Mount Lofty and Adelaide (Kent Town) Bureau of Meteorology stations. These stations are located 6 to 8 km south and west of the site as shown in Section 3.2.

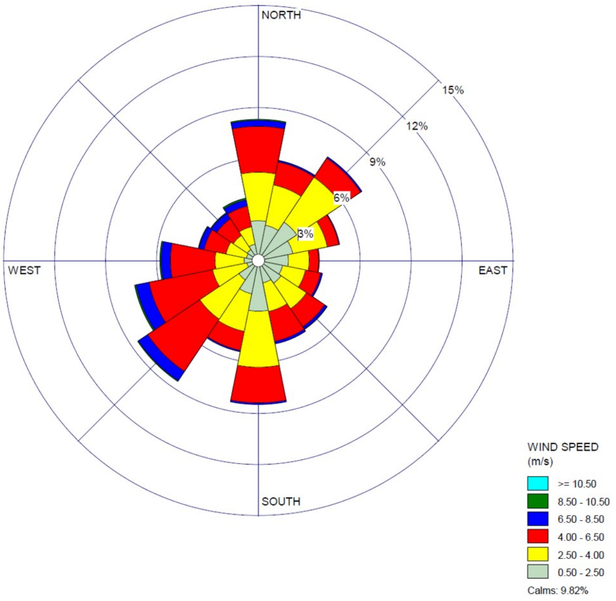
Figures 6.4 to 6.6 show a comparison of the predicted and measured wind roses for Mount Lofty station and Adelaide (Kent Town) station. As discussed earlier, the CALMET model year of 2009 has been adopted (as requested by the SA EPA).



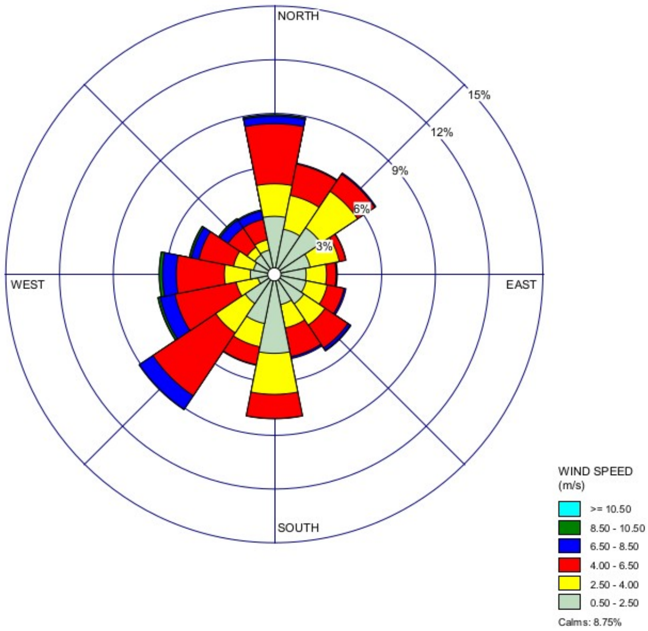


Mount Lofty Measured (2009 - 2014)	Mount Lofty predicted wind rose (2009)

Figure 6.4 - Mount Lofty Measured (2009 – 2014) vs 2009 Predicted Wind Roses



Adelaide (Kent Town) Measured (2009 - 2014)



Adelaide (Kent Town) predicted wind rose (2009)

Figure 6.5 - Adelaide (Kent Town) Measured (2009 – 2014) vs 2009 Predicted Wind Roses

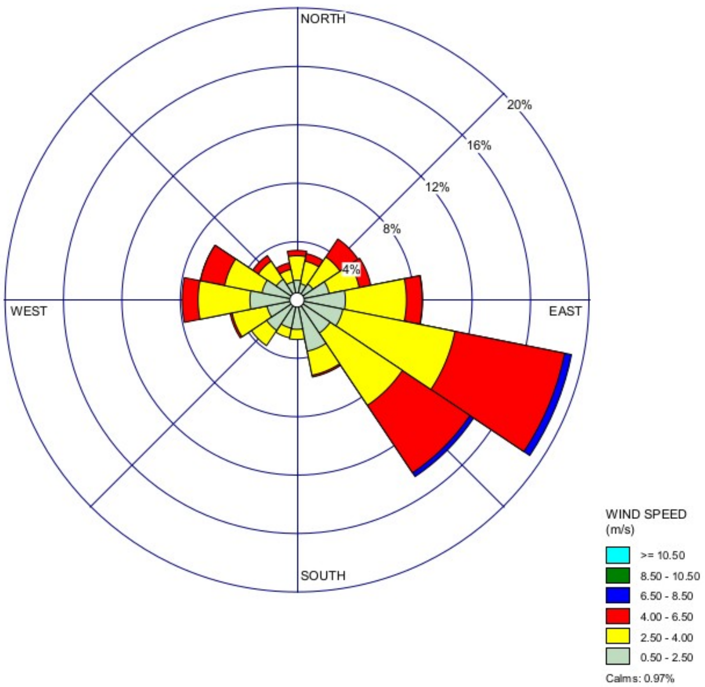


Figure 6.6 - CALMET Predicted Site Wind Rose 2009

The measured data set at Mount Lofty shows dominant westerly and easterly flow with minimal north easterly and south westerly flows, which is reflected in the CALMET 2009 predicted dataset. Differences include, a higher proportion of south easterly winds. At the Adelaide (Kent Town) station, wind directions are accurately represented by CALMET.

The predicted wind rose at the subject site shows similar wind patterns to those predicted at the Mount Lofty Bureau of Meteorology station, with minimal southerly and northerly components. The main difference is a higher proportion of easterly and south easterly winds and a low proportion of westerly winds. This is likely due to the subject site being located on the western face of the Adelaide Hills rather than the higher point of the range where the Mount Lofty station is located.

Table 6.2 presents a comparison of predicted and measured wind speeds.

Table 6.2 -- Comparison of Measured and Predicted Wind Speed Categories

Category (m/s)	Mount Lofty		Adelaide (Kent Town)		Site
	Measured	Predicted	Measured	Predicted	Predicted
0.50 - 2.50	29.0%	25.3%	25.8%	33.6%	36.1%
2.50 - 4.00	33.7%	33.2%	31.9%	23.4%	40.7%
4.00 - 6.50	23.9%	29.4%	27.7%	28.4%	21.4%
6.50 - 8.50	4.5%	8.1%	4.2%	5.1%	0.8%
8.50 - 10.50	0.9%	2.7%	0.5%	0.7%	0.0%
>= 10.50	0.1%	0.4%	0.1%	0.1%	0.0%
Calms	1.1%	0.8%	9.8%	8.7%	1.0%

In terms of wind speeds, the predicted data set is over-predicting lower speed categories (0.5 – 2.5 m/s), at the Adelaide (Kent Town) Station. This feature of the model has a potential to result in conservative pollutant concentrations, since lower wind speeds are associated with poor pollutant dispersion conditions. In relation to calms at the Adelaide (Kent Town) station, calm conditions are slightly lower with 9.8% measured compared with 8.7% measured. However, given that the low wind speeds are represented, the wind speed data predicted by CALMET is considered to be representative.

At the Mount Lofty station, low wind speeds are slightly under represented, with 29.0% measured and 25.3% predicted. In relation to calms, the predicted data set shows a slightly lower proportion of calms with 1.1% measured and 0.8% predicted. However, both data sets confirm that calms are a minor feature of the area (with measured and predicted proportions being less than 2% at all locations).

Overall, predicted wind conditions are considered appropriate for the assessment of potential air quality impacts from the proposed development.

6.7.2 Atmospheric Stability Class

The amount of turbulence in the ambient air has a major effect upon the rise and dispersion of emissions. The amount of turbulence in the atmosphere is often described using series of six Pasquill stability classes A, B, C, D, E and F. Of these, Class A denotes the most unstable or most turbulent conditions and class F denotes the most stable or least turbulent conditions. Figure 6.7 provides a summary of the predicted atmospheric stability conditions for the site.

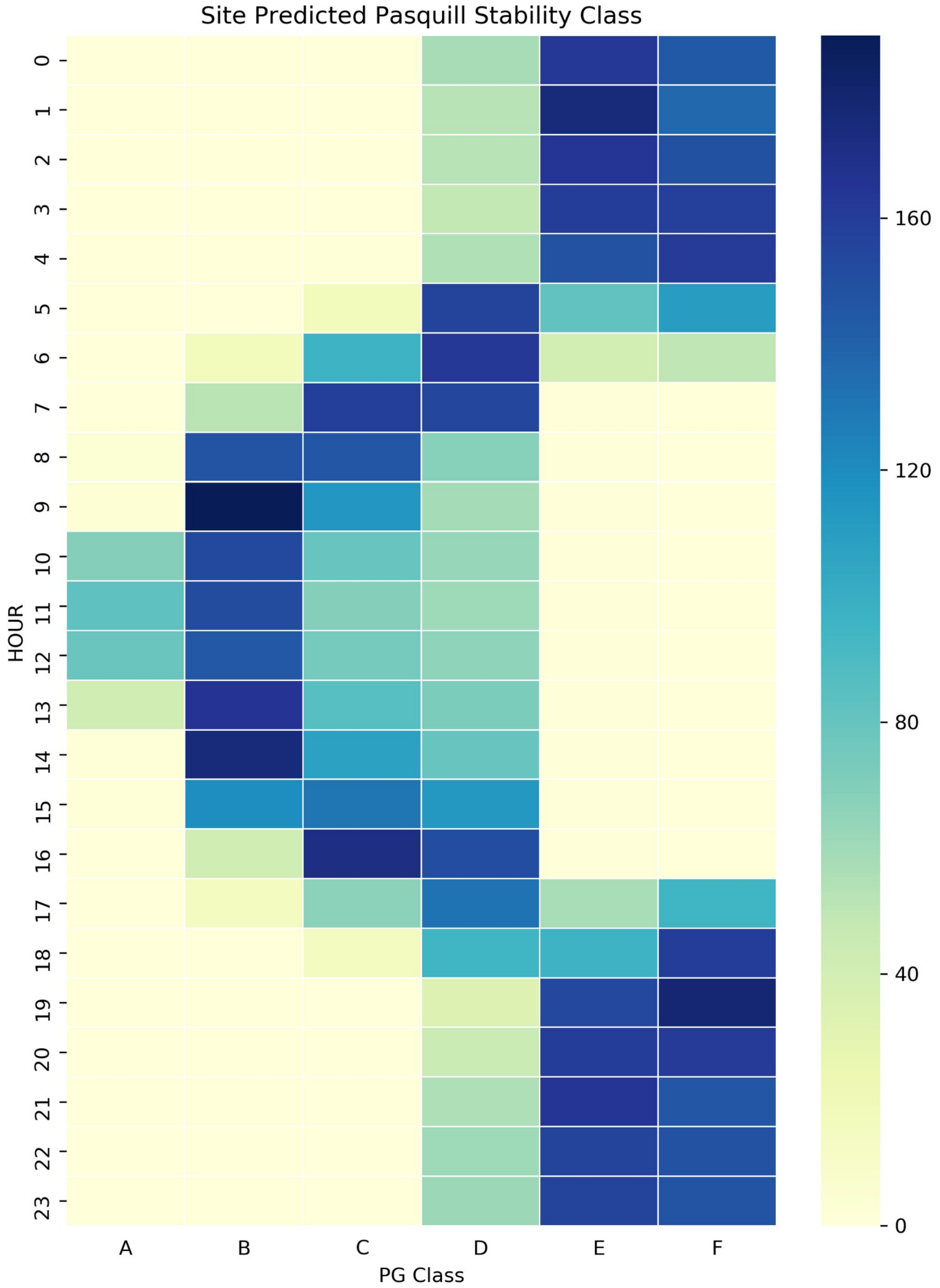


Figure 6.7 - CALMET Predicted Site Stability Classes

6.7.3 Mixing Heights

Figure 6.8 presents a plot showing predicted mixing heights for each hour of the day. The range and pattern of predicted mixing heights are considered typical of a rural area. As expected, higher mixing heights occur during the day time, while lower mixing heights occur during the night period when stable conditions are dominant and temperature inversions occur.

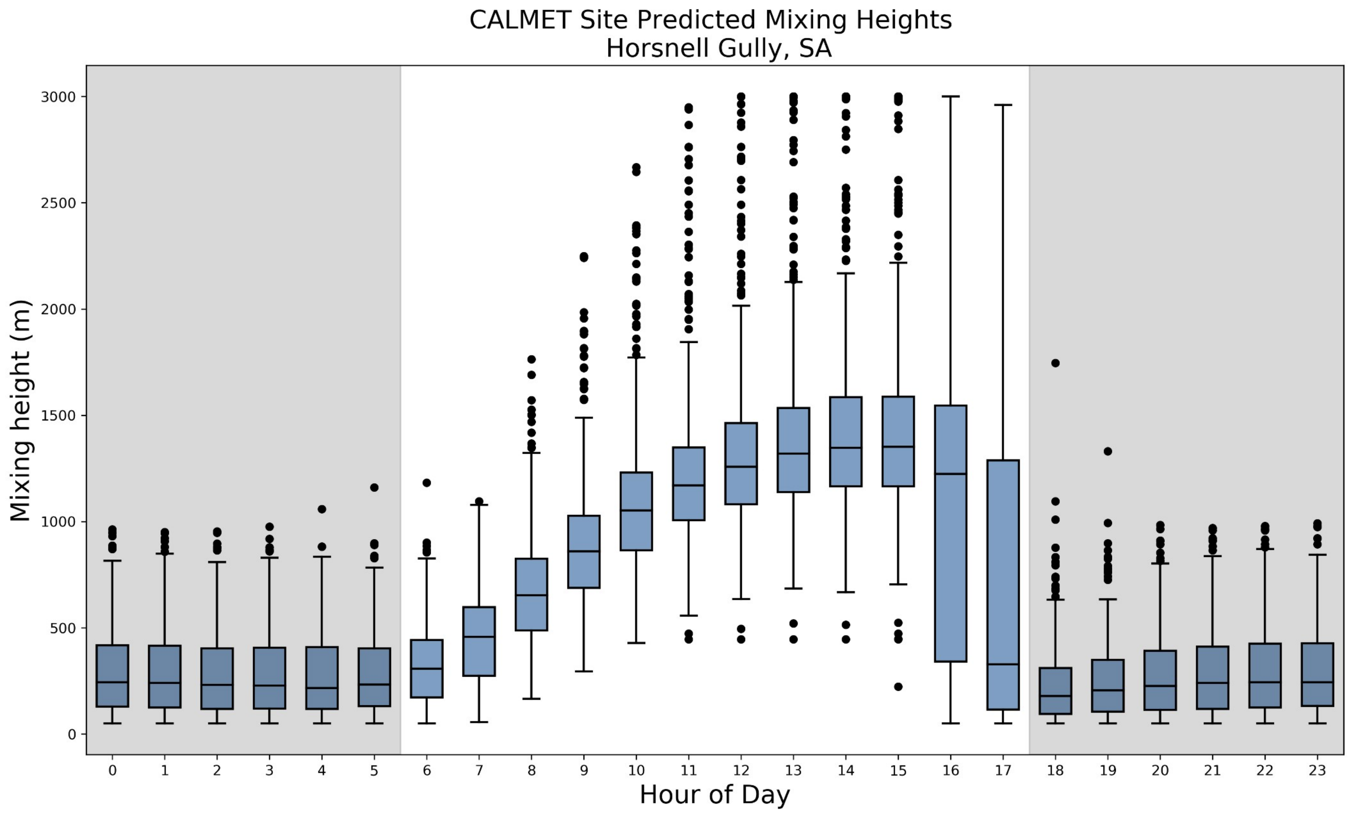


Figure 6.8 - CALMET Predicted site Mixing Heights

6.7.4 Temperature

Figure 6.9 presents a plot showing predicted temperatures for each hour of the day. The range and pattern of predicted temperatures are considered typical of a rural area. As expected, higher temperatures occur during the day time, while lower temperatures occur during the night period when there is no solar radiation. The average predicted temperature at the site is 15°C, which is comparable to the average measured temperatures of 13°C at the Mount Lofty BoM station and 18°C at the Adelaide (Kent Town) station.

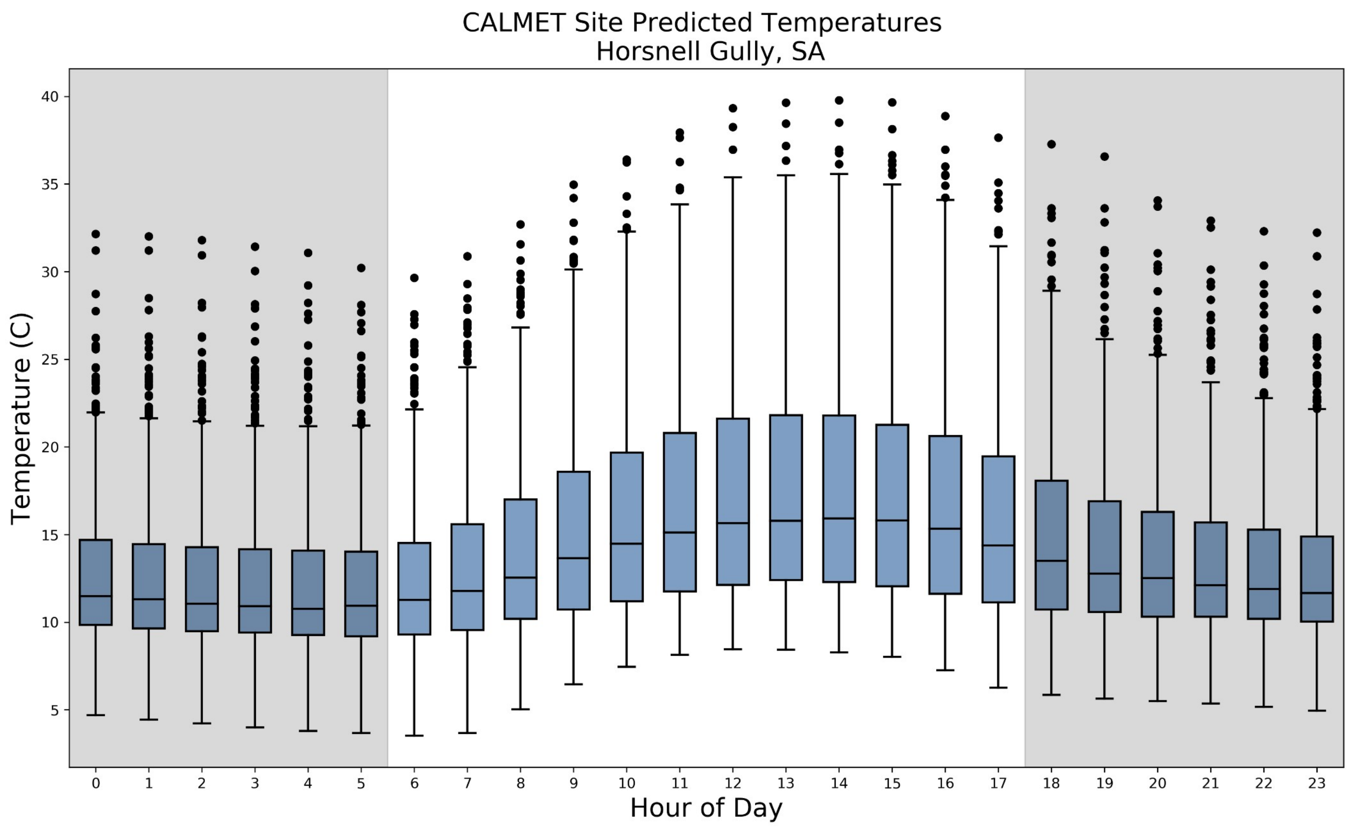


Figure 6.9 - CALMET Predicted Site Temperature

6.8 Summary of Outcomes

A review of the predicted data sets for the year 2009 indicate that the outcomes of CALMET model are suitable for predicting potential air quality impacts from the proposed development. Key meteorological parameters including wind field, stability class and temperature are considered to be representative of the subject site and surrounding area based on a comparison to measured data.

7 Air Emissions Data

7.1 Overview

The following sections present the emission factors and emission rates derived for each modelling scenario. These emission rates have been used in the CALPUFF modelling described later in Section 8.

7.2 Emission Factors

In order to predict emission rates for the relevant air emission sources, a review of available published literature relating to quarry and batching plant operations has been completed. The following documents have been utilised to estimate emissions, and are referenced in Table 7.1:

1. AP 42 (5th Edition), Compilation of Air Pollutant Emission Factors, Vol. 1 Stationary Point and Area Sources, Chapter 13.2.2, Unpaved Roads.
2. AP 42 (5th Edition), Compilation of Air Pollutant Emission Factors, Vol. 1 Stationary Point and Area Sources, Chapter 13.2.4, Aggregate Handling and Storage Piles, November 2006.
3. AP 42 (5th Edition), Compilation of Air Pollutant Emission Factors, Vol. 1 Stationary Point and Area Sources, Chapter 11.19.2, Crushed Stone Processing and Pulverised Mineral Processing, August 2004.
4. National Pollution Inventory, Emission Estimation Technique Manual for Mining (Version 3.1), January 2012.
5. AP 42 (5th Edition), Compilation of Air Pollutant Emission Factors, Vol. 1 Stationary Point and Area Sources, Chapter 11.12.1, Concrete Batching.
6. AP 42 (5th Edition), Compilation of Air Pollutant Emission Factors, Vol. 1 Stationary Point and Area Sources, Chapter 13.2.1, Paved Roads.

The following sections present details on the derivation of emission factors and rates used in the modelling.

Table 7.1 presents emission factors sourced from the US EPA AP42 and NPI literature. Assumptions in selecting or deriving emission factors are also presented in the last column of Table 7.1.

Table 7.1 - Emission Factors

Activity	Units	TSP	PM_{10}	$PM_{2.5}$	Reference	Comments
Extraction Area						
Extracted material handling	kg/Mg	0.00289	0.00137	0.00021	Ref 2, Eqn 1	Assumes 1% moisture content, 2.1 m/s wind based on measured wind speed at Mount Lofty BoM station (factored down to a height of 2 m)
Concrete Batching Plant						
Aggregate delivery	kg/Mg	0.00130	0.00062	0.00009	Ref 5 and Ref 2, Eqn 1	Assumes 1.77% moisture content (US AP 42 default for aggregate), 2.1 m/s wind based on measured wind speed at Mount Lofty BoM station (factored down to a height of 2 m)
Aggregate transfers	kg/Mg	0.00130	0.00062	0.00009	Ref 5 and Ref 2, Eqn 1	Assumes 1.77% moisture content (US AP 42 default for aggregate), 2.1 m/s wind based on measured wind speed at Mount Lofty BoM station (factored down to a height of 2 m)
Sand delivery	kg/Mg	0.00039	0.00019	0.00003	Ref 5 and Ref 2, Eqn 1	Assumes 1.77% moisture content (US AP 42 default for aggregate), 2.1 m/s wind based on measured wind speed at Mount Lofty BoM station (factored down to a height of 2 m)
Sand transfer	kg/Mg	0.00039	0.00019	0.00003	Ref 5 and Ref 2, Eqn 1	Assumes 1.77% moisture content (US AP 42 default for aggregate), 2.1 m/s wind based on measured wind speed at Mount Lofty BoM station (factored down to a height of 2 m)
Cement unloading to elevated storage silo (pneumatic)	kg/Mg	0.00050	0.00017	0.00005	Ref 5	Controlled emission factor
Fly ash unloading to elevated storage silo (pneumatic)	kg/Mg	0.00450	0.00240	0.00071	Ref 5	Controlled emission factor
Weigh hopper loading	kg/Mg	0.00260	0.00130	0.00038	Ref 5	Controlled emission factor
Mixer loading (truck mix)	kg/Mg	1.11800	0.31000	0.09118	Ref 5	Uncontrolled emission factor
Future Processing Plant						
Material transfer to process line	kg/Mg	0.00289	0.00137	0.00021	Ref 2, Eqn 1	Assumes 1% moisture content, 2.1 m/s wind based on measured wind speed at Mount Lofty BoM station (factored down to a height of 2 m)
Cone Crusher	kg/Mg	0.00060	0.00027	0.00005	Ref 3	No secondary crushing factors are available. Conservatively based on emission factor for tertiary crushing (controlled).
Screen Deck	kg/Mg	0.00110	0.00037	0.000025	Ref 3	Screening – controlled
Jaw Crusher	kg/Mg	0.00060	0.00027	0.00005	Ref 3	No primary crushing factors are available. Conservatively based on emission factor for tertiary crushing (controlled).
Reclaimer	kg/Mg	0.00110	0.00037	0.000025	Ref 3	Screening – controlled
Transfer Points	kg/Mg	0.00007	0.000023	0.000007	Ref 3	Transfer point - controlled
Material transfer to stockpiles	kg/Mg	0.00289	0.00137	0.00021	Ref 2, Eqn 1	Assumes 1% moisture content, 2.1 m/s wind based on measured wind speed at Mount Lofty BoM station (factored down to a height of 2 m)
Area Sources						
Pits	$kg/m^2/hr$	0.00002	0.00001	0.000001	Ref 4, Eqn 22	Assumes height of 0.5 m, 8.3 % silt content and wind and precipitation data from the Mount Lofty BoM station (factored down to a height of 0.5 m).
Stockpiles	$kg/m^2/hr$	0.0000009	0.00000047	0.0000001	Ref 4, Eqn 22	Assumes height of 5 m, 8.3% silt content and wind and precipitation data from the Mount Lofty BoM station (factored down to a height of 0.5 m).

Activity	Units	TSP	PM_{10}	$PM_{2.5}$	Reference	Comments
Blasting	kg/blast	7.37858	3.82345	0.57898	Ref 4, Eqn 19	Blasting area of 1040 m^2
Drilling	kg/hole	0.59000	0.31000	0.04130	Ref 4	A total of 54 holes assumes (based on assumed 3.8 m burden and 4.3 m spacing over a 1040 m^2 area)
Haul Routes						
On-site haul trucks over unsealed sections	g/VKT	4115	1170	117	Ref 1 Eqn 1	Silt content of 8.3% as per Table 13.2.2-1 of Ref 3, and average (empty, full) truck weight of 45 tonnes. 8.3% silt content represents the average of the data set provided in Ref 3.
Product trucks over unsealed sections	g/VKT	3186	906	91	Ref 1 Eqn 1	Silt content of 8.3% as per Table 13.2.2-1 of Ref 3, and average (empty, full) truck weight of 31 tonnes.
Product trucks over sealed access road	g/VKT	118	23	5	Ref 6	Silt loading value of 1.0 g/m^2 as per Table 13.2.1-4 of Ref 6, and average (empty, full) truck weight of 31 tonnes.
Concrete agitators over sealed access road	g/VKT	114	22	5	Ref 6	Silt loading value of 1.0 g/m^2 (for concrete batching as per Table 13.2.1-4 of Ref 6), and truck weight of 30 tonnes.

7.3 Emission Rates

7.3.1 Overview

Emission rates have been derived for an average throughput operating day and an assumed worst-case operating day. The average throughput operating day is based on the proposed throughput of each stage (as presented in Section 2.2), averaged over a 365 day year and 12 hour working day (6 am to 6 pm). A 220 tph throughput was assumed as worst case scenario. Results for the worst-case operating day have been compared to criteria associated with a 24-hour averaging period only.

In order to predict g/s emission rates for use in the air dispersion modelling, it is necessary to multiply the emission factors presented in Table 7.1 by the relevant multiplying factors:

- kg/Mg emission factors to be multiplied by material throughputs (e.g. Mg/year);
- kg/blast emissions to be multiplied by the total area of the blast area sources;
- kg/hole emissions to be multiplied by the number of drilling holes and the total area of the drilling area sources;
- g/VKT emission factors to be multiplied by amount of km vehicles travel over the haul route (e.g. km/hr);
- kg/m^2/hr emission factors to be multiplied by the total area of the area sources.

The following sections present details of input data used to derive emission rates from the emission factors.

7.3.2 Mitigation

With regards to mitigation, the following measures have been accounted for in the emission rates:

- mobile processing plant – water sprays; and
- standard watering rate (Level 1, < 2 L/m^2/hr) for all haul routes.

For a standard watering rate, a 50% control efficiency has been considered based on the recommendations of NPI Mining Manual.

For the proposed processing plant, controlled emission factors from the US AP 42 Chapter 11.19.2 emission factor documentation (as shown in Table 7.1) has been adopted to account for the use of water sprays. The controlled emission factor in the US AP 42 documentation is based on the use of water sprays within crushed stone processing plants.

7.3.3 Estimated Emissions

In order to derive maximum emission rates (g/s, for the maximum plant production rate) for the proposed quarry operations, the following client information has been considered:

- A summary of calculated average and daily maximum throughputs is provided below:

	Stage 1	Stage 2	Stage 3	Stage 3A
Average				
Annual Throughput (kt)	500	500	500	500
Daily Throughput (Tonnes)	1369.9	1369.9	1369.9	1369.9
Per Hour (Tonnes)	114.2	114.2	114.2	114.2
Worst-case Assumed				
Per Day (Tonnes)	2640.0	2640.0	2640.0	2640.0
Per Hour (Tonnes)	220.0	220.0	220.0	220.0

- Areas for exposed areas and stockpiles are shown in Table 7.1 and are based on plans provided by Client;
- Truck movement estimations:

Road Source	Truck Payload (tonnes)	Route Distance (m)	Average Throughput		Worst-Case Throughput	
			Throughput (t/hr)	Trucks Per Hour	Throughput (t/hr)	Trucks Per Hour
Concrete Agitators Sealed	21	544.5	33.0	1.6	50.0	2.4
Product Trucks Sealed Stage 1	40	265.4	114.2	2.9	220.0	5.5
Product Trucks Unsealed Stage 1	40	709	114.2	2.9	220.0	5.5
Product Trucks Sealed Stage 2	40	265.4	114.2	2.9	220.0	5.5
Product Trucks Unsealed Stage 2	40	709	114.2	2.9	220.0	5.5
Product Trucks Sealed Stage 3	40	265.4	114.2	2.9	220.0	5.5
Product Trucks Unsealed Stage 3	40	709	114.2	2.9	220.0	5.5
Product Trucks Sealed Stage 3A	40	265.4	114.2	2.9	220.0	5.5
Product Trucks Unsealed Stage 3A	40	709	114.2	2.9	220.0	5.5
Haul route – Stage 1	40	1669.3	114.2	2.9	220.0	5.5
Haul Route – Stage 2	40	811.2	114.2	2.9	220.0	5.5
Haul Route – Stage 3	40	689.6	114.2	2.9	220.0	5.5
Haul Route – Stage 3a	40	2182.3	114.2	2.9	220.0	5.5

Table 7.2 and 7.3 presents the emission rates derived for the quarry for an average and worst-case operating day, respectively. It is noted that the concrete batching plant and product truck access requires 24/7 flexibility. The modelling assumes all operations are from 6 am to 6 pm, which is the typical operating time period for the site. While there could be occasional operations out of hours

(when dispersion conditions are less favourable), the modelling is conservative by assuming all air emission sources are operating on the same day and the quarry is operating at a maximum capacity of 220 tonnes per hour (associated with the capacity of the processing plant).

Source IDs are also provided in Column 1 and have been used in the air dispersion modelling. Sources have been modelled as unit emission rates (i.e. 1 g/s, 1 g/s/m, 1 g/s/m^2) in individual CALPUFF files, and the results have been factored using the derived emission rates. The results for each source have then been added in CALSUM to provide total predicted concentrations in the surrounding area. Some air emission sources have been combined as one source in the modelling based on their close proximity to each other.

Table 7.2 - Proposed Quarry Estimated Emission Rates (g/s) – Average Daily Throughput

Source ID	Applicable Scenario/s	Activity	Factoring Value	Factoring Unit	Mitigation Reduction	Mitigation Description	TSP	PM_{10}	$PM_{2.5}$	Operating Time
Extraction Area – Material Handling										
S1-EF	Stage 1	Extraction – Stage 1	114.2	tonnes/hr	0%	None	0.0917	0.0434	0.0066	6 am - 6 pm
S3-EF	Stage 2	Extraction – Stage 2	114.2	tonnes/hr	0%	None	0.0917	0.0434	0.0066	6 am - 6 pm
S3-EF	Stage 3	Extraction – Stage 3	114.2	tonnes/hr	0%	None	0.0917	0.0434	0.0066	6 am - 6 pm
S3A-EF	Stage 3A	Extraction – Stage 3A	114.2	tonnes/hr	0%	None	0.0917	0.0434	0.0066	6 am - 6 pm
Concrete Batching Plant										
CB-SAD	All Stages	Aggregate Delivery	38.7	tonnes/hr	0%	None	0.0140	0.0066	0.0010	6 am - 6 pm
CD-SAT	All Stages	Aggregate Transfers	77.4	tonnes/hr	0%	None	0.0279	0.0132	0.0020	6 am - 6 pm
CB-SAD	All Stages	Sand Delivery	29.6	tonnes/hr	0%	None	0.0032	0.0015	0.0002	6 am - 6 pm
CB-SAT	All Stages	Sand Transfers	59.2	tonnes/hr	0%	None	0.0064	0.0030	0.0005	6 am - 6 pm
CB-CD	All Stages	Cement Unloading to elevated storage silo (pneumatic)	10.2	tonnes/hr	0%	None	0.0014	0.0005	0.0001	6 am - 6 pm
CB-WHL	All Stages	Weigh Hopper Loading	80.0	tonnes/hr	70%	Roofed enclosure	0.0173	0.0087	0.0025	6 am - 6 pm
CB-TL	All Stages	Mixer Loading (truck mix)	11.7	tonnes/hr	70%	Roofed enclosure	1.0899	0.3022	0.0889	6 am - 6 pm
Future Processing Plant – All Stages										
FP-TP1	All Stages	Material transfer to process line	114.2	tonnes/hr	0%	None	0.0917	0.0434	0.0066	6 am - 6 pm
FP-CR1	All Stages	Cone Crusher	114.2	tonnes/hr	0%	Controlled emission factor for dust suppression as per Table 7.1)	0.019	0.009	0.002	6 am - 6 pm
FP-SC1	All Stages	Screen Deck	114.2	tonnes/hr	0%		0.035	0.012	0.001	6 am - 6 pm
FP-CR2	All Stages	Jaw Crusher	114.2	tonnes/hr	0%		0.019	0.009	0.002	6 am - 6 pm
FP-SC2	All Stages	Reclaimer	114.2	tonnes/hr	0%		0.035	0.012	0.001	6 am - 6 pm
FP-TP3	All Stages	Material transfer to stockpiles	114.2	tonnes/hr	0%	None	0.0917	0.0434	0.0066	6 am - 6 pm
FP-S1/S2/S3/S3A	All Stages	Combined emission rates	-	-	-	-	0.2912	0.1273	0.0179	6 am - 6 pm
Area Sources										
CB-AREA	All Stages	Concrete batching plant stockpiles	811	m^2	30%	Three sided walls	0.0030	0.0015	0.0002	24 hours
FP-AREA	All Stages	Future processing plant stockpiles	7254	m^2	30%	Three sided walls	0.0272	0.0136	0.0020	24 hours
S1-AREA	Stage 1	Stage 1 Extraction Area	182367	m^2	0%	None	0.0476	0.0238	0.0036	24 hours
S1-Blasting	Stage 1	Stage 1 Drilling	1015	m^2	0%	None	0.1666	0.0863	0.0131	6 am - 6 pm

Source ID	Applicable Scenario/s	Activity	Factoring Value	Factoring Unit	Mitigation Reduction	Mitigation Description	TSP	PM_{10}	$PM_{2.5}$	Operating Time
S1-Drilling	Stage 1	Stage 1 Blasting	1015	m^2	0%	None	0.4284	0.2251	0.0300	6 am - 6 pm
S2-AREA	Stage 2	Stage 2 Extraction Area	293368	m^2	0%	None	0.0766	0.0383	0.0057	24 hours
S2-Blasting	Stage 2	Stage 2 Drilling	1020	m^2	0%	None	0.1675	0.0868	0.0131	6 am - 6 pm
S2-Drilling	Stage 2	Stage 2 Blasting	1020	m^2	0%	None	0.4307	0.2263	0.0301	6 am - 6 pm
S3-AREA1	Stage 3	Stage 3 Extraction Area 1	296554	m^2	0%	None	0.0775	0.0387	0.0058	24 hours
S3-AREA2	Stage 3	Stage 3 Extraction Area 2	54320	m^2	0%	None	0.0142	0.0071	0.0011	24 hours
S3-Blasting	Stage 3	Stage 3 Drilling	1020	m^2	0%	None	0.0465	0.0241	0.0037	6 am - 6 pm
S3-Drilling	Stage 3	Stage 3 Blasting	1020	m^2	0%	None	0.1196	0.0629	0.0084	6 am - 6 pm
S3A-AREA1	Stage 3a	Stage 3a Extraction Area 1	395383	m^2	0%	None	0.1033	0.0516	0.0077	24 hours
S3A-AREA2	Stage 3a	Stage 3a Extraction Area 2	54676	m^2	0%	None	0.0143	0.0071	0.0011	24 hours
S3A-Blasting	Stage 3a	Stage 3a Blasting	1007	m^2	0%	None	0.1653	0.0857	0.0130	6 am - 6 pm
S3A-Drilling	Stage 3a	Stage 3a Drilling	1007	m^2	0%	None	0.4251	0.2234	0.0298	6 am - 6 pm
Haul Routes										
CB-HR	All Stages	Concrete Batching Plant Haul Route (Sealed)	0.9	VKT/hr	0%	Level 1 Watering	0.0412	0.0079	0.0019	6 am - 6 pm
PROD-SL	All Stages	Product Haul Route (Sealed)	1.5	VKT/hr	0%	Level 1 Watering	0.0497	0.0095	0.0023	6 am - 6 pm
PROD-USL	All Stages	Product Haul Route (Unsealed)	4.0	VKT/hr	50%	Level 1 Watering	1.7907	0.5092	0.0509	6 am - 6 pm
S1-HR	Stage 1	Stage 1 Haul Route	9.5	VKT/hr	50%	Level 1 Watering	5.4461	1.5487	0.1549	6 am - 6 pm
S2-HR	Stage 2	Stage 2 Haul Route	4.6	VKT/hr	50%	Level 1 Watering	2.6465	0.7526	0.0753	6 am - 6 pm
S3-HR	Stage 3	Stage 3 Haul Route	3.9	VKT/hr	50%	Level 1 Watering	2.2498	0.6398	0.0640	6 am - 6 pm
S3A-HR	Stage 3A	Stage 3A Haul Route	6.2	VKT/hr	50%	Level 1 Watering	3.5599	1.0123	0.1012	6 am - 6 pm

Table 7.3 - Proposed Quarry Estimated Emission Rates (g/s) – Worst-Case Daily Throughput

Source ID	Applicable Scenario/s	Activity	Factoring Value	Factoring Unit	Mitigation Reduction	Mitigation Description	TSP	PM_{10}	$PM_{2.5}$	Operating Time
Extraction Area – Material Handling										
S1-EF	Stage 1	Extraction – Stage 1	220.0	tonnes/hr	0%	None	0.1767	0.0836	0.0127	6 am - 6 pm
S3-EF	Stage 2	Extraction – Stage 2	220.0	tonnes/hr	0%	None	0.1767	0.0836	0.0127	6 am - 6 pm
S3-EF	Stage 3	Extraction – Stage 3	220.0	tonnes/hr	0%	None	0.1767	0.0836	0.0127	6 am - 6 pm
S3A-EF	Stage 3A	Extraction – Stage 3A	220.0	tonnes/hr	0%	None	0.1767	0.0836	0.0127	6 am - 6 pm
Concrete Batching Plant										
CB-SAD	All Stages	Aggregate Delivery	38.7	tonnes/hr	0%	None	0.0140	0.0066	0.0010	6 am - 6 pm
CD-SAT	All Stages	Aggregate Transfers	77.4	tonnes/hr	0%	None	0.0279	0.0132	0.0020	6 am - 6 pm
CB-SAD	All Stages	Sand Delivery	29.6	tonnes/hr	0%	None	0.0032	0.0015	0.0002	6 am - 6 pm
CB-SAT	All Stages	Sand Transfers	59.2	tonnes/hr	0%	None	0.0064	0.0030	0.0005	6 am - 6 pm
CB-CD	All Stages	Cement Unloading to elevated storage silo (pneumatic)	10.2	tonnes/hr	0%	None	0.0014	0.0005	0.0001	6 am - 6 pm
CB-CD	All Stages	Fly ash unloading to elevated storage silo (pneumatic)	1.5	tonnes/hr	0%	None	0.0019	0.0010	0.0003	6 am - 6 pm
CB-WHL	All Stages	Weigh Hopper Loading	80.0	tonnes/hr	70%	Roofed enclosure	0.0173	0.0087	0.0025	6 am - 6 pm
CB-TL	All Stages	Mixer Loading (truck mix)	11.7	tonnes/hr	70%	Roofed enclosure	1.0899	0.3022	0.0889	6 am - 6 pm
Future Processing Plant – All Stages										
FP-TP1	All Stages	Material transfer to process line	220.0	tonnes/hr	0%	None	0.1767	0.0836	0.0127	6 am - 6 pm
FP-CR1	All Stages	Cone Crusher	220.0	tonnes/hr	0%	Controlled emission factor for dust suppression as per Table 7.1)	0.0367	0.0165	0.0031	6 am - 6 pm
FP-SC1	All Stages	Screen Deck	220.0	tonnes/hr	0%		0.0672	0.0226	0.0015	6 am - 6 pm
FP-CR2	All Stages	Jaw Crusher	220.0	tonnes/hr	0%		0.0367	0.0165	0.0031	6 am - 6 pm
FP-SC2	All Stages	Reclaimer	220.0	tonnes/hr	0%		0.0672	0.0226	0.0015	6 am - 6 pm
FP-TP3	All Stages	Material transfer to stockpiles	220.0	tonnes/hr	0%	None	0.1767	0.0836	0.0127	6 am - 6 pm
FP-S1/S2/S3/S3A	All Stages	Combined emission rates	-	-	-	-	0.5613	0.2454	0.0345	6 am - 6 pm
Area Sources										
CB-AREA	All Stages	Concrete batching plant stockpiles	811	m^2	30%	Three sided walls	0.0030	0.0015	0.0002	24 hours
FP-AREA	All Stages	Future processing plant stockpiles	7254	m^2	30%	Three sided walls	0.0272	0.0136	0.0020	24 hours
S1-AREA	Stage 1	Stage 1 Extraction Area	182367	m^2	0%	None	0.0476	0.0238	0.0036	24 hours

S1-Blasting	Stage 1	Stage 1 Drilling	1015	m^2	0%	None	0.1666	0.0863	0.0131	6 am - 6 pm
S1-Drilling	Stage 1	Stage 1 Blasting	1015	m^2	0%	None	0.4284	0.2251	0.0300	6 am - 6 pm
S2-AREA	Stage 2	Stage 2 Extraction Area	293368	m^2	0%	None	0.0766	0.0383	0.0057	24 hours
S2-Blasting	Stage 2	Stage 2 Drilling	1020	m^2	0%	None	0.1675	0.0868	0.0131	6 am - 6 pm
S2-Drilling	Stage 2	Stage 2 Blasting	1020	m^2	0%	None	0.4307	0.2263	0.0301	6 am - 6 pm
S3-AREA1	Stage 3	Stage 3 Extraction Area 1	296554	m^2	0%	None	0.0775	0.0387	0.0058	24 hours
S3-AREA2	Stage 3	Stage 3 Extraction Area 2	54320	m^2	0%	None	0.0142	0.0071	0.0011	24 hours
S3-Blasting	Stage 3	Stage 3 Drilling	1020	m^2	0%	None	0.0465	0.0241	0.0037	6 am - 6 pm
S3-Drilling	Stage 3	Stage 3 Blasting	1020	m^2	0%	None	0.1196	0.0629	0.0084	6 am - 6 pm
S3A-AREA1	Stage 3a	Stage 3a Extraction Area 1	395383	m^2	0%	None	0.1033	0.0516	0.0077	24 hours
S3A-AREA2	Stage 3a	Stage 3a Extraction Area 2	54676	m^2	0%	None	0.0143	0.0071	0.0011	24 hours
S3A-Blasting	Stage 3a	Stage 3a Blasting	1007	m^2	0%	None	0.1653	0.0857	0.0130	6 am - 6 pm
S3A-Drilling	Stage 3a	Stage 3a Drilling	1007	m^2	0%	None	0.4251	0.2234	0.0298	6 am - 6 pm
Haul Routes										
CB-HR	All Stages	Concrete Batching Plant Haul Route (Sealed)	1.3	VKT/hr	0%	Level 1 Watering	0.0412	0.0079	0.0019	6 am - 6 pm
PROD-SL	All Stages	Product Haul Route (Sealed)	2.9	VKT/hr	0%	Level 1 Watering	0.0959	0.0184	0.0045	6 am - 6 pm
PROD-USL	All Stages	Product Haul Route (Unsealed)	7.8	VKT/hr	50%	Level 1 Watering	3.4511	0.9814	0.0981	6 am - 6 pm
S1-HR	Stage 1	Stage 1 Haul Route	18.4	VKT/hr	50%	Level 1 Watering	10.4956	2.9846	0.2985	6 am - 6 pm
S2-HR	Stage 2	Stage 2 Haul Route	8.9	VKT/hr	50%	Level 1 Watering	5.1004	1.4504	0.1450	6 am - 6 pm
S3-HR	Stage 3	Stage 3 Haul Route	7.6	VKT/hr	50%	Level 1 Watering	4.3358	1.2330	0.1233	6 am - 6 pm
S3A-HR	Stage 3A	Stage 3A Haul Route	12.0	VKT/hr	50%	Level 1 Watering	6.8605	1.9509	0.1951	6 am - 6 pm

7.4 Modelled Source Locations

Figures 7.1 to 7.6 present the modelled source locations for the proposed quarry. Source IDs are described in Table 7.2.

Figure 7.1 - Concrete Batching Plant – Modelled Sources

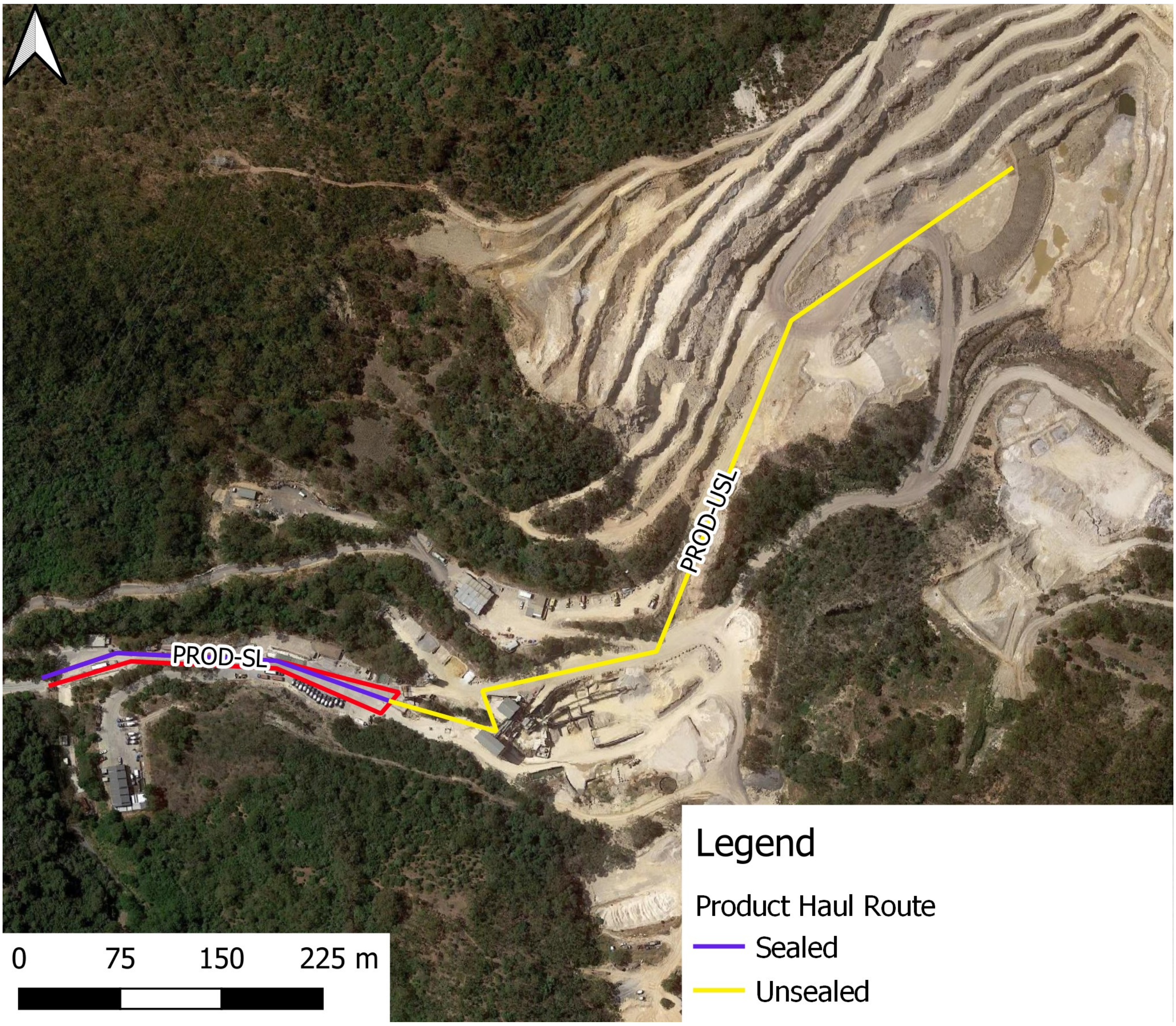


Figure 7.2 - Product Haul Route – Modelled Sources

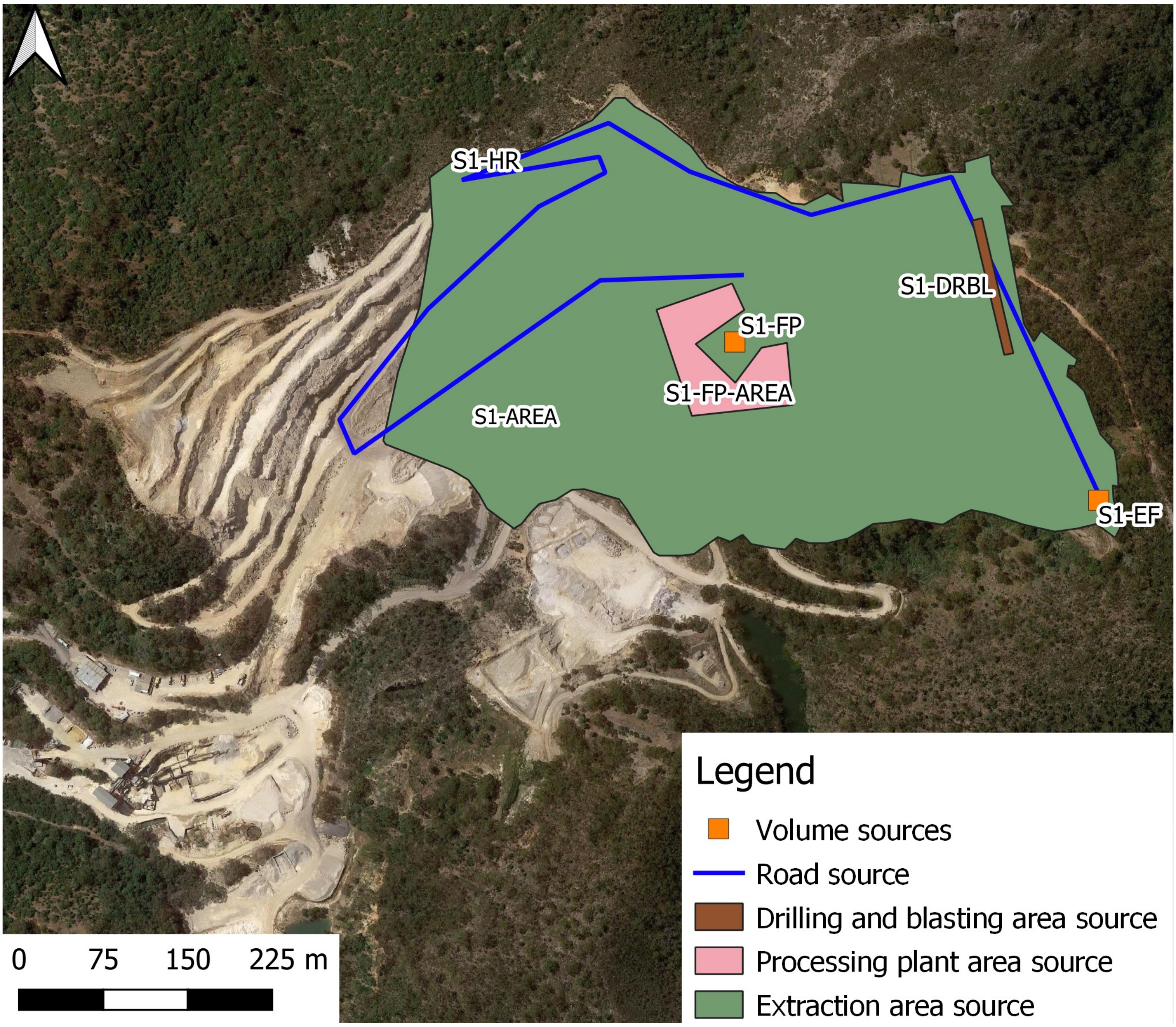


Figure 7.3 - Proposed Stage 1 – Modelled Sources

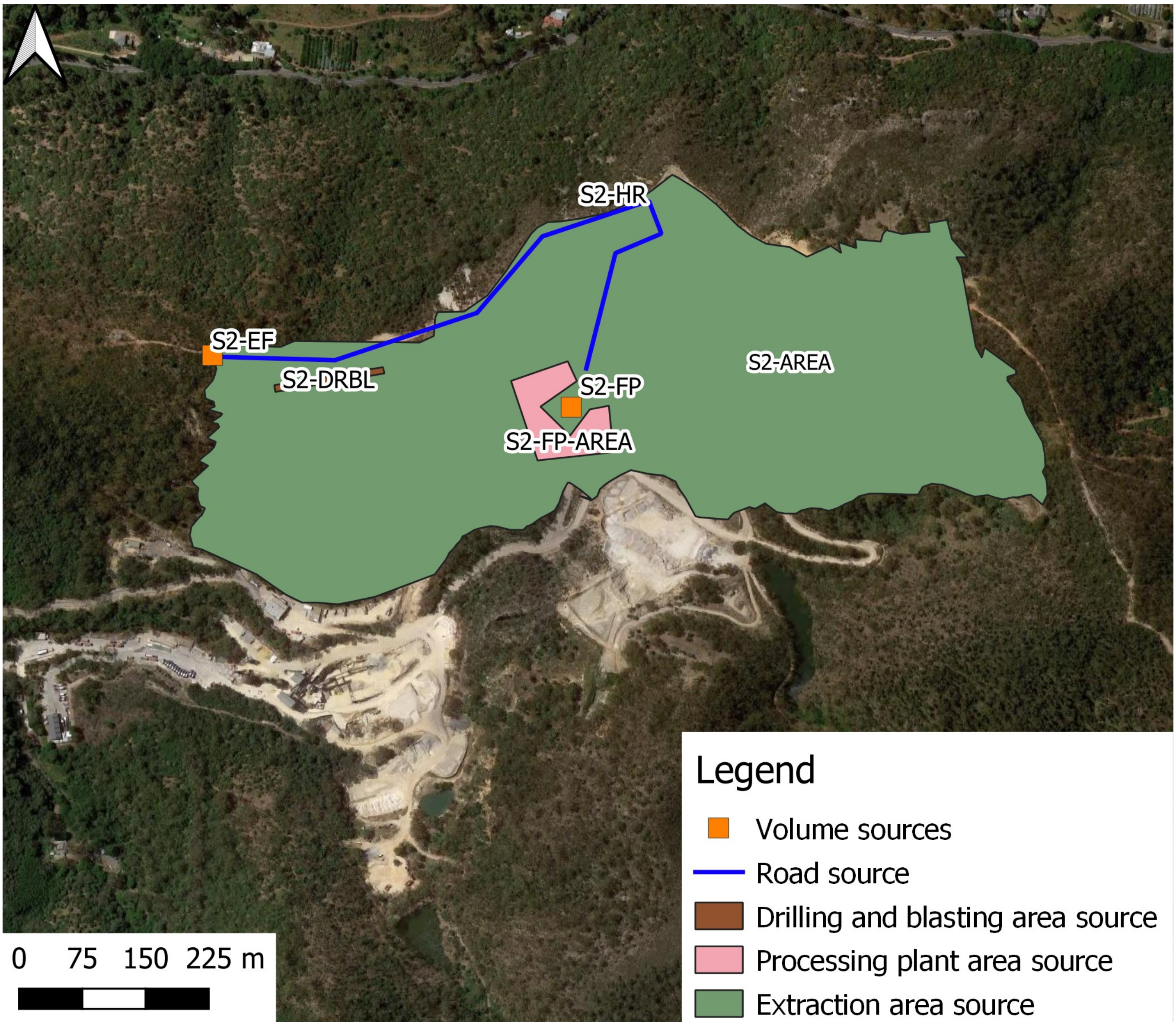


Figure 7.4 - Proposed Stage 2 – Modelled Sources

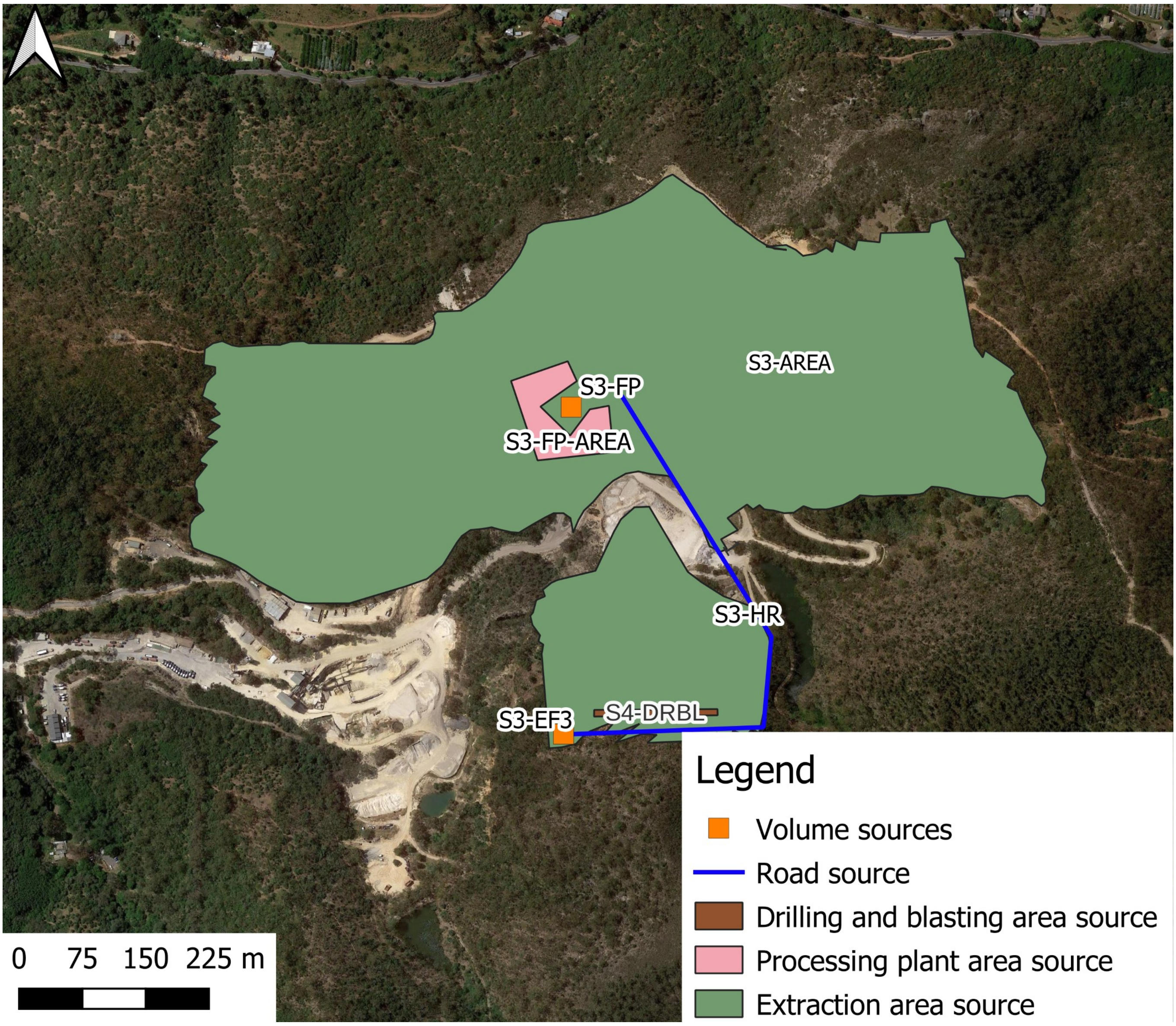


Figure 7.5 - Proposed Stage 3 – Modelled Sources

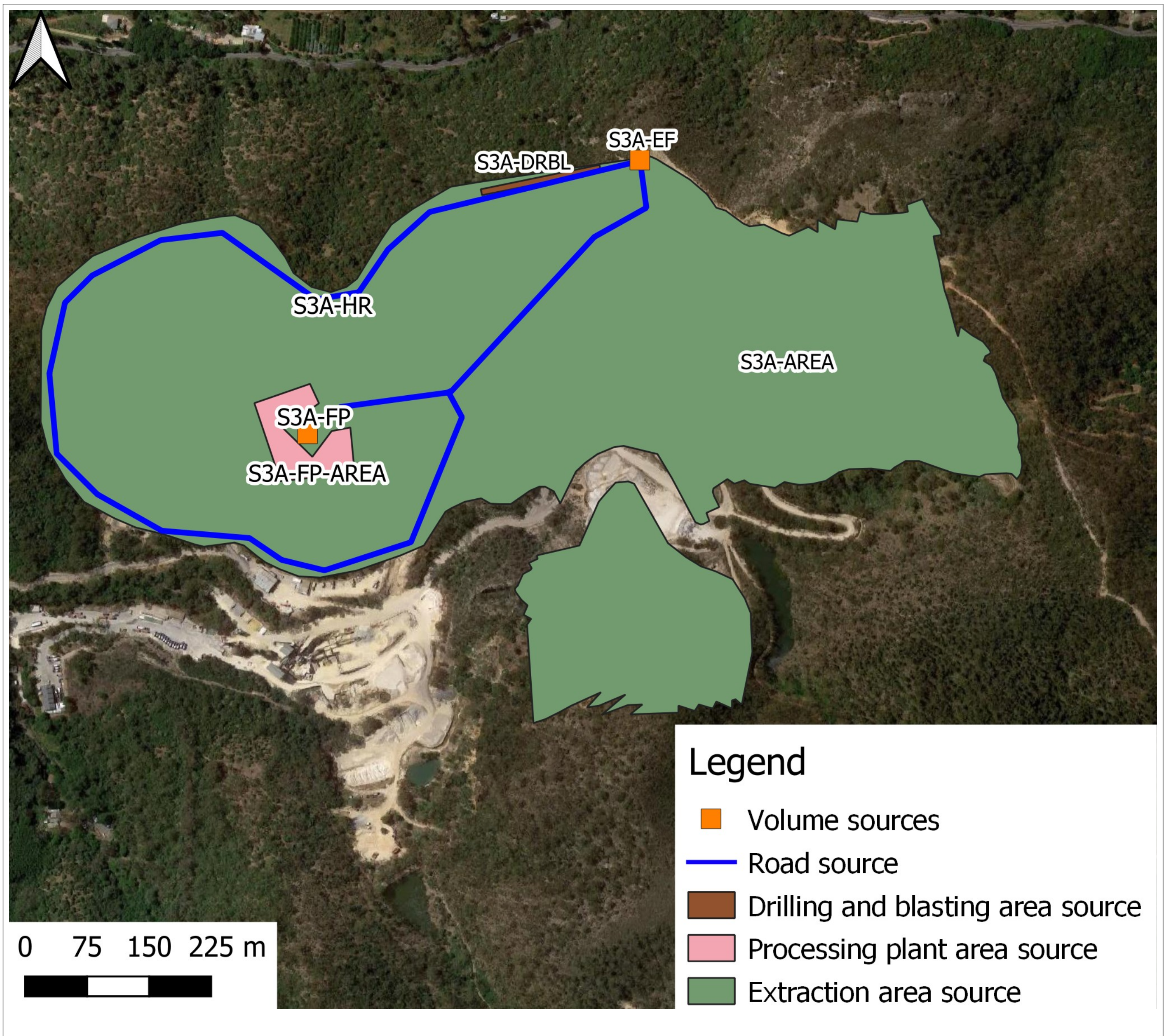


Figure 7.6 - Proposed Stage 3A – Modelled Sources

8 Air Dispersion Modelling

8.1 Overview

The following sections present details of the CALPUFF air dispersion modelling.

8.2 Meteorological Data

Meteorological data has been derived using CALMET. Full details of the inputs and verification outcomes of the CALMET modelling are provided in Section 6.

8.3 Emissions Data

The modelling scenarios and air emissions data used in CALPUFF are provided in the previous Section 7.

8.4 Deposited Dust Data

To allow for the modelling of dust deposition from the site, CALPUFF requires size parameters for dry deposition particles. CALPUFF requires both a Geometric Mass Mean Diameter and Geometric Standard Deviation to compute a deposition velocity. A review of existing literature has determined that limited studies have been conducted to determine the size parameters of rock quarry material. In the absence of any specific studies into size parameters, values have been adopted based on previous air quality assessments which have used CALPUFF to model dry deposition from rock quarry sources. Assessments reviewed include basalt quarries located in the Solomon Islands[4] and Cedar Point, NSW[5] as well as a Limestone quarry in Canada[6] and a Black Andersite quarry at Karuah, NSW[7]. Table 8.1 presents the range of values for TSP, PM_{10} and $PM_{2.5}$.

Table 8.1 - Summary of available quarry dust size parameters

	TSP		PM_{10}		$PM_{2.5}$	
	Geometric Mass Mean Diameter (Microns)	Geometric Standard Deviation (Microns)	Geometric Mass Mean Diameter (Microns)	Geometric Standard Deviation (Microns)	Geometric Mass Mean Diameter (Microns)	Geometric Standard Deviation (Microns)
Range	7.79 - 20	0 – 4.7	1.9 – 5	0 – 2.3	0.48 – 1	0 – 1.5

4 Golder Associates, March 2014. JEJEVO/ISABEL B Projects, Air Quality Assessment Monitoring Report. Report No. 137633001-6004-R-Rev0-2400.

5 Environmental Resources Management Australia, May 2012, Ceder Point Quarry Assessment.

6 Trinity Consultants, Novemebr 2015. CALPUFF Project Modelling Report (Detailed Air Dispersion Modelling Report). Project 134801.0035.

7 SLR Global Environmental Solutions, July 2013. Proposed Karuah East Quarry Projects, Pacific Highway, Karuah Air Quality Impact Assessment & Greenhouse Gas Assessment. Report Number 630.02482-R4R0.

	TSP		PM_{10}		$PM_{2.5}$	
	Geometric Mass Mean Diameter (Microns)	Geometric Standard Deviation (Microns)	Geometric Mass Mean Diameter (Microns)	Geometric Standard Deviation (Microns)	Geometric Mass Mean Diameter (Microns)	Geometric Standard Deviation (Microns)
Adopted	7.79	2.53	4.4	1.7	1	1

The range of size parameters for TSP, PM_{10} and $PM_{2.5}$ are noted to have limited variability between the assessments reviewed. A median value from all of the studies has been adopted for the size parameters (PM_{10} and $PM_{2.5}$) modelled in CALPUFF. A conservative approach has been adopted and TSP has been modelled using the minimum value of the range.

It should be noted that, to predict total deposited dust (mg/m^2/month), dry flux outputs for TSP (which covers the range of relevant particle sizes) has been adopted for comparison to the deposited dust limit.

8.5 Source Parameters

CALPUFF has been used to model to emission sources for the validation and assessment year. Volume, area and road sources have been adopted in CALPUFF to represent the range of air emission sources at the quarry. Area sources have been used for all exposed surface areas. Line sources have been used for all haul routes. All other emission sources have been modelled as volume sources. Source locations are presented in Section 7.4. Table 8.2 to 8.4 presents the modelled source parameters.

Table 8.2 - Volume Source Parameters

Activity/Source Description	Source ID	Elevation (m)	Height (m)	Initial Sigma Y (m)	Initial Sigma Z (m)
Concrete Batching Plant – Sand and Aggregate Deliveries	CB-SAD	274.9	2.0	1.0	1.0
Concrete Batching Plant – Sand and Aggregate Transfers	CB-SAT	274.6	2.0	1.0	1.0
Concrete Batching – Cement Deliveries	CB-CD	273.1	20.0	1.0	1.0
Concrete Batching Plant – Weigh Hopper Loading	CB-WHL	272.5	4.0	1.0	1.0
Concrete Batching Plant – Truck Loading	CB-TL	257.8	2.0	1.0	1.0
Future Plant – Stage 1	FP-S1	364.1	2.0	10	1.0
Future Plant – Stage 2	FP-S2	335.7	2.0	10	1.0
Future Plant – Stage 3	FP-S3	352.1	2.0	10	1.0
Future Plant – Stage 3A	FP-S3A	352.1	2.0	10	1.0
Stage 1 – Extraction Point	S1-EF	414.9	2.0	1.0	1.0
Stage 2 – Extraction Point	S2-EF	379.1	2.0	1.0	1.0
Stage 3 – Extraction Point	S3-EF	337.1	2.0	1.0	1.0
Stage 3A – Extraction Point	S3A-EF	337.1	2.0	1.0	1.0

Table 8.3 - Area Source Parameters

Activity/Source Description	Source ID	Elevation (m)	Height (m)	Initial Sigma Z (m)	Area (m^2)
Future Plant - Stockpile	FP-AREA	302	5	1.0	7254
Concrete Batching Plant - Stockpile	CB-AREA	274.2	2	1.0	811
Stage 1 – Extraction Area	S1-AREA	368.9	0	1.0	182367
Stage 1- Drilling and Blasting	S1-DRBL	407.7	0	1.0	1015
Stage 2 – Extraction Area	S2-AREA	343.8	0	1.0	293368

Activity/Source Description	Source ID	Elevation (m)	Height (m)	Initial Sigma Z (m)	Area (m^2)
Stage 2 – Drilling and Blasting	S2-DRBL	364.4	0	1.0	1020
Stage 3 – Extraction Area 1	S3-AREA-1	335.2	0	1.0	296554
Stage 3 – Extraction Area 2	S3-AREA-2	347.3	0	1.0	54320
Stage 3– Drilling and Blasting	S3-DRBL	358.3	0	1.0	1020
Stage 3A – Area 1	S3A-AREA-1	339.6	0	1.0	395383
Stage 3A – Area 2	S3A-AREA-2	347.3	0	1.0	54676
Stage 3A – Drilling and Blasting	S3A-DRBL	318.1	0	1.0	1007

Table 8.4 - Line Source Parameters

Activity/Source Description	Source ID	Height (m)	Initial Sigma Y (m)	Initial Sigma Z (m)	Total Line Length (m)
Concrete Batching Plant – Haul Route	CB-HR	2.0	4.2	3.4	544.5
Product Haul Route - Sealed	PROD-SL	2.0	4.2	3.4	265.4
Product Haul Route - Unsealed	PROD-US	2.0	4.2	3.4	709
Stage 1 – Haul Route	S1-HR	2.0	4.2	3.4	1541.9
Stage 2 – Haul Route	S2-HR	2.0	4.2	3.4	1242.9
Stage 3 – Haul Route	S3-HR	2.0	4.2	3.4	982.4
Stage 3A – Haul Route	S3A-HR	2.0	4.2	3.4	2127.8

8.6 Discrete Receptors

Figure 8.1 presents the modelled discrete receptors. A total of 26 receptors have been modelled at ground level to represent the nearest residential houses.

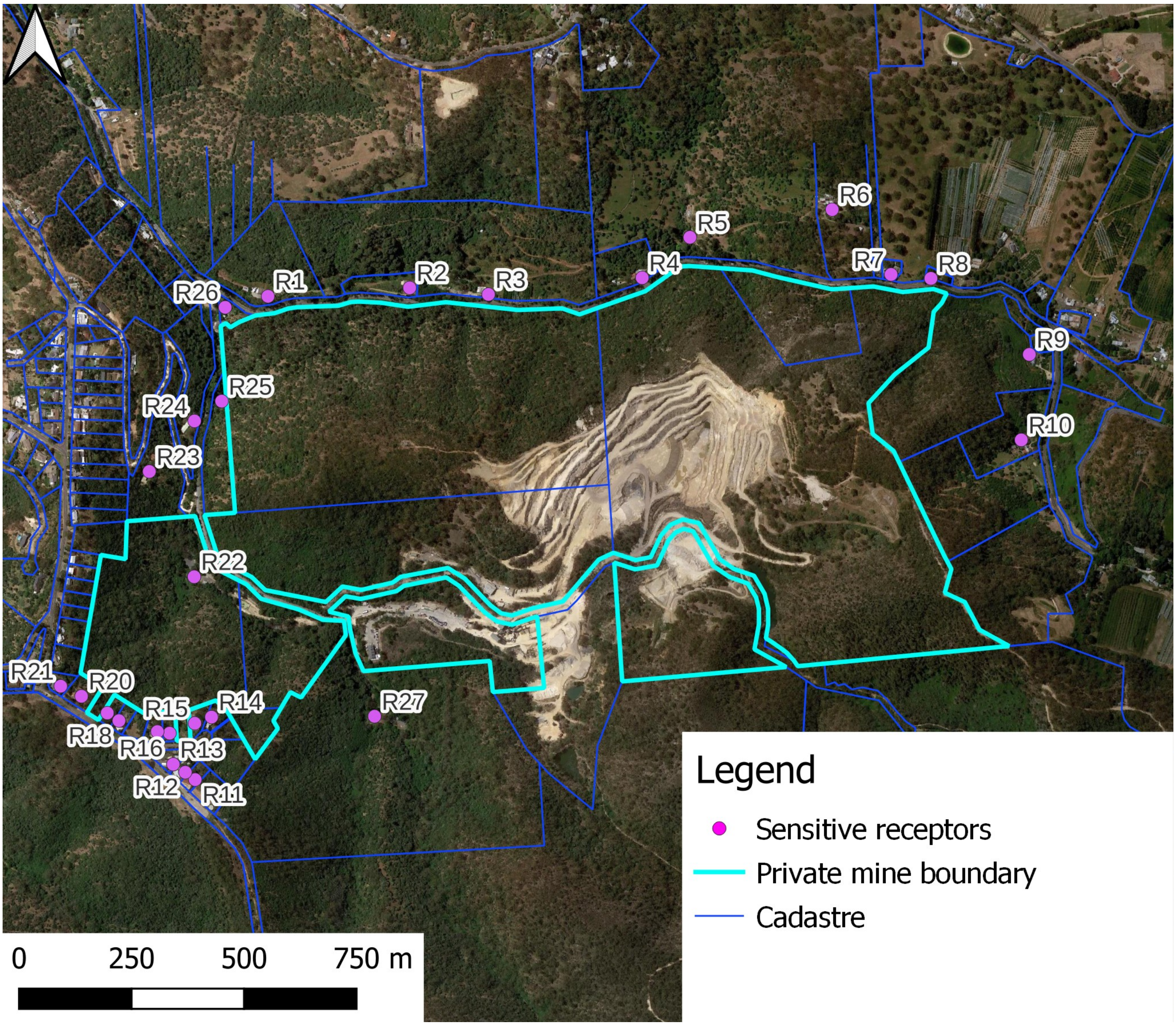


Figure 8.1 - Modelled Discrete Receptors

9 Predicted Results

Table 9.1 and 9.2 presents the predicted results for an average and worst-case throughput operating day. The highest result across all 27 modelled discrete receptors are shown in the results tables. Detailed results for each modelled discrete receptor are presented in Appendix B.

Table 9.1 - Predicted Results – Average Throughput Day

Pollutant	Maximum Predicted Ground Level Concentration at Discrete Receptors (µg/m^3)				AVG Time	Criteria
	Stage 1	Stage 2	Stage 3	Stage 3A		
Source Only						
TSP	44.4	44.9	41.8	48.5	24-hour	120
	4.8	3.2	3.1	3.8	Annual	90
PM_{10}	20.0	20.7	19.3	24.8	24-hour	50
	1.8	1.3	1.3	2.5	Annual	25
$PM_{2.5}$	4.5	4.6	4.5	5.0	24-hour	25
	0.3	0.3	0.3	0.3	Annual	8
Deposited Dust	1.6	1.0	0.7	1.7	g/m^2/month	4
Cumulative						
TSP	78.9	79.4	76.3	83.0	24-hour	120
	37.5	35.8	35.7	36.4	Annual	90
PM_{10}	36.1	36.8	35.4	40.9	24-hour	50
	17.1	16.6	16.6	17.8	Annual	25
$PM_{2.5}$	11.0	11.1	11.0	11.5	24-hour	25
	6.4	6.4	6.4	6.4	Annual	8
Deposited Dust	-	-	-	-	g/m^2/month	4

Table 9.2 - Predicted Results – Worst-Case Throughput Day

Pollutant	Maximum Predicted Ground Level Concentration at Discrete Receptors (µg/m^3)				AVG Time	Criteria
	Stage 1	Stage 2	Stage 3	Stage 3A		
Source Only						
TSP	81.9	63.0	57.7	70.1	24-hour	120
PM_{10}	31.9	28.3	26.3	31.0	24-hour	50
$PM_{2.5}$	5.3	5.4	5.3	5.7	24-hour	25
Cumulative						
TSP	116.4	97.4	92.2	104.6	24-hour	120
PM_{10}	48.0	44.4	42.4	47.1	24-hour	50
$PM_{2.5}$	11.8	11.9	11.8	12.2	24-hour	25

The results of the modelling demonstrate compliance with the air quality criteria for all the stages of the proposed development for the average and worst-case scenarios. The highest predicted concentrations are associated with Stages 1 and 3A, but in general, the concentrations are similar across stages (due to an identical material throughput). Concentrations differ due to extraction footprints, which also affects haul routes and worst-case extraction face locations. The highest pollutant prediction (relative to the ambient air quality goal) is for PM_{10} 24-hour. Ground level concentration plots for PM_{10} 24-hour during the worst-case operating day are presented in Appendix C.

The modelling is noted to take into account water cart spraying on the haul routes and water sprays at the mobile processing plant.

10 Crystalline Silica Review

10.1 Air Quality Criteria

The following sections presents a review of cyrstalline silica predictions, with a comparison to the interim air quality goal of 3 µg/m^3 (as PM_{10}).

10.2 Background RCS

Ambient RCS has been undertaken by Hanson during August and September 2022. The results are summarised in Table 10.1. The monitoring location is located along Coach Road, west of the quarry site.

Table 10.1 - Mesaured RCS Concentrations

Date	Measured RCS Concentrations (µg/m^3)
18/07/2022	0.073
24/07/2022	0.087
30/07/2022	0.076
05/08/2022	0.1 (wood burning nearby)
11/08/2022	0.030
17/08/2022	0.0080
23/08/2022	0.025
29/08/2022	0.026
04/09/2022	0.018
12/09/2022	0.027
18/09/2022	0.033
24/09/2022	0.019
Average Across All Days	0.044

In addition to the above data, based on a review of literature, three studies in South-East Queensland have been identified which have involved RCS sampling in areas surrounding various quarries from 2007 to present. These quarries are located in Mt Cotton[8], Yatala[9] and Oxenford[10]. Table 10.2 presents the background RCS concentrations measured at these locations and the RCS to $PM_{2.5}$ ratio for the same monitoring period.

8 DSITIA, Mount Cotton Quarry Dust Investigation, December 2008 to December 2009, Final Version.

9 DSITIA, Ormeau/Yatala Air Quality Investigation, March 2017.

10 DSITIA, Oxenford Air Monitoring Project, Fact Sheet: Oxenford Crystalline Silica and Dust Deposition – Interim Results from May to August 2020.

Table 10.2 - Background RCS Concentrations

Study Area	Measured RCS Concentrations	RCS:$PM_{2.5}$ Ratio	Averaging Time	Distance from Quarry
Mt Cotton	Site 1 – 0.14 µg/m^3 Site 2 – 0.26 µg/m^3	0.027 0.039	1 year	Site 1 – 1 km from quarry site Site 2 (neighbouring property): • 200 m from quarry truck site access route • 600 m from processing plant • 1000 m from quarry pit
Ormeau	Harts Road - 0.04 µg/m^3 Vennor Drive - 0.03 µg/m^3	0.0067 0.0093	14 months	Distance from 3 different quarries: • Harts Rd - 600 m, 1.6 km and 2.3 km • Vennor Dr - 2 km, 1.7 km and 1.3 km
Oxenford	0.04 µg/m^3	0.010	4 months	Not provided.

The measured RCS concentrations ranged from 0.03 µg/m^3 to 0.26 µg/m^3. The measured 0.044 µg/m^3 near White Rock Quarry is noted to be within the range of this data set, and similar to the results measured or Ormeau and Oxenford.

Ultimately, the purpose of reviewing background RCS concentrations is to allow for an assessment of cumulative impacts associated with proposed quarry operations (background RCS plus contribution from quarry). For the purpose of this review, the measured 0.044 µg/m^3 concentration has been adopted as an annual average for assessment against the relevant RCS annual average ambient air quality goal. Use of this measured concentration is considered conservative, as it is based on only 12 weeks of sampling. There is a potential that the measured concentration over 1-year would be lower (due to averaging/smoothing out of data). Furthermore, as the quarry was in operation at the time of the sampling, it is assumed that the quarry operations has some contribution to the measured RCS.

10.3 RCS to PM_{10} Ratio

Emissions factors for quarries are provided as typical particle size fractions of TSP, PM_{10} and $PM_{2.5}$. There are no available emission factors for RCS that have been identified during this review. In the absence of such information, one approach is to estimate RCS concentrations by factoring predicted PM_{10} concentrations by a known ratio of RCS to PM_{10} found in quarries.

Key sources for the quarry site include haul truck routes, processing plant and the extraction area (i.e. wind erosion, extraction activity, drill/blasting). RCS emissions from the site are influenced by the crystalline silica content of the rock being extracted. Sandstone-based material, as extracted at the White Rock Quarry (and typical of what is to be found in the Adelaide region and elsewhere in Australia), has a crystalline silica content in the order of 70%. This does not mean that 70% of PM_{10} emissions emitted from the quarry is expected to be crystalline silica, as not all particulate emissions from the quarry are from the rock deposit. In fact, the majority of emissions are associated with truck movements over haul routes (in the order of 40% of total emissions), for which the crystalline silica content is expected to be lower.

As a conservative approach, a 70% RCS composition has been assumed for all emission sources.

10.4 Predicted RCS Concentrations

Based on the above information, the following RCS concentrations are predicted for each stage of the quarry development.

Table 10.3 - Predicted RCS Concentrations

Parameter	Maximum Predicted Ground Level Concentration at Receptors (µg/m^3)			
	Stage 1	Stage 2	Stage 3	Stage 3A
PM_{10} Source Only[a]	1.8	1.3	1.3	2.5
RCS Source Only	1.3	0.9	0.9	1.8
Background RCS	0.044	0.044	0.044	0.044
RCS Cumulative	1.3	1.0	1.0	1.8
Criteria	3 µg/m^3			

[a] Based on Table 9.1 results

The predicted RCS concentrations for each stage of the quarry are well below the 3 µg/m^3 ambient air quality goal. Overall, based on the information gathered to date, crystalline silica concentrations in the surrounding area are expected to be within acceptable levels with the proposed quarry in operation. As noted previously, the assessment is conservative by assuming a 70% RCS composition (in PM_{10}) for all emission sources and it is likely that the adopted background RCS is relatively high.

11 Conclusion

An air quality assessment using air dispersion modelling has been undertaken for the proposed development; of the Hanson White Rock Quarry at Horsnells Gully Road, Horsnell Gully. To assess the potential for air quality impacts, computational air dispersion modelling has been undertaken to predict particulate (TSP, PM_{10} and $PM_{2.5}$) and deposited dust concentrations at the nearest sensitive receptor groups. The conclusions of the assessment are summarised below:

- The nearest sensitive receptors are dwellings located on rural residential land to the north and north-east of the site at the Norton Summit Township. The nearest dwelling is located 30 m north of the property boundary. The suburb of Skye is located 50 m to the west of the of the development site.
- The main air emission sources for the site include haul routes, the processing plant, concrete batching plant, extraction activity and wind erosion over extraction areas.
- The results of the modelling, assuming Level 1 haul route watering and a processing plant with water sprays, indicate compliance with the air quality criteria for all the stages of the proposed development for the average and worst-case scenarios. In addition to the watering and processing plant controls, it is essential that sealed access roads are cleaned regularly and maintained at all times to ensure silt loading is minimised.

Overall, the proposed quarry development is expected to result in increased particulate concentrations in the surrounding area, however, the potential for dust impacts can be effectively managed to achieve the relevant air quality goals with the above measures are in place.

Appendix A - Air Quality Glossary

APPENDIX A: GLOSSARY OF AIR QUALITY TERMINOLOGY	
Conversion of ppm to mg/m^3	Where R is the ideal gas constant; T, the temperature in Kelvin (273.16 + T°C); and P, the pressure in mm Hg, the conversion is as follows: $mg\ m^{-3} = (P/RT) \times \text{Molecular weight} \times (\text{concentration in ppm})$ $= \frac{P \times \text{Molecular weight} \times (\text{concentration in ppm})}{62.4 \times (273.2 + T°C)}$
g/s	Grams per second
mg/m^3	Milligrams (10^{-3}) per cubic metre.
$\mu g/m^3$	Micrograms (10^{-6}) per cubic metre.
ppb	Parts per billion.
ppm	Parts per million.
PM_{10}, $PM_{2.5}$	Fine particulate matter with an equivalent aerodynamic diameter of less than 10 or 2.5 micrometres respectively. Fine particulates are predominantly sourced from combustion processes. Vehicle emissions are a key source in urban environments.
50th percentile	The value exceeded for 50 % of the time.

Appendix B – Detailed Modelling Results (Base Scenario)

Table B1 - Stage 1 - Detailed Results - Average Throughput

No.	X	Y	Source Only ug/m3							Cumulative ug/m3						
			TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust	TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust
			24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$	24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$
1	289832	6133248	8.8	1.5	3.5	0.6	0.7	0.1	0.37	43.3	34.2	19.6	15.9	7.2	6.2	-
2	290147	6133267	14.1	2.7	5.4	1.0	0.8	0.1	0.66	48.6	35.3	21.5	16.3	7.3	6.2	-
3	290322	6133252	18.2	3.7	6.8	1.4	1.1	0.2	0.95	52.6	36.4	22.9	16.7	7.6	6.3	-
4	290664	6133289	23.9	4.8	9.2	1.8	1.4	0.2	1.08	58.4	37.5	25.3	17.1	7.9	6.3	-
5	290770	6133379	24.2	3.0	10.4	1.2	1.5	0.1	0.56	58.7	35.7	26.5	16.5	8.0	6.2	-
6	291086	6133441	43.6	2.3	17.3	1.0	2.1	0.1	0.40	78.1	35.0	33.4	16.3	8.6	6.2	-
7	291217	6133297	23.0	2.8	9.7	1.2	1.3	0.1	0.54	57.4	35.4	25.8	16.5	7.8	6.2	-
8	291306	6133288	27.0	2.5	10.8	1.1	1.3	0.1	0.47	61.5	35.1	26.9	16.4	7.8	6.2	-
9	291524	6133119	31.5	2.3	13.8	1.0	1.7	0.1	0.40	66.0	35.0	29.9	16.3	8.2	6.2	-
10	291507	6132929	38.7	3.6	16.9	1.6	2.0	0.2	0.74	73.2	36.3	33.0	16.9	8.5	6.3	-
11	289670	6132173	18.3	1.0	9.3	0.4	1.5	0.1	0.16	52.8	33.6	25.4	15.7	8.0	6.2	-
12	289648	6132190	17.2	1.0	8.8	0.4	1.4	0.1	0.16	51.7	33.6	24.9	15.7	7.9	6.2	-
13	289621	6132207	15.8	0.9	8.2	0.4	1.3	0.1	0.15	50.3	33.6	24.3	15.7	7.8	6.2	-
14	289707	6132312	20.7	1.3	9.6	0.5	1.6	0.1	0.20	55.2	33.9	25.7	15.8	8.1	6.2	-
15	289669	6132298	19.0	1.1	8.9	0.5	1.5	0.1	0.18	53.5	33.8	25.0	15.8	8.0	6.2	-
16	289613	6132277	16.2	1.0	7.8	0.4	1.3	0.1	0.16	50.6	33.6	23.9	15.7	7.8	6.2	-
17	289586	6132280	15.5	0.9	7.3	0.4	1.2	0.1	0.15	50.0	33.6	23.4	15.7	7.7	6.2	-
18	289501	6132304	14.3	0.8	6.8	0.4	1.0	0.1	0.14	48.8	33.5	22.9	15.7	7.5	6.2	-
19	289475	6132321	14.3	0.8	6.8	0.4	1.0	0.1	0.14	48.8	33.5	22.9	15.7	7.5	6.2	-
20	289417	6132359	14.1	0.8	6.7	0.3	1.0	0.1	0.13	48.6	33.4	22.8	15.6	7.5	6.2	-
21	289371	6132381	13.4	0.7	6.4	0.3	1.0	0.1	0.13	47.9	33.4	22.5	15.6	7.5	6.2	-
22	289668	6132624	14.2	1.5	5.6	0.6	1.1	0.1	0.23	48.7	34.1	21.7	15.9	7.6	6.2	-
23	289568	6132858	11.9	1.3	4.7	0.5	0.7	0.1	0.27	46.3	33.9	20.8	15.8	7.2	6.2	-
24	289669	6132971	9.7	1.4	4.2	0.6	0.8	0.1	0.32	44.2	34.1	20.3	15.9	7.3	6.2	-
25	289729	6133015	9.8	1.6	4.2	0.6	0.7	0.1	0.35	44.3	34.2	20.3	15.9	7.2	6.2	-
26	289737	6133224	7.7	1.3	3.2	0.5	0.5	0.1	0.31	42.2	34.0	19.3	15.8	7.0	6.2	-
27	290069	6132314	44.4	3.2	20.0	1.2	4.5	0.3	0.53	78.9	35.8	36.1	16.5	11.0	6.4	-
	Criteria		**120**	**90**	**50**	**25**	**25**	**8**	**4**	**120**	**90**	**50**	**25**	**25**	**8**	**4**

Table B2 - Stage 2 - Detailed Results - Average Throughput

No.	X	Y	Source Only ug/m3							Cumulative ug/m3						
			TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust	TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust
			24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$	24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$
1	289832	6133248	8.5	1.5	4.1	0.7	0.7	0.1	0.38	43.0	34.2	20.2	16.0	7.2	6.2	-
2	290147	6133267	14.7	2.5	6.9	1.1	0.9	0.1	0.65	49.2	35.1	23.0	16.4	7.4	6.2	-
3	290322	6133252	16.2	3.1	7.1	1.3	1.3	0.2	0.78	50.6	35.7	23.2	16.6	7.8	6.3	-
4	290664	6133289	24.5	3.1	12.0	1.3	1.8	0.2	0.50	59.0	35.7	28.1	16.6	8.3	6.3	-
5	290770	6133379	26.8	1.9	12.6	0.8	1.7	0.1	0.34	61.2	34.6	28.7	16.1	8.2	6.2	-
6	291086	6133441	29.6	1.4	13.4	0.6	1.7	0.1	0.22	64.1	34.0	29.5	15.9	8.2	6.2	-
7	291217	6133297	19.2	1.4	8.6	0.6	1.1	0.1	0.22	53.7	34.0	24.7	15.9	7.6	6.2	-
8	291306	6133288	21.6	1.2	9.8	0.6	1.2	0.1	0.18	56.1	33.8	25.9	15.9	7.7	6.2	-
9	291524	6133119	17.5	1.0	8.3	0.5	1.1	0.1	0.18	51.9	33.6	24.4	15.8	7.6	6.2	-
10	291507	6132929	16.5	1.3	9.3	0.6	1.2	0.1	0.27	51.0	34.0	25.4	15.9	7.7	6.2	-
11	289670	6132173	16.6	0.9	9.9	0.4	1.6	0.1	0.14	51.0	33.5	26.0	15.7	8.1	6.2	-
12	289648	6132190	15.8	0.9	9.6	0.4	1.5	0.1	0.14	50.3	33.5	25.7	15.7	8.0	6.2	-
13	289621	6132207	14.9	0.8	9.1	0.4	1.5	0.1	0.14	49.3	33.5	25.2	15.7	8.0	6.2	-
14	289707	6132312	18.3	1.2	11.0	0.6	1.8	0.1	0.19	52.7	33.8	27.1	15.9	8.3	6.2	-
15	289669	6132298	17.0	1.1	10.4	0.5	1.7	0.1	0.17	51.5	33.7	26.5	15.8	8.2	6.2	-
16	289613	6132277	14.6	0.9	9.1	0.4	1.4	0.1	0.15	49.1	33.6	25.2	15.7	7.9	6.2	-
17	289586	6132280	13.6	0.9	8.6	0.4	1.4	0.1	0.14	48.1	33.5	24.7	15.7	7.9	6.2	-
18	289501	6132304	11.5	0.8	7.1	0.4	1.1	0.1	0.13	46.0	33.4	23.2	15.7	7.6	6.2	-
19	289475	6132321	11.5	0.7	6.7	0.4	1.0	0.1	0.13	46.0	33.4	22.8	15.7	7.5	6.2	-
20	289417	6132359	11.5	0.7	6.3	0.3	1.0	0.1	0.12	46.0	33.4	22.4	15.6	7.5	6.2	-
21	289371	6132381	11.2	0.7	6.2	0.3	1.0	0.1	0.12	45.7	33.3	22.3	15.6	7.5	6.2	-
22	289668	6132624	13.2	1.5	6.1	0.6	1.2	0.1	0.23	47.7	34.1	22.2	15.9	7.7	6.2	-
23	289568	6132858	11.1	1.3	4.8	0.6	0.8	0.1	0.27	45.5	33.9	20.9	15.9	7.3	6.2	-
24	289669	6132971	9.8	1.5	4.7	0.6	0.8	0.1	0.33	44.3	34.1	20.8	15.9	7.3	6.2	-
25	289729	6133015	10.2	1.7	4.9	0.7	0.8	0.1	0.38	44.7	34.3	21.0	16.0	7.3	6.2	-
26	289737	6133224	7.7	1.4	3.7	0.6	0.6	0.1	0.33	42.2	34.0	19.8	15.9	7.1	6.2	-
27	290069	6132314	44.9	3.2	20.7	1.3	4.6	0.3	0.55	79.4	35.8	36.8	16.6	11.1	6.4	-
	Criteria		**120**	**90**	**50**	**25**	**25**	**8**	**4**	**120**	**90**	**50**	**25**	**25**	**8**	**4**

Table B3 - Stage 3 - Detailed Results - Average Throughput

No.	X	Y	Source Only ug/m3							Cumulative ug/m3						
			TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust	TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust
			24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$	24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$
1	289832	6133248	7.1	1.1	3.6	0.5	0.7	0.1	0.27	41.6	33.7	19.7	15.8	7.2	6.2	-
2	290147	6133267	10.8	1.5	5.0	0.7	0.8	0.1	0.37	45.2	34.1	21.1	16.0	7.3	6.2	-
3	290322	6133252	11.9	1.7	5.4	0.8	1.1	0.1	0.39	46.4	34.4	21.5	16.1	7.6	6.2	-
4	290664	6133289	15.8	1.5	8.1	0.7	1.4	0.1	0.20	50.3	34.2	24.2	16.0	7.9	6.2	-
5	290770	6133379	16.2	1.1	8.5	0.5	1.4	0.1	0.16	50.7	33.7	24.6	15.8	7.9	6.2	-
6	291086	6133441	25.1	0.9	14.1	0.5	1.8	0.1	0.13	59.6	33.6	30.2	15.8	8.3	6.2	-
7	291217	6133297	17.3	1.0	9.6	0.5	1.2	0.1	0.16	51.8	33.6	25.7	15.8	7.7	6.2	-
8	291306	6133288	15.2	0.9	8.6	0.5	1.0	0.1	0.15	49.7	33.6	24.7	15.8	7.5	6.2	-
9	291524	6133119	13.9	0.8	7.4	0.4	1.0	0.1	0.12	48.4	33.5	23.5	15.7	7.5	6.2	-
10	291507	6132929	19.8	1.1	10.9	0.6	1.4	0.1	0.19	54.3	33.8	27.0	15.9	7.9	6.2	-
11	289670	6132173	11.5	0.8	7.2	0.4	1.3	0.1	0.13	46.0	33.5	23.3	15.7	7.8	6.2	-
12	289648	6132190	11.5	0.8	6.7	0.4	1.2	0.1	0.13	46.0	33.4	22.8	15.7	7.7	6.2	-
13	289621	6132207	11.5	0.8	6.2	0.4	1.1	0.1	0.13	46.0	33.4	22.3	15.7	7.6	6.2	-
14	289707	6132312	18.8	1.1	9.6	0.5	1.6	0.1	0.18	53.3	33.8	25.7	15.8	8.1	6.2	-
15	289669	6132298	16.6	1.0	8.5	0.5	1.4	0.1	0.16	51.0	33.6	24.6	15.8	7.9	6.2	-
16	289613	6132277	13.7	0.8	7.2	0.4	1.1	0.1	0.14	48.2	33.5	23.3	15.7	7.6	6.2	-
17	289586	6132280	13.0	0.8	6.9	0.4	1.1	0.1	0.13	47.5	33.4	23.0	15.7	7.6	6.2	-
18	289501	6132304	11.6	0.7	6.1	0.3	1.0	0.1	0.12	46.0	33.3	22.2	15.6	7.5	6.2	-
19	289475	6132321	11.4	0.7	6.0	0.3	1.0	0.1	0.12	45.9	33.3	22.1	15.6	7.5	6.2	-
20	289417	6132359	11.0	0.6	5.8	0.3	0.9	0.1	0.12	45.5	33.3	21.9	15.6	7.4	6.2	-
21	289371	6132381	10.5	0.6	5.5	0.3	0.9	0.1	0.11	45.0	33.2	21.6	15.6	7.4	6.2	-
22	289668	6132624	14.9	1.4	6.3	0.6	1.2	0.1	0.24	49.4	34.0	22.4	15.9	7.7	6.2	-
23	289568	6132858	10.3	1.2	4.5	0.5	0.8	0.1	0.28	44.7	33.8	20.6	15.8	7.3	6.2	-
24	289669	6132971	9.2	1.3	4.4	0.6	0.8	0.1	0.32	43.7	33.9	20.5	15.9	7.3	6.2	-
25	289729	6133015	9.2	1.4	4.3	0.6	0.7	0.1	0.34	43.7	34.0	20.4	15.9	7.2	6.2	-
26	289737	6133224	6.6	1.0	3.0	0.5	0.6	0.1	0.24	41.0	33.7	19.1	15.8	7.1	6.2	-
27	290069	6132314	41.8	3.1	19.3	1.3	4.5	0.3	0.51	76.3	35.7	35.4	16.6	11.0	6.4	-
Criteria			**120**	**90**	**50**	**25**	**25**	**8**	**4**	**120**	**90**	**50**	**25**	**25**	**8**	**4**

Table B4 - Stage 3A - Detailed Results - Average Throughput

No.	X	Y	Source Only ug/m3							Cumulative ug/m3						
			TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust	TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust
			24-hour	Annual	24-hour	Annual	24-hour	Annual	g/m^2/month	24-hour	Annual	24-hour	Annual	24-hour	Annual	g/m^2/month
1	289832	6133248	10.2	2.6	6.9	0.8	0.8	0.1	0.88	45.2	34.4	22.0	16.4	7.5	6.2	-
2	290147	6133267	26.9	4.0	18.1	1.2	1.3	0.2	0.24	52.4	35.3	24.2	16.6	7.6	6.3	-
3	290322	6133252	38.0	5.2	19.1	2.6	1.5	0.2	0.35	53.2	36.0	25.2	16.9	8.0	6.3	-
4	290664	6133289	59.0	5.8	28.6	2.9	2.9	0.3	0.61	69.8	36.4	38.0	17.2	9.2	6.4	-
5	290770	6133379	66.8	3.5	20.6	1.2	3.0	0.2	0.56	71.2	34.8	36.0	16.6	9.5	6.3	-
6	291086	6133441	48.4	2.6	15.0	0.8	2.3	0.1	0.29	62.2	34.0	35.2	16.3	8.6	6.2	-
7	291217	6133297	29.2	2.6	16.0	0.7	1.9	0.1	0.29	56.1	34.0	27.8	16.0	8.2	6.2	-
8	291306	6133288	30.0	2.2	16.2	0.6	1.6	0.1	0.26	56.5	33.8	27.5	16.2	8.4	6.2	-
9	291524	6133119	47.2	1.8	18.6	0.5	1.5	0.1	0.27	51.7	33.6	24.8	16.8	8.0	6.2	-
10	291507	6132929	34.0	2.2	18.2	0.6	1.2	0.1	0.29	48.5	33.9	24.3	16.9	7.9	6.2	-
11	289670	6132173	42.0	1.0	10.3	0.5	2.2	0.1	0.33	54.5	33.7	26.8	16.8	8.2	6.2	-
12	289648	6132190	40.9	1.0	10.0	0.6	2.7	0.1	0.34	53.8	33.7	26.5	15.8	8.2	6.2	-
13	289621	6132207	38.3	1.6	13.9	0.6	2.6	0.1	0.33	52.9	33.7	26.0	15.9	8.5	6.2	-
14	289707	6132312	40.5	2.5	12.8	0.6	2.6	0.1	0.52	59.0	34.1	28.9	16.2	8.5	6.2	-
15	289669	6132298	45.6	2.3	16.2	0.6	2.8	0.1	0.26	56.8	34.0	27.6	16.9	8.9	6.2	-
16	289613	6132277	40.2	1.8	14.5	0.5	2.6	0.1	0.38	53.6	33.8	26.0	16.8	8.5	6.2	-
17	289586	6132280	38.9	1.7	13.2	0.5	1.9	0.1	0.37	52.3	33.7	25.8	16.8	8.0	6.2	-
18	289501	6132304	32.4	0.9	11.7	0.6	1.2	0.1	0.36	49.2	33.6	23.8	15.9	8.7	6.2	-
19	289475	6132321	30.9	0.9	11.2	0.6	1.2	0.1	0.35	48.9	33.6	23.4	15.9	8.0	6.2	-
20	289417	6132359	28.3	0.9	10.1	0.5	1.4	0.1	0.35	48.9	33.5	26.2	15.8	7.6	6.2	-
21	289371	6132381	24.8	0.8	9.0	0.5	1.4	0.1	0.33	48.6	33.5	25.8	15.8	7.6	6.2	-
22	289668	6132624	30.6	2.8	9.2	0.7	1.5	0.2	0.28	51.1	34.5	25.8	16.0	8.9	6.2	-
23	289568	6132858	19.2	2.6	5.6	0.9	0.8	0.1	0.85	47.7	34.3	23.5	16.0	7.5	6.2	-
24	289669	6132971	18.0	2.8	5.0	0.8	0.9	0.2	0.92	46.5	34.6	23.2	16.4	7.6	6.2	-
25	289729	6133015	19.9	3.2	5.8	0.9	0.9	0.2	0.69	47.3	34.8	23.5	16.2	7.6	6.2	-
26	289737	6133224	13.5	2.6	5.0	0.7	0.8	0.1	0.79	43.7	34.3	20.9	16.0	7.2	6.2	-
Criteria			120	90	50	25	25	8	4	120	90	50	25	25	8	4
Criteria			120	90	50	25	25	8	4	120	90	50	25	25	8	4

Table B5 - Stage 1 - Detailed Results - Worst-case Throughput

No.	X	Y	Source Only ug/m3							Cumulative ug/m3						
			TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust	TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust
			24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$	24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$
1	289832	6133248	16.6	2.7	6.1	1.0	0.9	0.1	0.67	51.1	35.4	22.2	16.3	7.4	6.2	-
2	290147	6133267	26.6	4.9	9.9	1.8	1.1	0.2	1.22	61.1	37.5	26.0	17.1	7.6	6.3	-
3	290322	6133252	34.4	6.9	12.6	2.5	1.3	0.3	1.78	68.9	39.5	28.7	17.8	7.8	6.4	-
4	290664	6133289	45.2	9.0	16.3	3.3	2.1	0.4	2.03	79.7	41.7	32.4	18.6	8.6	6.5	-
5	290770	6133379	43.7	5.5	18.2	2.1	2.3	0.2	1.04	78.2	38.2	34.3	17.4	8.8	6.3	-
6	291086	6133441	81.9	4.2	31.9	1.7	3.6	0.2	0.73	116.4	36.9	48.0	17.0	10.1	6.3	-
7	291217	6133297	42.7	5.0	17.7	2.0	2.1	0.2	0.99	77.2	37.7	33.8	17.3	8.6	6.3	-
8	291306	6133288	50.9	4.5	20.0	1.8	2.3	0.2	0.85	85.4	37.2	36.1	17.1	8.8	6.3	-
9	291524	6133119	57.0	4.2	23.9	1.7	2.8	0.2	0.73	91.5	36.8	40.0	17.0	9.3	6.3	-
10	291507	6132929	69.2	6.4	28.5	2.7	3.3	0.3	1.32	103.7	39.1	44.6	18.0	9.8	6.4	-
11	289670	6132173	31.4	1.6	15.5	0.7	2.2	0.1	0.27	65.9	34.3	31.6	16.0	8.7	6.2	-
12	289648	6132190	29.5	1.6	14.7	0.7	2.1	0.1	0.26	64.0	34.2	30.8	16.0	8.6	6.2	-
13	289621	6132207	27.3	1.6	13.7	0.7	1.9	0.1	0.26	61.8	34.2	29.8	16.0	8.4	6.2	-
14	289707	6132312	34.9	2.1	15.7	0.9	2.3	0.1	0.33	69.4	34.7	31.8	16.2	8.8	6.2	-
15	289669	6132298	32.3	1.9	14.8	0.8	2.1	0.1	0.31	66.8	34.5	30.9	16.1	8.6	6.2	-
16	289613	6132277	27.8	1.6	13.0	0.7	1.9	0.1	0.27	62.3	34.3	29.1	16.0	8.4	6.2	-
17	289586	6132280	26.7	1.6	12.2	0.7	1.7	0.1	0.26	61.2	34.2	28.3	16.0	8.2	6.2	-
18	289501	6132304	24.6	1.4	11.3	0.6	1.5	0.1	0.24	59.1	34.0	27.4	15.9	8.0	6.2	-
19	289475	6132321	24.6	1.3	11.3	0.6	1.5	0.1	0.23	59.0	34.0	27.4	15.9	8.0	6.2	-
20	289417	6132359	24.1	1.3	11.1	0.5	1.5	0.1	0.22	58.6	33.9	27.2	15.8	8.0	6.2	-
21	289371	6132381	23.0	1.2	10.6	0.5	1.4	0.1	0.21	57.4	33.8	26.7	15.8	7.9	6.2	-
22	289668	6132624	21.8	2.3	8.4	0.9	1.4	0.1	0.35	56.2	34.9	24.5	16.2	7.9	6.2	-
23	289568	6132858	20.1	2.0	7.8	0.8	1.0	0.1	0.41	54.6	34.7	23.9	16.1	7.5	6.2	-
24	289669	6132971	15.9	2.3	6.4	0.9	1.0	0.1	0.52	50.4	35.0	22.5	16.2	7.5	6.2	-
25	289729	6133015	16.8	2.6	6.7	1.0	1.0	0.1	0.58	51.3	35.2	22.8	16.3	7.5	6.2	-
26	289737	6133224	14.5	2.4	5.6	0.9	0.7	0.1	0.56	49.0	35.0	21.7	16.2	7.2	6.2	-
27	290069	6132314	62.8	4.8	27.6	1.8	5.3	0.3	0.79	97.3	37.4	43.7	17.1	11.8	6.4	-
	Criteria		**120**	**90**	**50**	**25**	**25**	**8**	**4**	**120**	**90**	**50**	**25**	**25**	**8**	**4**

Table B6 - Stage 2 - Detailed Results - Worst-case Throughput

No.	X	Y	Source Only ug/m3							Cumulative ug/m3						
			TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust	TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust
			24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$	24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$
1	289832	6133248	14.3	2.6	6.4	1.1	0.9	0.1	0.64	48.7	35.2	22.5	16.4	7.4	6.2	-
2	290147	6133267	25.3	4.2	11.1	1.7	1.3	0.2	1.13	59.7	36.9	27.2	17.0	7.8	6.3	-
3	290322	6133252	29.1	5.5	11.9	2.2	1.6	0.3	1.40	63.5	38.1	28.0	17.5	8.1	6.4	-
4	290664	6133289	41.3	5.5	18.9	2.1	2.5	0.3	0.90	75.8	38.2	35.0	17.4	9.0	6.4	-
5	290770	6133379	46.6	3.4	20.6	1.4	2.6	0.2	0.61	81.1	36.1	36.7	16.7	9.1	6.3	-
6	291086	6133441	53.3	2.5	23.0	1.1	2.8	0.1	0.39	87.8	35.1	39.1	16.4	9.3	6.2	-
7	291217	6133297	34.7	2.4	14.7	1.0	1.7	0.1	0.39	69.2	35.1	30.8	16.3	8.2	6.2	-
8	291306	6133288	39.0	2.1	16.7	0.9	2.0	0.1	0.32	73.5	34.7	32.8	16.2	8.5	6.2	-
9	291524	6133119	30.8	1.8	13.8	0.8	1.8	0.1	0.32	65.2	34.4	29.9	16.1	8.3	6.2	-
10	291507	6132929	29.6	2.3	14.9	1.0	1.8	0.1	0.47	64.1	34.9	31.0	16.3	8.3	6.2	-
11	289670	6132173	26.7	1.4	15.1	0.6	2.2	0.1	0.23	61.1	34.1	31.2	15.9	8.7	6.2	-
12	289648	6132190	25.5	1.4	14.6	0.6	2.1	0.1	0.23	60.0	34.0	30.7	15.9	8.6	6.2	-
13	289621	6132207	24.1	1.3	13.9	0.6	2.0	0.1	0.22	58.6	34.0	30.0	15.9	8.5	6.2	-
14	289707	6132312	29.1	1.9	16.7	0.8	2.5	0.1	0.30	63.6	34.5	32.8	16.1	9.0	6.2	-
15	289669	6132298	27.3	1.7	15.8	0.8	2.3	0.1	0.27	61.8	34.3	31.9	16.1	8.8	6.2	-
16	289613	6132277	23.7	1.5	13.9	0.7	2.0	0.1	0.24	58.2	34.1	30.0	16.0	8.5	6.2	-
17	289586	6132280	22.1	1.4	13.1	0.6	1.9	0.1	0.23	56.6	34.0	29.2	15.9	8.4	6.2	-
18	289501	6132304	18.7	1.2	10.9	0.6	1.5	0.1	0.20	53.2	33.9	27.0	15.9	8.0	6.2	-
19	289475	6132321	18.7	1.2	10.3	0.5	1.5	0.1	0.20	53.2	33.8	26.4	15.8	8.0	6.2	-
20	289417	6132359	18.6	1.1	9.7	0.5	1.4	0.1	0.19	53.1	33.8	25.8	15.8	7.9	6.2	-
21	289371	6132381	18.1	1.0	9.4	0.5	1.3	0.1	0.18	52.6	33.7	25.5	15.8	7.8	6.2	-
22	289668	6132624	19.5	2.2	8.7	0.9	1.5	0.1	0.33	54.0	34.8	24.8	16.2	8.0	6.2	-
23	289568	6132858	17.8	2.0	7.4	0.8	1.0	0.1	0.40	52.3	34.6	23.5	16.1	7.5	6.2	-
24	289669	6132971	14.9	2.3	6.7	1.0	1.0	0.1	0.52	49.4	34.9	22.8	16.3	7.5	6.2	-
25	289729	6133015	16.1	2.6	7.3	1.1	1.0	0.2	0.60	50.6	35.3	23.4	16.4	7.5	6.3	-
26	289737	6133224	12.8	2.3	5.8	1.0	0.8	0.1	0.55	47.3	34.9	21.9	16.3	7.3	6.2	-
27	290069	6132314	63.0	4.6	28.3	1.8	5.4	0.3	0.80	97.4	37.2	44.4	17.1	11.9	6.4	-
	Criteria		**120**	**90**	**50**	**25**	**25**	**8**	**4**	**120**	**90**	**50**	**25**	**25**	**8**	**4**

Table B7 - Stage 3 - Detailed Results - Worst-case Throughput

No.	X	Y	Source Only ug/m3							Cumulative ug/m3						
			TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust	TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust
			24-hour	Annual	24-hour	Annual	24-hour	Annual	g/m^2/month	24-hour	Annual	24-hour	Annual	24-hour	Annual	g/m^2/month
1	289832	6133248	11.0	1.8	5.1	0.8	0.8	0.1	0.45	45.5	34.4	21.2	16.1	7.3	6.2	-
2	290147	6133267	18.9	2.5	8.1	1.1	1.0	0.1	0.65	53.4	35.2	24.2	16.4	7.5	6.2	-
3	290322	6133252	20.3	2.9	8.8	1.3	1.4	0.2	0.68	54.7	35.6	24.9	16.6	7.9	6.3	-
4	290664	6133289	26.3	2.6	13.0	1.1	1.9	0.1	0.35	60.8	35.2	29.1	16.4	8.4	6.2	-
5	290770	6133379	27.6	1.8	14.0	0.8	2.0	0.1	0.28	62.1	34.5	30.1	16.1	8.5	6.2	-
6	291086	6133441	43.1	1.5	22.4	0.8	2.8	0.1	0.22	77.5	34.2	38.5	16.1	9.3	6.2	-
7	291217	6133297	29.5	1.7	14.9	0.8	1.8	0.1	0.29	64.0	34.3	31.0	16.1	8.3	6.2	-
8	291306	6133288	25.9	1.6	13.2	0.8	1.5	0.1	0.26	60.4	34.2	29.3	16.1	8.0	6.2	-
9	291524	6133119	24.2	1.4	12.1	0.7	1.6	0.1	0.21	58.7	34.0	28.2	16.0	8.1	6.2	-
10	291507	6132929	34.1	1.9	17.1	0.9	2.2	0.1	0.32	68.5	34.5	33.2	16.2	8.7	6.2	-
11	289670	6132173	19.0	1.3	10.9	0.6	1.8	0.1	0.20	53.4	33.9	27.0	15.9	8.3	6.2	-
12	289648	6132190	18.9	1.2	10.2	0.6	1.7	0.1	0.20	53.4	33.9	26.3	15.9	8.2	6.2	-
13	289621	6132207	18.8	1.2	9.4	0.6	1.5	0.1	0.20	53.3	33.8	25.5	15.9	8.0	6.2	-
14	289707	6132312	29.9	1.7	14.3	0.8	2.1	0.1	0.28	64.4	34.3	30.4	16.1	8.6	6.2	-
15	289669	6132298	26.5	1.5	12.8	0.7	1.9	0.1	0.25	61.0	34.2	28.9	16.0	8.4	6.2	-
16	289613	6132277	22.1	1.3	10.9	0.6	1.6	0.1	0.22	56.6	34.0	27.0	15.9	8.1	6.2	-
17	289586	6132280	21.0	1.2	10.4	0.6	1.5	0.1	0.21	55.5	33.9	26.5	15.9	8.0	6.2	-
18	289501	6132304	18.6	1.1	9.2	0.5	1.3	0.1	0.19	53.1	33.7	25.3	15.8	7.8	6.2	-
19	289475	6132321	18.3	1.0	9.1	0.5	1.3	0.1	0.19	52.8	33.7	25.2	15.8	7.8	6.2	-
20	289417	6132359	17.5	1.0	8.7	0.5	1.3	0.1	0.18	52.0	33.6	24.8	15.8	7.8	6.2	-
21	289371	6132381	16.7	0.9	8.3	0.4	1.2	0.1	0.18	51.2	33.6	24.4	15.7	7.7	6.2	-
22	289668	6132624	22.2	2.0	9.1	0.9	1.5	0.1	0.35	56.7	34.7	25.2	16.2	8.0	6.2	-
23	289568	6132858	15.2	1.8	6.5	0.8	1.0	0.1	0.42	49.6	34.4	22.6	16.1	7.5	6.2	-
24	289669	6132971	13.9	2.0	6.3	0.8	1.0	0.1	0.50	48.4	34.6	22.4	16.1	7.5	6.2	-
25	289729	6133015	14.2	2.1	6.4	0.9	1.0	0.1	0.55	48.7	34.8	22.5	16.2	7.5	6.2	-
26	289737	6133224	10.2	1.7	4.7	0.7	0.7	0.1	0.41	44.7	34.3	20.8	16.0	7.2	6.2	-
27	290069	6132314	57.7	4.4	26.3	1.8	5.3	0.3	0.73	92.2	37.1	42.4	17.1	11.8	6.4	-
Criteria			**120**	**90**	**50**	**25**	**25**	**8**	**4**	**120**	**90**	**50**	**25**	**25**	**8**	**4**

Table B8 - Stage 3A - Detailed Results - Worst-case Throughput

No.	X	Y	Source Only ug/m3							Cumulative ug/m3						
			TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust	TSP	TSP	PM_{10}	PM_{10}	$PM_{2.5}$	$PM_{2.5}$	Dust
			24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$	24-hour	Annual	24-hour	Annual	24-hour	Annual	$g/m^2/month$
1	289832	6133248	17.7	3.1	7.7	1.3	1.1	0.2	0.80	52.2	35.8	23.8	16.6	7.6	6.3	-
2	290147	6133267	31.2	4.7	13.4	1.9	1.6	0.2	1.15	65.7	37.3	29.5	17.2	8.1	6.3	-
3	290322	6133252	32.4	5.8	14.0	2.5	1.9	0.3	1.28	66.9	38.5	30.1	17.8	8.4	6.4	-
4	290664	6133289	58.3	6.3	27.5	2.8	3.4	0.3	1.02	92.8	39.0	43.6	18.1	9.9	6.4	-
5	290770	6133379	60.4	3.7	29.5	1.7	3.6	0.2	0.63	94.9	36.3	45.6	17.0	10.1	6.3	-
6	291086	6133441	48.9	2.4	22.7	1.2	2.7	0.1	0.37	83.4	35.1	38.8	16.5	9.2	6.2	-
7	291217	6133297	38.0	2.4	18.0	1.1	2.2	0.1	0.36	72.4	35.1	34.1	16.4	8.7	6.2	-
8	291306	6133288	39.1	2.1	18.3	1.0	2.2	0.1	0.29	73.6	34.7	34.4	16.3	8.7	6.2	-
9	291524	6133119	30.6	1.7	13.9	0.8	1.8	0.1	0.29	65.1	34.3	30.0	16.1	8.3	6.2	-
10	291507	6132929	25.0	2.1	12.9	1.0	1.6	0.1	0.43	59.5	34.8	29.0	16.3	8.1	6.2	-
11	289670	6132173	33.9	1.7	17.5	0.8	2.5	0.1	0.30	68.4	34.4	33.6	16.1	9.0	6.2	-
12	289648	6132190	32.9	1.7	17.0	0.8	2.4	0.1	0.29	67.3	34.4	33.1	16.1	8.9	6.2	-
13	289621	6132207	31.5	1.7	16.4	0.7	2.3	0.1	0.28	66.0	34.3	32.5	16.0	8.8	6.2	-
14	289707	6132312	41.8	2.4	20.9	1.0	3.0	0.1	0.40	76.2	35.1	37.0	16.3	9.5	6.2	-
15	289669	6132298	38.1	2.2	19.3	0.9	2.7	0.1	0.36	72.6	34.8	35.4	16.2	9.2	6.2	-
16	289613	6132277	32.9	1.9	16.9	0.8	2.4	0.1	0.31	67.3	34.5	33.0	16.1	8.9	6.2	-
17	289586	6132280	30.9	1.8	16.0	0.8	2.2	0.1	0.30	65.4	34.4	32.1	16.1	8.7	6.2	-
18	289501	6132304	25.7	1.6	13.5	0.7	1.8	0.1	0.26	60.2	34.2	29.6	16.0	8.3	6.2	-
19	289475	6132321	24.6	1.5	12.9	0.7	1.7	0.1	0.26	59.1	34.2	29.0	16.0	8.2	6.2	-
20	289417	6132359	24.6	1.4	11.7	0.6	1.6	0.1	0.25	59.1	34.1	27.8	15.9	8.1	6.2	-
21	289371	6132381	24.1	1.4	11.4	0.6	1.6	0.1	0.24	58.6	34.0	27.5	15.9	8.1	6.2	-
22	289668	6132624	25.8	2.9	11.1	1.2	1.7	0.2	0.45	60.3	35.5	27.2	16.5	8.2	6.3	-
23	289568	6132858	22.6	2.7	9.0	1.1	1.2	0.2	0.56	57.1	35.3	25.1	16.4	7.7	6.3	-
24	289669	6132971	19.6	3.2	8.3	1.3	1.2	0.2	0.75	54.1	35.8	24.4	16.6	7.7	6.3	-
25	289729	6133015	21.9	3.7	9.2	1.5	1.2	0.2	0.89	56.4	36.4	25.3	16.8	7.7	6.3	-
26	289737	6133224	16.2	2.8	6.9	1.1	0.9	0.2	0.69	50.7	35.5	23.0	16.4	7.4	6.3	-
27	290069	6132314	70.1	5.5	31.0	2.1	5.7	0.4	1.01	104.6	38.1	47.1	17.4	12.2	6.5	-
Criteria			**120**	**90**	**50**	**25**	**25**	**8**	**4**	**120**	**90**	**50**	**25**	**25**	**8**	**4**

Appendix C – Concentration Plots (Base Scenario)

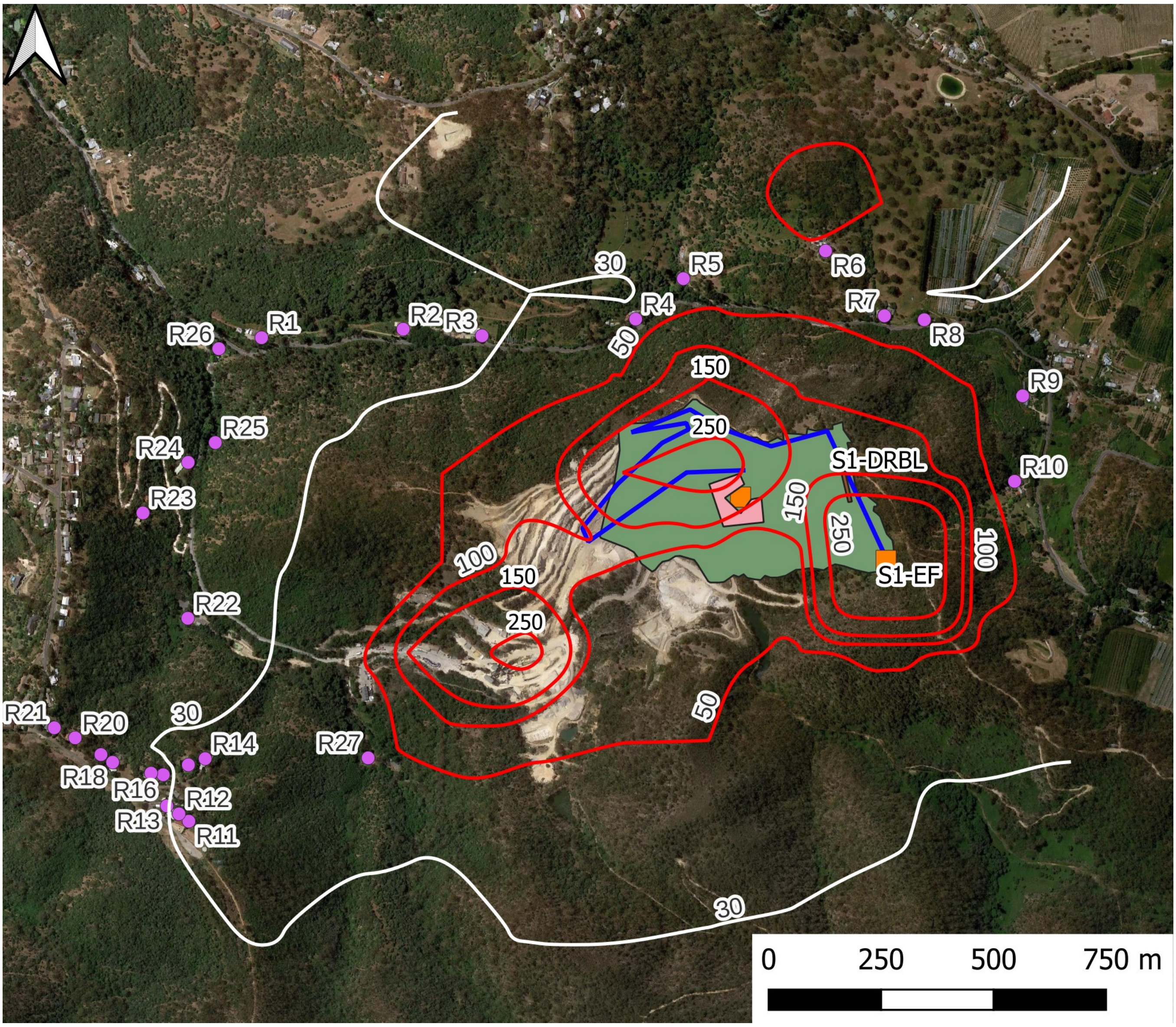


Figure C1: Stage 1 – Worst-case Daily Throughput - Predicted Ground Level PM_{10} 24-hour Concentrations (Cumulative)

Stage 3A **Scenario:** Worst-case daily throughput	**Pollutant:** PM_{10} **Averaging Time:** 24-hour **Units:** µg/m³ **Criteria:** 50

Appendix D – Proposed Development Plans