Appendix A - Air Quality Report

cdmsmith.com

RUSTLERS ROOST AND QUEST 29 - AIR QUALITY ASSESSMENT

Project ID: 14207

17/05/2022

Release: R0

Prepared For:

CDM Smith

Assured Environmental

DOCUMENT CONTROL PAGE

Project Title: RUSTLERS ROOST AND QUEST 29 - AIR QUALITY ASSESSMENT

Project Reference ID: 14207

Report Prepared by:

Assured Environmental
Unit 7, 142 Tennyson Memorial Avenue
Tennyson, QLD, 4105

Report Prepared for:

CDM Smith
Level 4, 51 Alfred Street
Fortitude Valley, QLD, 4006

M. Clifton

Author: Michelle Clifton

Reviewer: Craig Beyers

Table 1: History of Revisions

Revision	Date	Issued to	Changes
R0	17/05/2022	T. Kinny	Initial Release

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

°C	Degrees centigrade
Conversion of ppm to mg/m^3	Where R is the ideal gas constant; T, the temperature in kelvin (273.16 + T°C); and P, the pressure in mm Hg, the conversion is as follows: mg m^3 = (P/RT) x Molecular weight x (concentration in ppm) = P x Molecular weight x (concentration in ppm) 62.4 x (273.2 + T°C) For the purposes of the air quality assessment all conversions were made at 0°C unless stated otherwise.
g/s	Grams per second.
g/m^2	Gram per metre square.
g/m^2/month	Gram per metre square per month.
ha	Hectares.
m	Metre.
m/s	Metres per second
mg/m^3	Milligrams (10-3) per cubic metre. Conversions from mg/m^3 to parts per volume concentrations (i.e., ppm) are calculated at 0 °C.
kg	Kilograms.
kg/annum	Kilograms per annum.
km	Kilometre
µg/m^3	Micrograms (10-6) per cubic metre. Conversions from µg/m^3 to parts per volume concentrations (i.e., ppb) are calculated at 0 °C.
ppb	Parts per billion.
ppm	Parts per million.
PM_{10}, $PM_{2.5}$, PM_1	Fine particulate matter with an equivalent aerodynamic diameter of less than 10, 2.5 or 1 micrometres, respectively. Fine particulates are predominantly sourced from combustion processes. Vehicle emissions are a key source in urban environments.
TSP	Total suspended particulate.
70th percentile	The value exceeded for 70 % of the time.

ABBREVIATIONS

AQMP	Air Quality Management Plan
DES	Department of Environment and Science
EA	Environmental Authority
ERA	Environmentally Relevant Activities
GLC	Ground Level Concentration
ML	Mining Lease
Mtpa	Million tonnes per annum
NEPC	National Environment Protection Council
NEPM	National Environment Protection (Ambient Air Quality) Measure (Air NEPM)
NPI	National Pollutant Inventory
NT EPA	Northern Territory Environmental Protection Authority
TSF	Tailings Storage Facility

1 INTRODUCTION

1.1 Background

Rustlers Roost and Quest 29 are brownfield sites on Mineral Leases (ML) located in the Mount Bundey locality, approximately 85 km south-east of Darwin, Northern Territory (NT). The sites have a history of gold mining activity, with gold first discovered in the 1940s and activities occurring over intermittent periods during the past 70 years. Primary Gold Limited (PGO) (the Proponent) is proposing to redevelop the existing mine by expanding open-cut gold mining operations and connecting the two non-contiguous sites with a haul road (the Project).

1.2 Scope of Assessment

Assured Environmental (AE) was appointed by CDM Smith on behalf of PGO to undertake an air quality assessment of the redevelopment of the Project in response to the Request for Additional Information regarding the submitted Environmental Impact Statement (EIS).

Specifically, Northern Territory Environmental Protection Authority (NT EPA) requested the following information:

- Provide detailed specifications for the proposed smelter.
- Provide predicted emissions including likely volumes and characteristics of airborne particulates and gaseous contaminants/toxicants.
- Identify and assess the potential impacts from the smelter on the receiving environment.
- Provide an assessment of the potential impacts of fallout from the smelter on the surrounding environment (including flora and fauna) using the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2016).

In accordance with the requirements of the above guidelines, computational modelling and first principle calculations have been undertaken to assess the potential for adverse amenity and health impacts as a result of the proposed development.

1.3 This Report and Limitations

This report summarises the methodology, results, and conclusions of the air quality assessment.

The limitations identified with this assessment are primarily the performance of proposed equipment and the stack parameters, which were not available for some plant. Where this occurred, AE have compared the equipment to our measurement database to identify suitable parameters.

For the smelter, AE have utilised previously measured emissions from another overseas gold smelting operation. This previous emissions monitoring has identified that all emissions of SO_2 and SO_3 (as H_2SO_4 (sulphur trioxide as sulphuric acid)) were below the limit of detection. As such H_2SO_4 has not been considered in this assessment.

2 MINING OPERATIONS

2.1 Overview

The Rustlers Roost and Quest 29 mine sites are located approximately 11 km apart and are connected by an existing unsealed access track, which will be upgraded to accommodate haulage of ore from the Quest 29 satellite pits to a proposed processing facility at Rustlers Roost.

Ore mined at both sites will be processed at a new purpose-built processing facility located at the Rustlers Roost site to produce gold bullion which will be trucked off-site for sale. The rate of production will be up to 5 million tonnes per annum (Mtpa) over an approximately 10-year life-of-mine (LOM). Following completion of mining activities, the Project area will be closed and rehabilitated in accordance with an approved Mine Closure Plan (MCP).

An accommodation camp for the Project workforce will be located on ML 29814 which is part of the Toms Gully Mine tenements (Figure 1). The Project includes the expansion of existing pits, waste rock landforms, water storage dams and internal roads. Two new pits will be constructed at Rustlers Roost (Annie's Dam pit and Annie's Oakley pit) and new infrastructure includes an onsite processing plant, a tailings storage facility, a landfill, laydown area, administration office, accommodation camp and groundwater bores for water supply. At Quest 29 the Project includes expansion of the five existing pits (Zamu, Taipan, South Koolpin, North Koolpin and BHS pits).

2.2 Operational Activities

The Proponent is proposing to re-develop and expand the Project area and gold mining operations. A summary of the Project is provided in Table 2

Table 2: Summary of Operational Activities

Component	Tenement	Activities
Open cut mining (including drill and blasting)	Rustlers Roost (ML 1083)	One main pit (22.93 ha and from 50 m to 189 m depth) and two small pits - Total pits area of 76.1 ha: ▪ Main pit = 69.9 ha ▪ Annie's Dam pit = 4.4 ha ▪ Annie Oakley pit = 6.2 ha
	Quest 29 (ML 29783)	Total pits area of 28.2 ha and depth to 75 m: ▪ BHS pit = 1.7 ha ▪ North Koolpin pit = 4.7 ha ▪ South Koolpin pit = 6.4 ha ▪ Taipan pit = 4 ha ▪ Zamu pit = 11.4 ha
Ore processing	Rustlers Roost (ML 1083)	Screens, crushers, and ball mill to grind ore. Carbon in Leach (CIL) process with use of cyanide. Furnace to melt crude gold into gold bars.
Haul Road	Between both ML	Transportation of Quest 29 product to Rustlers Roost
Power station	Rustlers Roost (ML 1083)	10 x 2.5 MW Natural gas engines and 6 MW Battery Energy Storage System (BESS)

2.3 Open Cut Mining

The Project will involve open-cut mining and expansion of all existing open-cut pits, and two additional new pits at Rustlers Roost and supporting infrastructure.

The mine sites are located approximately 11 km apart and are connected by an existing unsealed access track, which will be upgraded to accommodate haulage of ore from the Quest 29 satellite pits to Rustlers Roost processing facility. Ore mined at both sites will be processed at a new purpose-built processing facility located at the Rustlers Roost site to produce gold bullion. The mining operations will use a drill and blast technique involving the use of ammonium nitrate (ANFO). The rate of production will be up to 5 Mtpa over an approximately 10-year LOM.

Waste rock generated in the extraction and production process will be deposited in surface waste rock dumps (WRD) and will be used to backfill a number of pits where mine scheduling permits.

- At Quest 29, a new surface WRD is proposed to be developed to dispose of the waste from mining Zamu pit, with waste material from the remaining pits to be backfilled into Zamu pit.
- At Rustlers Roost, the majority of the waste rock material will be deposited within the existing surface WRD (expansion to the north-west) and a portion backfilled into the existing Rustlers Roost pit.

2.4 Ore Processing

Mined ore will be processed using a CIL processing method, which extracts gold from the ore by mixing with a cyanide solution. Tailings produced from the processing facility will be deposited in a TSF to be constructed as part of the proposal. The key physical components of the Project are summarised:

- Processing plant and ROM – The processing facility will be constructed in the northern portion of Rustlers Roost. The processing plant area will include the crushed ore stockpile, process water and stormwater pond, process plant infrastructure, power station and transformers, diesel facility, refuelling area, LPG tanks, process plant and reagent stores, building infrastructure.
- Haul road – A haul road is required to transport product ore from Quest 29 to Rustlers Roosts ROM for processing. The 11 km existing access road between the Project areas will be upgraded to accommodate heavy vehicles for haulage of ore. The haul road will be a two lane road (8 m wide) with a design speed of 60 km/h.
- Tailings storage facility – The TSF will be located in the southern section of ML 1083 with a disposal volume of over 4 Mtpa for a total of 48 Mt capacity (i.e. 10 years production). The TSF will be raised in height progressively over a 10-year period to reach storage capacity for the LOM.
- Mine laydown area – A compacted earth mine laydown area covering approximately 6.0 ha will be constructed in the Rustlers Roost portion of the Project area.

2.5 Schedule

Construction activities will occur within the first 12 months following approvals. Construction will be undertaken between up to 24 hours per day, and activities will include land clearing and site preparation, upgrade of access/haul road, office/administration and amenities, processing facility, accommodation camp; and construction of TSF.

Mining operations will commence in year two on completion of the critical infrastructure. The Rustlers Roost open-cut pit mining schedule is proposed to occur in five stages over an approximate 9-to-10-year duration. Quest 29 will be mined over a 4 to 6-year period in five stages as a satellite reserve to feed the processing plant located at Rustlers Roost.

Processing will occur in year two following commencement of mining and will be on-going (24/7) for the ten-year mine duration. Processing will continue for a number of months following cessation of mining until all remaining ore stockpiles have been processed.

The proposed mining stages are summarised:

- Rustlers Roost pit dewatering starting at the end of 2021 and finishing in April 2023;
- Rustlers Roost mining operations starting in April 2023 and finishing at the end of 2031;
- Quest 29 pits dewatering starting at the end of 2024 and finishing in April 2031;
- Quest 29 mining operations starting at the end of 2024 and finishing at the end of 2031; and
- Processing operation is proposed to run from July 2023 until March 2033.

2.6 Equipment

Table 3 provides a list of the type and maximum quantity of equipment to be utilised for the Project.

Table 3: Equipment List and Quantity

Type	Size	Quantity (Maximum)
Excavator	125-200 t	2
Excavator	30 t	1
Trucks (for mining and haulage)	100 - 135 t	8
Dozer	50 t	2
Water cart	80 kL	1
Grader	4.3 m	1
Drill	Track mounted top hammer	3
MMU	Open pit unit	1
Loaders	3 – 6.5 m^3	2
Light vehicles	Various	10

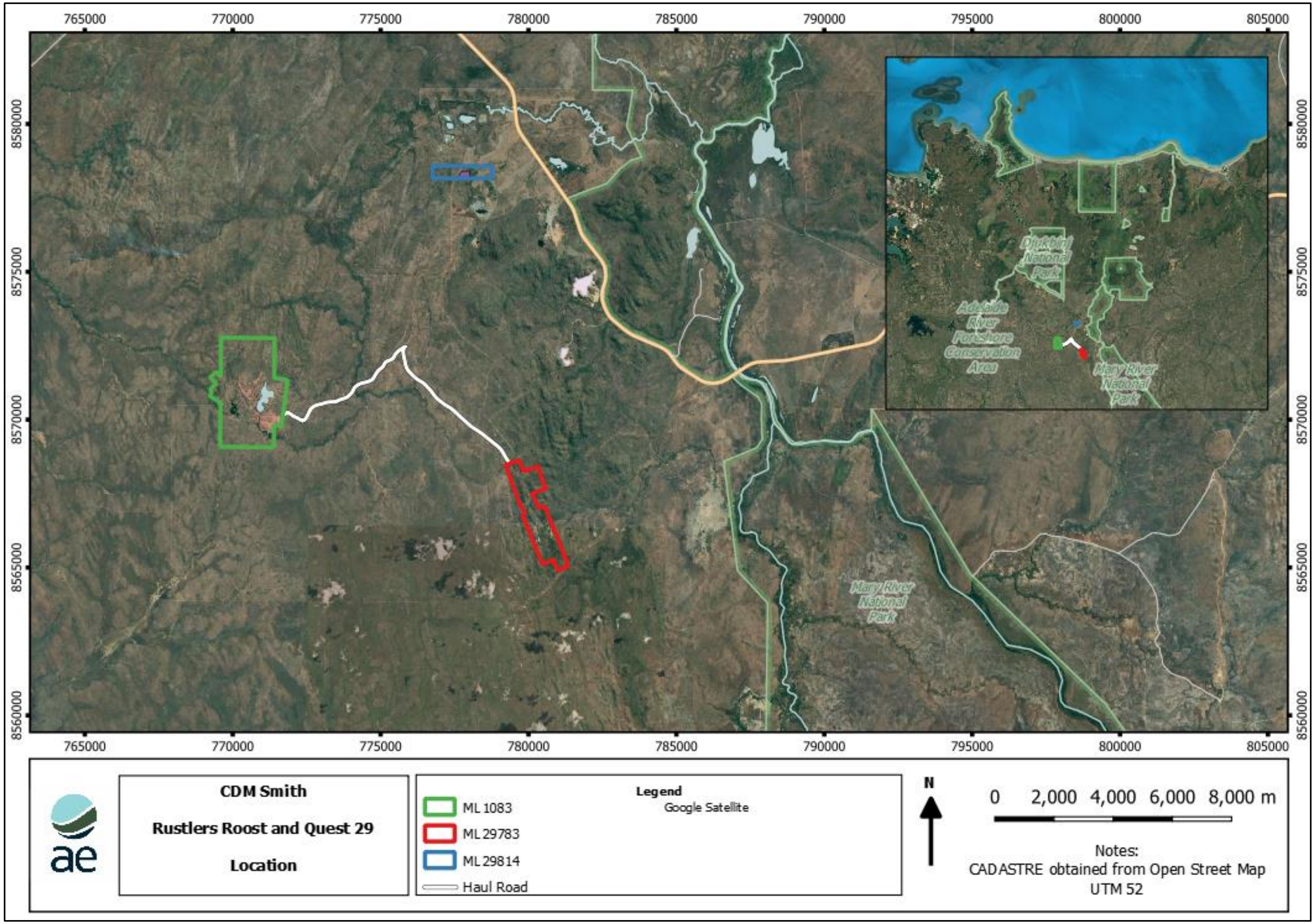


Figure 1: Site Location

3 DESCRIPTION OF ENVIRONMENTAL VALUES

3.1 Location

Rustlers Roost and Quest 29 are brownfield sites on ML located in the Mount Bundey locality, approximately 85 km south-east of Darwin. The main Project areas of Rustlers Roost and Quest 29 are located between 5 km and 12 km directly south-west of the Arnhem Highway on Old Mount Bundey Station, Perpetual Pastoral Lease (PPL) 1163 and McKinlay River Pastoral Station (PPL 1184).

Access to all three non-contiguous portions of the Project is via a station track located south of the Arnhem Highway. Primary infrastructure includes the Goanna Park Junior Police Ranger Training Centre located approximately 2.5 km from the Project area, Corroboree Park Tavern and roadhouse located approximately 11 km north, several granite quarries to the east, and the Mary River Wilderness Retreat and Bark Hut Inn 8 km east at the closest point.

The Mount Bundey Military Training Area encompasses a major land use in the region, consisting of over 100,000 ha. The training area is located approximately 11 km to the east of the Project area and adjoins the eastern boundary of the Mary River National Park. Mary River National Park is located approximately 6 km east of the Project and Djukbinj National Park is 10 km north.

3.2 Terrain

Figure 2 illustrates the local topography, as obtained from STRM at 30 m intervals.

3.3 Climatic Conditions

The climate of the region is broadly classified as tropical monsoonal. It is characterised by seasonal shifting of the prevailing winds and consequently marked changes of air mass properties. Two distinct seasons can be identified, a summer wet season and winter dry season, with two subsidiary transitional periods between them. The dry season occurs from May to September and is characterised by prevailing south-easterly winds. The hot, "dry-wet" transition from October to November has high humidity and variable winds. The wet season occurs from December to March, with dominant northwest to westerly winds. The hot, "wet-dry" transition of April has variable winds, although predominantly from a westerly direction.

Figure 3 presents the 20-year climatic conditions as observed at Bureau of Meteorology's (BOM) Middle Point (3 pm data was obtained from Darwin Airport as it was not available for Middle Point.

3.4 Receptors

When completing this report, consideration has been given to the potential impacts of the changed operation to sensitive receptors as well as sensitive land uses as shown in Figure 3.

These receptors include important wetlands (W1-W5), sites of conservations significance (SS1 – SS4), national parks (NP1 – NP6) and residential uses (R1 – R4). Additionally, 12 locations representing Indigenous sites of importance were assessed; however the Proponent has asked for the locations of these sites to not be identified.

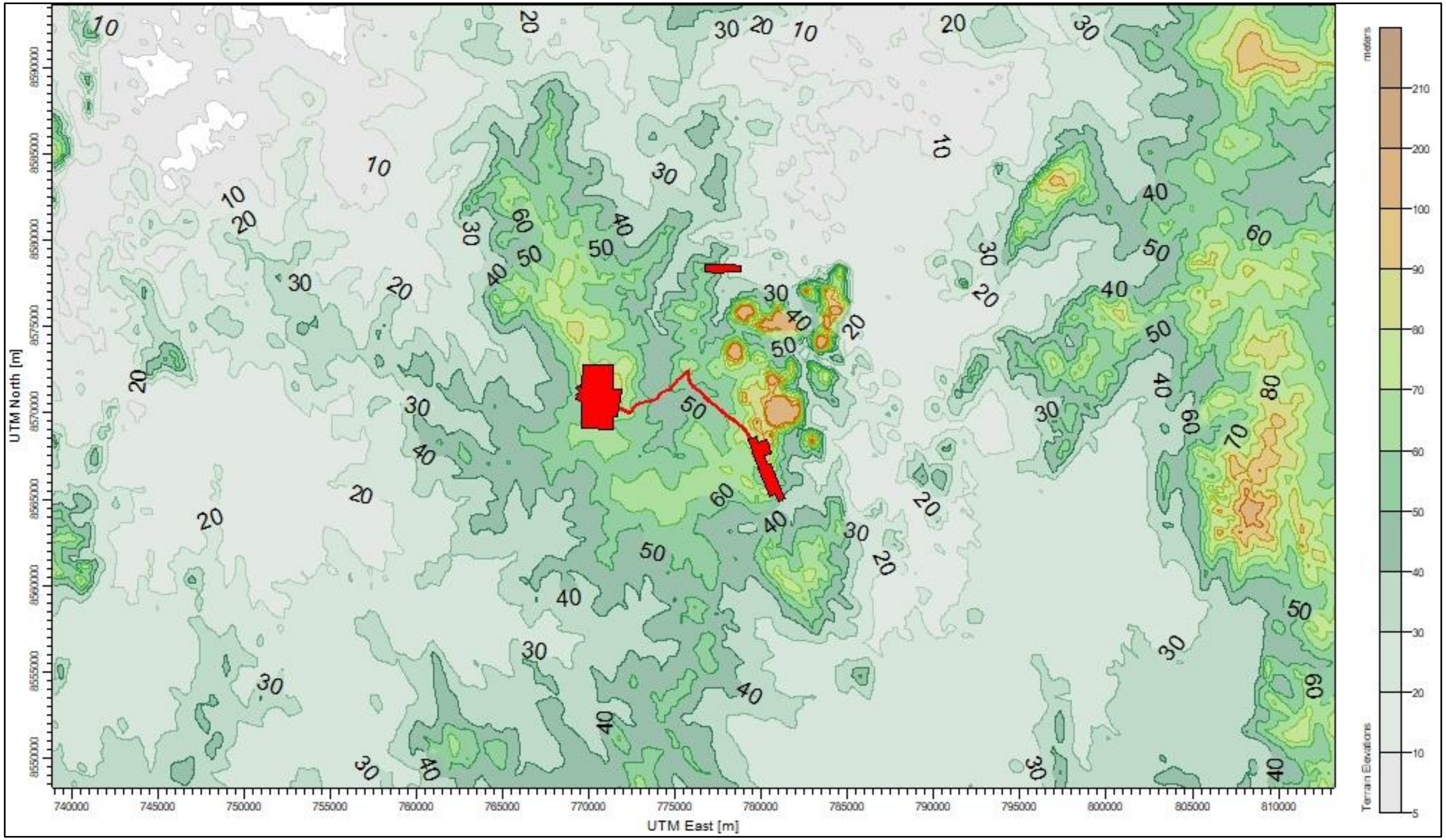


Figure 2: Surrounding Topography (Extracted from CALPUFF)

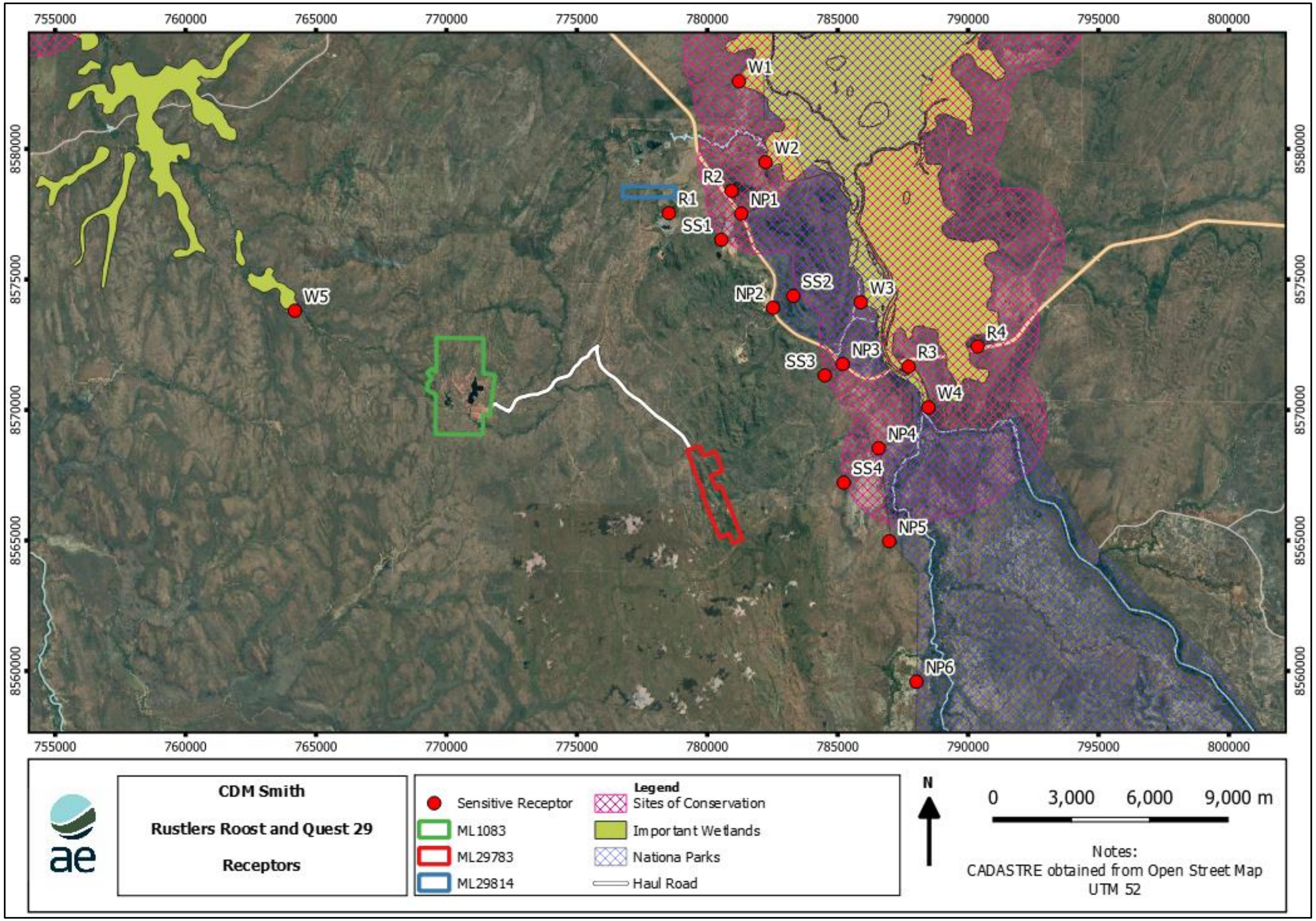


Figure 3: Modelled Sensitive Receptors

Average Temperature (Min, Max, Mean over 20-year Average)

Average Rainfall and Rainfall Days (20-year Average)

Relative Humidity (20-year Average)

Wind Speed (20-year Average)

Figure 4: Climatic Conditions (BOM Gympie)

4 LEGISLATIVE REQUIREMENTS

4.1 Ambient Air Quality NEPM

The National Environment Protection Council (NEPC) defines national ambient air quality standards and goals in consultation, and with agreement from all Australian state and territory governments. These were first published in 1998 in the National Environment Protection (Ambient Air Quality) Measure (Air NEPM).

A number of Australian states have adopted the Air NEPM standards as air quality objectives. Although the NT government has not yet legislated the use of the Air NEPM standards, these standards are widely used in environmental assessments in the NT and throughout Australia. The NEPM standards are presented in Table 3. In 2025, the objectives for $PM_{2.5}$ and SO_2 are becoming more reducing further. Due to the long-term nature of the Project, these more lower objectives will be applied.

Table 4: Ambient Air Quality NEPM Standards

Pollutant	Averaging Period	Concentration Maximum (µg/m^3)	
		Current Objective	From 2025
PM_{10}	1 day	50	-
	1 year	25	-
$PM_{2.5}$	1 day	25	20
	1 year	8	7
Carbon Monoxide (CO)	8 hours	11,000	-
Nitrogen Dioxide (NO_2)	1 hour	164	-
	1 year	31	-
Sulphur Dioxide (SO_2)	1 hour	286	57
	1 day	57	-
Lead	1 year	0.5	-

4.2 NSW Approved Methods

The Air NEPM does not provide assessment criteria for metals or gases. However, for jurisdictions such as the Northern Territory that do not have specific air quality objectives for metals or gases, the objectives provided in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (2016), published by the NSW EPA are commonly used.

Table 5: Approved Methods Ground Level Concentration Criteria

Pollutant	Averaging Period	Concentration (µg/m3)
TSP	Annual	90
Deposited Dust	Annual: Incremental	2 g/m^2/month
	Annual: Total	4 g/m^2/month
Antimony	1 hour	9
Arsenic	1 hour	0.09

Pollutant	Averaging Period	Concentration (µg/m3)
Barium	1 hour	9
Cadmium	1 hour	0.018
Chromium III	1 hour	9
Chromium VI	1 hour	0.09
Copper dusts and mists	1 hour	18
Iron oxide fumes	1 hour	90
Magnesium oxide fumes	1 hour	180
Manganese	1 hour	18
Mercury inorganic	1 hour	1.8
Nickel	1 hour	0.18
Zinc oxide fumes	1 hour	90
Cyanide	1 hour	90
Nitrogen dioxide	1 hour	246
	Annual	62
Acetaldehyde (Odour)	1 hour	42
Benzene	1 hour	29
Biphenyl	1 hour	24
1.3-butadiene	1 hour	40
Chloroethane (Ethyl chloride)	1 hour	48
Chloroform	1 hour	900
1,2-Dichloroethylene	1 hour	14400
Ethylbenzene	1 hour	8000
Formaldehyde	1 hour	20
Hydrogen Cyanide	1 hour	200
n-hexane	1 hour	3200
Methanol (odour)	1 hour	3000
Phenol (Odour)	2 hour	20
Benzo(a)pyrene as PAH	1 hour	0.4
Styrene (Odour)	1 hour	120
Toluene (Odour)	1 hour	360
Vinyl chloride	1 hour	24
Xylenes (Odour)	1 hour	190
Dioxins and Furans	1 hour	0.000002
SO_2	24 hour	228

5 EXISTING AIR ENVIRONMENT

5.1 Ambient Monitoring

To assess cumulative impacts, ambient monitoring data has been obtained from the Northern Territory Environmental Protection Authority (NT EPA) for 2020, as this is the same year as the meteorological dataset utilised in this assessment.

Although there are no ambient air monitoring stations in the vicinity of the Project Site, there are three monitoring locations around the Darwin region (Palmerston, Stokes Hill, and Winnellie) with monitoring data for 2020.

Review of the Palmerston data obtained from the NT EPA, identified elevated particulate concentrations compared to the other monitoring sites. It is suspected that this may be due to the monitoring station being located in very close proximity to the bay which is expected to result in elevated levels due to the presence of salt spray. The Stokes Hill monitoring station is also very close to the bay and elevated particulate concentrations were also observed. As such, Winnellie monitoring data is considered has been assessed for this Project as it is further inland, and considered to be more representative of the Project Site.

The pollutants monitored at this site, which are relevant to this assessment are CO, SO_2, NO_2, PM_{10} and $PM_{2.5}$.

The *Northern Territory Ambient Air Quality Monitoring Report 2020* (NT EPA, 2021) confirms the following exceedences at Winnellie during 2020:

- There was one exceedence of the PM_{10} 24-hour objective as a result of exceptional event (bushfire smoke) on 5 June 2020. This exceedence has been removed from the data analysis;

- There were seven exceedences of the $PM_{2.5}$ 24-hour objective as a result of exceptional events (bushfire smoke) on 2 – 3 May, 4 – 6 June, 25 June, and 8 July 2020. These exceedences have been removed from the data analysis; and

- There were no exceedences of NO_2, SO_2 or CO during 2020.

There are no monitoring stations that record total suspended particles (TSP); in lieu of this, research indicates that in rural areas, PM_{10} typically represents 49% of total TSP, therefore, TSP concentrations have been estimated based on the application of this ratio[a].

Table 6 provides a summary of the background concentrations for 2020. For this assessment, the hourly background concentrations presented in Figure 5 to Figure 9 have been modelled contemporaneously. Where no data is available, the annual average has been applied and negative values have been removed.

[a] Air Noise Environment Pty Ltd (1999) 'Fine dust and the implications for the coal industry', ACARP Project C7009.

Table 6: Summary of Background Concentrations at Winnellie for 2020 (Exceedences Removed)

Compound	Time Period	24-hour Concentration (µg/m^3)			Annual Average (µg/m^3)
		Max	90th Percentile	70th Percentile	
CO	8-hour	864	296	237	200
NO_2	1-hour	43.2	9.5	5.6	5.1
SO_2	1-hour	3.5	2.3	1.9	1.6
	24-hour	2.8	2.0	1.8	1.6
TSP	Annual	100.4	56.3	40.5	33.5
PM_{10}	24-hour	46.8	27.6	19.8	16.4
$PM_{2.5}$	24-hour	23.6	12.4	7.7	5.9

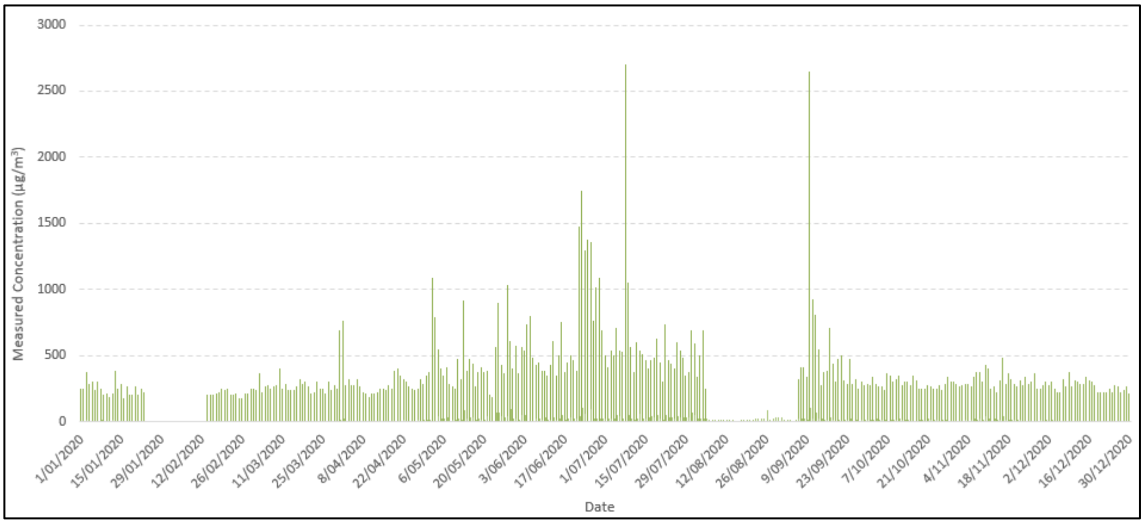


Figure 5: Hourly CO Concentrations at Winnellie for 2020

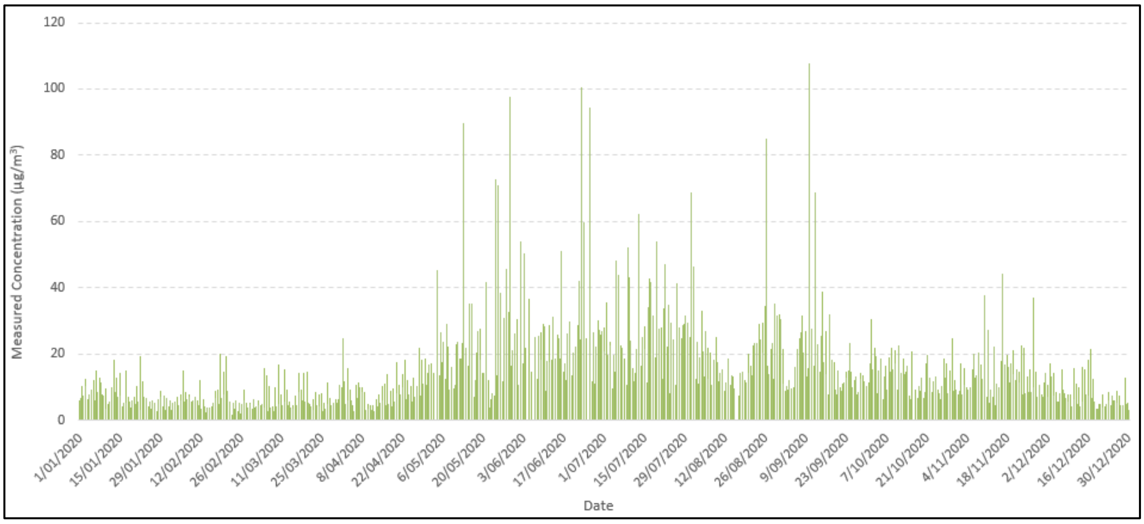


Figure 6: Hourly NO_2 Concentrations at Winnellie for 2020

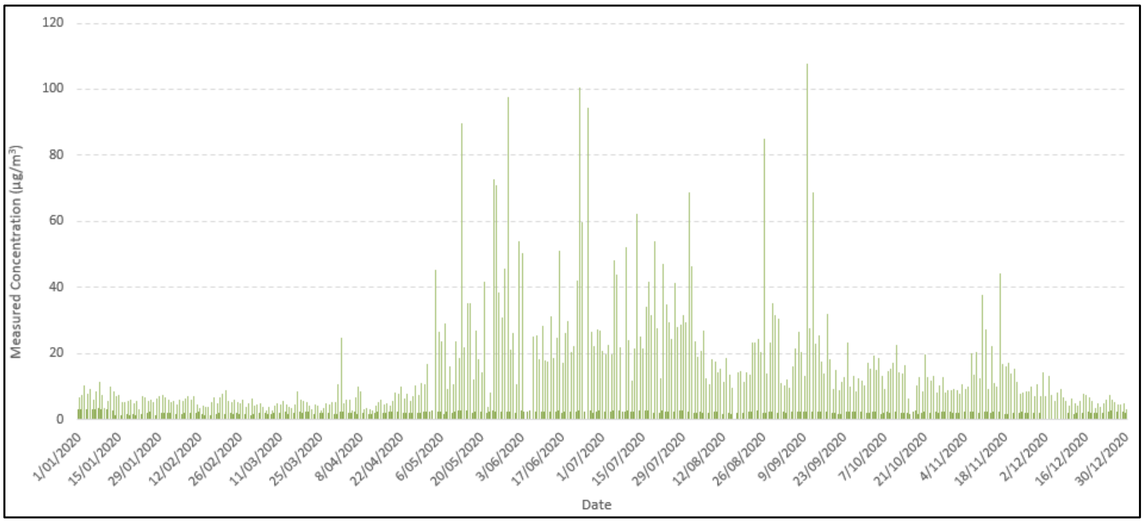


Figure 7: Hourly SO_2 Concentrations at Winnellie for 2020

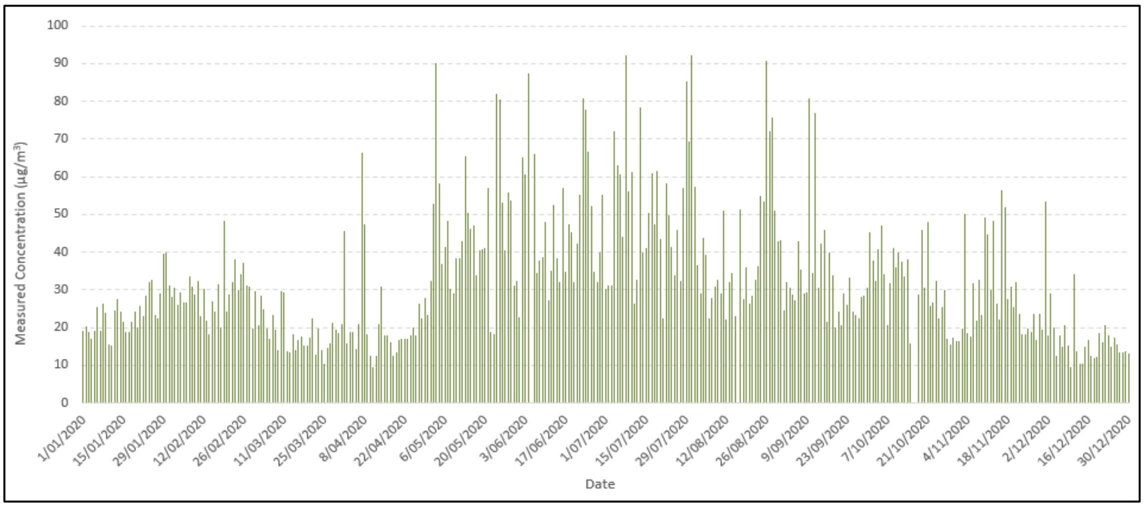


Figure 8: Hourly PM_{10} Concentrations at Winnellie for 2020

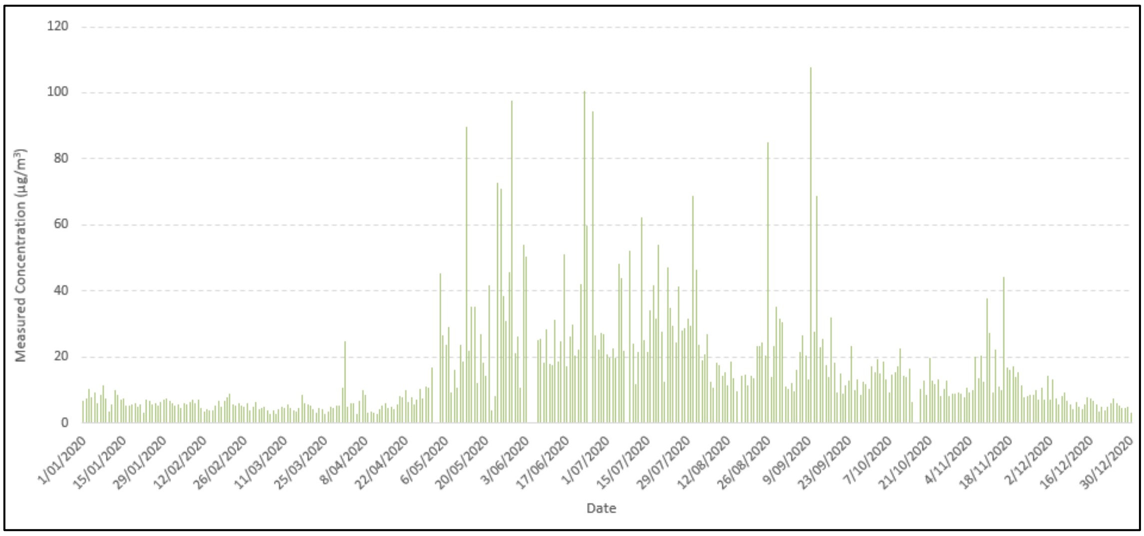


Figure 9: Hourly $PM_{2.5}$ Concentrations at Winnellie for 2020

NT EPA does not monitor dust deposition, however for the purposes of this assessment background dust deposition has been assumed to be 2 g/m^2/month, which is the baseline level for NSW Approved Methods.

5.2 Surrounding Industrial Land uses

The region supports a number of extractive resources enterprises, including the HB Quarry and Boral Quarry as shown in Figure 10. A review of the National Pollution Inventory (NPI) database has identified that only the Boral Quarry submits annual reports. Due to the separation distances between the industries, the cumulative impact from the quarries is expected to be negligible and therefore these operations have not been assessed.

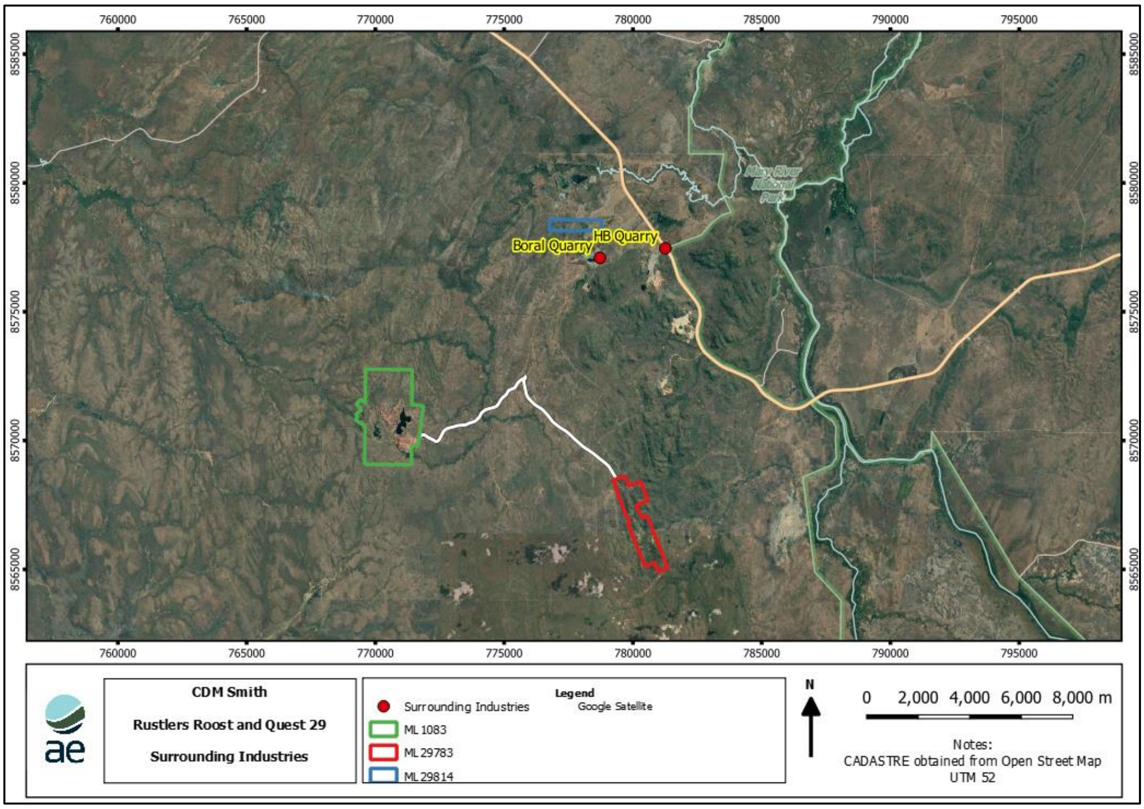


Figure 10: Surrounding Industries

6 MODELLING METHODOLOGY

6.1 TAPM Predictions

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

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

For the purpose of the assessment, meteorological modelling has been undertaken using TAPM (The Air Pollution Model) and CALMET to predict localised meteorological conditions. The meteorological data derived from these models have been used as an input for the CALPUFF dispersion modelling.

A site-specific meteorological dataset has been determined using the prognostic model TAPM (The Air Pollution Model). Prognostic models, such as TAPM, permit the development of localised meteorological datasets, based on synoptic weather conditions. The model predicts the regional flows important to dispersion, such as sea breezes and terrain induced flows, against a background of larger-scale meteorology provided by synoptic analyses.

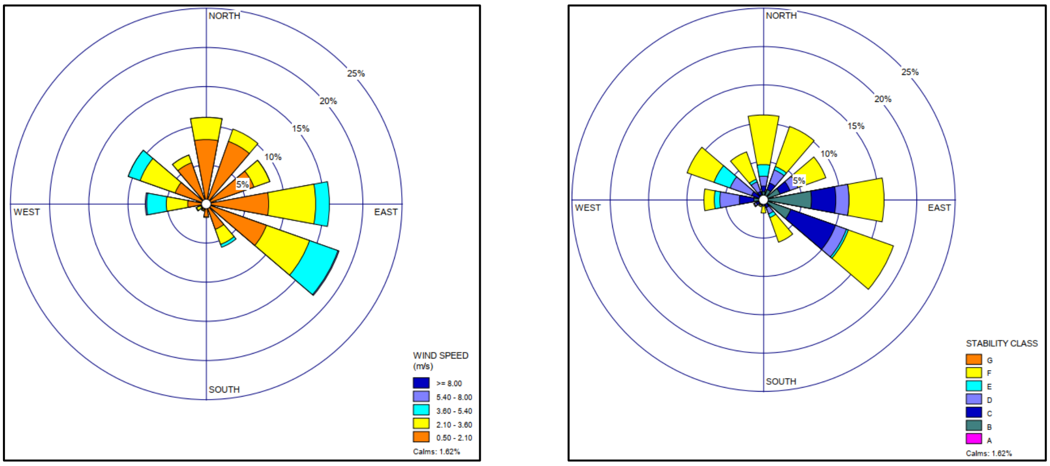
The output of this model, when used with a diagnostic meteorological model, such as CALMET, provides a meteorological dataset suitable for introduction into the wind field results. This methodology is the recommended approach for the modelling of contaminant concentrations using CALMET[b].

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

Table 7: Summary of Meteorological Modelling Parameter

Model	Aspect	Assigned Parameter
TAPM (v4.04)	Year Modelled	One full year - 2020 which is compared to long-term observations to demonstrate suitability. Observations from BOM Middle Point and Mount Bundey were assimilated into TAPM
	Coordinates	Latitude: -12°52.5 min / Longitude: 131°33.0 min
	Domain Grids	80 x 80 x 25 grid points
	Nesting Spacing	18 km, 10 km, 3 km, and 1 km
CALMET (v 7.1)	Databases	Default databases for sea temperature, terrain and land cover applied
	Model Domain	76-km x 76-km grid (400 m grid intervals)
	Terrain Data	Nasa Shuttle Radar Topography Mission (SRTM) 1-second (approximately 30 m) digital elevation model
	Land Use	Default from USGS for 1 km spacing. Review of the land use was undertaken and updated based on recent aerial imagery
	Vertical Layers	12 Layers - 20 m, 50 m, 75 m, 150 m, 200 m, 500 m, 750 m, 1,000 m, 1,500 m, 2,000 m, 3,000 m, and 4,000 m

Figure 11 presents the annual wind rose and stability class rose for the Rustlers Roost ML during 2020. Detailed meteorological analysis of the dataset is presented in Appendix A.



Wind Rose　　Stability Class Rose

Figure 11: Predicted Annual Wind and Stability Class Roses at Rustlers Roost ML for 2020

6.2 CALPUFF Dispersion Modelling

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

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

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

6.3 Receptors

A computational grid of 28 km by 27 km at 400 m spacing has been modelled.

6.4 Other Settings

For the purposes of the assessment, the air dispersion modelling has utilised the following settings for CALPUFF:

- three-dimensional mode using meteorological data file from CALMET;
- ISC rural wind speed profile;
- no chemical transformation;
- no gaseous deposition;
- transitional plume rise;
- stack tip downwash for point sources;
- partial plume penetration for point sources;
- dispersion coefficients using Pasquill–Gifford coefficients or turbulence calculated from micro-meteorology;
- no adjustment of dispersion curves for roughness;
- partial plume path adjustment method for terrain using default coefficients;
- building wakes were modelled using BPIP-Prime model; and
- pit retentions reductions were applied were suitable.

7 AIR EMISSION ESTIMATION

7.1 Overview

Emissions from the mining operations and processing of up to 5 Mtpa are typically particulates (TSP, PM_{10}, and $PM_{2.5}$) associated with material transfers and vehicle movements. Power generation from the CAT (or equivalent) engines will emit particulates and gaseous pollutants. Table 8 presents a summary of the sources and types of emissions from the Project.

Table 8: Summary of Potential Emissions

Element	Activity	Potential Emissions
Mining	Vehicle movements on unpaved roads	Particulates
	Blasting and drilling	Particulates
	Ore extraction	Particulates and metals
	Material transfers	Particulates and metals
	Wind erosion from stockpiles	Particulates and metals
	Wind erosion from exposed areas	Particulates
Haul road	Heavy truck movements on unpaved roads	Particulates
Processing	Emissions from crushing/screening material transfers	Particulates and metals
	Emissions from carbon in leach	Cyanide and hydrogen cyanide
	Emissions from carbon regeneration kiln (slurry drying)	Combustion gases
	Emissions from smelting (gold room furnace)	Metals, gaseous compounds, and particulates
Power generation	Emissions from CAT engines (or equivalent)	Particulates and gaseous compounds

7.2 Composition of Ore

The composition of ore has been provided based on 131 ore samples. Detailed composition of ore is listed in Table 12.

Table 9: Composition of Ore

Compound	Ore Composition (mg/kg)
Antimony	0.27
Arsenic	86.02
Barium	637.33
Cadmium	0.00
Chromium	46.12
Copper	29.02
Iron	63734
Lead	8.44
Magnesium	8313.59

Compound	Ore Composition (mg/kg)
Manganese	1037.18
Nickel	27.37
Zinc	62.95
Sulphur	1788

7.3 Scenario Assessed

Based on the schedule in Section 2.5, this assessment will consider one scenario which is expected to impact the closest receptors. The scenario is based on the operational production when Quest 29 will be mined at the same time as Rustlers Roost. This scenario is scheduled to occur for approximately one year and is considered worst-case as listed in Table 10.

Table 10: Scenario Assessed

Aspect	Expected 2030 Operations
Rustlers Roost mining	4.25 Mtpa
Processing	Ore: 600 tph (wet) every hour of the year Gold dore: 50 kg smelting per batch (104 batches per annum)
Power generation	10 x 2.5 MW CAT G3520H engines (or equivalent)
Quest 29 mining	0.75 Mtpa
Haul road	0.75 Mtpa

7.4 Sources of Emissions

7.4.1 Mining Emissions

Dust emissions from the mining are fugitive particulates TSP, PM_{10} and $PM_{2.5}$. The main sources of fugitive particulates are from the following sources:

- wheel generated emissions on unpaved roads;
- material unloading from trucks;
- drilling and blasting rock;
- screening, crushing, and conveying of material; and
- wind erosion from stockpiles and exposed surfaces.

Emission estimates for the above activities have been derived based on the USEPA AP-42: Compilation of Air Emission Factors (US Environmental Protection Agency, Various Dates) and National Pollution Inventory (NPI) *Emission Estimation Technique Manual for Mining* (2012).

Emission factors within these documents are used to estimate emissions of TSP, PM_{10} and $PM_{2.5}$ to the air from various sources. Emission factors relate to the quantity of a substance emitted from a source to some measure of activity associated with the source.

7.4.2 Mining Operations and Processing Facility (Crushing Circuit)

Mining operations at Rustlers Roost and Quest 29 were assessed as listed in Table 10 with a combined production rate of 5 Mtpa. The main activities are as follows:

- Drilling and blasting;
- Material transfers (truck loading/unloading of ore, overburden, and waste rock);
- Wind erosion;
- Heavy and light vehicles on haul roads; and
- Combustion emissions.

The processing facility comprises screens, crushers, material transfers, ball mill and stockpiles. The plant is designed to operate at 700 t/hour at full production. Processing will be constant and operate all hours of the year.

Table 11 represents the emissions from the mining and processing facility (crushing circuit) from the crushing, screening, and transfer of the ore based on the operational information detailed in Appendix B. Figure 12 and Figure 13 presents the location of sources for Rustlers Roost and Quest 29 respectively.

The mining and processing circuit includes the following emission controls:

- dust suppression (water) and Level 2 watering of haul roads (>2L/m^2/hour);
- revegetation of waste rock and decommissioned stockpiles;
- filters during drilling holes for blasting activities;
- dust extraction systems from the reserve product hopper, HPGR screen hopper and ball mill. The extraction system includes a series of cyclones to reduce particulates;
- The fine ore (crushed ore) product will be maintained in a covered stockpile; and
- A small stockpile maintained outside (open) for emergency use.

The fine ore is transferred from the covered stockpile to the Mill Circuit which is a wet process.

Table 11: Summary of Emission Rates: Mining and Process Facility (Crushing Circuit)

Activity	Emission Rate (g/sec)		
	TSP	PM_{10}	$PM_{2.5}$
Wind Erosion	5.51	2.76	0.28
Material Handling	8.27	4.01	0.73
Crushing and Screening	5.35	2.14	1.86
Unpaved Haul Roads	20.22	5.58	2.12
Drill and Blast	0.22	0.11	0.01
Total	**39.57**	**14.60**	**4.99**

Emissions from the ball mill, undersize screen hopper and reserve product hopper will be exhausted through a cyclone cluster to capture emissions of particulates. For this sources, the parameters in Table 12 have been applied and are based on the cyclone performance of 20 mg/m^3 as required by the Protection of the Environment (Clean Air) Operations 2010 for milling of non-ferrous ore. The performance of the cyclone cluster will be determined during the detailed design stage and will apply best practice emissions control.

Table 12: Modelled Stack Parameters and Emission Rates for Cyclone

Parameter	Value	Data Source
Stack Location (UTM Zone 52)	770495, 8571740	Plans
Stack Height	3 m above roof	Typical
Building Height	12 m	Assumed
Operating Hours	24 hours per day	Client
Exit Temperature	343 K	
Diameter	1 m	Typical
Velocity	10 m/s	
Emission rates (g/sec)		
Total Suspended Particulates	0.16	Cyclone performance is 20 mg/m^3 as per POEO for milling of non-ferrous primary production.
Particulate matter ≤10.0 µm	0.16	
Particulate matter ≤2.5 µm	0.16	

7.4.3 Processing Plant (Milling Circuit)

Once the ore is crushed to the required size, the fine ore is separated from the metals using cyanidation and carbon in leach adsorption processes. This includes drying of the slurry (carbon regeneration kiln), acid wash (to remove inorganics), elution, electrowinning, dewatering, and smelting.

7.4.3.1 Cyanide Volatilisation from CIL Tanks

Carbon in leach (CIL) involves the removal of complex gold ions from solution by adsorption onto activated carbon. Slurry that has undergone cyanidation in a number of tanks. In each tank, the gold is adsorbed onto granular activated carbon that is extracted.

Emissions of cyanide will occur from the volatilisation of cyanide from the process tanks is presented in the NPI EET for Gold Ore Processing. The equation estimates the HCN emissions from an individual process tanks is:

$$E = \left(\left(0.013\ x\ HCN_{(aq)} + 0.46\right)x\ A\ x\ T\ x0.96/10^3\right)$$

Where:

- E = Emission of CN (kg)
- $[HCN_{(aq)}]$ = [NaCN] x $10^{(9.2\ -\ pH)}$
- [NaCN] = Concentration (as 150 mg/l) of NaCN in the leach/adsorption tank
- pH = 10 pH in the leach/adsorption tank
- A = Surface area (225 m^2 per tank) of the leach/adsorption tank
- T = Period of emissions (hours)

The plant will operate 24 hours per day. Therefore, the calculated emission rate is 0.028 g/sec of cyanide from each tank. There are nine identical tanks, therefore an overall emission rate of 0.25 g/sec of cyanide has been modelled.

The cyanide emissions from the electrowinning processing are negligible (NPI EET for Gold Ore Processing).

7.4.3.2 Tailings Storage Facility

The tailings storage facility (TSF) is a wet facility. As such, particulate emissions are negligible (NPI EET for Gold Ore Processing). However, to calculate the cyanide volatilisation from tailings dam, approximately 2,040 tonnes per year NaCN will be added to the process water, which is the equivalent of 1,083 tonnes per year. Based on the TSF return water (1,017,000 kL/year, an estimated hydrogen cyanide emission rate of 0.59 g/sec and cyanide emission rate of 0.56 g/sec.

7.4.3.3 Summary of Cyanide Emissions

Table 13 provides a summary of hydrogen cyanide and cyanide emissions from the mill circuit.

Table 13: Summary of Cyanide Emissions

Release	Emission Rates (g/sec)	
	HCN	Cyanide
CIL Tanks (per tank)	0.029	0.028
Electrowinning	Negligible	Negligible
TSF (volatilisation)	0.59	0.56
Carbon Regeneration Kiln	Negligible	Negligible

7.4.3.4 Carbon Regeneration Kiln

The gold process includes a carbon regeneration kiln which dries the product. The NPI for Gold Ore Processing states that the emissions from the kiln are combustion related and that cyanide emissions are negligible.

The proposed kiln will have a capacity of 500 kg per hour and be fuelled by LPG at a rate of 0.18 GJ per hour. Table 14 presents the emission rates from the carbon regeneration kiln.

Table 14: Modelled Stack Parameters and Emission Rates for Carbon Regeneration Kiln

Parameter	Value	Data Source
Stack Location (UTM Zone 52)	770492, 8571752	Plans
Stack Height	3 m above roof	Typical
Building Height	12 m	Assumed
Operating Hours	24 hours per day	Client
Exit Temperature	351 K	AE database for carbon regeneration kiln
Diameter	0.43 m	
Flow Rate	0.16 Nm^3/sec	
Velocity	4.1 m/s	
Emission rates (g/sec)		
Carbon monoxide	0.22	NPI for Combustion in Boilers (LPG (Butane))
Oxides of nitrogen	1.26	
Total Suspended Particulates	0.07	
Particulate matter ≤10.0 µm	0.07	

Parameter	Value	Data Source
Particulate matter ≤2.5 µm	0.04	
Sulphur dioxide [a)]	0.10	
Polychlorinated dioxins and furans (TEQ)	2.82 x10^{-11}	
Mercury [b)]	1.41 x10^{-7}	

a) Composition of fuel is SO_2; composition of ore is presented as sulphur. SO_2 emissions assume 100% conversion of sulphur in ore to SO_2

b) No mercury analysed as part of the ore composition. Mercury emissions from fuel combustion only.

7.4.3.5 Furnace (Gold Room)

The final stage of the processing facility is the smelting of the product to create crude gold bars. An LPG fired Furnace Technologies A200 Batch Smelting Furnace will melt 50 kg batches of crude gold which takes approximately four hours. Only one batch will be smelted per day. The smelter consumes 350 MJ per hour and will operate approximately 416 hours per annum over 104 days.

Smelting is a process where the melting of crude gold separates impurities that float to the surface as slag. The slag is poured off and the molten gold is poured into moulds for off-site transportation and sale.

Emission rates for the smelter have been obtained from the following:

- NPI EET for Gold Ore Processing (latest version);
- NPI EET for Combustion in Boilers (latest version); and
- Air emissions data from Assured Environmental's database.

The emissions from the furnace are the combustion of LPG and metals in the crude gold. Using mass balance calculations from NPI Gold Ore Processing, fuel consumption and the composition of ore, the emissions per batch can be calculated.

For the purposes of this assessment, the following is noted:

- To be conservative, the SO_2 emissions are based on total sulphur (S) from the composition of ore and SO_2 from combustion of fuel;

- The emissions from combustion and composition of ore are added together to provide the total emission rates from the process;

- The elemental data provided did not include mercury. Therefore, for the smelting process, mercury emissions are based on fuel combustion only.

Assured Environmental have undertaken emissions monitoring of a gold smelting operations at other locations. All of the data has identified that SO_2 and SO_3 (as H_2SO_4 (sulphur trioxide as sulphuric acid)) are below the limit of detection; as such H_2SO_4 has not been considered in this assessment.

In lieu of information relating to the stack parameters, data from AE's monitoring at other gold furnaces has been used. Table 15 presents the stack parameters and emission rates for the gold smelter.

The emission rates presented in Table 15 are based on no emissions control; whilst the Proponent has confirmed a scrubber will be added to the process to reduce emissions, information relating to the neutralising agent and the compounds the agent will target is currently unknown. As such, the emissions presented in this table are considered to represent upset conditions and be conservative in nature.

Table 15: Modelled Stack Parameters and Emission Rates for Gold Furnace

Parameter	Value	Data Source
Stack Location (UTM Zone 52)	770214, 8571744	Plans
Stack Height	3 m above roof	Typical
Building Height	10 m	Assumed
Operating Hours	4 hours per day [a)]	Client
Batch quantity	50 kg	Client
Exit Temperature	295 K	AE database for gold furnace for similar quantity
Diameter	0.3 m	
Flow Rate	0.66 Nm^3/sec	
Velocity	14.3 m/s	
Emissions control	Scrubbing system installed on exhaust	Client
Emission rates without the scrubber (g/sec)		
Total Suspended Particulates	0.0023	AE database for gold furnace for similar batch quantity
Particulate matter ≤10.0 μm	0.0023	
Particulate matter ≤2.5 μm	0.0023	
Antimony	3.79 x10^{-9}	NPI for Combustion in Boilers (LPG (Butane)) <u>and</u> composition of ore used as detailed in NPI Gold Ore Processing
Arsenic	1.19 x10^{-6}	
Barium	8.85 x10^{-6}	
Cadmium	6.36 x10^{-11}	
Chromium	6.41 x10^{-7}	
Copper	4.03 x10^{-7}	
Iron	8.85 x10^{-4}	
Lead	1.17 x10^{-7}	
Magnesium	1.15 x10^{-4}	
Manganese	1.44 x10^{-5}	
Nickel	3.80 x10^{-7}	
Zinc	8.74 x10^{-7}	
Mercury [b)]	1.15 x10^{-9}	
Sulphur dioxide [c)]	0.001	
Oxides of nitrogen	0.01	
Carbon monoxide	0.002	
Polychlorinated dioxins and furans (TEQ)	2.30 x10^{-13}	

a) Modelling for 4 hours per day is on a diurnal weekly profile to ensure that all hours of the day are assessed
b) No mercury analysed as part of the ore composition. Mercury emissions from fuel combustion only.
c) Composition of fuel is SO_2; composition of ore is presented as sulphur. SO_2 emissions assume 100% conversion of sulphur in ore to SO_2

7.4.4 Power Station

A 31-Megawatt (MW) power station, to be located adjacent to the process plant, will provide power for the plant and other operations at Rustlers Roost. The power station will be located adjacent to the processing plant. The power plant comprises:

- 10 x 2.5 MW Natural gas engines (CAT G3520H); and
- 6 MW Battery Energy Storage System.

The only air emissions from the power plant are from the CAT engines. All 10 engines will be used at full production. Manufacturers specifications only provide concentration limits for nitrogen oxides (NO_X); two concentrations are provided 250 mg/Nm^3 and 500 mg/Nm^3. For the purposes of this assessment, the highest manufacturer's concentration (500 mg/m^3) has been compared to the emission factors from the NPI *Emission Estimation Technique (EET) for Combustion in Engines* (latest version) have been used to estimate emissions. In lieu of any other pollutant data, the remaining compounds have been estimated using the NPI EET.

For the purposes of this assessment, the emissions presented in Table 16 are for 100% load for and modelled as a constant emission rate (all hours of the year). The location of the gensets is in the NW corner of the processing plant (Figure 14).

Table 16: Modelled Stack Parameters and Emission Rates for Each Gas Engine

Parameter	Value	Data Source
Stack Location (UTM Zone 52)	770150, 8571917 770150, 8571903 770150, 8571885 770150, 8571867 770150, 8571847 770188, 8571917 770188, 8571903 770188, 8571885 770188, 8571867 770188, 8571847	Plans
Stack Height	6 m	Typical
Operating Hours	24/7	All hours of the day
Exit Temperature	673 K	Manufacturer's Data
Diameter	0.35 m	Assumed
Flow Rate	2.97 Nm^3/sec	Manufacturer's Data
Velocity	31 m/s	Calculated from flow rate
Gas consumption	236 m^3/hour	Calculated from 2.5 MWh
Emission rates (g/sec)		
Oxides of Nitrogen	1.48	Manufacturer's (500 mg/Nm^3)
Carbon monoxide	0.611	NPI
Particulate matter ≤10.0 μm	8.45 x10^{-5}	NPI
Particulate matter ≤2.5 μm	8.45 x10^{-5}	NPI
Acetaldehyde	9.18 x10^{-3}	NPI
Benzene	4.83 x10^{-4}	NPI

Parameter	Value	Data Source
Biphenyl	2.33 x10^{-4}	NPI
1,3-Butadiene	2.93 x10^{-4}	NPI
Chloroethane	2.05 x10^{-6}	NPI
Chloroform	3.13 x10^{-5}	NPI
1,2-Dichloroethane	2.95 x10^{-6}	NPI
Ethylbenzene	4.35 x10^{-5}	NPI
Formaldehyde	0.058	NPI
n-Hexane	0.001	NPI
Methanol	0.003	NPI
Phenol	2.63 x10^{-5}	NPI
Polycyclic aromatic hydrocarbons (B[a]Peq)	1.90 x10^{-7}	NPI
Styrene	2.59 x10^{-5}	NPI
Sulphur dioxide	8.52 x10^{-4}	NPI
Toluene	4.48 x10^{-4}	NPI
Vinyl Chloride Monomer	1.63 x10^{-5}	NPI
Xylenes	2.02 x10^{-4}	NPI

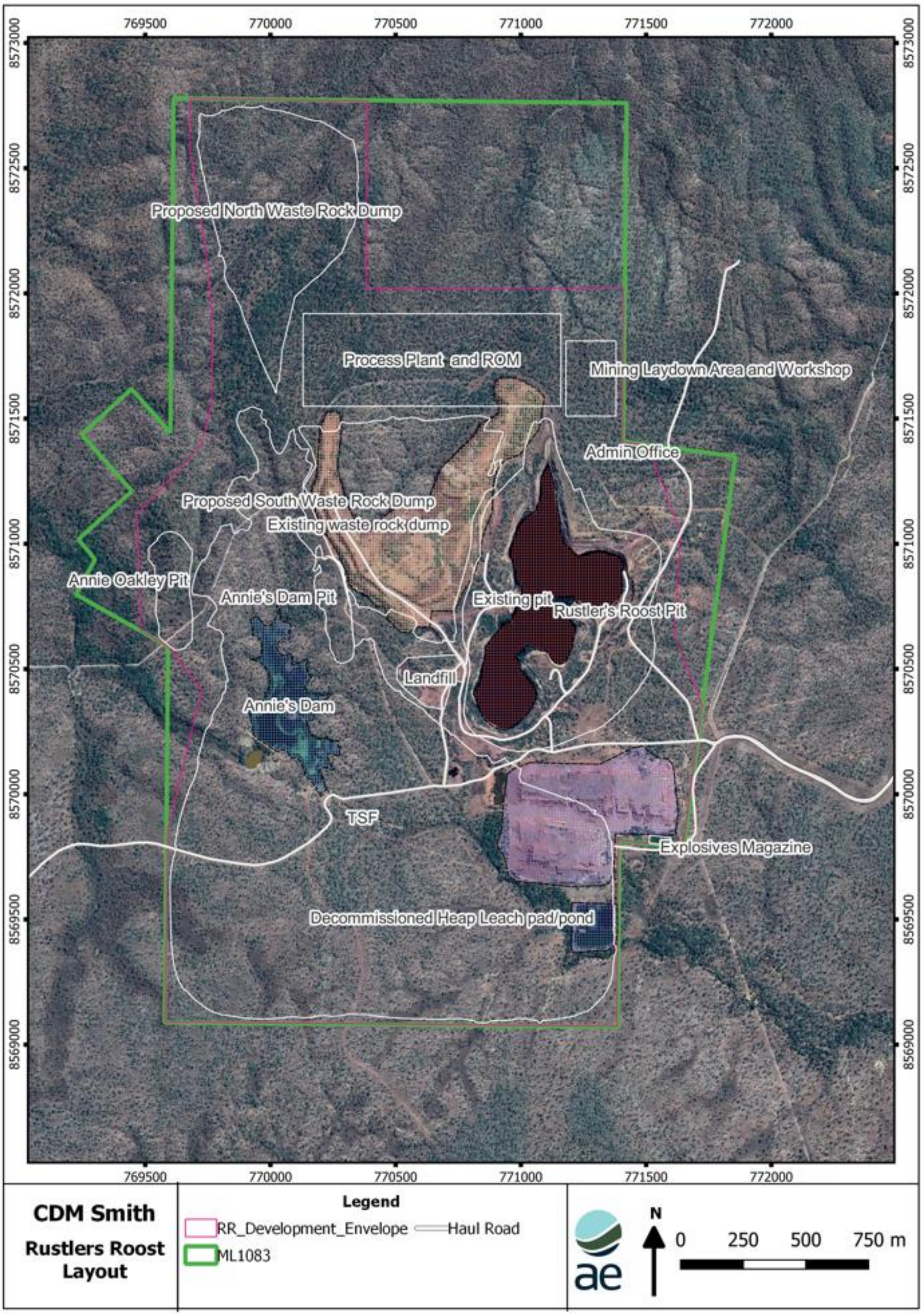


Figure 12: Rustlers Roost Layout

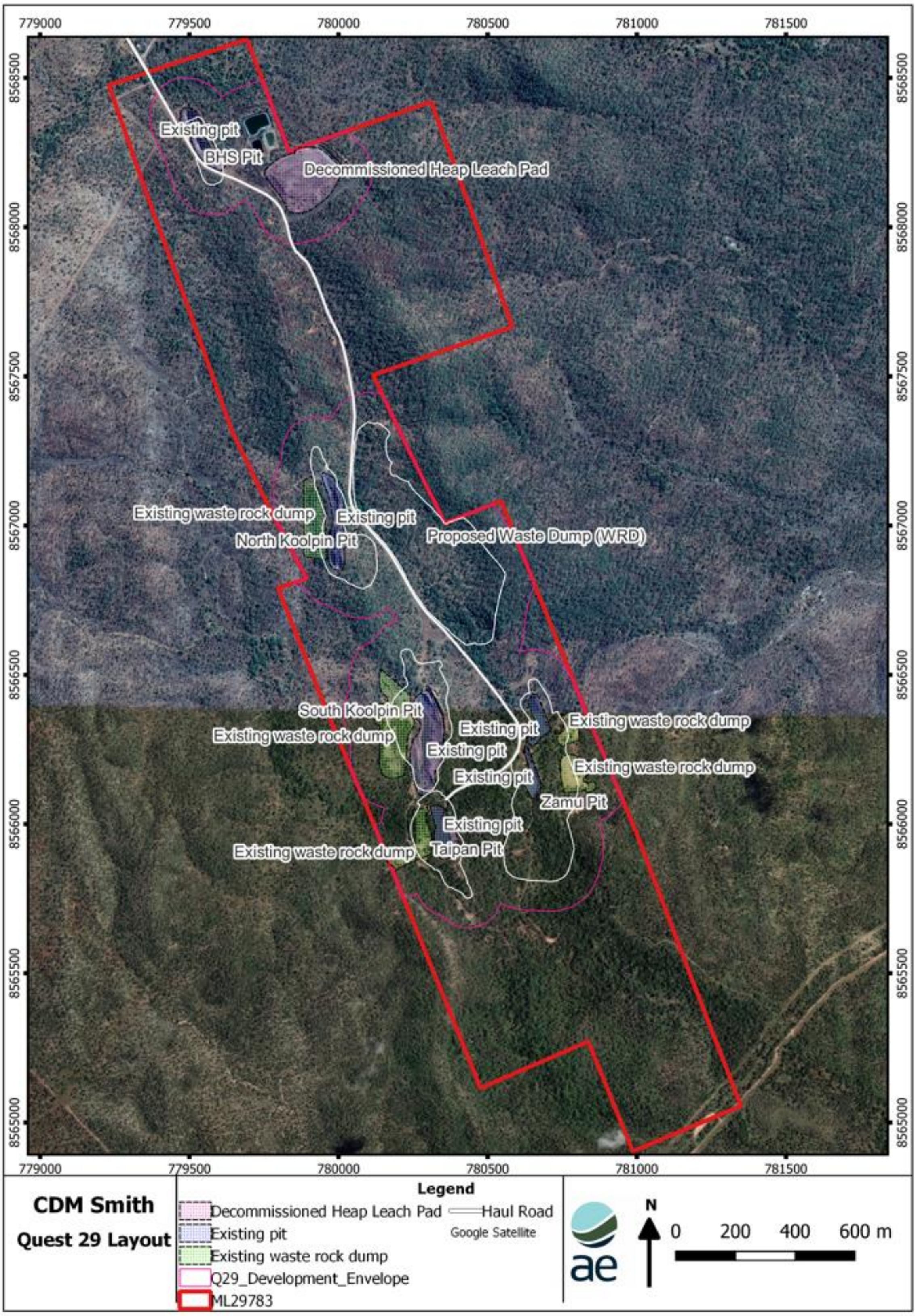


Figure 13: Quest 29 Layout

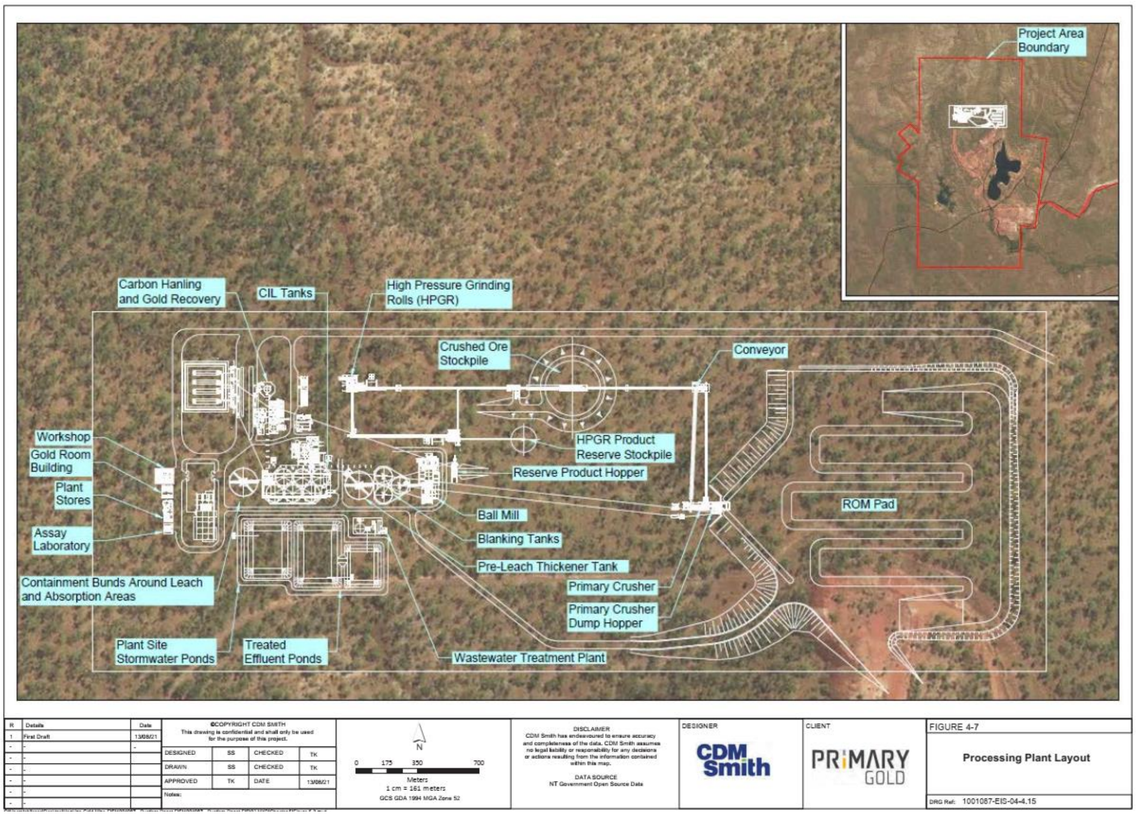


Figure 14: Processing Plant Layout

7.4.5 Vehicle Combustion Emissions

Fugitive combustion emissions will be released from the mining fleet. Emission estimations have been calculated using the emission factors in NPI Emission Estimation Technique for Combustion in Engines (2008).

To estimate emissions from industrial vehicles the following data is used:

- Engine power or fuel use and number of vehicles
- Emission factors and load factors (NPI); and
- Estimated number of hours operational per annum.

Table 17 presents the modelled vehicle emissions based on the expected operational usage.

Table 17: Vehicle Exhaust Emissions

Vehicle	Engine kWh	Quantity	Hours Operating per Annum	Emission Rates (g/sec)						
				PM_{10}	$PM_{2.5}$	CO	NO_x	PAH	SO_2	Formaldehyde
Haul Truck	1125	8	8322	0.80	0.736	5.58	13.06	2.26×10^{-4}	0.0091	0.356
Water Cart	1125	1	8322	0.10	0.092	0.70	1.63	2.82×10^{-5}	0.0011	0.045
Loader	144	2	8322	0.04	0.038	0.14	0.46	2.36×10^{-5}	0.0003	0.010
Dozer	306	2	7884	0.08	0.072	0.24	0.84	3.28×10^{-5}	0.0006	0.019
Excavator	322	3	7884	0.11	0.098	0.36	1.45	7.00×10^{-5}	0.0009	0.016
Grader	75	1	3504	0.004	0.003	0.01	0.04	7.92×10^{-7}	3.13×10^{-5}	0.001
Light vehicles	122	10	4380	0.0004	0.0004	0.003	0.001	2.64×10^{-8}	2.80×10^{-5}	0

8 PREDICTED GROUND LEVEL CONCENTRATIONS

8.1 Summary

The results in this section are presented as follows:

- Total predicted concentrations at sensitive receptors and Indigenous sites of importance from all operations. These results include the contemporaneous background concentrations in Section 5.1; and

- Review of incremental impacts from the Project from all operations.

8.2 Total Predicted Concentrations

The maximum predicted ground level concentrations from pollutants where background concentrations are available is presented in Table 18. It can be seen from the table that compliance is achieved at all receptors for all pollutants.

Table 18: Summary of Maximum Predicted Incremental Ground Level Concentrations at Sensitive Receptors and Indigenous Sites of Importance

Pollutant	Averaging Period	Maximum Predicted GLC (µg/m³)		Criteria (µg/m³)	Compliant?
		Sensitive Receptors	Indigenous Sites of Importance		
TSP	Annual	33.6	33.6	90	Y
PM_{10}	24 hours	46.8	47.7	50	Y
	Annual	17.7	18.3	25	Y
$PM_{2.5}$	24 hours	23.6	23.6	25 / 20	Y
	Annual	6.3	6.4	7	Y
Deposited Dust	Total	2.002	2.004	4 g/m²/ month	Y
Nitrogen dioxide (as 50% NO_X)	1 hour	63.6	98.7	164	Y
	Annual	6.1	6.6	31	Y
Carbon monoxide	15 minutes	3104	3106	100000	Y
	1 hour	2699	2701	30000	Y
	8 hours	879	880	10000	Y
Sulphur dioxide	10 minutes	5.4	6.1	712	Y
	1 hour	3.8	4.2	57	Y
	24 hours	2.9	2.9	228	Y
	Annual	1.6	1.6	57	Y

Review of the maximum PM_{10} 24-hour concentrations identify that for all receptors, the impacts are predicted to occur on 4 June 2020, when the background concentrations were 35.6 µg/m³. The maximum 24-hour $PM_{2.5}$ concentration exceeds the future limit of 20 µg/m³, a review of the results identified that these concentrations are driven by the background concentrations on 24 June 2020, when the measured concentration was 23.6 µg/m³.

8.3 Incremental Predicted Concentrations

The results in this section are the incremental (i.e. Project associated) concentrations as presented in Section 7.4. Table 19 presents a summary of the maximum predicted incremental ground level concentrations at the sensitive receptors and Indigenous site of importance. It can be seen that the predicted concentrations comply at all receptors for all pollutants and time periods.

Table 19: Summary of Maximum Predicted Incremental Ground Level Concentrations at Sensitive Receptors and Indigenous Sites of Importance

Pollutant	Averaging Period	Maximum Predicted GLC (µg/m³)		Criteria (µg/m³)	Compliant?
		Sensitive Receptors	Indigenous Sites of Importance		
TSP	Annual	0.1	0.2	90	Y
PM_{10}	24 hours	11.6	15.2	50	Y
	Annual	1.3	1.9	25	Y
$PM_{2.5}$	24 hours	3.5	3.8	25	Y
	Annual	0.4	0.5	7	Y
Deposited Dust	Incremental	0.002	0.004	2 g/m²/ month	Y
Antimony	1 hour	4.95×10^{-5}	6.11×10^{-5}	9	Y
Arsenic	1 hour	0.016	0.020	0.09	Y
Barium	1 hour	0.118	0.146	9	Y
Cadmium	1 hour	1.22×10^{-6}	1.60×10^{-6}	0.018	Y
Chromium III	1 hour	0.009	0.011	9	Y
Chromium VI	1 hour	1.79×10^{-4}	2.21×10^{-4}	0.09	Y
Copper	1 hour	0.005	0.007	18	Y
Iron	1 hour	11.8	14.6	90	Y
Lead	Annual	0.0	0.0	0.5	Y
Magnesium	1 hour	9.4	13.3	180	Y
Manganese	1 hour	0.19	0.24	18	Y
Mercury	1 hour	2.09×10^{-6}	2.64×10^{-6}	1.8	Y
Nickel	1 hour	0.005	0.006	0.18	Y
Zinc	1 hour	0.036	0.032	90	Y
Cyanide	1 hour	29.5	30.7	90	Y
Nitrogen dioxide (as 50% NO_X)	1 hour	36.2	94.9	164	Y
	Annual	1.0	1.6	31	Y
Carbon monoxide	15 minutes	33.5	89.0	100000	Y
	1 hour	29.1	77.4	30000	Y
	8 hours	12.1	26.7	10000	Y
Acetaldehyde	1 hour	0.321	1.095	42	Y
Benzene	1 hour	0.017	0.058	29	Y
Biphenyl	1 hour	0.008	0.028	24	Y

Pollutant	Averaging Period	Maximum Predicted GLC (µg/m³)		Criteria (µg/m³)	Compliant?
		Sensitive Receptors	Indigenous Sites of Importance		
1.3-butadiene	1 hour	0.010	0.035	40	Y
Chloroethane	1 hour	7.18E-05	2.44 x10^{-4}	48	Y
Chloroform	1 hour	1.10 x10^{-3}	3.73 x10^{-3}	900	Y
1,2-Dichloroethylene	1 hour	1.03 x10^{-4}	3.52 x10^{-4}	14400	Y
Ethylbenzene	1 hour	1.53 x10^{-3}	5.20 x10^{-3}	8000	Y
Formaldehyde	1 hour	2.468	7.149	20	Y
n-hexane	1 hour	0.042	0.143	3200	Y
Methanol	1 hour	0.096	0.328	3000	Y
Phenol	2 hour	0.0009	0.0031	20	Y
Benzo(a)pyrene as PAH	1 hour	0.0012	0.0011	0.4	Y
Styrene	1 hour	0.0009	0.0031	120	Y
Sulphur dioxide	10 minutes	2.7	2.7	712	Y
	1 hour	1.9	1.9	57	Y
	24 hours	0.2	0.4	228	Y
	Annual	0.0	0.0	57	Y
Toluene	1 hour	0.0157	0.0534	360	Y
Vinyl chloride	1 hour	0.0006	0.0019	24	Y
Xylenes	1 hour	0.0071	0.0241	190	Y
Dioxins and Furans	1 hour	4.19 x10^{-10}	5.28 x10^{-10}	2 x10^{-6}	Y
Hydrogen cyanide	1 hour	32.1	33.5	200	Y

For the purposes of this study, total chromium has been separated into chromium III and chromium VI using research by Rada (2019)[c] which states that chromium VI is typically 2.1% of total chromium. Chromium III is assumed to be 97.9% of total chromium.

As detailed in Section 7.4, Assured Environmental have undertaken stack emissions monitoring of gold smelters and other processing equipment. All sulphuric acid results have been below the limit of detection. When predicting the emissions of sulphur from the ore composition as part of the furnace emissions calculations, SO_2 emissions assume 100% conversion of sulphur in ore to SO_2.

[c] Rada, E.C. (2019) special waste valorization and renewable energy generation under a circular economy: which priorities? Energy Production and Management in the 21st Century III

8.4 Contemporaneous Background Analysis: PM_{10}

Table 20 presents maximum predicted source contribution of PM_{10} receptor concentrations at each of the identified sensitive receptors. Also presented in this table is the coincident background concentration and predicted cumulative receptor concentration for the same period.

Table 20: Maximum Predicted 24-Hour Average Source Contribution PM_{10} Concentrations (µg/m^3)

Receptor ID	Source Contribution (A)	Existing Background (B)	Cumulative (A + B)
R1	3.4	15.5	18.8
R2	4.2	9.7	13.9
R3	6.1	13.1	19.1
R4	2.1	9.1	11.1
NP1	2.2	6.5	8.7
NP2	2.6	9.6	12.2
NP3	7.0	13.1	20.0
NP4	4.2	16.4	20.6
NP5	7.4	6.0	13.4
NP6	3.4	6.0	9.4
SS1	3.0	6.5	9.5
SS2	4.3	16.8	21.1
SS3	5.3	9.1	14.4
SS4	6.4	11.3	17.8
W1	0.7	14.6	15.3
W2	1.5	9.7	11.2
W3	2.7	16.8	19.5
W4	4.3	11.5	15.8
W5	11.6	20.2	31.8
IS1	15.2	20.2	35.4
IS2	7.6	16.8	24.4
IS3	5.4	9.1	14.5
IS4	2.8	6.5	9.3
IS5	2.3	11.8	14.2
IS6	1.8	6.5	8.3
IS7	1.2	6.5	7.6
IS8	1.3	6.5	7.7
IS9	2.3	11.8	14.2
IS10	3.7	6.5	10.2
IS11	2.0	11.8	13.9
IS12	1.9	6.5	8.4
Air Quality Objective			**50**

IS = Indigenous Site of Importance. The Proponent have requested the location of the sites to be withheld.

The results of the modelling confirm that emissions from the existing activities are predicted to result in maximum off-site PM_{10} concentrations of 71% of the relative criterion specified in the Approved Methods.

8.5 Contemporaneous Background Analysis: $PM_{2.5}$

Table 20 presents maximum predicted source contribution of $PM_{2.5}$ receptor concentrations at each of the identified sensitive receptors.

Table 21: Maximum Predicted 24-Hour Average Source Contribution $PM_{2.5}$ Concentrations (μg/m^3)

Receptor ID	Source Contribution (A)	Existing Background (B)	Cumulative (A + B)
R1	0.8	3.0	3.8
R2	1.1	1.3	2.5
R3	1.5	2.6	4.0
R4	0.5	1.5	2.1
NP1	0.5	0.5	1.1
NP2	0.7	0.5	1.3
NP3	1.7	2.6	4.2
NP4	1.1	2.5	3.7
NP5	2.3	1.6	3.9
NP6	1.1	2.2	3.3
SS1	0.7	0.5	1.2
SS2	0.9	3.5	4.5
SS3	1.5	1.5	3.0
SS4	1.7	1.4	3.1
W1	0.2	6.2	6.4
W2	0.4	3.0	3.4
W3	0.7	3.5	4.3
W4	1.2	2.4	3.6
W5	3.5	7.4	10.9
IS1	3.8	7.4	11.3
IS2	1.6	3.5	5.2
IS3	1.3	1.5	2.8
IS4	0.7	0.5	1.2
IS5	0.5	0.5	1.1
IS6	0.4	0.5	1.0
IS7	0.3	0.5	0.8
IS8	0.3	0.5	0.9
IS9	0.5	0.5	1.1
IS10	0.9	0.5	1.5
IS11	0.5	1.5	2.0
IS12	0.5	0.5	1.0
Air Quality Objective			**50**

The results of the modelling confirm that emissions from the existing activities are predicted to result in maximum off-site $PM_{2.5}$ concentrations of 45% of the relative criterion.

8.6 Contemporaneous Background Analysis: NO_2

Table 20 presents maximum predicted source contribution of NO_2 receptor concentrations at each of the identified sensitive receptors with coincident background concentration and predicted cumulative receptor concentration for the same period.

Table 22: Maximum Predicted 1-Hour Average Source Contribution NO_2 Concentrations (µg/m^3)

Receptor ID	Source Contribution (A)	Existing Background (B)	Cumulative (A + B)
R1	18.5	13.6	32.1
R2	6.2	6.8	13.0
R3	22.9	1.7	24.5
R4	6.7	1.9	8.6
NP1	7.1	4.2	11.3
NP2	12.1	11.5	23.6
NP3	20.5	1.7	22.2
NP4	21.3	11.0	32.3
NP5	23.0	3.7	26.6
NP6	16.7	21.3	37.9
SS1	11.4	15.9	27.3
SS2	14.1	5.7	19.8
SS3	26.2	3.4	29.6
SS4	19.4	2.3	21.7
W1	7.3	11.2	18.6
W2	5.4	10.8	16.2
W3	11.3	2.5	13.8
W4	15.2	0.0	15.2
W5	36.2	33.1	69.3
IS1	69.8	19.8	89.6
IS2	94.9	2.9	97.9
IS3	26.0	8.9	34.9
IS4	10.7	4.2	14.9
IS5	17.1	4.2	21.3
IS6	4.5	4.2	8.7
IS7	6.4	3.2	9.6
IS8	26.7	4.2	30.9
IS9	17.1	2.6	19.7
IS10	31.5	3.5	35.1
IS11	13.4	14.1	27.5
IS12	6.8	7.7	14.5
Air Quality Objective			**164**

8.7 Contemporaneous Background Analysis: SO_2

Table 20 presents maximum predicted source contribution of SO_2 receptor concentrations at each of the identified sensitive receptors with coincident background concentration and predicted cumulative receptor concentration for the same period.

Table 23: Maximum Predicted 1-Hour Average Source Contribution SO_2 Concentrations (µg/m^3)

Receptor ID	Source Contribution (A)	Existing Background (B)	Cumulative (A + B)
R1	0.5	2.49	3.0
R2	0.3	2.57	2.9
R3	0.6	1.00	1.6
R4	0.5	0.40	0.9
NP1	0.3	2.52	2.8
NP2	0.5	2.29	2.8
NP3	0.7	1.66	2.4
NP4	0.4	0.00	0.4
NP5	0.5	1.20	1.7
NP6	0.4	1.57	1.9
SS1	0.4	2.52	2.9
SS2	0.5	0.00	0.5
SS3	0.5	1.72	2.2
SS4	0.5	0.86	1.3
W1	0.1	1.20	1.3
W2	0.3	2.57	2.9
W3	0.3	2.29	2.6
W4	0.8	1.46	2.3
W5	1.9	1.40	3.3
IS1	1.9	2.37	4.2
IS2	1.7	0.00	1.7
IS3	0.5	0.51	1.0
IS4	0.5	0.00	0.5
IS5	0.6	0.00	0.6
IS6	0.3	2.52	2.8
IS7	0.2	2.57	2.8
IS8	0.4	1.57	2.0
IS9	0.6	0.00	0.6
IS10	1.0	0.00	1.0
IS11	0.3	1.51	1.8
IS12	0.5	1.20	1.7
Air Quality Objective			**57**

The predicted pollutant concentration isopleths are presented in Appendix C.

8.8 Summary of Results

The analysis of the results has identified that the maximum predicted total and incremental ground level concentrations at the sensitive receptors and Indigenous site of importance comply at all receptors for all pollutants and time periods.

Review of the maximum PM_{10} 24-hour concentrations identify that for all receptors, the impacts are predicted to occur on 4 June 2020, when the background concentrations were 35.6 µg/m^3. The maximum 24-hour $PM_{2.5}$ concentration exceeds the future limit of 20 µg/m^3, a review of the results identified that these concentrations are driven by the background concentrations on 24 June 2020, when the measured concentration was 23.6 µg/m^3.

9 MITIGATION MEASURES

The mine aims to reduce emissions of dust and other pollutants by implementing the following control measures listed in Table 24.

Table 24: Mitigation Controls by Activity

Activity	Mitigation Measure
Mining / Trafficable Area	▪ Limit high dust generating activities (e.g., removal of topsoil/overburden and blasting) to periods of favourable weather conditions. ▪ Dampen down (approx. rate of >2 litres/m²/hour) work areas, stockpiles, access roads and other hardstand areas by water spraying when visual surveillance indicates excessive dust generation. ▪ Restrict vehicle movements to designated routes to the extent practicable. ▪ Enforce speed limits on internal roads. ▪ Maintain road surfaces in good condition. ▪ Prevent and clean up any raw material / product spillages or dust accumulation on driveways or sealed roads. ▪ Use dust extraction systems on drill rigs where possible, or use fabric filters
Processing Plant	▪ Use water sprays and/or dust collection systems as identified. ▪ Use enclosed conveyors. ▪ Maintain equipment in accordance with the original equipment manufacturers' specifications. ▪ Dampen materials prior to transport/handling.
Stockpiles	▪ Limit the height of any stockpiles, where practicable. ▪ Regularly water stockpiles to keep down dust emissions. ▪ Apply additional water sprays to stockpiles during high wind conditions.
Transport of Materials	▪ Ensure that incoming and outgoing truckloads of materials are covered during transport

10 CONCLUSIONS

Primary Gold Limited (PGO) (the Proponent) is proposing to redevelop the existing mine by expanding open-cut gold mining operations and connecting the two non-contiguous sites with a haul road. At full production, the combined output of the two mines will be 5 Mtpa.

Meteorological modelling has been undertaken using TAPM and CALMET to predict localised meteorological conditions. The meteorological data derived from these models have been used as an input for the CALPUFF dispersion modelling. Observations from two BOM monitoring stations have been included in the meteorological modelling and a comparison of the output to the observations has identified that the model is suitable for the assessment.

Emissions calculations have been undertaken for a number of activities including mining operations (drill and blast, vehicle movements, material transfers etc), processing plant (crushing and milling), drying, smelting and power generation. The emission rates have been calculated using approved methodologies (NPI) and data from AE's emissions monitoring database.

Control measures which confirm to best practice and performance standards have been used in this assessment and identified in Appendix B and Table 24.

The assessment has considered sensitive receptors including residential, natural (wetlands, national parks, and conservation) and Indigenous sites of importance. The results show that compliance with the assessment criteria is achieved at all receptors for all pollutants and time periods.

APPENDIX A: METEOROLOGICAL REVIEW

Section of Representative Year: Mount Bundey North

To determine the most representative meteorological year to utilise in the modelling, seven years (2012 - 2019) of meteorological observations from BOM Mount Bundey North (station number 014893) and BOM Middle Point (station 014041) were reviewed. Figure 15 presents the wind roses for 2017 – 2021 for Mount Bundey North.

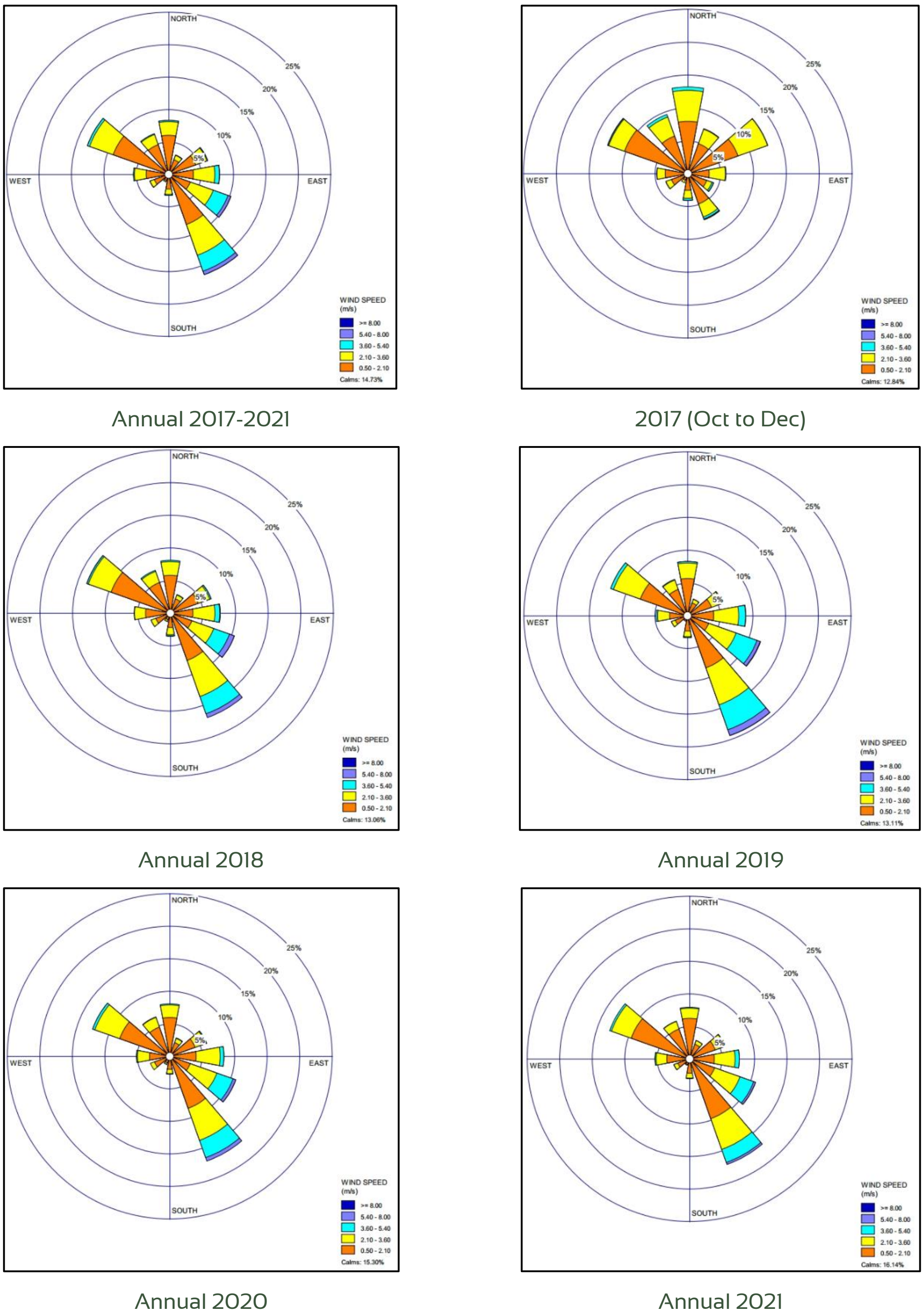


Figure 15: Long-term Wind Roses from BOM Mount Bundey North (2017 - 2021)

Figure in this section present the observed annual and seasonal wind roses for BOM Mount Bundey. The following is noted:

- The weather station was installed in October 2017; therefore the annual 2017 wind roses is significantly different to the other annual wind roses;
- The annual wind roses for 2017 - 2021 show that the dominant wind directions are south easterly and NWN wind flows.
- The annual wind roses are very similar (except 2017) annual data since 2017.

Table 25 presents a yearly comparison of various meteorological parameters against the four-year dataset. It can be seen from Table 25 that 2020 is the most representative year based on the rainfall, wind speed and percentage of calm conditions.

Table 25: Data Analysis for Mount Bundey North

Parameter		Year					
		2017-2021	2017b)	2018	2019	2020	2021
Wind Conditions	Data Availability	99.9	-	100	99.9	100	99.7
	Calm Conditions (%)	14.73	-	13.06	13.11	15.30	16.14
	Ave. Wind Speed (m/s)	1.53	-	1.59	1.70	1.54	1.42
Rainfall	Data Availability	99.9	-	100	99.9	100	99.7
	Rainfall (mm)	1,438	-	2,048	870	1,363	1,760
	Average Hourly Rainfall (mm/hour)	0.16	-	0.23	0.10	0.16	0.20
Correlations of Datasets by Month	RH (%)		-	0.98	0.97	0.96	0.99
	Temperature (°C)		-	0.97	0.92	0.98	0.94
	Wind Speed (m/s)		-	0.89	0.91	0.87	0.81

a) Based on long-term data from BOM website
b) A comparison with the 2017 data has not been undertaken as it was only operational since Oct 2017.

As such, 2020 is considered the most representative year for locations close to Mount Bundey North.

Validation of Model Performance

An evaluation of the performance of the meteorological model is presented in this section. The evaluation compares the observed meteorological data from BOM Mount Bundey North with the output from CALMET, which included data assimilation in TAPM.

When comparing the data, it should be noted that the wind direction purchased from BOM was presented in 16-cardinal points (i.e. 22.5° intervals) whereas the CALMET model output is at 0.01° intervals. As a result, there are discrepancies in the wind directions between BOM and CALMET.

Figure 16 presents a comparison of the 9 am, 3 pm and annual 2020 predicted and observed wind roses at BOM Mount Bundey North monitoring station which is located approximately 30 km to the east of Quest 29 ML.

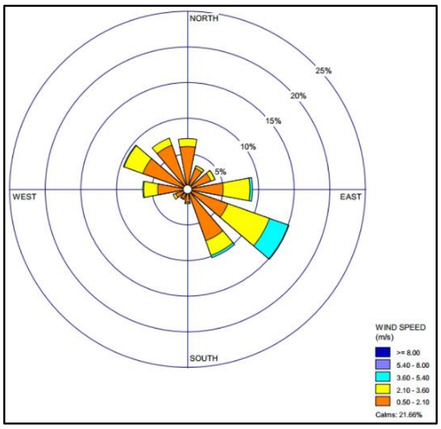
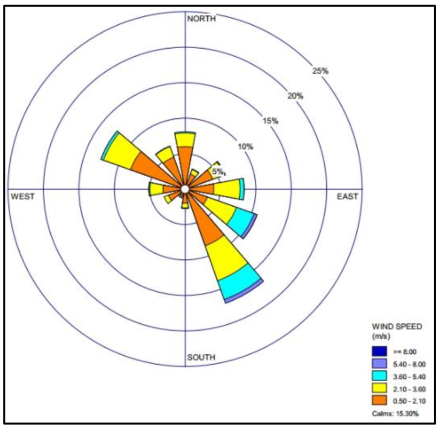
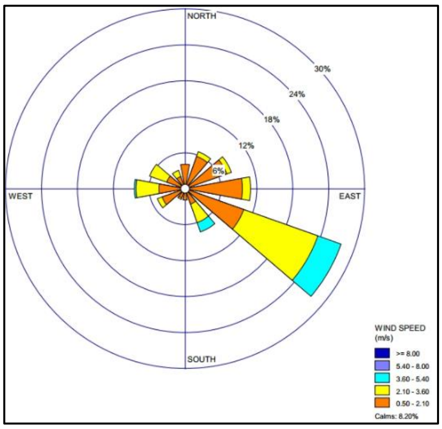
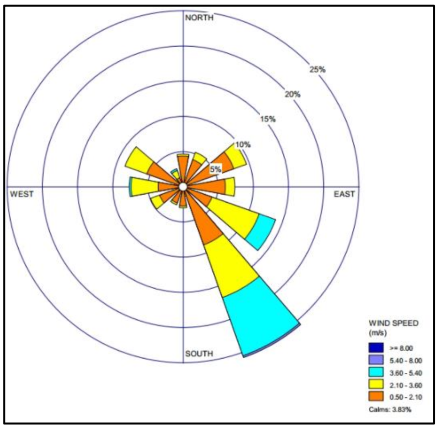
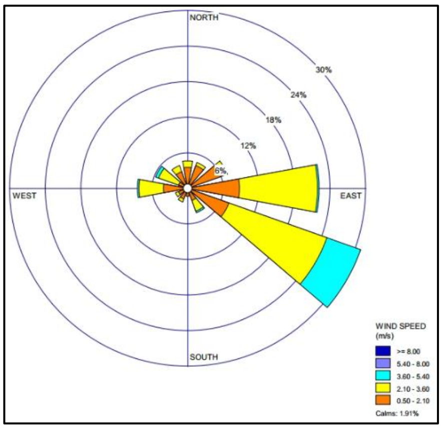
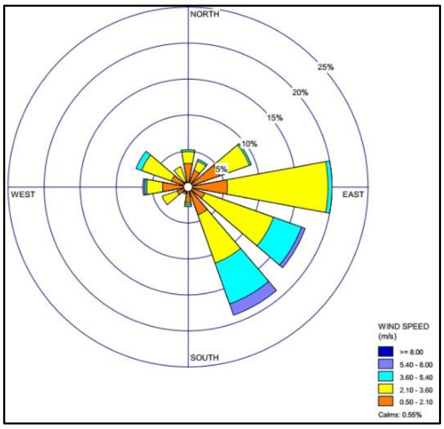
Period	BOM Mount Bundey Predicted (2020)	BOM Mount Bundey Observed (2020)
Annual		
0900		
1500		

Figure 16: Comparison of Predicted (2020) and BOM Observed Wind Roses (2020) at BOM Mount Bundey North

Figure 17 shows the probability density functions that graphically compare statistical distributions of individual meteorological parameters between TAPM/CALMET output and observational data, as extracted from the BOM Mount Bundey North location.

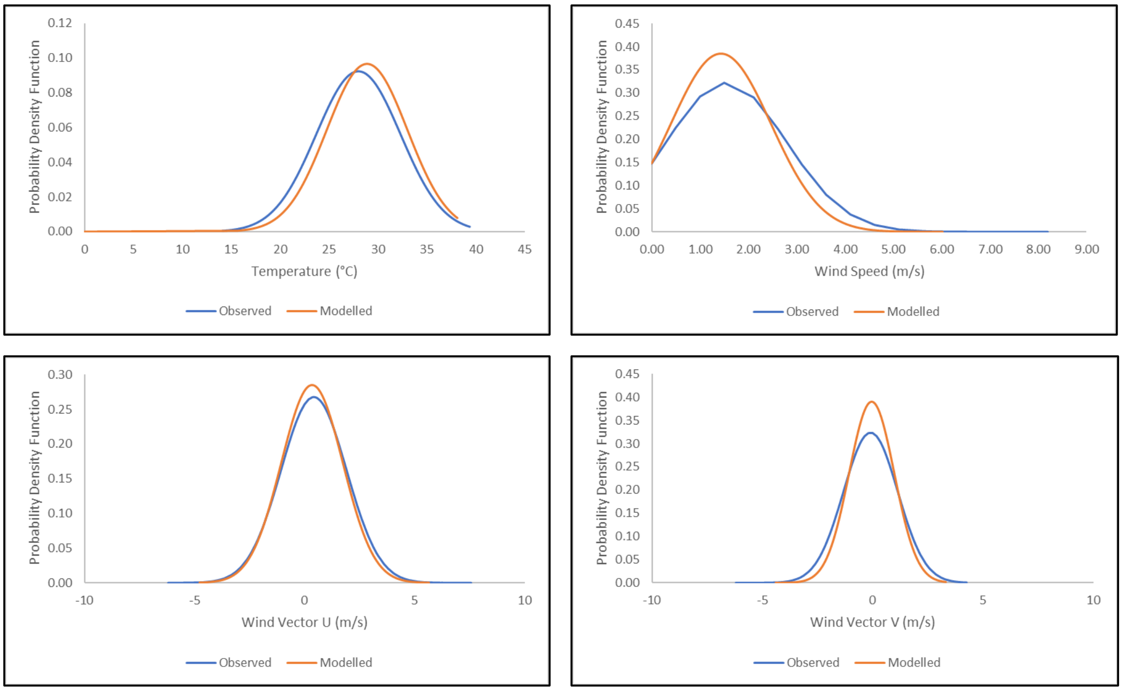


Figure 17: Probability Density Functions (pdf) Comparing Observational and Modelled Data at BOM Mount Bundey North

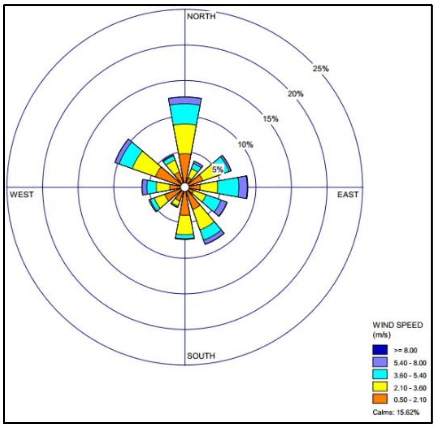
Review of the data has identified that the modelled and observed datasets are very similar, with the following noted:

- The modelled temperatures are more likely to be higher than those observed;
- The model has a cut of wind speed of 6 m/s;
- The wind vectors U (east/west component) and V (south/north component) are very similar.

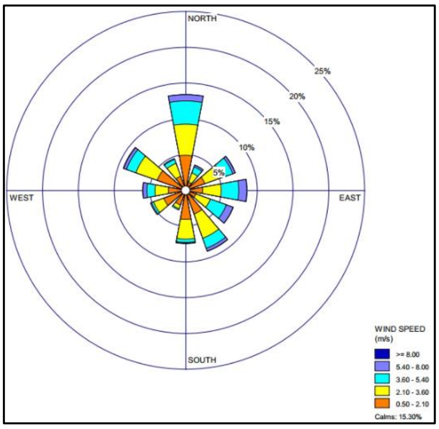
On this basis, the prognostic dataset is considered suitable for the purposes of the assessment.

Section of Representative Year: Middle Point

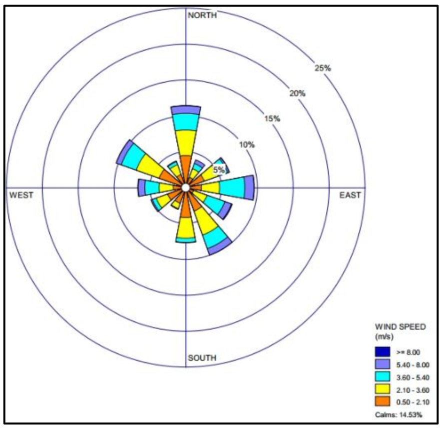
To determine the most representative meteorological year to utilise in the modelling, seven years (2017 - 2021) of meteorological observations from Middle Point (station 014041) were reviewed. Figure 15 presents the wind roses for 2017 – 2021 for Middle Point.



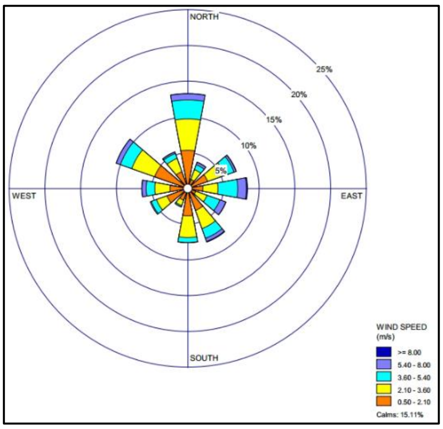
Annual 2017-2021



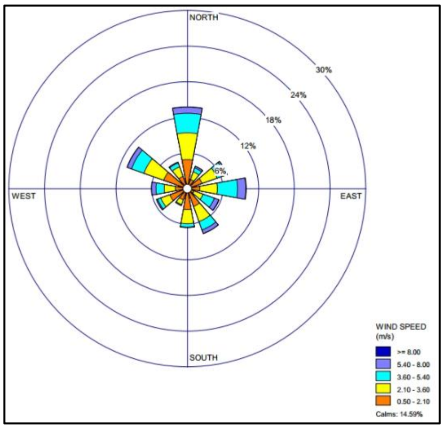
Annual 2017



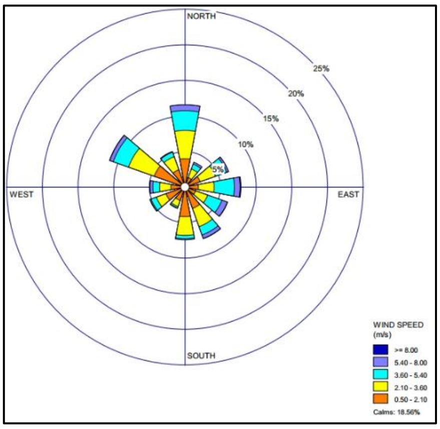
Annual 2018



Annual 2019



Annual 2020



Annual 2021

Figure 18: Long-term Wind Roses from BOM Middle Point (2017 - 2021)

The following is noted observed annual wind roses for BOM Middle Point:

- The annual wind roses for 2017 - 2021 show that the dominant wind directions are northerly and NWN wind flows.

- The annual wind roses are very similar.

Table 25 presents a yearly comparison of various meteorological parameters against the four-year dataset. It can be seen from Table 25 that 2020 is the most representative year based on the rainfall, and wind speed.

Table 26: Data Analysis for Middle Point

Parameter		Year					
		2017-2021	2017	2018	2019	2020	2021
Wind Conditions	Data Availability	99.8	99.9	99.9	99.9	99.7	99.5
	Calm Conditions (%)	15..4	15.3	15.1	14.5	14.6	18.6
	Ave. Wind Speed (m/s)	2.17	2.13	2.16	2.30	2.24	2.07
Rainfall	Data Availability	99.8	100	99.9	99.9	99.7	99.5
	Rainfall (mm)	1,386	1,404	1,681	911	1,441	1,615
	Average Hourly Rainfall (mm/hour)	0.16	0.16	0.19	0.10	0.16	0.18
Correlations of Datasets by Month	RH (%)		0.90	0.96	0.98	0.91	0.98
	Temperature (°C)		0.97	0.97	0.98	0.95	0.95
	Wind Speed (m/s)		0.63	0.41	0.72	0.85	0.52

a) *Based on long-term data from BOM website*

As such, 2020 is considered the most representative year for locations close to Middle Point.

Validation of Model Performance: Middle Point

An evaluation of the performance of the meteorological model is presented in this section. The evaluation compares the observed meteorological data from BOM Middle Point with the output from CALMET, which included data assimilation in TAPM.

When comparing the data, it should be noted that the wind direction purchased from BOM was presented in 16-cardinal points (i.e. 22.5° intervals) whereas the CALMET model output is at 0.01° intervals. As a result, there are discrepancies in the wind directions between BOM and CALMET. Based on this, it is considered the model is predicting weather parameters sufficiently.

Figure 16 presents a comparison of the 9 am, 3 pm and annual 2020 predicted and observed wind roses at BOM Middle Point monitoring station which is located approximately 38 km to the NE of Rustlers Roost ML. Comparison of the BOM site observed wind roses with predicted wind roses indicate that whilst the model has more wind flows from the east at 9 am and more northerly flows at 3 pm.

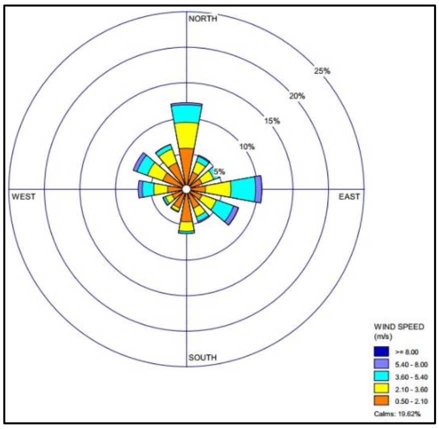
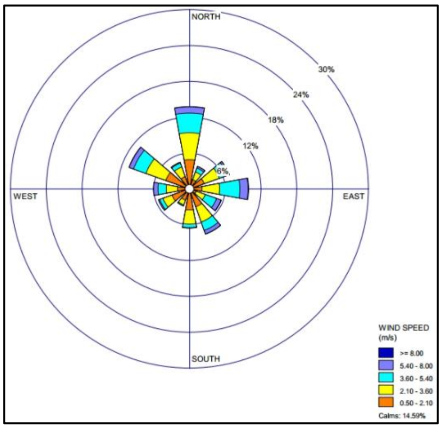
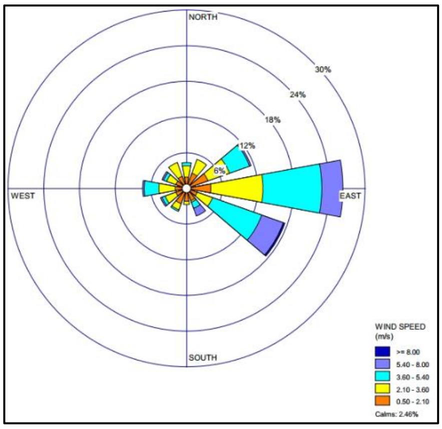
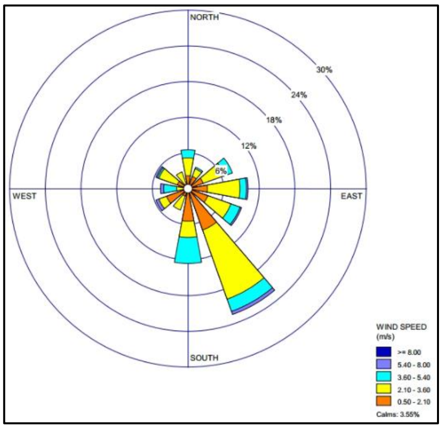
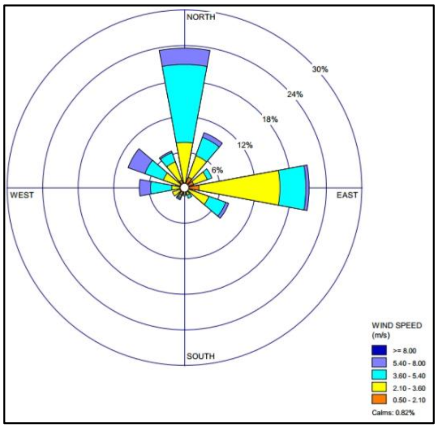
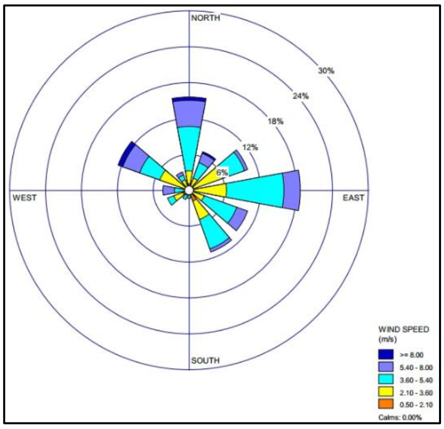
Period	BOM Middle Point Predicted (2020)	BOM Middle Point Observed (2020)
Annual		
0900		
1500		

Figure 19: Comparison of Predicted (2020) and BOM Observed Wind Roses (2020) at BOM Middle Point

Figure 17 shows the probability density functions that graphically compare statistical distributions of individual meteorological parameters between TAPM/CALMET output and observational data, as extracted from the BOM Middle Point location.

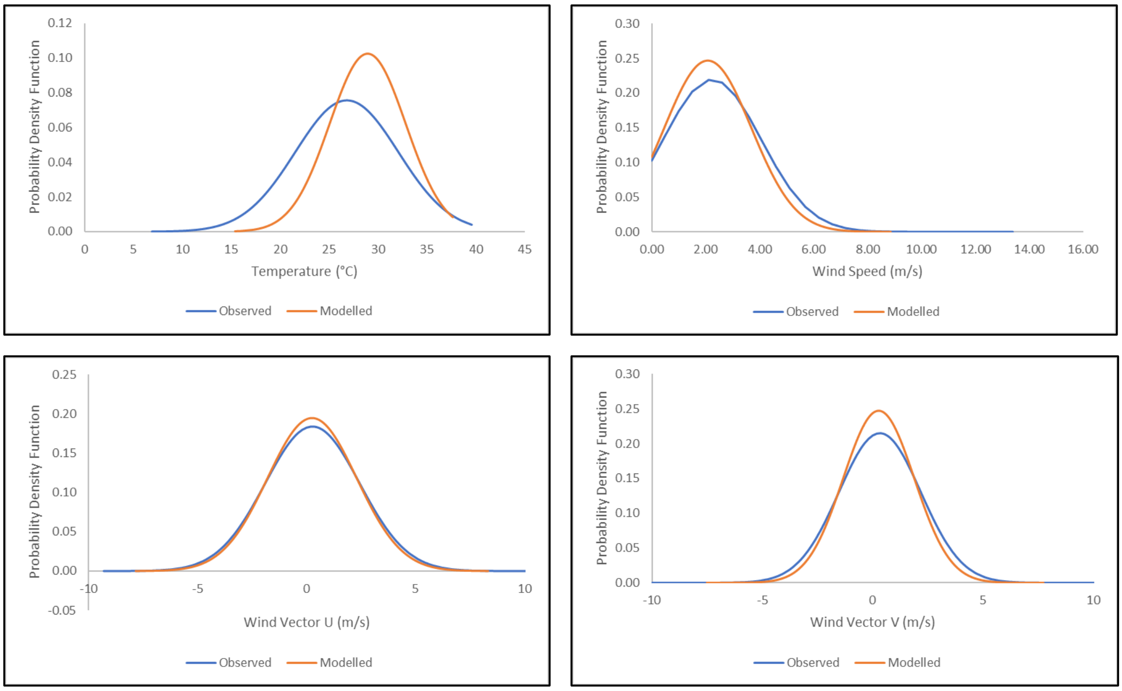


Figure 20: Probability Density Functions (pdf) Comparing Observational and Modelled Data at BOM Middle Point

Review of the data has identified that the modelled and observed datasets are very similar, with the following noted:

- The modelled temperatures are more likely to be higher than those observed;
- The model has a cut of wind speed of 9 m/s;
- The wind vectors U (east/west component) and V (south/north component) are very similar.

On this basis, the prognostic dataset is considered suitable for the purposes of the assessment.

Prognostic Dataset Review at Project Site

This section provides an analysis of the prognostic meteorological dataset extracted from the CALMET model for 2020 at the Rustlers Roost ML.

Predicted Atmospheric Stability

The amount of turbulence in the ambient air has a major effect upon the rise and dispersion of emissions. In particular, the amount of turbulence in the atmosphere plays a key role in diffusion of an emitted plume in the air with stronger turbulence (increased instability) increasing the rate of diffusion. Where the atmosphere exhibits weak turbulence (increased stability), downwind contaminant concentrations can be expected to increase due to the limited diffusion.

Figure 21 presents the diurnal variability in atmospheric stability identified in the predicted meteorological dataset. As can be seen, atmospheric instability increased during the day where the influence of solar energy drives convection in the atmosphere. Conversely, increased stability can be seen during night periods where stable conditions are predicted for more than 90% of the time.

Monin-Obukhov Length

The Monin-Obukhov Length represents a parameter (with dimension of length) which provides a relationship between parameters characterising dynamic, thermal, and buoyant processes. The parameter, first described by Obukhov in 1946, is the characteristic height scale of the dynamic sub-layer of the atmosphere and is positive for stable stratifications and negative for unstable stratifications.

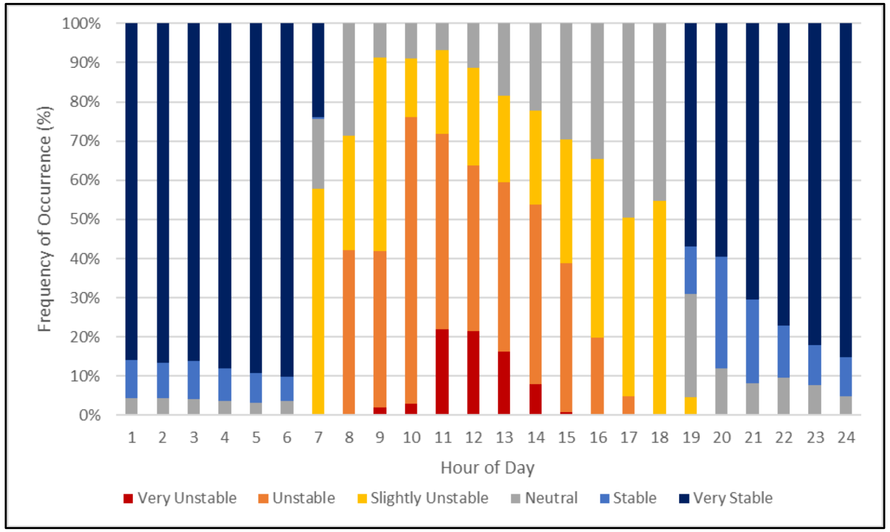
Figure 21 presents a graphical representation of the reciprocal of the Monin-Obukhov length (1/L) for the 2020 prognostic (CALMET) dataset. In this figure, neutral stability conditions have the 1/L value of zero (0), stable conditions have positive values of 1/L and unstable conditions have negative values of 1/L. The more positive 1/L value, the more stable the atmosphere is assumed to be by the model. Similarly, the more negative 1/L becomes, the more unstable the atmosphere is assumed to be by the model.

Predicted Atmospheric Mixing Height

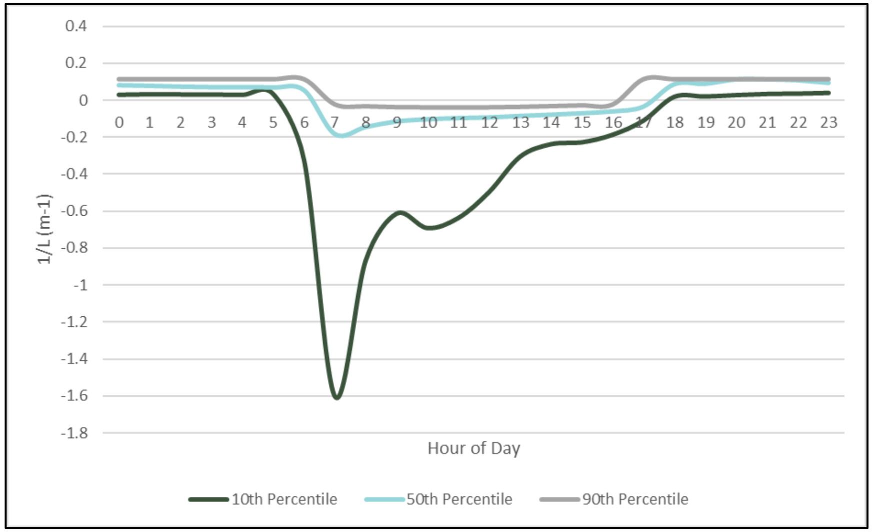
Figure 21 presents an illustration of diurnal variations in maximum and average mixing heights predicted by CALMET at the Subject Site across the 2020 prognostic meteorological dataset. As expected, an increase in mixing height during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights generally occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and growth of the convective mixing layer. The highest maximum mixing height for the Subject Site occurs during the late afternoon period.

Temperature

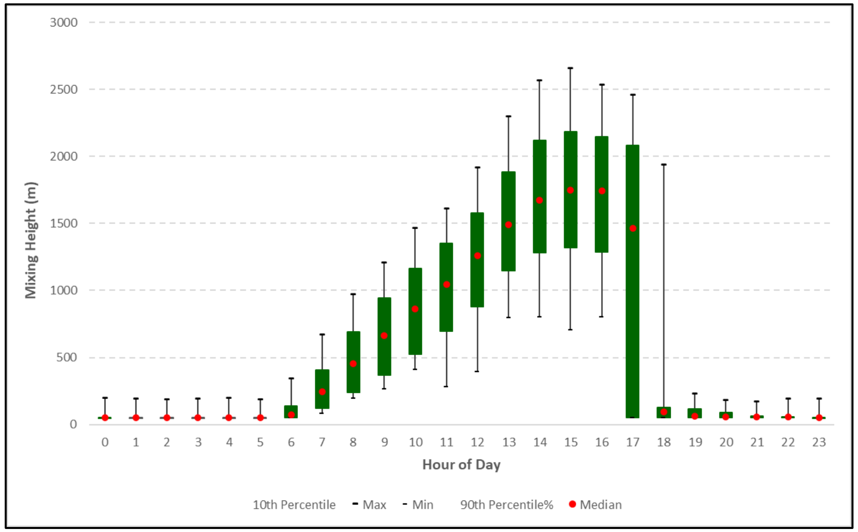
Figure 21 presents an illustration of diurnal variations in maximum and average temperatures predicted by CALMET at the Subject Site across the 2020 prognostic meteorological dataset.



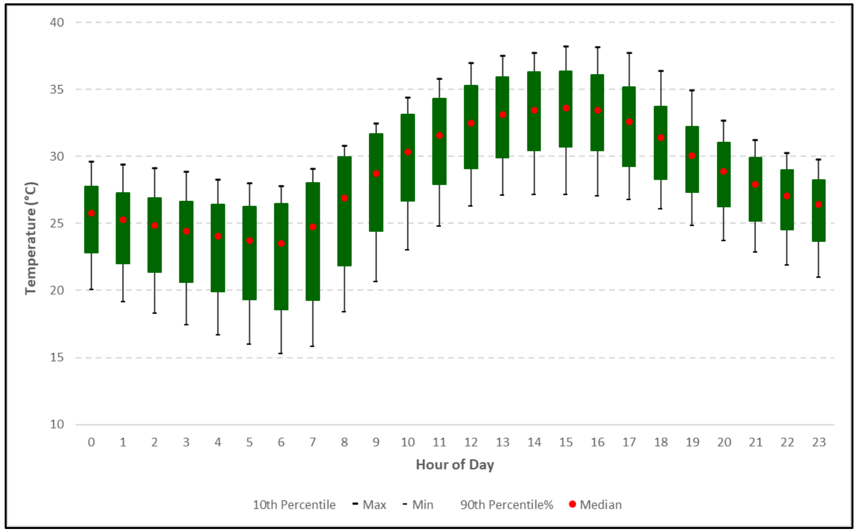
Annual Atmospheric Stability by Hour



Annual Variability of Monin-Obukhov Length by Hour



Atmospheric Mixing Height by Hour



Temperature by Hour

Figure 21: Meteorological Analysis at Rustlers Roost ML

APPENDIX B: EMISSION ESTIMATION

Emission factors shown in Table 27 and operational information listed in Table 28 can be used to estimate emissions of TSP, PM_{10} and $PM_{2.5}$ to the air from various sources associated with the site.

Table 27: Emission Factor by Activity

Activity	Units	TSP Emission Factor	PM_{10} Emission Factor	$PM_{2.5}$ Emission Factor	Source
Wind Erosion for exposed areas	kg/ha/hr	0.4	0.2	PM_{10} x 0.075	NPI Mining
Wind Erosion from active stockpiles	kg/ha/hr	1.8 x U x (365-RD)/365	TSP x 0.5	PM_{10} x 0.075	NPI Mining
Wheel generated particulates on unpaved roads (heavy vehicles)	kg/VKT	$\frac{0.4536}{1.6093} x\, 4.9\, x \left(\frac{s}{12}\right)^{0.7} x \left(\frac{W}{3}\right)^{0.45}$	$\frac{0.4536}{1.6093} x\, 1.5\, x \left(\frac{s}{12}\right)^{0.9} x \left(\frac{W}{3}\right)^{0.45}$	PM10 x (0.105)	NPI Mining
Wheel generated particulates on unpaved roads (light vehicles)	kg/VKT	$1.69\, x \frac{\left(\frac{s}{12}\right) x \left(\frac{S}{48}\right)^{0.3}}{\left(\frac{M}{0.5}\right)^{0.3}} - 0.0013$	$0.51\, x \frac{\left(\frac{s}{12}\right) x \left(\frac{S}{48}\right)^{0.5}}{\left(\frac{M}{0.5}\right)^{0.2}} - 0.0013$	PM10 x (0.105)	NPI Mining
Excavators on overburden	kg/t	0.025	0.012	PM_{10} x (0.053/0.35)	NPI Mining
Trucks dumping overburden		0.012	0.0043	PM_{10} x (0.105)	NPI Mining
Primary crushing and screening	kg/t	0.01	0.004	PM_{10} x (0.053/0.35)	NPI Mining
Secondary Crushing	kg/t	0.03	0.012	PM_{10} x (0.053/0.35)	NPI Mining
Tertiary Crushing	kg/t	0.03	0.01	PM_{10} x (0.053/0.35)	NPI Mining
Loading and unloading to stockpiles	kg/t	$0.74\, x\, 0.0016\, x \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$	$0.35\, x\, 0.0016\, x \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$	$0.053\, x\, 0.0016\, x \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$	NPI Mining

Where:

- M = material moisture content (%)
- S = material silt content (or surface content in unpaved roads (%) or silt loading on paved roads (g/m^2))
- U = wind speed (m/s)
- RD = rainfall days >0.25 mm
- W = mean vehicle weight (tonnes)
- Area (m^2)

Table 28: List of Activity Data and Assumptions for Dust Emission Rates for Mining Operations

Parameter	Units	Rustlers Roost	Quest 29
Operating Times			
Operating hours	hrs per day	24	24
Operating days	day / year	365	365
Volumes / Areas			
Year 2030 Production	Mtpa	4.25	0.75
Exposed Areas (Pit)	ha	69.9	11.4
Exposed stockpiles	ha	92.0	16.6
Rehabilitated Area	ha	14.5	15.1
Material Transfer			
Overburden Removed	Mtpa	0.16	0.08
Overburden Stockpile Transfers	Mtpa	0.32	0.16
Loading Trucks	Mtpa	4.80	0.91
Vehicle Movements			
Mining Haul Truck Weight (unladen)	tonnes	249	
Mining Haul Truck Weight (laden)	tonnes	363	
Main Haul Road length (Q29 to ROM)	km	-	13
Internal Haul Road Lengths	km	8	3
Main Haul Road (Q29 to ROM)	VKT	-	81,230
Internal Haul Roads	VKT	67,231	21,681
Drilling and Blasting			
Number of Holes	per blast	200	-
Explosive used	kg per blast	200	-
Area per Blast	m²	1600	-
Number of Blasts per Year	-	50	-
Weather			
Mean wind speed (BOM Middle Point)	m/s	1.54	
Wind speed >5.4 m/s	%	0.33	
Rainfall >0.25 mm	Days per yr	86	
Material Characteristics			
Ore material moisture content	%	5	
Moisture content of overburden /unpaved road	%	7.9	
Silt content of overburden / unpaved road	%	6.9	
Emission Controls			
Drilling (fabric filters)	%	99	
Material transfers (loading stockpiles)	%	0	
Material transfers (processing)	%	0	
Material transfers (loading trucks)	%	0	

Parameter	Units	Rustlers Roost	Quest 29
Unpaved roads	%	75	
Wind erosion of stockpiles /exposed areas	%	Varies. Wet tailings: 100% Vegetation established: 40% Revegetation: 90% No controls for active stockpiles	
In pit retention	%	TSP – 50% / PM_{10} – 5%	

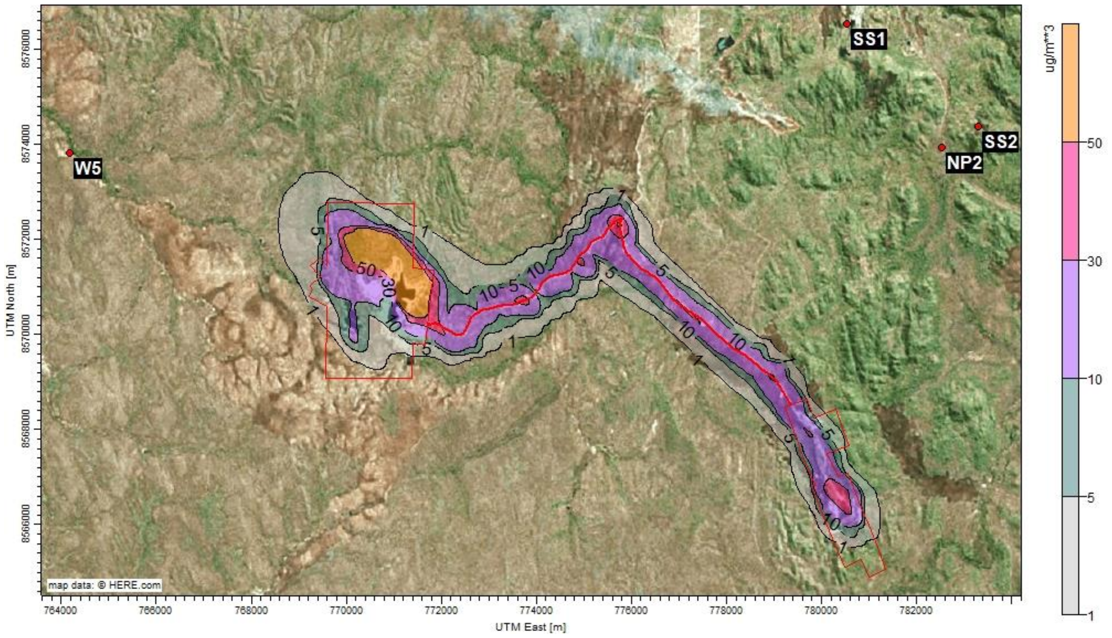
Table 29: List of Activity Data and Assumptions for Dust Emission Rates for Processing Plant: Crusher Circuit

Parameter	Units	Crushing Circuit
Operating Times		
Operating hours	hrs per day	24
Operating days	day / year	365
Volumes / Areas		
Hourly capacity	tph	700
Exposed stockpiles	ha	0.27
Processing and Material Transfer		
ROM Stockpile loading / unloading	tph	700 / 700
Dump Hopper	tph	700
Primary Crusher and screen	tph	700
Secondary Crusher and screen	tph	850
Fines Screens (wet)	tph	600
HPGR Dry screen	tph	100
HPGR Screen	tph	1,300
Stockpile Reclaim	tph	700
Miscellaneous material transfers	tph	2,800
Weather		
Mean wind speed (BOM Middle Point)	m/s	1.54
Rainfall >0.25 mm	Days per yr	86
Controls Measures		
Material transfers (loading ROM pad)	%	0
Material transfers (processing)	%	Dust suppression (50%)
Material transfers (conveyors)	%	Enclosed (70%)
Crushing and screening	%	Dust suppression (50%)
Dry screen	%	0
Wind erosion	%	Crushed stockpile covered (99%)

APPENDIX C: PREDICTED POLLUTION ISOPLETHS (INCREMENTAL)

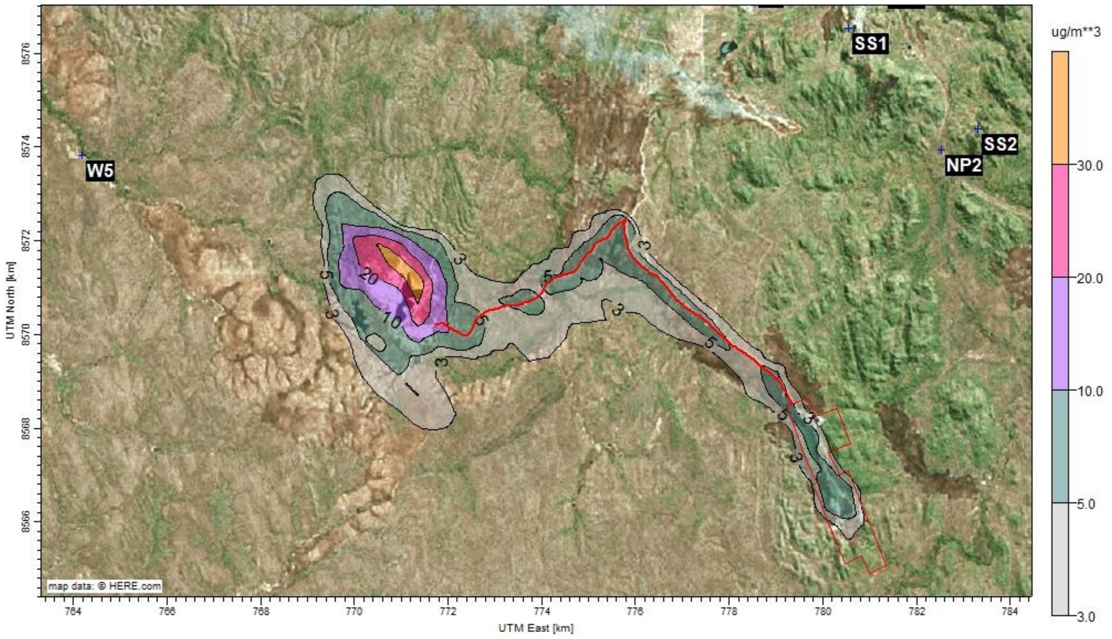
Isopleths illustrate the spatial distribution of ground-level concentrations across the modelling domain for each time period of interest. However, this process of interpolation causes a smoothing of the base data that can lead to minor differences between the contours and receptor model predictions.

The isopleths presented in this Appendix are incremental only due to the dominating influence of the background concentrations.



Pollutant:	Period:	Percentile:	Criteria:
TSP	1 Year	100th	90 µg/m³

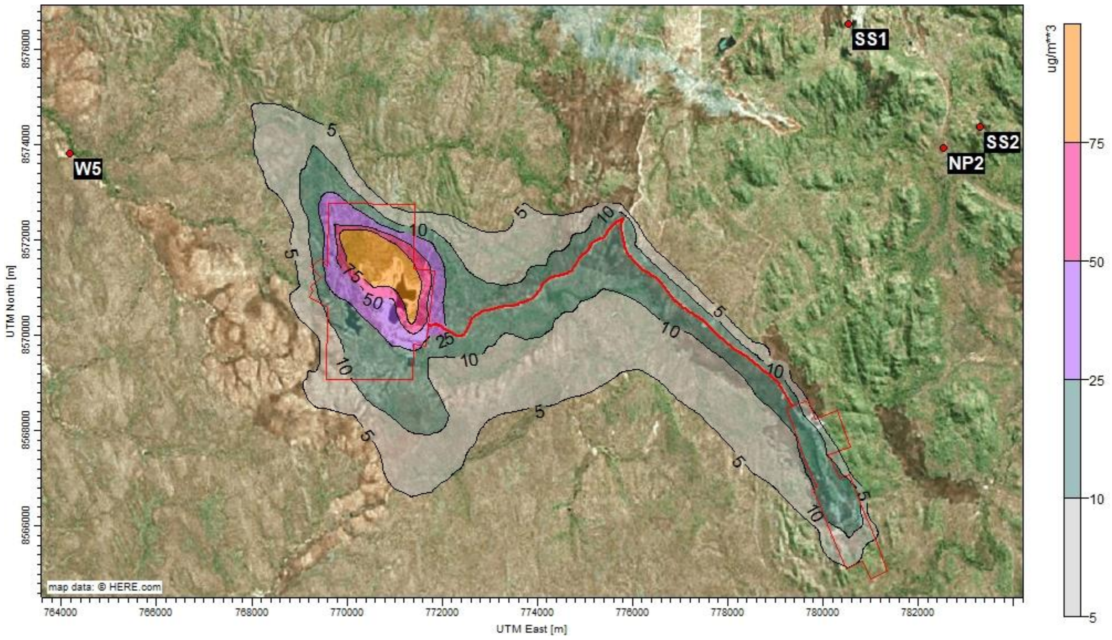
Figure 22: Annual Average TSP Concentration
Background Concentrations: Excluded



Pollutant:	Period:	Percentile:	Criteria:
PM_{10}	24 Hour	100th	50 µg/m³

Figure 23: Maximum 24-hour PM_{10} Concentration

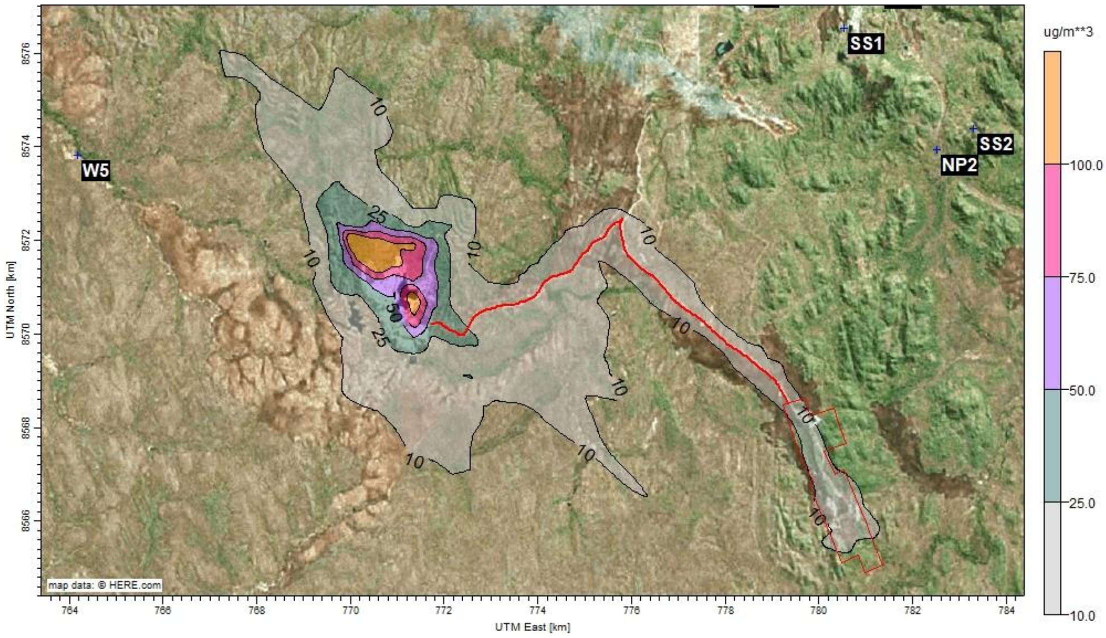
Background Concentrations: Excluded



Pollutant:	Period:	Percentile:	Criteria:
PM_{10}	1 Year	100th	25 µg/m³

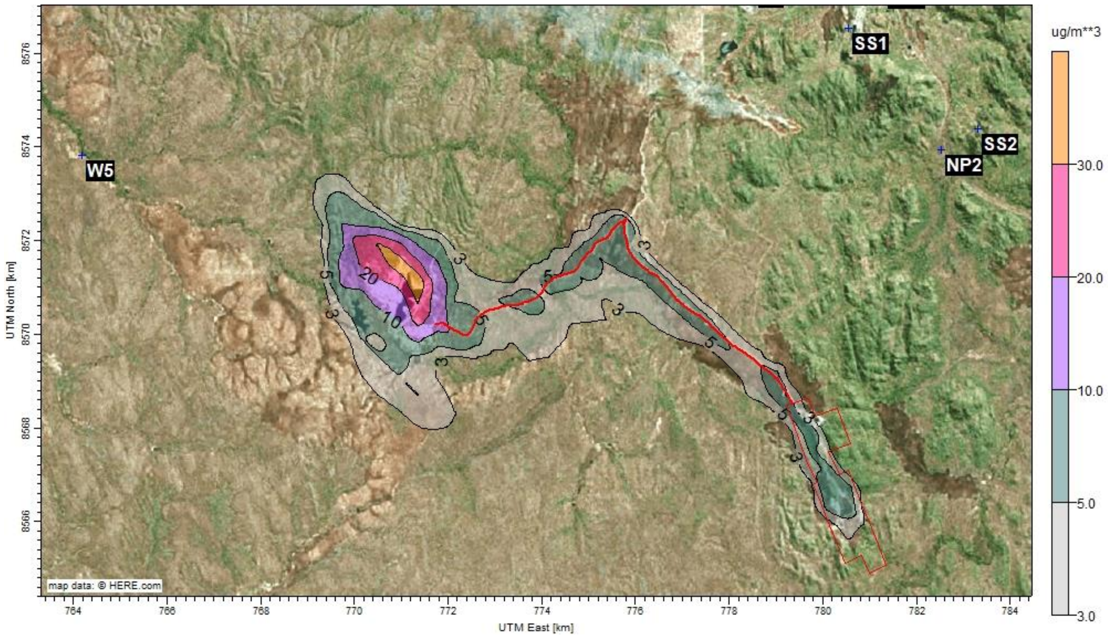
Figure 24: Annual Average PM_{10} Concentration

Background Concentrations: Excluded



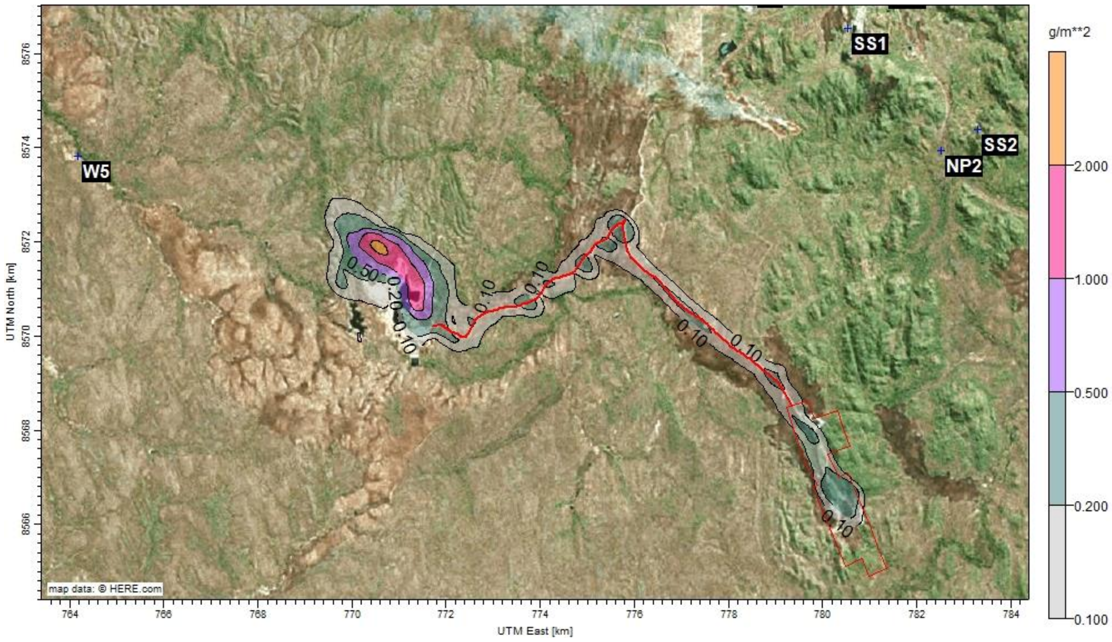
Pollutant:	Period:	Percentile:	Criteria:
$PM_{2.5}$	24 hours	100th	25 / 20 µg/m3

Figure 25: Maximum 24-hour $PM_{2.5}$ Concentration
Background Concentrations: Excluded



Pollutant:	Period:	Percentile:	Criteria:
$PM_{2.5}$	1 Year	100th	7 µg/m3

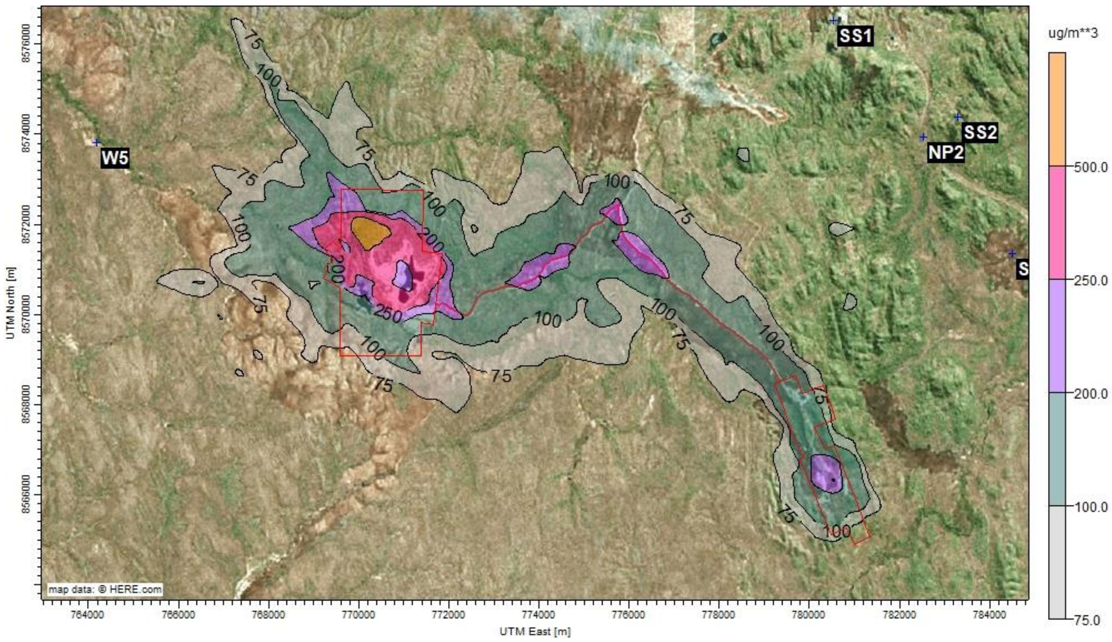
Figure 26: Annual Average $PM_{2.5}$ Concentration
Background Concentrations: Excluded



Pollutant:	Period:	Percentile:	Criteria:
Deposited Dust	1 Month	100th	2 g/m^2/month

Figure 27: Monthly deposited dust

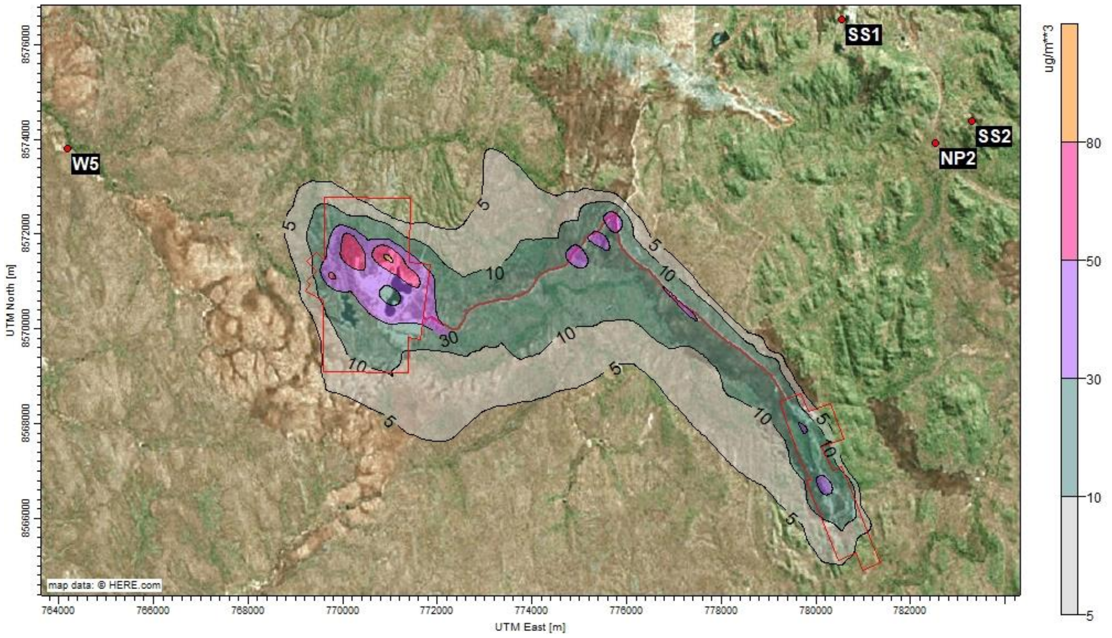
Background Concentrations: Excluded



Pollutant:	Period:	Percentile:	Criteria:
NO_2 (50% NO_X)	1 hour	100th	164 µg/m^3

Figure 28: Maximum 1-hour NO_2 Concentration

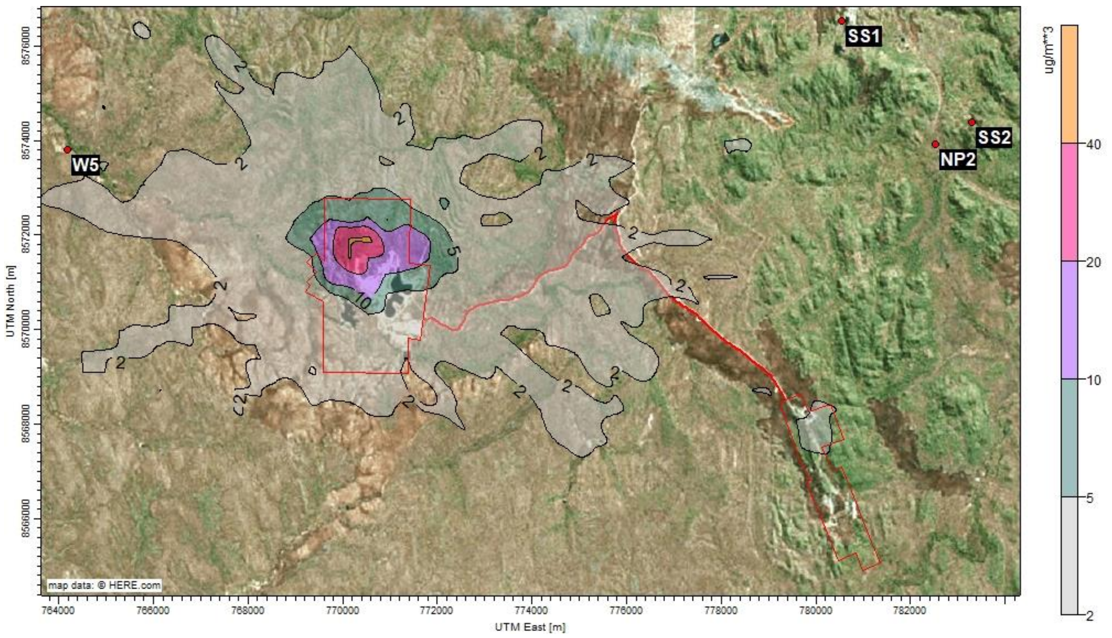
Background Concentrations: Excluded



Pollutant:	Period:	Percentile:	Criteria:
NO_2 (50% NO_X)	1 Year	100th	31 µg/m³

Figure 29: Annual Average NO_2 Concentration

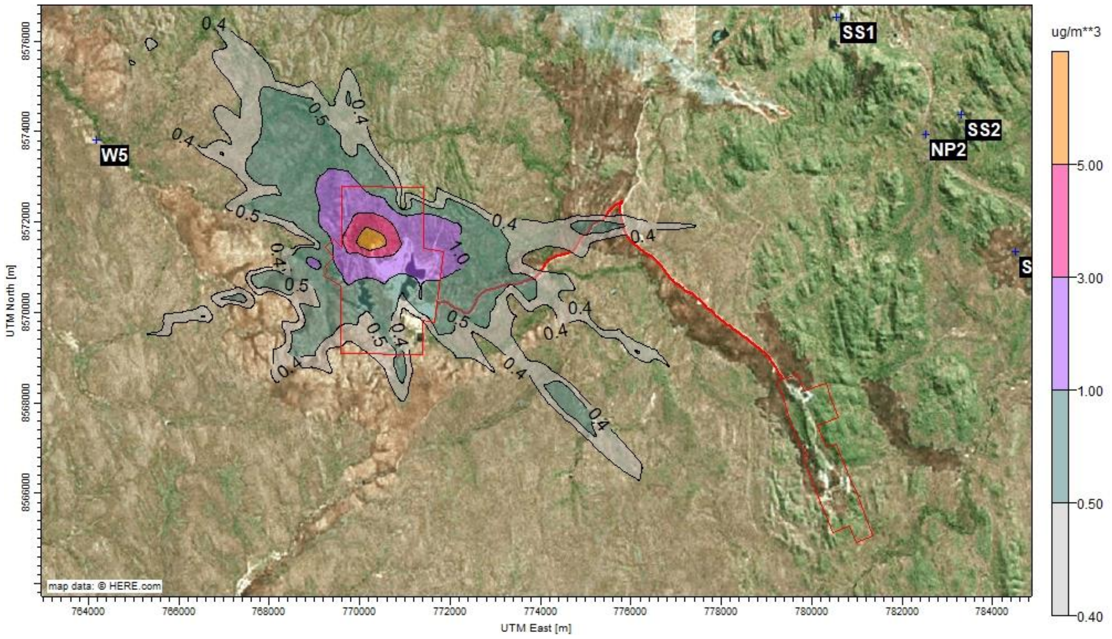
Background Concentrations: Excluded



Pollutant:	Period:	Percentile:	Criteria:
SO_2	1 hour	100th	57 µg/m³

Figure 30: Maximum 1-hour SO_2 Concentration

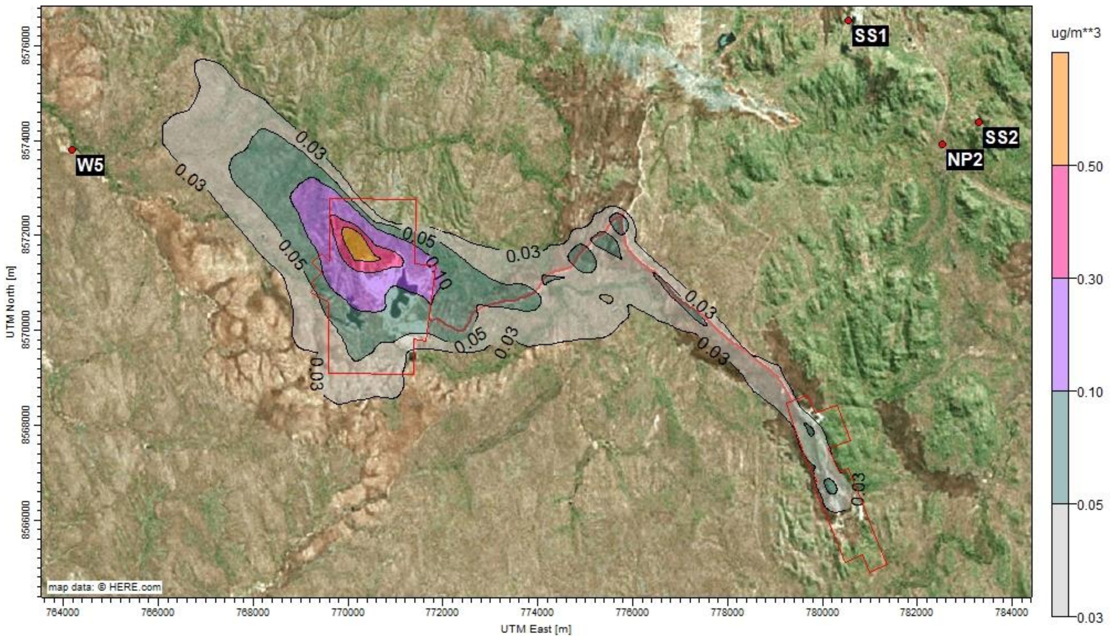
Background Concentrations: Excluded



Pollutant:	Period:	Percentile:	Criteria:
SO_2	24 Hours	100th	57 µg/m^3

Figure 31: Maximum 24-hour SO_2 Concentration

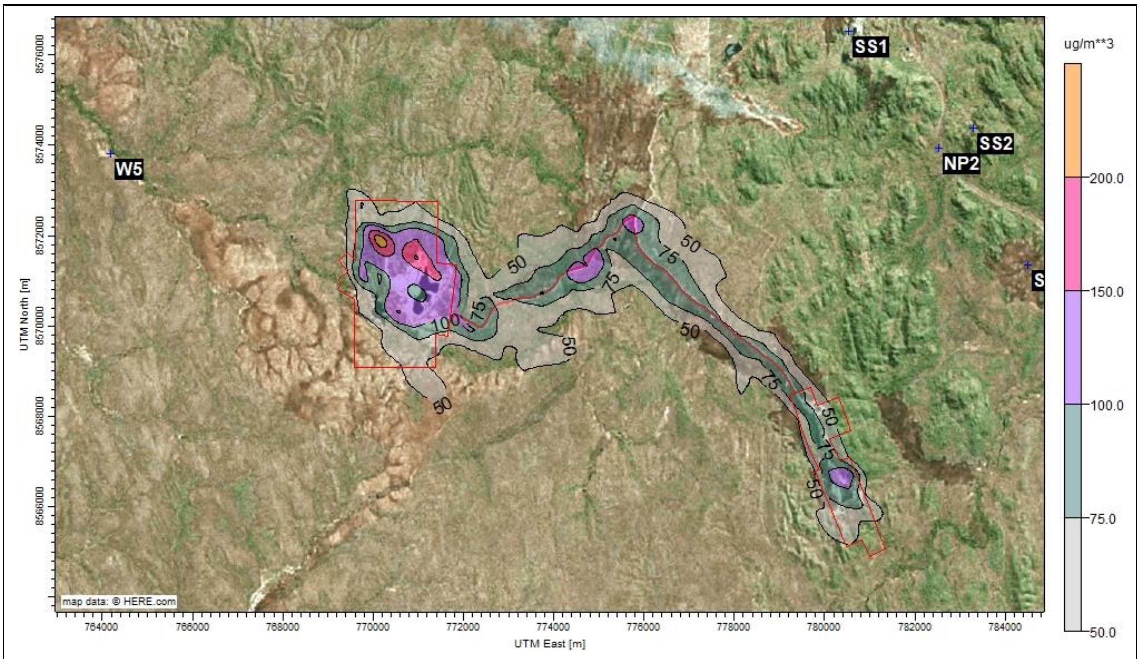
Background Concentrations: Excluded



Pollutant:	Period:	Percentile:	Criteria:
SO_2	1 Year	100th	60 µg/m^3

Figure 32: Annual Average SO_2 Concentration

Background Concentrations: Excluded



Pollutant:	Period:	Percentile:	Criteria:
CO	8 hour	100th	11,000 μg/m^3

Figure 33: Maximum 1-hour NO_2 Concentration

Background Concentrations: Excluded