Appendix 8

Air Quality Impact Assessment

Prepared by Todoroski Air Sciences Pty Ltd

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AIR QUALITY IMPACT ASSESSMENT
BUNGENDORE SANDS
EXTENSION PROJECT

Grantham Park Holdings Pty Limited

13 January 2020

Job Number 19091012

Prepared by

Todoroski Air Sciences Pty Ltd

Suite 2B, 14 Glen Street

Eastwood, NSW 2122

Phone: (02) 9874 2123

Fax: (02) 9874 2125

Email: info@airsciences.com.au

Air Quality Impact Assessment
Bungendore Sands Extension Project

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1 INTRODUCTION

Todoroski Air Sciences has prepared this report for RW Corkery & Co Pty Limited on behalf of Grantham Park Holdings Pty Limited. The report presents an assessment of potential air quality impacts associated with the proposed ongoing extraction of sand at the existing Bungendore Sands Quarry located at Bungendore, New South Wales (NSW) (hereafter referred to as the Project).

The Project is seeking to expand its existing extraction area and allow for a maximum annual production of sand up to 400,000 tonnes per annum (tpa) and extend the life of the operations by approximately 20 years.

This air quality impact assessment has been prepared in general accordance with the New South Wales (NSW) Environment Protection Authority (EPA) document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**).

To assess the potential air quality impacts associated with the Project, this report comprises:

- A background to the Project and description of the proposed site and operations;
- A review of the existing meteorological and air quality environment surrounding the site;
- A description of the dispersion modelling approach and emission estimation used to assess potential air quality impacts; and,
- Presentation of the predicted results and discussion of the potential air quality impacts and associated mitigation and management measures.

2 PROJECT BACKGROUND

2.1 Project setting

The Project site is located approximately 5 kilometres (km) north of Bungendore and, approximately 31km northeast of Queanbeyan with the surrounding land use characterised as predominantly rural. The northeastern boundary of the site is situated along Butamaroo Creek which, along with Turallo Creek to the southwest of the Project, drains into Lake George approximately 1km northwest of the Project.

Located to the southwest of the Project are two sand quarry developments, identified as Corkhill Quarry approximately 1.6km from the Project, and Holcim's Leone/Monier Quarry approximately 2.5km from the Project. **Figure 2-1** presents the location of the Project with reference to the two sand quarry developments.

Figure 2-2 presents a pseudo three-dimensional visualisation of the topography in the general vicinity of the Project. The Project site can be characterised as relatively flat with undulating hills to the east and a ridgeline to the west of the Project site.

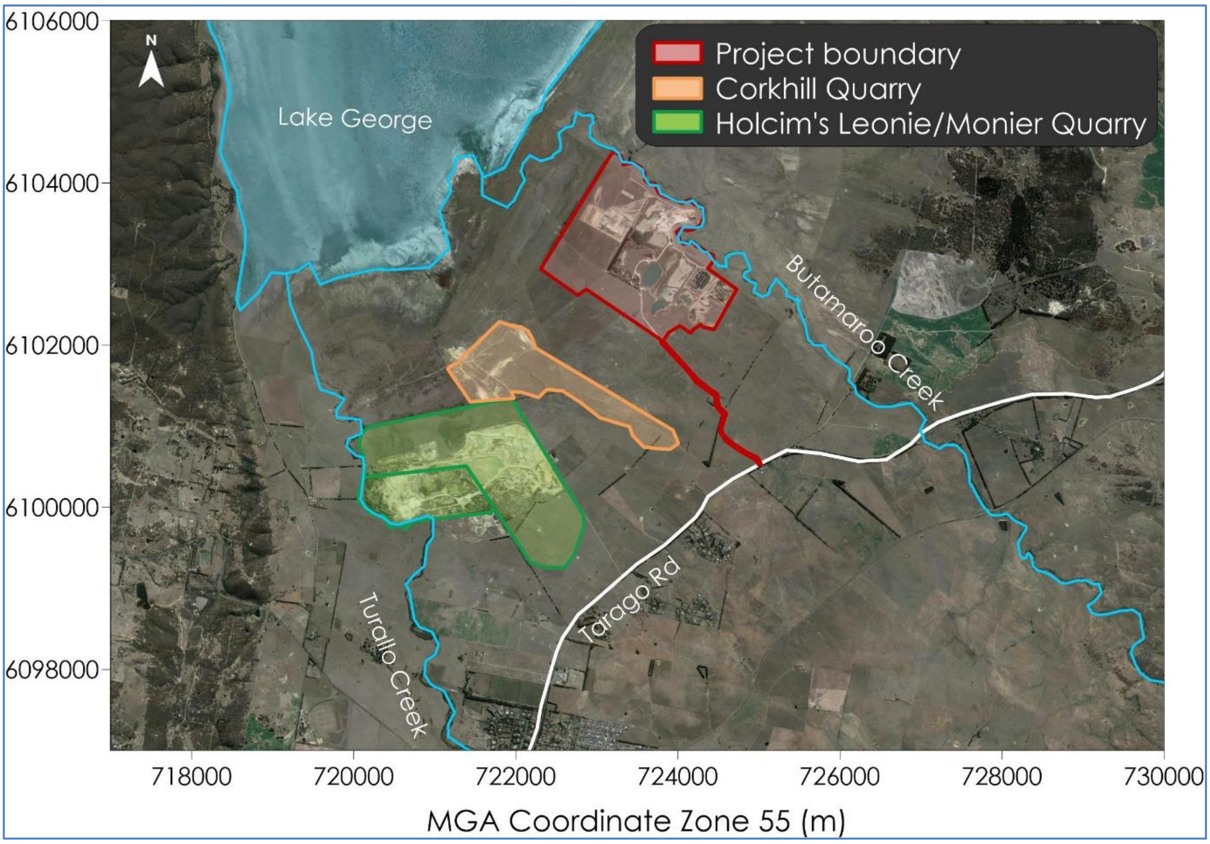

Figure 2-1: Project setting

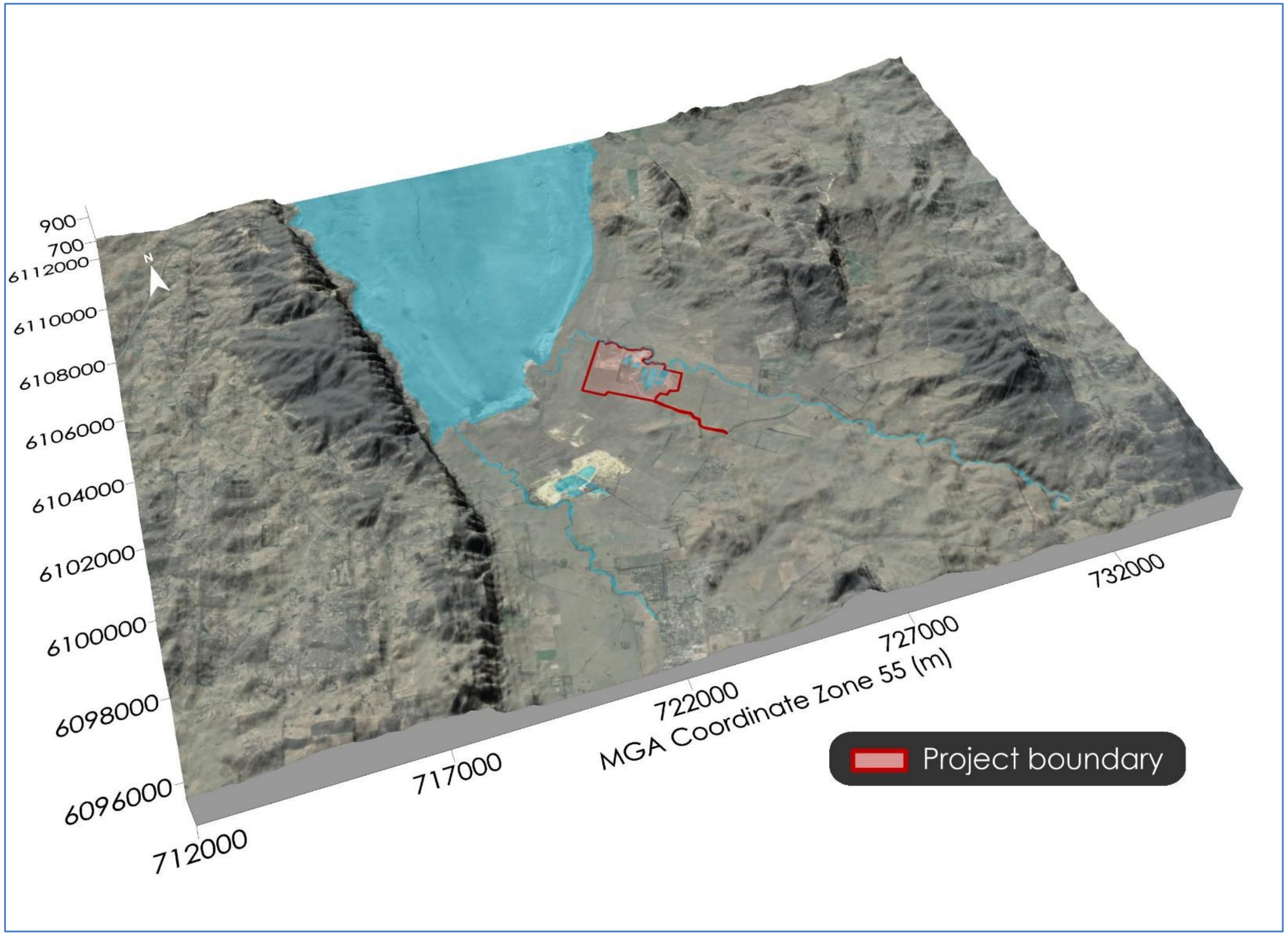

Figure 2-2: Representative visualisation of topography in the area surrounding the Project

2.2 Project description

2.2.1 Existing operations

The existing operations at the quarry are undertaken using typical extraction equipment including scrapers, excavators and haul trucks. Overburden and interburden is stripped and stockpiled in completed extraction cells ready to be shaped to form the intended final landform. The target sand resource is extracted using an excavator and transported with off-road haul trucks and stockpiled in the Sand Classifying Plant area prior to processing.

The sand resource is selectively blended and fed into the sand classifying plant which uses water to remove clay and silt from the sand and to achieve the required size grading. The water discharged from processing operations in the sand classifying plant contains high concentrations of suspended solids and is managed in the fines settlement operations. Processed material is stockpiled and transported off-site along the site access road which intersects at Tarago Road. The site access road is unsealed.

The existing operations have a current production rate of approximately 180,000tpa of product sand with each extraction cell containing between 20% and 30% of overburden and interburden, and between 10% and 20% of the raw feed material as fines.

2.2.2 Proposed operations

The Project seeks to expand the existing extraction area to allow for a maximum production rate of 400,000tpa of washed sand products and extend the life of the operations by approximately 20 years.

The Project would operate in a similar manner to existing operations with sand processed at the sand classifying plant and transported off-site. The quantity of extracted material would be similar to the existing operations, with approximately 600,000tpa of material extracted comprising of 60,000tpa of overburden and 60,000tpa of interburden. The raw material processed in the sand classifying plant comprising of 80,000tpa of fines and 400,000tpa product material.

Extraction operations would continue in the current extraction area (extraction cell E1) with extraction proceeding from southwest to northeast. Extraction would then progress to the proposed extraction areas in numerical order from extraction cell E2 to extraction cell E10. Typically, two or three extraction cells would operate concurrently, with one cell nearing the end of its extraction life and the subsequent cell at an early stage in its extraction life.

Figure 2-3 provides an indicative site layout of the Project and **Figure 2-4** presents the receptor locations surrounding the Project. The nearest residential receptor to the Project is located approximately 2.5km to the south of the site entrance.

The proposed operational hours for the Project are listed in **Table 2-1** below and are identical to the operational hours for the approved operations.

Table 2-1: Operational hours for the Project

Activity	Monday to Friday	Saturday	Sunday
Site Establishment	6:00am – 5:00pm	6:00am – 2:00pm	-
Extraction	6:00am – 5:00pm	6:00am – 2:00pm	-
Processing	6:00am – 5:00pm	6:00am – 2:00pm	-
Loading and Transportation	6:00am – 5:00pm	6:00am – 2:00pm	-
Rehabilitation	6:00am – 5:00pm	6:00am – 2:00pm	7:00am – 6:00pm
Maintenance	6:00am – 5:00pm	6:00am – 2:00pm	7:00am – 6:00pm

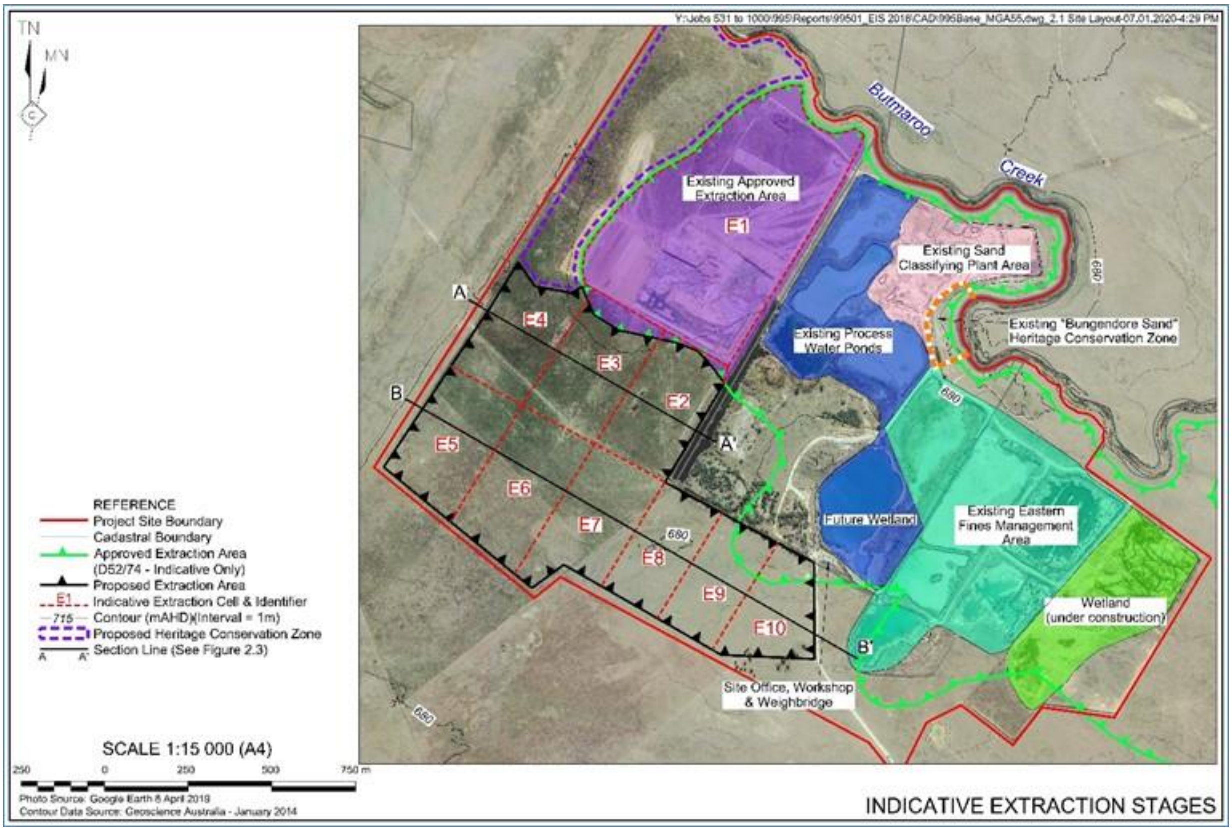

Figure 2-3: Site layout for the Project

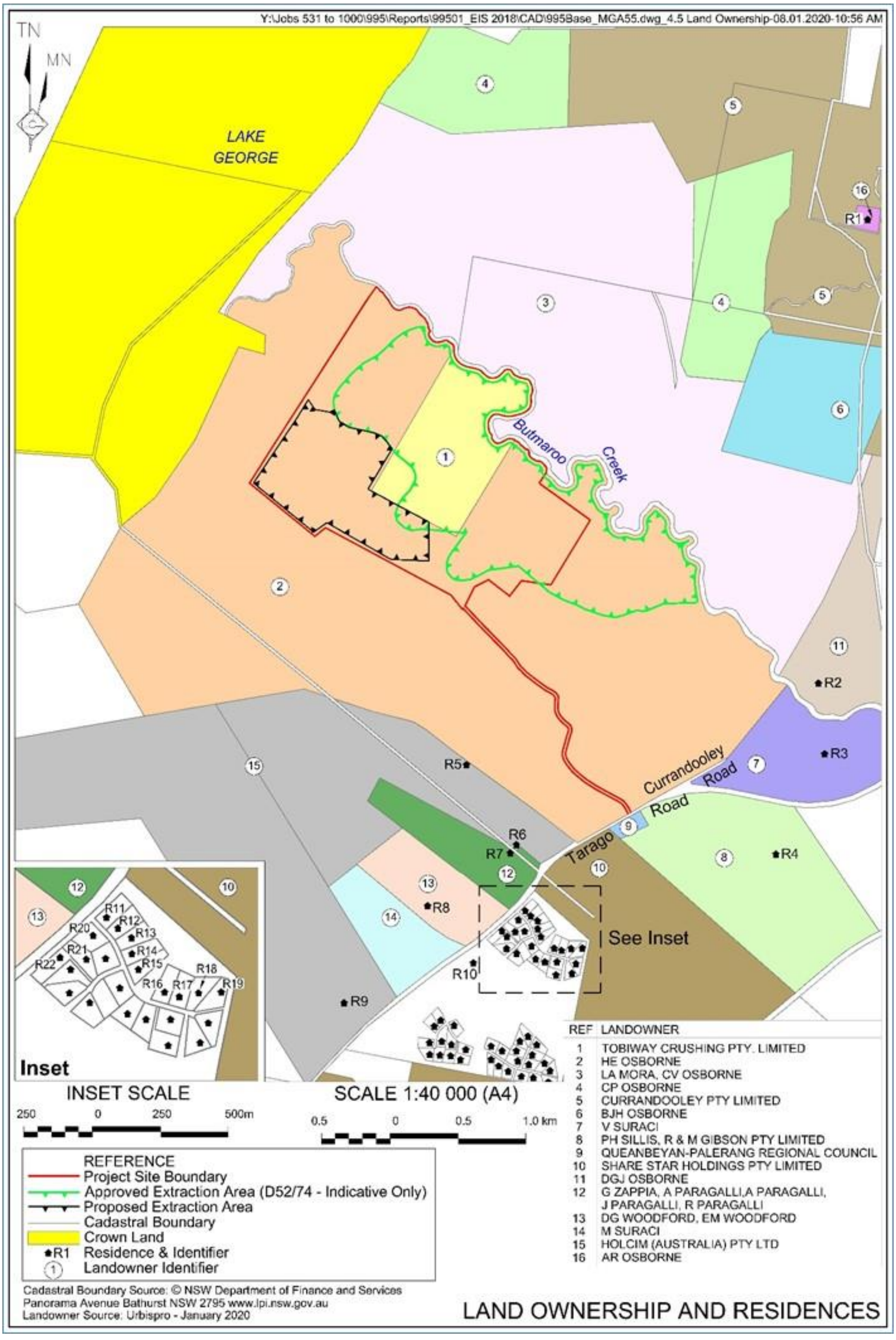

Figure 2-4: Site layout for the Project

3 AIR QUALITY CRITERIA

3.1 Particulate matter

Particulate matter consists of dust particles of varying size and composition. Air quality goals refer to measures of the total mass of all particles suspended in air defined as the Total Suspended Particulate matter (TSP). The upper size range for TSP is nominally taken to be 30 micrometres (µm) as in practice particles larger than 30 to 50µm will settle out of the atmosphere too quickly to be regarded as air pollutants.

Two sub-classes of TSP are also included in the air quality goals, namely PM_{10}, particulate matter with equivalent aerodynamic diameters of 10µm or less, and $PM_{2.5}$, particulate matter with equivalent aerodynamic diameters of 2.5µm or less.

Particulate matter, typically in the upper size range, that settles from the atmosphere and deposits on surfaces is characterised as deposited dust. The deposition of dust on surfaces may be considered a nuisance and can adversely affect the amenity of an area by soiling property in the vicinity.

3.2 NSW EPA impact assessment criteria

Table 3-1 summarises the air quality goals that are relevant to this assessment as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2017**).

The air quality goals for total impact relate to the total pollutant burden in the air and not just the contribution from the Project. Consideration of background pollutant levels needs to be made when using these goals to assess potential impacts.

Table 3-1: NSW EPA air quality impact assessment criteria

Pollutant	Averaging Period	Impact	Criterion
TSP	Annual	Total	90 µg/m³
PM_{10}	Annual	Total	25 µg/m³
	24 hour	Total	50 µg/m³
$PM_{2.5}$	Annual	Total	8µg/m³
	24 hour	Total	25 µg/m³
Deposited dust	Annual	Incremental	2 g/m²/month
		Total	4 g/m²/month

Source: **NSW EPA, 2017**
µg/m³ = micrograms per cubic metre
g/m²/month = grams per square metre per month

3.3 Crystalline silica

Silica occurs in nature in a crystalline or amorphous form, and may be synthetically produced in amorphous forms. Silica is commonly found in soil and rocks, the most common form is quartz, followed by cristobalite and tridymite. The crystalline form of silica has potential to cause adverse health effects in humans. Occupational exposure to respirable crystalline silica has potential to result in silicosis (**NIOSH, 1974**).

Various jurisdictions have developed criteria for acceptable levels of exposure to crystalline silica. These include the Victorian criterion adopted from Californian reference exposure level values, and occupational standards. **Table 3-2** presents the Victorian impact assessment criteria (**VIC EPA, 2007**) which are the most stringent available standards for respirable crystalline silica and which are applied to the Project.

Table 3-2: Air Quality Criterion for Respirable Silica

Pollutant	Averaging period	Criterion (µg/m³)	Organisation
Respirable crystalline silica (as $PM_{2.5}$)	Annual	3	VIC EPA

Source: VIC EPA (2007)

4 EXISTING ENVIRONMENT

This section describes the existing environment including the climate and ambient air quality in the area surrounding the Project.

4.1 Local climatic conditions

Long-term climatic data from the closest Bureau of Meteorology (BoM) weather station at Canberra Airport Comparison (Site No. 070014) were analysed to characterise the local climate in the proximity of the Project. Canberra Airport Comparison weather station is located approximately 26.3km southwest of the Project.

Table 4-1 and **Figure 4-1** present a summary of data from the Canberra Airport Comparison weather station collected over a 32 to 72 year period for the various meteorological parameters.

The data indicate that January is the hottest month with a mean maximum temperature of 28.0 degrees Celsius (°C) and July is the coldest month with a mean minimum temperature of -0.1°C.

Rainfall decreases during the colder months, with an annual average rainfall of 615.4 millimetres (mm) over 72.0 days. The data indicate that November is the wettest month with an average rainfall of 64.4mm over 7.5 days and June is the driest month with an average rainfall of 40.5mm over 5.7 days.

Relative humidity levels exhibit little variability over the day and seasonal fluctuations. Mean 9am relative humidity ranges from 60% in December to 85% in June and July. Mean 3pm relative humidity levels range from 37% in January and December to 60% in June.

Wind speeds during the warmer months have a greater spread between the 9am and 3pm conditions compared to the colder months. Mean 9am wind speeds range from 6.1 kilometres per hour (km/h) in March to 10.9km/h in October. Mean 3pm wind speeds range from 14.4km/h in April and May to 20.7km/h in September and October.

Table 4-1: Monthly climate statistics summary – Canberra Airport Comparison weather station

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature													
Mean max. temp. (°C)	28.0	27.1	24.5	20.0	15.6	12.3	11.4	13.0	16.2	19.4	22.7	26.1	19.7
Mean min. temp. (°C)	13.2	13.1	10.7	6.7	3.2	1.0	-0.1	1.0	3.3	6.1	8.8	11.4	6.5
Rainfall													
Rainfall (mm)	58.5	56.4	50.7	46.0	44.4	40.5	41.4	46.2	52.0	62.4	64.4	53.2	615.4
No. of rain days	5.6	5.1	4.8	4.8	5.1	5.7	5.8	7.0	7.0	7.8	7.5	5.8	72.0
9am conditions													
Mean temp. (°C)	19.1	18.3	16.2	12.3	8.0	5.0	3.9	5.9	9.6	13.2	15.6	18.1	12.1
Mean R.H. (%)	63	68	71	75	82	85	85	78	71	65	63	60	72
Mean W.S. (km/h)	7.5	6.4	6.1	6.5	6.9	7.8	8.5	9.9	10.4	10.9	9.8	9.1	8.3
3pm conditions													
Mean temp. (°C)	26.5	25.7	23.3	19.0	14.7	11.4	10.5	12.1	15.1	18.2	21.4	24.6	18.5
Mean R.H. (%)	37	40	42	46	54	60	58	52	49	47	41	37	47
Mean W.S. (km/h)	16.9	15.2	14.6	14.4	14.4	15.4	17.1	19.8	20.7	20.7	19.6	19.0	17.3

Source: **Bureau of Meteorology, 2019 (September 2019)**

R.H. – Relative Humidity, W.S. – wind speed

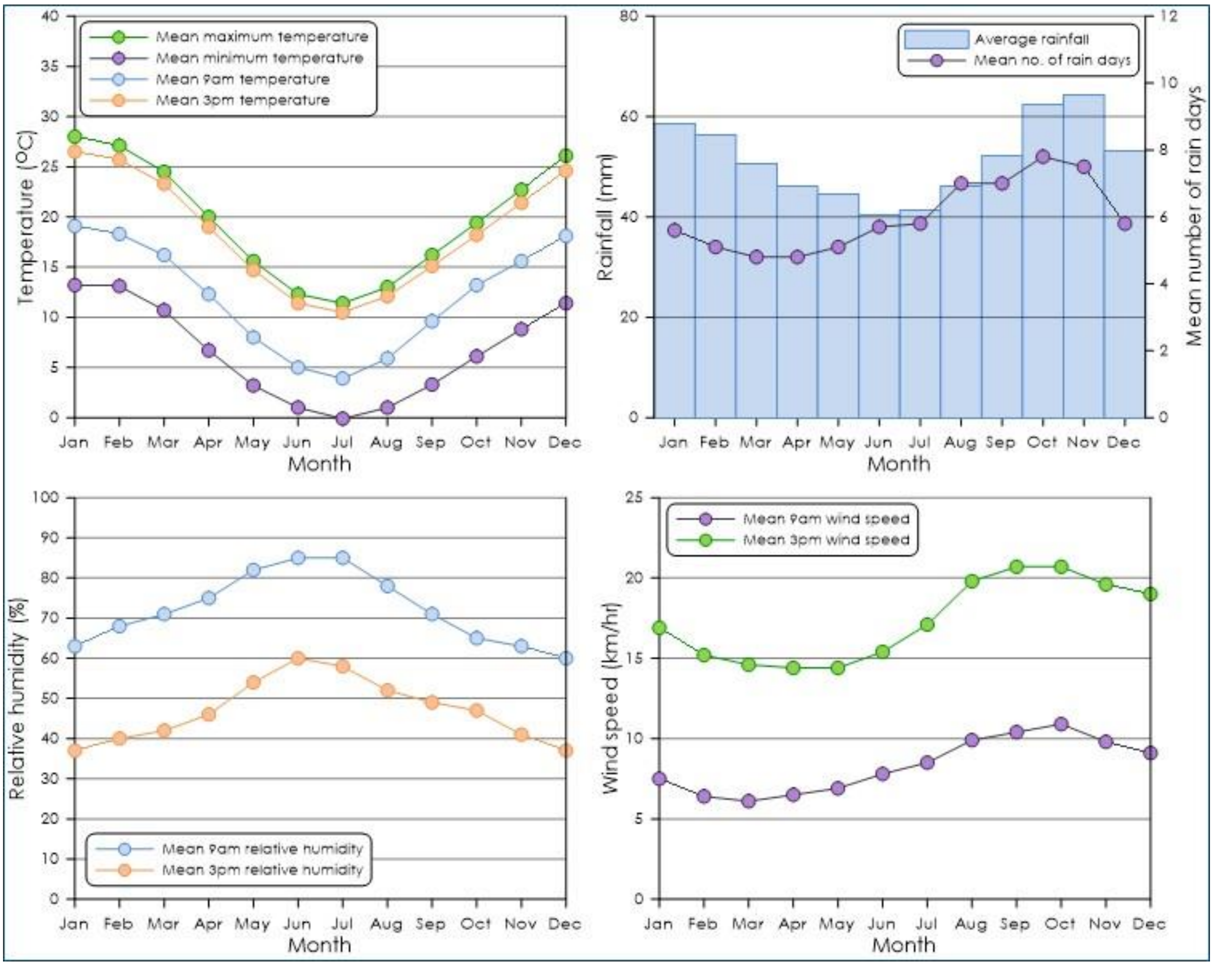

Figure 4-1: Monthly climate statistics summary – Canberra Airport Comparison weather station

4.2 Local meteorological conditions

Annual and seasonal windroses for the Canberra Airport (Site No. 070351) weather station during the 2017 calendar period are presented in **Figure 4-2**.

The 2017 calendar year was selected as the meteorological year for the dispersion modelling based on an analysis of long-term data trends in meteorological data recorded and appropriate monitoring data for the area as outlined in **Appendix A**.

On an annual basis, winds predominantly occur from the northwest and the north-northwest with varied winds from other directions. In summer, winds occur predominantly from the northwest and east. In autumn, winds predominantly occur from the southeast. During winter, winds occur predominantly from the northwest and north-northwest. Spring has a similar distribution to the annual distribution with winds predominantly from the northwest and varied winds from other directions.

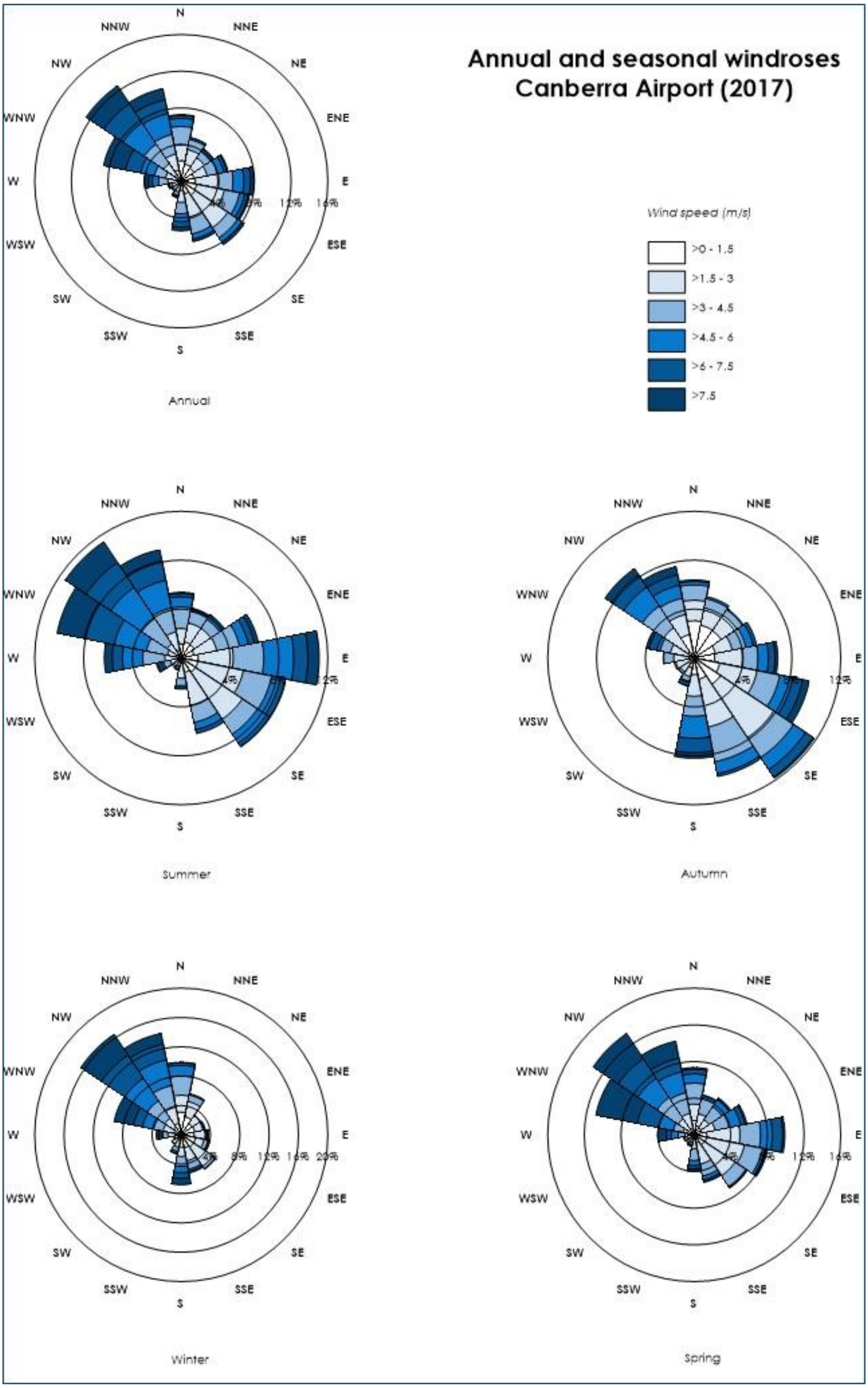

Figure 4-2 : Annual and seasonal windroses – Canberra Airport weather station (2017)

4.3 Local air quality monitoring

The main sources of air pollutants in the area surrounding the Project would include emissions from active sand quarrying, agricultural activities and anthropogenic activities such as various commercial activities and motor vehicle exhaust.

Ambient air quality monitoring data from the Project site are not available. Therefore, the available data from air quality monitors operated by the Australian Capital Territory (ACT) Health Protection Service (HPS) were used to quantify the existing background level for assessed pollutants at the Project site.

These include the Civic, Florey and Monash monitors located approximately 31.9km west-southwest, 38.8km southwest and 42.5km south-southwest from the Project, respectively.

4.3.1 PM_{10} monitoring

A summary of the available PM_{10} monitoring data from the ACT HPS monitoring stations is presented in **Table 4-2**. Recorded 24-hour average PM_{10} concentrations are presented in **Figure 4-3.**

A review of **Table 4-2** indicates that the annual average PM_{10} concentrations for all monitoring stations reviewed were below the relevant criterion of 25µg/m³ in each year of the review. The maximum 24-hour average PM_{10} concentrations were found to exceed the relevant criterion of 50µg/m³ during 2015 and 2018. It should be noted that annual periods which contain less than 75% data are excluded for estimating an annual average in **Table 4-2**

Table 4-2: Summary of PM_{10} levels from NSW OEH monitoring (µg/m³)

Year	Civic	Florey	Monash	Criterion
	Annual average			
2014	9.9	10.3	10.2	**25**
2015	11.3	10.7	10.0	**25**
2016	10.7	10.0	9.8	**25**
2017	9.5	9.9	9.9	**25**
2018	11.8	12.1	-	**25**
	Maximum 24-hour average			
2014	27.9	28.1	32.2	**50**
2015	**73.6**	**76.2**	**53.1**	**50**
2016	37.3	29.8	37.9	**50**
2017	45.6	31.2	27.9	**50**
2018	**136.9**	**153.2**	**174.7**	**50**

It can be seen from **Figure 4-3** that PM_{10} concentrations are fairly uniform throughout the year with no discernible trend.

Anomalously high PM_{10} concentrations were recorded in May 2015, March 2018 and December 2018 at all monitors and have been attributed to regional dust storm events (**NSW OEH 2015, NSW OEH 2018a & NSW OEH 2018b**).

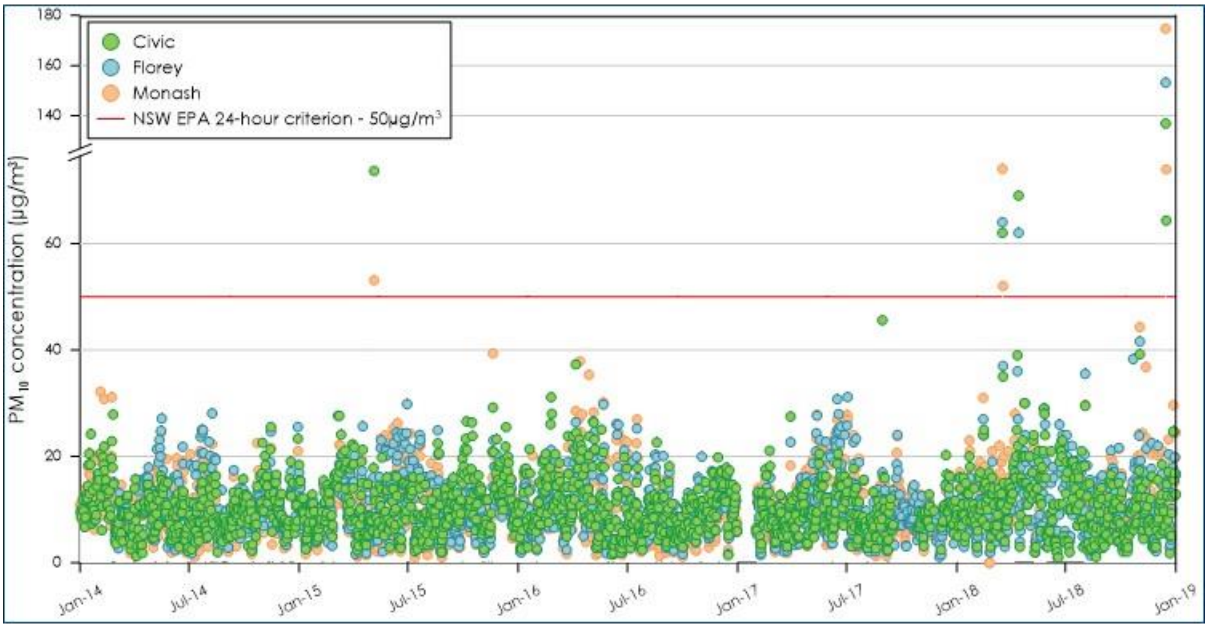

Figure 4-3: 24-hour average PM_{10} concentrations

4.3.2 $PM_{2.5}$ monitoring

A summary of the available data from the NSW OEH monitoring stations is presented in **Table 4-3**. Recorded 24-hour average $PM_{2.5}$ concentrations are presented in **Figure 4-4**.

Table 4-3 indicates that the annual average $PM_{2.5}$ concentrations for the monitoring stations were below the annual average criterion of 8µg/m³ in each year of the review. It should be noted that annual periods which contain less than 75% data are excluded for estimating an annual average in **Table 4-3.**

The maximum 24-hour average $PM_{2.5}$ concentrations at the Civic and Florey monitoring stations were found to exceed the relevant criterion of 25µg/m³ on occasion during the review period. The Monash monitoring station exceeded the relevant criterion on occasion in each year of the review.

Table 4-3: Summary of $PM_{2.5}$ levels from NSW OEH monitoring (µg/m³)

Year	Civic	Florey	Monash	Criterion
	Annual average			
2014	-	6.7	-	**8**
2015	-	7.4	6.9	**8**
2016	5.6	7.1	7.0	**8**
2017	5.9	**8.2**	7.3	**8**
2018	6.9	-	7.1	**8**
	Maximum 24-hour average			
2014	-	**28.8**	19.9	**25**
2015	13.1	**32.6**	**26.5**	**25**
2016	19.6	**39.3**	**27.6**	**25**
2017	**42.1**	**34.0**	**25.3**	**25**
2018	**31.4**	**35.0**	**26.0**	**25**

It can be seen from **Figure 4-4** that 24-hour average $PM_{2.5}$ concentrations nominally peak in winter with domestic wood burning elevating fine particulate concentrations. The Monash monitor recorded the overall highest levels during the review period.

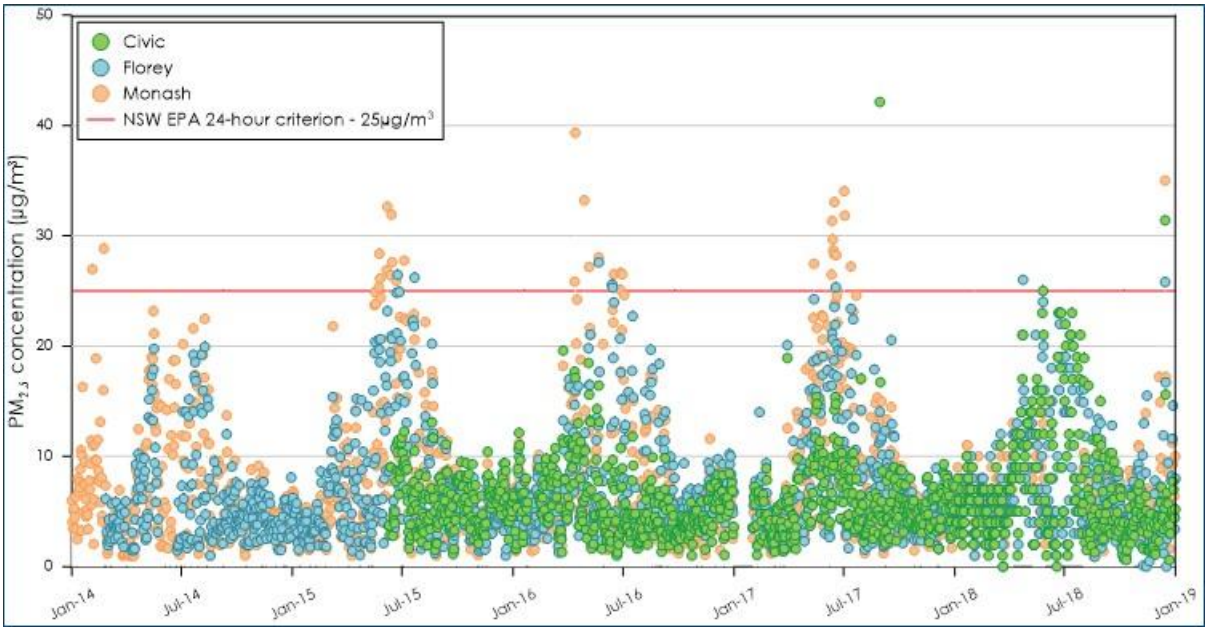

Figure 4-4: 24-hour average $PM_{2.5}$ concentrations

4.3.3 Estimated background levels

As outlined above, there are no readily available site specific monitoring data, and therefore the background air quality levels from the Civic monitor for the 2017 calendar year were used to represent the background levels for the Project.

The 2017 calendar period corresponds to the period of meteorological modelling based on an analysis of long-term data trends in meteorological data and appropriate monitoring data recorded for the area as outlined in **Appendix A**.

We note the Civic monitor is located closest to the Project site and provides a sufficient dataset for 2017. It is noted that the Civic monitor is located in an urban carpark setting which would generally experience higher particulate levels. This would present a conservative estimate of background levels for the Project site used to assess the cumulative impacts.

4.3.3.1 $PM_{2.5}$ and PM_{10}

Annual average $PM_{2.5}$ and PM_{10} values from the Civic monitoring station for the 2017 calendar year were used to represent the background levels for the Project (see **Table 4-2** and **Table 4-3**).

4.3.3.2 TSP and Deposited dust

In the absence of available data, estimates of the annual average background TSP and deposited dust concentrations can be determined from a relationship between $PM_{10,}$ TSP and deposited dust concentrations and the measured PM_{10} levels.

This relationship assumes that an annual average PM_{10} concentration of 25µg/m^3 corresponds to a TSP concentration of 90µg/m^3 and a dust deposition value of 4g/m^2/month. This assumption is based on the NSW EPA air quality impact criteria.

Applying this relationship with the measured annual average PM_{10} concentration of 9.6µg/m^3 indicates an approximate annual average TSP concentration and deposition value of 34.2µg/m^3 and 1.5g/m^2/month, respectively.

4.3.3.3 Summary of background levels

The background air quality levels applied in this assessment are as follows:

- 24-hour average $PM_{2.5}$ and PM_{10} concentrations - variable
- Annual average $PM_{2.5}$ concentrations – 5.9µg/m^3;
- Annual average PM_{10} concentrations – 9.5µg/m^3;
- Annual average TSP concentrations – 34.2µg/m^3; and,
- Annual average deposited dust levels – 1.5g/m^2/month

5 DISPERSION MODELLING APPROACH

5.1 Introduction

The following sections are included to provide the reader with an understanding of the model and modelling approach applied for the assessment. The CALPUFF is an advanced air dispersion model which can deal with the effects of complex local terrain on the dispersion meteorology over the modelling domain in a three-dimensional, hourly varying time step.

The model was setup in general accord with the methods provided in the NSW EPA document *Generic Guidance and Optimum Model Setting for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia'* (**TRC**, **2011**).

5.2 Modelling methodology

Modelling was undertaken using a combination of the CALPUFF Modelling System and The Air Pollution Model (TAPM). The CALPUFF Modelling System includes three main components: CALMET, CALPUFF and CALPOST and a large set of pre-processing programs designed to interface the model to standard, routinely available meteorological and geophysical datasets.

5.2.1 Meteorological modelling

The TAPM model was applied to the available data to generate a three dimensional upper air data file for use in CALMET. The centre of analysis for the TAPM modelling used is 35deg 11.5min south and 149deg 27min east. The simulation involved an outer grid of 30km, with three nested grids of 10km, 3km and 1km with 35 vertical grid levels.

The CALMET domain was run on an initial domain of 30 x 30km grid with a 0.6km grid resolution and refined for a final domain of 10 x 10km with a 0.1km grid resolution. The available meteorological data for January 2017 to December 2017 from nearby BoM meteorological monitoring sites were included in the simulation. **Table 5-1** outlines the parameters used from the station.

Table 5-1: Surface observation stations

Weather Stations	Parameters						
	WS	WD	CH	CC	T	RH	SLP
Canberra Airport (BoM) (Station No. 070351)	✓	✓	✓	✓	✓	✓	✓
Tuggeranong (Isabella Plains) AWS (BoM) (Station No. 070339)	✓	✓			✓	✓	✓
Braidwood Racecourse AWS (BoM) (Station No. 069132)	✓	✓			✓	✓	✓

WS = wind speed, WD= wind direction, CH = cloud height, CC = cloud cover, T = temperature, RH = relative humidity, SLP = sea level pressure

Local land use and detailed topographical information was included to produce realistic fine scale flow fields (such as terrain forced flows) in surrounding areas, as shown in **Figure 5-1**.

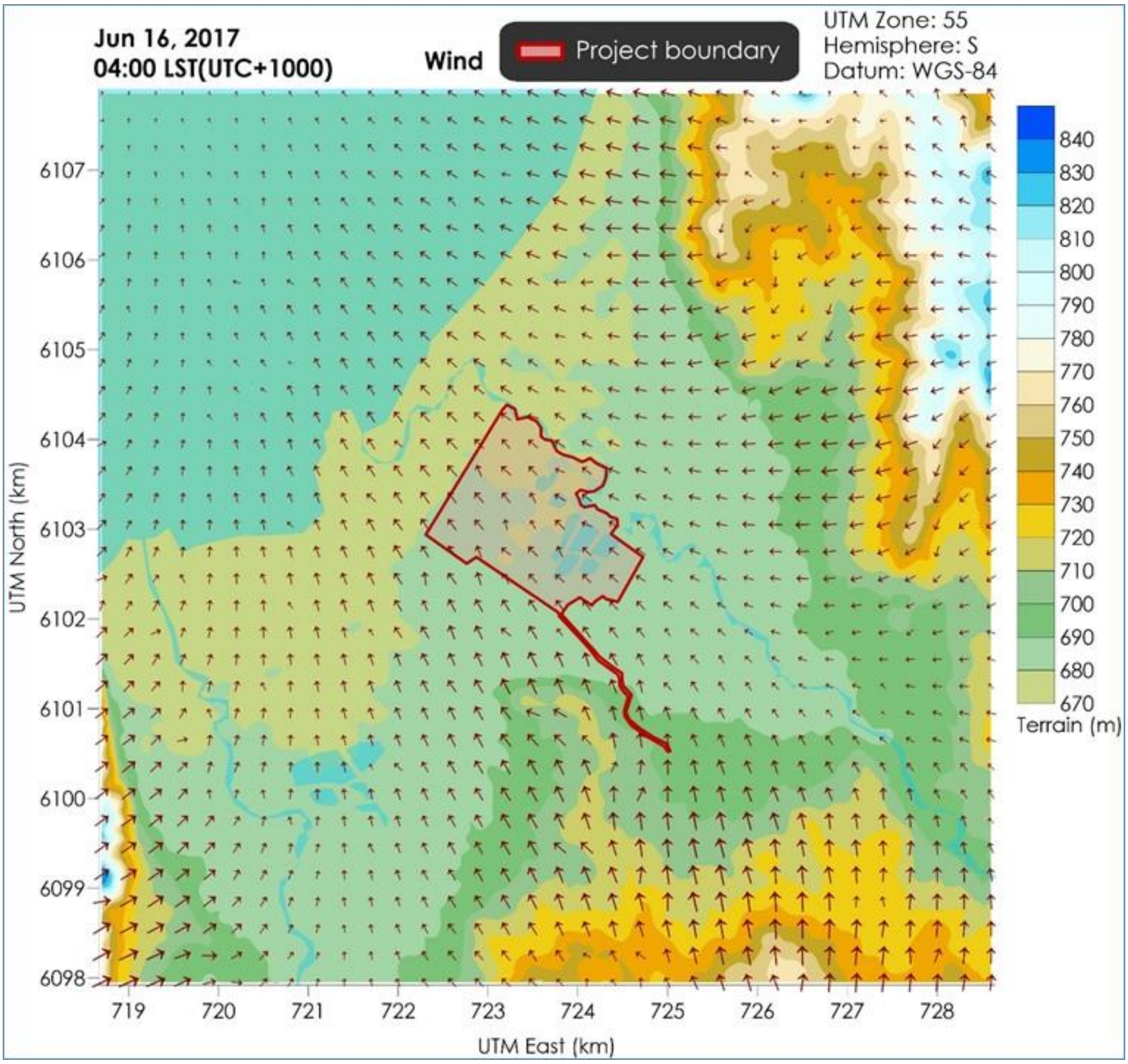

Figure 5-1: Representative 1-hour average snapshot of wind field for the Project

CALMET generated meteorological data were extracted from a point within the CALMET domain and are graphically represented in **Figure 5-2** and **Figure 5-3**.

Figure 5-2 presents the annual and seasonal windroses from the CALMET data. Overall, the windroses generated in the CALMET modelling reflect the expected wind distribution patterns of the area as determined based on the available measured data and the expected terrain effects on the prevailing winds. **Figure 5-3** includes graphs of the temperature, wind speed, mixing height and stability classification over the modelling period and shows sensible trends considered to be representative of the area.

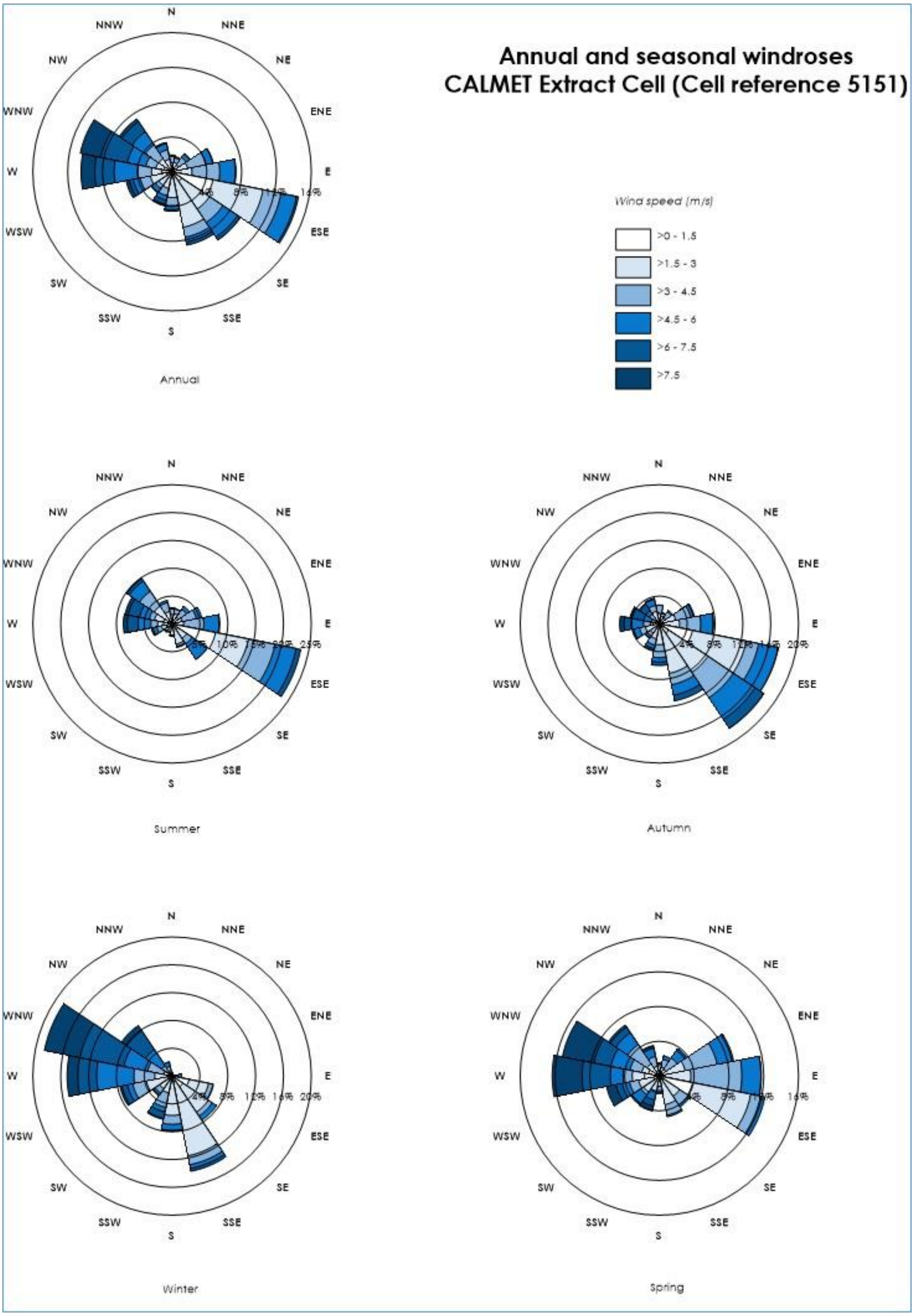

Figure 5-2: Annual and seasonal windroses from CALMET (Cell ref 5151)

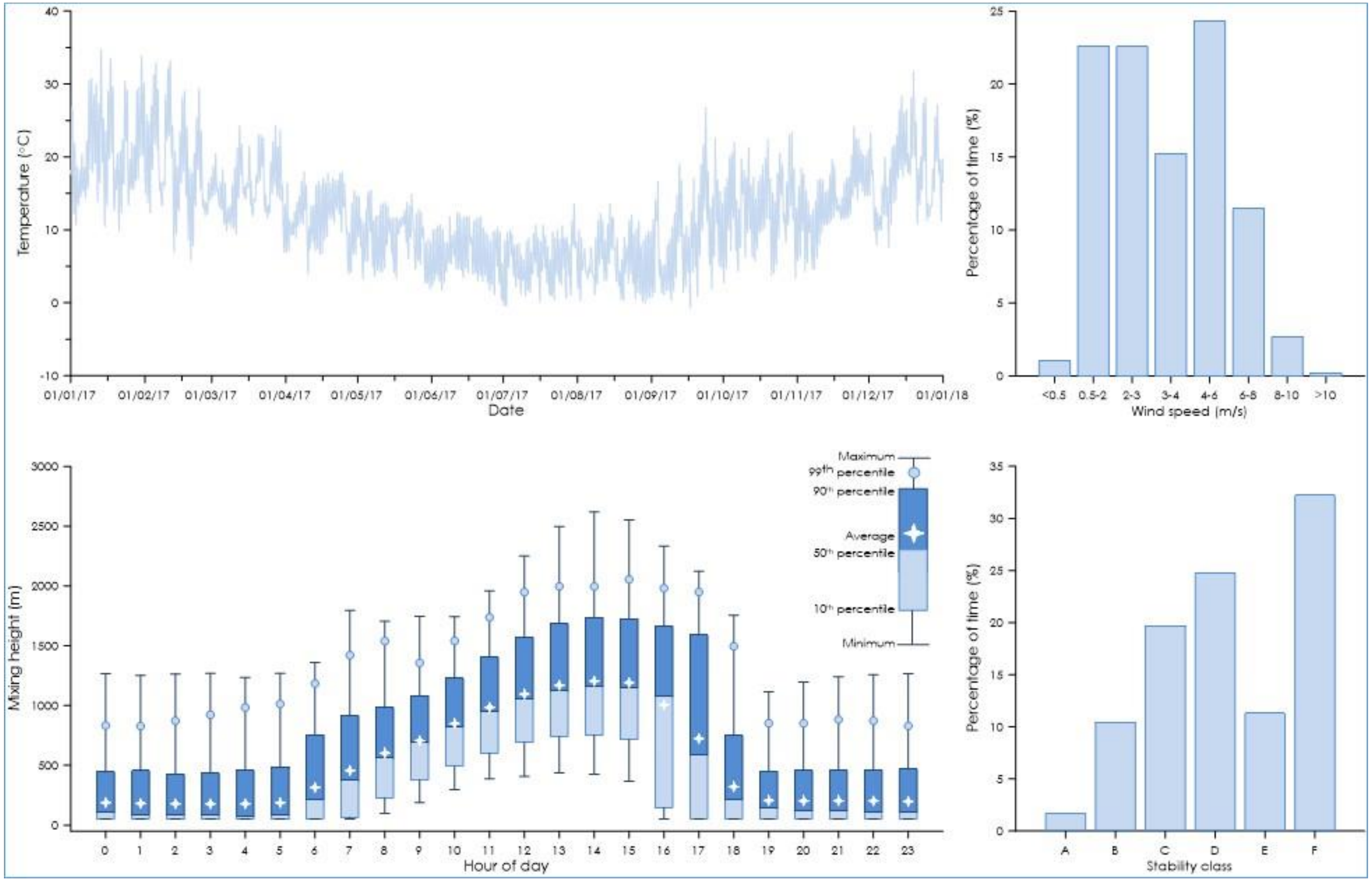

Figure 5-3: Meteorological analysis of CALMET (Cell Ref 5151)

5.3 Dispersion modelling

Dust emissions from each operational activity of the Project were represented by a series of volume sources and were included in the CALPUFF model via an hourly varying emission file. Meteorological conditions associated with dust generation (such as wind speed) and levels of dust generating activity were considered in calculating the hourly varying emission rate for each source.

It should be noted that as a conservative measure, the effect of the precipitation rate (rainfall) in reducing dust emissions has not been considered in this assessment.

5.4 Modelling scenario

This assessment considered three operating scenarios for the Project. Each of the activities associated with the different stages were analysed in regard to the quantity of material extracted and handled in each scenario, the location of the activity and the potential to generate dust at the receptor locations.

The three operating scenarios representing the Project were investigated in detail to identify an existing baseline of air quality impacts from the Project, and those which would likely represent a worst-case operating scenario. These include:

- Existing Operations: Sand extraction occurring from the current extraction area (E1) with an assumed extraction rate of 270,000tpa which includes 27,000tpa of overburden and 27,000tpa of interburden. The raw material processed in the sand classifying plant comprising of 36,000tpa of fines and 180,000tpa of product sand.
- Scenario 1: Sand extraction occurring from the proposed extraction area in extraction cells E2 and E3 with an assumed extraction rate of 600,000tpa which includes 60,000tpa of overburden and 60,000tpa of interburden. The raw material processed in the sand classifying plant comprising of 80,000tpa of fines and 400,000tpa of product sand.
- Scenario 2: Sand extraction occurring from the proposed extraction area in extraction cells E9 and E10 with an assumed extraction rate of 600,000tpa which includes 60,000tpa of overburden and 60,000tpa of interburden. The raw material processed in the sand classifying plant comprising of 80,000tpa of fines and 400,000tpa of product sand.

5.5 Emission estimation

The significant dust generating activities associated with operation of the Project are identified as stripping of overburden and interburden, loading/unloading of material, vehicles travelling on-site, dozer activities and windblown dust from exposed areas and stockpiles. The on-site vehicle and plant equipment also have the potential to generate particulate emissions from the diesel exhaust.

Dust emission estimates for each of the scenarios have been calculated by analysing the various types of dust generating activities taking place and utilising suitable emissions sourced from both locally developed and United States Environmental Protection Agency (US EPA) developed documentation.

An average and a peak scenario have been assessed for each of the modelling scenarios listed above for the operation of the Project. The average scenario is based on the proposed annual tonnage of sand processed at the site. Peak scenarios are based on the maximum daily truck movements and assessed for 24-hour impacts.

A summary of the estimated TSP emissions for each scenario is presented in **Table 5-2**. Detailed calculations of the dust emission estimates are provided in **Appendix B**.

The estimated TSP emissions in **Table 5-2** indicates the Project would likely double the potential dust emissions compared to the existing operations. The estimate peak scenarios are approximately double the average scenario.

Table 5-2: Summary of estimated TSP emissions for the Project (kg/year)

Activity	Average TSP Emissions		
	Existing	Scenario 1	Scenario 2
Total TSP emissions – Average	90,795	139,485	136,754
Total TSP emission - Peak	129,867	240,435	233,380

5.5.1 Emissions from other quarry operations

It is noted that cumulative impacts would occur concurrently from the operation of the Project and from the other regional sand quarry operations. Information regarding the current consents or proposed projects of the other regional sand quarry operations was unable to be attained at the time of this assessment.

As there is insufficient information regarding these operations to include in the dispersion modelling, the potential for cumulative impacts have been considered using an alternative approach. This approach assesses the potential change in air quality impacts associated with the operation of the Project compared to existing levels to determine if a cumulative impact would arise.

The existing operations are modelled to provide an estimate of the contribution to air quality impacts at the surrounding receptor locations and the change in impact associated with the proposed Project is assessed to determine the level of additional impact the proposed Project would have on the cumulative air quality levels.

It can be expected that the other regional sand quarry operations would continue to operate at their approved limit and would not change with the Project. The Project is the only change occurring which would influence the existing approved level of cumulative impact.

6 DISPERSION MODELLING RESULTS

This section presents the predicted air quality levels which may arise from air emissions generated by the Project.

6.1 Dust concentrations

The dispersion model predictions presented in this section include those for the operation of the Project in isolation (incremental impact) and the operation of the Project with consideration of other sources (total cumulative impact). The results show the predicted:

- Maximum 24-hour average $PM_{2.5}$ and PM_{10} concentrations;
- Annual average $PM_{2.5,}$ PM_{10} and TSP concentrations; and,
- Annual average dust (insoluble solids) deposition rates.

It is important to note that when assessing impacts per the maximum 24-hour average levels, these predictions are based on the highest predicted 24-hour average concentrations which were modelled at each point within the modelling domain for the worst day (i.e. a 24-hour period) during the one year long modelling period.

Associated isopleth diagrams of the dispersion modelling results are presented in **Appendix C**.

Table 6-1 and **Table 6-2** present the predicted incremental and cumulative particulate dispersion modelling results at each of the assessed receptor locations for scenario 1 and scenario 2.

The cumulative (total) impact is defined as the modelling impact associated with the operation of the Project combined with the estimated ambient background levels in **Section 4.3.3**.

The predicted incremental results show that minimal incremental effects would arise at the residential receptor locations due to the Project in each scenario. The predicted cumulative results indicate that all of the assessed receptors are predicted to experience levels below the relevant criteria for each of the assessed dust metrics in each scenario.

Table 6-1: Dust dispersion modelling results for residential receptors – Scenario 1

Receptor ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/mth)	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	TSP (µg/m³)	DD* (g/m²/mth)
	Incremental						Cumulative			
	24-hr ave.	Ann. ave.	24-hr ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.
	Air quality impact criteria									
	-	-	-	-	-	2	8	25	90	4
R2	0.4	<0.1	2.0	0.1	0.3	<0.1	5.9	9.6	34.5	1.5
R3	0.4	<0.1	2.3	0.1	0.3	<0.1	5.9	9.6	34.5	1.5
R4	0.4	<0.1	2.4	0.1	0.3	<0.1	5.9	9.6	34.5	1.5
R5	0.6	<0.1	3.5	0.2	0.5	<0.1	5.9	9.7	34.7	1.5
R6	0.4	<0.1	3.0	0.1	0.3	<0.1	5.9	9.6	34.5	1.5
R7	0.4	<0.1	2.7	0.1	0.3	<0.1	5.9	9.6	34.5	1.5
R8	0.3	<0.1	1.4	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R9	0.2	<0.1	0.7	<0.1	<0.1	<0.1	5.9	9.5	34.3	1.5

Receptor ID	PM$_{2.5}$ (µg/m^3)		PM$_{10}$ (µg/m^3)		TSP (µg/m^3)	DD (g/m^2/mth)	PM$_{2.5}$ (µg/m^3)	PM$_{10}$ (µg/m^3)	TSP (µg/m^3)	DD* (g/m^2/mth)
	Incremental						Cumulative			
	24-hr ave.	Ann. ave.	24-hr ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.
	Air quality impact criteria									
	-	-	-	-	-	2	8	25	90	4
R10	0.3	<0.1	1.4	<0.1	0.1	<0.1	5.9	9.5	34.3	1.5
R11	0.3	<0.1	2.0	<0.1	0.2	<0.1	5.9	9.6	34.4	1.5
R12	0.3	<0.1	2.0	<0.1	0.2	<0.1	5.9	9.6	34.4	1.5
R13	0.3	<0.1	2.0	<0.1	0.2	<0.1	5.9	9.6	34.4	1.5
R14	0.3	<0.1	1.9	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R15	0.3	<0.1	1.9	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R16	0.3	<0.1	1.8	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R17	0.3	<0.1	1.9	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R18	0.3	<0.1	2.0	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R19	0.3	<0.1	2.1	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R20	0.3	<0.1	1.9	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R21	0.3	<0.1	1.8	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R22	0.3	<0.1	1.7	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5

*Deposited dust

Table 6-2: Dust dispersion modelling results for residential receptors – Scenario 2

Receptor ID	PM$_{2.5}$ (µg/m^3)		PM$_{10}$ (µg/m^3)		TSP (µg/m^3)	DD (g/m^2/mth)	PM$_{2.5}$ (µg/m^3)	PM$_{10}$ (µg/m^3)	TSP (µg/m^3)	DD* (g/m^2/mth)
	Incremental						Cumulative			
	24-hr ave.	Ann. ave.	24-hr ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.
	Air quality impact criteria									
	-	-	-	-	-	2	8	25	90	4
R2	0.4	<0.1	2.0	0.1	0.3	<0.1	5.9	9.6	34.5	1.5
R3	0.4	<0.1	2.3	0.1	0.3	<0.1	5.9	9.6	34.5	1.5
R4	0.4	<0.1	2.5	0.1	0.3	<0.1	5.9	9.6	34.5	1.5
R5	0.6	<0.1	3.7	0.2	0.5	<0.1	5.9	9.7	34.7	1.5
R6	0.5	<0.1	3.1	0.1	0.3	<0.1	5.9	9.6	34.5	1.5
R7	0.5	<0.1	2.9	0.1	0.3	<0.1	5.9	9.6	34.5	1.5
R8	0.3	<0.1	1.3	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R9	0.1	<0.1	0.7	<0.1	<0.1	<0.1	5.9	9.5	34.3	1.5
R10	0.3	<0.1	1.4	<0.1	0.1	<0.1	5.9	9.5	34.3	1.5
R11	0.4	<0.1	2.2	<0.1	0.2	<0.1	5.9	9.6	34.4	1.5
R12	0.4	<0.1	2.1	<0.1	0.2	<0.1	5.9	9.6	34.4	1.5
R13	0.4	<0.1	2.1	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R14	0.3	<0.1	2.0	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R15	0.3	<0.1	2.0	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R16	0.3	<0.1	1.9	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R17	0.3	<0.1	2.0	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R18	0.3	<0.1	2.1	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R19	0.4	<0.1	2.2	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R20	0.4	<0.1	2.0	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R21	0.3	<0.1	1.9	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5
R22	0.3	<0.1	1.8	<0.1	0.1	<0.1	5.9	9.6	34.3	1.5

*Deposited dust

6.2 Potential cumulative dust impacts

As noted in **Section 5.5.1**, to assess the potential for cumulative impacts to arise, in the absence of modelling the other regional sand quarry operations, the estimated change in air quality level of the existing operations compared with the proposed Project have been used to determine the incremental change on the cumulative air quality level in the local area.

Table 6-3 presents the predicted annual average TSP, PM_{10}, $PM_{2.5}$ and deposited dust levels at the most impacted receptor (R5) for the Existing and Project (Scenario 1 and Scenario 2). The incremental change is calculated as the difference in the predicted level for the Project and Existing scenarios.

It is clear from **Table 6-3** that the incremental change in the annual average levels is small at the most impacted receptor. The estimated change in dust levels is only a small fraction of the relevant impact assessment criteria level (<1% of the criteria) and it can be expected that any change to the existing cumulative level associated with the Project would likely go unnoticed.

Table 6-3: Incremental change in annual average dust levels associated with the Project at R5

Dust metric	Scenario	Predicted annual average level for R5 (µg/m³)	Incremental change compared to Existing scenario (µg/m³)	Criteria	Percentage of criteria (%)
TSP	Existing	0.2	-	90	-
	Scenario 1	0.5	0.3		0.3
	Scenario 2	0.5	0.2		0.3
PM_{10}	Existing	0.1	-	25	-
	Scenario 1	0.2	0.1		0.4
	Scenario 2	0.2	0.1		0.4
$PM_{2.5}$	Existing	0.02	-	8	-
	Scenario 1	0.03	0.01		0.2
	Scenario 2	0.03	0.01		0.1
DD	Existing	0.02	-	4	-
	Scenario 1	0.04	0.02		0.5
	Scenario 2	0.03	0.02		0.4

6.3 Assessment of Total (Cumulative) 24-hour average $PM_{2.5}$ and PM_{10} Concentrations

As shown in **Section 4.3** the maximum measured 24-hour concentrations of $PM_{2.5}$ and PM_{10} have in the past exceeded or come close to the relevant criterion level on occasion.

As a result, the NSW EPA Level 1 contemporaneous assessment approach of adding maximum background levels to maximum predicted levels from the Project would show levels above the criterion whether or not the Project was operating.

In such situations, the NSW EPA applies a Level 2 contemporaneous assessment approach where the measured background levels are added to the day's corresponding predicted dust level from the Project.

Ambient (background) $PM_{2.5}$ and PM_{10} concentration data corresponding with the year of modelling (2017) from the ACT HPS monitoring site at Civic have been applied in this case to represent the prevailing background levels in the vicinity of the Project and at representative residential receptor locations surrounding the Project.

Where data are unavailable in the monitoring datasets for the contemporaneous period, the 70th percentile of the monitoring dataset has been applied to substitute for these gaps. This approach provides a reasonable indication of the potential background level on days where data are unavailable.

Table 6-4 provides a summary of the findings from the Level 2 assessment at receptor locations for both $PM_{2.5}$ and PM_{10}. The results in **Table 6-4** indicate that the Project does not increase the number of days above the 24-hour average criterion at the assessed receptors for $PM_{2.5}$ and PM_{10}. Based on this result it can be inferred that the Project does not increase the number of days above the 24-hour average $PM_{2.5}$ and PM_{10} criterion at any of the receptor locations surrounding the Project.

Detailed tables of the contemporaneous assessment results are provided in **Appendix D**.

Table 6-4: NSW EPA contemporaneous assessment - maximum number of additional days above 24-hour average criterion

Receptor ID	$PM_{2.5}$	PM_{10}
R4	0	0
R5	0	0
R6	0	0

Time series plots of the predicted cumulative 24-hour average $PM_{2.5}$ and PM_{10} concentrations for selected Receptors R2, R3 and R5 are presented in **Figure 6-1** to **Figure 6-6** for Scenario 1 and Scenario 2, respectively.

The orange bars in the figures represent the contribution from the Project and the blue bars represent the applied background levels. It is clear from the figures that the Project has a small influence at the assessed receptor locations and in most cases would be difficult to discern beyond the existing background level.

Figure 6-1: Time series plots of predicted cumulative 24-hour average $PM_{2.5}$ (above) and PM_{10} (below) concentrations for R4, Scenario 1

Figure 6-2: Time series plots of predicted cumulative 24-hour average $PM_{2.5}$ (above) and PM_{10} (below) concentrations for R5, Scenario 1

Figure 6-3: Time series plots of predicted cumulative 24-hour average $PM_{2.5}$ (above) and PM_{10} (below) concentrations for R6, Scenario 1

Figure 6-4: Time series plots of predicted cumulative 24-hour average $PM_{2.5}$ (above) and PM_{10} (below) concentrations for R4, Scenario 2

Figure 6-5: Time series plots of predicted cumulative 24-hour average $PM_{2.5}$ (above) and PM_{10} (below) concentrations for R5, Scenario 2

Figure 6-6: Time series plots of predicted cumulative 24-hour average $PM_{2.5}$ (above) and PM_{10} (below) concentrations for R6, Scenario 2

6.4 Respirable crystalline silica

The assessment results show that the most affected residential receptor has a total maximum predicted incremental annual average $PM_{2.5}$ concentration level of less than 0.1µg/m^3. This level is due to the total dust from the site, and only a small portion of this dust would contain silica.

As the total level is over thirty times below the VIC EPA criteria of 3µg/m^3 for respirable crystalline silica, the actual level from the Project would be significantly below the criteria and thus, the Project would not result in an unacceptable level of respirable crystalline silica in the ambient air at residential receptors.

7 DUST MITIGATION AND MANAGEMENT

The proposed operations at the Project have the potential to generate dust emissions. To ensure that activities associated with the Project have a minimal effect on the surrounding environment and at residential receptor locations, it is recommended that all reasonable and practicable dust mitigation measures be utilised.

Suggested reasonable and practicable dust mitigation measures for the Project are listed in **Table 7-1**.

Table 7-1: Potential operational dust mitigation measures

Source	Mitigation Measure
General	Activities to be assessed during adverse weather conditions and modified as required (e.g. cease activity where reasonable levels of dust cannot be maintained using the available means).
	Weather forecast to be checked prior to undertaking material handling or processing.
	Engines of on-site vehicles and plant to be switched off when not in use.
	Vehicles and plant are to be fitted with pollution reduction devices where practicable.
	Vehicles are to be maintained and serviced according to manufacturer's specifications.
	Visual monitoring of activities is to be undertaken to identify dust generation.
Exposed areas/stockpiles	The extent of exposed surfaces and stockpiles is to be kept to a minimum.
	Exposed areas and stockpiles are either to be covered or are to be dampened with water as far as is practicable if dust emissions are visible, or there is potential for dust emissions outside operating hours.
	Minimise dust generation by undertaking rehabilitation earthworks when topsoil and subsoil stockpiles are moist and/or wind speed is below 10 m/s.
Material handling	Reduce drop heights from loading and handling equipment where practical.
	Dampen material when excessively dusty during handling.
Hauling activities	Haul roads should be watered using water carts such that the road surface has sufficient moisture to minimise on-road dust generation but not so much as to cause mud/dirt track out to occur.
	Regularly inspect haul roads and maintain surfaces to remove potholes or depressions
	Driveways and hardstand areas to be swept/cleaned regularly as required etc.
	Vehicle traffic is to be restricted to designated routes.
	Speed limits are to be enforced.
	Vehicle loads are to be covered when travelling off-site.

It is anticipated that the Project would develop a suitable Air Quality Management Plan for the site to assist with the management of air emissions. The Air Quality Management Plan would outline the measures to manage dust emissions at the site and include aspects such as key performance indicators, monitoring methods, response mechanisms, compliance reporting and complaints management.

The air emission controls applied at the site would be regularly assessed to ensure they are working effectively, and required modification or adjustments to the air emission control measures would be revised on a regular basis and documented in the AQMP.

8 SUMMARY AND CONCLUSIONS

This report has assessed the potential air quality impacts associated with the proposed operation of expanding the existing extraction area at the Bungendore Sands Quarry.

Air dispersion modelling was used to predict the potential for off-site dust impacts in the surrounding area due to the operation of the Project. The estimated emissions of dust applied in the modelling are likely to be conservative and would overestimate the actual impacts.

It is predicted that the Project would have a negligible incremental and cumulative impact at the surrounding residential receptor locations. The incremental change in air quality impact associated the proposed Project from the existing operation would increase, however this changes is considered to be negligible at the receptor locations.

Nevertheless, the site would apply appropriate dust management measures to ensure it minimises the potential occurrence of excessive air emissions from the site.

Overall, the assessment demonstrates that even using conservative assumptions, the Project can operate without causing any significant air quality impact at residential receptors in the surrounding environment.

9 REFERENCES

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Appendix A

Selection of Meteorological Year

Selection of meteorological year

A statistical analysis of the latest five contiguous years of meteorological data from the nearest BoM weather station with suitable available data, Canberra Airport weather station, is presented in **Table A-1**.

The standard deviation of the latest five years of meteorological data spanning 2014 to 2018 was analysed against the available measured wind speed, temperature and relative humidity. The analysis indicates that 2017 dataset is closest to the mean for wind speed, 2014 is closest for wind direction, 2018 is closest for temperature and 2015 is closest to the long-term average for relative humidity. This analysis suggests that the 2017 would be the most representative of the latest five contiguous years.

Table A-1: Statistical analysis results for Canberra Airport

Year	Wind speed	Wind direction	Temperature	Relative humidity
2014	0.43	0.13	0.17	0.28
2015	0.44	0.18	0.15	0.18
2016	0.60	0.23	0.20	0.21
2017	0.30	0.14	0.17	0.22
2018	0.41	0.15	0.15	0.48

Figure A-1 shows the frequency distributions for wind speed, temperature and relative humidity for the 2017 year compared with the mean of the 2014 to 2018 data set. The 2017 year data appear to be well aligned with the mean data.

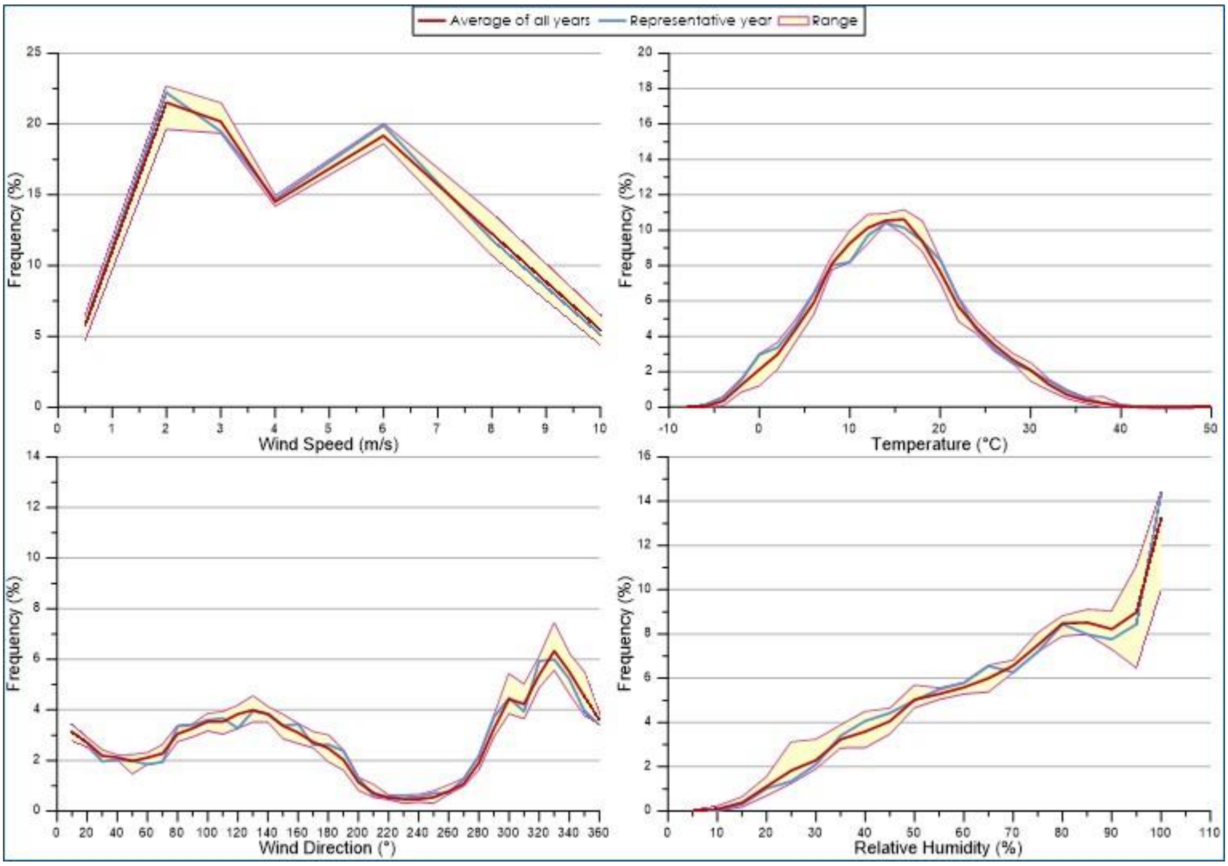

Figure A-1: Frequency distributions for wind speed, wind direction, temperature and relative humidity

Appendix B

Emission Calculations

Emission Calculation

The dust emissions from the Project have been estimated from the operational description of the proposed activities provided by the Proponent and have been combined with emissions factor equations and utilising suitable emission and load factors that relate to the quantity of dust emitted from particular activities based on intensity, the prevailing meteorological conditions and composition of the material being handled.

Emission factors and associated controls have been sourced from:

- United States (US) EPA AP42 Emission Factors (**US EPA, 1985 and Updates**);
- Office of Environment and Heritage document, "NSW Coal Mining Benchmarking Study: Best Practise Measures for Reducing Non-Road Diesel Exhaust Emissions, Final Report" (**EPA NSW, 2015**).

The emission factor equations used for each dust generating activity are outlined in **Table B-1** below. A detailed dust emission inventory for the different scenarios are presented in **Table B-2** to **Table B-7.**

Control factors include the following:

- Hauling on unpaved surfaces – 75% control for watering of trafficked areas;
- Dozer activity – 50% control for watering of shaped landform; and,
- Wind erosion from exposed areas – 50% control for watering of exposed areas.

Table B-1: Emission factor equations

Activity	Emission factor equation		
	TSP	PM_{10}	$PM_{2.5}$
Scraper stripping	$EF = 0.029\ kg/tonne$	$0.5 \times TSP$	$0.075 \times TSP$
Loading / emplacing material	$EF = 0.74 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M^{1.4}}{2}\right) kg/tonne$	$EF = 0.35 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M^{1.4}}{2}\right) kg/tonne$	$EF = 0.053 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M^{1.4}}{2}\right) kg/tonne$
Hauling on unsealed surfaces	$EF = \left(\frac{0.4536}{1.6093}\right) \times 4.9 \times (s/12)^{0.7} \times (1.1023 \times M/3)^{0.45} kg/VKT$	$EF = \left(\frac{0.4536}{1.6093}\right) \times 1.5 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45} kg/VKT$	$EF = \left(\frac{0.4536}{1.6093}\right) \times 0.15 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45} kg/VKT$
Hauling on sealed surfaces	$EF = 3.23 \times s.L.^{0.91} \times (1.1023 \times W)^{1.02} kg/VKT$	$EF = 0.62 \times s.L.^{0.91} \times (1.1023 \times W)^{1.02} kg/VKT$	$EF = 0.15 \times s.L.^{0.91} \times (1.1023 \times W)^{1.02} kg/VKT$
Dozers on overburden/interburden	$EF = 2.6 \times \frac{s^{1.2}}{M^{1.3}} kg/hour$	$EF = 0.45 \times \frac{s^{1.5}}{M^{1.4}} \times 0.75\ kg/hour$	$EF = 0.45 \times \frac{s^{1.5}}{M^{1.4}} \times 0.105\ kg/hour$
Screening (controlled)	$EF = 0.0011\ kg/tonne$	$EF = 0.00037\ kg/tonne$	$EF = 0.000025\ kg/tonne$
Grading roads	$EF = 0.04 \times \left(\frac{S}{1.609}\right)^{2.5} km$	$0.6 \times TSP$	$0.031 \times TSP$
Wind erosion on exposed areas, stockpiles	$EF = 850\ kg/ha/year$	$0.5 \times TSP$	$0.075 \times TSP$

EF = emission factor, U = wind speed (m/s), M = moisture content (%), s = silt content (%), s.L. = silt loading (g/m^2), W = average weight of vehicle (tonne), VKT = vehicle kilometres travelled (km).

Table B-2: Dust Emissions Inventory – Average Existing Scenario

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	Emission Factor TSP	Emission Factor PM10	Emission Factor PM2.5	Units	Var. 1	Units	Var. 2	Units	Size specific EF - TSP/PM10/PM25	Units	Var. 3	Units	Var. 4	Units
Scraper stripping overburden	783	392	59	27,000	t/yr	0.029	0.015	0.002											
Excavator loading overburden to haul truck	65	31	5	27,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling overburden to emplacement area	239	61	6	27,000	t/yr	0.035	0.009	0.001	kg/t	38	tonnes/load	0.6	km/return trip	2.38/0.61/0.06	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing overburden at area	65	31	5	27,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Dozer on overburden	16,347	3,950	1,716	1,954	hours/ year	16.735	4.044	1.757	kg/h	10	silt content in %	2	moisture content in %						
Loading interburden to haul truck	65	31	5	27,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Hauling interburden to emplacement area	239	61	6	27,000	t/yr	0.035	0.009	0.001	kg/t	38	tonnes/load	0.6	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing interburden at area	65	31	5	27,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Dozer on interburden	16,347	3,950	1,716	1,954	hours/ year	16.735	4.044	1.757	kg/h	10	silt content in %	2	moisture content in %						
Loading RAW sand to haul truck	523	247	37	216,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Hauling RAW sand to sand classifying plant for processing	6,918	1,763	176	216,000	t/yr	0.128	0.033	0.003	kg/t	38	tonnes/load	2.0	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Unloading sand to sand classifying plant for processing	523	247	37	216,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Loading RAW sand to screen at sand classifying plant for processing	523	247	37	216,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Screen	238	80	5	216,000	t/yr	0.001	0.000	0.000	kg/t										
Unloading processed sand to stockpile	436	206	31	180,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Rehandle processed sand material at product stockpile	87	41	6	36,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Loading product sand material to haul truck	436	206	31	180,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Hauling product sand offsite	25,001	6,372	637	180,000	t/yr	0.556	0.142	0.014	kg/t	33	tonnes/load	8.2	km/return trip	2.2/0.6/0.1	kg/VKT	4.8	s.c. in %	33	Ave GMV (t)
Hauling product material offsite (paved road)	78	15	4	180,000	t/yr	0.000	0.000	0.000	kg/t	33	tonnes/load	0.1	km/return trip	0.2/0.05/0.01	kg/VKT	2.0	s.L. in g/m2	33	Ave GMV (t)
Grading roads	26	15	1	39.72	km	0.6	0.4	0.0	kg/VKT	8	speed of graders in km/h								
Wind erosion - exposed area	21,675	10,838	1,626	51	ha	850	425	64	kg/ha/yr										
Exhaust emissions	898	898	871		kg/yr														
Total TSP emissions (kg/yr)	**90,795**	**29,323**	**6,965**																

Table B-3: Dust Emissions Inventory – Peak Existing Scenario

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	Emission Factor TSP	Emission Factor PM10	Emission Factor PM2.5	Units	Var. 1	Units	Var. 2	Units	Size specific EF - TSP/PM10/PM25	Units	Var. 3	Units	Var. 4	Units
Scraper stripping overburden	1,637	819	123	56,454	t/yr	0.029	0.015	0.002											
Excavator loading overburden to haul truck	137	65	10	56,454	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling overburden to emplacement area	501	128	13	56,454	t/yr	0.035	0.009	0.001	kg/t	38.00	tonnes/load	0.566	km/return trip	2.38/0.61/0.06	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing overburden at area	137	65	10	56,454	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Dozer on overburden	16,347	3,950	1,716	1,954	hours/ year	16.735	4.044	1.757	kg/h	10.00	silt content in %	2	moisture content in %						
Loading interburden to haul truck	137	65	10	56,454	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling interburden to emplacement area	501	128	13	56,454	t/yr	0.035	0.009	0.001	kg/t	38.00	tonnes/load	0.566	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing interburden at area	137	65	10	56,454	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Dozer on interburden	16,347	3,950	1,716	1,954	hours/ year	16.735	4.044	1.757	kg/h	10.00	silt content in %	2	moisture content in %						
Loading RAW sand to haul truck	1,093	517	78	451,630	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling RAW sand to sand classifying plant for processing	14,465	3,687	369	451,630	t/yr	0.128	0.033	0.003	kg/t	38.00	tonnes/load	2.044	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Unloading sand to sand classifying plant for processing	1,093	517	78	451,630	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Loading RAW sand to screen at sand classifying plant for processing	1,093	517	78	451,630	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Screen	497	167	11	451,630	t/yr	0.001	0.000	0.000	kg/t										
Unloading processed sand to stockpile	911	431	65	376,358	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Rehandle processed sand material at product stockpile	182	86	13	75,272	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Loading product sand material to haul truck	911	431	65	376,358	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling product sand offsite	52,274	13,323	1,332	376,358	t/yr	0.556	0.142	0.014	kg/t	33.00	tonnes/load	8.202	km/return trip	2.2/0.6/0.1	kg/VKT	4.8	s.c. in %	33	Ave GMV (t)
Hauling product material offsite (paved road)	162	31	8	376,358	t/yr	0.000	0.000	0.000	kg/t	33.00	tonnes/load	0.06	km/return trip	0.2/0.05/0.01	kg/VKT	2	s.L. in g/m2	33	Ave GMV (t)
Grading roads	26	15	1	39.72	km	0.6	0.4	0.0	kg/VKT	8	speed of graders in km/h								
Wind erosion - exposed area	21,675	10,838	1,626	51	ha	850	425	64	kg/ha/yr										
Exhaust emissions	1,242	1,242	1,205		kg/yr														
Total TSP emissions (kg/yr)	**129,867**	**40,216**	**8,427**																

Table B-4: Dust Emissions Inventory – Average Scenario 1

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	Emission Factor TSP	Emission Factor PM10	Emission Factor PM2.5	Units	Var. 1	Units	Var. 2	Units	Size specific EF - TSP/PM10/PM25	Units	Var. 3	Units	Var. 4	Units
Scraper stripping overburden	1,740	870	131	60,000	t/yr	0.029	0.015	0.002											
Excavator loading overburden to haul truck	145	69	10	60,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling overburden to emplacement area	1,346	343	34	60,000	t/yr	0.090	0.023	0.002	kg/t	38	tonnes/load	1.4	km/return trip	2.38/0.61/0.06	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing overburden at area	145	69	10	60,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Dozer on overburden	16,347	3,950	1,716	1,954	hours/ year	16.735	4.044	1.757	kg/h	10	silt content in %	2	moisture content in %						
Loading interburden to haul truck	145	69	10	60,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Hauling interburden to emplacement area	1,346	343	34	60,000	t/yr	0.090	0.023	0.002	kg/t	38	tonnes/load	1.4	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing interburden at area	145	69	10	1,954	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Dozer on interburden	16,347	3,950	1,716		hours/ year	16.735	4.044	1.757	kg/h	10	silt content in %	2	moisture content in %						
Loading RAW sand to haul truck	1,162	550	83	480,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Hauling RAW sand to sand classifying plant for processing	27,077	6,901	690	480,000	t/yr	0.226	0.058	0.006	kg/t	38	tonnes/load	3.6	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Unloading sand to sand classifying plant for processing	1,162	550	83	480,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Loading RAW sand to screen at sand classifying plant for processing	1,162	550	83	480,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Screen	528	178	12	480,000	t/yr	0.001	0.000	0.000	kg/t										
Unloading processed sand to stockpile	968	458	69	400,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Rehandle processed sand material at product stockpile	194	92	14	80,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Loading product sand material to haul truck	968	458	69	400,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Hauling product sand offsite	55,557	14,160	1,416	400,000	t/yr	0.556	0.142	0.014	kg/t	33	tonnes/load	8.2	km/return trip	2.2/0.6/0.1	kg/VKT	4.8	s.c. in %	33	Ave GMV (t)
Hauling product material offsite (paved road)	173	33	8	400,000	t/yr	0.000	0.000	0.000	kg/t	33	tonnes/load	0.1	km/return trip	0.2/0.05/0.01	kg/VKT	2.0	s.L. in g/m2	33	Ave GMV (t)
Grading roads	26	15	1	40	km	0.6	0.4	0.0	kg/VKT	8	speed of graders in km/h								
Wind erosion - exposed area	13,643	6,821	1,023	32	ha	850	425	64	kg/ha/yr										
Exhaust emissions	898	898	871		kg/yr														
Total TSP emissions (kg/yr)	**139,485**	**40,524**	**7,967**																

Table B-5: Dust Emissions Inventory – Peak Scenario 1

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	Emission Factor TSP	Emission Factor PM10	Emission Factor PM2.5	Units	Var. 1	Units	Var. 2	Units	Size specific EF - TSP/PM10/PM25	Units	Var. 3	Units	Var. 4	Units
Scraper stripping overburden	3,638	1,819	273	125,453	t/yr	0.029	0.015	0.002											
Excavator loading overburden to haul truck	304	144	22	125,453	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling overburden to emplacement area	2,815	717	72	125,453	t/yr	0.090	0.023	0.002	kg/t	38.00	tonnes/load	1.432	km/return trip	2.38/0.61/0.06	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing overburden at area	304	144	22	125,453	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Dozer on overburden	16,347	3,950	1,716	1,954	hours/ year	16.735	4.044	1.757	kg/h	10.00	silt content in %	2	moisture content in %						
Loading interburden to haul truck	304	144	22	125,453	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling interburden to emplacement area	2,815	717	72	125,453	t/yr	0.090	0.023	0.002	kg/t	38.00	tonnes/load	1.432	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing interburden at area	304	144	22	125,453	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Dozer on interburden	16,347	3,950	1,716	1,954	hours/ year	16.735	4.044	1.757	kg/h	10.00	silt content in %	2	moisture content in %						
Loading RAW sand to haul truck	2,429	1,149	174	1,003,622	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling RAW sand to sand classifying plant for processing	56,616	14,429	1,443	1,003,622	t/yr	0.226	0.058	0.006	kg/t	38.00	tonnes/load	3.6	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Unloading sand to sand classifying plant for processing	2,429	1,149	174	1,003,622	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Loading RAW sand to screen at sand classifying plant for processing	2,429	1,149	174	1,003,622	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Screen	1,104	371	25	1,003,622	t/yr	0.001	0.000	0.000	kg/t										
Unloading processed sand to stockpile	2,024	957	145	836,352	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Rehandle processed sand material at product stockpile	405	191	29	167,270	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Loading product sand material to haul truck	2,024	957	145	836,352	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling product sand offsite	116,164	29,606	2,961	836,352	t/yr	0.556	0.142	0.014	kg/t	33.00	tonnes/load	8.202	km/return trip	2.2/0.6/0.1	kg/VKT	4.8	s.c. in %	33	Ave GMV (t)
Hauling product material offsite (paved road)	361	69	17	836,352	t/yr	0.000	0.000	0.000	kg/t	33.00	tonnes/load	0.06	km/return trip	0.2/0.05/0.01	kg/VKT	2	s.L. in g/m2	33	Ave GMV (t)
Grading roads	26	15	1	39.72	km	0.6	0.4	0.0	kg/VKT	8	speed of graders in km/h								
Wind erosion - exposed area	13,643	6,821	1,023	32	ha	850	425	64	kg/ha/yr										
Exhaust emissions	1,242	1,242	1,205		kg/yr														
Total TSP emissions (kg/yr)	**240,435**	**68,018**	**11,179**																

Table B-6: Dust Emissions Inventory – Average Scenario 2

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	Emission Factor TSP	Emission Factor PM10	Emission Factor PM2.5	Units	Var. 1	Units	Var. 2	Units	Size specific EF - TSP/PM10/PM25	Units	Var. 3	Units	Var. 4	Units
Scraper stripping overburden	1,740	870	131	60,000	t/yr	0.029	0.015	0.002											
Excavator loading overburden to haul truck	145	69	10	60,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling overburden to emplacement area	658	168	17	60,000	t/yr	0.044	0.011	0.001	kg/t	38	tonnes/load	0.7	km/return trip	2.38/0.61/0.06	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing overburden at area	145	69	10	60,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Dozer on overburden	16,347	3,950	1,716	1,954	hours/ year	16.735	4.044	1.757	kg/h	10	silt content in %	2	moisture content in %						
Loading interburden to haul truck	145	69	10	60,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Hauling interburden to emplacement area	658	168	17	60,000	t/yr	0.044	0.011	0.001	kg/t	38	tonnes/load	0.7	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing interburden at area	145	69	10	60,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Dozer on interburden	16,347	3,950	1,716	1,954	hours/ year	16.735	4.044	1.757	kg/h	10	silt content in %	2	moisture content in %						
Loading RAW sand to haul truck	1,162	550	83	480,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Hauling RAW sand to sand classifying plant for processing	24,490	6,242	624	480,000	t/yr	0.204	0.052	0.005	kg/t	38	tonnes/load	3.3	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Unloading sand to sand classifying plant for processing	1,162	550	83	480,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Loading RAW sand to screen at sand classifying plant for processing	1,162	550	83	480,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Screen	528	178	12	480,000	t/yr	0.001	0.000	0.000	kg/t										
Unloading processed sand to stockpile	968	458	69	400,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Rehandle processed sand material at product stockpile	194	92	14	80,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Loading product sand material to haul truck	968	458	69	400,000	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2.0	moisture content in %						
Hauling product sand offsite	55,557	14,160	1,416	400,000	t/yr	0.556	0.142	0.014	kg/t	33	tonnes/load	8.2	km/return trip	2.2/0.6/0.1	kg/VKT	4.8	s.c. in %	33	Ave GMV (t)
Hauling product material offsite (paved road)	173	33	8	400,000	t/yr	0.000	0.000	0.000	kg/t	33	tonnes/load	0.1	km/return trip	0.2/0.05/0.01	kg/VKT	2.0	s.L. in g/m2	33	Ave GMV (t)
Grading roads	26	15	1	39.72	km	0.6	0.4	0.0	kg/VKT	8	speed of graders in km/h								
Wind erosion - exposed area	14,875	7,438	1,116	35	ha	850	425	64	kg/ha/yr										
Exhaust emissions	898	898	871		kg/yr														
Total TSP emissions (kg/yr)	**136,754**	**40,130**	**7,958**																

Table B-7: Dust Emissions Inventory – Peak Scenario 2

Activity	TSP emission	PM10 emission	PM2.5 emission	Intensity	Units	Emission Factor TSP	Emission Factor PM10	Emission Factor PM2.5	Units	Var. 1	Units	Var. 2	Units	Size specific EF - TSP/PM10/PM25	Units	Var. 3	Units	Var. 4	Units
Scraper stripping overburden	3,638	1,819	273	125,453	t/yr	0.029	0.015	0.002											
Excavator loading overburden to haul truck	304	144	22	125,453	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling overburden to emplacement area	1,376	351	35	125,453	t/yr	0.044	0.011	0.001	kg/t	38.00	tonnes/load	0.7	km/return trip	2.38/0.61/0.06	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing overburden at area	304	144	22	125,453	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Dozer on overburden	16,347	3,950	1,716	1,954	hours/ year	16.735	4.044	1.757	kg/h	10.00	silt content in %	2	moisture content in %						
Loading interburden to haul truck	304	144	22	125,453	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling interburden to emplacement area	1,376	351	35	125,453	t/yr	0.044	0.011	0.001	kg/t	38.00	tonnes/load	0.7	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Emplacing interburden at area	304	144	22	125,453	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Dozer on interburden	16,347	3,950	1,716	1,954	hours/ year	16.735	4.044	1.757	kg/h	10.00	silt content in %	2	moisture content in %						
Loading RAW sand to haul truck	2,429	1,149	174	1,003,622	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling RAW sand to sand classifying plant for processing	51,206	13,050	1,305	1,003,622	t/yr	0.204	0.052	0.005	kg/t	38.00	tonnes/load	3.256	km/return trip	2.4/0.6/0.1	kg/VKT	4.8	s.c. in %	38	Ave GMV (t)
Unloading sand to sand classifying plant for processing	2,429	1,149	174	1,003,622	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Loading RAW sand to screen at sand classifying plant for processing	2,429	1,149	174	1,003,622	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Screen	1,104	371	25	1,003,622	t/yr	0.001	0.000	0.000	kg/t										
Unloading processed sand to stockpile	2,024	957	145	836,352	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Rehandle processed sand material at product stockpile	405	191	29	167,270	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Loading product sand material to haul truck	2,024	957	145	836,352	t/yr	0.002	0.001	0.000	kg/t	2.04	average of (WS/2.2)^1.3 in m/s	2	moisture content in %						
Hauling product sand offsite	116,164	29,606	2,961	836,352	t/yr	0.556	0.142	0.014	kg/t	33.00	tonnes/load	8.202	km/return trip	2.2/0.6/0.1	kg/VKT	4.8	s.c. in %	33	Ave GMV (t)
Hauling product material offsite (paved road)	361	69	17	836,352	t/yr	0.000	0.000	0.000	kg/t	33.00	tonnes/load	0.06	km/return trip	0.2/0.05/0.01	kg/VKT	2	s.L. in g/m2	33	Ave GMV (t)
Grading roads	26	15	1	39.72	km	0.6	0.4	0.0	kg/VKT	8	speed of graders in km/h								
Wind erosion - exposed area	14,875	7,438	1,116	35	ha	850	425	64	kg/ha/yr										
Exhaust emissions	1,242	1,242	1,205		kg/yr														
Total TSP emissions (kg/yr)	**233,380**	**66,522**	**11,060**																

Appendix C

Isopleth Diagrams

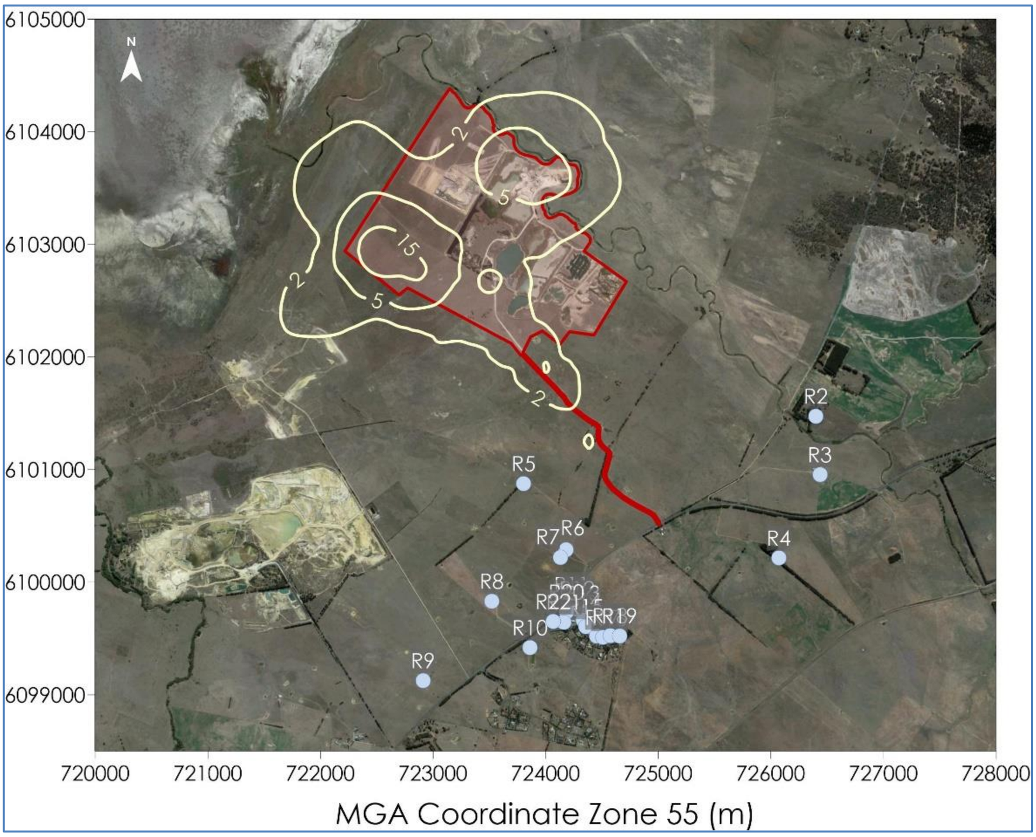

Figure C-1: Predicted incremental maximum 24-hour average $PM_{2.5}$ concentrations (µg/m³) – Scenario 1

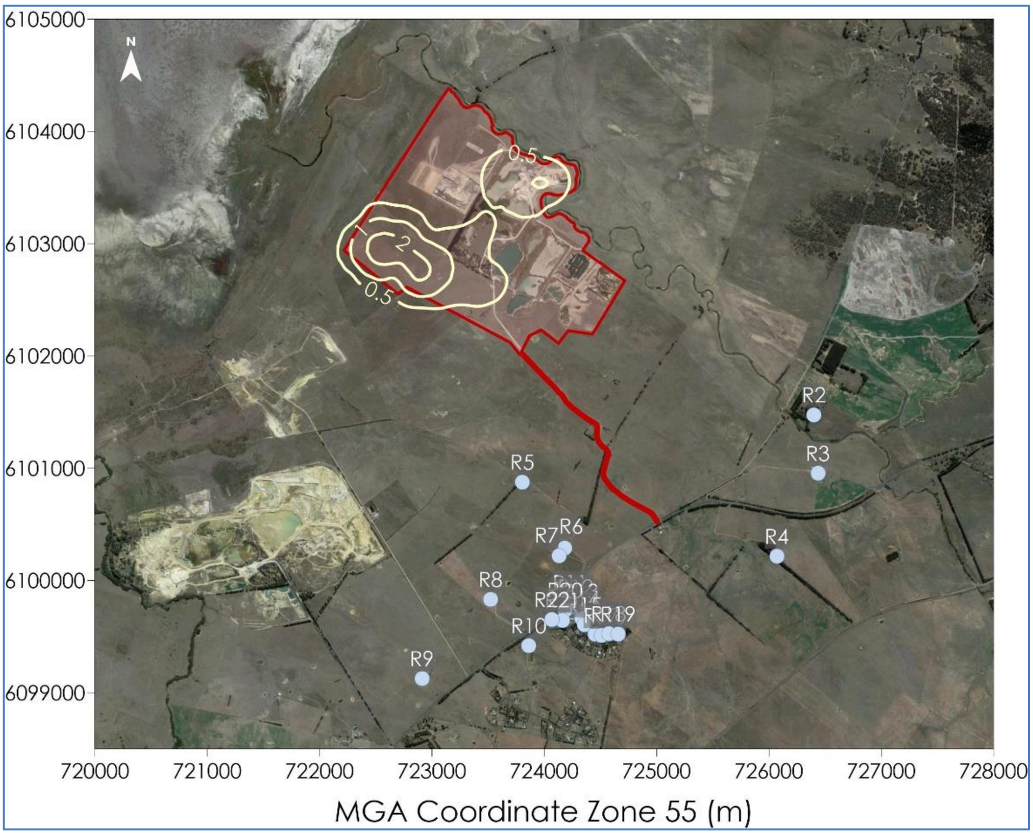

Figure C-2: Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m³) – Scenario 1

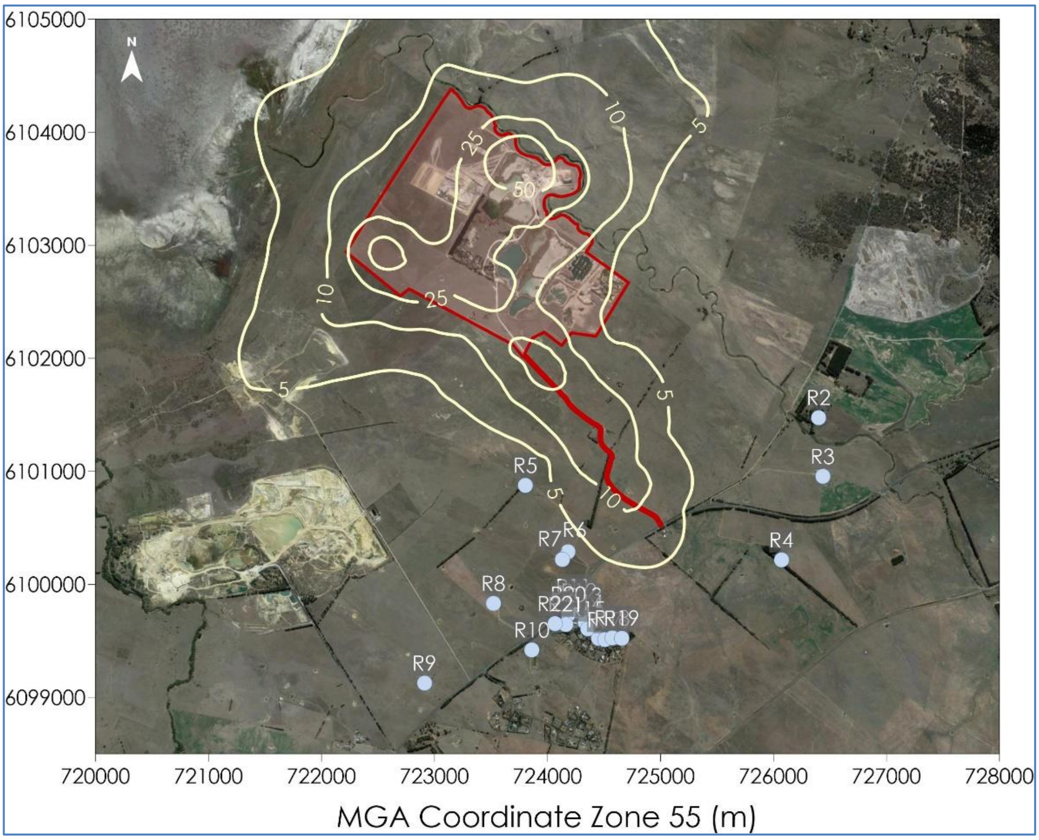

Figure C-3: Predicted incremental maximum 24-hour average PM_{10} concentrations (µg/m³) – Scenario 1

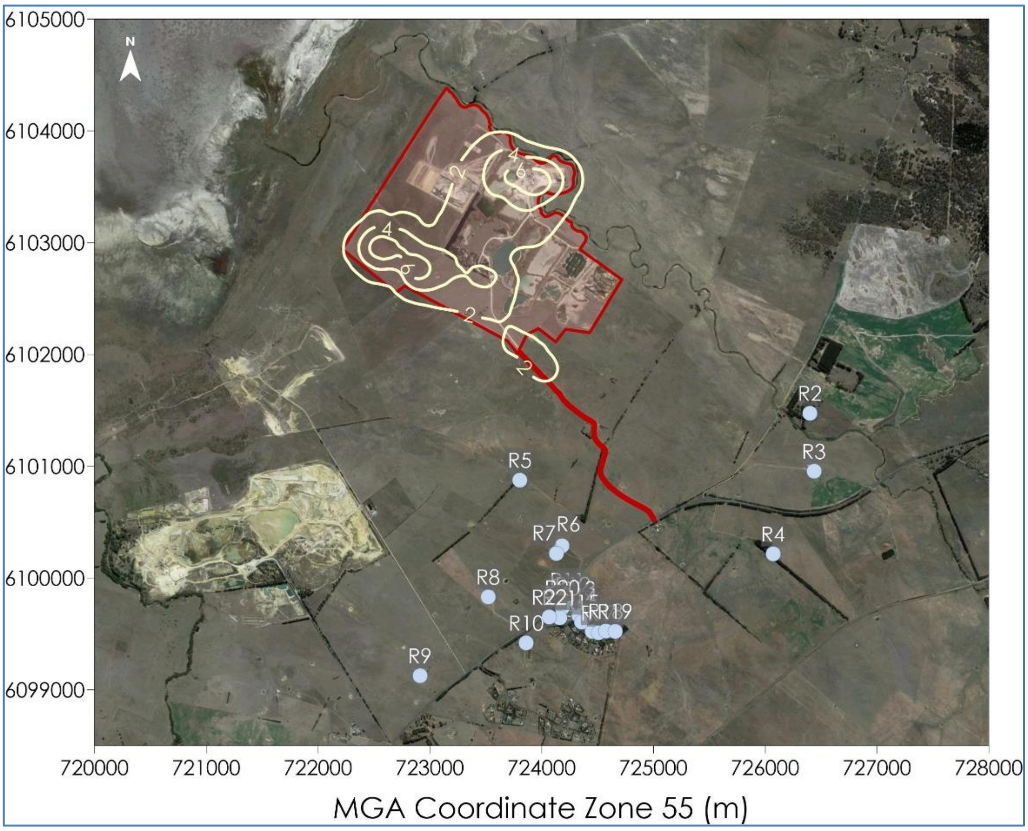

Figure C-4: Predicted incremental annual average PM_{10} concentrations (µg/m³) – Scenario 1

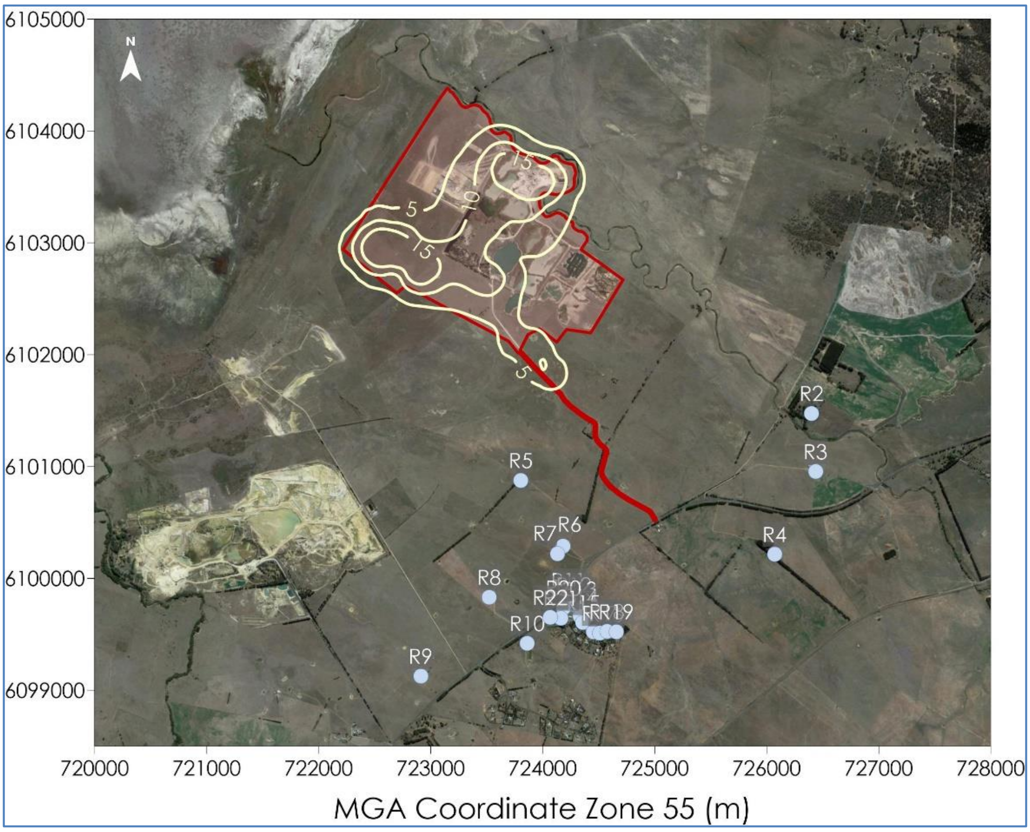

Figure C-5: Predicted incremental annual average TSP concentrations (µg/m³) – Scenario 1

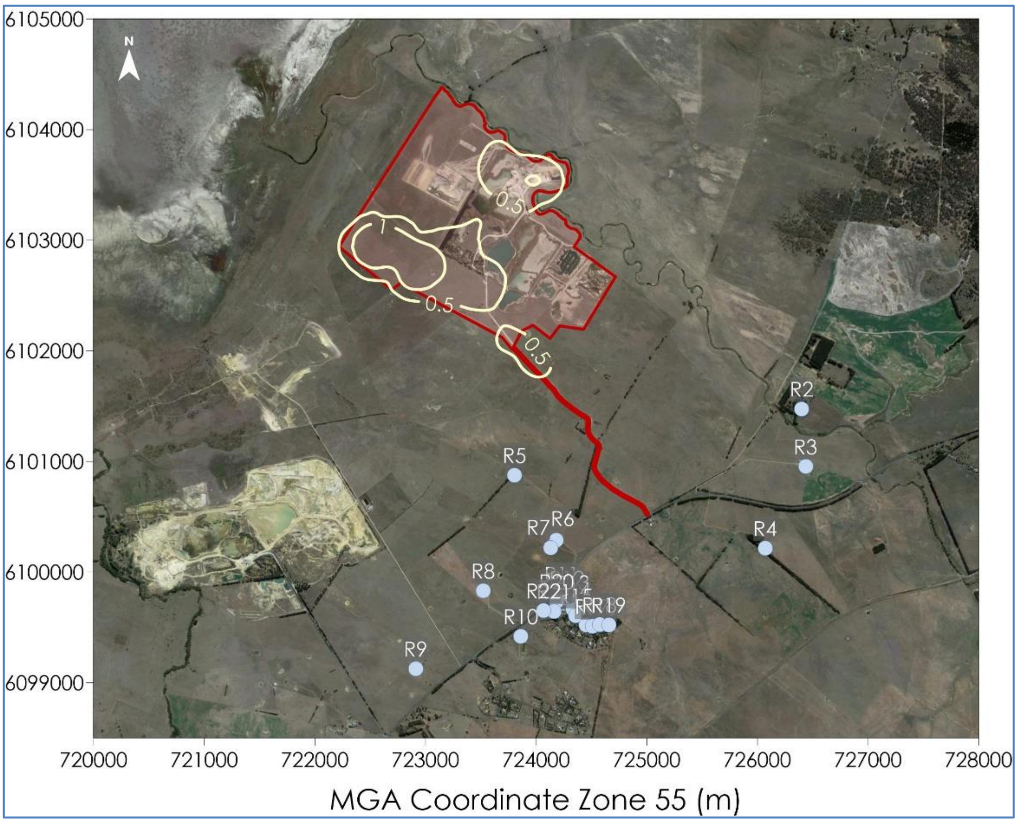

Figure C-6: Predicted incremental annual average dust deposition levels (g/m²/month) – Scenario 1

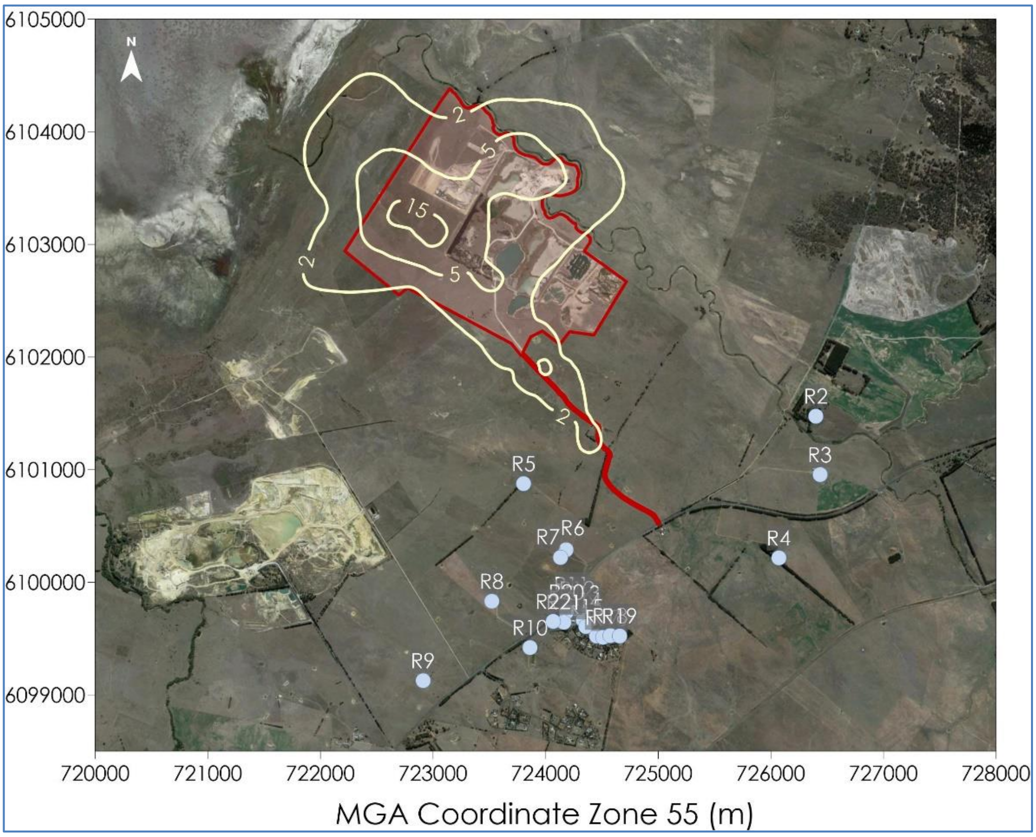

Figure C-7: Predicted incremental maximum 24-hour average $PM_{2.5}$ concentrations ($\mu g/m^3$) – Scenario 2

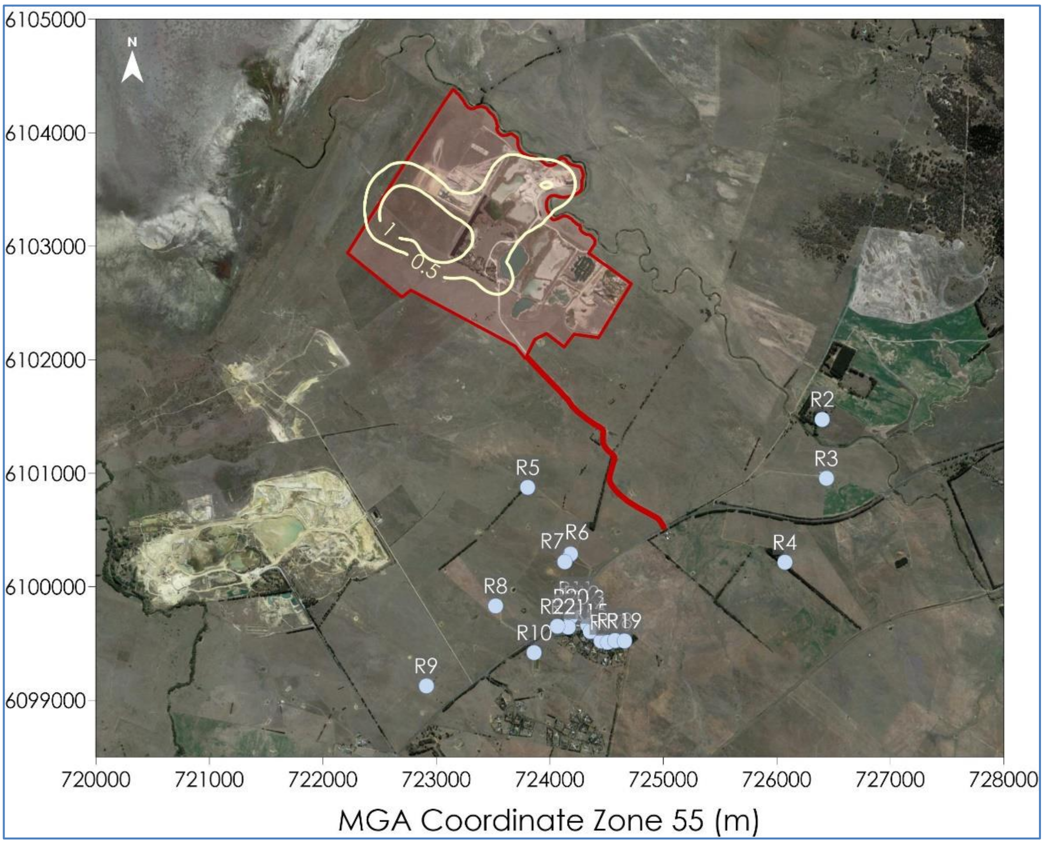

Figure C-8: Predicted incremental annual average $PM_{2.5}$ concentrations ($\mu g/m^3$) – Scenario 2

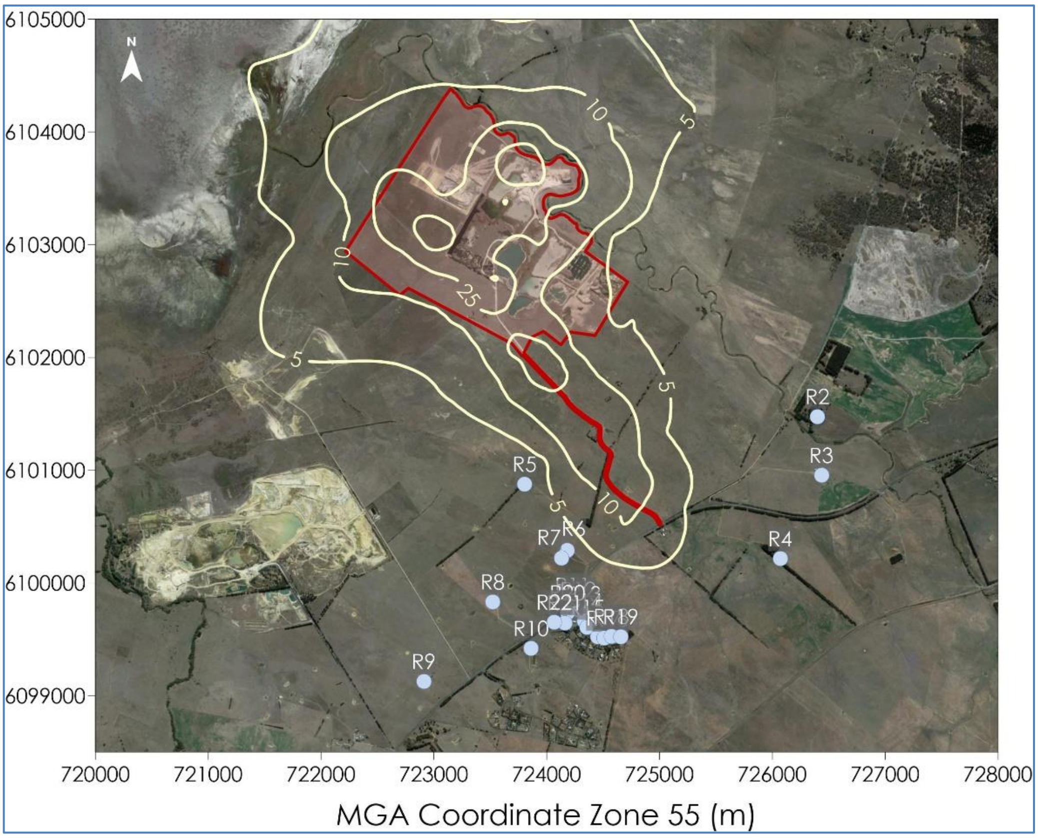

Figure C-9: Predicted incremental maximum 24-hour average PM_{10} concentrations (µg/m³) – Scenario 2

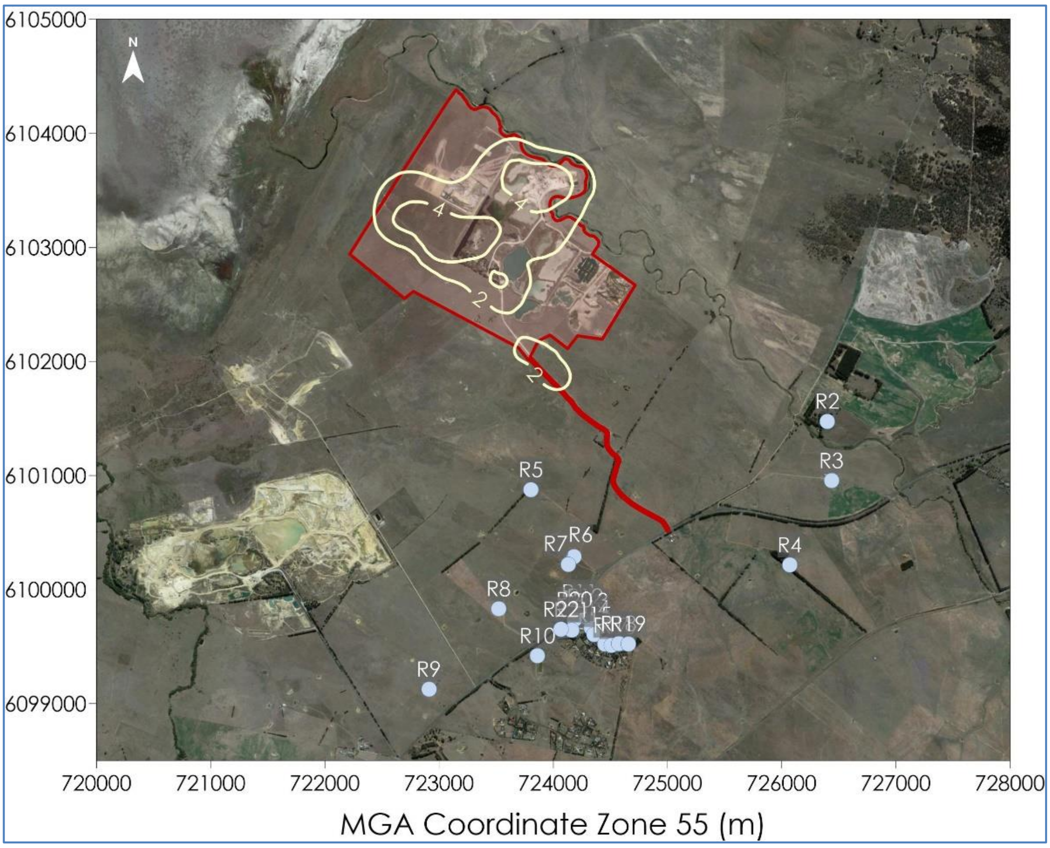

Figure C-10: Predicted incremental annual average PM_{10} concentrations (µg/m³) – Scenario 2

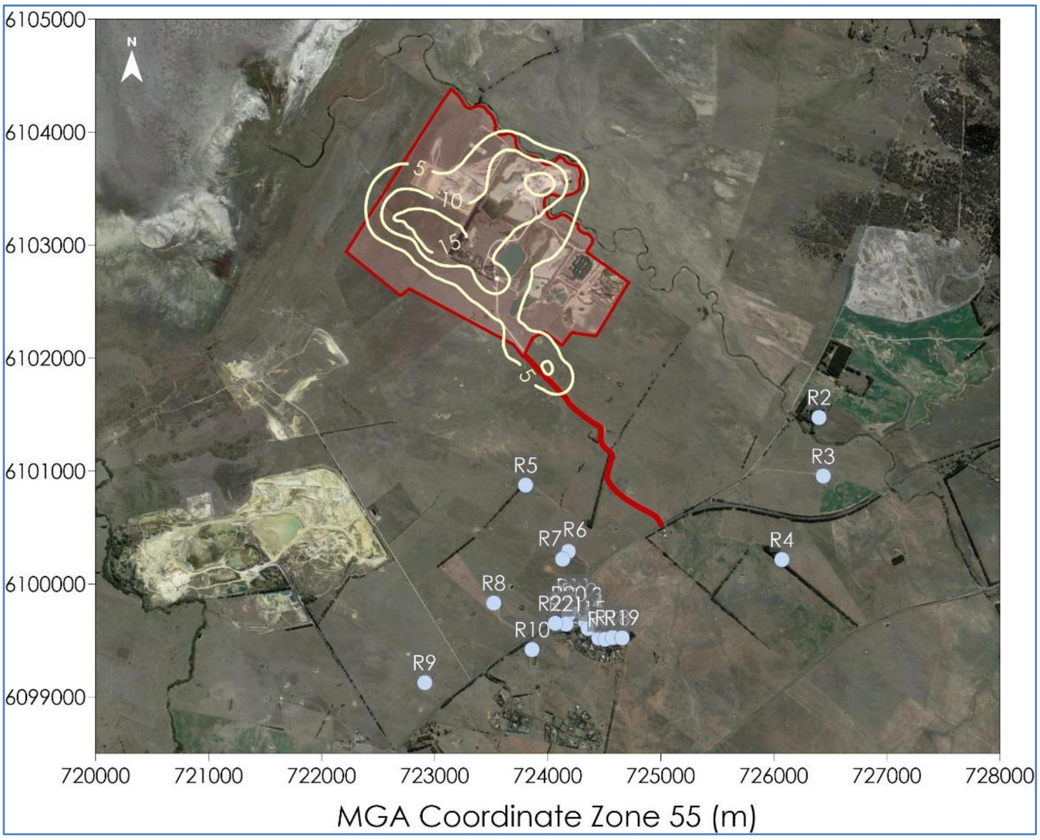

Figure C-11: Predicted incremental annual average TSP concentrations (µg/m³) – Scenario 2

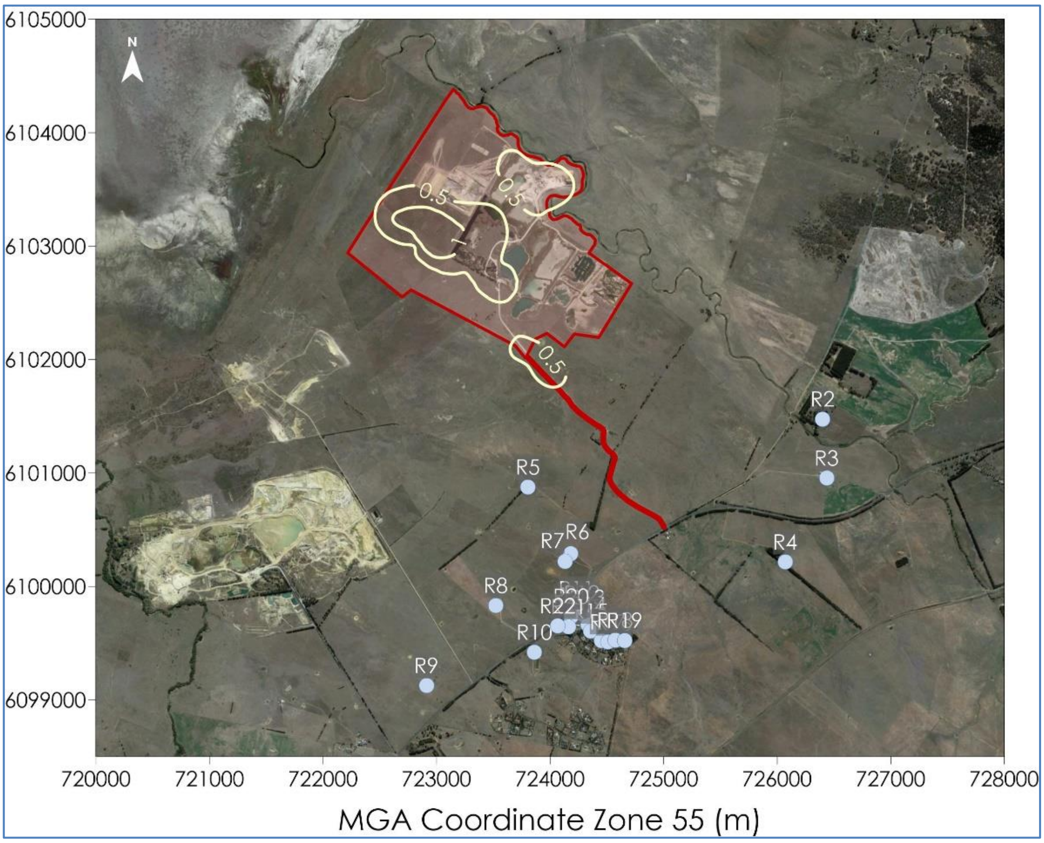

Figure C-12: Predicted incremental annual average dust deposition levels (g/m²/month) – Scenario 2

Appendix D

Further detail regarding 24-hour $PM_{2.5}$ and PM_{10} analysis

Further detail regarding 24-hour average $PM_{2.5}$ and PM_{10} analysis

The analysis below provides a cumulative 24-hour $PM_{2.5}$ and a cumulative 24-hour PM_{10} impact assessment in accordance with the NSW EPA Approved Methods; refer to the worked example on Page 46 to 47 of the Approved Methods.

The background level is the ambient level at Civic monitoring station for $PM_{2.5}$ and PM_{10}.

The predicted increment is the predicted level to occur at the receptor due to the Project.

The total is the sum of the background level and the predicted level. The totals may have minor discrepancies due to rounding.

Tables D-1 to **D-12** each assess selected receptors R4, R5 and R6 and shows the predicted maximum cumulative levels at the selected receptors for scenario 1 and scenario 2. The left half of the table examines the cumulative impact during the periods of highest background levels and the right half of the table examines the cumulative impact during the periods of highest contribution from the project.

The green shading represents days ranked per the highest background level but below the criteria.

The blue shading represents days ranked per the highest predicted increment level but below the criteria.

The orange shading represents days where the measured background level is already over the criteria.

Any value above the $PM_{2.5}$ criterion of 25µg/m^3 or above the PM_{10} criterion of 50µg/m^3 is in **bold red.**

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Table D-1: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R4, Scenario 1

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	42.1	0.0	42.1				
30/03/2017	18.9	0.0	18.9	11/06/2017	6.7	0.4	7.1
30/07/2017	17.0	0.1	17.2	14/06/2017	9.2	0.3	9.4
31/08/2017	16.7	0.0	16.7	15/06/2017	11.7	0.3	11.9
17/05/2017	15.4	0.0	15.4	16/06/2017	14.2	0.2	14.4
17/06/2017	15.4	0.0	15.4	14/07/2017	10.2	0.2	10.3
18/05/2017	14.8	0.0	14.8	18/07/2017	9.5	0.2	9.6
18/06/2017	14.8	0.0	14.8	1/05/2017	4.5	0.2	4.7
16/05/2017	14.2	0.0	14.2	12/09/2017	5.3	0.2	5.4
16/06/2017	14.2	0.2	14.4	6/05/2017	9.4	0.2	9.6
15/05/2017	11.7	0.0	11.7	15/08/2017	6.4	0.2	6.5

Table D-2: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R5, Scenario 1

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	42.1	0.0	42.1				
30/03/2017	18.9	0.0	18.9	16/06/2017	14.2	0.6	14.8
30/07/2017	17.0	0.0	17.0	20/05/2017	10.0	0.5	10.5
31/08/2017	16.7	0.0	16.7	13/05/2017	8.8	0.4	9.1
17/05/2017	15.4	0.2	15.6	27/06/2017	7.3	0.4	7.6
17/06/2017	15.4	0.0	15.4	2/07/2017	8.5	0.3	8.8
18/05/2017	14.8	0.1	14.9	3/07/2017	8.8	0.3	9.0
18/06/2017	14.8	0.0	14.8	22/04/2017	6.2	0.3	6.5
16/05/2017	14.2	0.0	14.2	13/07/2017	8.0	0.2	8.2
16/06/2017	14.2	0.6	14.8	23/05/2017	11.4	0.2	11.6
15/05/2017	11.7	0.0	11.7	16/07/2017	6.6	0.2	6.8

Table D-3: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R6, Scenario 1

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	42.1	0.0	42.1				
30/03/2017	18.9	0.0	18.9	20/05/2017	10.0	0.4	10.4
30/07/2017	17.0	0.0	17.0	16/06/2017	14.2	0.4	14.6
31/08/2017	16.7	0.0	16.7	27/06/2017	7.3	0.3	7.6
17/05/2017	15.4	0.1	15.4	2/07/2017	8.5	0.3	8.8
17/06/2017	15.4	0.0	15.4	13/05/2017	8.8	0.2	9.0
18/05/2017	14.8	0.0	14.8	16/07/2017	6.6	0.2	6.8
18/06/2017	14.8	0.0	14.8	3/07/2017	8.8	0.2	8.9
16/05/2017	14.2	0.0	14.2	13/07/2017	8.0	0.2	8.1
16/06/2017	14.2	0.4	14.6	22/04/2017	6.2	0.2	6.4
15/05/2017	11.7	0.0	11.7	23/05/2017	11.4	0.2	11.5

Table D-4: Cumulative 24-hour average PM10 concentration (µg/m³) – Receptor R4, Scenario 1

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	45.6	0.0	45.6	11/06/2017	8.0	2.4	10.5
30/03/2017	27.5	0.0	27.5	15/06/2017	14.3	1.6	15.9
23/02/2017	21.1	0.5	21.6	14/06/2017	13.2	1.6	14.8
17/05/2017	20.5	0.0	20.5	16/06/2017	18.6	1.1	19.7
17/06/2017	20.5	0.0	20.5	27/05/2017	12.2	1.0	13.2
14/12/2017	20.3	0.4	20.7	1/05/2017	6.1	1.0	7.1
16/05/2017	18.6	0.0	18.6	14/07/2017	13.2	1.0	14.1
16/06/2017	18.6	1.1	19.7	18/07/2017	11.5	0.9	12.4
24/02/2017	18.2	0.0	18.2	6/05/2017	9.8	0.9	10.7
13/07/2017	17.8	0.1	17.8	17/07/2017	14.1	0.9	15.0

Table D-5: Cumulative 24-hour average PM_{10} concentration ($\mu g/m^3$) – Receptor R5, Scenario 1

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	45.6	0.0	45.6	20/05/2017	16.0	3.5	19.6
30/03/2017	27.5	0.0	27.5	16/06/2017	18.6	3.2	21.8
23/02/2017	21.1	0.4	21.5	13/05/2017	9.5	2.7	12.3
17/05/2017	20.5	1.6	22.1	27/06/2017	12.2	2.2	14.3
17/06/2017	20.5	0.0	20.5	2/07/2017	13.3	1.9	15.2
14/12/2017	20.3	0.1	20.3	10/06/2017	6.7	1.6	8.2
16/05/2017	18.6	0.0	18.6	16/07/2017	9.0	1.6	10.6
16/06/2017	18.6	3.2	21.8	17/05/2017	20.5	1.6	22.1
24/02/2017	18.2	0.5	18.6	22/04/2017	14.0	1.5	15.5
13/07/2017	17.8	1.2	19.0	3/07/2017	15.2	1.5	16.6

Table D-6: Cumulative 24-hour average PM_{10} concentration ($\mu g/m^3$) – Receptor R6, Scenario 1

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	45.6	0.0	45.6	20/05/2017	16.0	3.0	19.0
30/03/2017	27.5	0.0	27.5	27/06/2017	12.2	2.2	14.4
23/02/2017	21.1	0.3	21.4	16/06/2017	18.6	2.1	20.7
17/05/2017	20.5	0.5	21.0	2/07/2017	13.3	1.8	15.2
17/06/2017	20.5	0.0	20.5	16/07/2017	9.0	1.7	10.7
14/12/2017	20.3	0.0	20.3	13/05/2017	9.5	1.5	11.1
16/05/2017	18.6	0.0	18.6	16/03/2017	7.3	1.1	8.4
16/06/2017	18.6	2.1	20.7	23/11/2017	9.6	1.1	10.7
24/02/2017	18.2	0.0	18.2	13/07/2017	17.8	1.0	18.8
13/07/2017	17.8	1.0	18.8	27/11/2017	9.6	1.0	10.6

Table D-7: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R4, Scenario 2

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	**42.1**	0.0	**42.1**				
30/03/2017	18.9	0.0	18.9	11/06/2017	6.7	0.4	7.1
30/07/2017	17.0	0.1	17.2	15/06/2017	11.7	0.2	11.9
31/08/2017	16.7	0.0	16.7	14/06/2017	9.2	0.2	9.4
17/05/2017	15.4	0.0	15.4	16/06/2017	14.2	0.2	14.4
17/06/2017	15.4	0.0	15.4	1/05/2017	4.5	0.2	4.7
18/05/2017	14.8	0.0	14.8	6/05/2017	9.4	0.2	9.6
18/06/2017	14.8	0.0	14.8	17/07/2017	10.3	0.2	10.5
16/05/2017	14.2	0.0	14.2	14/07/2017	10.2	0.1	10.3
16/06/2017	14.2	0.2	14.4	27/05/2017	7.3	0.1	7.4
15/05/2017	11.7	0.0	11.7	20/05/2017	10.0	0.1	10.1

Table D-8: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R5, Scenario 2

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	**42.1**	0.0	**42.1**				
30/03/2017	18.9	0.0	18.9	20/05/2017	10.0	0.6	10.6
30/07/2017	17.0	0.0	17.0	16/06/2017	14.2	0.6	14.8
31/08/2017	16.7	0.0	16.7	27/06/2017	7.3	0.4	7.7
17/05/2017	15.4	0.2	15.6	13/05/2017	8.8	0.4	9.1
17/06/2017	15.4	0.0	15.4	2/07/2017	8.5	0.3	8.8
18/05/2017	14.8	0.1	14.9	3/07/2017	8.8	0.2	9.0
18/06/2017	14.8	0.0	14.8	22/04/2017	6.2	0.2	6.4
16/05/2017	14.2	0.0	14.2	17/05/2017	15.4	0.2	15.6
16/06/2017	14.2	0.6	14.8	13/07/2017	8.0	0.2	8.2
15/05/2017	11.7	0.0	11.7	10/06/2017	5.5	0.2	5.8

Table D-9: Cumulative 24-hour average $PM_{2.5}$ concentration (µg/m³) – Receptor R6, Scenario 2

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	42.1	0.0	42.1				
30/03/2017	18.9	0.0	18.9	20/05/2017	10.0	0.5	10.5
30/07/2017	17.0	0.0	17.0	27/06/2017	7.3	0.4	7.6
31/08/2017	16.7	0.0	16.7	16/06/2017	14.2	0.4	14.6
17/05/2017	15.4	0.1	15.4	2/07/2017	8.5	0.3	8.8
17/06/2017	15.4	0.0	15.4	13/05/2017	8.8	0.2	9.0
18/05/2017	14.8	0.0	14.8	16/07/2017	6.6	0.2	6.8
18/06/2017	14.8	0.0	14.8	13/07/2017	8.0	0.2	8.2
16/05/2017	14.2	0.0	14.2	3/07/2017	8.8	0.2	8.9
16/06/2017	14.2	0.4	14.6	22/04/2017	6.2	0.2	6.4
15/05/2017	11.7	0.0	11.7	16/03/2017	3.6	0.1	3.7

Table D-10: Cumulative 24-hour average PM10 concentration (µg/m³) – Receptor R4, Scenario 2

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	45.6	0.0	45.6	11/06/2017	8.0	2.5	10.5
30/03/2017	27.5	0.0	27.5	15/06/2017	14.3	1.6	15.9
23/02/2017	21.1	0.5	21.6	14/06/2017	13.2	1.5	14.7
17/05/2017	20.5	0.0	20.5	16/06/2017	18.6	1.1	19.7
17/06/2017	20.5	0.0	20.5	1/05/2017	6.1	1.1	7.2
14/12/2017	20.3	0.5	20.7	27/05/2017	12.2	1.0	13.2
16/05/2017	18.6	0.0	18.6	17/07/2017	14.1	0.9	15.0
16/06/2017	18.6	1.1	19.7	6/05/2017	9.8	0.9	10.7
24/02/2017	18.2	0.0	18.2	14/07/2017	13.2	0.9	14.1
13/07/2017	17.8	0.1	17.8	18/07/2017	11.5	0.9	12.4

Table D-11: Cumulative 24-hour average PM_{10} concentration (µg/m³) – Receptor R5, Scenario 2

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	45.6	0.0	45.6	20/05/2017	16.0	3.7	19.7
30/03/2017	27.5	0.0	27.5	16/06/2017	18.6	3.0	21.6
23/02/2017	21.1	0.4	21.4	13/05/2017	9.5	2.8	12.3
17/05/2017	20.5	1.7	22.2	27/06/2017	12.2	2.3	14.4
17/06/2017	20.5	0.0	20.5	2/07/2017	13.3	1.9	15.2
14/12/2017	20.3	0.0	20.3	10/06/2017	6.7	1.7	8.3
16/05/2017	18.6	0.0	18.6	17/05/2017	20.5	1.7	22.2
16/06/2017	18.6	3.0	21.6	16/07/2017	9.0	1.6	10.6
24/02/2017	18.2	0.5	18.7	22/05/2017	16.3	1.5	17.8
13/07/2017	17.8	1.2	18.9	13/06/2017	9.5	1.5	11.0

Table D-12: Cumulative 24-hour average PM_{10} concentration (µg/m³) – Receptor R6, Scenario 2

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
30/08/2017	45.6	0.0	45.6	20/05/2017	16.0	3.1	19.2
30/03/2017	27.5	0.0	27.5	27/06/2017	12.2	2.3	14.5
23/02/2017	21.1	0.2	21.3	16/06/2017	18.6	2.0	20.7
17/05/2017	20.5	0.5	21.0	2/07/2017	13.3	1.9	15.2
17/06/2017	20.5	0.0	20.5	16/07/2017	9.0	1.7	10.8
14/12/2017	20.3	0.0	20.3	13/05/2017	9.5	1.6	11.1
16/05/2017	18.6	0.0	18.6	16/03/2017	7.3	1.2	8.5
16/06/2017	18.6	2.0	20.7	23/11/2017	9.6	1.1	10.7
24/02/2017	18.2	0.1	18.2	13/07/2017	17.8	1.1	18.8
13/07/2017	17.8	1.1	18.8	27/11/2017	9.6	1.1	10.7