

EA APPLICATION SUPPORTING REPORT

SAVANNAH GOLDFIELDS LTD

Appendix 15 Air Impact Assessment (SEG, 2023)



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1 Introduction

Wulguru Technical Services (WTS) on behalf of Laneway Resources Pty Ltd, engaged Simpson Engineering Group (SEG) to prepare a noise and vibration assessment for a proposed metals mining project, Agate Creek Mine Expansion (the Project), 40km south of Forsayth in north Queensland.

The air quality study has adopted regulatory dispersion modelling techniques and the particulate & dust levels have been assessed against the health and amenity goals.

This report addresses the following issues:

- Existing environment;
- Air quality goals
- Air emissions inventory;
- Likely change in air quality following commencement of operation;
- Recommendations for ongoing operation.

1.1 Project Description

The Project is large highly prospective epithermal system located approximately 48km south of Forsayth and 60km west of Kidston in North Queensland. The Project is an expansion of the existing open pit and has a 3-year life. The mining will involve conventional excavator and haul trucks to create a pit and external waste dump. The mining fleet comprises 4 trucks, a 30 tonne excavators and associated plant. Road trains take the ROM ore directly to an off-site processing facility. The average production of ore during the open pit phase is 0.25Mt. The mass of waste moved is approximately 1.25Mt per annum. The major emissions from the mine is particulate matter. Odours, fumes and other emissions are minor and would not have any offsite impacts.

1.2 Locality Description

The project is situated in a well-established grazing and mining region. The region is undulating, generally comprising open grazing and native scrublands. The location of the Project is shown on Figure 1. The closest community is Forsayth, situated to the NE of the site. Forsayth is service centre for the farming, mining and tourist industry. The area to the west of the site comprises the Rungulla Resources Reserve and the Rungulla National park. The national park comprises a wide range of sandstone formations, including outcrops of large, sculpted caves and pagoda-like sandstone features. The Agate Creek fossicking area is southwest of the site.

There is one dwelling 8 km from the project and a second dwellings within approximately 25 km of the site. It is understood the proponent has reached an agreement with the campground landowner to relocate the campground.

The Rungulla National Park and Rungulla Resources Reserve contains rugged sandstone country and the Gilbert River as well as springs, watercourses and refugia habitats. Rungulla National Park is approximately 75 km north to south and 42km east to west at widest extent. The closest section is 3.8km west of the site. The Rungulla Resources Reserve at its closest extent is 1.4km to the west of the site.

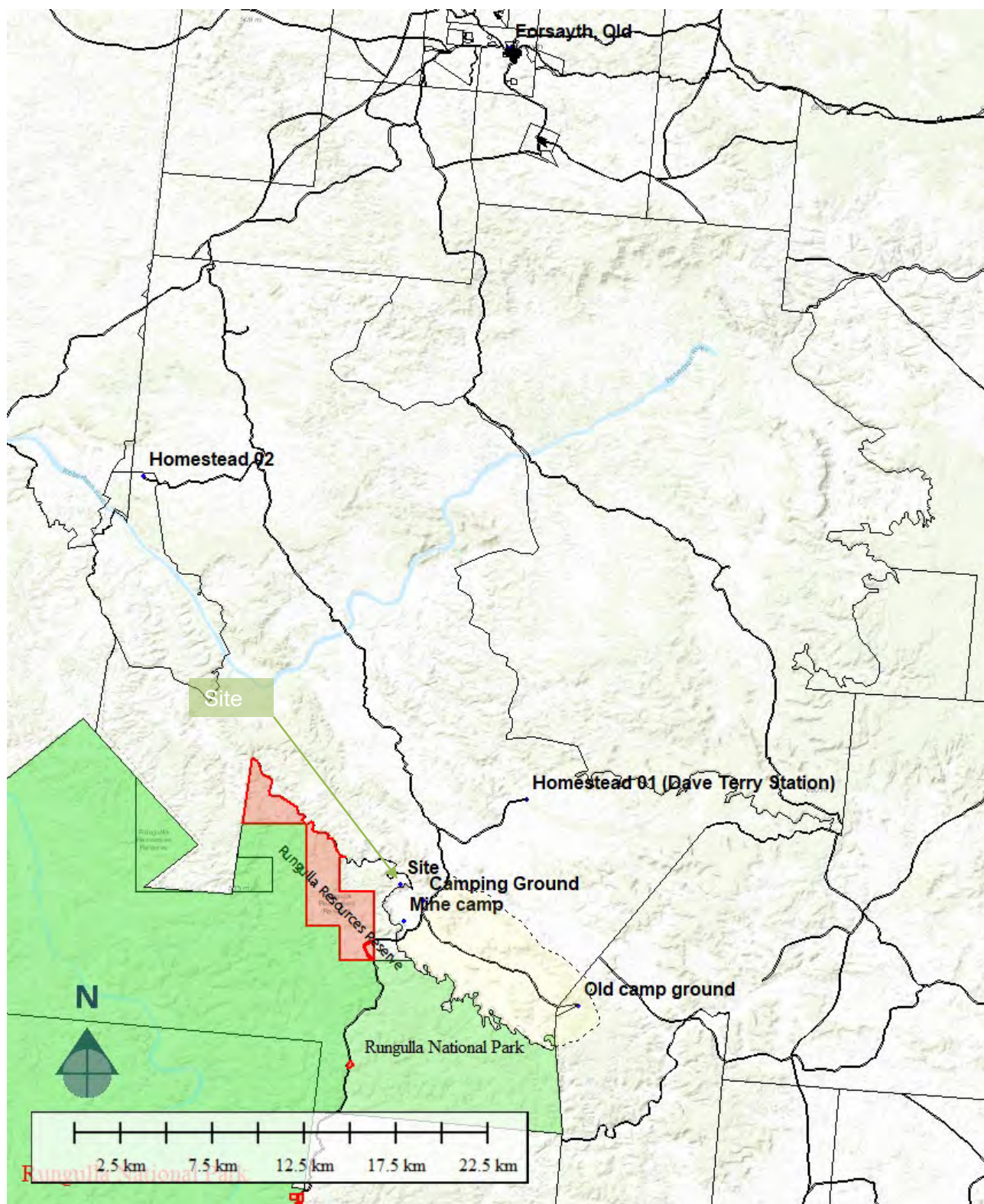


Figure 1: Regional View Showing the Project Area

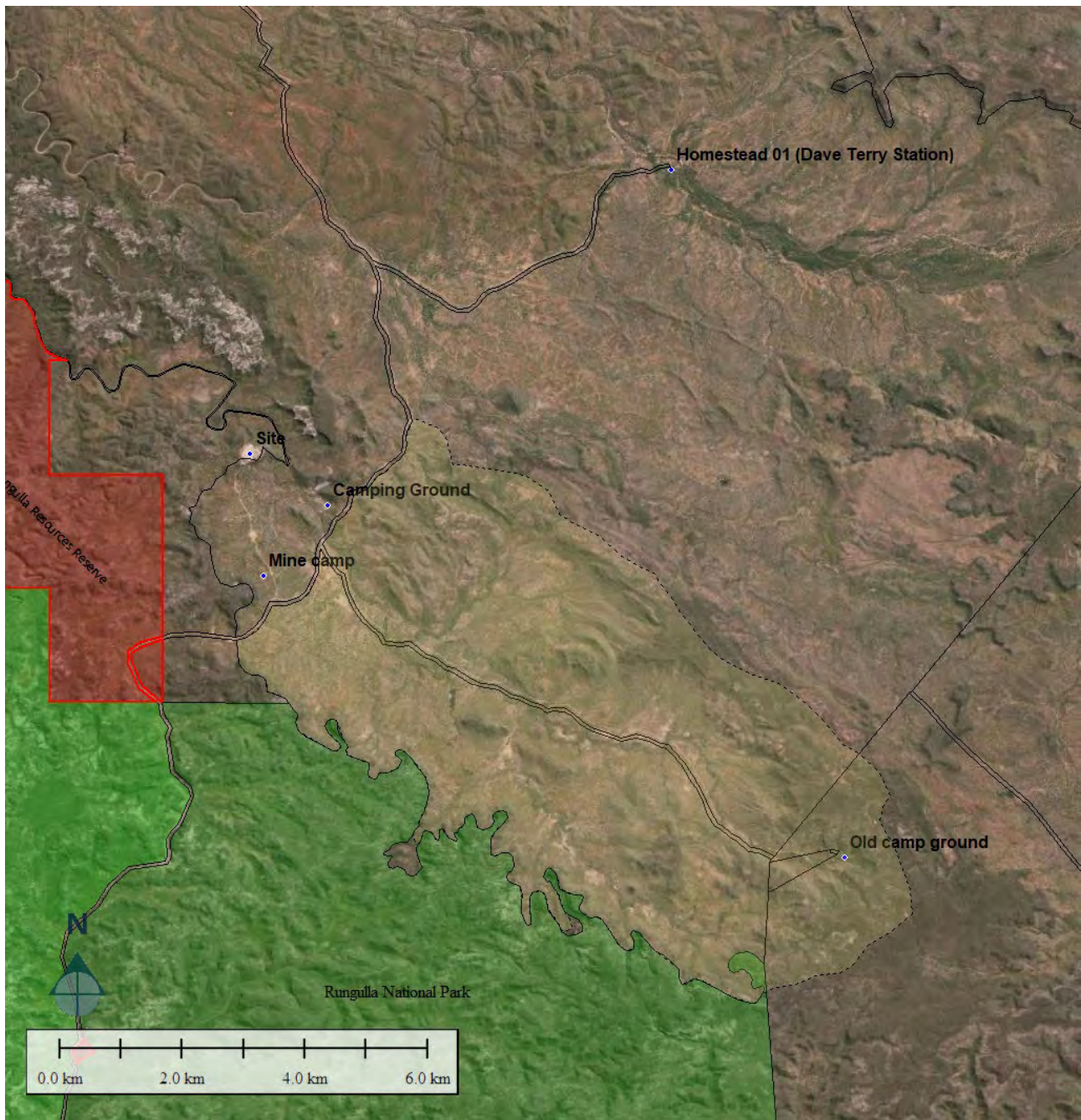


Figure 2: Site and Surroundings

2 Description of Existing Environment

2.1 Climate

The Project is situated in an inland tropical area. The region has a warm to hot climate with two distinct seasons, a dry winter season and a wet summer season. Based on the nearest relevant BOM weather station at Georgetown Airport¹, winter temperatures average from 13 °C to 30 °C, while summer temperatures range from around 24°C to 37°C. The region averages approximately 820 mm of rainfall each year, falling mostly between December and March.

During the wet summer season, the soil moisture content increases and there is increased grass ground cover. This results in lower dust emissions from most activities, including local roads. During the dry winter season, the soil moisture content reduces (particularly at the surface) and grass cover reduces. The dust emissions are more prevalent from most activities during this period. This is also the period when grass fires (including permit fire) are likely to occur. These types of fire release significant quantities of smoke into the lower atmosphere.

2.2 Air Quality

Potential sources of particulate emissions from the surrounding environment primarily comprise:

- farming and grazing activities;
- existing mining operations;
- unsealed roads; and
- smoke from grass/bush fires (permitted or otherwise).

Due to the lack of other industries in the area, the majority of emissions from the surrounding areas would be crustal matter that is released from farming activities, mining activities and unsealed roads. The characteristic of these emissions are particulates and dusts made up of crustal matter rather than other material that has specific limits. Based on this the air quality indicators that are processed in this report are PM_{2.5}, PM₁₀, TSP and dust deposition.

Based on the most recent published DES Queensland National Environment Protection (Ambient Air Quality) Measure monitoring of dust deposition and average PM₁₀, PM_{2.5} monitoring for Townsville² the expected particulate and dust exposure levels at all receptor locations are:

- Dust deposition of 53 mg/m²/day for all locations
- Particulate concentration of:
 - o PM_{2.5}(24 hour) = 8 µg/m³
 - o PM_{2.5}(annual average) = 7 µg/m³
 - o PM₁₀(24 hour) = 22 µg/m³
 - o PM₁₀(annual average) = 20.2 µg/m³

¹ Summary statistics CHARTERS TOWERS AIRPORT, Bureau of Meteorology (http://www.bom.gov.au/climate/averages/tables/cw_030124.shtml)

² Queensland air monitoring 2019, Queensland Government, State of the Environment, (https://www.qld.gov.au/__data/assets/pdf_file/0032/68657/air-monitoring-report.pdf)

2.3 Sensitive Receptors

One dwelling have been identified within 10km of the mine. The locations and separation distances are contained in Table 1. Second dwelling is situated 25km from the mine.

Table 1: Sensitive Receptors adjacent to the Mine

Receptors (Homesteads)	Distance [km]	Angle (degrees)
Mine Camp (non-sensitive receptor)	1.9	170
Campground	1.5	120
Old Camp Ground	11	125
Homestead 01 (Dave Terry station)	8	55
Homestead 02	25	330
Forsayth	45	7
Rungulla Resources Reserve	1.4	250
Rungulla National Park	3.8	235

The project's Mine Camp has been included. Whilst this site is modelled it is not classified as a sensitive receptor and is included for reference only. It is understood the proponent has reached an agreement with the campground landowner to relocate the campground. Thus the campground is included for completeness.

3 Air Quality Criteria

3.1 Guideline ESR/2015/1840 ERA

The Guideline ESR/2015/1840 ERA describes types of impacts that environmentally relevant activities can have in relation to air and outlines the information to be provided to the department as part of the ERA application process.

There are three key areas to be identified and addressed through the ERA application process:

- Identify the environmental values of the receiving air environment including the identification of any nearby sensitive places.
- Identify the possible impacts due to the proposed activity and all associated risks to environmental values.
- Identify the strategies to mitigate the identified risks to the environmental values.

It is necessary to identify the environmental values of the site, this is assisted by the following:

1. Describe the surrounding land.
2. Use of a scaled map with site and sensitive receptors.
3. Describe site topography.
4. Analyse and describe the prevailing site wind direction and speed.
5. Provide a description of the localised ambient air quality.

The department seeks to determine possible impacts to identified environmental values. To assist with this the following information is sought:

1. Identify and provide an overview of emissions and processes.
2. Describe the characteristics of the emissions.
3. Identify if an odour impact assessment is required.
4. Describe how air emissions will be avoided, minimised or otherwise managed in accordance with the EPP (Air).

Once the value and risk of each impact to the environmental value is known, mitigation strategies can be devised to address the risk. When selecting a mitigation strategy, the following will be provided:

1. Describe the control measure including equipment and techniques used.
2. Identify contingency plans in case of failure in a control measure.

3.2 Environmental Protection (Air) Policy

The Queensland Environmental Protection (Air) Policy 2019 (EPP(Air) 2019) commenced in 2019. The EPP (Air) 2019 (Part 2 Section 5) aims to achieve the object of the *Environmental Protection Act 1994* (the Act) in relation to Queensland's air environment. The object of the Act is "... to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development)."

Specifically, the EPP (Air) 2019 addresses the environmental values to be enhanced or protected namely—

- (a) the qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems; and
- (b) the qualities of the air environment that are conducive to human health and wellbeing; and
- (c) the qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property; and
- (d) the qualities of the air environment that are conducive to protecting agricultural use of the environment.

To meet the environmental values, Schedule 1 of the EPP (Air) nominates relevant air quality indicators and goals. Relevant air quality indicators from Schedule 1 dealing with particulates are included in Table 1.

Table 2: Excerpt from Environmental Protection (Air) Policy 2019 Schedule 1

Indicator	Environmental value	Air quality objectives ($\mu\text{g}/\text{m}^3$)	Period
PM _{2.5}	health and wellbeing	25	24 hours
		8	1 year
PM ₁₀	health and wellbeing	50	24 hours
		25	1 year
Total Suspended Particles	health and wellbeing	90	1 year
arsenic and compounds (measured as the total metal content in PM ₁₀)	health and wellbeing	0.006	1 year
lead and compounds (measured as the total metal content in total suspended particles)	health and wellbeing	0.5	1 year
manganese and compounds (measured as the total metal content in PM ₁₀)	health and wellbeing	0.16	1 year
Inorganic mercury vapour	health and wellbeing	1.1	1 year
manganese and compounds (measured as the total metal content in PM ₁₀)	health and wellbeing	0.0022	1 year

All these indicators are qualities of the air environment that are conducive to human health and wellbeing. The indicators apply at sensitive or commercial places. Since there is not a specific limit(s) for protected areas to preserve ecological values, it is considered reasonable in the first instance to apply these goals at Rungulla Resource Reserve and Rungulla National Park

3.3 NEPM

The current National Environment Protection (Ambient Air Quality) Measure has been included in Table 3 and Table 4.

Table 3: Excerpt from NEPM Schedule 2 Table 1: Standards and Goal for Pollutants other than Particles as PM_{2.5}

Pollutant	Averaging period	Maximum concentration	Goal within 10 years Maximum allowable exceedances
Particles as PM ₁₀	1 day	50 µg/m ³	5 days a year

Table 4: Excerpt from NEPM Schedule 2 Table 2: Advisory Reporting Standards and Goal for Particles as PM_{2.5}

Pollutant	Averaging period	Maximum concentration
Particles as PM _{2.5}	1 day	25 µg/m ³
	1 year	8 µg/m ³

A future goal is recommended to be adopted by the states. The goal for the year 2025 comprises:

- a) PM_{2.5} – 7 µg/m³ averaged over one year; and
- b) PM_{2.5} – 20 µg/m³ averaged over 24 hours.

3.4 Site Specific Air Quality Criteria

Particulates are often described as respirable and inhalable. Respirable particulates are those small enough to penetrate the nose and deep into the lung. Respirable particulates that penetrate past the nose and upper respiratory system are likely to be retained in the body. This involves Particulates having an aerodynamic diameter of up to 10 µm. Inhalable particulates are particulates which enter the body but are collected in the nose and upper respiratory system and rejected. Inhalable particulates are those having an aerodynamic diameter of nominally 10 µm and larger.

As a general guide particulates having diameters of 7 to 10 μm are mostly large enough to be caught by nose and throat. Particles in the range 0.5 to 7 μm are small enough to reach the lung yet large enough to be retained. Since these particulates remain in the lung they may be hazardous to health and well-being.

In summary, the applicable air quality criteria (from EPP Air) are:

- Particulate concentration of $\text{PM}_{2.5}$ 25 $\mu\text{g}/\text{m}^3$ averaged over 24 hours;
- Particulate concentration of $\text{PM}_{2.5}$ 8 $\mu\text{g}/\text{m}^3$ averaged over one year;
- Particulate concentration of PM_{10} of 50 $\mu\text{g}/\text{m}^3$ over a 24-hour averaging time;
- Particulate concentration of PM_{10} of 25 $\mu\text{g}/\text{m}^3$ over one year;
- Total suspended particulate 90 $\mu\text{g}/\text{m}^3$ averaged over a year; and,
- Dust deposition of 120 $\text{mg}/\text{m}^2/\text{day}$ averaged over one month;
- Particulate arsenic concentration in PM_{10} of 0.006 $\mu\text{g}/\text{m}^3$ over one year;
- Particulate lead concentration in TSP of 0.5 $\mu\text{g}/\text{m}^3$ over one year;
- Particulate manganese concentration in PM_{10} of 0.16 $\mu\text{g}/\text{m}^3$ over one year;
- Particulate mercury concentration in TSP of 0.006 $\mu\text{g}/\text{m}^3$ over one year;
- Particulate nickel concentration in PM_{10} of 0.0022 $\mu\text{g}/\text{m}^3$ over one year;

All these indicators (except deposition) are qualities of the air environment that are important to human health and wellbeing. The deposition (or dust fallout) is for assessing dust nuisance. The indicators apply at any sensitive or commercial place, such as residences, National Parks, schools, etc.

4 Air Quality Modelling

4.1 Modelling Methodology

Typically, particulate matter is characterised by its size. The particulate size ranges specified in ambient air criteria are total suspended particulate (TSP), particulate matter below 10 microns (PM_{10}) and particulate matter below 2.5 microns ($PM_{2.5}$). TSP includes both the PM_{10} and $PM_{2.5}$ fractions, and PM_{10} includes the 2.5 fraction.

Under normal conditions, particles with aerodynamic diameters of more than PM_{10} will typically fall out and be deposited onto the ground within several minutes of release.

The PM_{10} and $PM_{2.5}$ particulates do not have a significant settling velocity and will behave in a gaseous fashion, that is, the fall out time is significantly longer than a few minutes. The settling velocity for PM_{10} particles is nominally 5 mm/s while for $PM_{2.5}$ it is 0.5 mm/s. This may be compared with PM_{20} where the settling velocity is approximately 20 mm/s (Baumeister et al, 1982).

The air quality modelling methodology comprised three phases namely:

- 1) preparation of meteorological data The Air Pollution Model (TAPM) and Calmet;
- 2) development of an emissions database using
 - a) Australian National Pollution Inventory "Emission Estimation Technique Manual for Mining Version 3.1";
- 3) modelling of the likely downwind ground level concentrations using Calpuff.

4.1.1 Preparation of Meteorological Data

TAPM predicts meteorology and pollutant concentration for a range of pollutants important for air pollution applications. The model consists of coupled prognostic meteorological and air pollution concentration components, eliminating the need to have site-specific meteorological observations. Instead, the model predicts the flows important to local-scale air pollution, such as sea breezes and terrain induced flows, against a background of larger-scale meteorology provided by synoptic analyses.

Some limitations of TAPM include:

- it is not suitable for horizontal domain sizes above approximately 1,000 km by 1000 km.
- it cannot be used to accurately represent deep atmospheric circulations or extreme weather events (cyclones).
- it cannot be used for very steep terrain because of the use of a terrain following coordinate system in the model. Thus, the model cannot represent discontinuities in terrain height (for example, cliffs or bluffs).
- it assumes that cloud processes are resolved by the typical inner grid spacings used in the model (i.e. 3km or less). Therefore, no large-scale cloud convection parameterisation is included.

These limitations are of minor significance to the modelling of pollution for this study. The area of interest is much smaller than the maximum horizontal domain size. Extreme weather events (such

as cyclones) are not of interest from an air pollution perspective. The terrain does not have significant cliffs or bluff bodies within the region and it is expected that the inclusion of large-scale cloud convection would only slightly change the radiation and moisture balances.

TAPM is highly regarded in the scientific community as a suitable tool to develop meteorological data sets for sites without site-specific meteorological observations. However, the meteorological dataset can be improved by incorporating local meteorology.

The TAPM meteorological file developed for the site covered the two year period 2019 & 2020. This period was used for modelling since it is a comprehensive period and the most recent data sets. TAPM was configured with 4 nested grids with grid spacing of 30000m, 10000m, 3000m and 1000m. Additionally 40 grid points were used with 30 vertical grids. The model was centred on the location - 18°59.5' and 143°32'. All other settings were as per default.

The general features of winds affecting plume dispersion are illustrated in the wind rose diagrams for the years 2019 to 2020 (Appendix A: Windrose for Site). The wind roses summarise the wind statistics at a 10m height on site, as calculated by the TAPM meteorological model. The wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points – N, NNE, NE, ENE, E etc. The length of the bar represents the frequency of occurrence of winds from that direction, and the colour of the bar sections correspond to wind speed categories. It is noted that the predominant wind direction during the year is from the north-east through to the south-east. The representative frequency of Pasquil stability classes for the region is based on data from TAPM. Pasquil stability classes represent the stability of the atmosphere. The stability Class F conditions (stable conditions), which result in poor dispersion of pollutants does not occur during the day. Table 5: Frequency of Stability Classes at Site shows the frequency of stability classes for the site.

Table 5: Frequency of Stability Classes at Site

<i>Stability Class</i>	<i>Description</i>	<i>Frequency of Occurrence (%)</i>
A	Very unstable	4
B	Moderately unstable	15
C	Slightly unstable	15
D	Neutral	25
E	Slightly stable	18
F	Stable	24

4.1.2 Development of the Emissions database

The development of an accurate and representative particulates emissions database has been primarily based on National Pollution Inventory Emission Estimation Technique Manual for Mining Version 3.1 (NPI 2012). The main mining activities and processes that produce, or could produce, particulate emissions were identified for the operations. Flowcharts for handling of waste and ore were developed and an emission factor was attributed to every handling point, handling activity and transport section. In addition, emissions for exposed surfaces were identified and included in the database.

All emission factor equations and default emission factors in NPI are for uncontrolled emissions. However, this database has included the control effects from water trucks as is typically used at mines. In the model of the operations the emissions were calculated as an average and applied for. Calculating emissions is a four-step process:

1. Identify sources of emissions.
2. Obtain information on the scale of the activity.
3. Apply the relevant emission factor equation or default emission factor from NPI to the activity data, see Appendix C: Emissions Development & Justification;
4. Where applicable, apply control efficiency reduction factors-based water truck use or built-in controls.

The proposed operations comprise a truck and excavator to extract the waste and ore. The ore is taken to the ROM pad to the south of the pit and the waste is placed close to the pit and slightly north. The Modelling case is described in Table 6 and the emission factors are described in Table 7.

Table 6: Modelling Case

<i>Item</i>	<i>Case</i>
Maximum monthly ROM Ore (Tonnes/month)	20,833
Maximum monthly mining waste (Tonnes/month)	104,167
Relevant operations	Excavators on overburden and ore Haul trucks to waste dumps Haul trucks to ROM Graders on internal roads Water trucks on internal roads Bulldozer on overburden B-Double trucks taking ROM to offsite processing Drilling and Blasting
Type of Emission	Crustal Matter (soil, etc.)

Table 7: Particulate Emissions for Main Emitting Activities in Tonnes

Activity	Includes Control Factor	Emissions [t/a] for Particulate Fraction		
		TSP	PM ₁₀	PM _{2.5}
Excavator Loading Trucks	Water Cart Level 2 Watering (75%)	38.0	18.3	2.3
Trucks Moving on Site		21.4	6.3	0.8
Trucks Dumping Overburden		15.2	5.4	0.7
Trucks Dumping Ore		3.0	1.1	0.1
Dozer		22.3	5.4	0.7
Grader		0.3	0.1	0.0
Front End Loader		7.4	3.5	0.4
Watercart	Water Cart Level 2 Watering (75%)	11.1	3.3	0.4
Export Truck on Site	Water Cart Level 2 Watering (75%)	1.8	0.9	0.1
Drilling	-	19.3	5.7	0.7
Blasting	-	38.0	18.3	2.3
Wind Erosion	-	21.4	6.3	0.8

4.1.3 Dispersion Model

Calmet was used to process the exported 3D wind data from TAPM. The metrological grid was set for 50 by 50 cells with a cell dimension of 500m by 500m. Terrain was imported from SRTM 30m DEM³. CALPUFF was configured to use TAPM 3D wind data as an initial guess field for the model. All other settings were kept at the recommended default.

Calpuff v7 was used to determine the downwind ground level particulate concentrations and dust depositions. It is designed to predict ground-level concentrations or deposition of pollutants emitted from one or more sources, which may be stacks, area sources, volume sources, line sources or any combination of these.

The pit sources have been combined and modelled as a single area source in the Calpuff model. The area source is modelled as having dimensions similar to the extent of the source and an elevation of 3m above local terrain. A sampling/calculation grid of 76 by 76 grid with 500m spacing and a receptor at each of the sensitive receptors was used to develop the contours.

Refer to Appendix D for the Calpuff model layout.

³ Digital Elevation Data, Geosciences Australia, ga.gov.au/scientific-topics/national-location-information/digital-elevation-data

4.2 Air Quality Results

The calculated particulate emissions described in Section 4.1.2 were included in the Calpuff model at the appropriate locations. The likely particulate levels due to the operation of the mine at each nearby sensitive receptor have been determined and these are shown in Table 8 for Case 1.

The calculated air pollution contours (including background) are contained in Appendix B: Contours:

- Figure 1: PM_{2.5} (24 hour) maximum with concentration contours expressed in terms of µg/m³
- Figure 2: PM_{2.5} (annual average) with concentration contours expressed in terms of µg/m³
- Figure 3: PM₁₀ (24 hour) highest with concentration contours expressed in terms of µg/m³
- Figure 4: PM₁₀ (annual average) with concentration contours expressed in terms of µg/m³
- Figure 5: TSP (annual average) with concentration contours expressed in terms of µg/m³
- Figure 6: Dust Deposition (annual) – maximum month with deposition contours expressed in terms of mg/m²/day

Contours for the various metals fractions in the dust are not plotted due to the very low concentrations (well below criteria) with the site. However, the results are tabulated for each metal and sensitive receptor.

It is noted the dust deposition nuisance goal is exceeded at the Rungulla Resource Reserve. The goal is met 600m from the boundary by 1200m and in the shape of a half circle.

Table 8: Predicted Particulate Concentration and Dust Deposition for Sensitive Receptors (including assumed ambient levels)

Receptor		Calculated Particulate and Dust Levels at Nearby Sensitive Receptors						
		PM _{2.5} (24-hour) Maximum (µg/m ³)	PM _{2.5} (Annual Average) (µg/m ³)	PM ₁₀ (24-hour) Maximum (µg/m ³)	Number of Days Exceedance of 50 µg/m ³ PM ₁₀ (maximum) Per 2 Years	PM ₁₀ (Annual Average) (µg/m ³)	TSP (Annual Average) (µg/m ³)	Dust Deposition (Max month) (mg/m ² /day)
Limit		25	8	50	0	25	90	120
Existing Ambient		8	7	22	-	20	28	53
R1	Mine Camp	12	7	56	1	21	30	93
R2	Camping Ground	9	7	31	0	20	28	59
R3	Old Camping Ground	8	7	22	0	20	28	53
R4	Homestead1	8	7	22	0	20	28	53
R5	Homestead2	8	7	22	0	20	28	53
R6	Rungulla Resources Reserve	11	8	47	0	24	38	174
R7	Rungulla National Park	9	7	28	0	20	29	66

4.2.1 Dust Characterisation

The dust generated from the site is a combination of crustal matter that is liberated from truck movements and dust generated from the excavation and handling of waste rock and ore. Chemical characterisation of the waste rock has been provided in the C&R Consulting⁴ for the project.

A summary of the important characterisation of the waste rock as well as the limits from the EPP Air have been included in Table 9. The relevant metrics from the EPP Air have a value to protect human health and wellbeing.

Table 9: Waste Rock Chemical Characterisation and EPP Air Limits

Element	Medium Concentration		EPP Air Limits		
	mg/kg	Fraction	Level (µg/m³)	Time	Fraction
Aluminium	1300	0.0013	-	-	-
Antimony	0.4	4E-07	-	-	-
Arsenic	6.5	6.5E-06	0.006	1 Year	PM ₁₀
Barium	20	0.00002	-	-	-
Beryllium	6 ^{Note1}	0.000006 ^{Note1}	-	-	-
Cadium	2 ^{Note1}	0.000002 ^{Note1}	-	-	-
Chromium	8	0.000008	-	-	-
Cobalt	5	0.000005	-	-	-
Copper	11	0.000011	-	-	-
Iron	15650	0.01565	-	-	-
Lead	9	0.000009	0.5	1 Year	TSP
Manganese	192.5	0.000193	0.16	1 Year	PM ₁₀
Mercury (as inorganic mercury vapour)	0.3	3E-07	1.1	1 Year	
Molybdenum	1.85	1.85E-06	-	-	-
Nickel	8	0.000008	0.0022	1 Year	PM ₁₀
Selenium	2.5	2.5E-06	-	-	-
Thallium	0.1 ^{Note1}	0.0000001 ^{Note1}	-	-	-
Thorium	0.85	8.5E-07	-	-	-
Uranium	0.45	4.5E-07	-	-	-
Vanadium	9	0.000009	-	-	-
Zinc	35	0.000035	-	-	-

Note1: Median concentration statistic is below the limit of reporting and maximum concentration has been used.

It is assuming all dust emissions have similar speciation to that of waste rock. Table 10 shows the likely exposure of dusts at each sensitive receptor. For Rungulla Resource Reserve and Rungulla

⁴ Waste Rock Characterisation, Agate Creek Gold Mine, C&R Consulting, August 2022.

National Park the most exposed location has been identified, usually on the boundary. Elsewhere on these sites the exposure is much lower.

Table 10: Heavy Metal Impacts and Limit.

Species	Arsenic	Lead	Manganese	Mercury	Nickel
Metric	PM₁₀ Annual Average (µg/m³)	TSP Annual Average (µg/m³)	PM₁₀ Annual Average (µg/m³)	TSP Annual Average (µg/m³)	PM₁₀ Annual Average (µg/m³)
Limit	0.006	0.5	0.16	1.1	0.0022
R1	6.0E-06	2.16E-05	1.79E-04	7.21E-07	7.44E-06
R2	1.0E-06	3.18E-06	3.10E-05	1.06E-07	1.29E-06
R3	1.7E-08	4.33E-08	4.94E-07	1.44E-09	2.05E-08
R4	3.5E-08	9.72E-08	1.05E-06	3.24E-09	4.35E-08
R5	1.4E-08	3.32E-08	4.14E-07	1.11E-09	1.72E-08
R6	2.2E-05	9.00E-05	6.55E-04	3.00E-06	2.72E-05
R7	2.1E-06	6.30E-06	6.16E-05	2.10E-07	2.56E-06

All the sites show compliance with the EPP air for the relevant indicators.

4.3 Air Quality Assessment

The predicted average ground level concentrations at nearby sensitive areas have been modelled and Section 4.1 contains a full description of the modelling methods. The methodology includes both the expected maximum emission conditions and the worst-case meteorological conditions over a 2-year modelling simulation period. Specifically, the maximum month waste movement was applied for all months of the 2-year modelling simulation. This is a highly conservative assumption but adopted to address possible changes to the date of commencement. In reality there is only one peak month and for other months the emissions would be somewhat less normally pro-rata based on total waste and ore extracted/handled. Similarly, if total emissions are lower, then the environmental exposure levels would be pro-rata lower as well.

The ground level predictions were made at all sensitive locations and the contours cover adjacent land. All the techniques used to obtain the predictions have been referenced and key assumptions and data sets explained.

The cumulative effect from the existing uses has been included in the background level assumptions.

All the sites readily comply with all air quality limits. The Rungulla Resources Reserve exceeds the dust deposition goal. Dust deposition is a nuisance goal and does not strictly apply to the Rungulla Resource Reserve. The zone of dust deposition above the goal is a half circle having a radius of 600m. All sites are orders of magnitude below the heavy metal air quality limits at all sensitive receptors including the nearby Rungulla Resource Reserve. It is further noted that dusts from roads are decomposed granite with significantly lower fractions of heavy metals. Thus the likely impact is much lower than that presented.

The Mine Camp is not a sensitive receptor for the purpose of an air quality assessment and the results from this location are included for reference only.

4.4 Recommendations and Mitigation Measures

The modelling has incorporated level 2 watering for the haul route and excavator working area. The purpose of these measures are to provide mitigation for the campground and the workers camp. However, it is likely that these controls could be significantly relaxed when the wind is not blowing towards these receptors.

It is recommended that the mine adopt normal procedures to control dusts from the mine, Table 11 provides a summary of control procedures to mitigate dust emissions.

Table 11: Dust Mitigation Measures

Source	Mitigation Measure
Waste Material Dumping	Disturb the minimum area necessary for mining and rehabilitate promptly.
Haul Roads	Maintain haul roads in good condition and regular use of water truck. Investigate use of chemical suppressants if haul roads become too slippery.
Other Roads	Keep road distances to a minimum and maintain in good condition and regular use of water truck. Only drive on prepared/designated roads
Management	The site Air Quality Management Plan is to include a reactive component. Active management strategies such as reduction dust mitigation when meteorological monitoring indicates favourable wind directions.
Landholder consultation	Consultation with potentially impacted landowners and negotiation of relevant mitigation measures.

5 Conclusions

It was determined that the key issues to be addressed in the assessment is dust from all operations. Other types of air emissions have minor and impacts localised to the lease area. In relation to particulates (dusts), EPP(Air) provides environmental objectives associated with health and wellbeing and from the DERM Licensing and Permits, a single nuisance objective was obtained. The NEPM also provides environmental objectives.

The modelling was carried out using TAPM and Calmet to develop the meteorology data set used in the modelling. The particulate dispersion modelling simulation was carried out over 2 year period 2019 to 2020 using Calpuff.

The development of the representative particulate emissions database has been primarily based on National Pollution Inventory Emission Estimation Technique Manual for Mining Version 3.1. The main mining activities and processes that produce, or could produce, particulate emissions were identified for the operations. An emission factor (from NPI) was attributed to all significant handling points, handling activity and transport section. In addition, emissions from exposed surfaces were identified and included in the database.

The predicted average ground level concentrations at nearby sensitive areas were modelled and Section 4.1 Modelling Methodology contains a full description of the modelling methods. The methodology includes both normal and expected maximum emission conditions and the worst-case meteorological conditions.

One modelling case was developed, a fully developed mine operating at the maximum monthly capacity for the mine. Since it is possible that mining commencement could be delayed and to provide operational flexibility, the maximum month mining rate was applied throughout the year, even though it will not be sustained at that rate.

It was found that the mine readily complies with the air quality limits at all sensitive receptors. The modelling incorporated level 2 watering for haul routes and the working pad near the excavator. The watering has been recommended to mitigate impacts at the mining camp the campground. It is not required for the more distant homesteads. Part of the Rungulla Resources Reserve is subjected to dust deposition greater than the goal. Dust deposition is a nuisance goal and does not strictly apply to the Rungulla Resource Reserve. The zone of dust deposition above the goal is a half circle having a radius of 600m. All sensitive sites are orders of magnitude below the heavy metal air quality limits at all sensitive receptors including the nearby Rungulla Resource Reserve.

Glossary of Terms

PM ₁₀	particles in the air environment with an equivalent aerodynamic diameter of not more than 10microns.
PM _{2.5}	particles in the air environment with an equivalent aerodynamic diameter of not more than 2.5 microns
TSP	total suspended particles are particles in the air environment with an equivalent aerodynamic diameter of not more than 50 microns.
Air Emission	a substance released into the air.
CALMET	a diagnostic 3-dimensional meteorological model
CALPUFF	an air quality dispersion model
CALPOST	a postprocessing package
TAPM	A model that predicts three-dimensional meteorology and air pollution concentrations
Dust	An air suspension of particles of any solid material

References

Hurley PJ, Physick WL, Luhar AK Edwards M (2005) The Air Pollution Model (TAPM) Version 3. Part 2: Summary of Some Verification Studies. CSIRO Atmospheric Research

Scire J, Strimaitas G, Yamartino R (Jan 2000), A User's Guide for the. CALPUFF Dispersion Model. (Version 5).

Katestone Environmental, (May 2006) Air Quality Impact Assessment Study Of The Proposed Ensham Central Project

State of QLD (2019), Environmental Protection (Air) Policy 2019

National Pollutant Inventory (NPI). 2012. *Emission Estimation Technique Manual for Mining, Version 3.1, (January 2012)*. Available by download from the NPI website at: <http://www.npi.gov.au/reporting/industry-reporting-materials/emission-estimation-technique-manuals>

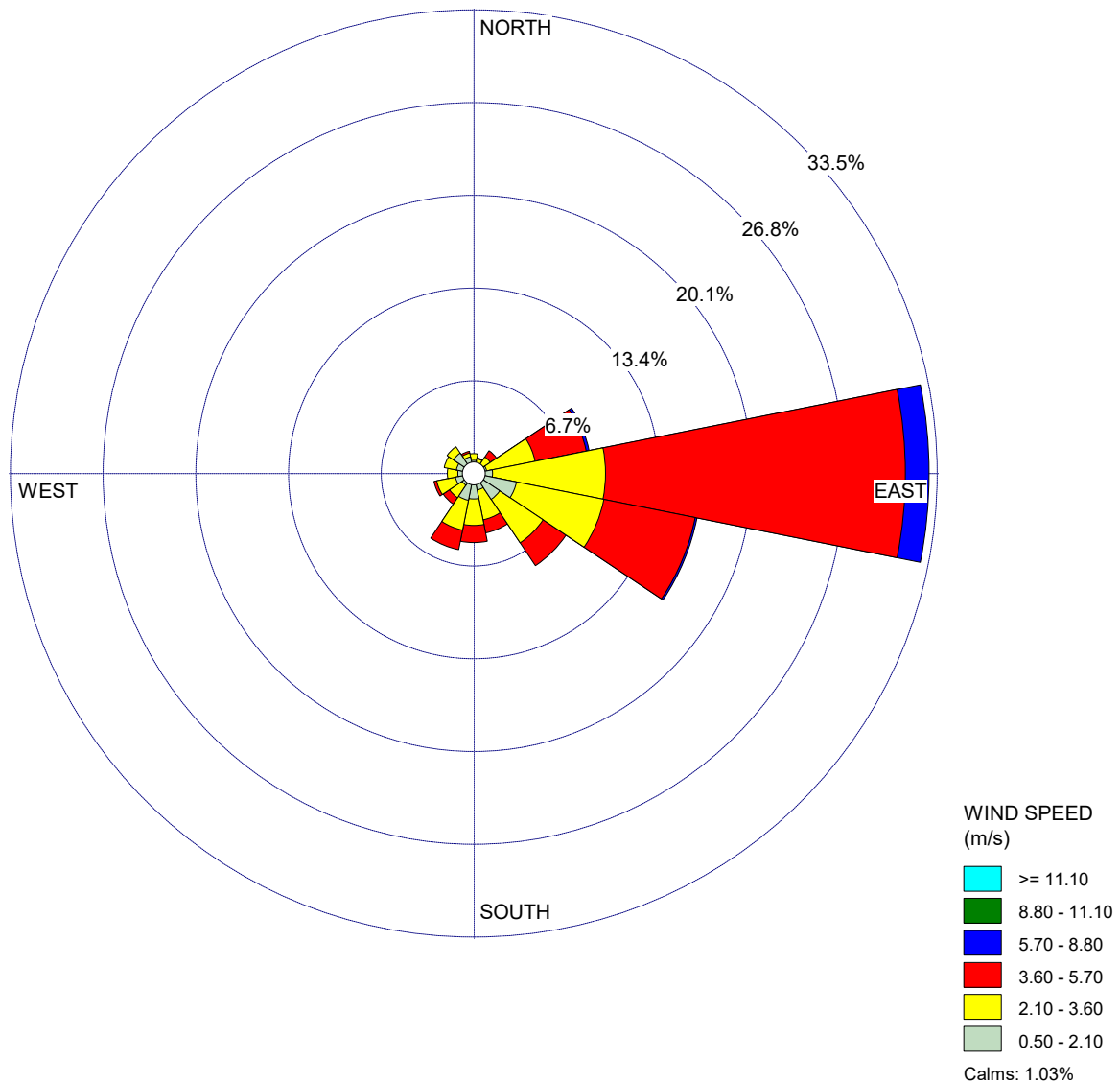
Appendix A: Windrose for Site

WIND ROSE PLOT:

Agate Creek
3 PM All Seasons

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:

Start Date: 1/01/2019 - 15:00
End Date: 31/12/2020 - 16:00

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

CALM WINDS:

1.03%

TOTAL COUNT:

1462 hrs.

AVG. WIND SPEED:

3.14 m/s

DATE:

25/01/2022

PROJECT NO.:

210410

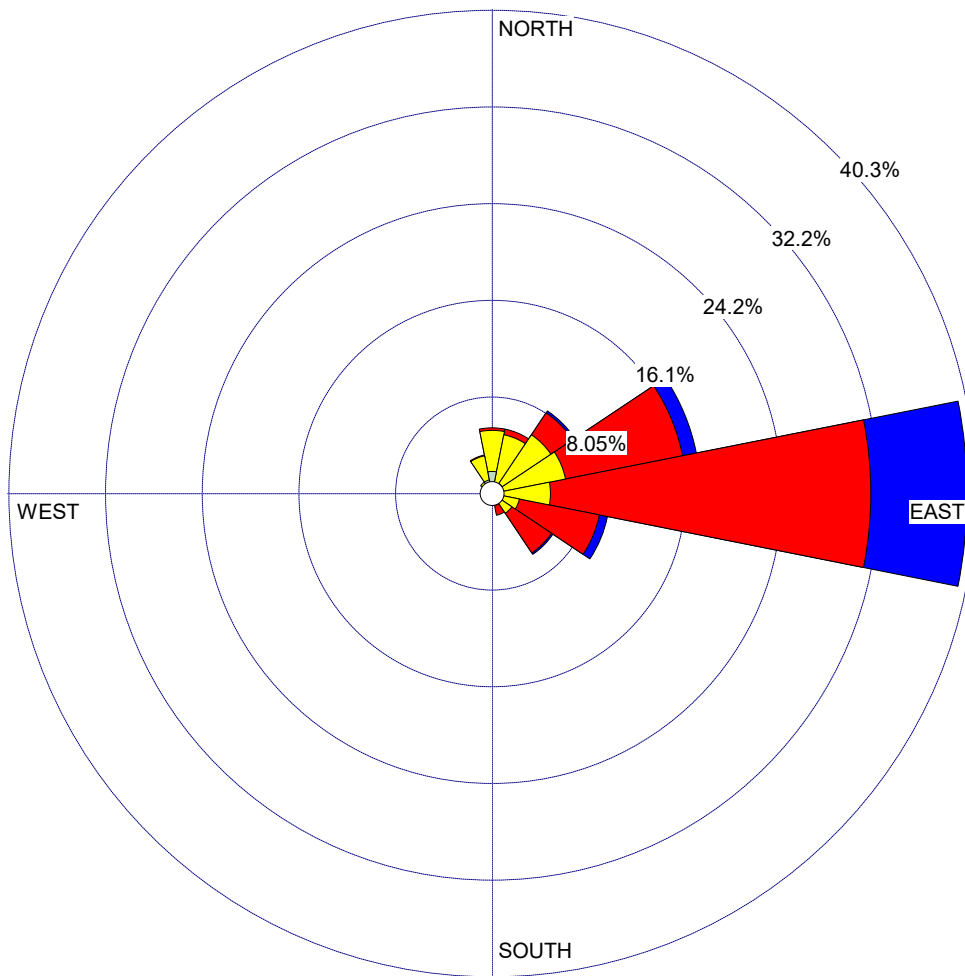


WIND ROSE PLOT:

Agate Creek
9 am All Seasons

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:

Start Date: 1/01/2019 - 09:00
End Date: 31/12/2020 - 10:00

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

CALM WINDS:

0.14%

TOTAL COUNT:

1462 hrs.

AVG. WIND SPEED:

3.97 m/s

DATE:

25/01/2022

PROJECT NO.:

210410

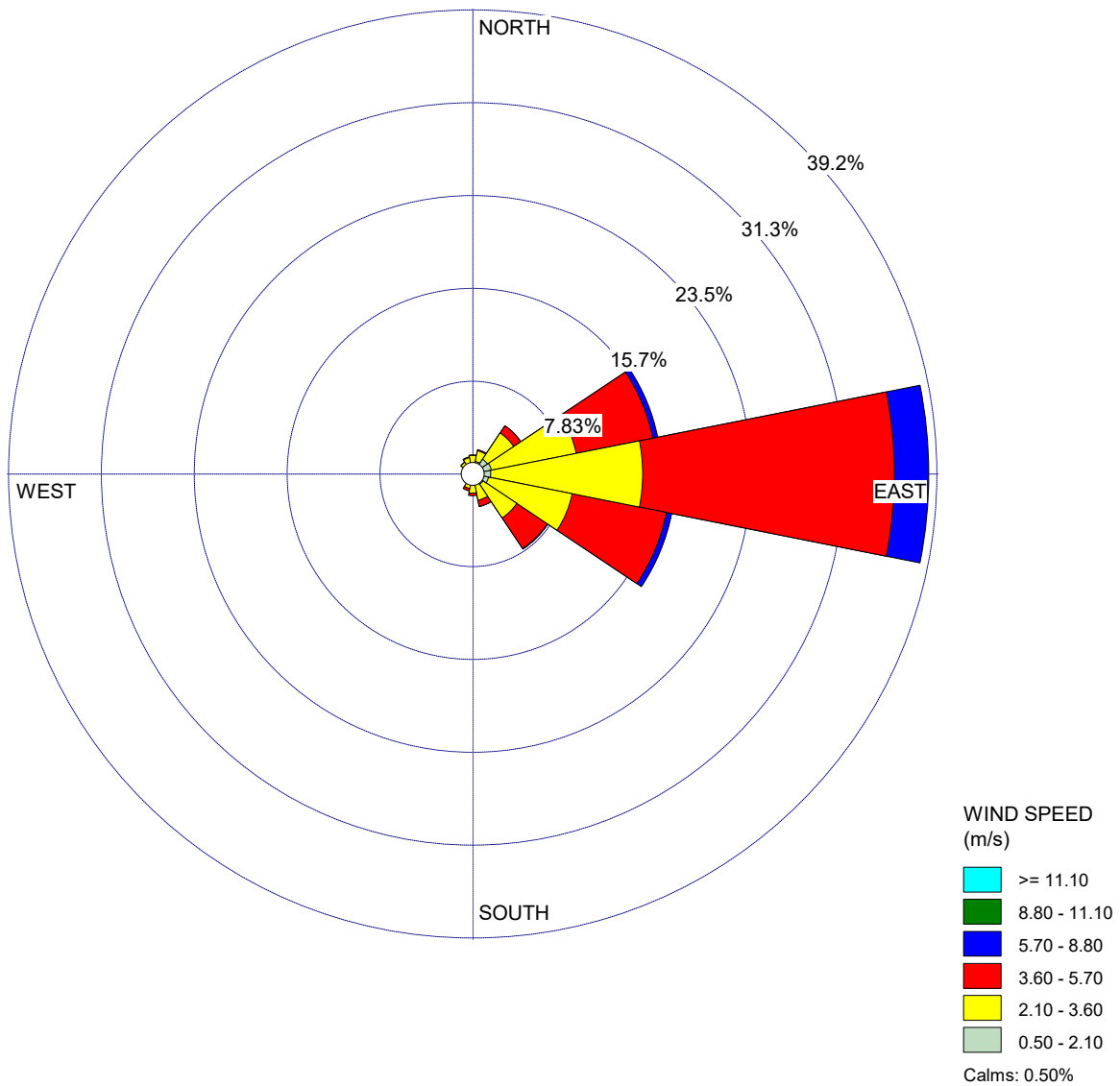


WIND ROSE PLOT:

Agate Creek
All Hours All Seasons

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:

Start Date: 1/01/2019 - 00:00
End Date: 31/12/2020 - 23:00

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

CALM WINDS:

0.50%

TOTAL COUNT:

17544 hrs.

AVG. WIND SPEED:

3.39 m/s

DATE:

25/01/2022

PROJECT NO.:

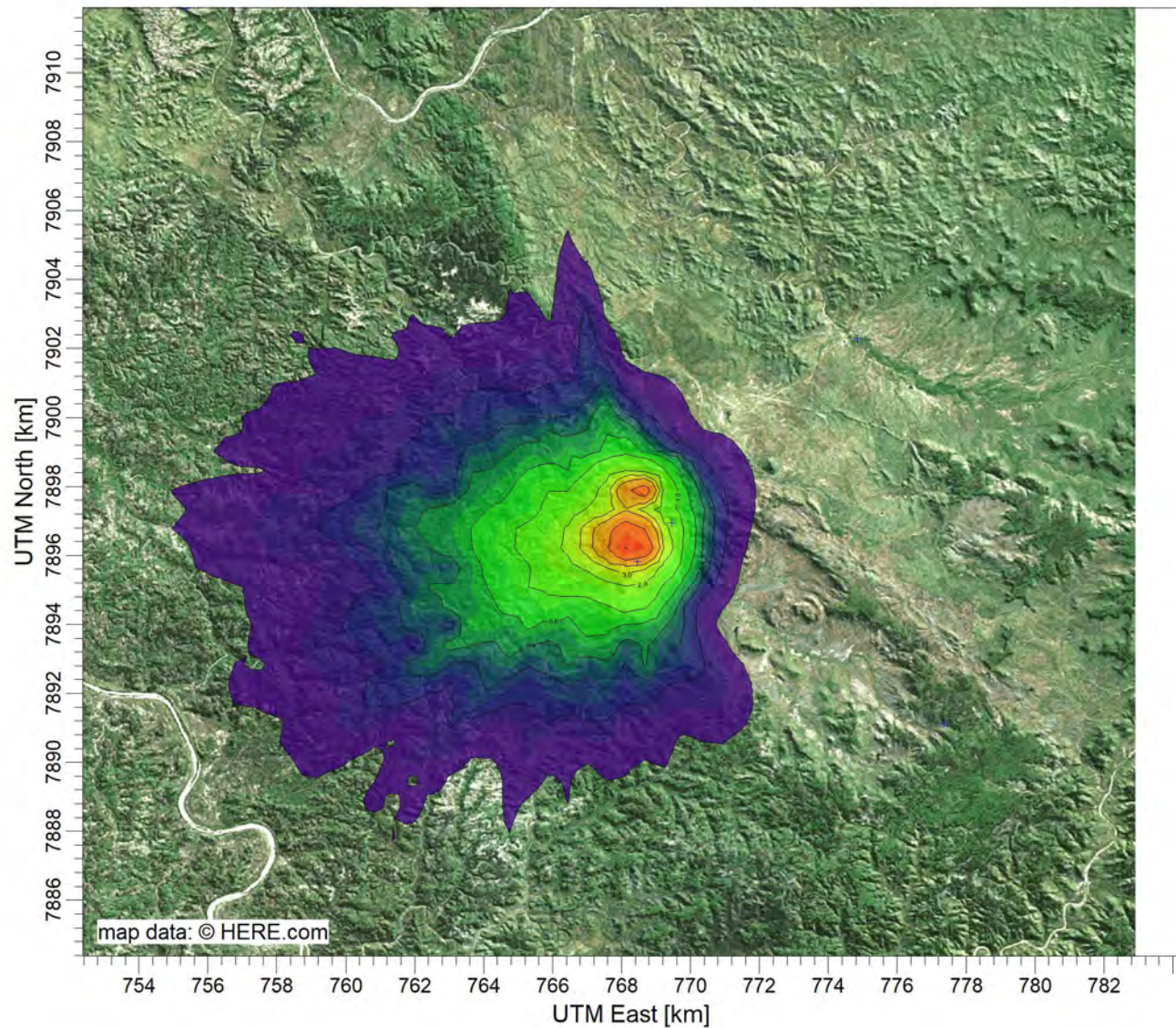
210410



Appendix B: Contours

PROJECT TITLE:

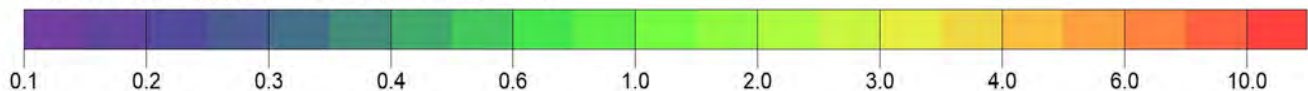
Agate Creek Expansion Air Quality Assessment
PM2.5 24 Hour Maximum



1 RANK 24 HOUR AVERAGE CONCENTRATION (PM2.5)

ug/m**3

Max = 20.6 [ug/m**3] at (X = 768465.00, Y = 7896424.00)



COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE:

1:200,000

0

5 km

DATE:

18/08/2022

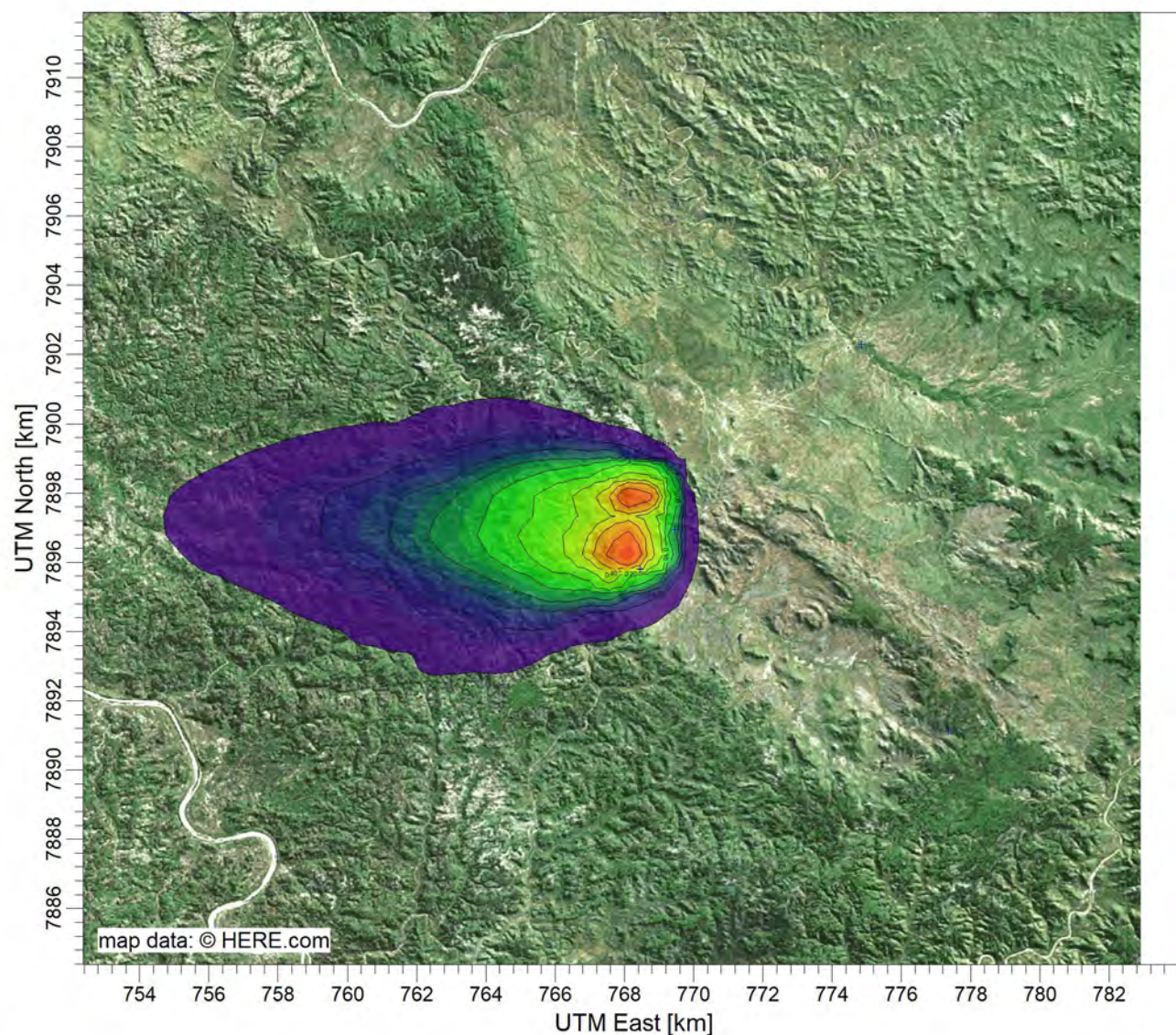
PROJECT NO.:

210929



PROJECT TITLE:

**Agate Creek Expansion Air Quality Assessment
PM2.5 Annual Average**



VALUE RUN LENGTH AVERAGE CONCENTRATION (PM2.5)

ug/m**3

Max = 5.70 [ug/m**3] at (X = 767965.00, Y = 7896424.00)



COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE:

1:200,000

0

5 km

DATE:

18/08/2022

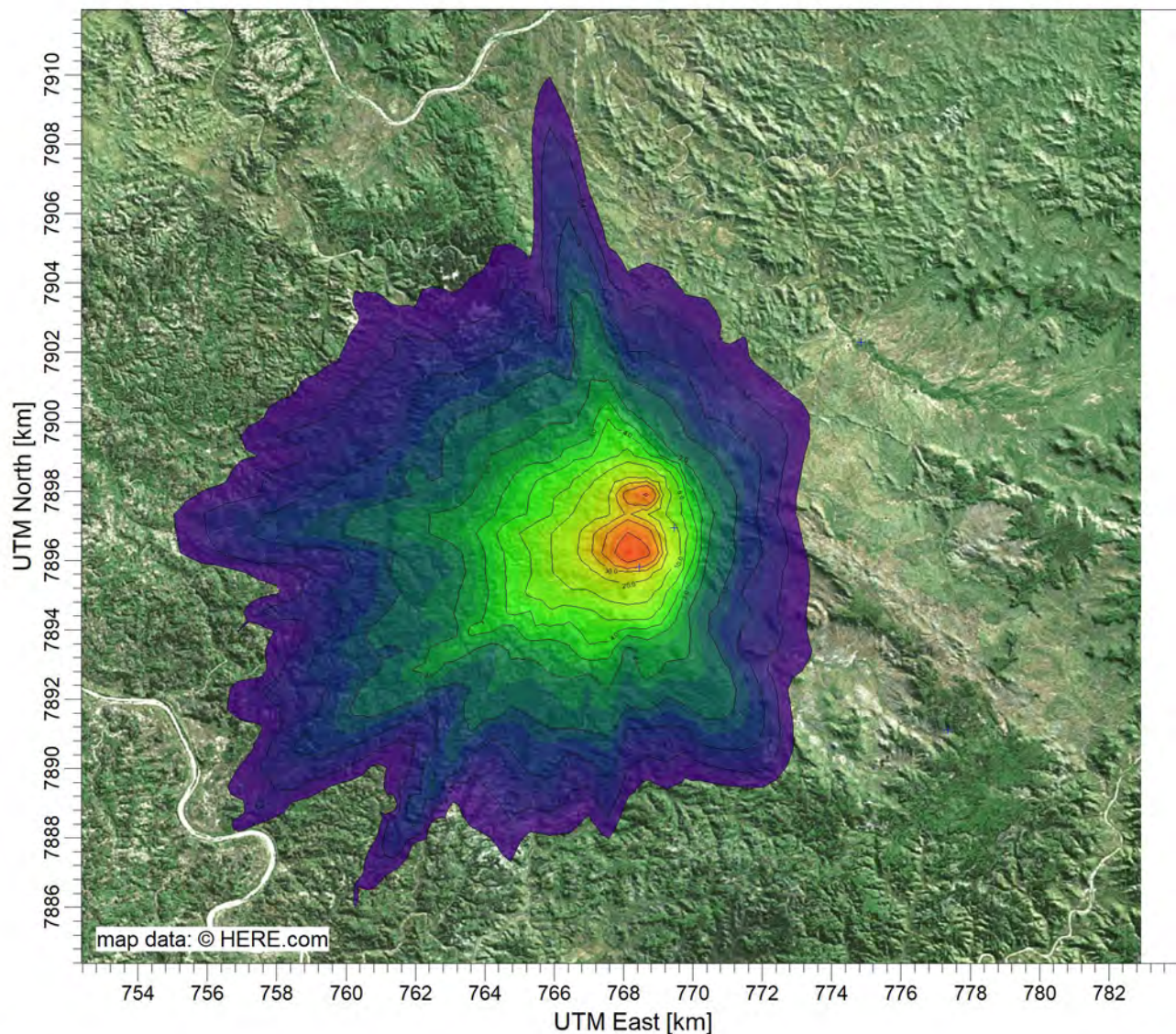
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210929



PROJECT TITLE:

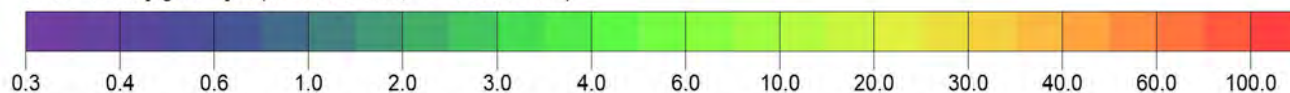
**Agate Creek Expansion Air Quality Assessment
PM10 24 Hour Maximum**



1 RANK 24 HOUR AVERAGE CONCENTRATION (PM10)

ug/m**3

Max = 173.2 [ug/m**3] at (X = 768465.00, Y = 7896424.00)



COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE:

1:200,000

0

5 km

DATE:

18/08/2022

PROJECT NO.:

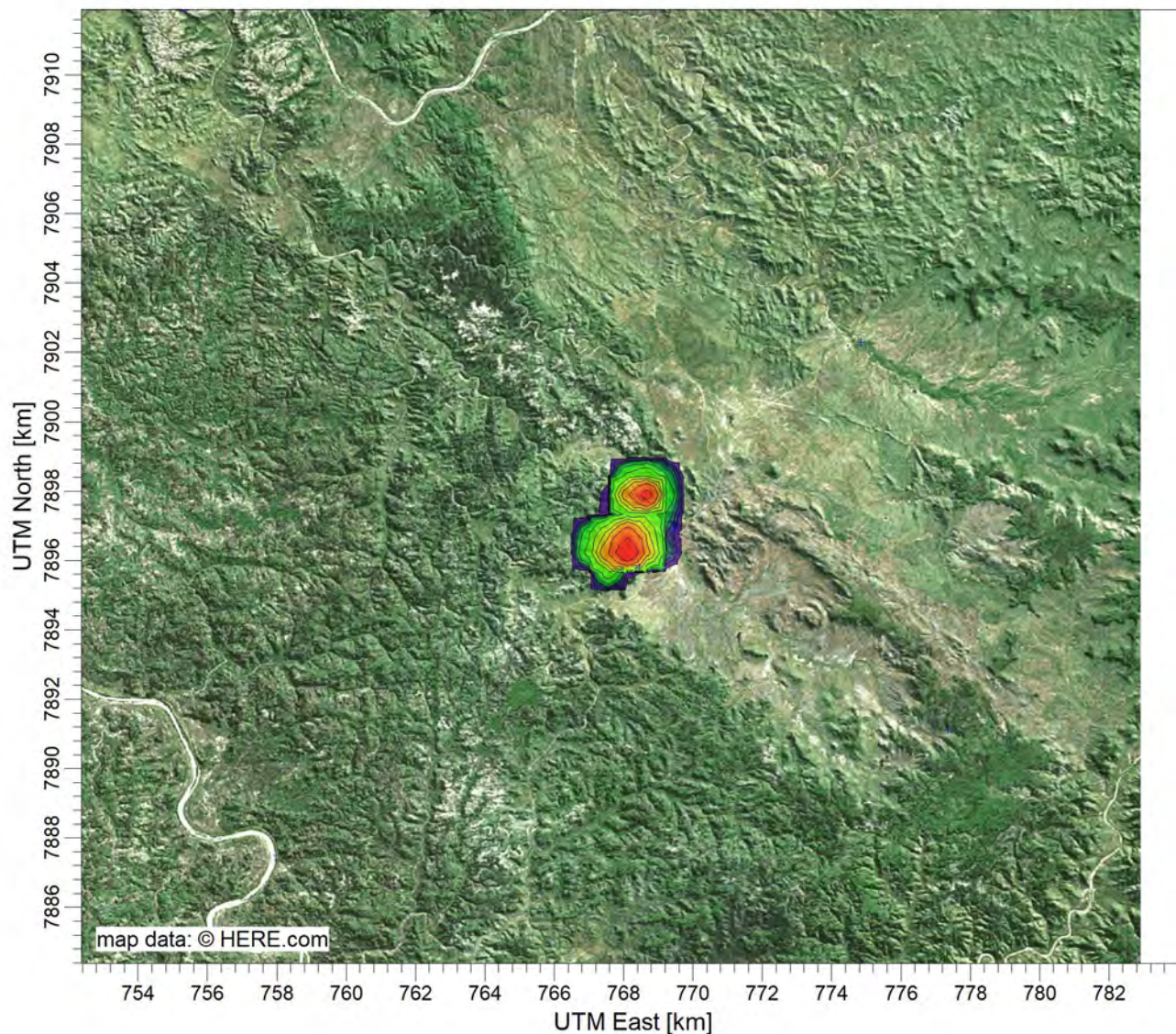


Simpson Engineering Group

210929

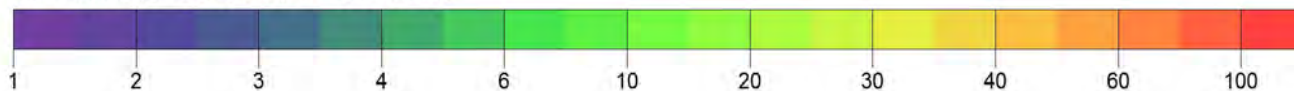
PROJECT TITLE:

Agate Creek Expansion Air Quality Assessment
PM10 - Number of Days that Exceed Limit on 2 Year Model



COUNTS COUNTS OF 24 HOUR AVERAGE CONCENTRATION EXCEEDANCES (PM10)

Max = 504 at (X = 767965.00, Y = 7896424.00)



COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE:

1:200,000

0

5 km

DATE:

18/08/2022

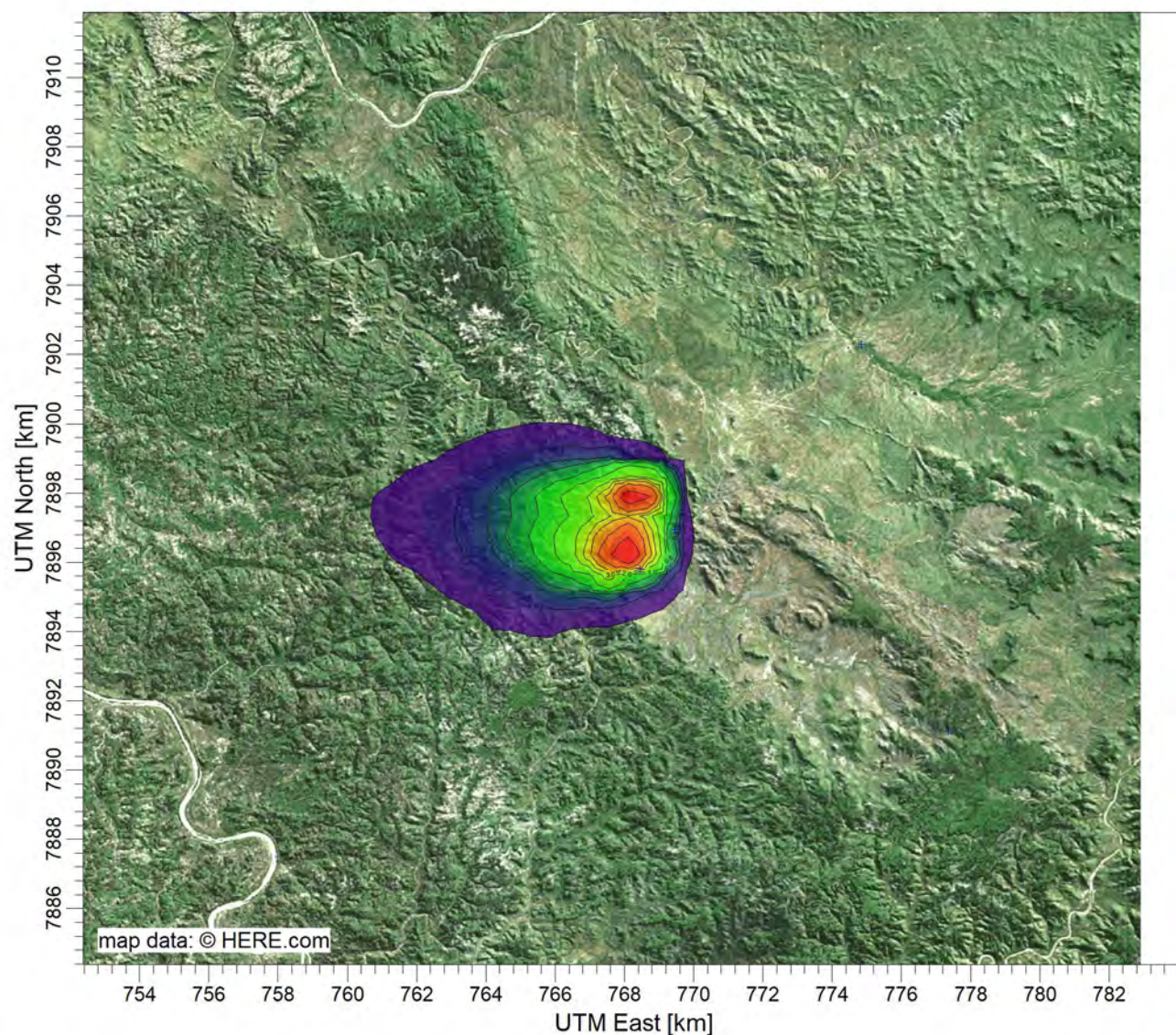
PROJECT NO.:

210929



PROJECT TITLE:

**Agate Creek Expansion Air Quality Assessment
PM10 Annual Average Concentration**



VALUE RUN LENGTH AVERAGE CONCENTRATION (PM10)

ug/m**3

Max = 48.4 [ug/m**3] at (X = 767965.00, Y = 7896424.00)



COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE:

1:200,000

0

5 km

DATE:

18/08/2022

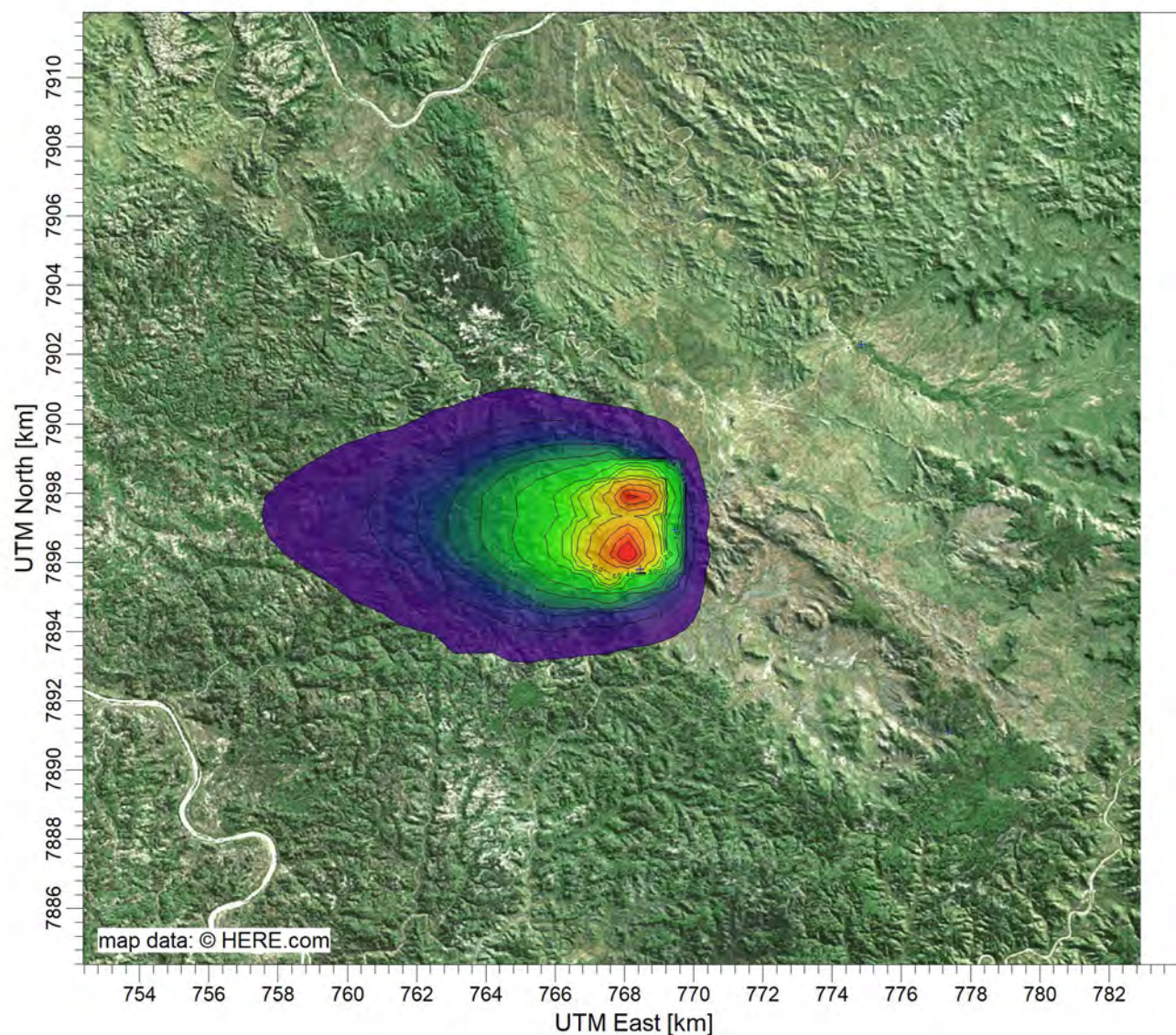
PROJECT NO.:

210929



PROJECT TITLE:

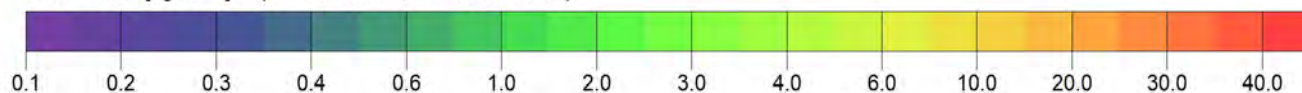
Agate Creek Expansion Air Quality Assessment
TSP Annual Average Concentration



VALUE RUN LENGTH AVERAGE CONCENTRATION (TSP)

ug/m**3

Max = 168.3 [ug/m**3] at (X = 767965.00, Y = 7896424.00)



COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE:

1:200,000

0  5 km

DATE:

18/08/2022

PROJECT NO.:

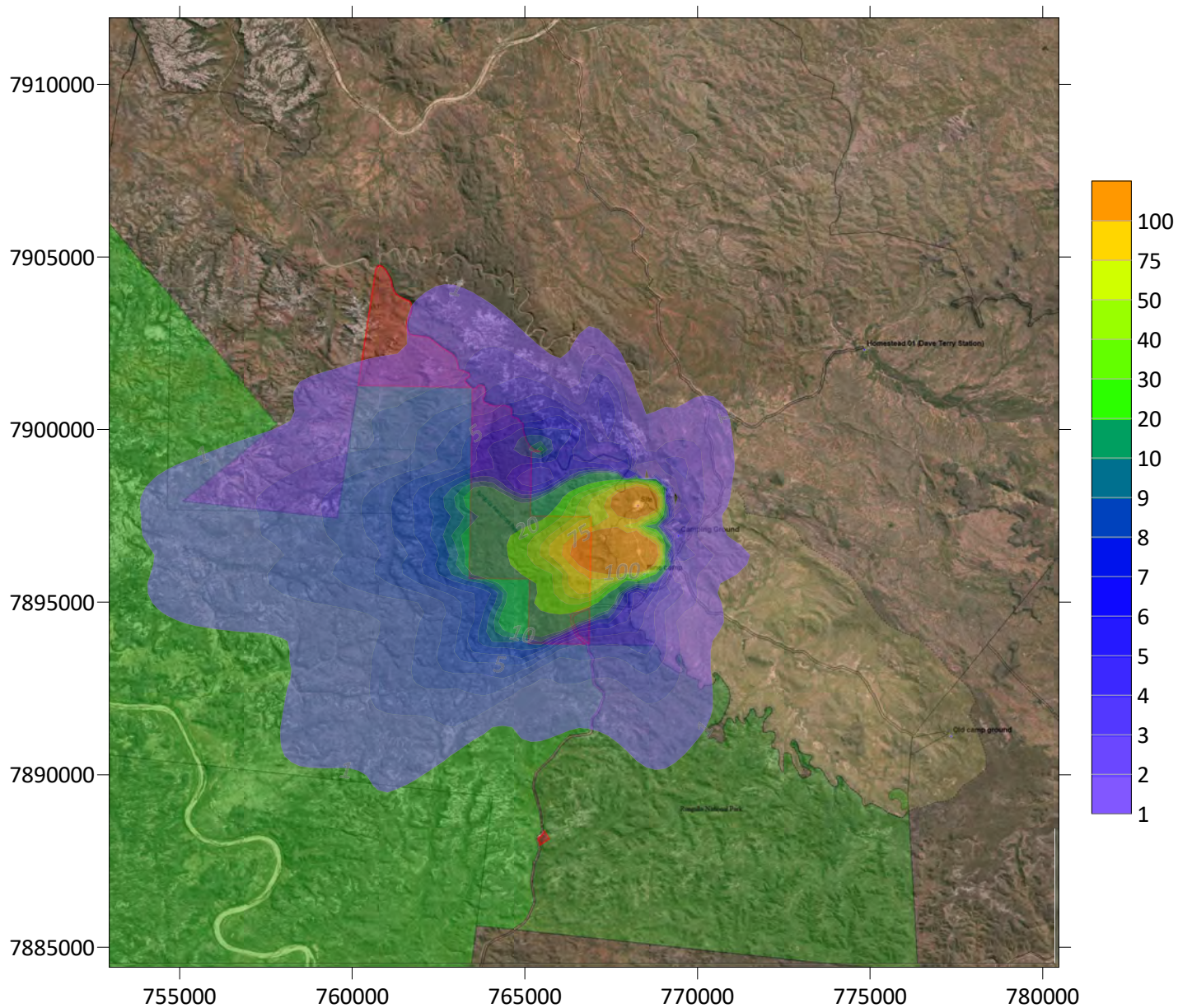


210929

Figure B6: Dust Deposition Maximum Month – (mg/m²/day) – Includes assumed background

Dust Deposition - Maximum Month

($\mu\text{g}/\text{m}^2/\text{day}$)



Appendix C: Emissions Development & Justification

Table 2: Emission Factor Equations and Default Emission Factors for Various Operations at Coal Mines 1, 2

Operation/Activity	TSP Equation	PM ₁₀ Equation	TSP Default Emission Factor	PM ₁₀ Default Emission Factor	PMR ₁₀ PM ₁₀ /TSP Ratio based on Emission Factors	Units	EFR
Draglines (on overburden).	$EF_{TSP} = 0.0046 \times \left(\frac{d^{1.1}}{M^{0.3}} \right)$	$EF_{PM_{10}} = 0.0022 \times \left(\frac{d^{0.7}}{M^{0.3}} \right)$	0.06	0.026	0.43	kg/bcm	B
Excavators/Shovels/ Front-end loaders (on overburden).	See Appendix A Section 1.1.2	See Appendix A Section 1.1.2	0.025	0.012	0.47	kg/t	U
Excavators/Shovels/ Front-end loaders (on coal).	$EF_{TSP} = 0.580 / (M)^{1.2}$	$EF_{PM_{10}} = 0.0447 / M^{0.9}$	0.029	0.014	0.48	kg/t	C
Bulldozers on coal.	$EF_{TSP} = 35.6 \times \frac{(s)^{1.2}}{(M)^{1.4}}$	$EF_{PM_{10}} = 6.33 \times \left(\frac{(s)^{1.5}}{(M)^{1.4}} \right)$	102	32.5	0.32	kg/h/vehicle	B
Bulldozer on material other than coal.	$EF_{TSP} = 2.6 \times \frac{(s)^{1.2}}{(M)^{1.3}}$	$EF_{PM_{10}} = 0.34 \times \left(\frac{(s)^{1.5}}{(M)^{1.4}} \right)$	17	4.1	0.24	kg/h/vehicle	B
Trucks (dumping overburden).	See Appendix A Section 1.1.6	See Appendix A Section 1.1.6	0.012	0.0043	0.35	kg/t	U
Trucks (dumping coal).	See Appendix A Section 1.1.7	See Appendix A Section 1.1.7	0.010	0.0042	0.42	kg/t	
Drilling.	See Appendix A Section 1.1.8	See Appendix A Section 1.1.8	0.59	0.31	0.52	kg/hole	C
Blasting ³ .	$EF_{TSP} = 0.00022 \times A^{1.5}$	$EF_{PM_{10}} = 0.000114 \times A^{1.5}$			0.52	kg/blast	C
Operation/Activity	TSP Equation	PM ₁₀ Equation	TSP	PM ₁₀	PMR ₁₀	Units	EFR

			Default Emission Factor	Default Emission Factor	PM ₁₀ /TSP Ratio based on Emission Factors		
Wheel and bucket ⁴	$EF_{TSP} = 0.74 \times 0.0016 \times \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$	$EF_{PM_{10}} = 0.35 \times 0.0016 \times \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$	0.00032	0.00015	0.47	kg/t	C
Wheel generated dust from unpaved roads at industrial sites	$EF_{TSP} = \frac{0.4536}{1.6093} \times 4.9 \times \left(\frac{s}{12}\right)^{0.7} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	$EF_{PM_{10}} = \frac{0.4536}{1.6093} \times 1.5 \times \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	4.23	1.25	0.30	kg/VKT	B
Wheel generated dust from unpaved roads (used by light duty vehicles)	$EF_{TSP} = 1.69 \times \frac{(s/12) \times (S/48)^{0.3}}{(M/0.5)^{0.3}} - 0.0013$	$EF_{PM_{10}} = 0.51 \times \frac{(s/12) \times (S/48)^{0.5}}{(M/0.5)^{0.2}} - 0.0013$	0.94	0.33	0.35	kg/VKT	B
Scrapers (travel mode)	$EF_{TSP} = 9.6 \times 10^{-6} \times s^{1.3} \times W^{2.4}$	$EF_{PM_{10}} = 1.32 \times 10^{-6} \times s^{1.3} \times W^{2.4}$	2.08	0.52	0.25	kg/VKT	A
Scrapers (removing topsoil)	See Appendix A Section 1.1.13	See Appendix A Section 1.1.13	0.029	0.0073	0.25	kg/t	E
Graders	$EF_{TSP} = 0.0034 \times S^{2.5}$	$EF_{PM_{10}} = 0.0034 \times S^{2.0}$	0.19	0.085	0.31	kg/VKT	B
Loading stockpiles	See Appendix A Section 1.1.15	See Appendix A Section 1.1.15	0.004	0.0017	0.42	kg/t	U
Unloading from stockpiles	See Appendix A Section 1.1.15	See Appendix A Section 1.1.15	0.03	0.013	0.42	kg/t	U
Loading to trains	See Appendix A Section 1.1.15	See Appendix A Section 1.1.15	0.0004	0.00017	0.42	kg/t	U
Miscellaneous transfer points (including conveying)	$EF_{TSP} = 0.74 \times 0.0016 \times \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$	$EF_{PM_{10}} = 0.35 \times 0.0016 \times \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$	0.00032	0.00015	0.47	kg/t/transfer point	U
Wind erosion	See Appendix A Section 1.1.17 to 1.1.18	See Appendix A Section 1.1.17 to 1.1.18	0.4	0.2	0.50	kg/ha/h	U

Equipment		Emission Factor			Factors						Emission Controlled (kg/hr)			Total (T/Annum)		
Type	Operation	TSP	PM ₁₀	Units	T/hr	Trips/hr	Trip km	Utilisation	Area (ha)	Control	TSP	PM ₁₀	PM _{2.5}	TSP	PM ₁₀	PM _{2.5}
EX1800		0.025	0.012	kg/t	347						8.7	4.2	0.5	38.0	18.3	2.3
777D (90t)	Moving	4.23	1.25	kg/VKT	347	4	1.2			75%	4.9	1.4	0.2	21.4	6.3	0.8
	Dumping Overburden	0.012	0.0043	kg/t	289						3.5	1.2	0.2	15.2	5.4	0.7
	Dumping Product	0.012	0.0043	kg/t	58						0.7	0.2	0.0	3.0	1.1	0.1
D10		17	4.1	kg/hr/v				0.3			5.1	1.2	0.2	22.3	5.4	0.7
Grader		0.19	0.085	kg/VKT			1.2	0.3			0.1	0.0	<0.1	0.3	0.1	0.0
992 Loader		0.029	0.014	kg/t	58						1.7	0.8	0.1	7.4	3.5	0.4
773 Watercart		4.23	1.25	kg/VKT			1.2	2		75%	2.5	0.8	0.1	11.1	3.3	0.4
Wind Erosion		0.4	0.2	kg/ha/hr					1		0.4	0.2	<0.1	1.8	0.9	0.1
Export Truck		4.23	1.25	kg/VKT	167	4.175	1			75%	4.4	1.3	0.2	19.3	5.7	0.7
Drilling											4.20	0.04	0.01	18.4	0.2	<0.1
Blasting											0.08	0.04	0.01	0.4	0.2	<0.1

The calculations for truck usage are based on 12 hours per day and 30 days per month.

Calculations Relating to Equipment

<u>Dump Truck Analysis</u>	
Distance travelled by dump trucks per loop (km)	1.2
Number of trucks per hour	4
<u>Road Truck Analysis</u>	
Distance Travelled by per loop on site (km)	4.2
Number of trucks per hour	4.2
<u>Grader analysis</u>	
Number of graders	1
Average speed (km/h)	15
Operating hours per month	130
<u>Bulldozer analysis</u>	
Number of bulldozers	2
Equipment utilisation factor	30%
Operating hours per month	108
<u>Wind erosion analysis</u>	
Actively worked areas (ha)	1
<u>Drill & Blasting</u>	
Holes drilled per hour	10
Area of blasting m ²	1000
Number of blasts per week	1