BHP – Western Ridge

Air Quality Assessment

Final Report
Version 6

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BHP – Western Ridge

Final Report

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Jon Harper	Director /Principal Air Quality Specialist	1180 BHP WesternRidge Ver6.docx
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Executive Summary

BHP Billiton Iron Ore (BHP) propose to expand the existing mining operations at Newman through the development of the Western Ridge Project (the Project) located approximately 10 kilometres (km) south west of the Newman townsite in the Pilbara region of Western Australia (WA). An air quality assessment was conducted to determine potential impacts associated with the progressive mining of 50 Million tonnes per annum from four deposits (Eastern Syncline, Bill's Hills, Mount Helen and Silver Knight), with ore processing occurring at the existing Whaleback hub.

Ore will be transported to the existing Whaleback hub for processing using a combination of truck haulage and overland conveyor. Initially truck haulage will be used to transport ore from the Eastern Syncline and Bill's Hills to the Whaleback ore processing hub. Once mining at the Mount Helen and Silver Knight deposits commence, it is proposed to construct a new crusher and an overland conveyor to transport this ore to the Whaleback ore processing hub.

Overview of assessment

An air quality assessment was conducted to determine potential air quality impacts of particulates (as TSP, PM_{10} and $PM_{2.5}$) associated with the progressive development of the Project. Emission rates were estimated using recognised and accepted methods of emissions estimation, which included published emission factors from the National Pollutant Inventory (NPI) Emission Estimation Technique Manual for Mining (EA, 2012). Emissions were estimated for the mining year 2029 based on the high forecast tonnages for this year. Background concentrations were incorporated into the model results to provide an indication of the potential cumulative impact.

Modelling impacts of TSP, $PM_{10,}$ and $PM_{2.5}$ emissions was undertaken using the CALMET/CALPUFF modelling suite. In the absence of onsite meteorological measurements, the Weather Research and Forecast (WRF) model was used to simulate the meteorology over the region for a representative meteorological year and then as input to the CALMET model to generate fine-resolution three-dimensional meteorological fields. Fine resolution terrain elevation (Shuttle Radar Topography Mission (SRTM)) data with 90 metre (m) resolution was used in conjunction with European Space Agency Climate Change Initiative Land Cover (ESACCI-LU) land-use data to characterise the geophysical environment.

Ground-level particulates (as TSP, PM_{10}, and $PM_{2.5}$ concentrations) predicted at sensitive receptor locations and the surrounding environment were compared with the relevant air quality assessment criteria (relevant to human amenity and health). Sensitive receptors are consistent with those used in other BHP mine modelling assessments in the Pilbara.

The modelling assessment considered the following scenarios:

- Existing: Mt Whaleback and Eastern Ridge operations. This scenario was also used to provide a broad model validation which indicated that the model (with a regional daily varying background concentration) was predicting the PM_{10} ground level concentrations at the Newman East monitor with a high degree of confidence. The model was shown to underpredict concentrations above 60 µg/m^3 at the Town Centre monitor, though the model did predict the maximum 24-hour PM_{10} concentration.
- Future, which is divided into two components:
    - Isolation: Proposed Western Ridge as a standalone operation (excluding cumulative impacts).

    - Cumulative: Proposed Western Ridge and Mt Whaleback and Eastern Ridge operations inclusive of the background concentrations to assess the potential cumulative impact of the Project in conjunction with existing emission sources in the area.

Key findings

The key findings of the assessment, in relation to human amenity and health assessment criteria adopted, are:

- For the Project in isolation of other emission sources;
    - For TSP, PM_{10} and $PM_{2.5}$ -The predicted maximum concentrations are well within the applicable criteria.

- For the Project with the cumulative scenario (Mt Whaleback mine and Eastern Ridge with background file);
    - For TSP -
        - The model is predicting a reduction in ground level concentrations across all statistics including the maximum concentrations.
        - The model is predicting that there will be a reduction in the number of excursions of the applicable criteria.
    - For PM_{10} and $PM_{2.5}$ -
        - The model is predicting a reduction in ground level concentrations across all statistics including the maximum concentrations.
        - The model is predicting that there will be a reduction in the number of excursions of the applicable criteria.

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1 Introduction

1.1 Background

BHP Billiton Iron Ore (BHP) propose to expand the existing mining operations at Newman through the development of the Western Ridge Project (the Project) located approximately 10 kilometres (km) south west of the Newman townsite in the Pilbara region of Western Australia.

The Project comprises open pit mining from four deposits (Eastern Syncline, Bill's Hills, Mount Helen and Silver Knight) (Figure 1-1) to be progressively mined. Ore will be transported to the existing Whaleback hub for processing using a combination of truck haulage and overland conveyor. Initially truck haulage will be used to transport ore from Eastern Syncline and Bill's Hills to the Whaleback ore processing hub. Once mining at the Mount Helen and Silver Knight deposits commences, it is proposed to construct a new crusher and an overland conveyor to transport this ore to the Whaleback ore processing hub.

The proposed mining rate for the Project is 50 Million tonnes per annum (Mtpa) of ore, noting this will replenish supplies from depleting ore reserves from the existing mining operations at Mt Whaleback and Eastern Ridge. The rate of ore processing through the Whaleback hub will therefore not increase because of the Project. The estimated life of mine is approximately 30 years.

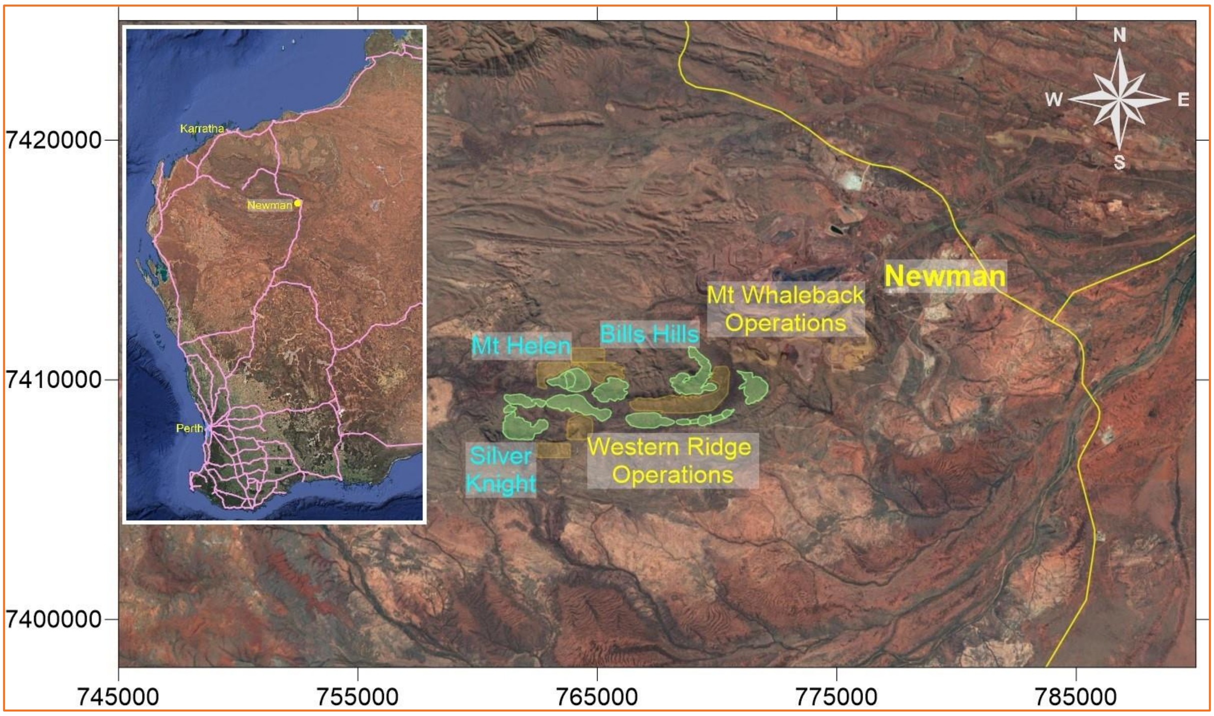

Figure 1-1: Project location and setting

1.2 Scope of work

Environmental Technologies & Analytics Pty Ltd (ETA) was engaged by BHP to undertake an air quality assessment for the Project. The scope of work included:

- Determining the study approach and methodology in Section 2.

- Generation of site-specific meteorological data and atmospheric dispersion modelling using the WRF-CALMET/CALPUFF model suite in Section 5.
- Project emission estimation and inventory in Section 6.
- An evaluation of the predicted ground-level concentrations of particulates and interpretation of the potential impact of the Project (Section 7).
- Conclusions of the assessment presented in Section 8.

The appendices contain supporting information.

2 Assessment methodology

This section outlines the air quality study and assessment approach. It includes the methodology applied to define the meteorological characteristics of the project area relevant to the assessment, the emission estimation, the dispersion, and the ambient assessment criteria selected for the purposes of determining the significance of the dispersion model results, and therefore the potential impact.

The study structure is shown in Figure 2-1.

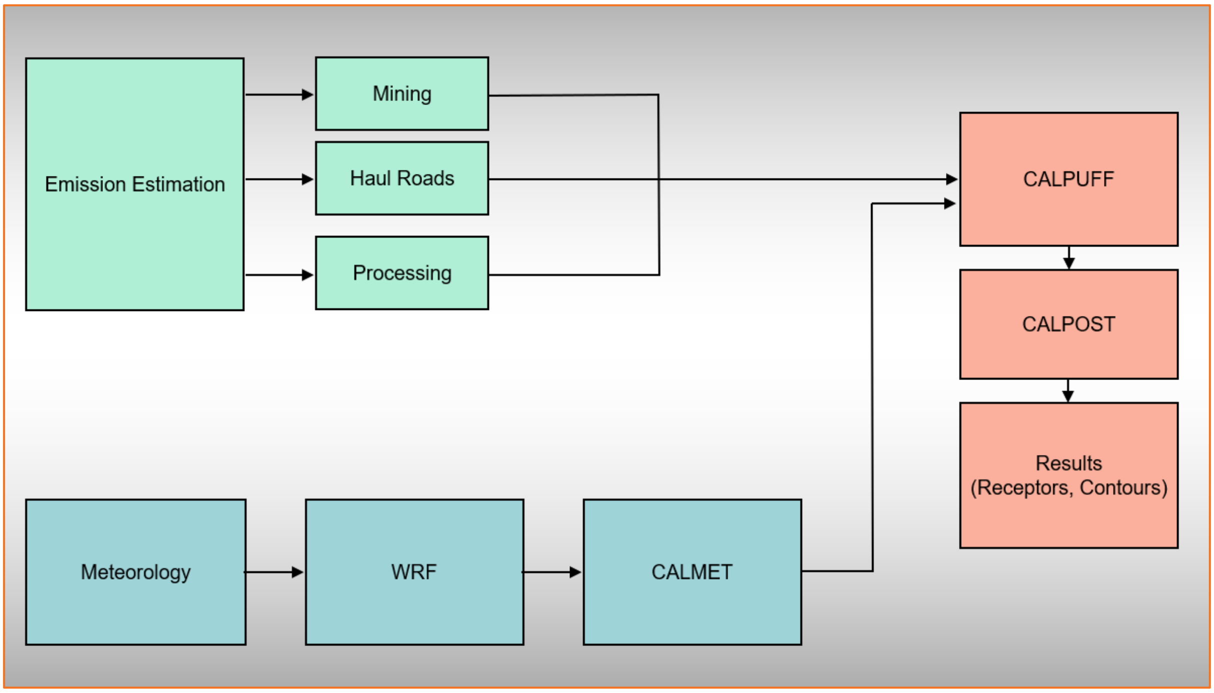

Figure 2-1: Air quality assessment – study approach

Comparison of the modelled results to the assessment criteria is intended to provide an objective evaluation of the potential impact of the operations at the nearest sensitive receptors. Modelled ground-level concentrations for key air pollutants have been compared to ambient air quality assessment criteria.

2.1 Meteorology

The meteorology component of a dispersion model is a key element for the effectiveness or representativeness of the dispersion model outputs. Both upper air and surface information are needed for modelling. In the absence of adequate onsite meteorological data, the Weather Research and Forecast (WRF V3.7) model (http://wrf-model.org/index.php) was used to generate hourly 3-dimensional data for the region. The 3-Dimensional meteorological data generated by WRF was input to CALMET for further processing to the finer resolution used in the dispersion modelling. This procedure will be referred to as the 'WRF-CALMET methodology'. The output from the CALMET meteorological model is then used to drive the pollution dispersion in the CALPUFF model.

2.2 Emissions estimation

Emission rates were estimated using national and internationally recognised and accepted methods of emissions estimation, which included published emission factors from the NPI Emission Estimation Technique Manual for Mining (EA, 2012) and components of the United States Environmental Protection Agency (USEPA) AP-42 contained with Chapter 13, Miscellaneous Sources.

2.3 Modelling

Air dispersion modelling has been conducted using CALPUFF - the dispersion module of the CALMET/CALPUFF suite of models. The model has been used to predict ground level concentrations across the model domain and at identified sensitive receptor locations. The potential air quality impacts associated with the Project have been considered in isolation of other emission sources as well as cumulatively with future operations and background concentrations.

2.4 Impact Assessment

Ground-level particulates (concentrations) predicted at sensitive receptors and the surrounding environment were compared with the relevant air quality assessment criteria. This assessment has considered the potential impact attributable to the Project, as well as the cumulative (background) impact (i.e. in conjunction with the existing emission sources in the area). The assessment has been made across the model domain, as well as at key sensitive receptor locations identified as being representative or important for assessment.

The ambient air quality and potential impacts are assessed in terms of the following particulate sizes:

- Total Suspended Particulates (TSP)
- PM_{10} (particulate matter with an aerodynamic diameter of 10 µm or less)
- $PM_{2.5}$ (particulate matter with an aerodynamic diameter of 2.5 µm or less).

3 Existing Environment

The climate and meteorological characteristics of the region control the dispersion, transformation and removal (or deposition) of pollutants from the atmosphere. This section outlines the key climate and meteorological characteristics of the region important for the dispersion, transformation and removal (or deposition) of pollutants from the atmosphere, and therefore ambient air quality.

3.1 Climate

According to the Koppen-Geiger climate system the Newman region is classified as 'BWh' indicating a hot desert climate where evaporation exceeds rainfall. The following sections outline the long-term meteorological statistics from the Bureau of Meteorology (BoM) automatic weather station (AWS) at Newman Airport, located approximately 9 km to the southeast of Newman. This AWS has been collecting meteorological data since 1998.

3.1.1 Local meteorology

The Pilbara region of Western Australia is characterised as semi-arid and has two primary seasons – wet and dry. The wet season, from October to April, is dominated by high temperatures and evaporation rates with isolated intense convective rainfall (thunderstorms) and cyclonic activity. The dry season, from May to September, is relatively dry with mild temperatures.

The long-term temperature statistics from the BoM AWS in Newman are presented in Figure 3-1. From this figure it is apparent that the wet season (summer) period has very warm to hot days and warm nights while the dry season (winter) has warm days with cool, and occasionally cold, nights.

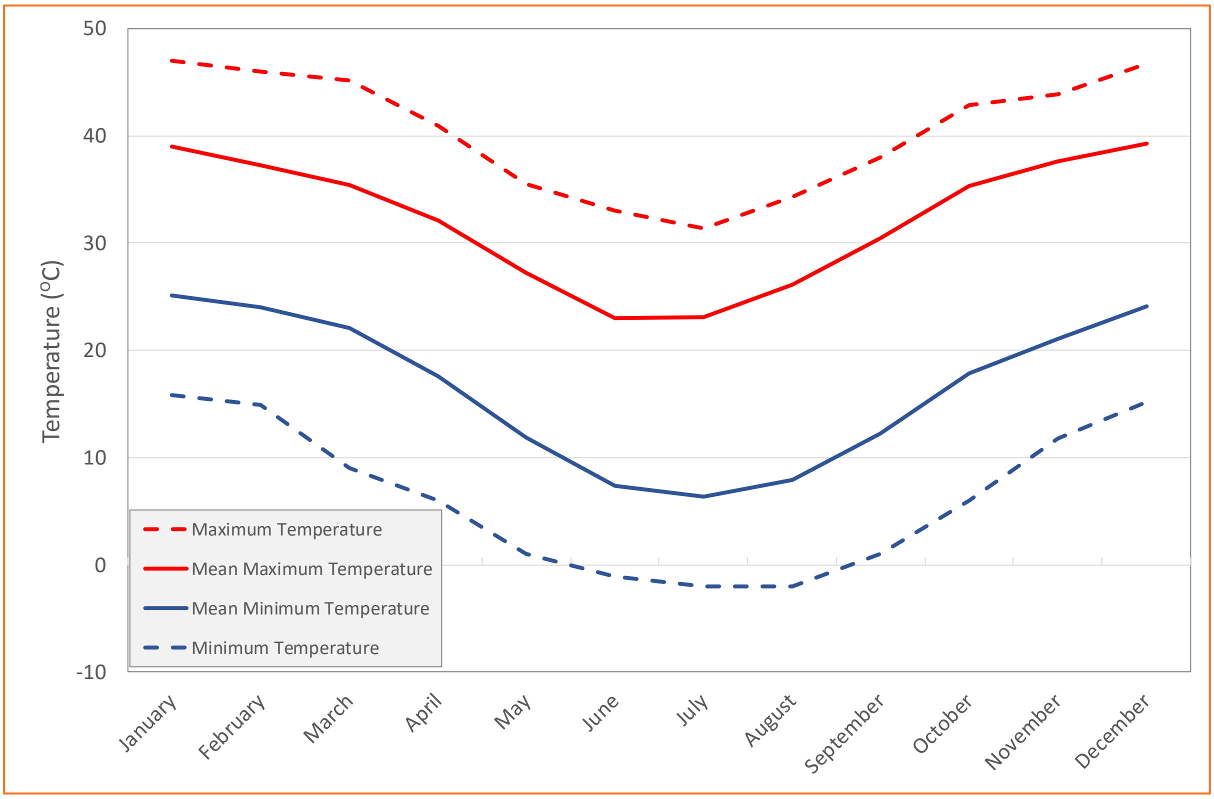

Figure 3-1: Long term temperature statistics (BoM, 2020)

The long term annual average rainfall at Newman is 330 millimetres (mm). While rainfall is mainly associated with the formation of the occasional afternoon thunderstorms, the impact of cyclonic rainfall is evident in Figure 3-2 where the maximum monthly rainfall is significantly greater than the average rainfall, particularly during the cyclone period from December to March.

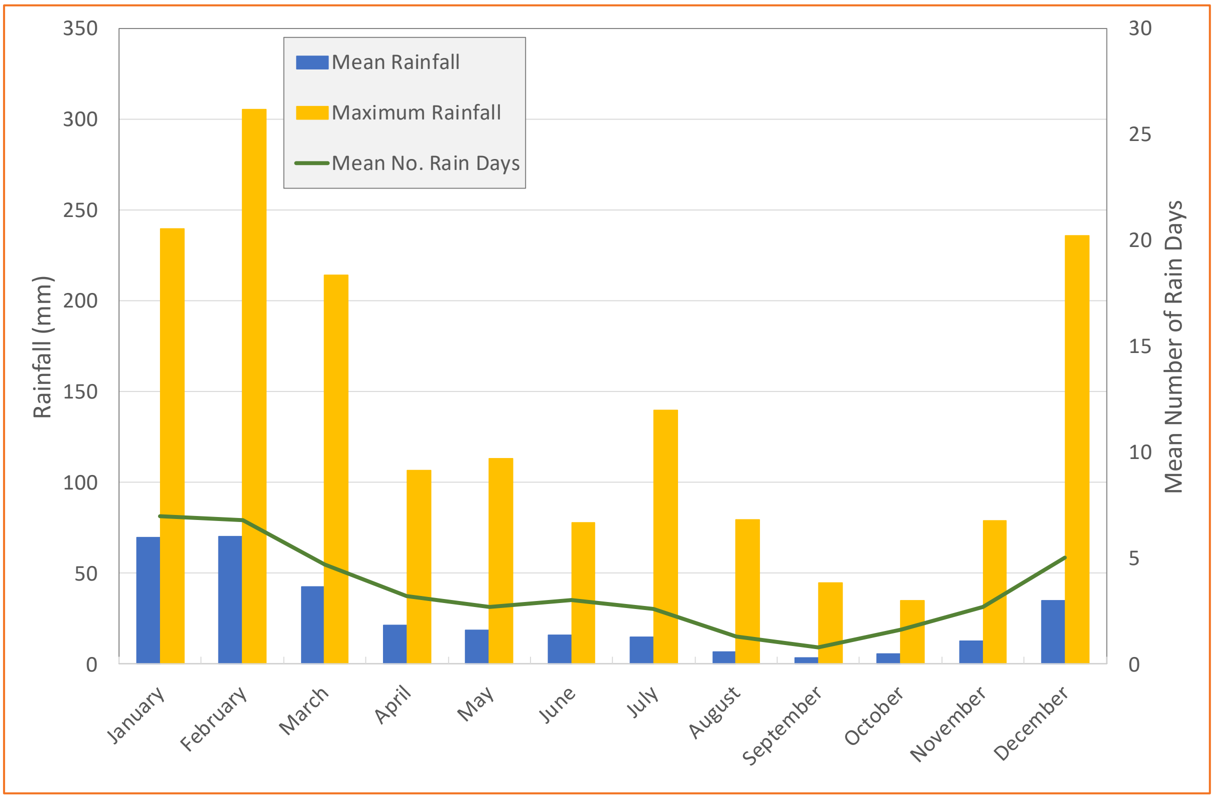

Figure 3-2: Long term rainfall statistics (BoM, 2020)

The annual rainfall, from 1997 to 2020, is presented in Figure 3-3. From this figure is apparent that the Newman region experiences a significant variation in the annual rainfall from a maximum of 619 mm in 1999 down to a minimum of 116 mm in 2019. Furthermore the period from 2018-2019 experienced the lowest two year rainfall since 1997.

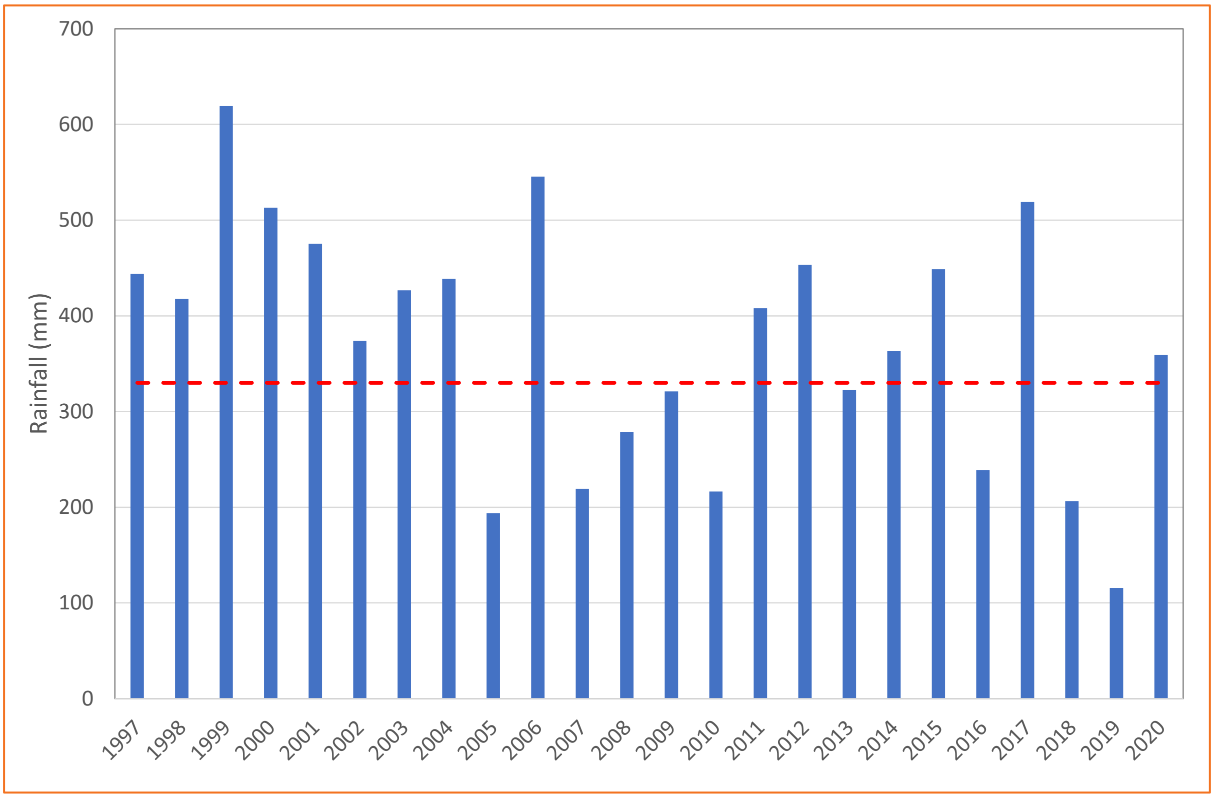

Figure 3-3: Annual Rainfall since 1997 (BoM, 2021)

3.2 Local Air quality

The Pilbara region is a naturally dusty environment with wind-blown dust being a significant contributor to the particulate loading. Within the aggregated emission inventory for the Pilbara, undertaken by SKM in 2000 for the 1999/2000 financial year, it was calculated that approximately 170,000 tonnes of particulate material was emitted as a result of wind erosion. Wildfires also account for a significant amount of the emissions with approximately 195,000 tonnes of particulates emitted. Note that these are calculated values (i.e. not monitored data) and will vary on an annual basis depending on a range of factors including the extent of erodible areas, area burnt, rainfall and wind speed.

4 Air quality assessment criteria

4.1 Definitions

Suspended solids or liquids in air are referred to as Particulate Matter (PM). Concentrations of particles suspended in air can be classified by an aerodynamic diameter, which describes the behaviour of the particle in the air based on its size and shape:

- Total Suspended Particulate (TSP) – refers to the total amount of the PM suspended in air (regardless of size). These larger particles are primarily associated with amenity or visibility issues and are likely to be removed by gravitational settling within a short time of being emitted (i.e. they settle to the ground or other surfaces fairly quickly).
- PM_{10} – refers to the total of suspended particulate matter less than 10 µm in aerodynamic diameter. Particles in this size range can enter bronchial and pulmonary regions of the respiratory tract and can impact human health. Particles in this size range can remain suspended for many days in the atmosphere.
- $PM_{2.5}$ – refers to the total of suspended particulate matter less than 2.5 µm in aerodynamic diameter. Epidemiological studies have shown that particles in this size range are associated with greater health impacts on humans than other particle sizes due to their ability to enter further into the lungs and into the alveoli. Particles in this size tend to be derived from combustion sources such as combustion of fossil fuels and biomass burning (WHO, 2005). These particles can remain suspended for months to years. An example of the relative particle sizes is presented in Figure 2-1.

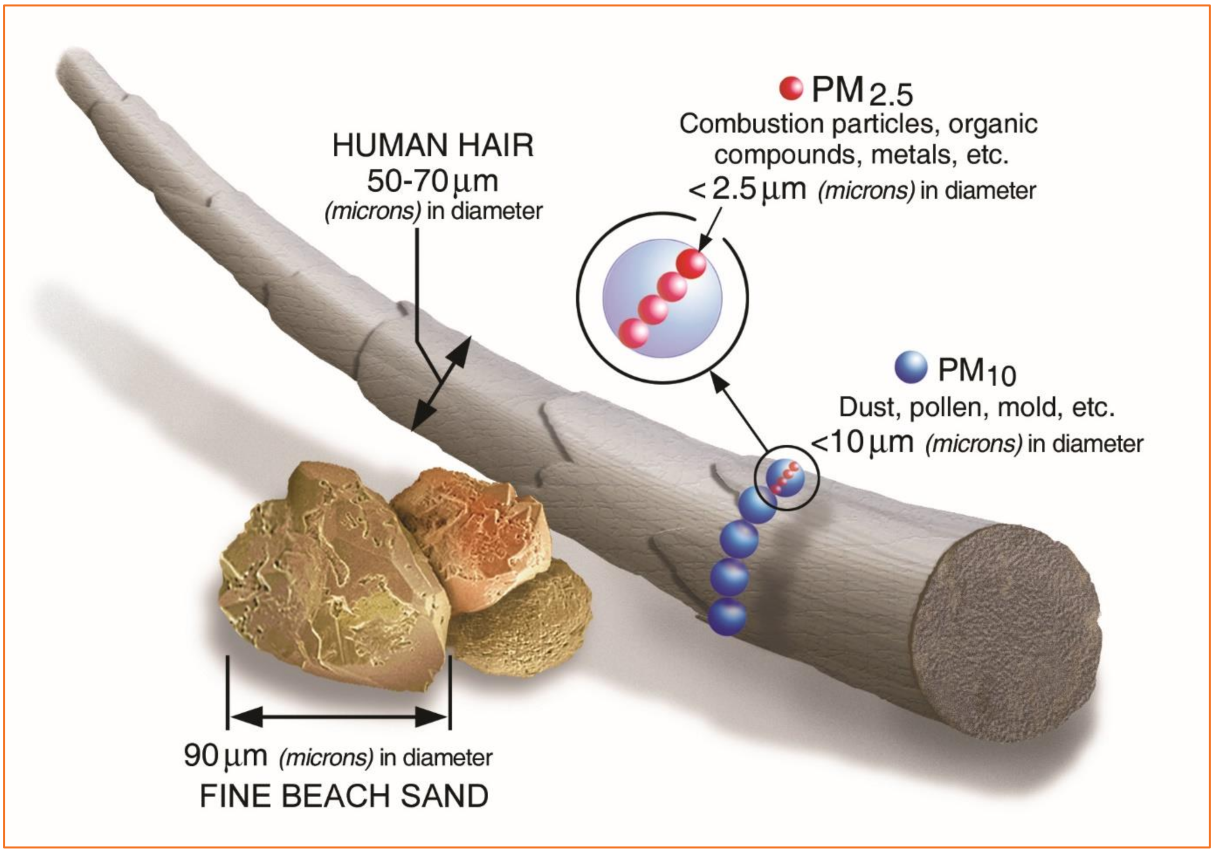

Figure 4-1: Example of particle sizes (USEPA, 2021)

4.2 Human Health Assessment and Amenity Criteria

Modelled ground level concentrations for particulates have been compared to ambient air quality assessment criteria to determine the potential changes in impact resulting from the Project.

The assessment criteria adopted for this study (for particulates) are primarily based on the DWER (2019; 2021) guidelines, which also reference the numerical values from the ambient air quality standards specified in the Ambient Air Quality NEPM (NEPC, 2021).

In their current draft form, the DWER (2019) guidelines for TSP/PM_{10}/$PM_{2.5}$ (defined as *criteria pollutants* in the guideline) require the criteria to generally be '…met at all existing and future offsite sensitive receptors in the modelling domain'. DWER (2021) draft guidelines address the settling or deposition of dust, noting that at time of this assessment the guideline is draft and subject to public consultation. The guidelines also state that the department may approve deviations to the assessment criteria on a case-by-case basis.

Within Port Hedland the Port Hedland Dust Management Taskforce (Taskforce), in their final report to government (DSD, 2016), recommended that the interim guideline of 70 µg/m^3 for PM_{10} (24-hour average and excluding natural events) continue to be applied to residential areas. This value is used to assess the potential health impact on community receptors within the project model domain. In its response to the final recommendations of the Taskforce, in October 2018 the State Government agreed that the air guideline value of 70 µg/m^3 should apply to residential areas, wherever people live on a permanent basis in Port Hedland. In addition, the DoH agreed to the continuation of the 10 exceedances per year of the air guideline value, as measured at Taplin Street, on the understanding that the overall population for the Port Hedland peninsula does not exceed 17,000 (ie the modelled population in the Health Risk Assessment). Consistent with the approach adopted by the NEPM, there is no limit on exceedances solely as a result of natural events.

The ambient air quality assessment criteria adopted in this study are shown in Table 4-1.

Table 4-1: Summary of Adopted Assessment Criteria

Pollutant	Air quality assessment criteria					Reference
	Concentration [1]	Concentration [2]	Averaging Period	Allowable Exceedances	Environmental value protected	
PM_{10}	25 µg/m^3	23 µg/m^3	annual	none	Human health	DWER (2021) consistent with NEPM (NEPC, 2021)
	70 µg/m^3	-	24-hour average	Not more than 10 days a year		Taskforce criteria (DSD, 2016)
$PM_{2.5}$	25 µg/m^3	23 µg/m^3	24-hour	exception event		DWER (2021) consistent with NEPM (NEPC, 2021)
	8 µg/m^3	8 µg/m^3	annual	none		
TSP	90 µg/m^3	82 µg/m^3	24-hour	none	Human health and amenity Proxy for protection of	DWER (2019)

Pollutant	Air quality assessment criteria					Reference
	Concentration [1]	Concentration [2]	Averaging Period	Allowable Exceedances	Environmental value protected	
					ecological values	

Notes:
1 Concentrations referenced to 0ºC (excluding reference to dust deposition)
2 Concentrations referenced to 25ºC (excluding reference to dust deposition)

5 Model Assessment

For this assessment, air dispersion modelling has been conducted using CALPUFF. The model has been used to predict ground level concentrations across the model domain and at identified sensitive receptor locations. The potential air quality impacts associated with the Project have been considered in isolation of other emission sources, as well as cumulatively with existing air quality of the region. The model was configured to predict the ground-level concentrations on a rectangular grid. The model domain was defined with the Southwest corner of the grid cell at 760.0 km Easting and 7404.0 km Northing (UTM Zone 50 S). Specifics for the modelling configuration are described further in this section.

5.1 Pilbara Strategic Environmental Assessment

During 2015 BHP undertook a Strategic Environmental Assessment (SEA) of potential cumulative impacts of operations within the Pilbara region, inclusive of all iron ore operations. As part of this assessment a Cumulative Air Quality Assessment was completed with one of the aims being to develop a base model for the region using the dispersion model CALPUFF. The assessment included identifying a representative model year, emissions estimation of sources within the study area, and modelling of the emission sources.

The components of the SEA that are relevant to this study include:

- The representative meteorological year was determined to be 2010
- The WRF model was utilised to generate 3-dimensional meteorology for the model domain
- Emission estimation was undertaken using emission factors from the National Pollutant Inventory (NPI) Emission Estimation Technique Manual for Mining Version 3.1 (EETM for Mining)
- Constant background concentrations, based off the BHP monitoring network, were incorporated for TSP and PM_{10}.

Where possible this assessment has utilised either an identical or similar approach to that outlined in the SEA with the following exceptions:

- Modelled year has been updated to 2020 (Appendix A)
- The background file was updated to the 2020 and now consists of a 24-hour varying file (Section 5.5).

5.2 Meteorological model

The meteorology component of a dispersion model is a key element for the effectiveness or representativeness of the dispersion model outputs. Both upper air and surface information are needed for modelling.

The following sections outline the process for the development of the meteorological file for this assessment.

5.2.1 WRF Model

The Weather Research and Forecast (WRF V3.7) model (http://wrf-model.org/index.php) was used to generate hourly 3-dimensional data for the region. WRF is the next-generation mesoscale numerical weather prediction system. The model was primarily designed to serve both operational forecasting and atmospheric research. WRF features multiple dynamical cores, a 3-dimensional variational data assimilation system and a software architecture allowing for computational parallelism and system extensibility. Further details on WRF are provided in Appendix B.

5.2.2 CALMET

The 3-Dimensional meteorological data generated by WRF was input to CALMET for further processing to the finer resolution used in the dispersion modelling. This procedure will be referred to as the 'WRF-CALMET methodology'. The output from the CALMET meteorological model is then used to drive the pollution dispersion in the CALPUFF model.

CALMET is a three-dimensional meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional, spatially and temporally varying meteorological fields that are utilised in the CALPUFF dispersion model.

CALMET utilised several datasets to resolve the surface and upper air meteorology occurring for each hour of the year:

- surface observations (Whaleback and Jimblebar) and gridded prognostic meteorological model (WRF) data.
- land use and topographical data.

CALMET was run for a 250 x 133 grid domain at a spatial resolution of 130 m. Vertically, the model consisted of 11 levels extending to 3,000 m. The southwest corner coordinates of the domain were 760.0 km Easting and 7405.0 km Northing (UTM Zone 50 S).

Shuttle Radar Topography Mission (SRTM) data with 90 m resolution was input into the CALMET model to indicate terrain heights within the model domain (Figure 5-1). This is an identical approach to that outlined in the SEA (BHP, 2015).

CALMET also requires geophysical data including gridded fields of land use categories. The default United States Geological Survey (USGS) land use classification system (14 category system) was substituted with a more up to date, finer resolution data obtained from the European Space Agency Climate Change Initiative Land Cover (ESACCI-LC) dataset. This is a similar approach to that outlined with the SEA, however improvements were made to account for the finer spatial resolution used in this assessment.

The CALMET results are provided in Appendix B.

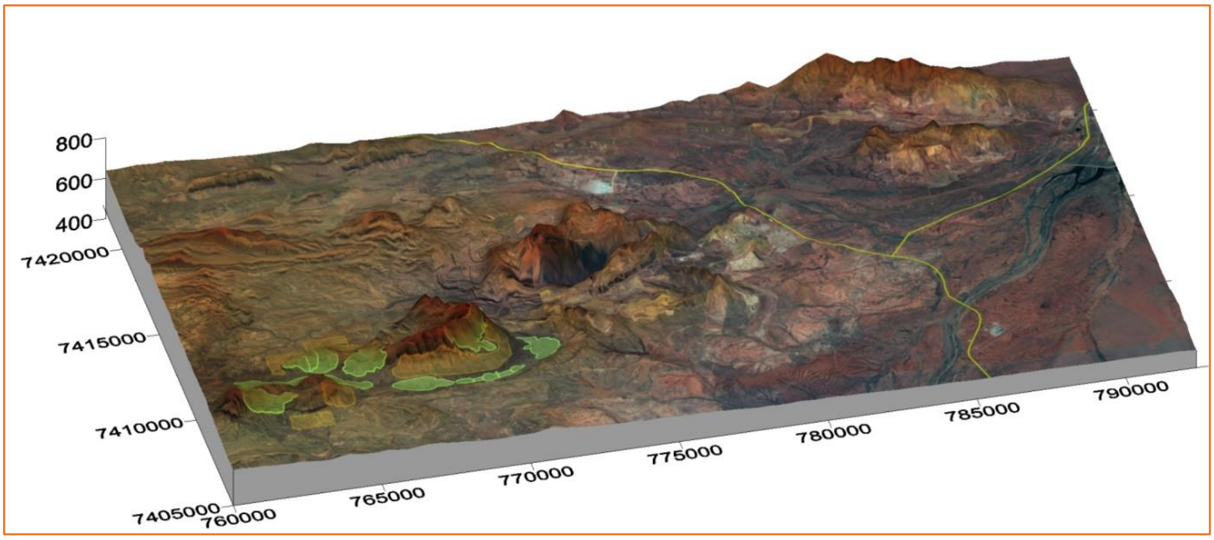

Figure 5-1: Image of SRTM terrain elevation used in CALMET (vertical height is exaggerated)

5.3 CALPUFF

CALPUFF is the dispersion module of the CALMET/CALPUFF suite of models. It is a multi-layer, multi species, non-steady-state puff dispersion model that can simulate the effects of time-varying and space-varying meteorological conditions on pollutant transport, transformation and removal. The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across released puffs and considers the complex arrangement of emissions from point, area, volume and line sources (Scire et al., 2000).

The CALPUFF model was set to calculate concentrations both on a set grid (gridded receptors) and at six specified locations (discrete receptors). The model domain was defined as 32.5 km in the east–west direction and 17.3 km in the north-south direction at a spacing of 130 m.

5.3.1 Emission sources

Each emission source for the Project was characterised as either area sources or volume sources in the dispersion model. Area sources were assigned to open areas while volume sources were assigned to mining activities in the pits and haul roads following the USEPA recommendations (USEPA, 2012). The locations of sources are presented in Appendix D as coordinates (GDA94, zone 50).

This approach varies slightly from the SEA (BHP, 2015) which, due to its large regional scale modelling, used a single area source which incorporated all predicted emissions for each mining operation. The modelling approach adopted for this assessment allows for each emission source to be modelled separately, which is appropriate given the smaller spatial size of the modelled grid.

For the cumulative assessment, the estimated emissions from the Whaleback and Eastern Ridge mining operations were included.

5.3.2 Particle size distribution

CALPUFF was set up to model depletion of the dust plume concentration through deposition. Since dust is subject to gravitation settling as well as deposition, information on particle size is critical. A particle size distribution for TSP, PM_{10} and $PM_{2.5}$ was estimated using a composite from the USEPA AP-42 manuals for 'aggregated handling and storage piles', 'industrial wind erosion' and 'unpaved roads'. These are shown in Table 5.1.

Table 5-1: Particle size distribution (USEPA, 2006)

Size range (µm)	TSP Cumulative (%)	PM_{10} Cumulative (%)	$PM_{2.5}$ Cumulative (%)
<2.5	9	30	100
2.5 - 5.0	17	57	-
5.0 - 7.5	24	80	-
7.5 - 10.0	30	100	-
10.0 - 15.0	44	-	-
15.0 - 23.0	59	-	-
23.0 - 30.0	74	-	-
30.0 - 40.0	89	-	-
40.0- 50.0	100	-	-

5.4 Receptors

The discrete receptor locations used in the assessment are listed in Table 5.2, and are shown in Figure 5-2. These locations are existing ambient air quality monitoring locations, are used for interpreting the model results and are consistent with those used in previous air quality assessments of the BHP Eastern Ridge operations.

It is important to note that of these six locations only the Town Monitor (R1) and Newman East (R2) are classified as 'sensitive receptors' in that they are within residential areas. The other four locations are BHP boundary monitors and are located outside of residential areas.

Table 5-2: Discrete receptor locations

ID	Location	Easting (m)	Northing (m)
R1	Town Monitor	779,414	7,414,521
R2	Newman East	781,232	7,413,739
R3	Newman Boundary 1	778,826	7,415,669
R4	Newman Boundary 2	777,239	7,413,124
R5	Newman Boundary 3	783,590	7,415,881
R6	Newman ER OB32	780,714	7,417,256

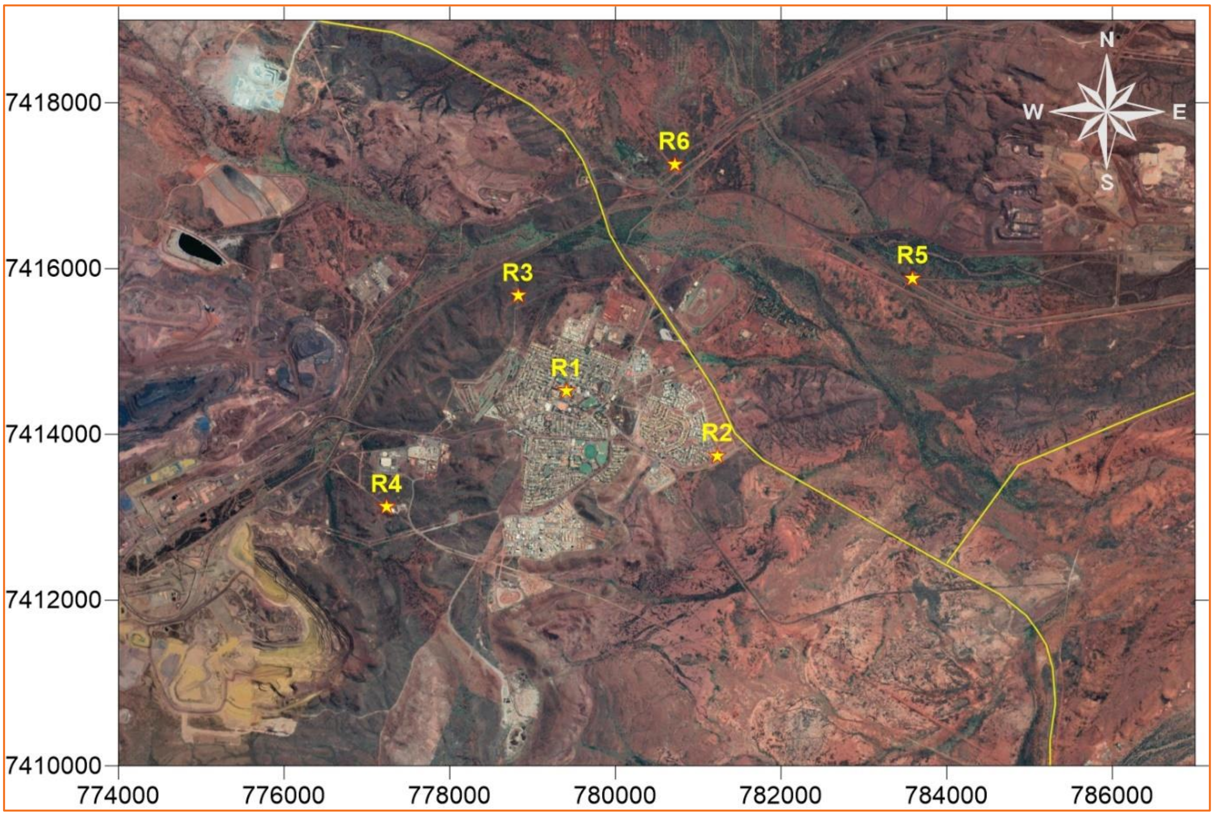

Figure 5-2: Discrete sensitive receptor locations

5.5 Background Air Quality

As outlined in Section 3.2 the Pilbara region is naturally dusty with wind-blown dust and wildfires being a significant contributor to dust emissions. To account for these additional particulate sources in the region a 24-hour variable PM_{10} background file was created.

Within the Newman region BHP operate a series of BAM1020 monitors (Figure 5-3) with the majority of these monitors being located between the Township of Newman and the mining and processing operations at either Eastern Ridge or Mt Whaleback. However four of the monitoring locations can be considered to be background monitors based on their distance from the operations. These monitors include:

- Background East BAM
- Background 2 South BAM
- Background West BAM
- Background 3 BAM north.

The 2020 hourly PM_{10} monitoring data for each of these four BAM monitors was obtained from BHP and the background file was derived using the following methodology:

- Indicative wind arcs were assigned to each monitor to ensure that the monitor was 'upwind' and the hourly PM_{10} concentration was not influenced by emissions from the mining or processing operations as well as potential emissions from within the Township of Newman. The assigned arcs are presented in Table 5-3.

- The hourly wind direction was based on the data recorded at the BHP Ophthalmia meteorological station.
- The hourly background PM_{10} concentration was determined by assigning the hourly PM_{10} data from the BAM1020 that was within the arc of influence.
- Note that the monitoring data from the Background West BAM monitor was only available from 26 March 2020 onwards. As can be seen from Table 5-3 the arc of influence for this monitor overlaps with that for the Background 3 BAM North monitor. When data for both monitors was available within the overlapping arc of influence the minimum hourly PM_{10} concentration was utilised.

The derived hourly data was then averaged to obtain a 24-hour average background concentration. The statistics of this 24-hour are tabulated in

- Table 5-4 and presented in Figure 5-4 as a time series graph.
- The 24-hour PM_{10} data was:
    - doubled to derive an indicative background TSP file
    - reduced by 70% to derive an indicative $PM_{2.5}$ background file.

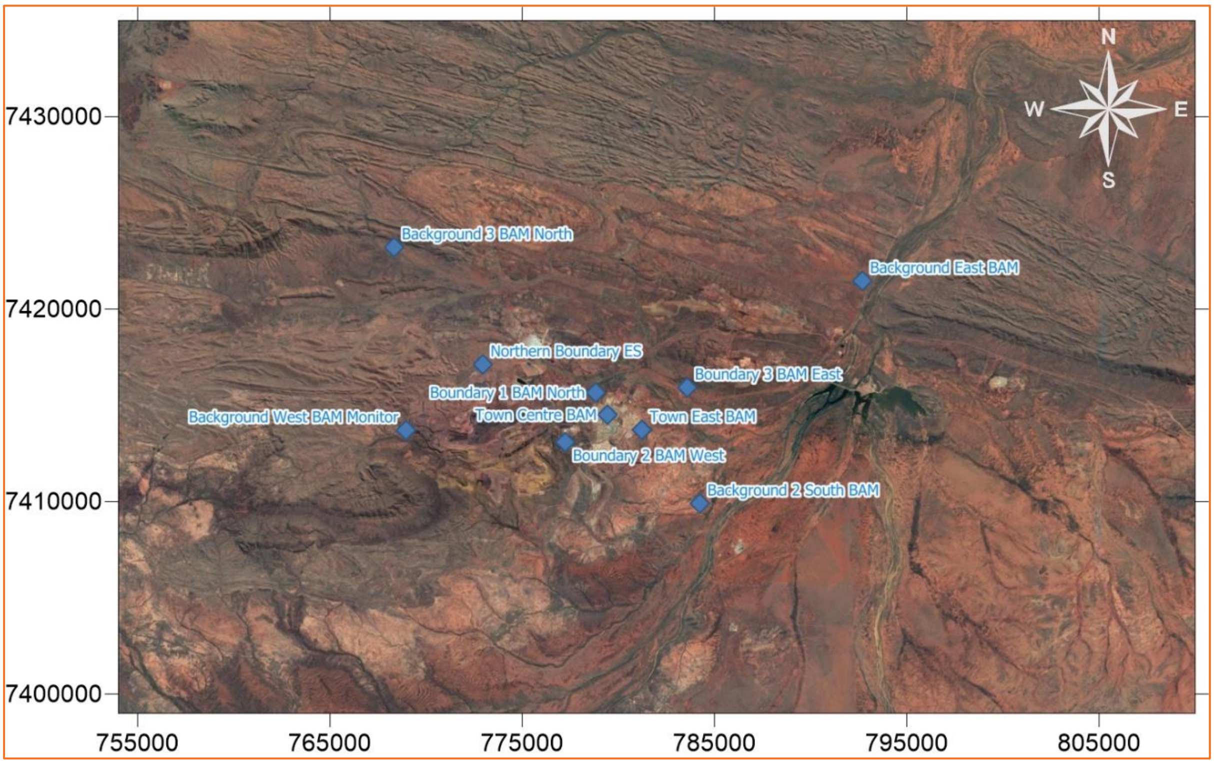

Figure 5-3: BHP ambient monitoring locations within the Newman region

Table 5-3: Arcs of influence for determining background concentrations

Monitor	From	To
Background East BAM	320°	75°
Background 2 South BAM	75°	225°
Background West BAM	225°	310°
Background 3 BAM north	225°	320°

Table 5-4: Statistics of 24-hour averaged PM_{10} background file

Statistic	Concentration ($\mu g/m^3$)
Maximum	76
99 Percentile	48.9
95 Percentile	28.6
90 Percentile	23.2
70 Percentile	15.3
Average	14.5
Number greater than 50 $\mu g/m^3$	4
Number greater than 70 $\mu g/m^3$	2

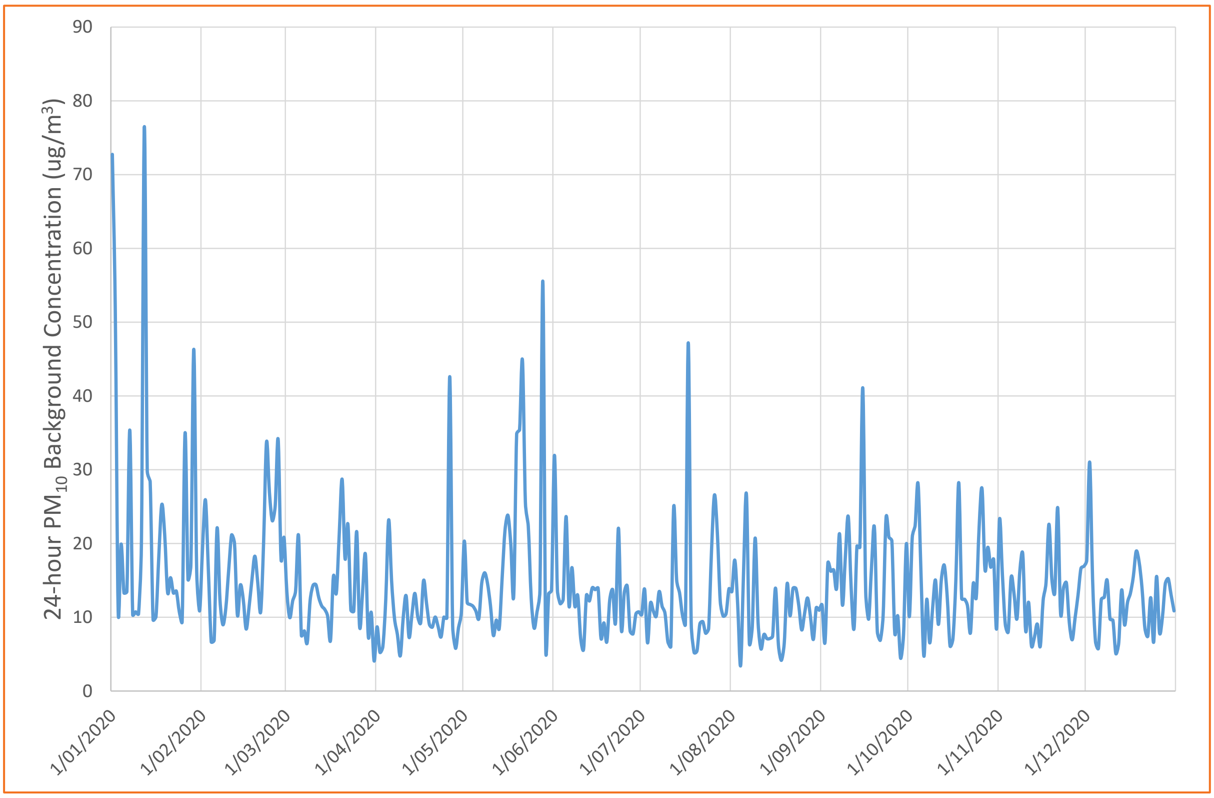

Figure 5-4: Time series graph of the 24-hour PM_{10} background file for the Newman region

6 Emissions to air estimation

When determining the potential impact of a facility, either existing or proposed, one of the critical inputs is the source emission file. The following sections outline the process whereby potential sources are identified, and quantified, based on the forecast throughput tonnage of the facility.

6.1 Emission Source Inventory

The key emission sources for the operating phase of the Project are associated with:

- drilling and blasting
- material handling from loading and unloading activities involving;
  - loading trucks
  - unloading trucks
  - bulldozing
  - crushing
- processing;
  - crushing
  - screening
  - material transfer including conveyors and transfer stations
- wheel generated dust from roads and haul roads
- wind erosion from stockpiles and open areas.

A summary of the estimated annual mining tonnages for the life of the mines within the Project (BHP, 2020) are presented in Table 6.1. From this table it is apparent that the maximum total tonnages, for Western Ridge, are predicted to occur in 2029, assuming that mining commences in 2024.

Table 6-1: Forecast mining tonnages (Mtpa)

Pit	Type	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Mt Helen	Ore	0	3.6	9.3	15.6	4.5	11.1	18.9	5.3	9.5	13.0	7.1
	Waste	0.0	4.9	7.8	10.3	3.6	40.5	49.3	14.2	26.0	34.6	15.6
Silver Knight	Ore	0.0	10.4	18.2	11.7	10.7	12.4	7.7	18.5	11.6	7.4	14.3
	Waste	0.0	4.0	9.0	6.4	6.9	28.8	11.5	16.2	4.0	3.9	8.6
Bill's Hill	Ore	0.0	1.4	8.9	20.2	13.9	12.0	11.5	2.2	0.0	0.0	0.00
	Waste	1.1	4.9	8.5	11.0	6.8	7.4	6.2	0.6	0.0	0.0	0.00
Eastern Syncline	Ore	1.9	6.8	8.5	2.5	0.0	4.8	0.0	0.0	0.0	0.0	2.4
	Waste	5.6	29.0	3.3	0.1	0.0	1.8	0.0	0.0	0.0	0.0	20.5
TOTAL		**8.6**	**65.0**	**73.5**	**77.8**	**46.5**	**118.8**	**105.1**	**57.0**	**51.1**	**58.9**	**68.5**

6.2 Emission estimates – Western Ridge

This section outlines the emission estimation process for the Project. Emission estimates are sourced from this inventory for inclusion in the dispersion model. It includes the emissions from mine operations, facilities and associated infrastructure including the road network. Emissions from all key sources have been identified according to accepted methods and, in accordance with the SEA (BHP, 2015), the NPI EETM for Mining (EA, 2012a) has been referenced for emission equations and values.

The emphasis of the emission estimation and modelling is on the potential impact from the operating phase of the various operations within the Project. Emission estimation of construction activities is excluded from the assessment due to their intermittent nature over the life of the Project.

The emission estimation process for the Mt Whaleback and Eastern Ridge operations, for both the existing and future scenarios are outlined in Appendix F.

6.2.1 Drilling

Emissions for drilling have been calculated using the default emissions contained within the EETM for Mining (EA, 2012a). The default values are:

- TSP: 0.59 kg/hole
- PM_{10}: 0.31 kg/hole
- $PM_{2.5}$: 30% of PM_{10} emissions

The statistics of the annual PM_{10} emissions from drilling for PM_{10} are contained in Appendix E.

6.2.2 Blasting

Emissions for drilling have been calculated using Equation 19 outlined in Appendix A of the EETM for Mining. This is represented by Equation 1:

Equation 1: $$EF_{TSP\ (kg/blast)} = 0.00022 \times A^{1.5}$$

Where A = blast area (m^2)

The emission factor for PM_{10} is taken as 52% of the TSP emission and the $PM_{2.5}$ emissions are taken as 30% of the PM_{10} emissions. The statistics of the annual PM_{10} emissions for blasting for PM_{10} are contained in Appendix D.

Within the model blasting was assumed to occur approximately twice per week within each pit area with blasting times at either 11am or 1pm.

6.2.3 Loading ore/waste

Emissions for loading ore and waste have been calculated using the default value for excavators and front end loaders on overburden of:

- TSP: 0.025 kg/t
- PM_{10}: 0.012 kg/t

The emission factor for $PM_{2.5}$ emissions is taken as 30% of the PM_{10} emissions. The statistics of the annual emissions for loading for PM_{10} are contained in Appendix E.

6.2.4 Unloading ore/waste

Emissions for unloading ore and waste have been calculated using the default values of:

- TSP: 0.012 kg/t
- PM_{10}: 0.0043 kg/t

The emission factor for $PM_{2.5}$ emissions is taken as 30% of the PM_{10} emissions. The statistics of the annual emissions for loading for PM_{10} are contained in Appendix E.

6.2.5 Bulldozing

Emissions for the operation of bulldozers on both ore and waste have been determined using Equation 16 and Equation 17 outlined in Appendix A of the EETM for Mining (EA, 2012) and presented below as Equation 2 for TSP and Equation 3 for PM_{10}. The silt and moisture contents used were the defaults listed in the manual (2% moisture, 10% silt).

Equation 2: $$EF_{TSP\,(kg/hr)} = 2.6 \times \frac{s^{1.2}{}_{(\%)}}{M^{1.3}{}_{(\%)}}$$

Equation 3: $$EF_{PM_{10}\,(kg/hr)} = 0.34 \times \frac{s^{1.5}{}_{(\%)}}{M^{1.4}{}_{(\%)}}$$

Where: s = silt content (%)
M = moisture (%)

The emission factor for $PM_{2.5}$ emissions is taken as 30% of the PM_{10} emissions. The statistics of the annual PM_{10} emissions for bulldozing are contained in Appendix E.

6.2.6 Front end loaders

Emissions for the operation of front end loaders, at the Run of Mine (ROM) pad, used the default emission factor listed in Appendix A of the EETM for Mining (EA, 2012) for overburden. These factors are:

- TSP: 0.025 kg/tonne
- PM_{10}: 0.012 kg/tonne

The emission factor for $PM_{2.5}$ emissions is taken as 30% of the PM_{10} emissions. The statistics of the annual emissions for loading for PM_{10} are contained in Appendix E.

6.2.7 Primary Crusher

The emissions for the primary crusher were determined using the default emission factors for high moisture content ores from Table 3 of the EETM for Mining (EA, 2012). These factors are:

- TSP: 0.01 kg/tonne
- PM_{10}: 0.004 kg/tonne

The emission factor for $PM_{2.5}$ emissions is taken as 30% of the PM_{10} emissions. The statistics of the annual emissions for loading for PM_{10} are contained in Appendix E.

6.2.8 Haul Roads

To determine emissions from wheel generated dust along the haul roads the default equation for 'unpaved roads from wheels' was utilised (Equation 2). The weight of the haul trucks was taken as 272 tonnes – being the average of an empty and fully laden CAT793E haul truck and the default silt content of 10% was utilised.

Equation 4: $$EF_{(kg/VKT)} = \frac{0.4536}{1.6093} \times k \times \left(\frac{s_{(\%)}}{12}\right)^{a} \times \left(\frac{W_{(t)}}{3}\right)^{b}$$

Where: k = constant (TSP = 4.9, PM_{10} = 1.5)
$s_{(\%)}$ = silt content (%)
$W_{(t)}$ = vehicle mass (t)
a = constant (TSP = 0.7, PM_{10} = 0.9)
b = constant (0.45)

The emission factor for $PM_{2.5}$ emissions is taken as 30% of the PM_{10} emissions. The statistics of the annual emissions for loading for PM_{10} are contained in Appendix E.

6.2.9 Wind erosion

The default emission factor for wind erosion in the EETM for Mining is a constant emission of 0.2 kg/ha/hr which, while potentially suitable for the calculation of annual emissions, is not suitable for inclusion in atmospheric modelling. This assessment used the modified Shao equation outlined in SKM (2005) which is represented as Equation 3:

Equation 5: $$PM_{10(g/m^2/s)} = k \times \left\{WS^3 \times \left(1 - \left(WS_O{}^2/WS^2\right)\right)\right\} \qquad WS > WS_O$$

$$PM_{10(g/m^2/s)} = 0 \qquad WS < WS_O$$

Where: WS = wind speed (m/s)
WS_0 = threshold for particulate matter lift off (m/s)
k is a constant

For this assessment the wind speed threshold was set at 5.4 m/s and the k constants were set at 5.3 x 10^{-6}, resulting in an overall emission rate of 0.4 kg/ha/hr for PM_{10} from open areas. This is higher than the emission rate of 0.2 kg/ha/hr specified in the EETM for Mining (EA, 2012) which, as outlined in SKM (2005), is derived for the Hunter Valley region of New South Wales (NSW). The SKM (2005) report notes that an applicable rate for the Pilbara region is 0.4 kg/ha/hr for PM_{10} which is the value used in this assessment. This increase in wind erosion emissions is based on a range of factors including increased wind speed, lower rainfall and higher evaporation rates in the Pilbara region.

The emission factor for TSP is taken as twice that of the PM_{10} emissions while $PM_{2.5}$ emissions are taken as 30% of the PM_{10} emissions (Table 5.1).

6.3 Emission Controls

Emissions controls (for dust abatement) were included in the emissions estimation and these controls are summarised in Table 6.2, along with the percentage reduction applied to each source type.

Table 6-2: Dust abatement in place (included in model)

	Equipment	Dust abatement description	Emission reduction
Mining	Bulldozing	None	0%
	Loading ore and waste	In pit reduction	5% (PM_{10}) 50% (TSP)
	Unloading waste	None	0%
	Unloading ore at ROM pad	None	0%
	Drilling	In pit reduction	5% (PM_{10}) 50% (TSP)
	Blasting	In pit reduction	5% (PM_{10}) 50% (TSP)
	Wind erosion (OSA and ROM pad)	Watering	15%
Haul road	Hauling	Level 1 watering	50% (75% availability) 25% (25% availability)
Processing Facility	Unloading ore into primary crusher by front end loader	Watering	50%
	Primary crushing of ore	Primarily enclosed	90%

6.4 Emission summary

A summary of the estimated annual emissions from the Project is shown in Table 6.3.

Table 6-3: Estimate of TSP, PM_{10} and $PM_{2.5}$ annual particulate emissions from the Project (kg/yr)

Source	Process	2029		
		TSP	PM_{10}	$PM_{2.5}$
Mining	Drilling	26,981	26,936	8,081
	Blasting	206,760	204,062	61,219
	Loading	1,485,349	1,354,638	406,391
	Unloading	1,537,604	550,975	165,293
	Bulldozers	422,433	102,840	30,852
	Front End Loaders	400,298	192,143	57,643
Processing	Primary Crusher	35,443	14,177	4,253
Wind Erosion	Wind Erosion	929,155	521,272	156,382
Haul Roads	Haul Roads	12,102,271	3,572,118	1,071,635
Total		17,146,294	6,539,161	1,961,749

7 Predicted air quality impact

Comparison of the modelled results to the assessment criteria is intended to provide an objective evaluation of the potential impact of the operations at the nearest sensitive receptors. Modelled ground-level concentrations for key air pollutants have been compared to ambient air quality assessment criteria to determine the potential impacts.

The results of the modelling are presented for two scenarios:

- Existing (Whaleback and Eastern Ridge for 2022 with current controls and background) indicative of model validation (Appendix C).
- Future -
    - Isolation - modelled results for Western Ridge exclusive and inclusive of the background concentrations (refer to Section 3.2).
    - Cumulative - modelled results for Western Ridge and the Mt Whaleback and Eastern Ridge operations inclusive of the background concentrations.

7.1 Particulates as TSP

To assess the potential air quality impact, modelled TSP concentrations are compared to the assessment criteria of 90 µg/m^3 as discussed in Section 4.2. The predicted ground level concentrations at the key sensitive receptor locations are presented for each scenario. The modelled concentration statistics[1] are provided in tabulated form for each scenario and include the background air quality estimate for the region. Figures demonstrating the ground level concentration contours are also presented.

7.1.1 Existing

The statistics of the TSP model results, for the existing scenario (Whaleback and Eastern Ridge for 2022 with current controls and with background concentrations), are presented in Table 7-1. These results indicate the model is predicting that both the Town Centre and Newman East monitors have elevated concentrations with up to 59 predicted excursions of the relevant criteria.

Table 7-1: Statistics of 24-hour TSP concentration at sensitive receptors – Existing including background (µg/m^3)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >90
1	Town Monitor	233	188	149	144	121	107	72	58	59
2	Newman East	204	173	137	136	113	100	65	53	49
3	Newman Boundary 1	224	195	170	167	125	108	75	61	70
4	Newman Boundary 2	306	281	210	204	179	144	85	71	102

[1] The statistics tables provide a summary of the distribution of predicted concentration as well as the number of exceedances of the relevant assessment criteria.

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >90
5	Newman Boundary 3	292	286	224	216	196	155	101	78	129
6	Newman ER OB32	217	161	154	149	129	115	83	66	89

The isopleths of the maximum predicted 24-hour TSP concentrations for the existing scenario (with background) are presented in Figure 7-1.

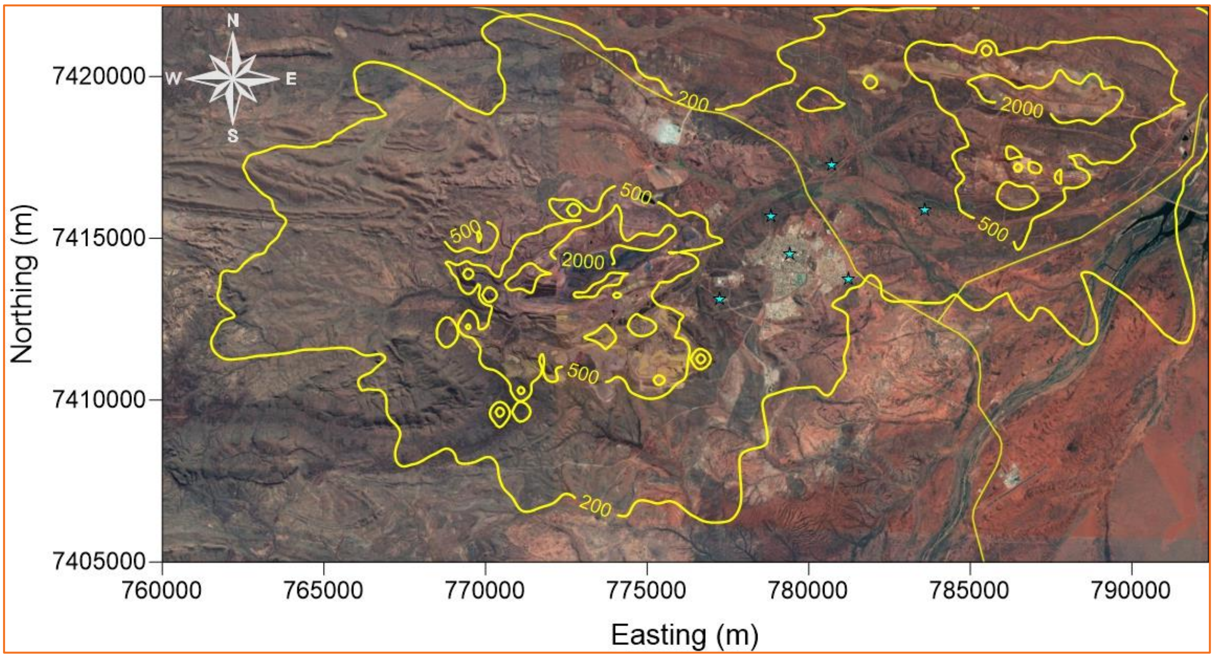

Figure 7-1: Maximum predicted existing 24-hour TSP concentrations - including background

7.1.2 Future

The statistics of the 24-hour predicted TSP concentrations for the proposed Western Ridge operations, in isolation of other sources, are presented in Table 7-2 while the statistics of the predicted cumulative concentrations (inclusive of background and the Mt Whaleback and Eastern operations) are presented in Table 7-3. The results indicate that:

- For Western Ridge in isolation:
  - The model predicts the maximum concentrations will remain below the applicable criteria.
- For the cumulative scenario:
  - When compared to the Western Ridge operations in isolation (Table 7-2), there is an increase in the predicted ground level concentrations, indicating that Mt Whaleback and Eastern Ridge operations have a greater predicted impact on the receptors than the proposed Western Ridge operations.

- When the predicted TSP concentrations for the future scenario are compared to those predicted for the current scenario (Table 7-1) it is apparent that:
  - The model is predicting a reduction across all statistics including the maximum concentrations.
  - The model is predicting that there will be a reduction in the number of excursions of the applicable criteria.

Table 7-2: Statistics of 24-hour TSP concentration at receptor locations[2] – Western Ridge in isolation (µg/m³)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >90
1	Town Monitor	40	33	27	25	17	10	1	3	0
2	Newman East	30	27	20	17	11	7	1	2	0
3	Newman Boundary 1	32	30	23	20	15	9	1	3	0
4	Newman Boundary 2	50	45	34	32	22	13	2	4	0
5	Newman Boundary 3	25	24	17	14	10	6	0	2	0
6	Newman ER OB32	26	24	18	16	12	7	1	2	0

Table 7-3: Statistics of 24-hour TSP concentration at receptor locations – Cumulative including background (µg/m³)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >90
1	Town Monitor	212	161	112	104	88	79	56	46	15
2	Newman East	198	158	113	111	91	79	54	45	19
3	Newman Boundary 1	196	155	104	94	83	76	57	47	11
4	Newman Boundary 2	276	207	166	145	119	97	58	52	43
5	Newman Boundary 3	205	200	158	155	125	106	70	57	56
6	Newman ER OB32	187	151	123	110	101	85	62	51	29

[2] Only R1 and R2 are considered sensitive receptor locations.

The isopleths of the maximum predicted 24-hour TSP concentrations for the proposed Western Ridge operations, in isolation of other sources, is presented in Figure 7-2. The predicted TSP ground level concentrations for the cumulative future scenario (inclusive of the proposed Western Ridge operations, and the future Mt Whaleback and Eastern Ridge operations, with background) is presented in Figure 7-3.

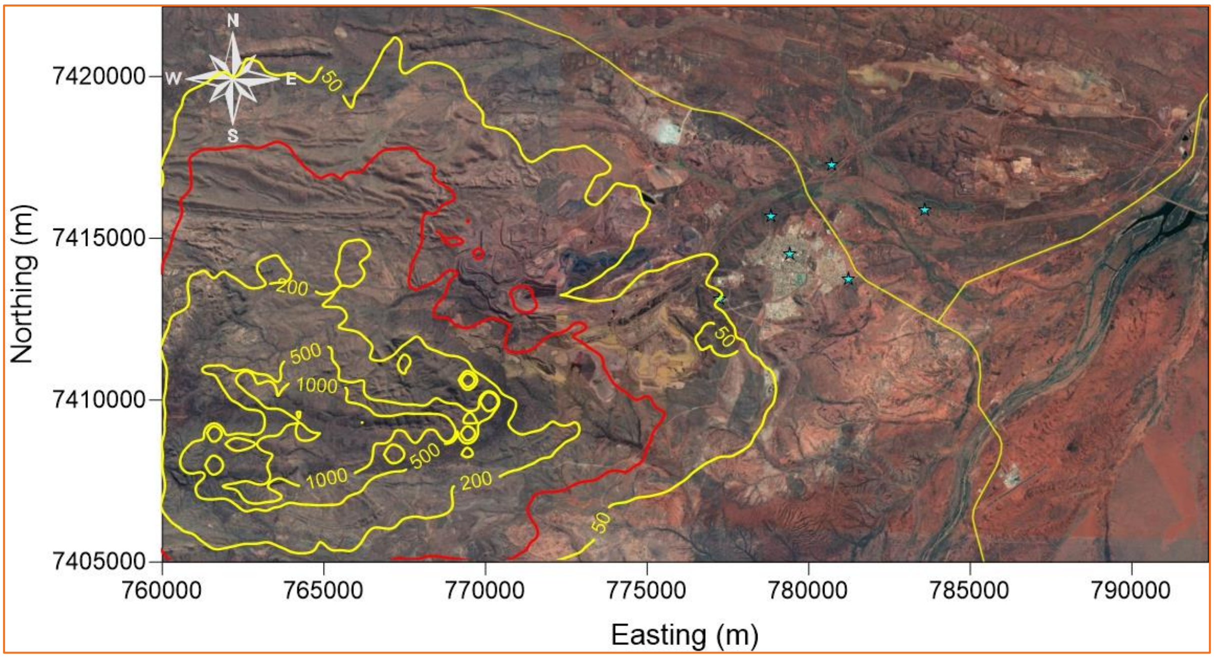

Figure 7-2: Maximum predicted future 24-hour TSP concentrations – Western Ridge in isolation

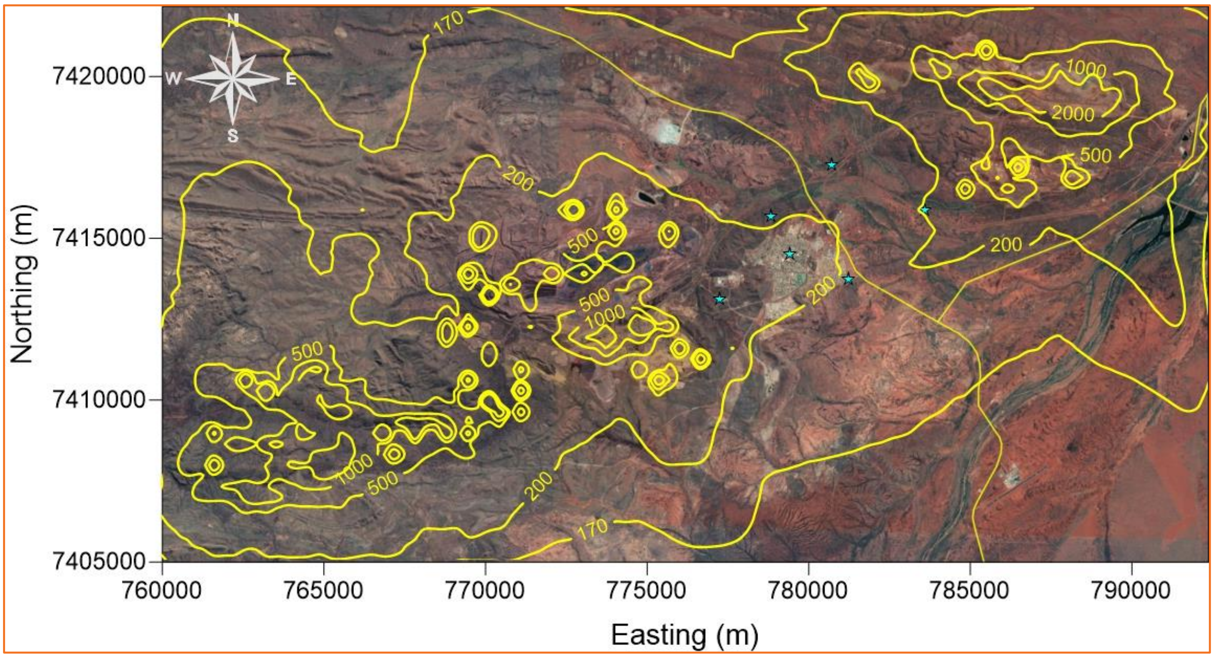

Figure 7-3: Maximum predicted future 24-hour TSP concentrations – Cumulative including background

7.2 Particulates as PM_{10}

To assess the potential air quality impact, modelled PM_{10} concentrations are compared to the assessment criteria of 70 µg/m^3 as discussed in Section 4.2. The predicted ground level concentrations at the key sensitive receptor locations are presented for each scenario. The modelled concentration statistics[3] are provided in tabulated form for each scenario and include the background air quality estimate for the region. Figures demonstrating the ground level concentration contours are also presented.

7.2.1 Existing

The statistics of the PM_{10} model results, for the existing scenario with background concentrations, are presented in Table 7-4. These results were utilised in the model validation study in Appendix C.

Table 7-4: Statistics of 24-hour PM_{10} concentration at receptor locations[4] – Existing including background (µg/m^3)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >70
1	Town Monitor	121	93	77	74	63	57	39	31	12
2	Newman East	112	91	77	75	63	54	36	29	11
3	Newman Boundary 1	120	95	84	77	67	59	40	32	15
4	Newman Boundary 2	177	142	114	110	91	77	44	37	45
5	Newman Boundary 3	170	168	141	120	106	85	54	43	65
6	Newman ER OB32	114	93	82	80	67	61	45	35	12

The isopleths of the annual average PM_{10} concentrations (with background) are presented in Figure 7-4 while the isopleths for the predicted maximum 24-hour PM_{10} concentrations are presented in Figure 7-5.

[3] The statistics tables provide a summary of the distribution of predicted concentration as well as the number of exceedances of the relevant assessment criteria.

[4] Only R1 and R2 are considered sensitive receptor locations

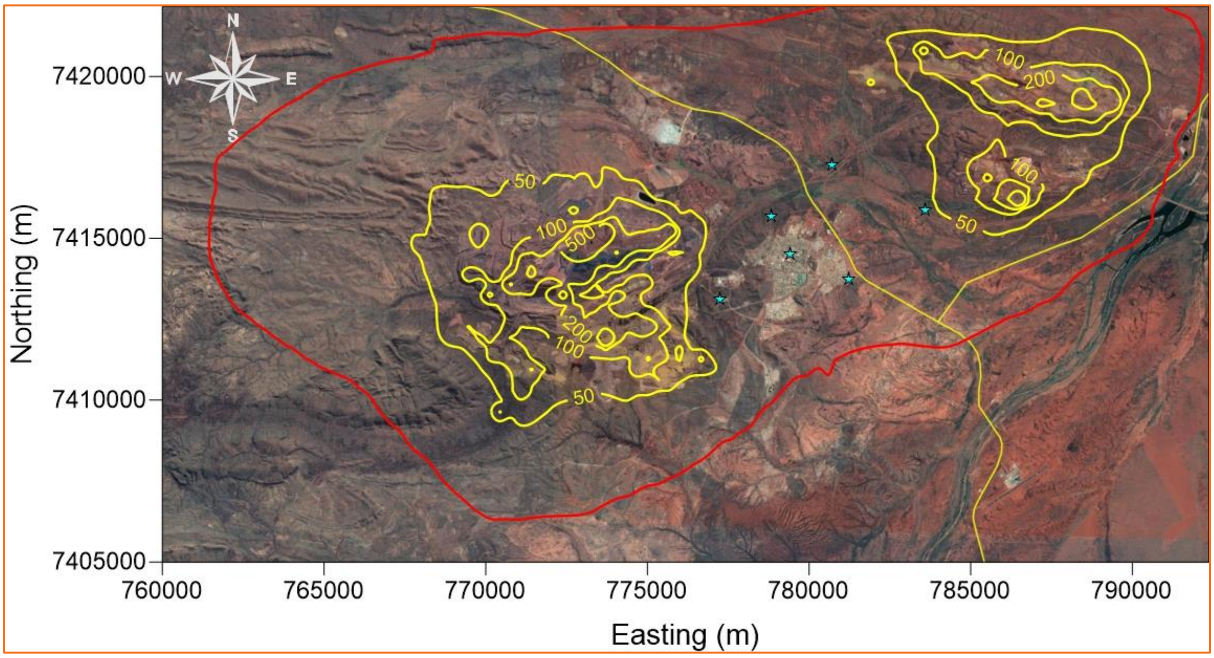

Figure 7-4: Predicted annual average PM_{10} concentrations - including background

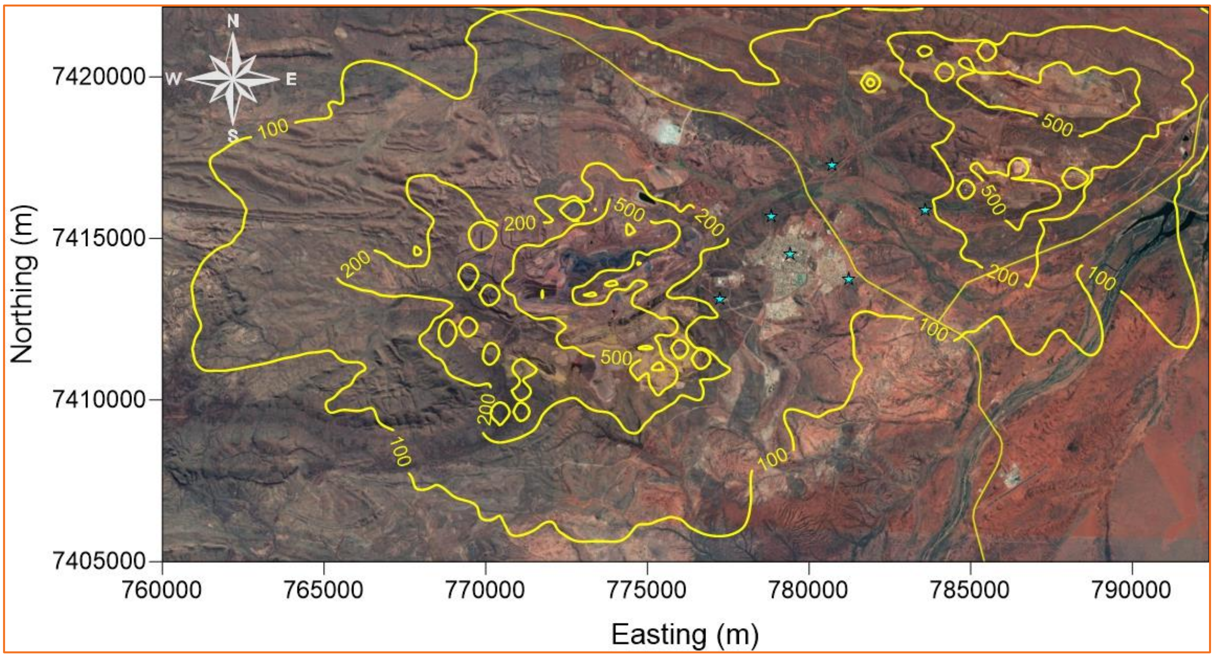

Figure 7-5: Maximum predicted existing 24-hour PM_{10} concentrations - including background

7.2.2 Future

The statistics of the 24-hour predicted PM_{10} concentrations for the proposed Western Ridge operations, in isolation of other sources, are presented in Table 7-5 while the statistics of the predicted cumulative concentrations (inclusive of background and the Mt Whaleback and Eastern operations) are presented in Table 7-6. The results indicate that:

- For Western Ridge in isolation:
  - The model predicts the maximum concentrations will remain below the applicable criteria.
- For the cumulative scenario:
  - There is an increase in the predicted concentrations compared to the Western Ridge operations in isolation (Table 7-5), indicating that the Mt Whaleback and Eastern Ridge operations have a greater predicted impact on the receptors than the proposed Western Ridge operations.
  - When the predicted PM_{10} concentrations for the future scenario are compared to those predicted for the current scenario (Table 7-4) it is apparent that:
    - The model is predicting a reduction across all statistics including the maximum concentrations.
    - The model is predicting that there will be a reduction in the number of excursions of the applicable criteria.

Table 7-5: Statistics of 24-hour PM_{10} concentration at receptor locations[5] – Western Ridge in isolation (µg/m³)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >70
1	Town Monitor	25	20	16	16	11	6	1	2	0
2	Newman East	19	17	13	12	8	5	0	1	0
3	Newman Boundary 1	20	18	14	13	10	6	1	2	0
4	Newman Boundary 2	31	26	20	19	14	8	1	2	0
5	Newman Boundary 3	16	16	11	10	7	4	0	1	0
6	Newman ER OB32	17	15	11	11	8	4	0	1	0

Table 7-6: Statistics of 24-hour PM_{10} concentration at receptor locations[6] – Cumulative including background (µg/m³)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >70
1	Town Monitor	119	82	64	59	51	43	30	25	2
2	Newman East	110	82	57	55	49	43	29	24	3
3	Newman Boundary 1	107	79	58	55	47	43	32	26	2

[5] Only R1 and R2 are considered sensitive receptor locations.

[6] Only R1 and R2 are considered sensitive receptor locations.

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >70
4	Newman Boundary 2	164	118	98	93	70	57	33	29	19
5	Newman Boundary 3	120	105	78	76	63	53	36	29	9
6	Newman ER OB32	99	77	65	59	52	44	34	28	2

The isopleths of the predicted PM_{10} concentrations are presented as follows:

- Figure 7-6 presents the predicted annual average PM_{10} concentrations for the proposed Western Ridge operations in isolation.
- Figure 7-7 presents the predicted maximum 24-hour PM_{10} concentrations for the proposed Western Ridge operations in isolation.
- Figure 7-8 presents the predicted annual average PM_{10} concentrations for the cumulative scenario (proposed Western Ridge, Mt Whaleback and Eastern Ridge operations) with background.
- Figure 7-9 presents the predicted maximum 24-hour PM_{10} concentrations for the cumulative scenario (proposed Western Ridge, Mt Whaleback and Eastern Ridge operations) with background.

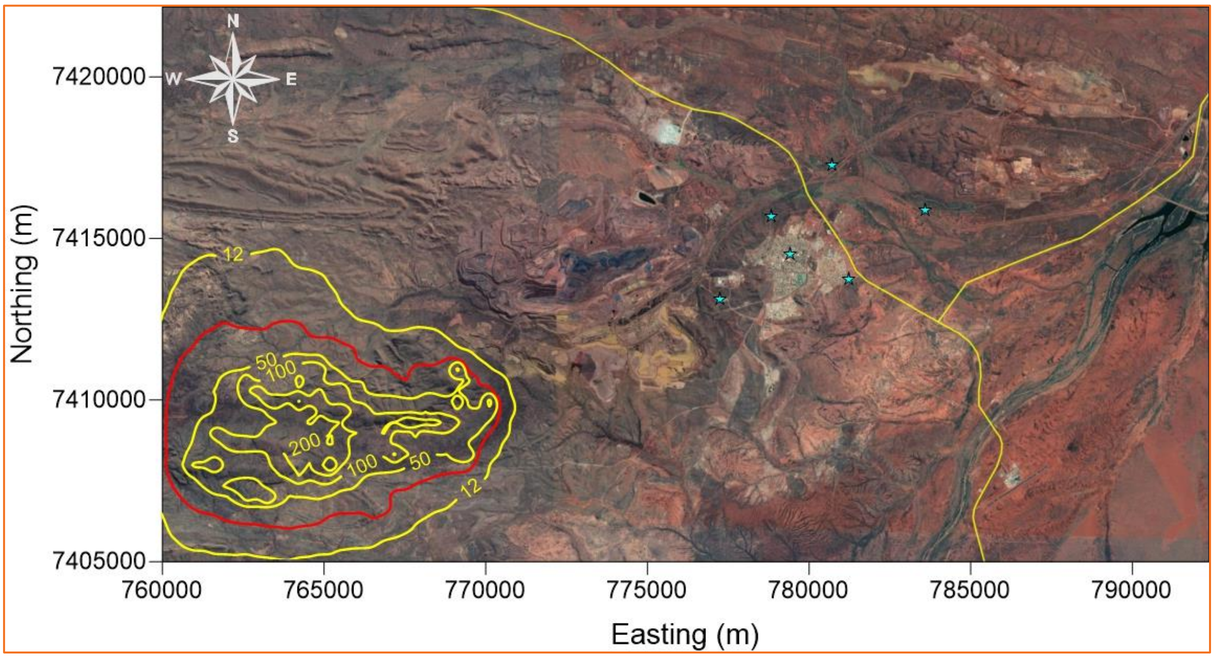

Figure 7-6: Predicted annual average PM_{10} concentrations – Western Ridge in isolation

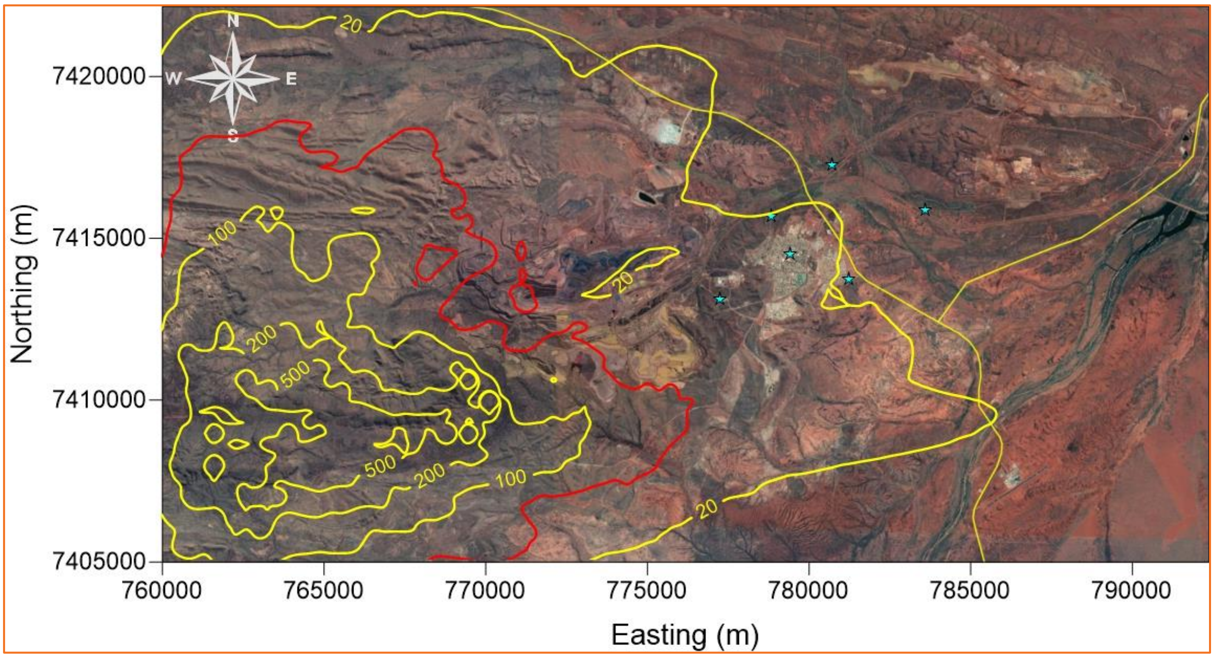

Figure 7-7: Maximum predicted future 24-hour PM_{10} concentrations – Western Ridge in isolation

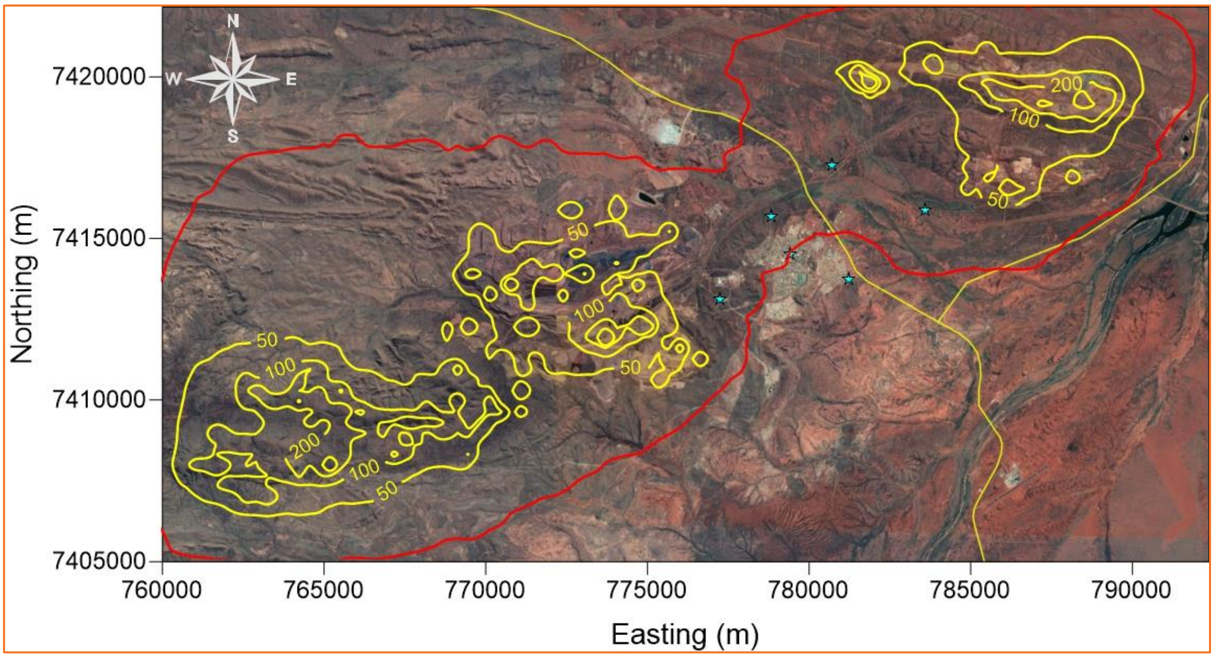

Figure 7-8: Predicted annual average PM_{10} concentrations – Cumulative including background

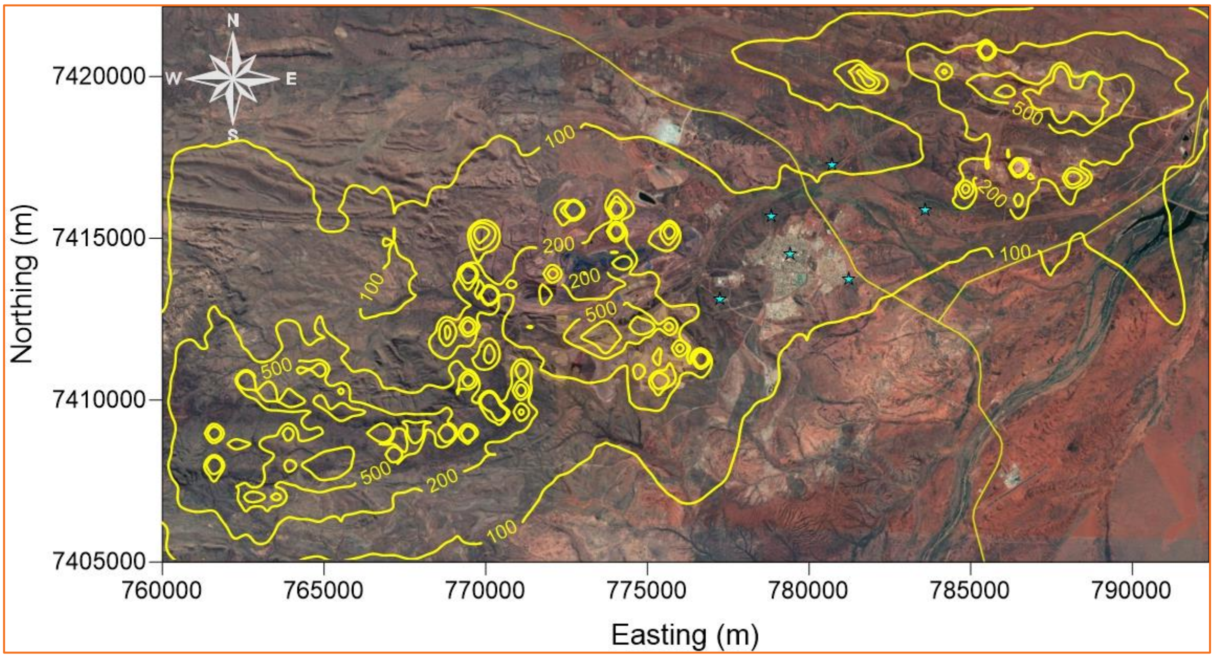

Figure 7-9: Maximum predicted future 24-hour PM_{10} concentrations – Cumulative including background

7.3 Particulates as $PM_{2.5}$

To assess the potential air quality impact, modelled $PM_{2.5}$, concentrations are compared to two criteria:

- DWER (2019) consistent with NEPM annual average of 8 µg/m³.
- DWER (2019) consistent with NEPM 24-hour average of 25 µg/m³.

The predicted ground level concentrations of particles as $PM_{2.5}$ at the key receptor locations are presented for each scenario. The modelled concentration statistics are tabulated for each scenario and include the background air quality estimate for the region. Figures demonstrating the ground level concentration contours are also presented.

7.3.1 Existing

The statistics of the $PM_{2.5}$ model results, for the existing scenario with background concentrations, are presented in Table 7-7.

Table 7-7: Statistics of 24-hour $PM_{2.5}$ concentration at receptor locations[7] – Existing including background (µg/m³)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >25
1	Town Monitor	40	28	25	24	20	18	12	10	4
2	Newman East	34	30	25	24	20	17	11	9	5
3	Newman Boundary 1	37	31	26	25	21	19	13	10	7
4	Newman Boundary 2	56	44	37	36	29	25	14	12	36
5	Newman Boundary 3	56	55	46	39	35	27	17	14	47
6	Newman ER OB32	35	30	26	25	22	20	14	11	9

The isopleths of the predicted annual average $PM_{2.5}$ concentrations, for the existing scenario with background, are presented in Figure 7-10 while the isopleths for the predicted maximum 24-hour PM_{10} concentrations are presented in Figure 7-11.

[7] Only R1 and R2 are considered sensitive receptor locations.

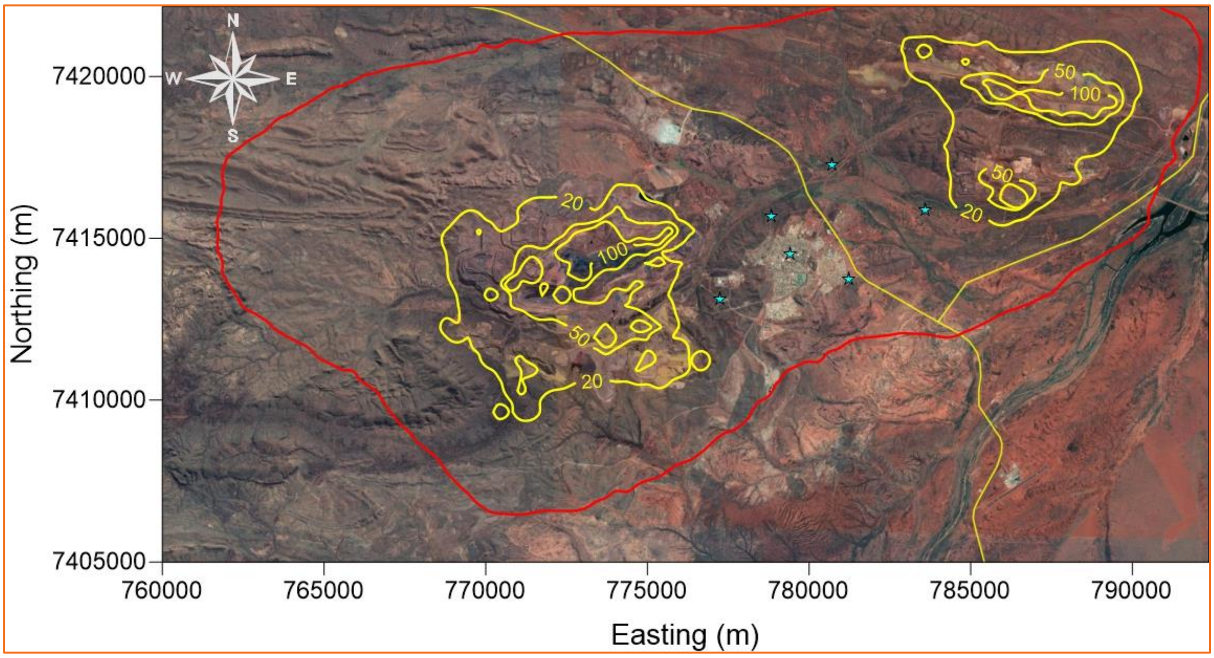

Figure 7-10: Predicted annual average $PM_{2.5}$ concentrations - including background

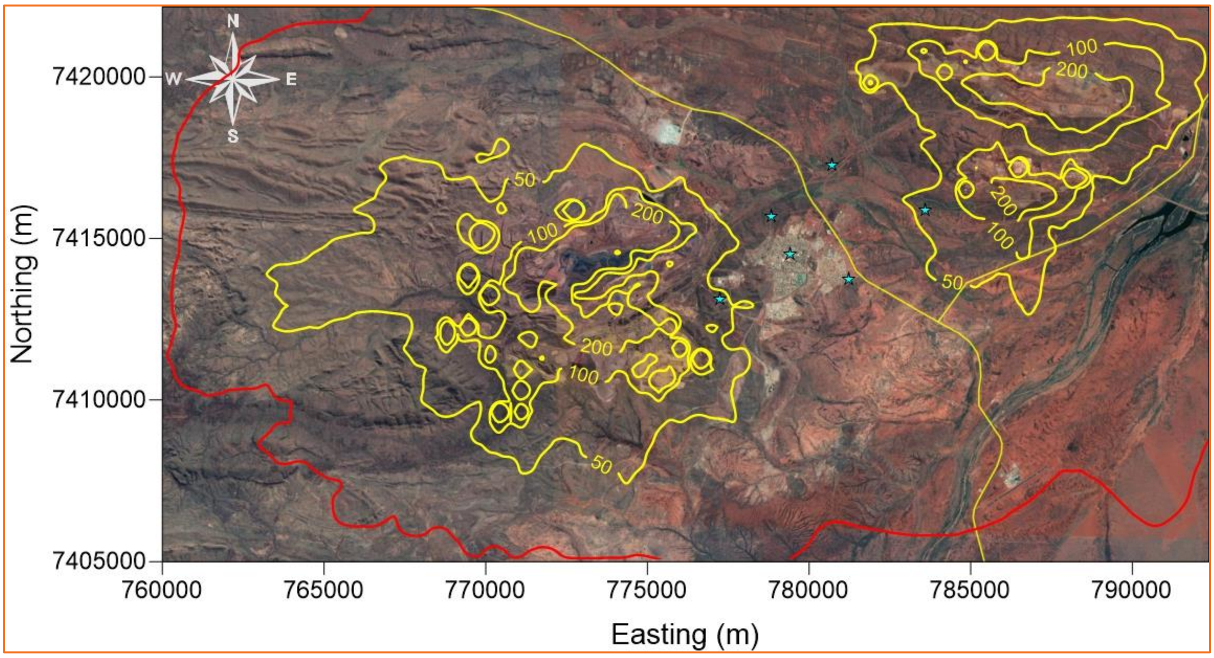

Figure 7-11: Maximum predicted existing 24-hour $PM_{2.5}$ concentrations - including background

7.3.2 Future

The statistics of the 24-hour predicted $PM_{2.5}$ concentrations for the proposed Western Ridge operations, in isolation of other sources, are presented in Table 7-8 while the statistics of the predicted cumulative concentrations (inclusive of background and the Mt Whaleback and Eastern operations) are presented in Table 7-9. The results indicate that:

- For Western Ridge in isolation:
  - The model predicts the maximum concentrations will remain below the applicable criteria.
- For the cumulative scenario:
  - There is an increase in the predicted concentrations compared to the Western Ridge operations in isolation (Table 7-8), indicating that the Mt Whaleback and Eastern Ridge operations have a greater predicted impact on the receptors than the proposed Western Ridge operations.
  - When the predicted PM_{10} concentrations for the future scenario are compared to those predicted for the current scenario (Table 7-7) it is apparent that:
    - The model is predicting a reduction across all statistics including the maximum concentrations.
    - The model is predicting that there will be a reduction in the number of excursions of the applicable criteria.

Table 7-8: Statistics of 24-hour $PM_{2.5}$ concentration at receptor locations[8] – Western Ridge in isolation (µg/m³)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >25
1	Town Monitor	8	7	5	5	4	2	0	1	0
2	Newman East	6	6	4	4	3	1	0	0	0
3	Newman Boundary 1	7	6	5	4	3	2	0	1	0
4	Newman Boundary 2	10	9	7	6	5	3	0	1	0
5	Newman Boundary 3	5	5	3	3	2	1	0	0	0
6	Newman ER OB32	6	5	4	4	3	1	0	0	0

[8] Only R1 and R2 are considered sensitive receptor locations.

Table 7-9: Statistics of 24-hour $PM_{2.5}$ concentration at receptor locations[9] – Cumulative including background ($\mu g/m^3$)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >25
1	Town Monitor	37	25	21	19	16	13	9	8	1
2	Newman East	34	26	18	17	15	14	9	7	2
3	Newman Boundary 1	33	24	18	17	15	14	10	8	1
4	Newman Boundary 2	52	39	32	30	22	18	10	9	15
5	Newman Boundary 3	39	33	25	24	20	17	11	9	5
6	Newman ER OB32	30	23	20	19	17	14	11	9	1

The isopleths of the predicted $PM_{2.5}$ concentrations are presented as follows:

- Figure 7-12 presents the predicted annual average $PM_{2.5}$ concentrations for the proposed Western Ridge operations in isolation.
- Figure 7-13 presents the predicted maximum 24-hour $PM_{2.5}$ concentrations for the proposed Western Ridge operations in isolation.
- Figure 7-14 presents the predicted annual average $PM_{2.5}$ concentrations for the cumulative scenario (proposed Western Ridge, Mt Whaleback and Eastern Ridge operations) with background.
- Figure 7-15 presents the predicted maximum 24-hour $PM_{2.5}$ concentrations for the cumulative scenario (proposed Western Ridge, Mt Whaleback and Eastern Ridge operations) with background.

[9] Only R1 and R2 are considered sensitive receptor locations.

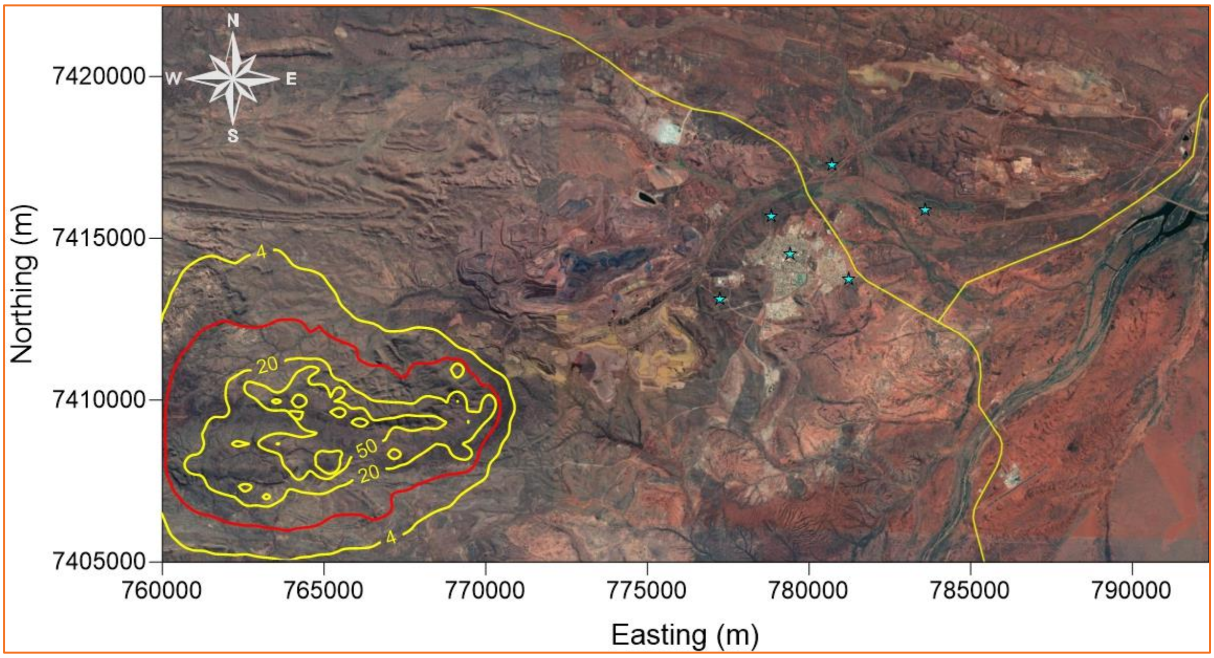

Figure 7-12: Predicted annual average $PM_{2.5}$ concentrations – Western Ridge in isolation

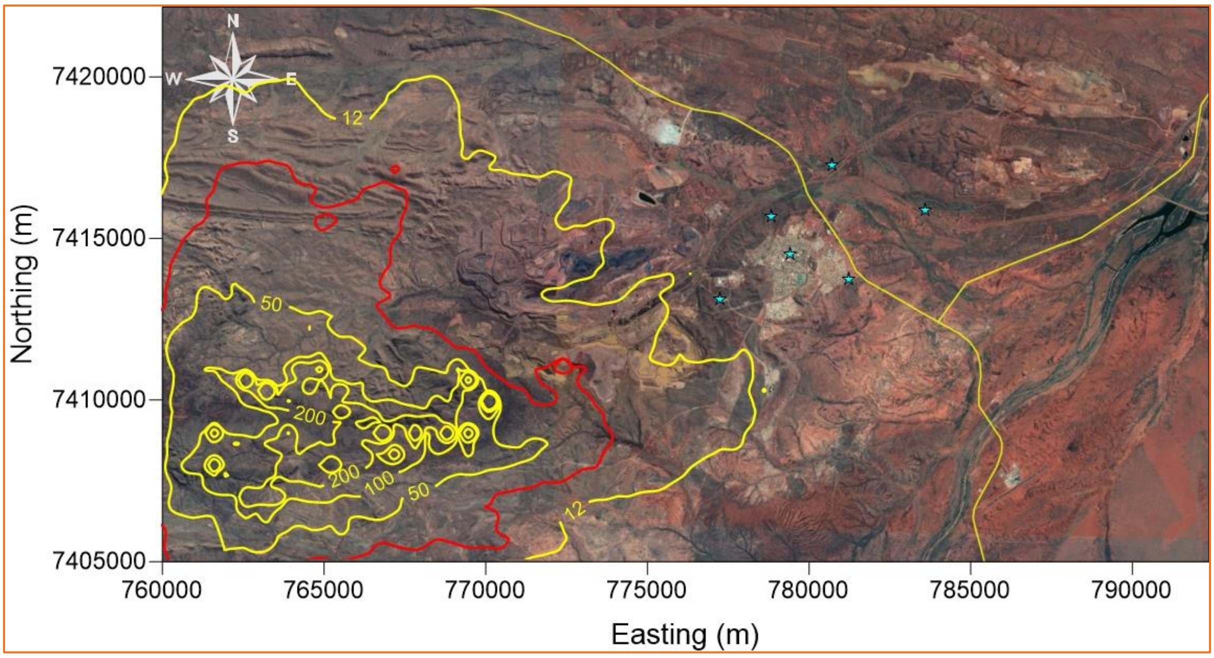

Figure 7-13: Maximum predicted future 24-hour $PM_{2.5}$ concentrations – Western Ridge in isolation

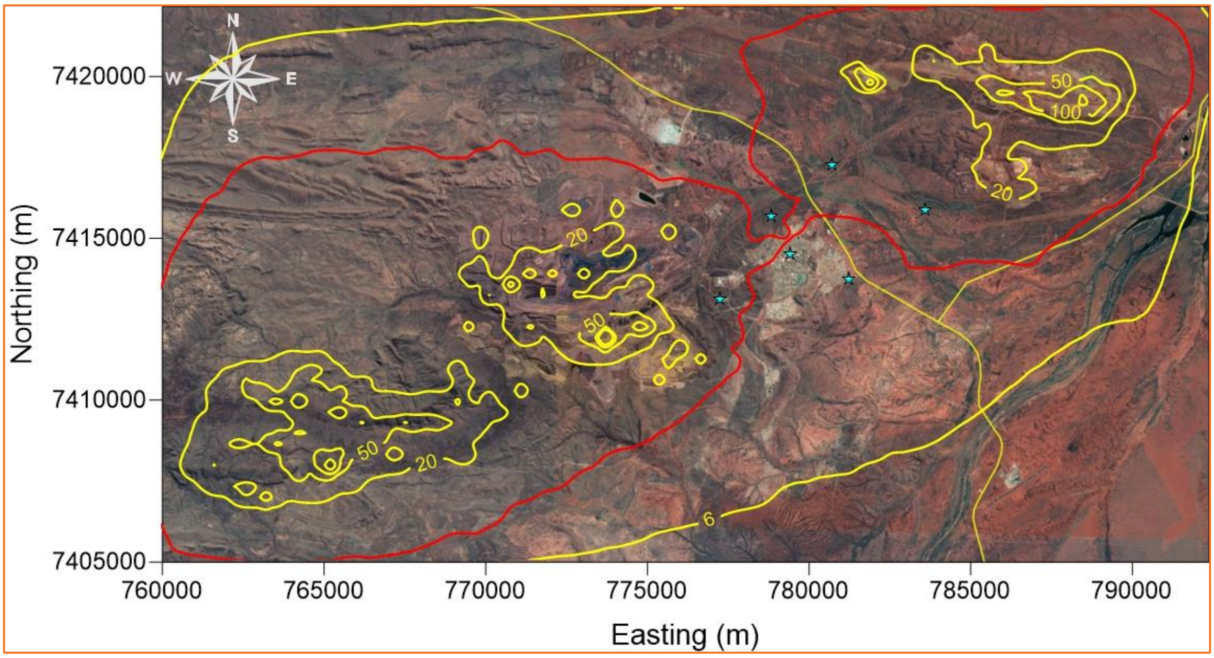

Figure 7-14: Predicted annual average $PM_{2.5}$ concentrations – Cumulative including background

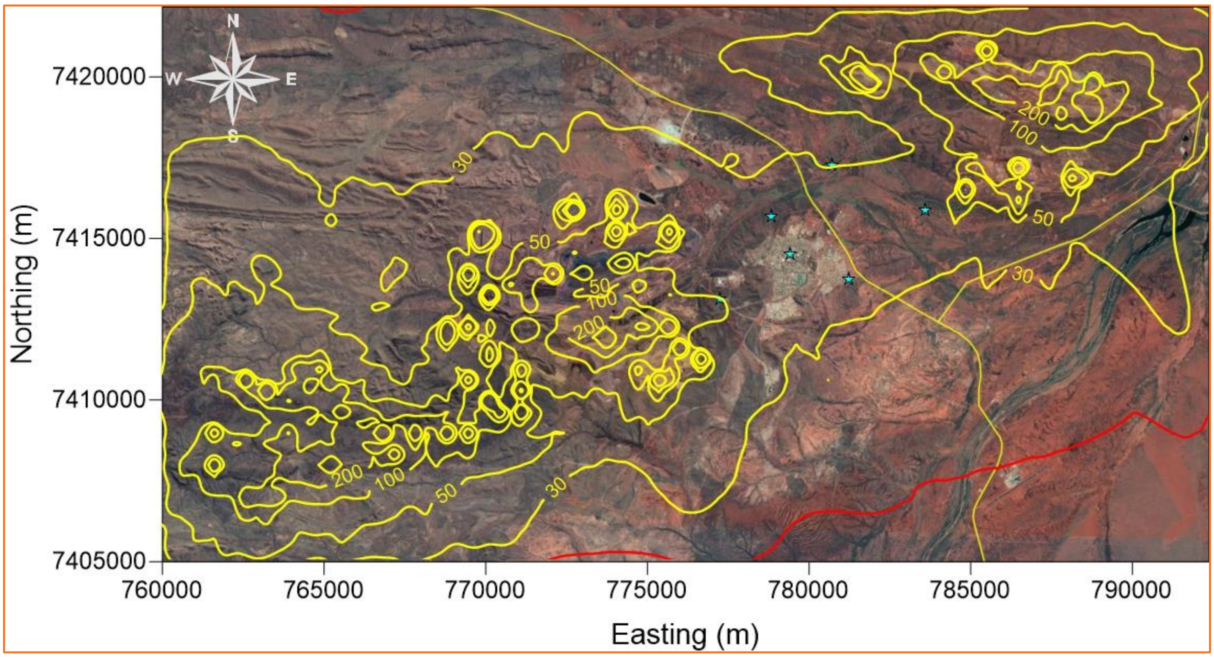

Figure 7-15: Maximum predicted future 24-hour $PM_{2.5}$ concentrations – Cumulative including background

8 Conclusions

This assessment has assessed the potential air quality impacts associated with mining, hauling and processing activities from the future mine development at Western Ridge. The Project involves the progressive open pit mining of 50 Mtpa from four deposits (Eastern Syncline, Bill's Hills, Mount Helen and Silver Knight) intended to replenish supplies from depleting reserves across the existing mining operations. Ore will be transported to the existing Whaleback hub for processing using a combination of truck haulage and overland conveyor. Initially truck haulage will be used to transport ore from the Eastern Syncline and Bill's Hills to the Whaleback ore processing hub. Once mining at the Mount Helen and Silver Knight deposits commences, it is proposed to construct a new crusher and an overland conveyor to transport this ore to the Whaleback ore processing hub.

The modelling assessment, using CALPUFF/CALMET has considered the following scenarios:

- Existing - Mt Whaleback and Eastern Ridge operations. This scenario was also used to provide a broad model validation which indicated that the model (with a regional daily varying background concentration) was predicting the PM_{10} ground level concentrations at the Newman East monitor with a high degree of confidence. The model was shown to underpredict concentrations above 60 µg/m^3 at the Town Centre monitor, though the model did predict the maximum 24-hour PM_{10} concentration.
- Future - which is divided into two components:
  - Isolation - Proposed Western Ridge as a standalone operation (excluding cumulative impacts).
  - Cumulative - Proposed Western Ridge and Mt Whaleback and Eastern Ridge operations inclusive of the background concentrations to assess the potential cumulative impact of the Project in conjunction with existing emission sources in the area.

For the proposed Western Ridge operation, emissions were estimated for mining year 2029 as this year has the highest forecast mining tonnage, based on the assumption that mining commences in 2024. The emission estimation was calculated utilising emission factors from the EETM for Mining (EA, 2012) and input into the CALPUFF dispersion model as volume sources to simulate mining, haulage and processing, and area sources to simulate wind-blown dust. Background concentrations were also included to provide an indication of the potential cumulative impact from the existing operations.

Ground-level particulates (concentrations for TSP, PM_{10} and $PM_{2.5}$) are predicted at sensitive receptors and the surrounding environment. Results are compared with the relevant air quality assessment criteria at the sensitive receptors, as an indicator of potential impact.

The key findings of the assessment are:

- For the Project in isolation of other emission sources;
  - For TSP, PM_{10} and $PM_{2.5}$ - The model predicts the maximum concentrations will remain below the applicable criteria.
- For the Project with the cumulative scenario (Mt Whaleback mine and Eastern Ridge with background file);
  - For TSP -
    - The model is predicting a reduction across all statistics including the maximum concentrations.
    - The model is predicting that there will be a reduction in the number of excursions of the applicable criteria.
  - For PM_{10} and $PM_{2.5}$ -

- The model is predicting a reduction across all statistics including the maximum concentrations.
- The model is predicting that there will be a reduction in the number of excursions of the applicable criteria.

9 References

BHP (2015). Pilbara Strategic Environmental Assessment – Cumulative Air Quality Assessment. https://www.bhp.com/-/media/bhp/regulatory-information-media/iron-ore/western-australia-iron-ore/0000/report-appendices/160316_ironore_waio_pilbarastrategicassessment_state_appendix9.pdf

BHP (2020). SUMMARY_FY21_deferred_Stripping_v12_updated Bene_updated_WR.xlsx

BoM (2020) Basic Climatological Station Metadata Current status: http://www.bom.gov.au/climate/averages/tables/cw_007176.shtml

BoM (2021). Annual rainfall data for Newman http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_stn_num=007176

DoE (2006). Air Quality Modelling Guidance Notes. Department of Environment, Western Australia.

DSD (2016). Port Hedland Dust Management Taskforce Report to Government. https://www.wa.gov.au/sites/default/files/2021-03/IMP-Appendix-2-Port-Hedland-Dust-Management-Taskforce-Report-to-Government.pdf

DWER (2019). Department of Water and Environmental Regulations. Guideline Air Emissions. Activities regulated under the: *Environmental Protection Act 1986*, Environmental Protection Regulations 1987 – Draft for external consultation, October 2019.

DWER (2021). Department of Water and Environmental Regulations. Guideline Dust Emissions. Activities regulated under the: *Environmental Protection Act 1986*, Environmental Protection Regulations 1987 – Draft for external consultation, July 2021.

Environment Australia (2012). National Pollutant Inventory Emission Estimation Technique Manual for Mining Version 3.1, Environment Australia, Canberra, Australia. http://www.npi.gov.au/system/files/resources/7e04163a-12ba-6864-d19a-f57d960aae58/files/mining.pdf

EPA (1999). Environmental Protection (Kwinana) (Atmospheric Wastes) Policy Approval Order, 1999. https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/EPP_KAW99.pdf

EPA (2016). Environmental Factor Guideline – Air Quality. Environmental Protection Authority, Western Australia. December 2016. Online at: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Air-Quality-131216_3.pdf

ESACCI. (2020). European Space Agency Climate Change Initiative (ESACCI) dataset. https://climate.esa.int/en/projects/land-cover/

Golder, D (1972). Relations among Stability Parameters in the Surface Layer, *Boundary-Layer Meteorology*, **3**: 47-58.

Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel (2006): World Map of the Köppen-Geiger climate classification updated. *Meteorol. Z.*, **15**, 259-263. DOI: 10.1127/0941-2948/2006/0130. Online at: http://koeppen-geiger.vu-wien.ac.at/

NEPC (2015). National Environment Protection (Ambient Air Quality) Measure, *as amended.* National Environment Protection Council, Australia. https://www.legislation.gov.au/Details/F2016C00215

NERDDC (1988). Air Pollution from Surface Coal Mining: Measurement, Modelling and Community Perception, Project No. 921, National Energy Research Development and Demonstration Council, Canberra.

NSW EPA (2017). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. New South Wales Environment Protection Authority. Online at: https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/air/approved-methods-for-modelling-and-assessment-of-air-pollutants-in-nsw-160666.pdf?la=en&hash=D4131297808565F94E13B186D8C70E7BD02B4C3D.

NSW Department of Planning, Industry and Environment (2020). Standards and goals for measuring air pollution. https://www.environment.nsw.gov.au/topics/air/understanding-air-quality-data/standards-and-goals

Qld Government (2017). State Government of Queensland, Australia. https://www.qld.gov.au/environment/pollution/monitoring/air/air-pollution/pollutants/particles.

Scire, J. S., Robe, F. R., Fernau, M. E., Yamartino, R. J., (2000). A User's Guide for the CALPUFF Dispersion Model (Version 5). Earth Tech Inc., Concord, Massachusetts.

Scire, J. S., Robe, F. R., Fernau, M. E., Yamartino, R. J., (2011). CALPUFF Modeling System Version 6 User Instructions. Earth Tech Inc., Concord, Massachusetts

Seinfeld, J. and S. Pandis (2006). *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*. Hoboken, New Jersey, John Wiley & Sons, Inc.

SKM (2000). Aggregated Emissions Inventory for the Pilbara Airshed 1999/2000. http://www.npi.gov.au/system/files/resources/d6662185-9280-6ef4-ed53-de54e1d3da8c/files/pilbara-airshed.pdf

SKM. (2005). Improvement of NPI Fugitive Particulate Matter Emission Estimation Techniques. http://www.npi.gov.au/system/files/resources/d9d46a4c-f76e-fdc4-5d59-fd3f8181c5b8/files/pm10may05.pdf

USEPA (1998). Western surface coal mining, AP-42 Chapter 11.9, United States Environment Protection Agency Office of Air Quality Planning and Standards.

USEPA (2006). Unpaved Roads, AP-42 Chapter 13.2.2, United States Environment Protection Agency Office of Air Quality Planning and Standards.

USEPA (2006b). Aggregate handling and storage piles, AP-42 Chapter 13.2.4, United States Environment Protection Agency Office of Air Quality Planning and Standards.

USEPA (2006c). Industrial wind erosion, AP-42 Chapter 13.2.5, United States Environment Protection Agency Office of Air Quality Planning and Standards.

USEPA (2012). Haul Road Workgroup Final Report Submission to EPA-OAQPS. https://kdheks.gov/bar/modeling/3-2-12_Haul_Roads_Guidance.pdf

USEPA (2016). Guideline on Air Quality Models (Appendix W to 40 CFR Part 51). U United States Environment Protection Agency, December 2016.

USEPA. (2021). https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

WHO. (2005). *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide; Global update 2005: Summary of risk assessment*. Available at:

https://apps.who.int/iris/bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_eng.pdf;jsessionid=8679320490C7D69DF1F00834D0A9FCB3?sequence=1.

WRF (2019). A Description of the Advanced Research WRF Model Version 4, NCAR Technical Note NCAR/TN 556, National Center for Atmospheric Research, Boulder, Co.

10 Acronyms and Glossary

Acronym	Description
AWS	Automatic Weather Station
BHP	BHP Billiton Iron Ore
BoM	Bureau of Meteorology
BWS	Belt wash station
C	Degrees Celsius (temperature)
CV	Conveyor
DSD	Department of State Development, Western Australia, Australia
DWER	Department of Water and Environmental Regulation
EA	Environment Australia
EE	Emissions estimation
EET	Emissions Estimation Technique
EF	Emission factor
EPA	Environmental Protection Authority Western Australia, Australia
EPAV	Environmental Protection Authority Victoria, Australia
EPP	Environmental Protection Policy
ESACCI-LC	European Space Agency Climate Change Initiative Land Cover dataset
ETA	Environmental Technologies& Analytics Pty Ltd
FEL	Front end loader
GDA94	Geocentric Datum of Australia 1994
GLC	Ground Level Concentration
g/m^2/month	Grams per square metre per month
g/s	grams per second
h/yr	Hours per year
kg	kilogram
kg/ha/yr	kilograms per hectare per year
kg/t	kilogram per tonne
kg/yr	kilograms per year
kPa	kiloPascals

Acronym	Description
km	kilometre
m	metre
m/s	metres per second
mm	millimetre
Mt	Million tonnes
Mtpa	Million tonnes per annum
NEPC	National Environment Protection Council
NEPM	National Environmental Protection Measure
NPI	National Pollutant Inventory
NSW	New South Wales
OSA	Overburden Storage Area
PM	Particulate matter, small particles and liquid droplets that can remain suspended in air.
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 10 µm or less.
PM_{10}	Particulate matter with an aerodynamic diameter of 2.5 µm or less.
Qld EPA	Queensland Environmental Protection Authority
ROM	Run of mine
SRTM	Shuttle Radar Topography Mission
t	Tonnes
t/h	Tonnes per hour
tpa	tonnes per annum
tph	tonnes per hour
TS	Transfer station
TSP	Total suspended particulates
UTM	Universal Transverse Mercator
$\mu g/m^3$	micro grams (one millionth of a gram) per cubic metre

Acronym	Description
µm	micrometre
USEPA	United States Environment Protection Agency
USGS	United States Geological Survey
WRF	Weather Research and Forecast (WRF V3.7) model

11 Appendices

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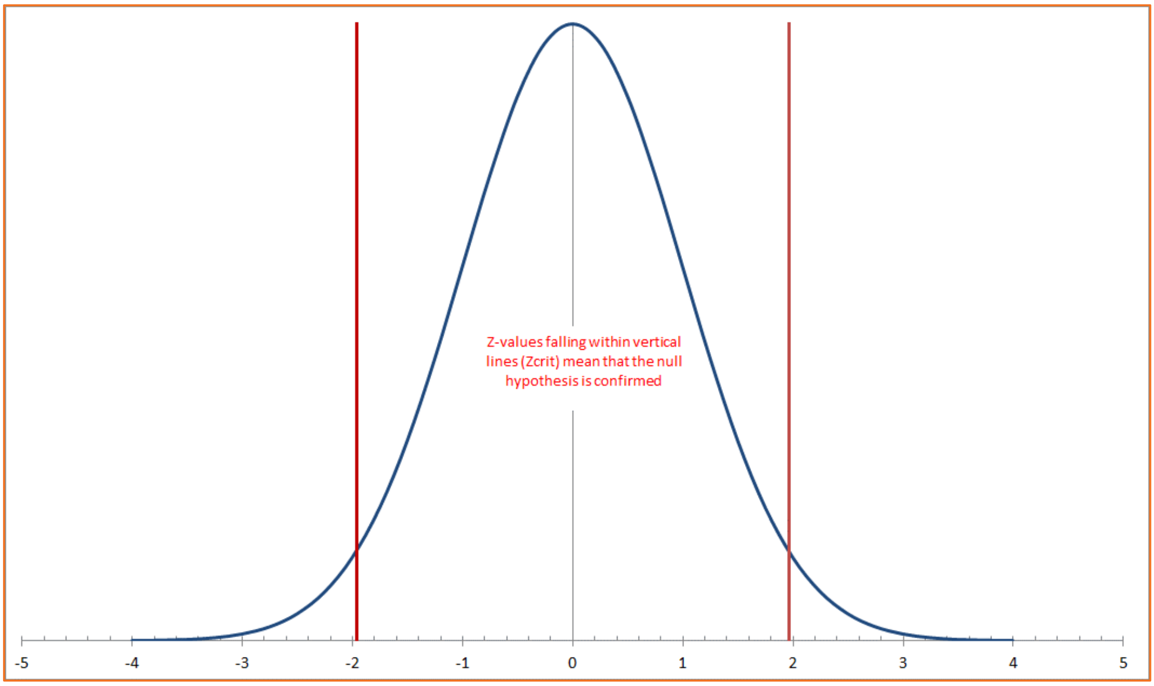
Appendix A – Selection of Representative Meteorological Year for Modelling

Generally, a minimum of one year of meteorological data is acceptable for dispersion modelling in Australia and New Zealand. The data must, however, adequately represent worst-case meteorological conditions and the data should be assessed in terms of representativeness against climatic averages. In other words, the meteorology for selected years must be deemed representative of the "normal" range of conditions in the area.

To determine the year of meteorological data to use for the dispersion modelling, 10-years of historical surface observations from BoM station at Newman Airport (2010 to 2020 inclusive) were reviewed. The Chi-squared goodness of fit test was used to statistically identify the representative modelling year based on recorded scalar meteorological parameters including wind speed and temperature.

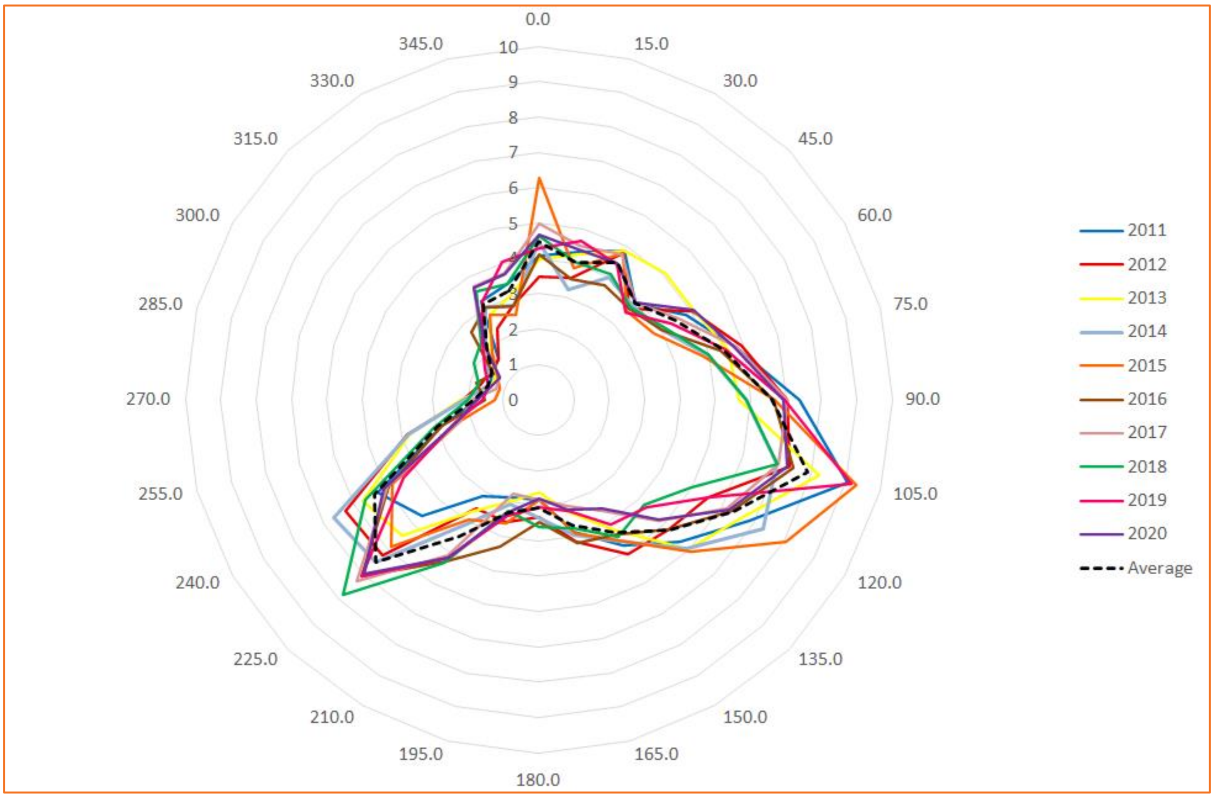
The null hypothesis is that there is no significant difference between hourly values in an individual year and the hourly averages for long term average values. If values fall within the vertical lines, then accept the null hypothesis (Appendix Figure 1). The null hypothesis is that there is no significant difference between percentage frequencies in an individual year and the percentage frequencies for long term average values. Note that only scalars were assessed (i.e., temperature and wind speed). Wind direction was assessed through radar plots.

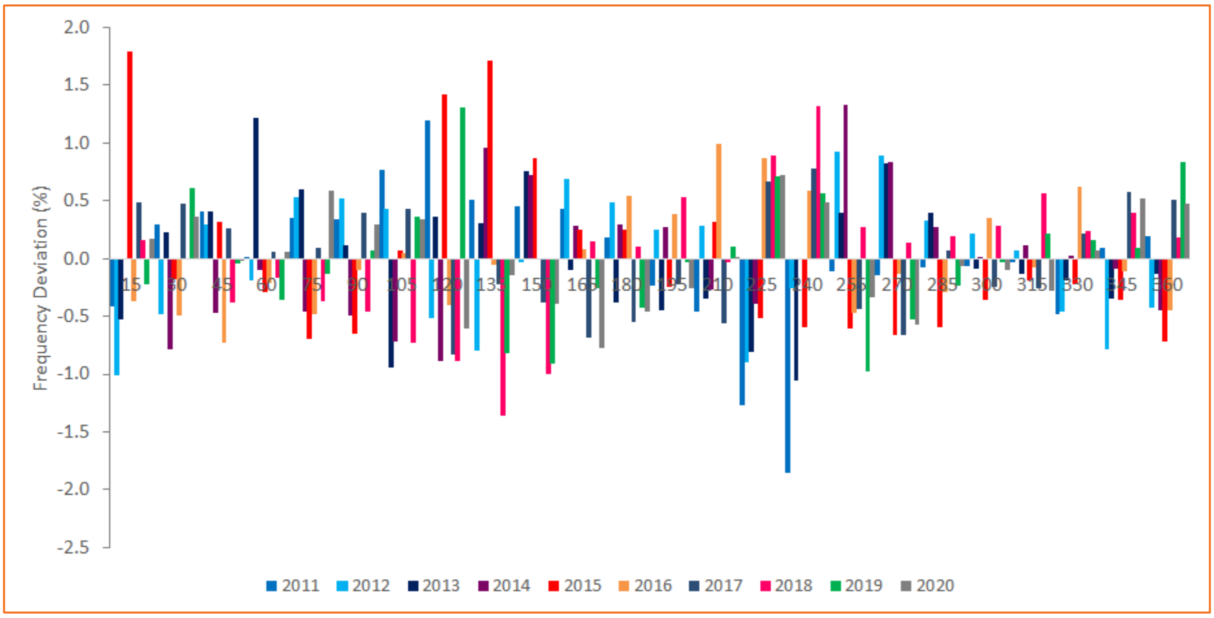


Appendix Figure 1: Null Hypothesis

A.1: Wind Direction and Speed

The average wind direction radar plots for 2010 to 2020 at Newman Airport are compared in Appendix Figure 2 (upper). Except for 2011, the wind direction pattern is generally consistent across all years. There are only minor inter-annual differences in wind direction for years 2011, 2012, 2014 and 2015 show the greatest deviation from long term wind directions, with values of greater 1% from the average for various directions (Appendix Figure 2, lower).





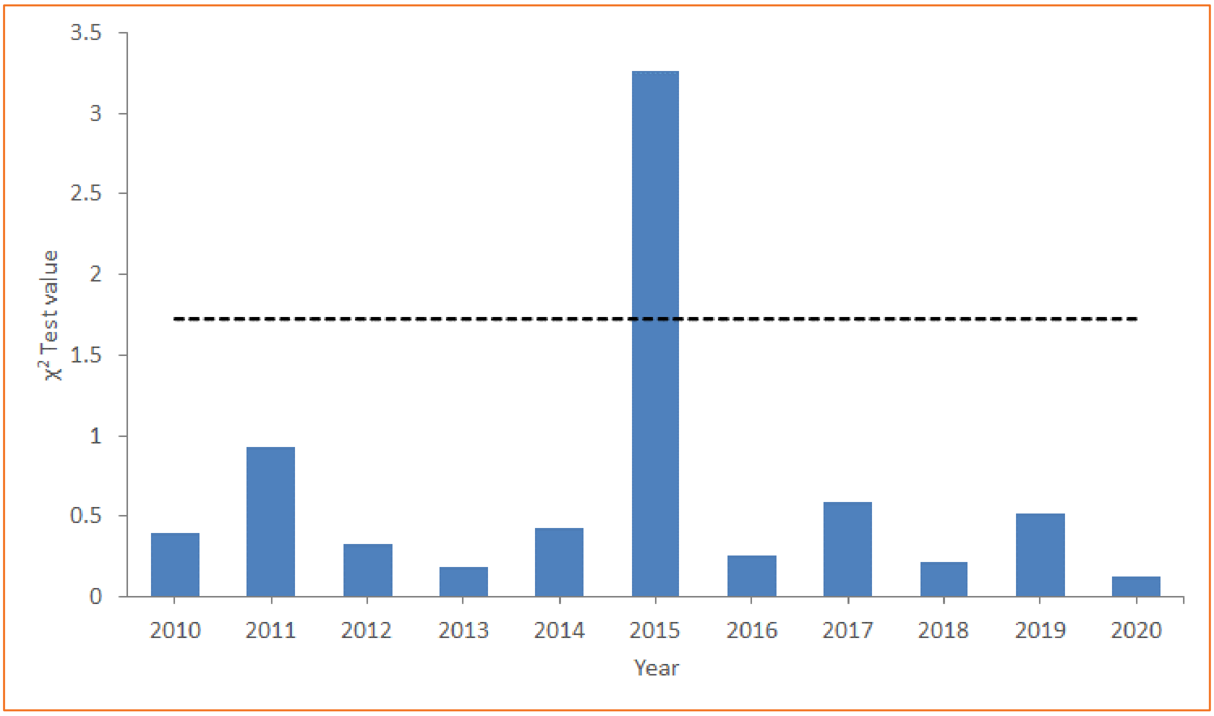
Appendix Figure 2: Wind direction radar plot (upper) and frequency deviation from the 11-year mean (lower) for Newman (2010-2020)

Appendix Table 1 shows the annual and long-term wind statistics at Newman Airport. For the 10th percentiles, 2010, 2016, 2018 and 2019 are closest to long-term averages. For average wind speeds, 2012, 2018, 2019 and 2020 are closest to long-term average conditions. The 90th percentiles show that 2014, 2016, 2019 and 2020 are closest to long-term averages.

Chi-squared goodness of fit test results for wind speed indicate that percentage frequencies for all years, except 2015 were representative of 10 year mean percentage frequencies at the 99.5% confidence interval (Appendix Figure 3).

Appendix Table 1: Wind speed statistics for Newman Airport for 2010-2020. Units are km/h.

	10th Percentile	Average	90th Percentile
2010	4.8	12.7	21.6
2011	4.9	13.4	22.9
2012	4.1	12.5	22.3
2013	4.4	12.7	21.9
2014	3.8	11.9	20.7
2015	3.0	11.6	20.0
2016	4.7	12.1	20.4
2017	4.0	11.8	20.3
2018	4.7	12.5	21.7
2019	4.9	12.5	21.4
2020	4.5	12.4	21.4
Average	4.7	12.4	20.9



Appendix Figure 3: Chi-squared goodness of fit test result for wind speed. Dashed line indicates 0.995 significance level.

A.2: Temperature

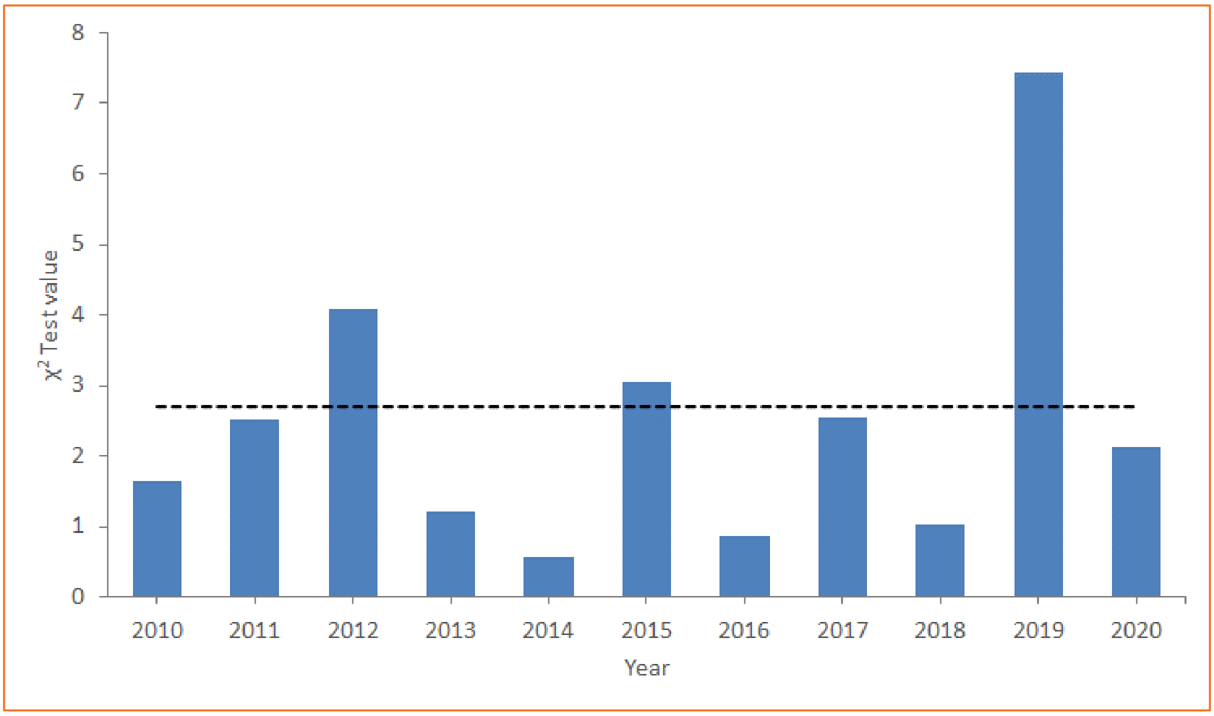
Appendix Table 2 shows the annual and long-term temperature statistics at Newman Airport. For the 10th percentiles, 2010, 2011, 2015, 2016, 2017 and 2020 are closest to long-term averages. For average temperatures, 2010, 2016 and 2018 are closest to long-term average conditions. The 90th percentiles show that 2014, 2016 and 2020 are closest to long-term averages.

The Chi-squared goodness of fit test results for temperature indicate that temperature frequency percentage values during 2012, 2015 and 2019 were significantly different to long term averages (Appendix Figure 4).

Appendix Table 2 Temperature statistics for Newman Airport for 2010-2020

	10th Percentile	Average	90th Percentile
2010	12.6	24.9	36.6
2011	12.9	24.0	34.0
2012	11.9	23.7	34.0
2013	13.5	24.8	35.6
2014	12.3	24.8	35.9
2015	12.4	24.5	36.7
2016	13.0	24.7	35.8
2017	12.5	24.1	34.6
2018	11.9	24.8	36.0
2019	13.1	26.1	37.8

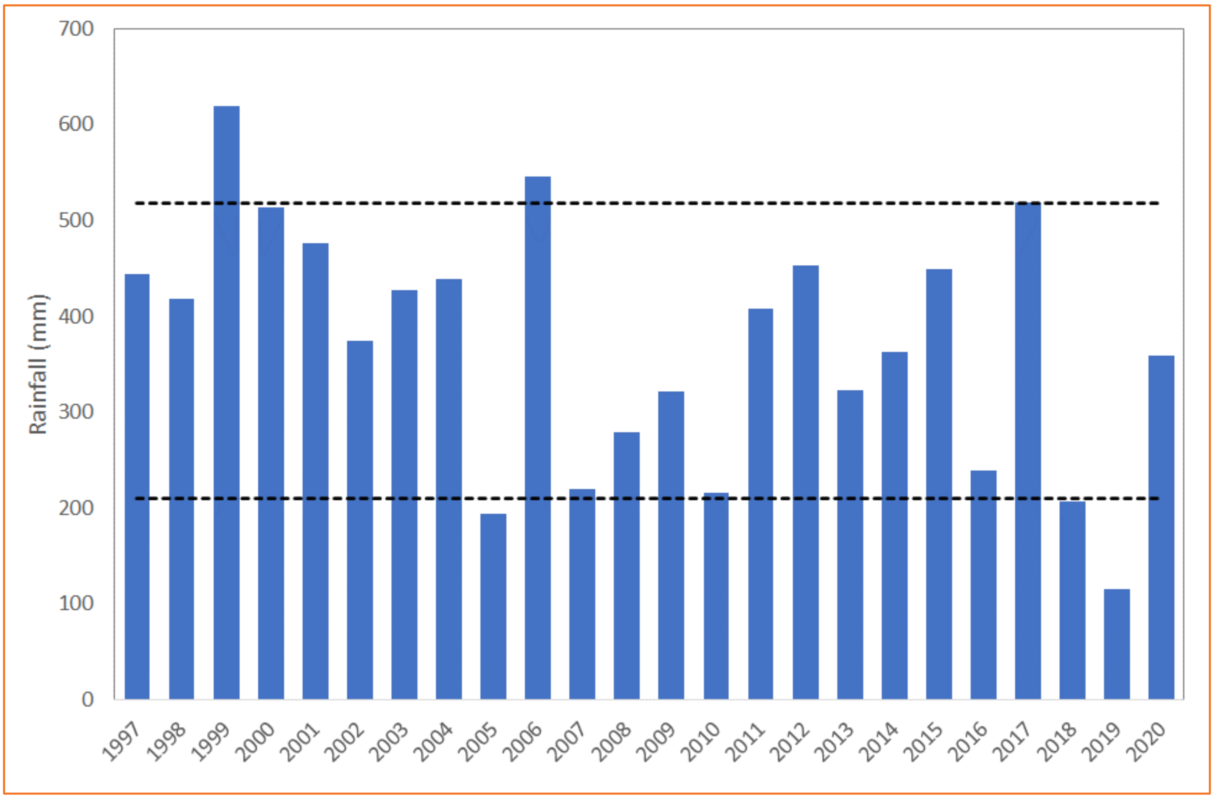
	10th Percentile	Average	90th Percentile
2020	13.0	25.3	35.8
Average	12.7	24.9	35.8



Appendix Figure 4: Chi-squared goodness of fit test result for temperature. Dashed line indicates 0.975 significance level.

A.3: Rainfall

The annual rainfall at Newman for the 23-year period (1997-2020) is displayed in Appendix Figure 5. There is a significant variation of rainfall between each year. During the 23-year period, all years except 1999, 2005, 2006, 2007, 2010, 2017, 2018 and 2019 all fall within the 10th and 90th percentile long-term rainfall totals. This indicates that the remaining years had no major "outlier" annual rainfall totals, notwithstanding the highly variable nature of rainfall over the region.



Appendix Figure 5: Median annual rainfall at Newman Airport between 1997 and 2020. Dotted lines indicate 23-year 10th and 90th percentile rainfall values.

In summary:

- For wind speed only 2015 was statistically different to longer term conditions.
- For temperature 2012, 2015 and 2019 were significantly different to longer term average values.
- Wind direction displayed highest interannual variability for 2011, 2012, 2014 and 2015.
- Rainfall, although highly variable, showed that over the most recent 10-year period, that 2011 to 2016, and 2020 fell within the 10th and 90th percentile 23-year rainfall totals.

Based on the above analysis, the years that are consistently closest to long-term average conditions are 2010, 2013, 2016 and 2020. Given that the most complete ambient monitoring data is for 2020, it was decided that dispersion modelling be performed for that year.

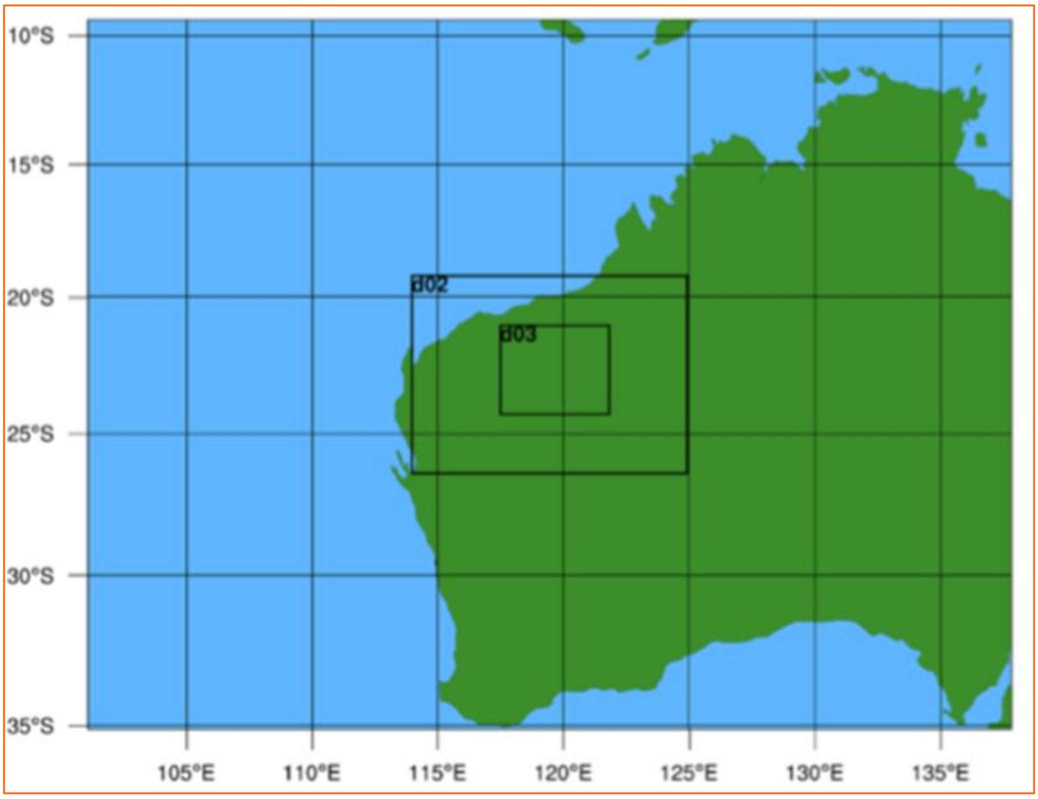
Appendix B– Meteorology

B.1: WRF

WRF was developed (and continues to be developed) in the United States by a collaborative partnership including the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (the National Center for Environmental Prediction (NCEP), the Forecast Systems Laboratory (FSL), the Air Force Weather Agency (AFWA), the Naval Research Laboratory, the University of Oklahoma, the Federal Aviation Administration (FAA) and others. (WRF, 2019).

WRF is a fully compressible, Eulerian, non-hydrostatic meso-scale numerical model developed by the National Center for Atmospheric Research (NCAR) and the National Oceanic and Atmospheric Administration (NOAA) in the United States. WRF is suitable for a broad spectrum of applications across scales ranging from metres to thousands of kilometres. The model utilises global reanalysis data to produce fine-scale 3-dimensional meteorological fields that considers local terrain and land-use effects.

WRF was run with a three-nest structure (40 km, 13.3 km and 4.4 km horizontal grid space resolution) centred on 23.055°S and 119.25°E. This is shown in Appendix Figure 6. The model vertical resolution consists of 28 pressure levels.[10].



Appendix Figure 6: Three nest structure, WRF model

[10] Eta levels are terrain-following vertical coordinates

Physics options in WRF are to represent atmospheric radiation, surface and boundary layer as well as cloud and precipitation processes. The physics options selected for the modelling are summarised in Appendix Table 3.

Appendix Table 3: WRF Physics Options Selected for Model

	Domain 1	Domain 2	Domain 3	Explanatory Notes
mp_physics	3	3	3	WRF single moment 3-class scheme
ra_lw_physics	1	1	1	Rapid radiative transfer model scheme
ra_sw_physics	1	1	1	Dudhia scheme for cloud and clear sky absorption and scattering
Radt	30	15	5	Time step for radiation schemes
sf_sfclay_physics	1	1	1	MM5 based on MOST
sf_surface_physics	2	2	2	Noah land surface model with 6 soil layers
bl_pbl_physics	1	1	1	Non-local K-scheme with entrainment layer
bldt	0	0	0	Boundary layer time step (0=every time step)
cu_physics	1	1	1	Kain-Fritch scheme using mass flux approach for domain 1 only.
cudt	5	5	5	Cumulus physics time step (minutes)

Six-hourly global final analysis synoptic data (from http://nomads.ncdc.noaa.gov/data/gfsanl/) was used to initialise the model and provide boundary conditions.

Land-use and terrain data was sourced from the United State Geological Services (USGS) database. Inspection of the land-use indicates an acceptable resolution and category for the model area with shrub land being the dominant vegetation type. A review of the Vegparm.tbl [11] reveals that these are based on North American parameterisations, with marked seasonal differences to allow for winter snow cover. These are clearly inappropriate for the Pilbara region. A non-seasonally varying roughness length value of 0.4 m was assigned to the shrub land category based on a study by Peel *et al*. (2005) for Spinifex vegetation in the Pilbara. Albedo was also set to 0.2 based on values cited in Peel *et al*. (2005). Other parameters such as Bowen ratio were adjusted to allow for the drier climate of the Pilbara.

The selection of an appropriate Land Surface Model (LSM) is critically important to provide the boundary conditions at the land-atmosphere interface because:

- The Planetary Boundary Layer (PBL) schemes are sensitive to surface fluxes.
- The cloud/cumulus schemes are sensitive to the PBL structures.
- There is a need to capture mesoscale circulations forced by surface variability in albedo, soil moisture/temperature and land use.

[11] A table consisting of land-use specific surface roughness, albedo and Bowen ratio.

The Noah Land-Surface Model was selected in this case to account for the sub-grid-scale fluxes. This sophisticated scheme provides four quantities to the parent atmospheric model (WRF), namely:

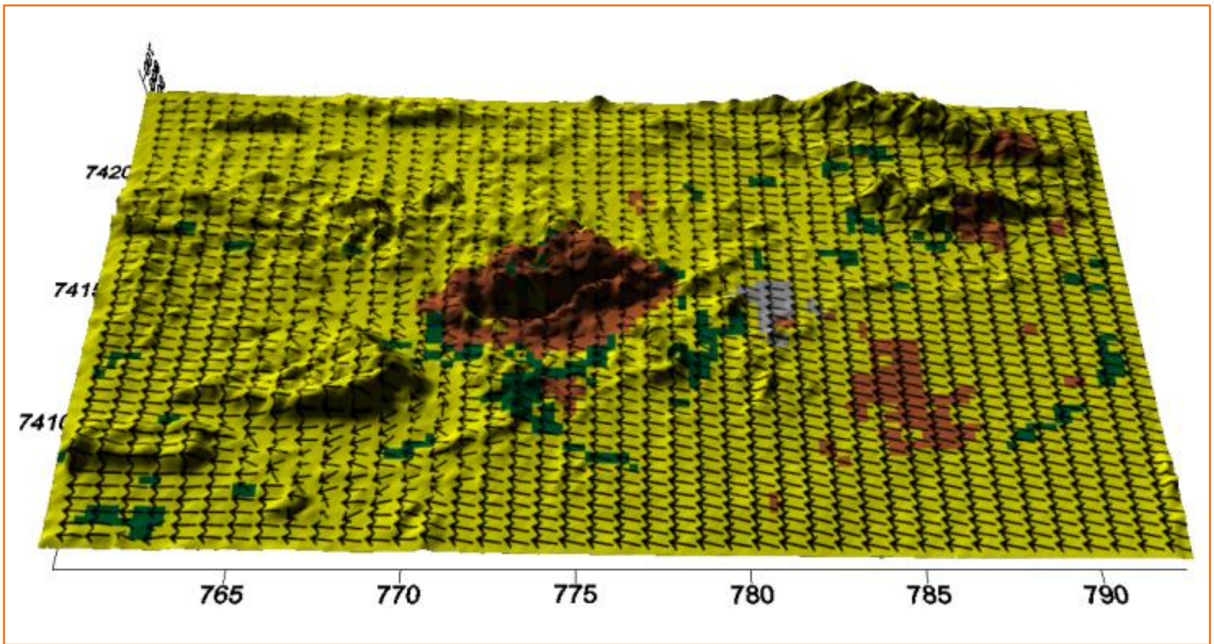
- surface sensible heat flux
- surface latent heat flux
- upward longwave radiation
- upward (reflected) shortwave radiation.

B.2: CALMET

CALMET Results

Wind

An example of early morning surface wind fields generated by CALMET for the model domain is shown in Appendix Figure 2. Colours depict dominant land cover (yellow = range land, grey = urban, brown = barren land, green=forest), and arrows depict wind flow direction. The existence of non-steady state meteorology as depicted by the flow along valleys and deflection around terrain is clearly demonstrated in Appendix Figure 7.

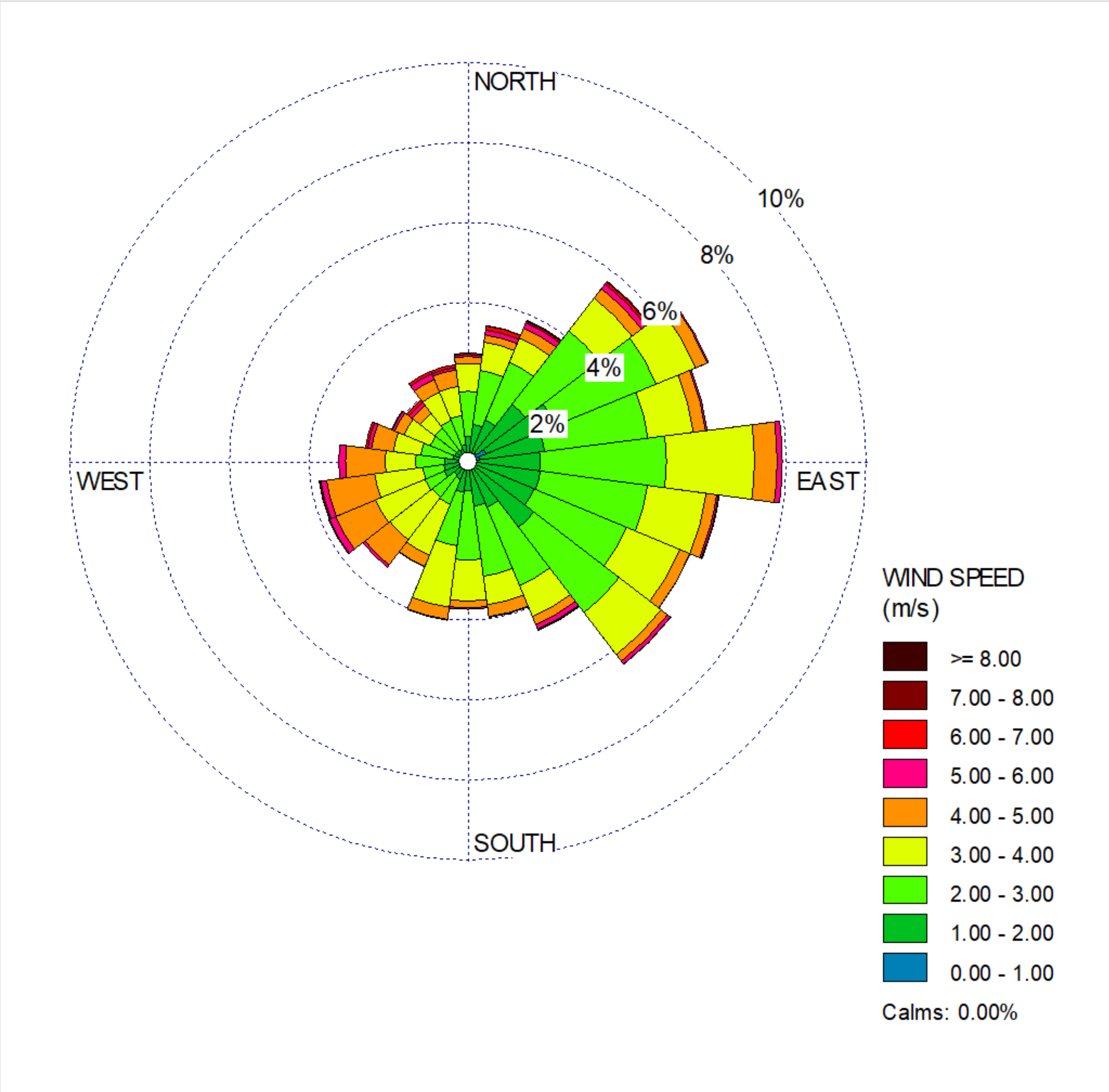


Appendix Figure 7: Example of surface wind vectors generated by CALMET.

Selected meteorological variables were extracted from the gridded CALMET output for three points corresponding to Western Ridge. The characteristics of the 10 m winds are illustrated in the annual wind rose diagrams the 12-month period from January 2020 – December 2020. These are shown in Appendix Figure 8. 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, etc. The bar at the top of each wind rose diagram represents winds blowing from the north (i.e., northerly winds), and so on. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds.

The major features of the wind rose is as follows:

- Prevailing wind directions at all three locations are predominantly north easterly to south-easterly.
- Strongest winds are from the northeast.
- Winds from the northwest are relatively rare.
- Calm conditions (<0.5 m/s) occur for less than 1% of the year.



Appendix Figure 8: Annual wind rose for Western Ridge mine.

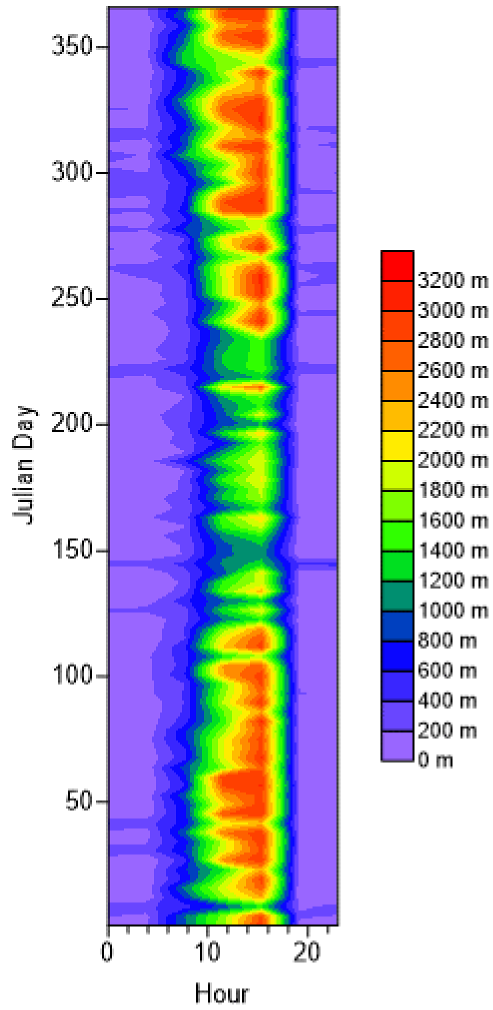
Mixing Height

Mixing height is the depth of the atmospheric surface layer beneath an elevated temperature inversion. It is an important parameter within air pollution meteorology. Vertical diffusion or mixing of a plume is limited by the mixing height, as the air above this layer tends to be stable, with restricted vertical motion.

A series of internal algorithms within CALMET is used to calculate mixing heights for the subject site where it is assumed that mixing height is formed through mechanical means (wind speed) at night and through a mixture of mechanical and convective means (wind speed and solar radiation) during the day (Scire et al. 2008). During the night and early morning when the convective mixed layer is absent or small, the full depth of the planetary boundary layer (PBL) may be controlled by mechanical turbulence. During the day, the height of the PBL during convective conditions is then taken as the maximum of the estimated (or measured if available) convective boundary layer height and the estimated (or measured if available) mechanical mixing height. It is calculated from the early morning potential temperature sounding (prior to sunrise), and the time varying surface heat flux to calculate the time evolution of the convective boundary layer.

The seasonal and hourly variation of mixing height at Western Ridge is summarised as a Hovmöller plot[12] in Appendix Figure 9. Highest mixing heights occur during the mid-afternoon and during the spring to late summer when solar insolation is at its highest. Winter months generally have lower maximum mixing heights.

[12] The Hovmöller plot is a way of representing data on two axes: in this case hour of day on x- and Julian day on y-axis.



Appendix Figure 9: Hovmöller plot of hourly mixing heights

Stability

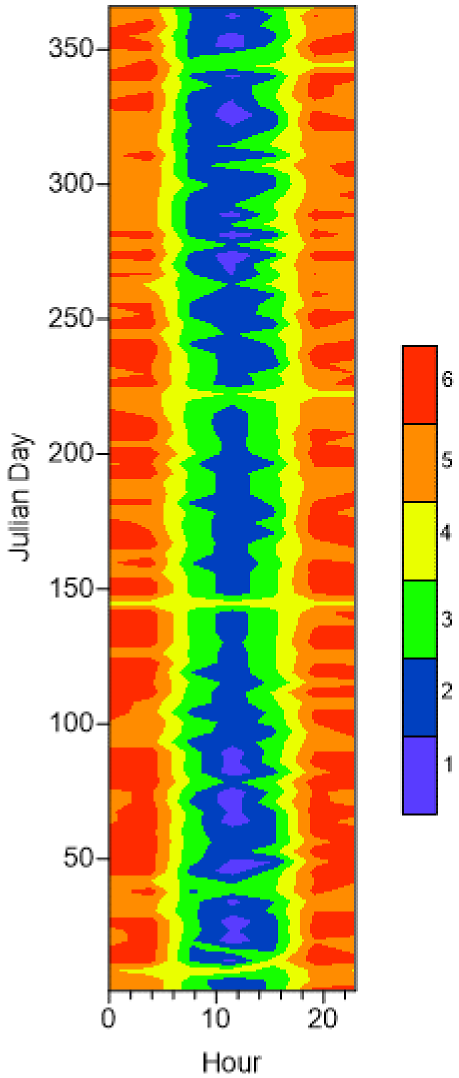
An important aspect of pollutant dispersion is the level of turbulence in the lowest 1 km or so of the atmosphere, known as the planetary boundary layer (PBL). Turbulence controls how effectively a plume is diffused into the surrounding air and hence diluted. It acts by increasing the cross-sectional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

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

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

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

The hourly averaged Pasquill-Gifford stability, computed from all data in the CALMET surface file, are presented in Appendix Figure 10. This plot indicates that the atmosphere is stable overnight and reaches maximum instability around midday. The unstable conditions occur as radiation from the sun heats the surface layer of the atmosphere and drives convection. Instability is slightly reduced during the winter months in response to reduced solar insolation.



Appendix Figure 10: Hovmöller plot of hourly stability.

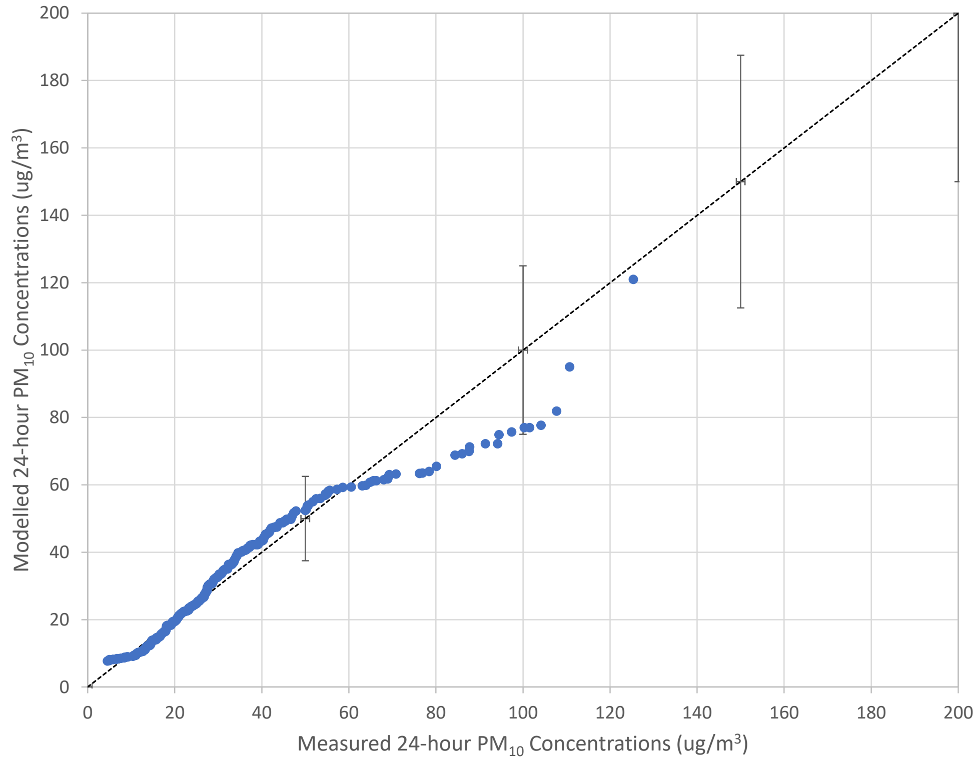
Appendix C – Model Validation

As outlined in Section 5.1 the modelled year was converted from 2010, which was the modelled year in the SEA, to 2020. To verify the performance of the model for this updated annual period a brief model verification study was undertaken. For this study the following steps were taken:

- Emission estimation was undertaken for the Mt Whaleback and Eastern Ridge operations for the FY22 period (Appendix F). This period was utilised as the forecast mining tonnages were similar to those in 2020.
- The CALPUFF model was run and the background PM_{10} file for 2020 (Section 5.5) was added to the model results.
- The modelled results were compared to the 24-hour PM_{10} monitoring data from 2020 at the Town Centre and Newman East monitors as a quantile/quantile graph (highest to lowest).

The Q:Q comparison plot at Town Centre is presented in Appendix Figure 11 where it can be seen that:

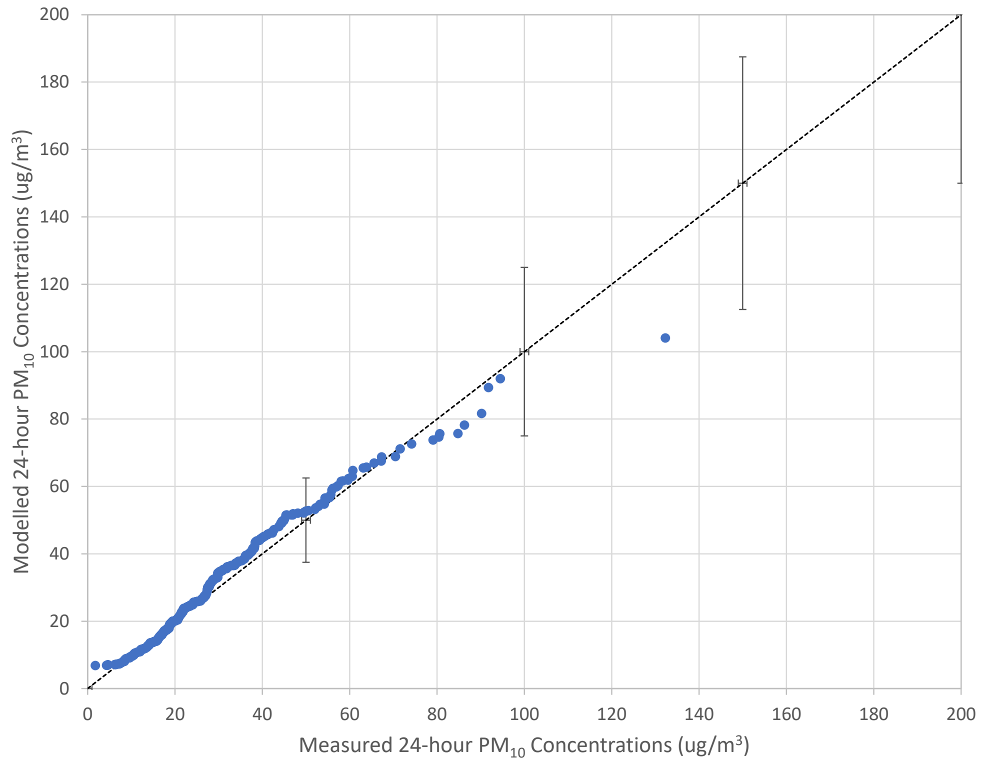
- The modelled and measured concentrations closely align up to around 60 µg/m^3.
- Beyond 60 µg/m^3 the model underpredicts the measured concentrations.
- The model does predict the maximum monitored concentration.



Appendix Figure 11: Quantile/quantile plot of measured versus modelled 24-hour PM_{10} concentrations at the Town Centre monitor

The Q:Q comparison plot for the Newman East monitor is presented in Appendix Figure 12 where it can be seen that:

- Nearly all the modelled and measured concentrations closely align.
- The model does underpredict the maximum monitored concentration.



Appendix Figure 12: Quantile/quantile plot of measured versus modelled 24-hour PM_{10} concentrations at the Newman East monitor

The statistics of the 2020 24-hour PM_{10} monitored and modelled concentrations are presented in Appendix Table 4. From this table the following can be inferred:

- At the Town Centre Monitor;
  - The underprediction of the model at the upper percentiles is very apparent (99 and 95 percentile) while there is good agreement at the lower percentiles (90 and 70 percentile).
  - The model is slightly underpredicting the annual average.
  - The model is underpredicting the number of excursions of 70 µg/m^3.
- At the Newman East Monitor;
  - The model underpredicts the maximum and 99 percentile concentrations.
  - The model predicts the lower percentiles (95, 90 and 70) very well.
  - There is effectively no difference in the annual average concentration between the model and monitored data.
  - The model accurately predicts the number of excursions of 70 µg/m^3.

Appendix Table 4: Statistics of monitored and modelled concentrations (µg/m³)

Statistic	Town Centre		Newman East	
	Monitored	Modelled	Monitored	Modelled
Maximum	125	121	132	104
99 Percentile	103	77	88	79
95 Percentile	77	63	61	63
90 Percentile	55	57	53	54
70 Percentile	35	39	34	36
Average	31.9	30.6	28.6	28.5
Number greater than 50 µg/m³	46	52	40	50
Number greater than 70 µg/m³	20	12	12	11

Appendix D– Emission Sources and Parameters

D.1: Mining Parameters

Appendix Table 5: Western Ridge mining

Source Id	Easting	Northing	Effective Height (m)	Sigma Y	Sigma Z
MH-Drill1	763340	7409926	1.5	75	0.70
MH-Drill2	764048	7409958	1.5	75	0.70
MH_Drill3	765528	7409409	1.5	75	0.70
MH-Drill4	765878	7409799	1.5	75	0.70
BH-Drill1	768457	7409735	1.5	75	0.70
BH-Drill2	769117	7409854	1.5	75	0.70
BH-Drill3	769380	7410809	1.5	75	0.70
SK-Drill1	761509	7409170	1.5	75	0.70
SK-Drill2	761390	7408096	1.5	75	0.70
SK-Drill3	761939	7407761	1.5	75	0.70
SK-Drill4	763769	7409186	1.5	75	0.70
SK-Drill5	764374	7408979	1.5	75	0.70
SK-Drill6	766674	7408334	1.5	75	0.70
SK-Drill7	767422	7408406	1.5	75	0.70
SK-Drill8	769404	7408263	1.5	75	0.70
MH-Blast1	763698	7410117	20	31.1	9.30
MH-Blast2	764151	7409735	20	31.1	9.30
MH-Blast3	765719	7409361	20	31.1	9.30
MH-Blast4	765671	7409846	20	31.1	9.30
BH-Blast1	768696	7409560	20	31.2	9.30
BH-Blast2	769285	7410109	20	31.2	9.30
BH-Blast3	769484	7410618	20	31.2	9.30
SK-Blast1	762050	7409043	20	27.8	9.30
SK-Blast2	761366	7407865	20	27.8	9.30
SK-Blast3	762249	7407857	20	27.8	9.30
SK-Blast4	763292	7409098	20	27.8	9.30
SK-Blast5	764573	7408740	20	27.8	9.30
SK-Blast6	766881	7408167	20	27.8	9.30
SK-Blast7	767868	7408239	20	27.8	9.30
SK-Blast8	769476	7408334	20	27.8	9.30
MH-Load1	763602	7409942	6	75	2.79
MH-Load2	764382	7409942	6	75	2.79
MH-Load3	765656	7409504	6	75	2.79
MH-Load4	766085	7409743	6	75	2.79
BH-Load1	768345	7409958	6	75	2.79
BH-Load2	769372	7409950	6	75	2.79
BH-Load3	769149	7411032	6	75	2.79
SK-Load1	761851	7409138	6	75	2.79
SK-Load2	761231	7407992	6	75	2.79
SK-Load3	761947	7408016	6	75	2.79
SK-Load4	763563	7408995	6	75	2.79
SK-Load5	765091	7408589	6	75	2.79
SK-Load6	766396	7408390	6	75	2.79
SK-Load7	767566	7408255	6	75	2.79
SK-Load8	769539	7408247	6	75	2.79

Source Id	Easting	Northing	Effective Height (m)	Sigma Y	Sigma Z
UW-1	762655	7410149	2	75	0.93
UW-2	763181	7410547	2	75	0.93
UW-3	764151	7411064	2	75	0.93
UW-4	764955	7411024	2	75	0.93
UW-5	764828	7410443	2	75	0.93
UW-6	765544	7410419	2	75	0.93
UW-7	766985	7408971	2	75	0.93
UW-8	767780	7408971	2	75	0.93
UW-9	768529	7408947	2	75	0.93
UW-10	769237	7409011	2	75	0.93
UW-11	769913	7409249	2	75	0.93
UW-12	770168	7410109	2	75	0.93
UW-13	762655	7407053	2	75	0.93
UW-14	763435	7407045	2	75	0.93
UW-15	764263	7407801	2	75	0.93
UW-16	764358	7408215	2	75	0.93
Bull1	762647	7410332	2	75	0.93
Bull2	763387	7410467	2	75	0.93
Bull3	764271	7410905	2	75	0.93
Bull4	764796	7411207	2	75	0.93
Bull5	765186	7410380	2	75	0.93
Bull6	767422	7408875	2	75	0.93
Bull7	768274	7408796	2	75	0.93
Bull8	769022	7408836	2	75	0.93
Bull9	769794	7409035	2	75	0.93
Bull10	770224	7409663	2	75	0.93
Bull11	763101	7407021	2	75	0.93
Bull12	764478	7407682	2	75	0.93
Bull13	764151	7408271	2	75	0.93
UnOre1	765035	7408151	2	75	0.93
UnOre2	765369	7408127	2	75	0.93
UnOre3	765027	7407881	2	75	0.93
UnOre4	765337	7407873	2	75	0.93
FEL1	765210	7408111	3.0	20.0	1.40
FEL2	765496	7407984	3.0	20.0	1.40
FEL3	765202	7407952	3.0	20.0	1.40
Crush1	765727	7407936	2.0	3.8	0.93
P201-D	771210	7409582	1.5	75	0.70
P201-B	771277	7409886	20	18.2	9.30
P201-L	771443	7409735	6	75	2.79
ESWASTE-UW1	770310	7409495	2	75	0.93
ESWASTE-UW2	770382	7409826	2	75	0.93
ESWASTE-UW3	770473	7409729	2	75	0.93
ESWASTE-Bull1	770431	7409628	2	75	0.93
ESWASTE-Bull2	770548	7409762	2	75	0.93

D.2: Haul Road Parameters

Appendix Table 6: Western Ridge Haul Roads

Source Id	Easting	Northing	Effective Height (m)	Sigma Y	Sigma Z
HR1	761760	7408394	8.5	16.7	7.9
HR2	761919	7408517	8.5	16.7	7.9
HR3	762090	7408633	8.5	16.7	7.9
HR4	762289	7408688	8.5	16.7	7.9
HR5	762480	7408736	8.5	16.7	7.9
HR6	762671	7408760	8.5	16.7	7.9
HR7	762878	7408744	8.5	16.7	7.9
HR8	763097	7408740	8.5	16.7	7.9
HR9	763288	7408724	8.5	16.7	7.9
HR10	763483	7408716	8.5	16.7	7.9
HR11	763690	7408680	8.5	16.7	7.9
HR12	763893	7408649	8.5	16.7	7.9
HR13	764124	7408617	8.5	16.7	7.9
HR14	764315	7408577	8.5	16.7	7.9
HR15	764494	7408517	8.5	16.7	7.9
HR16	764677	7408446	8.5	16.7	7.9
HR17	764872	7408370	8.5	16.7	7.9
HR18	765039	7408279	8.5	16.7	7.9
HR19	765178	7408127	8.5	16.7	7.9
HR20	761979	7408915	8.5	16.7	7.9
HR21	762158	7408863	8.5	16.7	7.9
HR22	762361	7408796	8.5	16.7	7.9
HR23	761712	7407519	8.5	16.7	7.9
HR24	761907	7407479	8.5	16.7	7.9
HR25	762102	7407455	8.5	16.7	7.9
HR26	762301	7407427	8.5	16.7	7.9
HR27	762496	7407411	8.5	16.7	7.9
HR28	762703	7407407	8.5	16.7	7.9
HR29	762910	7407383	8.5	16.7	7.9
HR30	763093	7407300	8.5	16.7	7.9
HR31	763264	7407192	8.5	16.7	7.9
HR32	763280	7407001	8.5	16.7	7.9
HR33	764056	7408462	8.5	16.7	7.9
HR34	764155	7408267	8.5	16.7	7.9
HR35	764251	7408088	8.5	16.7	7.9
HR36	764303	7407908	8.5	16.7	7.9
HR37	763901	7409695	8.5	16.7	7.9
HR38	763984	7409548	8.5	16.7	7.9
HR39	764171	7409480	8.5	16.7	7.9
HR40	764366	7409417	8.5	16.7	7.9
HR41	764565	7409385	8.5	16.7	7.9
HR42	764752	7409309	8.5	16.7	7.9
HR43	764955	7409249	8.5	16.7	7.9
HR44	765142	7409186	8.5	16.7	7.9
HR45	765341	7409114	8.5	16.7	7.9
HR46	765532	7409047	8.5	16.7	7.9
HR47	765715	7408971	8.5	16.7	7.9
HR48	765791	7408776	8.5	16.7	7.9
HR49	765755	7408581	8.5	16.7	7.9
HR50	765735	7408378	8.5	16.7	7.9

Source Id	Easting	Northing	Effective Height (m)	Sigma Y	Sigma Z
HR51	765572	7408275	8.5	16.7	7.9
HR52	765397	7408195	8.5	16.7	7.9
HR53	765270	7408036	8.5	16.7	7.9
HR54	763423	7410057	8.5	16.7	7.9
HR55	763224	7410133	8.5	16.7	7.9
HR56	763089	7410260	8.5	16.7	7.9
HR57	762974	7410403	8.5	16.7	7.9
HR58	762767	7410467	8.5	16.7	7.9
HR59	764096	7410376	8.5	16.7	7.9
HR60	764235	7410547	8.5	16.7	7.9
HR61	764346	7410686	8.5	16.7	7.9
HR62	764482	7410841	8.5	16.7	7.9
HR63	764617	7411012	8.5	16.7	7.9
HR64	765576	7409751	8.5	16.7	7.9
HR65	765381	7409739	8.5	16.7	7.9
HR66	765174	7409739	8.5	16.7	7.9
HR67	764971	7409719	8.5	16.7	7.9
HR68	764788	7409620	8.5	16.7	7.9
HR69	764641	7409508	8.5	16.7	7.9
HR70	765015	7409906	8.5	16.7	7.9
HR71	764892	7410033	8.5	16.7	7.9
HR72	764880	7410252	8.5	16.7	7.9
HR73	764999	7410419	8.5	16.7	7.9
HR74	765210	7410447	8.5	16.7	7.9
HR75	769838	7409592	8.5	16.7	7.9
HR76	769651	7409520	8.5	16.7	7.9
HR77	769464	7409464	8.5	16.7	7.9
HR78	769257	7409405	8.5	16.7	7.9
HR79	769058	7409365	8.5	16.7	7.9
HR80	768843	7409345	8.5	16.7	7.9
HR81	768616	7409345	8.5	16.7	7.9
HR82	768413	7409341	8.5	16.7	7.9
HR83	768202	7409341	8.5	16.7	7.9
HR84	767983	7409345	8.5	16.7	7.9
HR85	767772	7409349	8.5	16.7	7.9
HR86	767577	7409329	8.5	16.7	7.9
HR87	767383	7409293	8.5	16.7	7.9
HR88	767172	7409285	8.5	16.7	7.9
HR89	766969	7409269	8.5	16.7	7.9
HR90	766754	7409285	8.5	16.7	7.9
HR91	766555	7409210	8.5	16.7	7.9
HR92	766372	7409130	8.5	16.7	7.9
HR93	766177	7409062	8.5	16.7	7.9
HR94	765970	7408995	8.5	16.7	7.9
HR95	769850	7409389	8.5	16.7	7.9
HR96	770017	7409261	8.5	16.7	7.9
HR97	770172	7409385	8.5	16.7	7.9
HR98	770255	7409568	8.5	16.7	7.9
HR99	770267	7409771	8.5	16.7	7.9
HR100	768668	7409158	8.5	16.7	7.9
HR101	768688	7408975	8.5	16.7	7.9
HR102	768505	7408887	8.5	16.7	7.9
HR103	768294	7408887	8.5	16.7	7.9
HR104	768091	7408871	8.5	16.7	7.9

Source Id	Easting	Northing	Effective Height (m)	Sigma Y	Sigma Z
HR105	769408	7408350	8.5	16.7	7.9
HR106	769368	7408537	8.5	16.7	7.9
HR107	769157	7408533	8.5	16.7	7.9
HR108	768962	7408541	8.5	16.7	7.9
HR109	768767	7408537	8.5	16.7	7.9
HR110	768556	7408525	8.5	16.7	7.9
HR111	768357	7408549	8.5	16.7	7.9
HR112	768154	7408549	8.5	16.7	7.9
HR113	767948	7408553	8.5	16.7	7.9
HR114	767745	7408577	8.5	16.7	7.9
HR115	767550	7408577	8.5	16.7	7.9
HR116	767355	7408609	8.5	16.7	7.9
HR117	767148	7408629	8.5	16.7	7.9
HR118	766949	7408653	8.5	16.7	7.9
HR119	766754	7408621	8.5	16.7	7.9
HR120	766539	7408597	8.5	16.7	7.9
HR121	766344	7408589	8.5	16.7	7.9
HR122	766153	7408553	8.5	16.7	7.9
HR123	765966	7408466	8.5	16.7	7.9
HR124	769356	7408756	8.5	16.7	7.9
HR125	769348	7408963	8.5	16.7	7.9
HR126	767311	7408290	8.5	16.7	7.9
HR127	767263	7408474	8.5	16.7	7.9
HR128	767160	7408836	8.5	16.7	7.9
HR129	767024	7408975	8.5	16.7	7.9
HR130	766806	7408983	8.5	16.7	7.9
WB-HR30	771984	7411113	8.5	16.7	7.9
WB-HR31	772079	7410942	8.5	16.7	7.9
WB-HR32	772148	7410754	8.5	16.7	7.9
WB-HR33	772047	7411251	8.5	16.7	7.9
WB-HR34	772255	7411415	8.5	16.7	7.9
WB-HR36	773134	7412792	8.5	16.7	7.9
WB-HR37	773427	7412822	8.5	16.7	7.9
WB-HR38	773674	7412971	8.5	16.7	7.9
WB-HR39	773877	7413190	8.5	16.7	7.9
WB-HR40	774107	7413382	8.5	16.7	7.9
WB-HR41	774373	7413525	8.5	16.7	7.9
WB-HR42	774645	7413653	8.5	16.7	7.9
WB-HR43	774931	7413703	8.5	16.7	7.9
WB-HR90	772899	7412708	8.5	16.7	7.9
WB-HR91	772960	7412652	8.5	16.7	7.9
WB-HR92	773066	7412573	8.5	16.7	7.9
WB-HR93	773118	7412468	8.5	16.7	7.9
WB-HR94	773048	7412314	8.5	16.7	7.9
WB-HR95	772972	7412135	8.5	16.7	7.9
WB-HR96	772856	7412019	8.5	16.7	7.9
WB-HR97	772689	7411929	8.5	16.7	7.9
WB-HR98	772609	7411865	8.5	16.7	7.9
WB-HR100	772672	7411767	8.5	16.7	7.9
WB-HR104	774466	7413412	8.5	16.7	7.9
WB-HR105	774741	7413530	8.5	16.7	7.9
WB-HR106	774964	7413632	8.5	16.7	7.9
WB-HR107	774245	7413374	8.5	16.7	7.9

Source Id	Easting	Northing	Effective Height (m)	Sigma Y	Sigma Z
WB-HR271	771229	7409868	8.5	16.7	7.9
WB-HR272	771000	7409675	8.5	16.7	7.9
WB-HR273	770701	7409668	8.5	16.7	7.9
WB-HR274	771400	7409963	8.5	16.7	7.9
WB-HR275	771670	7410134	8.5	16.7	7.9
WB-HR276	771916	7410296	8.5	16.7	7.9
WB-HR277	772132	7410505	8.5	16.7	7.9

Appendix E – Emission Rates

E.1: Mining Sources

Appendix Table 7: Western Ridge PM_{10} Mining Emission Rates (g/s)

Source Id	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average
MH-Drill1	0.10	0.10	0.10	0.10	0.10	0.10
MH-Drill2	0.10	0.10	0.10	0.10	0.10	0.10
MH_Drill3	0.10	0.10	0.10	0.10	0.10	0.10
MH-Drill4	0.10	0.10	0.10	0.10	0.10	0.10
BH-Drill1	0.12	0.12	0.12	0.12	0.12	0.05
BH-Drill2	0.12	0.12	0.12	0.12	0.12	0.05
BH-Drill3	0.12	0.12	0.12	0.12	0.12	0.05
SK-Drill1	0.09	0.09	0.09	0.09	0.09	0.04
SK-Drill2	0.09	0.09	0.09	0.09	0.09	0.04
SK-Drill3	0.09	0.09	0.09	0.09	0.09	0.04
SK-Drill4	0.09	0.09	0.09	0.09	0.09	0.04
SK-Drill5	0.09	0.09	0.09	0.09	0.09	0.04
SK-Drill6	0.09	0.09	0.09	0.09	0.09	0.04
SK-Drill7	0.09	0.09	0.09	0.09	0.09	0.04
SK-Drill8	0.09	0.09	0.09	0.09	0.09	0.04
MH-Blast1	58.28	58.28	0.00	0.00	0.00	0.81
MH-Blast2	58.28	58.28	0.00	0.00	0.00	0.81
MH-Blast3	58.28	58.28	0.00	0.00	0.00	0.81
MH-Blast4	58.28	58.28	0.00	0.00	0.00	0.81
BH-Blast1	58.28	0.00	0.00	0.00	0.00	0.35
BH-Blast2	58.28	0.00	0.00	0.00	0.00	0.35
BH-Blast3	58.28	0.00	0.00	0.00	0.00	0.35
SK-Blast1	41.59	0.00	0.00	0.00	0.00	0.25
SK-Blast2	41.59	0.00	0.00	0.00	0.00	0.25
SK-Blast3	41.59	0.00	0.00	0.00	0.00	0.25
SK-Blast4	41.59	0.00	0.00	0.00	0.00	0.25
SK-Blast5	41.59	0.00	0.00	0.00	0.00	0.25
SK-Blast6	41.59	0.00	0.00	0.00	0.00	0.25
SK-Blast7	41.59	0.00	0.00	0.00	0.00	0.25
SK-Blast8	41.59	0.00	0.00	0.00	0.00	0.25
MH-Load1	4.66	4.66	4.66	4.66	4.66	4.66
MH-Load2	4.66	4.66	4.66	4.66	4.66	4.66
MH-Load3	4.66	4.66	4.66	4.66	4.66	4.66
MH-Load4	4.66	4.66	4.66	4.66	4.66	4.66
BH-Load1	2.34	2.34	2.34	2.34	2.34	2.34
BH-Load2	2.34	2.34	2.34	2.34	2.34	2.34
BH-Load3	2.34	2.34	2.34	2.34	2.34	2.34
SK-Load1	1.86	1.86	1.86	1.86	1.86	1.86
SK-Load2	1.86	1.86	1.86	1.86	1.86	1.86
SK-Load3	1.86	1.86	1.86	1.86	1.86	1.86
SK-Load4	1.86	1.86	1.86	1.86	1.86	1.86
SK-Load5	1.86	1.86	1.86	1.86	1.86	1.86
SK-Load6	1.86	1.86	1.86	1.86	1.86	1.86
SK-Load7	1.86	1.86	1.86	1.86	1.86	1.86
SK-Load8	1.86	1.86	1.86	1.86	1.86	1.86
UW-1	0.92	0.92	0.92	0.92	0.92	0.92
UW-2	0.92	0.92	0.92	0.92	0.92	0.92

Source Id	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average
UW-3	0.92	0.92	0.92	0.92	0.92	0.92
UW-4	0.92	0.92	0.92	0.92	0.92	0.92
UW-5	0.92	0.92	0.92	0.92	0.92	0.92
UW-6	0.92	0.92	0.92	0.92	0.92	0.92
UW-7	0.17	0.17	0.17	0.17	0.17	0.17
UW-8	0.17	0.17	0.17	0.17	0.17	0.17
UW-9	0.17	0.17	0.17	0.17	0.17	0.17
UW-10	0.17	0.17	0.17	0.17	0.17	0.17
UW-11	0.17	0.17	0.17	0.17	0.17	0.17
UW-12	0.17	0.17	0.17	0.17	0.17	0.17
UW-13	0.98	0.98	0.98	0.98	0.98	0.98
UW-14	0.98	0.98	0.98	0.98	0.98	0.98
UW-15	0.98	0.98	0.98	0.98	0.98	0.98
UW-16	0.98	0.98	0.98	0.98	0.98	0.98
Bull1	1.13	1.13	1.13	1.13	0.00	0.23
Bull2	1.13	1.13	1.13	1.13	0.00	0.23
Bull3	1.13	1.13	1.13	1.13	0.00	0.23
Bull4	1.13	1.13	1.13	1.13	0.00	0.23
Bull5	1.13	1.13	1.13	1.13	0.00	0.23
Bull6	1.13	1.13	1.13	1.13	0.00	0.23
Bull7	1.13	1.13	1.13	1.13	0.00	0.24
Bull8	1.13	1.13	1.13	1.13	0.00	0.23
Bull9	1.13	1.13	1.13	1.13	0.00	0.23
Bull10	1.13	1.13	1.13	1.13	0.00	0.23
Bull11	1.13	1.13	1.13	1.13	0.00	0.22
Bull12	1.13	1.13	1.13	1.13	0.00	0.23
Bull13	1.13	1.13	1.13	1.13	0.00	0.23
UnOre1	1.21	1.21	1.21	1.21	1.21	1.21
UnOre2	1.21	1.21	1.21	1.21	1.21	1.21
UnOre3	1.21	1.21	1.21	1.21	1.21	1.21
UnOre4	1.21	1.21	1.21	1.21	1.21	1.21
FEL1	2.70	2.70	2.70	2.70	2.70	2.03
FEL2	2.70	2.70	2.70	2.70	2.70	2.04
FEL3	2.70	2.70	2.70	2.70	2.70	2.02
Crush1	0.54	0.54	0.54	0.54	0.54	0.45
P201-D	0.04	0.04	0.04	0.04	0.04	0.01
P201-B	11.58	11.58	0.00	0.00	0.00	0.21
P201-L	2.38	2.38	2.38	2.38	2.38	2.38
ESWASTE-UW1	0.72	0.72	0.72	0.72	0.72	0.72
ESWASTE-UW2	0.72	0.72	0.72	0.72	0.72	0.72
ESWASTE-UW3	0.72	0.72	0.72	0.72	0.72	0.72
ESWASTE-Bull1	1.13	1.13	1.13	1.13	0.00	0.14
ESWASTE-Bull2	1.13	1.13	1.13	1.13	0.00	0.14

E.2: Wind Erosion Emissions

Appendix Table 8: Western Ridge PM_{10} wind erosion emissions (g/s)

Source Id	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average
WE1	316.15	28.07	0.00	0.00	0.00	0.85
WE2	316.15	28.07	0.00	0.00	0.00	0.85
WE3	316.15	28.07	0.00	0.00	0.00	0.85
WE4	316.15	28.07	0.00	0.00	0.00	0.85
WE5	316.15	28.07	0.00	0.00	0.00	0.85
WE6	316.15	28.07	0.00	0.00	0.00	0.85
WE7	316.15	28.07	0.00	0.00	0.00	0.85
WE8	316.15	28.07	0.00	0.00	0.00	0.85
WE9	316.15	28.07	0.00	0.00	0.00	0.85
WE10	316.15	28.07	0.00	0.00	0.00	0.85
WE11	316.15	28.07	0.00	0.00	0.00	0.85
WE12	316.15	28.07	0.00	0.00	0.00	0.85
WE13	316.15	28.07	0.00	0.00	0.00	0.85
WE14	316.15	28.07	0.00	0.00	0.00	0.85
WE15	316.15	28.07	0.00	0.00	0.00	0.85
WE16	353.35	31.37	0.00	0.00	0.00	0.95
WE17	353.35	31.37	0.00	0.00	0.00	0.95
WE18	353.35	31.37	0.00	0.00	0.00	0.95
WE19	353.35	31.37	0.00	0.00	0.00	0.95
WE20	353.35	31.37	0.00	0.00	0.00	0.95
WE21	353.35	31.37	0.00	0.00	0.00	0.95
WE22	353.35	31.37	0.00	0.00	0.00	0.95
WE23	353.35	31.37	0.00	0.00	0.00	0.95

E.3: Haul Road Emissions

Appendix Table 9: Western Ridge haul road emissions (g/s)

Source Id	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average
HR1	0.35	0.35	0.35	0.35	0.24	0.27
HR2	0.35	0.35	0.35	0.35	0.24	0.27
HR3	0.35	0.35	0.35	0.35	0.24	0.27
HR4	0.35	0.35	0.35	0.35	0.24	0.27
HR5	0.94	0.94	0.94	0.94	0.63	0.71
HR6	0.94	0.94	0.94	0.94	0.63	0.71
HR7	0.94	0.94	0.94	0.94	0.63	0.71
HR8	0.94	0.94	0.94	0.94	0.63	0.71
HR9	0.94	0.94	0.94	0.94	0.63	0.71
HR10	0.94	0.94	0.94	0.94	0.63	0.71
HR11	1.53	1.53	1.53	1.53	1.02	1.15
HR12	1.53	1.53	1.53	1.53	1.02	1.15
HR13	1.12	1.12	1.12	1.12	0.75	0.84
HR14	1.12	1.12	1.12	1.12	0.75	0.84
HR15	1.12	1.12	1.12	1.12	0.75	0.84
HR16	1.12	1.12	1.12	1.12	0.75	0.84
HR17	0.88	0.88	0.88	0.88	0.59	0.66
HR18	0.88	0.88	0.88	0.88	0.59	0.66
HR19	0.88	0.88	0.88	0.88	0.59	0.66
HR20	0.59	0.59	0.59	0.59	0.39	0.44
HR21	0.59	0.59	0.59	0.59	0.39	0.44
HR22	0.59	0.59	0.59	0.59	0.39	0.44
HR23	0.82	0.82	0.82	0.82	0.55	0.62
HR24	0.82	0.82	0.82	0.82	0.55	0.62
HR25	0.82	0.82	0.82	0.82	0.55	0.62
HR26	0.82	0.82	0.82	0.82	0.55	0.62
HR27	0.82	0.82	0.82	0.82	0.55	0.62
HR28	0.82	0.82	0.82	0.82	0.55	0.62
HR29	0.82	0.82	0.82	0.82	0.55	0.62
HR30	0.82	0.82	0.82	0.82	0.55	0.62
HR31	0.82	0.82	0.82	0.82	0.55	0.62
HR32	1.24	1.24	1.24	1.24	0.82	0.93
HR33	1.24	1.24	1.24	1.24	0.82	0.93
HR34	1.24	1.24	1.24	1.24	0.82	0.93
HR35	1.24	1.24	1.24	1.24	0.82	0.93
HR36	1.24	1.24	1.24	1.24	0.82	0.93
HR37	0.64	0.64	0.64	0.64	0.42	0.48
HR38	0.64	0.64	0.64	0.64	0.42	0.48
HR39	0.64	0.64	0.64	0.64	0.42	0.48
HR40	0.64	0.64	0.64	0.64	0.42	0.48
HR41	1.27	1.27	1.27	1.27	0.85	0.95
HR42	1.27	1.27	1.27	1.27	0.85	0.95
HR43	1.27	1.27	1.27	1.27	0.85	0.95
HR44	1.27	1.27	1.27	1.27	0.85	0.95
HR45	1.27	1.27	1.27	1.27	0.85	0.95
HR46	1.27	1.27	1.27	1.27	0.85	0.95
HR47	1.27	1.27	1.27	1.27	0.85	0.95
HR48	2.65	2.65	2.65	2.65	1.77	1.98
HR49	2.65	2.65	2.65	2.65	1.77	1.98
HR50	3.18	3.18	3.18	3.18	2.12	2.39

Source Id	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average
HR51	3.18	3.18	3.18	3.18	2.12	2.39
HR52	3.18	3.18	3.18	3.18	2.12	2.39
HR53	3.18	3.18	3.18	3.18	2.12	2.39
HR54	1.54	1.54	1.54	1.54	1.03	1.16
HR55	1.54	1.54	1.54	1.54	1.03	1.16
HR56	1.54	1.54	1.54	1.54	1.03	1.16
HR57	1.54	1.54	1.54	1.54	1.03	1.16
HR58	1.54	1.54	1.54	1.54	1.03	1.16
HR59	1.54	1.54	1.54	1.54	1.03	1.16
HR60	1.54	1.54	1.54	1.54	1.03	1.16
HR61	1.54	1.54	1.54	1.54	1.03	1.16
HR62	1.54	1.54	1.54	1.54	1.03	1.16
HR63	1.54	1.54	1.54	1.54	1.03	1.16
HR64	2.95	2.95	2.95	2.95	1.97	2.21
HR65	2.95	2.95	2.95	2.95	1.97	2.21
HR66	2.95	2.95	2.95	2.95	1.97	2.21
HR67	0.64	0.64	0.64	0.64	0.42	0.48
HR68	0.64	0.64	0.64	0.64	0.42	0.48
HR69	0.64	0.64	0.64	0.64	0.42	0.48
HR70	1.54	1.54	1.54	1.54	1.03	1.16
HR71	1.54	1.54	1.54	1.54	1.03	1.16
HR72	1.54	1.54	1.54	1.54	1.03	1.16
HR73	1.54	1.54	1.54	1.54	1.03	1.16
HR74	1.54	1.54	1.54	1.54	1.03	1.16
HR75	0.92	0.92	0.92	0.92	0.61	0.69
HR76	0.92	0.92	0.92	0.92	0.61	0.69
HR77	0.92	0.92	0.92	0.92	0.61	0.69
HR78	0.92	0.92	0.92	0.92	0.61	0.69
HR79	0.92	0.92	0.92	0.92	0.61	0.69
HR80	0.92	0.92	0.92	0.92	0.61	0.69
HR81	1.38	1.38	1.38	1.38	0.92	1.03
HR82	1.38	1.38	1.38	1.38	0.92	1.03
HR83	1.38	1.38	1.38	1.38	0.92	1.03
HR84	1.38	1.38	1.38	1.38	0.92	1.03
HR85	1.38	1.38	1.38	1.38	0.92	1.03
HR86	1.38	1.38	1.38	1.38	0.92	1.03
HR87	1.38	1.38	1.38	1.38	0.92	1.03
HR88	1.38	1.38	1.38	1.38	0.92	1.03
HR89	1.38	1.38	1.38	1.38	0.92	1.03
HR90	1.38	1.38	1.38	1.38	0.92	1.03
HR91	1.38	1.38	1.38	1.38	0.92	1.03
HR92	1.38	1.38	1.38	1.38	0.92	1.03
HR93	1.38	1.38	1.38	1.38	0.92	1.03
HR94	1.38	1.38	1.38	1.38	0.92	1.03
HR95	0.28	0.28	0.28	0.28	0.19	0.21
HR96	0.28	0.28	0.28	0.28	0.19	0.21
HR97	0.28	0.28	0.28	0.28	0.19	0.21
HR98	0.28	0.28	0.28	0.28	0.19	0.21
HR99	0.28	0.28	0.28	0.28	0.19	0.21
HR100	0.28	0.28	0.28	0.28	0.19	0.21
HR101	0.28	0.28	0.28	0.28	0.19	0.21
HR102	0.28	0.28	0.28	0.28	0.19	0.21
HR103	0.28	0.28	0.28	0.28	0.19	0.21

Source Id	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average
HR104	0.28	0.28	0.28	0.28	0.19	0.21
HR105	0.59	0.59	0.59	0.59	0.39	0.44
HR106	0.59	0.59	0.59	0.59	0.39	0.44
HR107	0.18	0.18	0.18	0.18	0.12	0.13
HR108	0.18	0.18	0.18	0.18	0.12	0.13
HR109	0.18	0.18	0.18	0.18	0.12	0.13
HR110	0.18	0.18	0.18	0.18	0.12	0.13
HR111	0.18	0.18	0.18	0.18	0.12	0.13
HR112	0.18	0.18	0.18	0.18	0.12	0.13
HR113	0.18	0.18	0.18	0.18	0.12	0.13
HR114	0.18	0.18	0.18	0.18	0.12	0.13
HR115	0.18	0.18	0.18	0.18	0.12	0.13
HR116	0.18	0.18	0.18	0.18	0.12	0.13
HR117	0.53	0.53	0.53	0.53	0.35	0.40
HR118	0.53	0.53	0.53	0.53	0.35	0.40
HR119	0.53	0.53	0.53	0.53	0.35	0.40
HR120	0.53	0.53	0.53	0.53	0.35	0.40
HR121	0.53	0.53	0.53	0.53	0.35	0.40
HR122	0.53	0.53	0.53	0.53	0.35	0.40
HR123	0.53	0.53	0.53	0.53	0.35	0.40
HR124	0.41	0.41	0.41	0.41	0.27	0.31
HR125	0.41	0.41	0.41	0.41	0.27	0.31
HR126	1.18	1.18	1.18	1.18	0.79	0.89
HR127	1.18	1.18	1.18	1.18	0.79	0.89
HR128	0.82	0.82	0.82	0.82	0.55	0.62
HR129	0.82	0.82	0.82	0.82	0.55	0.62
HR130	0.82	0.82	0.82	0.82	0.55	0.62
WB-HR30	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR31	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR32	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR33	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR34	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR36	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR37	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR38	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR39	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR40	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR41	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR42	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR43	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR57	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR58	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR59	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR60	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR90	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR91	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR92	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR93	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR94	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR95	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR96	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR97	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR98	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR100	0.30	0.30	0.30	0.30	0.22	0.24

Source Id	Maximum	99th Percentile	95th Percentile	90th Percentile	70th Percentile	Average
WB-HR104	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR105	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR106	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR107	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR271	1.21	1.21	1.21	1.21	0.91	0.99
WB-HR272	1.21	1.21	1.21	1.21	0.91	0.99
WB-HR273	1.21	1.21	1.21	1.21	0.91	0.99
WB-HR274	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR275	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR276	0.30	0.30	0.30	0.30	0.22	0.24
WB-HR277	0.30	0.30	0.30	0.30	0.22	0.24

Appendix F – Whaleback Emissions

The key emission sources for the operating phase of the Mt Whaleback operations are associated with:

- drilling and blasting
- material handling from loading and unloading activities involving
    - loading trucks
    - unloading trucks
    - bulldozing
    - crushing
- processing:
    - crushing
    - screening
    - stacking, reclaiming and rail load out
    - material transfer including conveyors and transfer stations
- wheel generated dust from roads and haul roads
- wind erosion from stockpiles and open areas.

For this assessment emission estimation was undertaken for two separate years – FY22 to represent the existing scenario and FY30 for inclusion within the cumulative (future) scenario. The tonnages for the respective years are as follows:

- FY22 with the following tonnages:
    - Mt Whaleback 104.7 Mtpa comprising:
        - Ore – 27.9 Mtpa
        - Waste – 76.8 Mtpa
    - Eastern Ridge 50.3 Mtpa comprising:
        - Ore – 27.1 Mtpa
        - Waste – 23.2 Mtpa
- FY30 with the following tonnages:
    - Mt Whaleback 40.8 Mtpa comprising:
        - Ore – 19.3 Mtpa
        - Waste – 21.5 Mtpa
    - Eastern Ridge 29.9 Mtpa comprising:
        - Ore – 11.0 Mtpa
        - Waste – 18.9 Mtpa