Final Report

Atlas Corunna Downs – Air Quality Assessment

Document control number: AQU-WA-003-21675

Date: 9 February 2017

Pacific Environment Limited

Technologies Consulting Monitoring

www.pacific-environment.com

Project name: Atlas Corunna Downs – Air Quality Assessment

Document control number: AQU-WA-003-21675

Prepared for: Atlas Iron Limited

Approved for release by: Jon Harper

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Document Control

Version	Date	Comment	Prepared by	Reviewed by
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Final	9-02-2017	Final	L. Gowrisanker	J. Harper

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Executive summary

Project description

Atlas Iron Limited (Atlas) is seeking environmental approvals for the Corunna Downs project ("the Project"). Atlas engaged Pacific Environment Ltd (PEL) to undertake an air quality assessment to support its environmental approvals process.

The Corunna Downs project is located approximately 33 kilometres (km) south-west of the town of Marble Bar and 241 km south-east of Port Hedland in the Pilbara region of Western Australia.

The Project will use conventional drill, blast, truck and excavators to mine approximately 4 million tonnes per annum (Mtpa) of iron ore. The finished product will be hauled from the mine to the Pilbara Ports Authority (PPA) multi-user berth facility at Utah Point using road trains. Mining is anticipated to occur over a five to six year period.

The objective of this study is to assess the potential air quality impact from the operations of the Project as currently defined.

Overview of assessment

For the purpose of the air quality assessment, the Project comprises the mine, ore processing facilities and associated infrastructure including road network, buildings and support facilities.

Air quality assessment criteria provide the framework to assess effects of predicted (modelled) emissions on the environment (ie. human health). In WA, the assessment criteria are applied at sensitive receptors which are defined as areas where people reside or congregate.

Modelled ground level concentrations for key pollutants of interest have been compared to ambient air quality assessment criteria in order to determine the potential impact. The assessment has considered the potential impact associated with the Project, as well as the cumulative impact (ie in conjunction with the background air quality expected in the project area). The assessment has been made generally across the model domain, as well as at key sensitive receptor locations identified as being representative of protected environmental values. A set of four sensitive receptors were defined and these include dwellings as well as locations of interest.

Key findings of the assessment

Corunna Downs project impact in isolation of other emission sources

The Project was modelled to estimate the contribution of emissions from under a single operating design scenario; mining and processing associated with handling approximately 6 Mtpa of material.

Particles as TSP, PM_{10}, $PM_{2.5}$, and dust deposition were modelled to represent the potential impact of the operations on the environment (ie, human health and the natural environment).

The modelling results for the Project in isolation of other emission sources in the region indicate the following

- TSP – 24-hour average
  - the 'Project only' impact at the Proposed Camp is about 32% of the criteria
  - Very low impact can be expected at the remaining three sensitive receptors.
- PM_{10} – 24-hour average
  - the maximum 24-hr PM_{10} is predicted to occur at the Proposed Camp and is about 30% of the criteria
  - No significant impact is predicted at the remaining three receptors.
- PM_{10} – annual average
  - the maximum annual average PM_{10} is predicted to occur at the Proposed Camp and is about 11% of the criteria
  - No significant impact is predicted at the remaining three receptors.
- $PM_{2.5}$ – 24-hour average
  - The maximum 24-hour average $PM_{2.5}$ is predicted to present very minimal (less than 10% of criteria) across the four sensitive receptors.
- $PM_{2.5}$ – annual average
  - No impact can be expected across the four sensitive receptors

In summary, the Project in isolation of other emission sources in the region, presents minimal impact on the air quality in the region.

Cumulative impact with other emission sources

The Project was modeled in conjunction with the background concentrations as measured at the Port Hedland Industries Council (PHIC) Yule River monitoring station, to estimate the potential cumulative impact on the environment following the introduction of the project. The Project included emissions from the operations under a single design scenario. Emissions from the construction scenario were not assessed.

In the absence of site specific background monitoring information, background levels have been adopted from a representative monitoring station and the cumulative impact should be read in conjunction with background levels adopted.

Both short term impacts (24-hour timeframe) and long term impacts (1-year) were considered. The following can be summarized:

- the maximum 24-hour TSP and PM_{10} concentrations can be expected to be above the relevant criterion. This could be attributed to the elevated levels of background adopted in the assessment.
- the maximum 24-hour $PM_{2.5}$ concentrations is predicted to be below the relevant criteria

- the annual average PM_{10} and $PM_{2.5}$ concentrations are predicted to be below the relevant criterion.

In summary, the introduction of the Project presents no significant impact on the air quality in the region.

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1 Introduction

Atlas Iron Limited is seeking environmental approvals for the Corunna Downs Project.

Atlas commissioned Pacific Environment Limited (PEL) to undertake an air quality assessment as part of the process to obtain environmental approval. The purpose of the air quality assessment is to predict the potential impact on air quality from the Corunna Downs project (as it is currently defined) in areas surrounding the project (as determined at selected sensitive receptors).

1.1 Project description

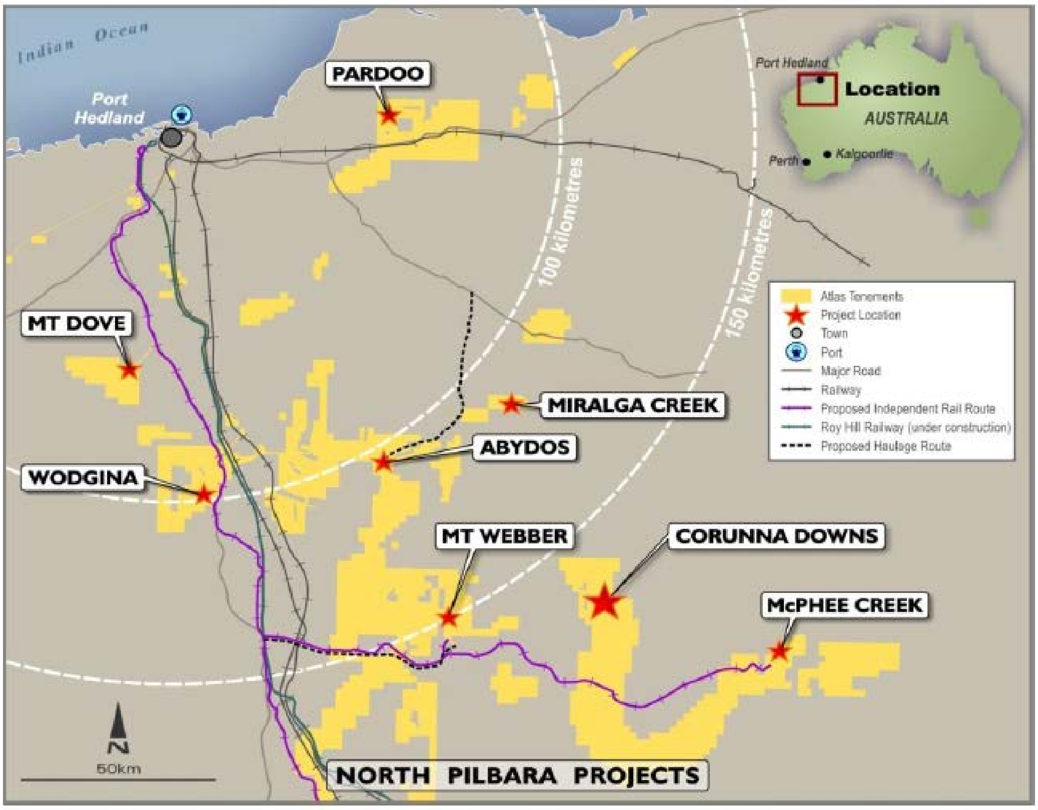
The Corunna Downs project ("the Project") is located in the Pilbara region of Western Australia at approximately 33 kilometres (km) south-west of the town of Marble Bar and 241 km south-east of Port Hedland. The site location, in a regional context, is shown in Figure 1-1.

The Corunna Downs project will use conventional drill, blast, truck and excavators to mine approximately 4 million tonnes per annum (Mtpa) of iron ore. The finished product will be hauled from the mine to the Pilbara Ports Authority (PPA) multi-user berth facility at Utah Point using road trains. Mining is anticipated to occur over a five to six year period.

For the purpose of the air quality assessment, the Project comprises the:

- Mines – open pits.
- Screening and Crushing plants
- Waste dumps
- Associated infrastructure includes:
  - Road network from the mine pits to the Run of Mine (RoM) pad.
  - Buildings and support facilities including mine operations centre, contractors laydown yards, explosives storage and camp, general administration facilities and other service facilities.

Ambient air quality and potential impacts are assessed in terms of particles as TSP, $PM_{10,}$ $PM_{2.5}$ and dust deposition



Regional location plan

Figure 1-1: Site location in regional context (Atlas, 2015)

1.2 Report structure

This report describes the methods and findings of an assessment of the potential impact to air quality arising from the Project, as currently proposed. The assessment includes:

- Study methodology (Section 2)
- Emission estimation (Section 3)
- Atmospheric dispersion modelling results (Section 5)
- Conclusions (Section 6)

Supporting information is contained in the Appendices.

2 Assessment Approach

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

2.1 Climate Assessment Methodology

The climate and meteorological characteristics of the region control the dispersion, transformation and removal (or deposition) of pollutants from the atmosphere (i.e. ambient air quality). There are no meteorological stations onsite and reference was made to the closed BoM station at Marble Bar (18km from the Project) that records hourly wind speed and wind direction amongst other parameters. Analysis of 10-year of historical surface observations at the BoM Marble Bar station identified 2015 as the most representative meteorological year.

2.2 Emission Estimation

An emissions inventory has been developed for the Project. Emissions from all key sources associated with the Project have been identified according to accepted methods. Emissions of particles from the proposed operations have been estimated for one year of operations, and are based on proposed operational activities associated with 6 Mtpa of material moved for the forecast period of January 2018 to December 2018. A detailed analysis of the emission estimation process is presented in Section 3.

2.3 Dispersion Modelling

Air dispersion modelling requires both upper air data and surface air data (or assumptions).

2.3.1 Meteorological model

The meteorology applied within a dispersion model is a key factor for the effectiveness or representativeness of the dispersion model outputs. Both upper air and surface information are needed for modelling (or assumptions). For the purposes of this assessment, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) designed prognostic model TAPM (The Air Pollution Model) was used to obtain the required meteorological data at the project location for inclusion in the assessment (in a format suitable for AERMET). The setup of this meteorological modelling is outlined in Section 4.1.

2.3.2 Dispersion model

For this assessment, air dispersion modelling has been conducted using the USEPA approved model AERMOD (and AERMET, for the associated meteorological component). The model has been used to predict ground level concentrations across the model domain and at nominated sensitive receptor locations. In the absence of site-specific monitoring data, background PM_{10} concentration is based on available air quality information from the PHIC's Yule River monitor. This approach is considered acceptable for reasons stated in Section4.2.1.5.

2.3.3 Modelled operating scenarios and assumptions

The air quality assessment has taken into account only the operational phase impacts of the Project. Emissions associated with the construction phase of the project are not considered or assessed.

For this study, the emissions and impacts from a single operational scenario has been presented. The assessment takes into account the emission sources associated with:

- Open pit mining
- Ore extraction and processing
- Loading of final product onto Road Trains for transport to Utah Point.

2.4 Ambient Assessment Criteria and Sensitive Receptors

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 receptor. This assessment has considered the potential impact attributable to the Project, as well as the cumulative impact (ie. in conjunction with the existing emission sources in the study area). The assessment has been made generally across the model domain, as well as at key sensitive receptor locations identified as being representative of the protected values.

2.4.1 Assessment criteria

Assessment criteria selected for the study are based on:

- Local guidelines, criteria or standards adopted by the Western Australian Department of Environment Regulation (DER) or Environmental Protection Authority (EPA), and
- National standards adopted by the WA State Government.

The National Environmental Protection (Ambient Air Quality) Measure 2016 (NEPM) defines ambient air quality standards for criteria pollutants, including (but not limited to) NO_2, PM_{10} and $PM_{2.5}$ (NEPC, 2016).

The set of NEPM ambient air standards are intended to be protective of human health and wellbeing. In Western Australia, this criterion is applied to sensitive receptors, defined as residences, hospitals, school and other places where people may congregate including sporting and recreational venues.

In December 2015, the DER released Ambient Air Quality criteria (Draft WA DER) as part of its Environmental Risk Assessment Framework (DER 2015). Precedence will be given to the Draft WA DER criteria. The concentrations presented in these tables have been adjusted to a standard temperature of 25ºC as the model (AERMOD) uses this parameter (as opposed to 0ºC which is used in Australia).

Table 2: *Assessment Criteria*

Pollutant	Guideline Value	Unit	Averaging Period	Reference
NO_2	0.12 (226) [a]	ppm ($\mu g/m^3$)	1-hour	Draft WA DER (2015)
	0.03 (56) [a]	ppm ($\mu g/m^3$)	1-year	Draft WA DER (2015)
TSP	82	$\mu g/m^3$	24-hour	Draft WA DER (2015)
PM_{10}	46 [a]	$\mu g/m^3$	24-hour	Draft WA DER (2015)
	27.5 [a]	$\mu g/m^3$	1-year	Draft WA DER (2015)
$PM_{2.5}$	23	$\mu g/m^3$	24-hour	Draft WA DER (2015)
	7	$\mu g/m^3$	1-year	

a. Concentrations at 25ºC

2.4.1.1 Dust Deposition Criteria

There is no formal dust deposition criterion available in WA. As such reference has been made to the New South Wales (NSW) criteria (DEC, 2001) for deposited dust and they are normally applied for assessments in WA. The NSW criteria set a maximum increase of 2g/m^2/month in dust levels with a maximum total deposited dust level of 4g/m^2/month. Deposited dust is assessed as insoluble solids as defined by AS 3580.10.1-1991. It is noted that the above criterion were set to address nuisance dust and not as an indicator for assessing impact on vegetation or fauna.

2.4.2 Sensitive receptors

For the purposes of air quality assessment, the WA DER defines sensitive receptors as '*a location where people are likely to reside or congregate; this may include a dwelling, school, hospital, nursing home, child care facility or public recreation area or land zoned residential that is either developed or undeveloped'*.

For the current assessment, a combination of residential dwellings and other locations of interest were identified and defined as sensitive receptors. Modelled ambient air quality concentrations were determined at these locations. The key sensitive receptors are listed in Table 2.1 and shown in Figure 2-1. The following can be stated:

- Comet Gold mine is not a dwelling but a location of interest
- Proposed Camp, MB Travellers Rest and Residence are locations where people reside.

Table 2.1: Sensitive receptor locations

Receptor ID	Receptor Type	Easting (m)	Northing (m)
Proposed Camp	Dwelling	779,690	7,633,274
Comet Gold Mine	Location of interest	782,903	7,649,733
MB Travellers Rest	Dwelling	785,509	7,656,052
Residence	Dwelling	786,188	7,655,767

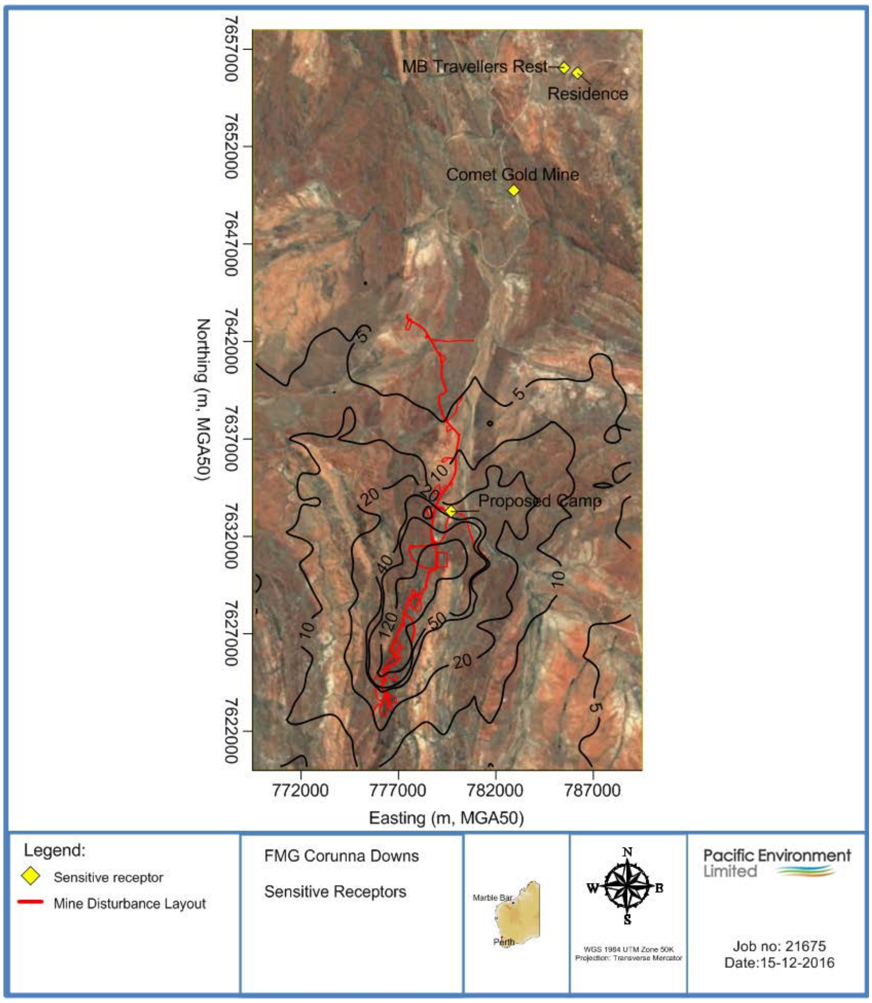


Figure 2-1: Sensitive receptor locations

3 Emission Estimation

This section outlines the emission estimation process used to develop the emission inventory for the Project (operations phase only). Emission estimates are sourced from this project specific inventory for inclusion in the dispersion model. It includes the emissions from land disturbance, all mining and processing circuits, vehicles, plant and machinery.

It is noted that the construction phase activities are expected to contribute particle (dust) emissions as a result of earthworks, mainly:

- Preparation of the site for mining and support activities, including initial clearing / disturbance of vegetation
- Construction of mine pits and infrastructure, processing plant, roads, support facilities.

The emphasis of the emission estimation and modelling is on the potential impact from the operating phase of the project. Emission estimation of construction activities is excluded from the assessment.

3.1 Sources of Emission

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

- Mining operations
  - Blasting
  - Drilling
  - Material loading be excavators
  - Material unloading from haul trucks
  - Wheel generated dust from haul roads
  - Bulldozers on ore and waste
  - Conveyors
  - Wind erosion from stockpiles and open areas
  - Material loading into crusher by front end loader
- Processing plant operations (crushing and screening)
- Stackers
- Loading of final product into Road Trains

The emission estimation techniques used in this assessment have been primarily sourced from the National Pollution Inventory (NPI) literature. Where available, emission data supplied by Atlas has been used.

Mining will occur at a maximum rate of 6 Mtpa (ore and waste) with an approximate 50% split between ore and waste.

The estimated annual emissions from the mining operations are presented in Table 3.1. The emission control factors applied are shown in Table 3.2.

Table 3.1: *PM_{10} emissions (mining) – operational phase*

Activity	PM_{10} (kg/year)	Controls
Drilling	15,770	In pit retention
Blasting	6,010	In pit retention
FEL loading into ore into trucks - inpit	45,098	In pit retention
FEL loading into waste into trucks - inpit	23,039	In pit retention
Trucks dumping ore onto RoM Pad stockpiles	1,346	No controls
Trucks dumping ore onto dump hopper	7,824	Water sprays
Trucks dumping waste onto waste dumps	8,690	No controls
Bulldozer on ore (inpit)	17,845	In pit retention
Bulldozer on waste	17,845	No controls
FEL loading ore into dump pockets from RoM Pad	2,172	Water sprays
Primary Crushing (PC)	15,780	No controls
Conveyor from PC to SC	7,890	No controls
Secondary Crushing	47,341	No controls
Conveyor from SC to Stacker	7,890	No controls
Stacking	3,945	Water sprays
Loading ore onto Road Trains	23,652	Water sprays
Total	253,389	

Table 3.2: *Emission control factors*

Activity	Control	Reference
Water sprays	50%	NPI (2012)
In pit retention TSP	50%	NPI (2012)
In pit retention PM_{10}	5%	NPI (2012)

The top 20 estimated emission sources (by the 99th percentile) operations are presented in Figure 3-1. Emissions from loading of waste and ore contribute to the largest emission rates of sources from operations at the facility.

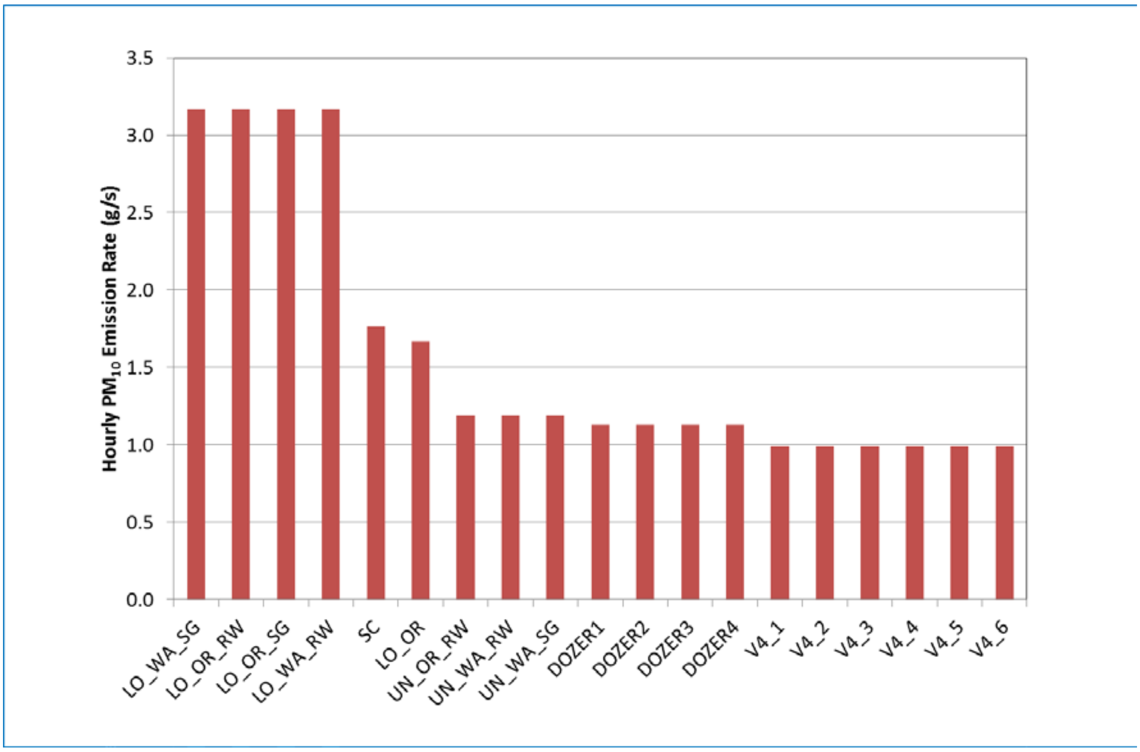


Figure 3-1: Top 20 calculated PM_{10} emission rates with emission controls

Further details including the emission parameters, emission equations used and resultant emission rates are discussed in the Appendix C.

4 Atmospheric Dispersion Modelling

This assessment used a suite of modelling tools to estimate air quality impacts. TAPM and AERMET were used to generate three-dimensional meteorological fields for a representative year, 2015. AERMOD was used for dispersion modelling. Below is a short description of these models and their set-up for this study.

4.1 Meteorological Modelling

4.1.1 TAPM

The Air Pollution Model (TAPM) was used to generate the meteorological data needed for AERMET, the meteorological pre-processor for AERMOD.

TAPM, is a three dimensional meteorological and air pollution model produced by the CSIRO Division of Atmospheric Research (Hurley, 2002a, 2002b; Hurley et al., 2002a, 2002b; Hibberd et al., 2003; Luhar & Hurley, 2003). TAPM solves the fundamental fluid dynamics and scalar transport equations to predict meteorology and pollutant concentrations. It consists of coupled prognostic meteorological and air pollution concentration components, eliminating the need to have site-specific meteorological observations. The model predicts airflow important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

All surface and upper air meteorological data were generated using TAPM (v4.0.4). TAPM was run for a full year (2015) with two nested domains (10 km, 3 km) centred at 21.4S and 119.41E. The output from TAPM was extracted to create an onsite met file and an upper air file in FSL format for input into AERMET.

4.1.2 AERMET

To drive AERMET, meteorological data is required to be prepared in certain formats. Two meteorological data files are required: surface met file and upper air file. In the absence of surface and upper air meteorological data in the model domain, extracted data from TAPM were used as input for AERMET.

The following parameters were extracted from TAPM for input as surface file into AERMET:

- Net radiation
- Temperature

The following parameters were based on BoM Marble Bar for input as surface file into AERMET:

- Precipitation
- Wind speed
- Wind direction

- Relative humidity and
- Station pressure

The upper air file for AERMET provides information on the vertical structure of the atmosphere and requires minimum two soundings per day: around sunrise and sunset. These data were also extracted from TAPM and formatted into an FSL file.

In applying the AERMET meteorological processor to prepare the meteorological data for the AERMOD model appropriate values for three surface characteristics needed to be determined:

- Surface roughness length
- Albedo
- Bowen ratio.

The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero based on a logarithmic profile. The surface roughness length influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer.

The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux. Average land use characteristics were derived from TAPM and are based on USGS Land Use Category Number 51. These land use parameters were input into AERMET across all sectors (Table 4.1).

Table 4.1: *Land-use characteristics input for AERMET*

Surface roughness lenth (m)	Albedo	Bowen Ratio
0.15	0.25	3

Data for AERMOD was generated using Lakes Environment’s AERMET View v9.2.0 software (US EPA AERMET executable AERMET_15181.exe). The main AERMET options and assumptions used are listed below:

- Threshold wind speed of 0.5m/s was used.
- Adjust surface friction velocity (ADJ_U*) option was used for low winds.
- Adjust horizontal meander using LOWWIND2 was used for low winds.

A plot of the wind roses generated based on AERMET output meteorological data is presented in Figure 4-1. Quality assurance was undertaken on the AERMET output meteorological data and is detailed in the Appendices.

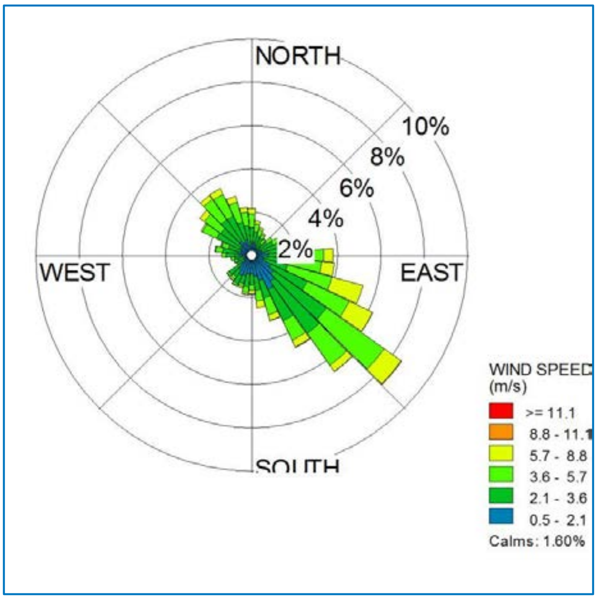


Figure 4-1: *Annual windrose generated by AERMET (2015)*

4.2 Dispersion Modelling

4.2.1 AERMOD

AERMOD is the acronym or common name for the AERMIC Dispersion Model. It was designed by the AERMIC Committee (the American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee) to treat elevated and surface emission sources in terrain that is simple or complex (Perry, Cimorelli et al, 2005). AERMET, a USEPA approved meteorological processor is the processor used to generate the meteorological file in an appropriate format for use in AERMOD.

In November 2006 AERMOD replaced the ISCST3 model as the USEPA's regulatory model for near-field applications (less than 50 km) for simple and complex terrain (USEPA, 2008a). In October 2013, the Environmental Protection Authority (EPA) of Victoria adopted AERMOD as the replacement for AUSPLUME for regulatory air impact assessment in Victoria.

AERMOD is a steady state model and assumes that over time, the average concentrations distribution within a plume is Gaussian. AERMOD was used to predict the dispersion of PM_{10} and NO_2 at one receptor within the region.

A sample AERMOD input file typical of those used in this assessment is presented in the Appendix D. The main model options and assumptions used are listed below:

- all sources were modelled as volume sources
- building wake effects were excluded
- surface and upper air meteorological data generated by AERMET (Section 4.1.2)
- terrain information was obtained from Shuttle Radar Topography Mission (SRTM) at 1 arc, 30m resolution

- TSP, PM_{10} and $PM_{2.5}$ were modelled as gas accounting for dry depletion. Depositional parameters are provided in Section 4.2.1.1
- pollutant concentrations were modelled across four discrete receptors (Section 2.4.2) and uniform gridded receptors (Section 4.2.1.3).

The emission source parameters for all modelled sources are presented in the Appendices.

4.2.1.1 Deposition Modelling

Dry deposition occurs from gravitational sedimentation, impaction, and diffusion to surfaces. In this assessment, gravitational settling is the only form of dry deposition evaluated.

Gravitational deposition of the particles depends on the corresponding settling velocity and airborne concentrations. The settling velocity of a particle depends on the particle size, density and properties of the atmosphere including density and viscosity. Reference was made to the NSW SPCC (1988) report and USEPA 2006 to estimate size distribution for particles less than 30µm in diameter (Table 4.2). The mean diameter and geometric mean mass adopted for this study are presented in Table 4.2.

Table 4.2: *Particle Size Distribution input into AERMOD*

Particle size	Mean Diameter	% by weight
PM_{30} to PM_{15}	22.5	36
PM_{15} to PM_{10}	12.5	17
PM_{10} to PM_{5}	7.5	23
PM_{5} to $PM_{2.5}$	3.75	17
$<PM_{2.5}$	1.25	7

An emission file was generated for TSP, PM_{10} and $PM_{2.5}$ with their corresponding particle size distributions; pollutant concentrations were modelled accounting for dry depletion. Dry deposition was modelled as an output from the TSP model file.

4.2.1.2 Source Characteristics

A total of 49 volume sources were used to represent emissions: 28 sources to represent operational emissions from mining including wind erosion and 21 sources to represent emissions of wheel generated dust.

Details of the sources including source identification, type, location and characteristics (height, horizontal and vertical spreads) are also presented in the Appendices. The source parameters listed are identical to those used in the modelling input files and are included in this report for transparency.

4.2.1.3 Grid System

AERMOD can calculate concentrations both on a set grid (gridded receptors) and at specified locations (discrete receptors). The model was configured to predict the ground-level concentrations on a rectangular grid. The model domain was defined as 36.8 km in the north–south direction and 19.2 km in the east-west direction and has its southwest corner at

769700, 7620200 m (50K UTM). This grid approach was chosen to restrict the duration of model runs while using the particle deposition algorithms. An additional four discrete receptors were included to give an indication of ambient concentrations at specific locations (Section 2.4.2).

4.2.1.4 Model outputs

The model outputs the ambient concentrations at a temperature of 25ºC and pressure of 1 atmosphere (101.3kPa). This section details the model results for ‘Project only’ scenario and ‘Cumulative’ scenario that includes existing background concentrations (Section 5). The emissions used in the modelling are presented in Section 3, and the assessment criteria are discussed in Section 2.4.1.

4.2.1.5 Background pollutant levels

The Pilbara region of Western Australia is bushfire prone with these generally occurring between July and January, during the dry season. Background dust levels will be elevated during this time (AIC, 2008).

No information is available on PM_{10} monitoring undertaken in the region. As such reference was made to the available air quality information at the Port Hedland Industries Council (PHIC) monitor at Yule River. This monitor is located 30km inland from Port Hedland and is considered representative of the background air quality expected in inland Pilbara. Statistics of the 24-hour PM_{10} concentrations recorded at the Yule River monitor for 2015 is presented in Table 4.3.

Table 4.3: Statistics of 24-hour PM_{10} at Yule River for 2015 (PHIC, 2016)

Statistics	Value (µg/m^3)
Maximum	101
99th Percentile	69
95th Percentile	48
90th Percentile	41
70th Percentile	25
Average	22.1

In the absence of TSP monitoring data, background TSP levels are taken as 1.6 the PM_{10} background adopted for the assessment. This approach is consistent with the particle size distribution adopted in the study (Section 4.2.1.1).

There are no $PM_{2.5}$ monitoring available in the project locality and the background levels are assumed to be 15% of the PM_{10} used for the assessment. This approach is consistent with the particle size distribution adopted in the study (Section 4.2.1.1).

There is no publicly available information on the dust deposition levels in the region; therefore this report will assess the Project only increments against the NSW DER incremental criteria of 2g/m^2/month.

4.3 Model Uncertainty

Atmospheric dispersion models represent a simplification of the many complex processes involved in determining ground-level concentrations of substances.

Model uncertainty is composed of model chemistry/physics uncertainties, data uncertainties, and stochastic uncertainties. In addition, there is inherent uncertainty in the behaviour of the random turbulence. The generic sources of uncertainty in dispersion models and their potential effects on this assessment are summarised in Table 4.4.

Table 4.4: Summary of main sources of modelling uncertainty

Source	Effects
Oversimplification of physics in model code (varies with type of model)	A variety of effects that can lead to both under-prediction and over-prediction. Errors are greater in Gaussian plume models, which do not include the effects of non-steady-state meteorology (i.e., spatially- and temporally-varying meteorology).
Errors in emissions data	Ground-level concentrations are proportional to emission rate. Plume rise is affected by source dimensions, temperature and exit velocity.
Errors in wind data	Wind direction affects direction of plume travel. Wind speed affects plume rise and dilution of plume, resulting in potential errors in distance of plume impact from source, and magnitude of impact.
Errors in stability estimates	Gaussian plume models use estimates of stability class, and 3-D models use explicit vertical profiles of temperature and wind (which are used directly or indirectly to estimate stability class for Gaussian models). In either case, errors in these parameters can cause either under prediction or over prediction of ground-level concentrations.
Errors in temperature	Usually the effects are small, but temperature affects plume buoyancy, with potential errors in distance of plume impact from source, and magnitude of impact.
Inherent uncertainty	Models predict ‘ensemble mean’ concentrations for any specific set of input data (say on a 1-hour basis), i.e., they predict the mean concentrations that would result from a large set of observations under the specific conditions being modelled. However, for any specific hour with those exact mean hourly conditions, the predicted ground-level concentrations will never exactly match the actual pattern of ground-level concentrations, due to the effects of random turbulent motions and random fluctuations in other factors such as temperature.

5 Predicted Air Quality Impact

The maximum ground level concentrations of the key pollutants of concern have been predicted across the model domain and interpreted at the four nominated sensitive receptor locations. The cumulative results for the Project are also presented. Modelled results are presented in tables (statistics) and as contour maps showing the cumulative ground level concentrations for pollutants modelled.

5.1 Assessment of TSP

5.1.1 24-hour average

Modelled TSP concentrations have been compared to the Draft WA DER 24-hour average criteria of 82µg/m³ (Section 2.4.1). The model results indicate the following:

- Excluding background (Table 5.1)
  - the Project only impact at the Proposed Camp is about 32% of the criteria
  - Very low impact can be expected at the remaining three sensitive receptors.
- Including background (Table 5.2)
  - the maximum 24-hour average TSP is predicted to be above the criteria across all four receptors. It is worth noting that the maximum background value adopted (161µg/m³) is well above the criteria.
- Contour plots of maximum 24-hour average TSP concentrations excluding and including background are presented in Figure 5-1 and Figure 5-2 respectively.

Table 5.1: Predicted 24-hour TSP concentrations at the sensitive receptors excluding background (µg/m³)

Statistics	Proposed Camp	Comet Gold Mine	MB Travellers Rest	Residence
Maximum	27	1	1	1
99th Percentile	18	1	1	1
95th Percentile	15	1	0	0
90th Percentile	12	0	0	0
70th Percentile	5	0	0	0
Average	5	0	0	0
Count > 82µg/m³	0	0	0	0

Table 5.2: Predicted 24-hour TSP concentrations at the sensitive receptors including background ($\mu g/m^3$)

Statistics	Proposed Camp	Comet Gold Mine	MB Travellers Rest	Residence	Background	Criteria
Maximum	164	162	162	162	161	82
99^{th} Percentile	117	110	110	110	110	
95^{th} Percentile	80	77	77	77	77	
90^{th} Percentile	70	67	66	66	66	
70^{th} Percentile	47	41	41	41	41	
Average	40	36	36	36	35	
Count > $82 \mu g/m^3$	17	14	14	14	14	

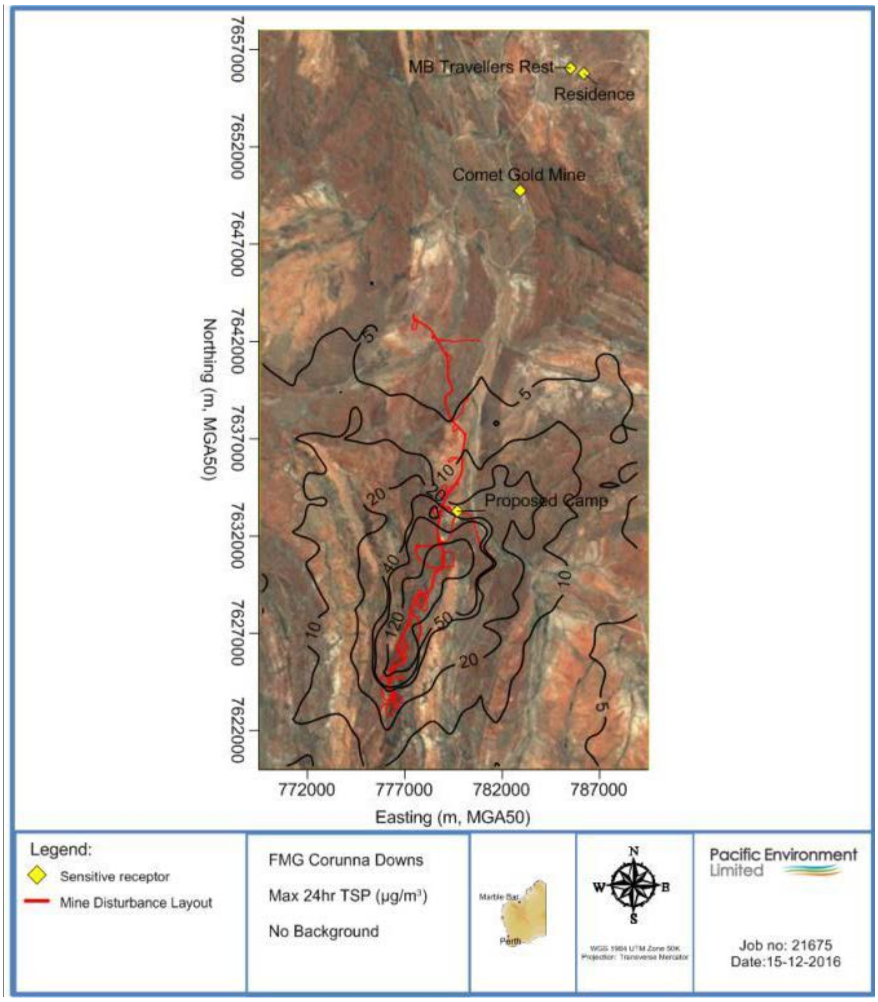


Figure 5-1: Contour plot of m*aximum 24-hour TSP concentrations (excluding background)*

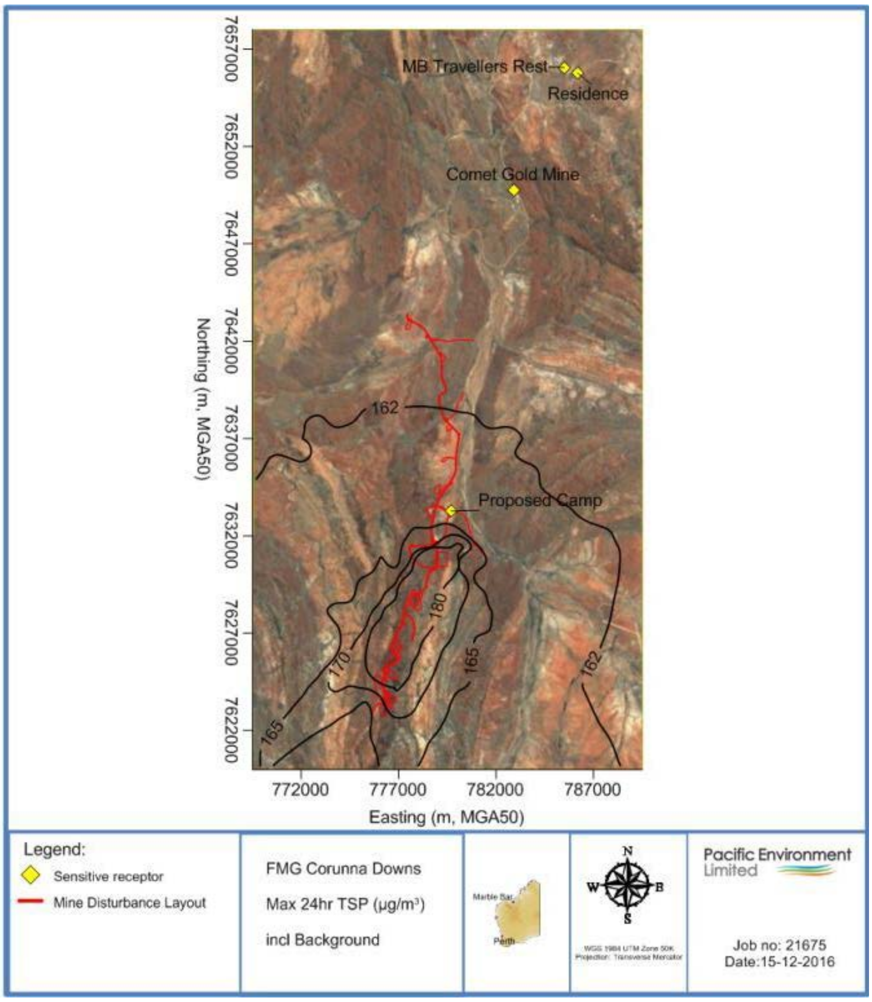


Figure 5-2: Contour plot of m*aximum 24-hour TSP concentrations (including background)*

5.2 Assessment of PM_{10}

5.2.1 24-hour average

Modelled PM_{10} concentrations have been compared to the Draft WA DER 24-hour average criteria of 46µg/m³ (Section 2.4.1). The model results indicate the following:

- Excluding background (Table 5.3)
  - Across all receptors, the maximum 24-hr PM_{10} is predicted to occur at the Proposed Camp and is about 30% of the criteria.
  - No significant impact is predicted at the remaining three receptors.
- Including background (Table 5.4)
  - the maximum 24-hour average PM_{10} levels predicted to be above the criteria across all four sensitive receptors.
  - Attention should be drawn to the background concentrations adopted, with these values well above or approaching the criteria up until the 90th percentile value.

- Given the elevated background levels adopted in the assessment, the impact from the Project is predicted to be very minimal at all receptors.

- Contour plots of maximum 24-hour average PM_{10} concentrations excluding and including background are presented in Figure 5-3 and Figure 5-4 respectively.

Table 5.3: Predicted 24-hour PM_{10} concentrations at the sensitive receptors excluding background ($\mu g/m^3$)

Statistics	Proposed Camp	Comet Gold Mine	MB Travellers Rest	Residence
Maximum	14	1	0	0
99^{th} Percentile	11	1	0	0
95^{th} Percentile	8	0	0	0
90^{th} Percentile	7	0	0	0
70^{th} Percentile	3	0	0	0
Average	3	0	0	0
Count > $46\mu g/m^3$	0	0	0	0

Table 5.4: Predicted 24-hour PM_{10} concentrations at the sensitive receptors including background ($\mu g/m^3$)

Statistics	Proposed Camp	Comet Gold Mine	MB Travellers Rest	Residence	Background	Criteria
Maximum	102	101	101	101	101	46
99^{th} Percentile	72	69	69	69	69	
95^{th} Percentile	50	48	48	48	48	
90^{th} Percentile	43	42	42	42	41	
70^{th} Percentile	28	26	26	26	25	
Average	25	22	22	22	22	
Count > $46\mu g/m^3$	27	24	24	24	23	

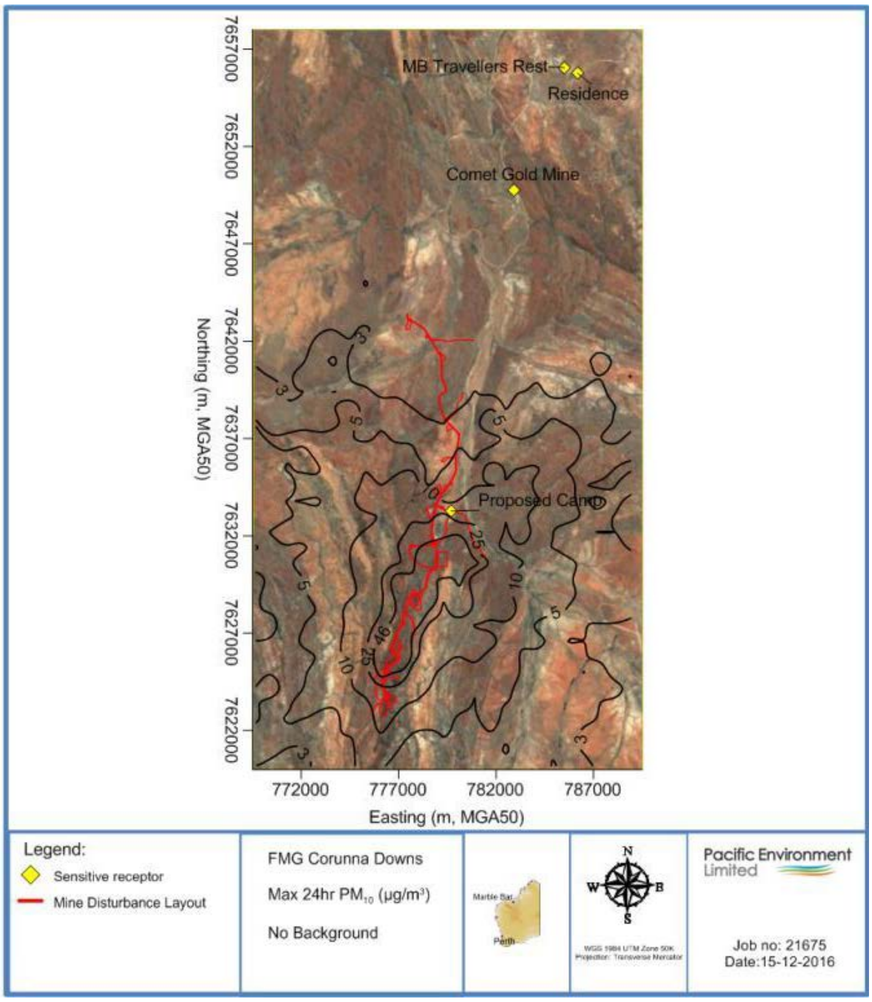


Figure 5-3: Contour plot of m*aximum 24-hour PM_{10} concentrations (excluding background)*

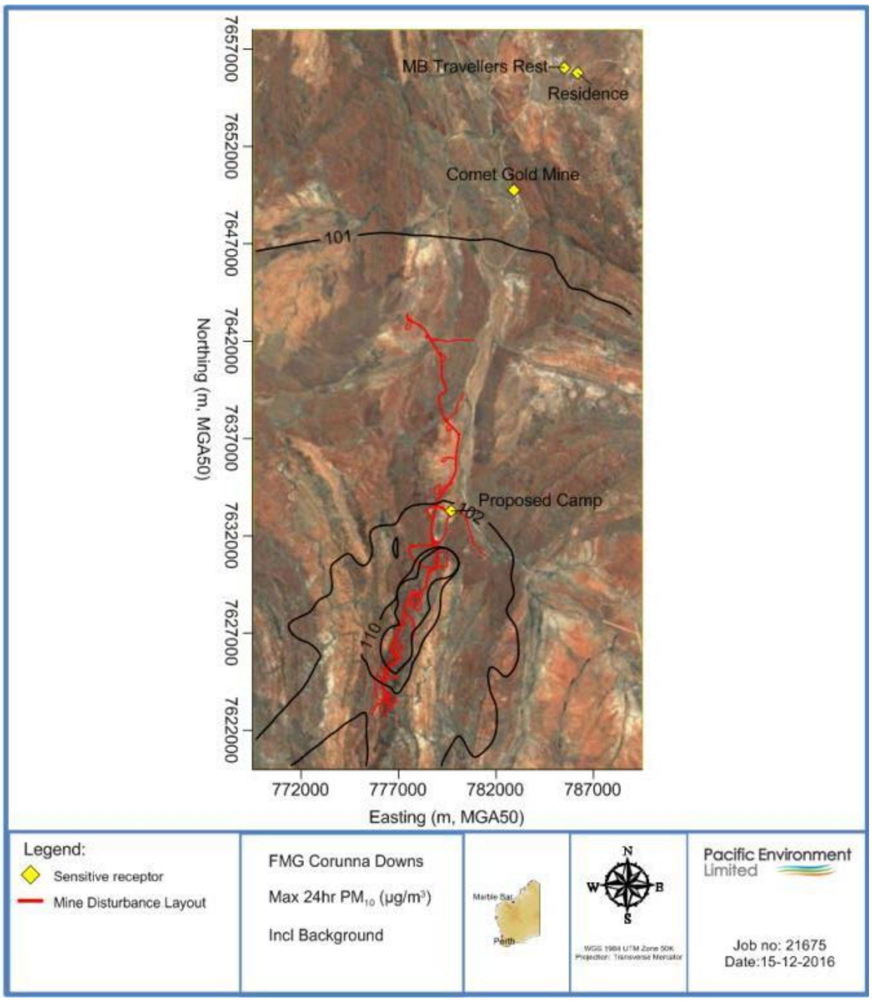


Figure 5-4: Contour plot of m*aximum 24-hour PM_{10} concentrations (including background)*

5.2.2 Annual average

Modelled annual average PM_{10} concentrations have been compared to the Draft WA DER annual average criteria of 27.5µg/m³ (Section 2.4.1).

- Excluding background (Table 5.5):
  - At the Proposed Camp, the annual average PM_{10} concentrations can be expected to be about 11% of the criteria.
  - No impact is predicted across the remaining three sensitive receptors.
- Including background (Table 5.5):
  - at the Proposed Camp, the annual average PM_{10} concentrations can be expected to be below the criteria
  - no impact is predicted across the remaining three receptors.

Contour plots of Project only and cumulative annual average PM_{10} are presented in Figure 5-5 and Figure 5-6 respectively.

Table 5.5: Predicted annual average PM_{10} concentrations at the sensitive receptors ($\mu g/m^3$)

Scenario	Proposed Camp	Comet Gold Mine	MB Travellers Rest	Residence	Background	Criteria
Project only impact	3	0	0	0	22	27.5
Project incl Background	25	22	22	22		

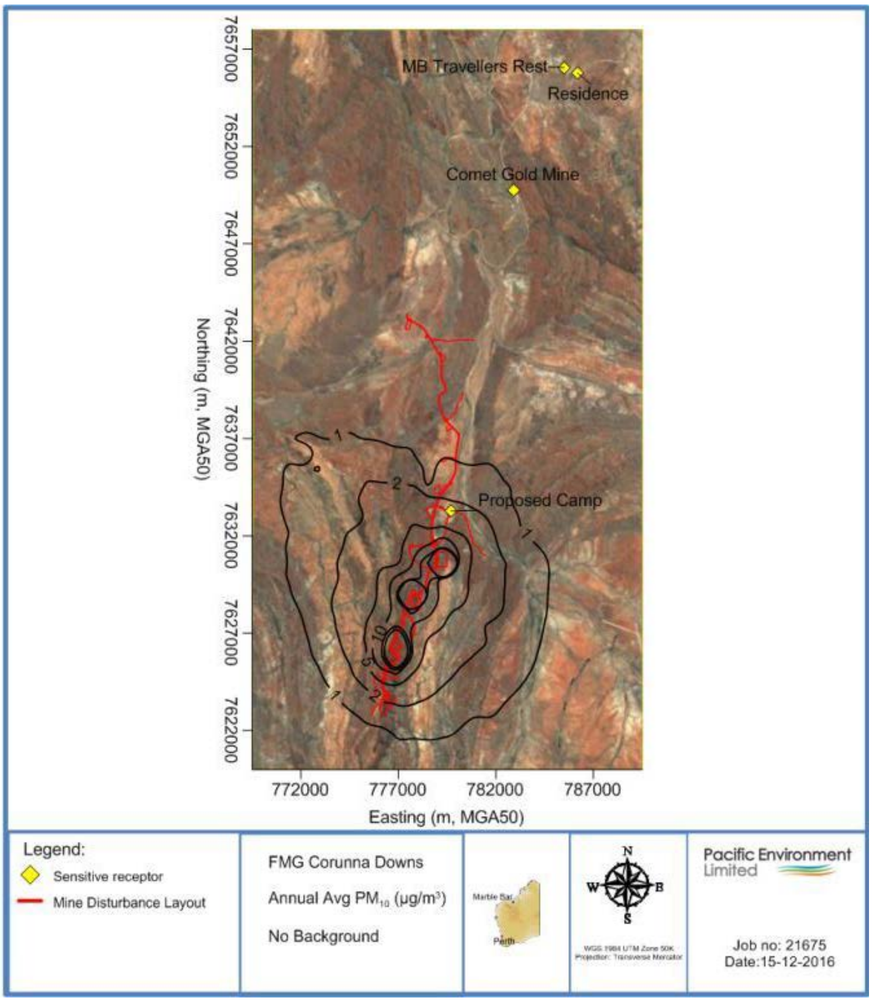


Figure 5-5: *Annual average PM_{10} concentrations (no background)*

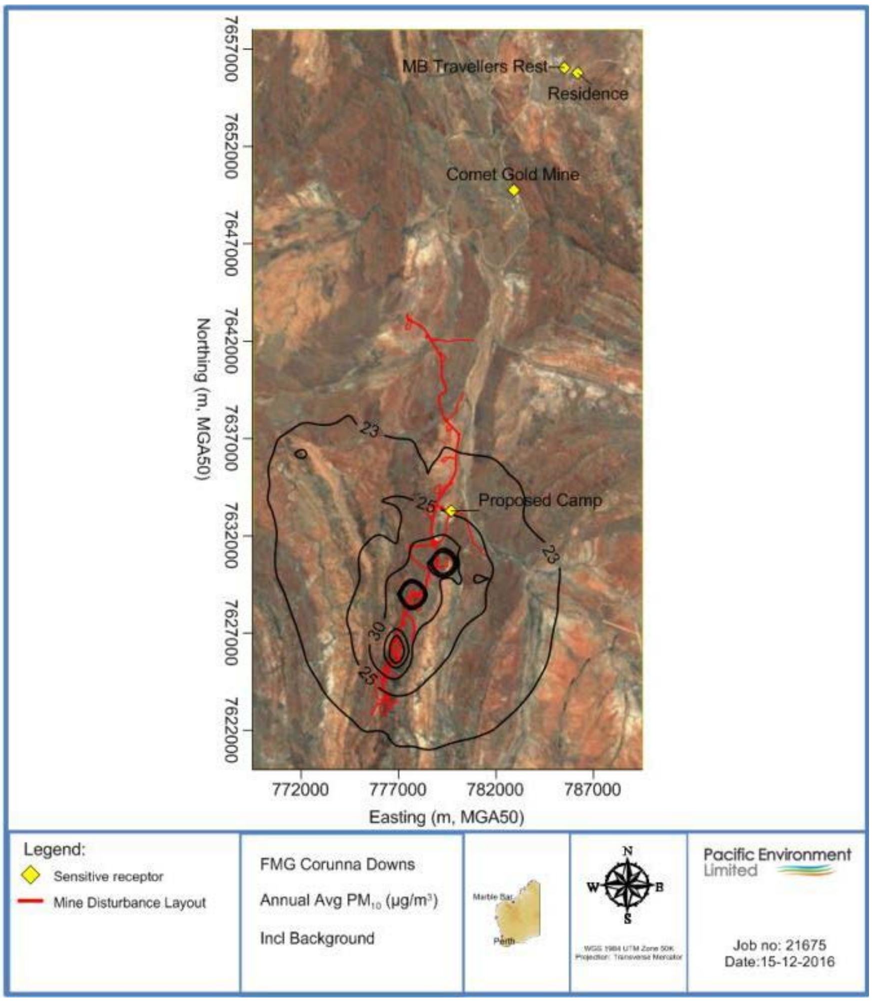


Figure 5-6: *Annual average PM_{10} concentrations (including background)*

5.3 Assessment of $PM_{2.5}$

5.3.1 24-hour average

Modelled $PM_{2.5}$ concentrations have been compared to the Draft WA DER 24-hour average criteria of 23µg/m³ (Section 2.4.1).

- Excluding background (Table 5.6):
  - The maximum 24-hour average $PM_{2.5}$ is predicted to present very minimal (less than 10% of criteria) to no impact at the four sensitive receptors.
- Including background (Table 5.6):
  - The maximum concentration expected across the four receptors (15µ/m³) is about 65% of the criterion. It is worth noting that these values show no significant variation from the background levels adopted in the assessment.
- Contour plots of the maximum 24-hour average $PM_{2.5}$ concentrations both excluding and including background are presented in Figure 5-7 and Figure 5-8 respectively.

Table 5.6: Predicted 24-hour $PM_{2.5}$ concentrations at the sensitive receptors excluding background ($\mu g/m^3$)

Statistics	Proposed Camp	Comet Gold Mine	MB Travellers Rest	Residence
Maximum	2	0	0	0
99th Percentile	2	0	0	0
95th Percentile	1	0	0	0
90th Percentile	1	0	0	0
70th Percentile	1	0	0	0
Average	0	0	0	0
Count > 23µg/m³	0	0	0	0

Table 5.7: Predicted 24-hour $PM_{2.5}$ concentrations at the sensitive receptors including background ($\mu g/m^3$)

Statistics	Proposed Camp	Comet Gold Mine	MB Travellers Rest	Residence	Background	Criteria
Maximum	15	15	15	15	15	
99th Percentile	11	10	10	10	10	
95th Percentile	8	7	7	7	7	
90th Percentile	7	6	6	6	6	23
70th Percentile	4	4	4	4	4	
Average	4	3	3	3	3	
Count > 23µg/m³	0	0	0	0	0	

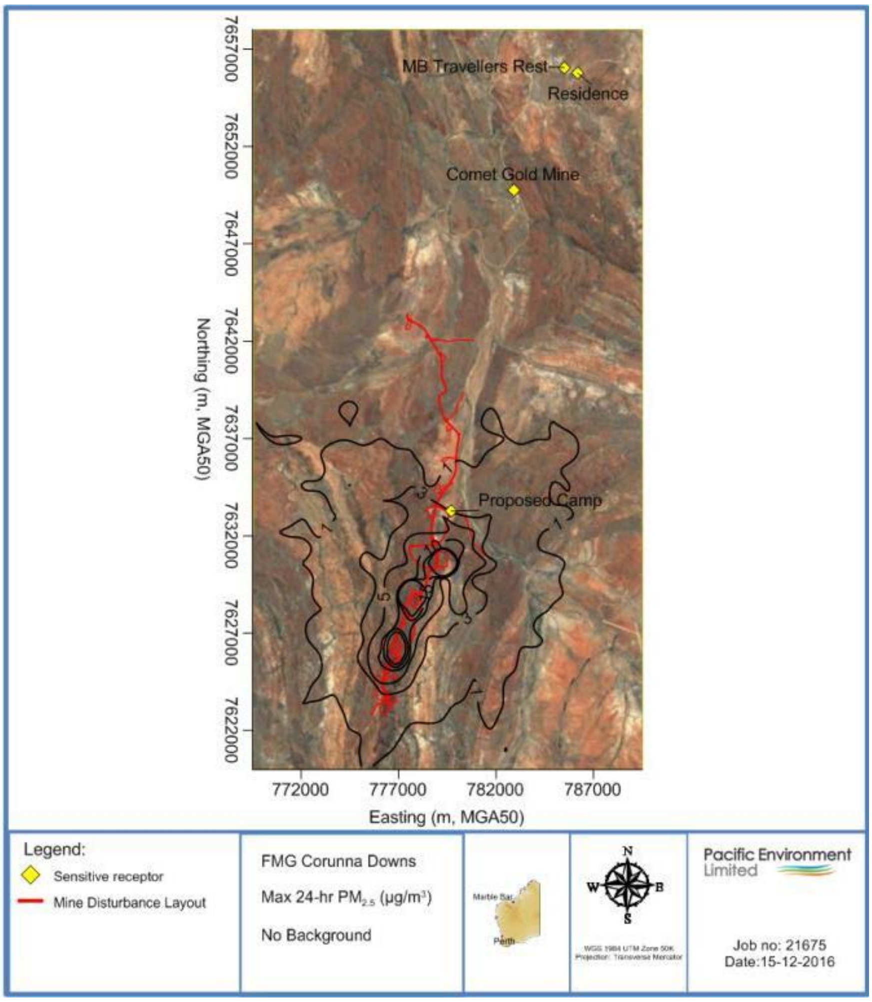


Figure 5-7: Contour plot of m*aximum 24-hour $PM_{2.5}$ concentrations (excluding background)*

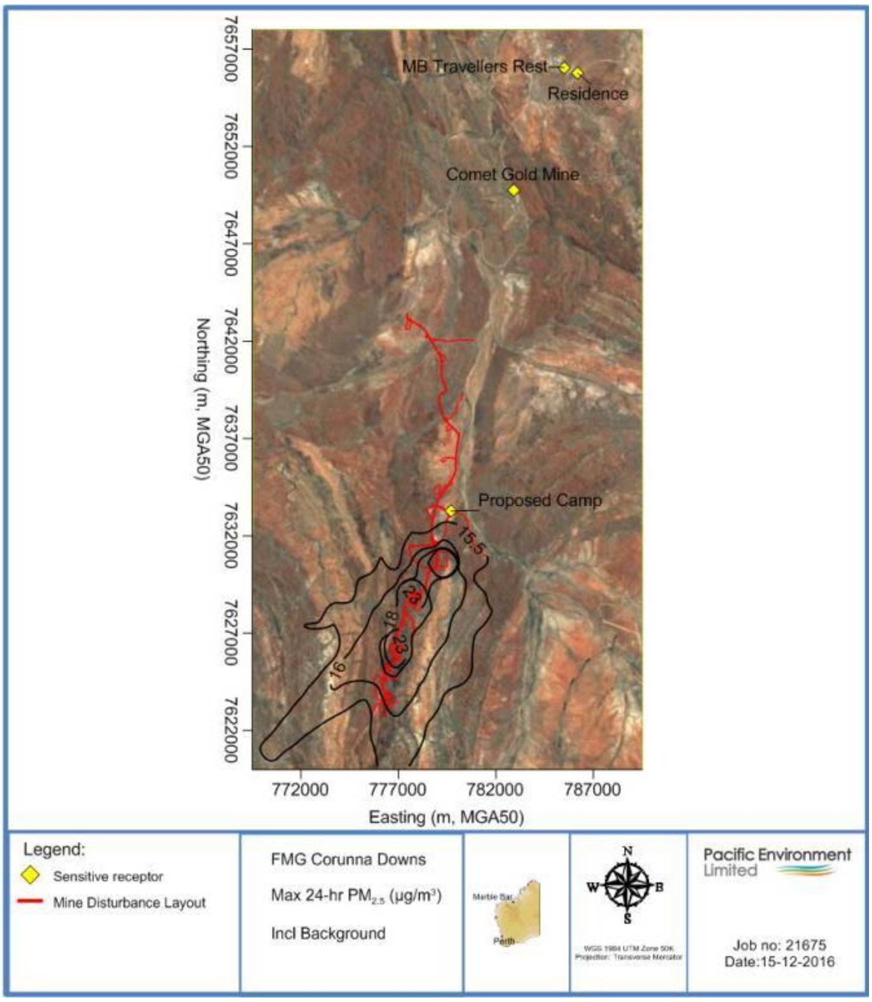


Figure 5-8: Contour plot of m*aximum 24-hour $PM_{2.5}$ concentrations (including background)*

5.3.2 Annual average

Modelled annual average $PM_{2.5}$ concentrations have been compared to the Draft WA DER annual average criteria of 7µg/m³ (Section 2.4.1).

- Excluding background (Table 5.8):
  - No impact can be expected across the four sensitive receptors
- Including background (Table 5.8):
  - At the Proposed Camp, the annual average concentrations are predicted to be about 57% of the criteria.
  - No significant impact can be expected across the three sensitive receptors

Contour plot of Project only and cumulative annual average $PM_{2.5}$ is presented in Figure 5-9 and Figure 5-10 respectively.

Table 5.8: Predicted annual average $PM_{2.5}$ concentrations at the sensitive receptors (µg/m^3)

Scenario	Proposed Camp	Comet Gold Mine	MB Travellers Rest	Residence	Background	Criteria
Project only	0	0	0	0		
Project incl Background	4	3	3	3	3	7

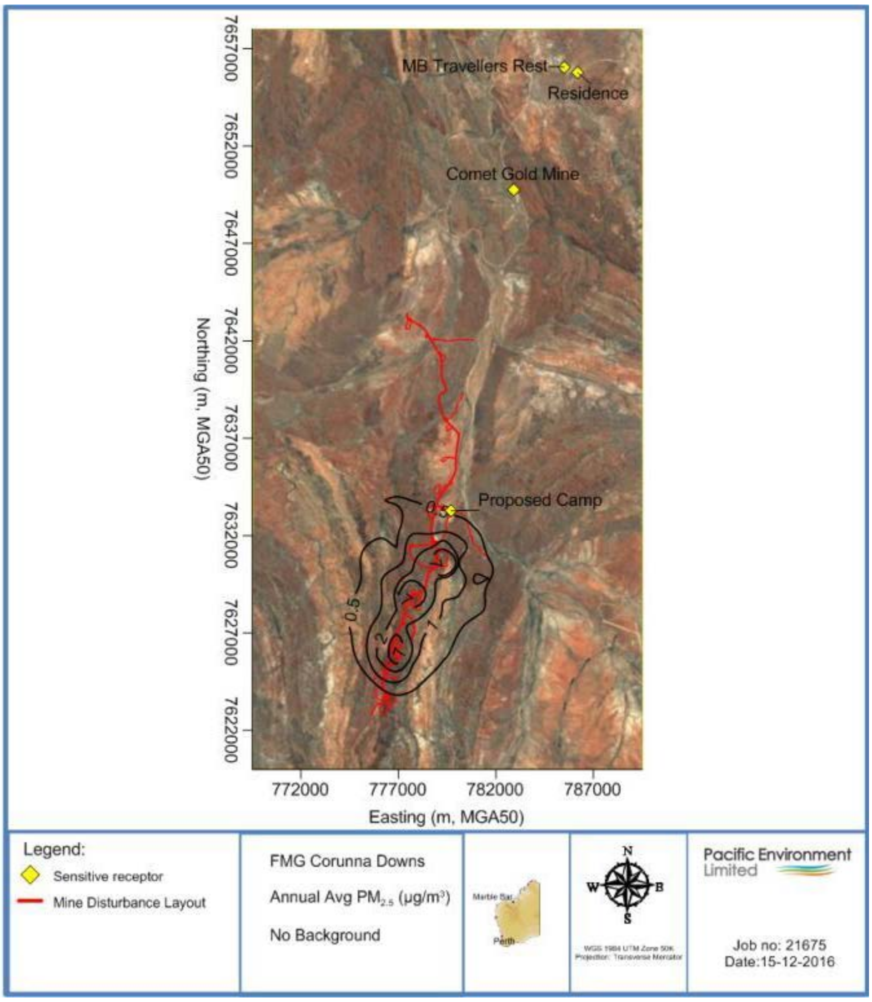


Figure 5-9: *Annual average $PM_{2.5}$ concentrations (no background)*

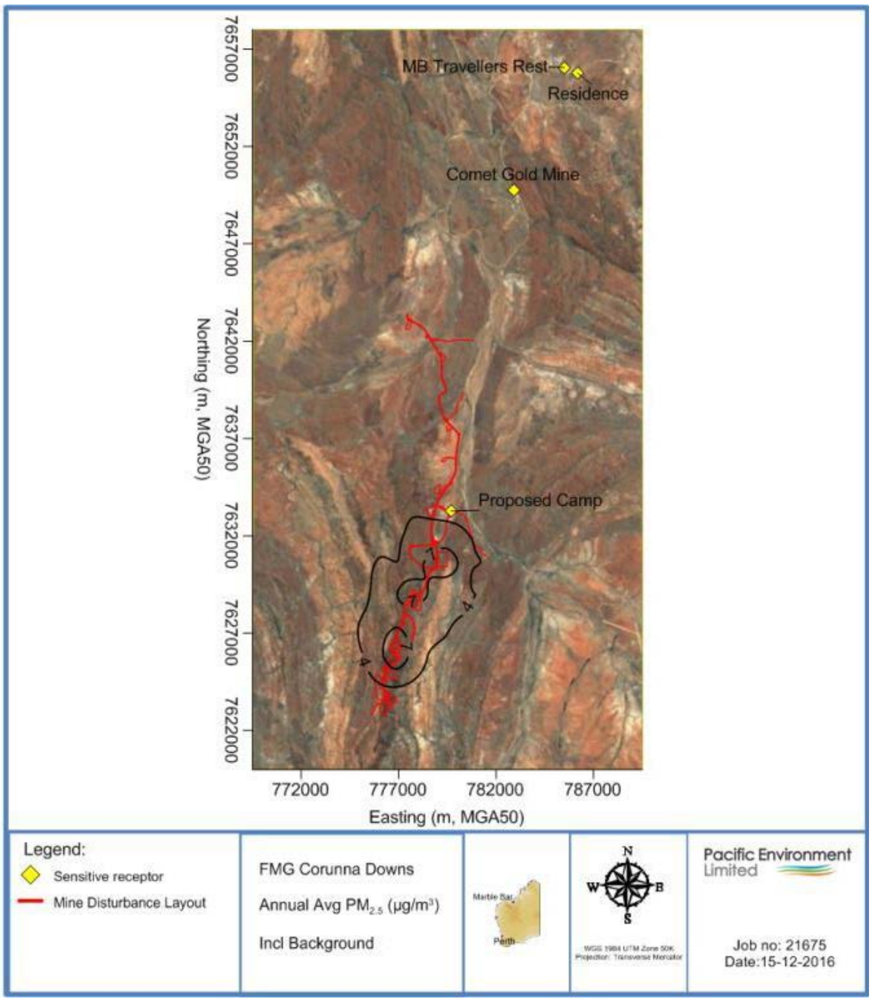


Figure 5-10: *Annual average $PM_{2.5}$ concentrations (including background)*

5.4 Assessment of Dust Deposition

5.4.1 Monthly average

Given the remoteness of the region and lack of information on background dust deposition levels, predicted monthly dust deposition levels have been assessed against the NSW DEC incremental criteria of 2g/m^2/month (Section 2.4.1.1).

The model results indicate the following:

- Excluding background (Table 5.6):
  - No significant impact is predicted across the four sensitive receptors.

Contour plot of maximum monthly dust deposition levels (excluding background) is presented in Figure 5-11.

Table 5.9: Predicted maximum monthly dust deposition levels at the sensitive receptors – excluding background (g/m^2/30days)

Statistics	Proposed Camp	Comet Gold Mine	MB Travellers Rest	Residence	Criteria
Maximum	0.1	0.0	0.0	0.0	2

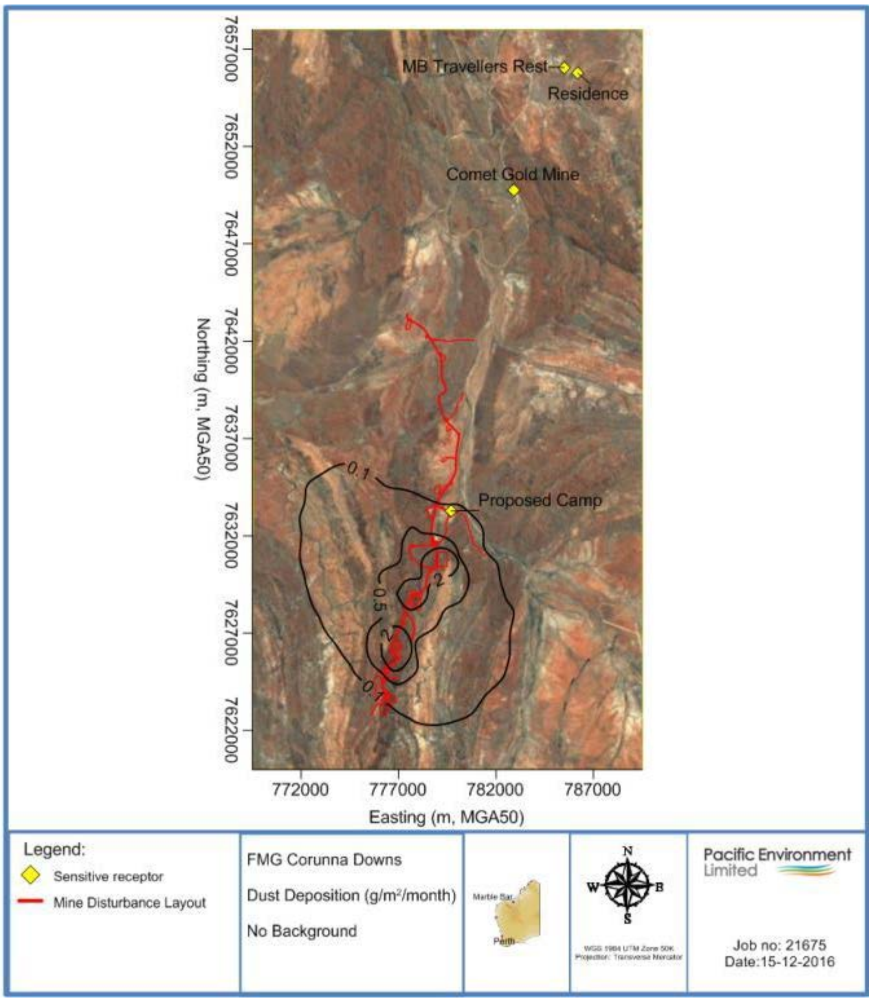


Figure 5-11: *Maximum monthly dust deposition levels at receptors - excluding background (g/m^2/month)*

6 Conclusion

6.1 Representative Meteorological Year

Given the lack of air quality monitoring in the region, the selection of a representative model year was based on identifying the most representative meteorological year. For this purposes, meteorological data recorded at the nearest BoM station at Marble Bar was analysed over a period of 10 years (2005-2015).

The review identified 2015 as the most representative meteorological year.

6.2 Assessment Criteria

Modelled cumulative TSP concentrations, for this assessment, have been compared to the following criteria:

- Draft WA DER 24-hour criteria of 82 µg/m³

Modelled cumulative PM_{10} concentrations, for this assessment, have been compared to the following criteria:

- Draft WA DER 24-hour criteria of 46 µg/m³
- Draft WA DER annual average criteria of 27.5 µg/m^3.

Modelled cumulative $PM_{2.5}$ concentrations, for this assessment, have been compared to the following criteria:

- Draft WA DER 24-hour criteria of 23 µg/m³
- Draft WA DER annual average criteria of 7 µg/m^3.

Modelled dust deposition levels for this assessment have been compared to the NSW DEC criteria of 2g/m^2/month.

6.3 Modelled Results and Potential Impact

A summary of the modelled results and the potential impact across the four sensitive receptors is presented below:

- the maximum 24-hour TSP and PM_{10} concentrations (including background) can be expected to be above the relevant criteria. This could be attributed to the elevated levels of background adopted in the assessment.
- the maximum 24-hour $PM_{2.5}$ concentrations (including background) is predicted to be below the DER criteria
- the annual average TSP, PM_{10} and $PM_{2.5}$ concentrations (including background) is predicted to be below the relevant criteria.

- the dust deposition levels (excluding background) can be expected to be below the relevant criterion

In summary, there is no significant impact from the Corunna Downs project on region's air quality.

7 References

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8 Appendices

Appendix A
Climate and representative meteorological year

A1 Climate of the region

The data collected from the BoM station at Marble Bar climate monitoring station (BOM, 2016) was used to describe the prevailing meteorological conditions in the study area.

Meteorological data obtained included statistics of rainfall, temperature and relative humidity. In addition, reference has been made to hourly meteorological parameters (wind speed, wind direction, temperature and relative humidity) recorded at the BoM Marble Bar station. This data analysis provides a general description and understanding of the local climate and supports the emission estimations and dispersion model set-up. Analysis of meteorological data is also used in the analysis to identify or determine a representative year for dispersion modelling.

A1.1 Wind Speed and Wind Direction

The annual wind rose for Marble Bar, as recorded at the Bureau of Meteorology location (2005–2015) is presented in Figure 8-1. It shows that the dominant annual wind direction is from east southeast.

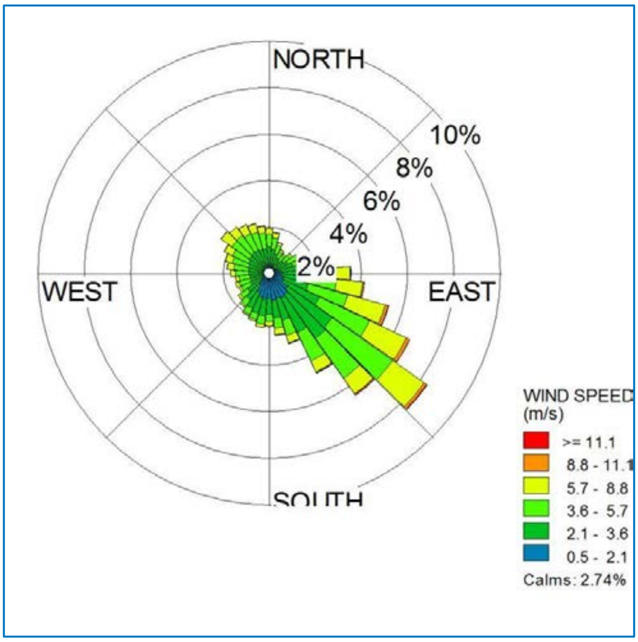

Figure 8-1: *Annual wind rose recorded at BoM Marble Bar station (2005-2015)*

A2.1 Rainfall

The Pilbara climate is semi-arid, characterised by hot, dry summers with irregular cyclonic rains and mild, dry winters (Leighton 2004). Rainfall, in the context of dispersion modelling, is important for understanding the likelihood of natural dust suppression occurring.

Rainfall in the region is highly variable and predominantly limited to summer through to early winter very little rainfall occurring between late winter and spring. The lesser number of rain days (less than 6 days each month) confirms the influence of cyclones on rainfall in the region. Rainfall statistics are illustrated in Figure 8-2 and shows the average monthly rainfall and average days of rain per month measured between 2000 and 2016 (BoM, 2016).

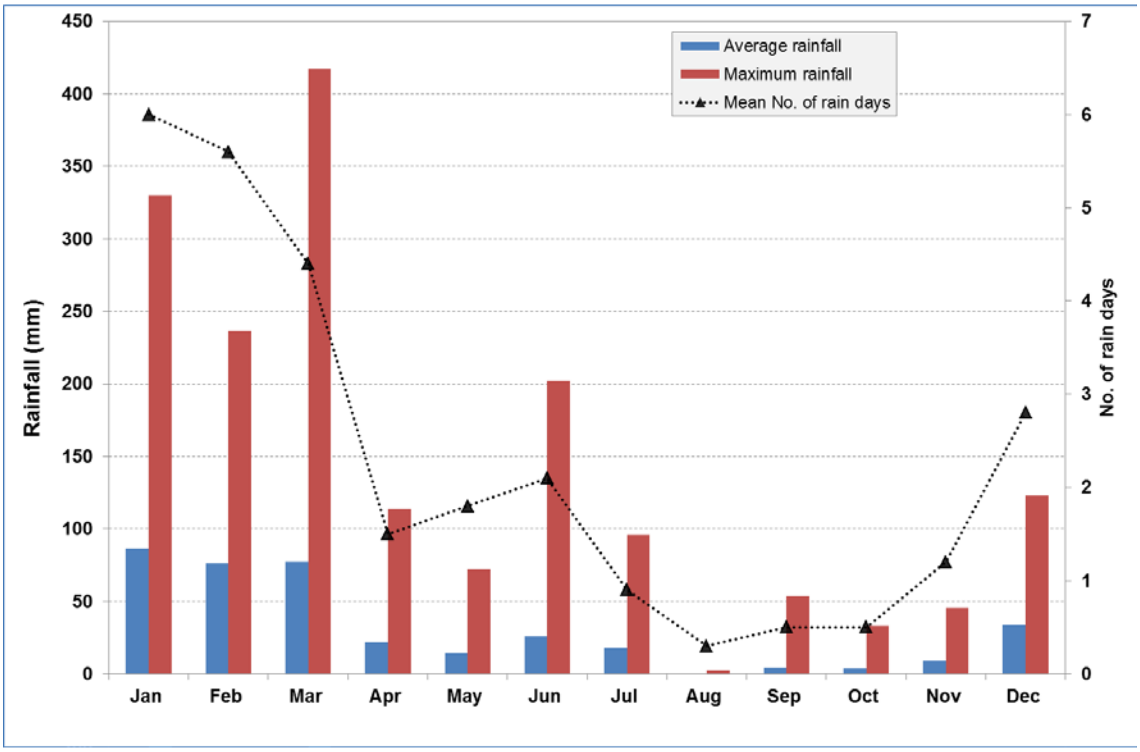

Figure 8-2: Monthly *rainfall data for Marble Bar (2000-2016) (BoM, 2016)*

A3.1 Temperature

Air temperature, in the context of dispersion modelling, is important for understanding the buoyancy of the dust generated on site, and the likelihood of the development of mixing and inversion layers in the model domain.

The long term monthly temperature statistics for BoM Marble Bar is presented in Figure 8-3. This figure shows the average monthly maxima and minima as well as the highest and lowest temperature recorded during the period 2000 to 2016.

Average temperatures at the BoM Marble Bar station ranges from 26.1˚C to 41.8˚C during summer, with a maximum temperature of up to 49˚C recorded. During winter, the temperature typically varies from 12.2˚C to 30.2˚C, with lowest minimum of 5˚C.

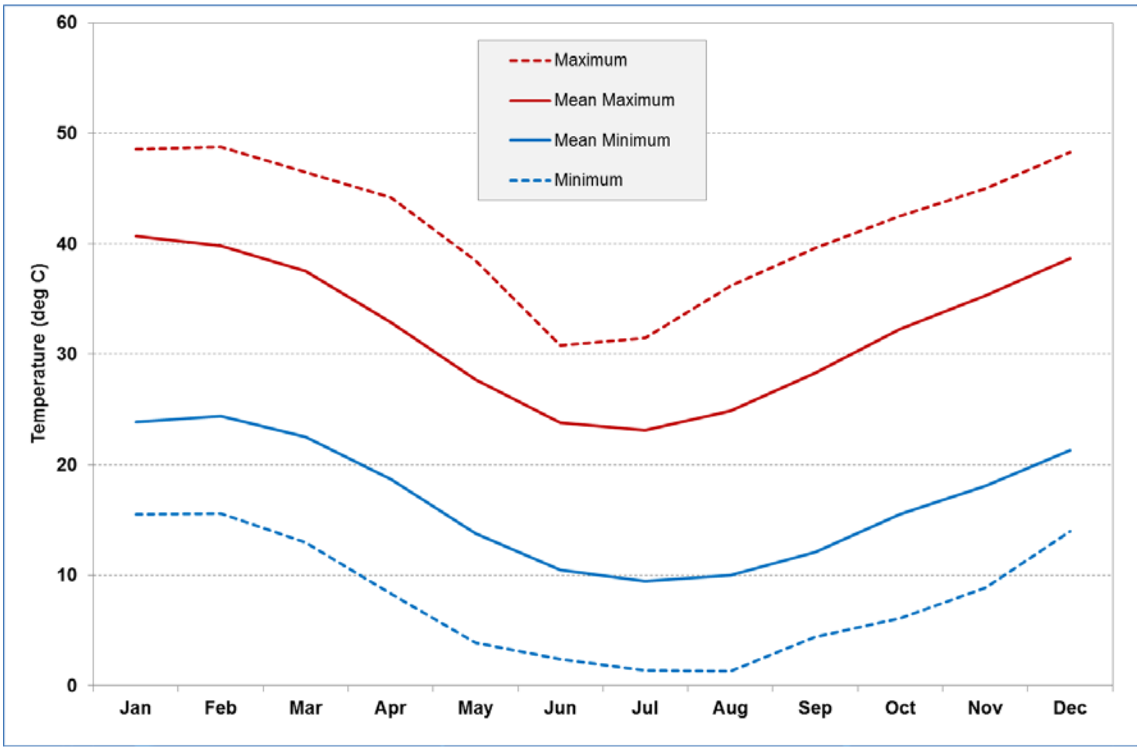

Figure 8-3: *Monthly temperature data for Marble Bar (2000-2016) (BoM, 2016)*

A4.1 Relative humidity

Relative humidity, in the context of dispersion modelling, is important to understand reduced visibility. High relative humidity can significantly increase the effect of pollution on visibility. Particles would accumulate water and grow to sizes at which they are more efficient at scattering light and reduce visibility.

The long term humidity statistics recorded at the Marble Bar station at 9 am and 3 pm is presented in Figure 8-4. For the majority of the year, humidity is less than 50% reflecting the arid climate of the region. Relatively higher humidity is observed in summer and mid-winter (associated with higher rainfall in these months).

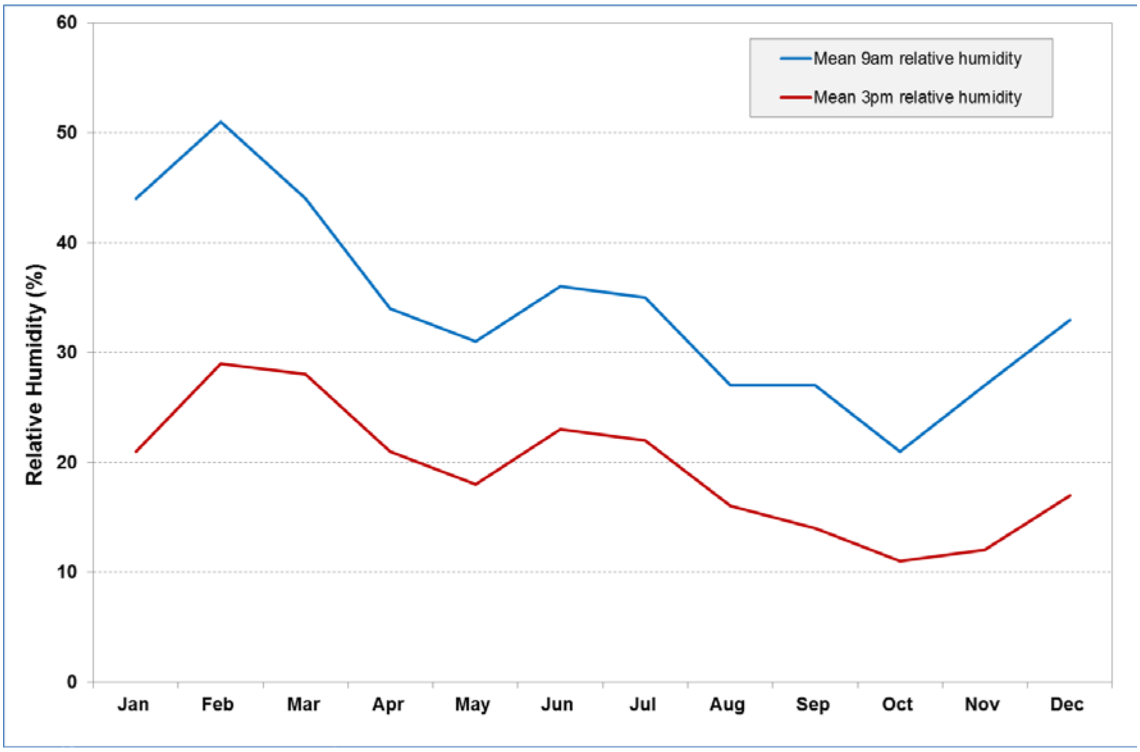

Figure 8-4: *Monthly relative humidity data for Marble Bar (2001-2010) (BoM, 2016)*

A5.1 Representative year

In order to determine the most applicable meteorological year for use in dispersion modelling, 11-year of historical surface observations from the BoM Marble Bar station for the period 2005 to 2015 inclusive were reviewed. Statistical analysis was adopted to determine the representative year.

A plot of annual rainfall for the period 2001 to 2015 is presented in Figure 8-5. Over the 15 year period, 2001 and 2010 recorded rainfall below 10th percentile while 2006 and 2013 recorded rainfall above the 90th percentile value. Of the remaining 11 year period, year 2002, 2009, 2015, 2012, 2008, 2005, 2014, 2003, 2004 and 2007 (in order of preference) provide the closest representation of average conditions expected in the region.

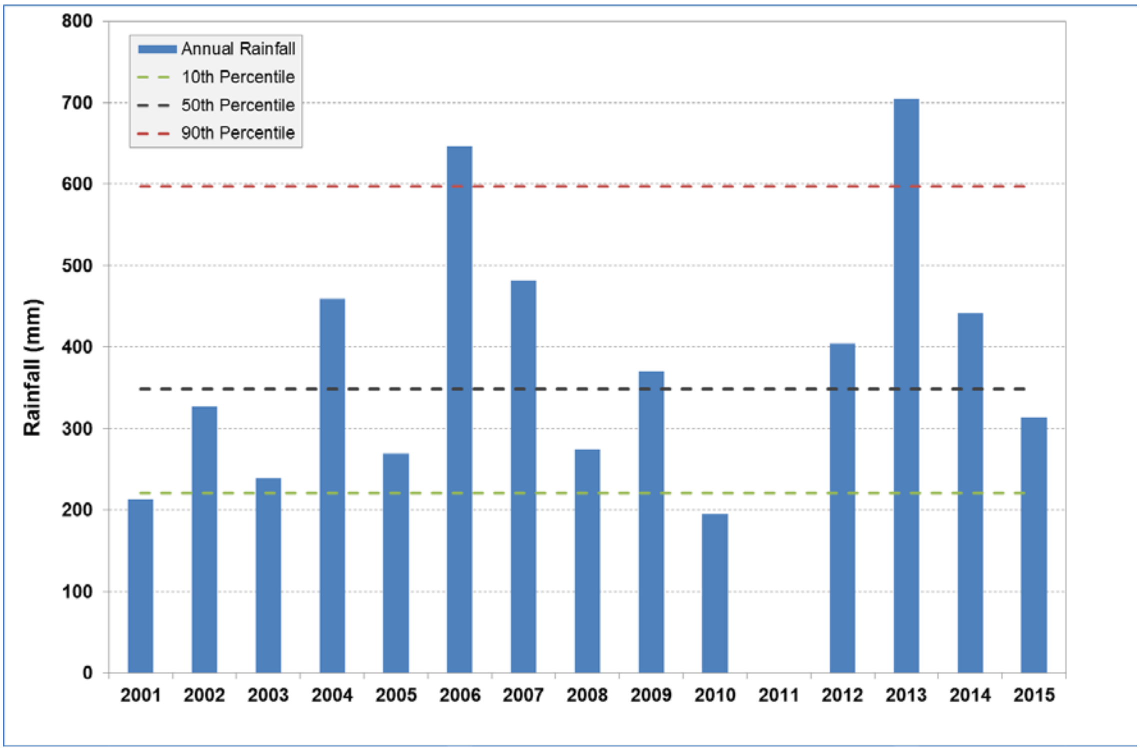

Figure 8-5: Annual rainfall data for Marble Bar (2001-2015) (BoM, 2016)

A5.1.1 Statistical Analysis

The Mann-Whitney U test was used to statistically identify the representative modelling year based on recorded meteorological parameters including wind speed and temperature. This test was used to assess the Marble Bar meteorological data.

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 by month, day and hour. If values fall within the vertical lines (at 5% CI, two tailed), then accept the null hypothesis (Figure 8-6). It is noted that only scalars were assessed (i.e. temperature and wind speed).

The Z-Score in the test indicates how closely an individual year represents the average of all the years. The smaller the Z-Score, the more representative an individual year is, in term of the specific weather parameter tested.

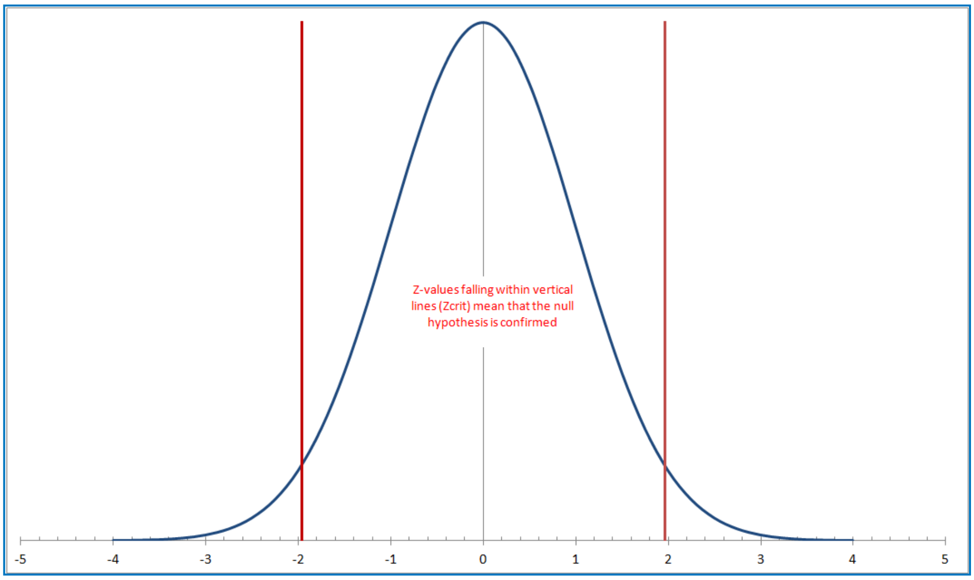

Figure 8-6: *Null Hypothesis for Mann-Whitney U test*

A5.2.1 Wind Speed

Mann-Whitney U test results for wind speed indicate that 2008 is the most representative of the 11-year mean conditions followed by 2009, 2010, 2007 and 2015 in order of preference (Figure 8-7). From 2009 to 2015, 2009 is the most suitable followed by 2010 and 2015 in the order of preference.

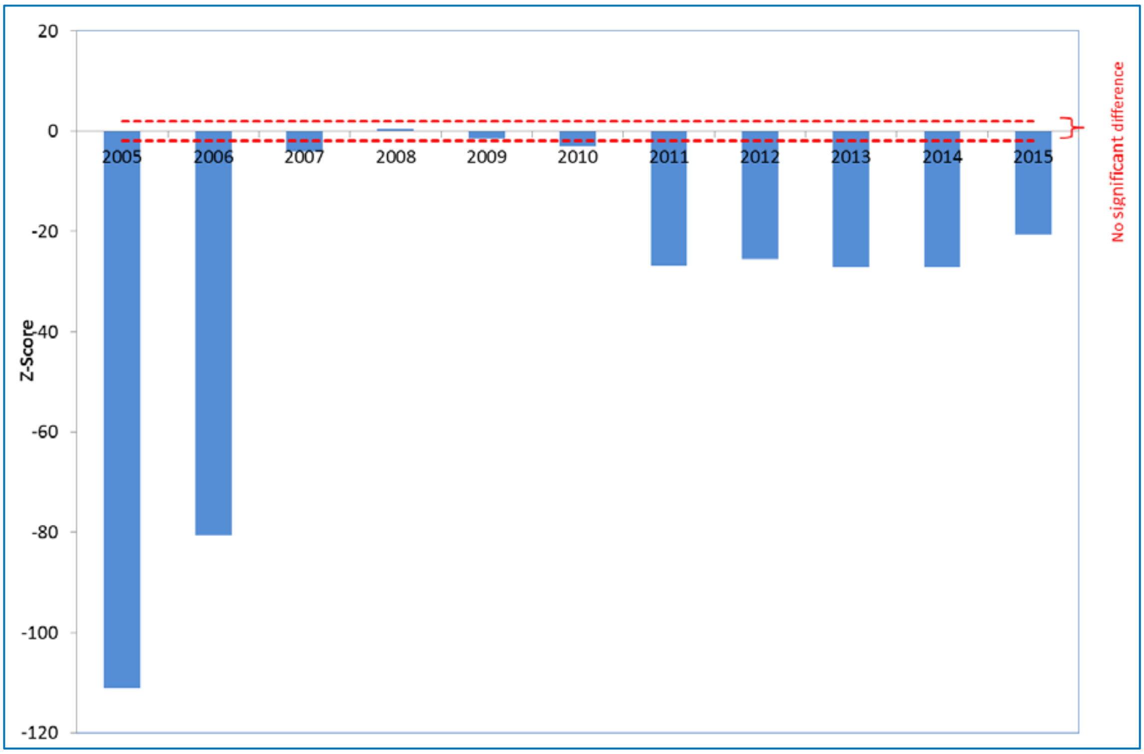

Figure 8-7: *Mann-Whitney U test result for wind speed*

A5.3.1 Temperature

Mann-Whitney U test results for temperature indicate that years 2015, 2009, 2014 and 2007 are the most representative followed by 2008, 2013, 2012 and 2010 in order of preference (Figure 8-8). For meteorological data from 2009 to 2015, 2015 is the most suitable followed by 2009, 2014, 2013, 2012 and 2010 in order of preference.

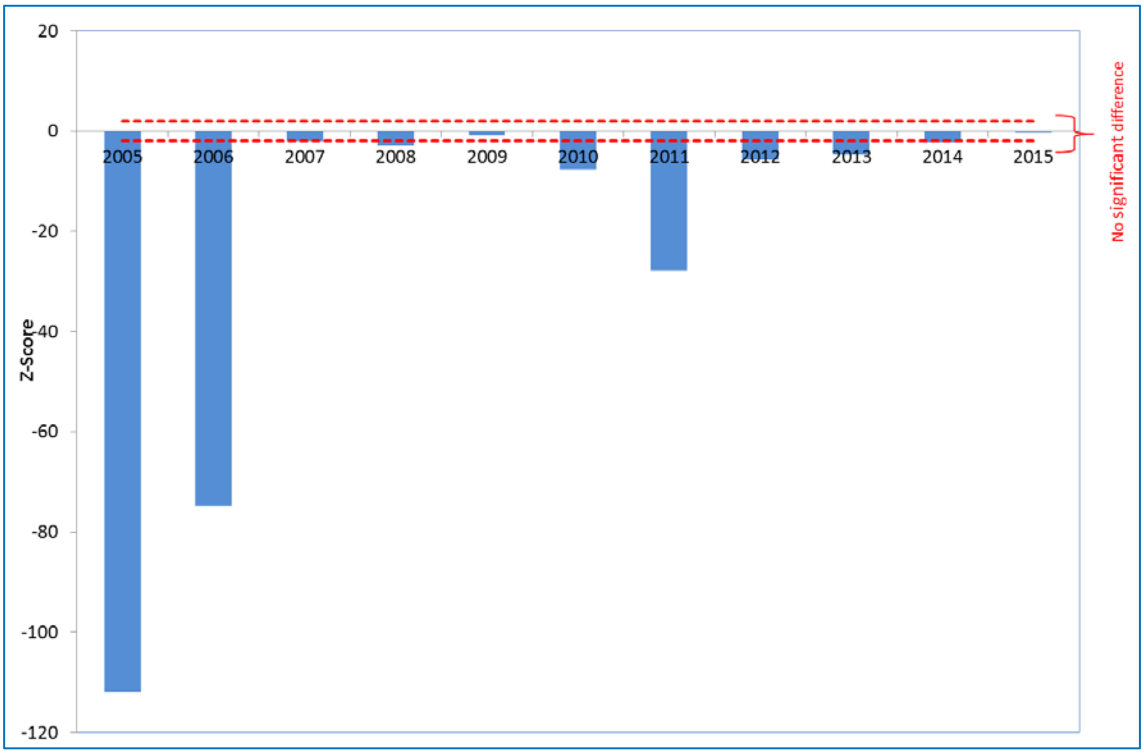

Figure 8-8: *Mann-Whitney U test result for temperature*

A6.1 Selection of Representative Year

The analysis of meteorological parameters indicated that a number of years were representative of the long term average conditions. For the period from 2009 to 2015, the representative years are:

- Rainfall – 2009, 2015, 2012 and 2014 (in order of preference)
- Wind – 2009, 2010 and 2015 (in the order of preference)
- Temperature – 2015, 2009, 2014, 2013, 2012 and 2010 (in the order of preference)

The meteorological conditions highlight that the most representative years in terms of rainfall, wind speed and temperature were considered to be 2009 and 2015. The most recent year 2015 was selected for this assessment.

Further analysis was conducted based on 1-hour wind speed and wind direction to confirm 2015 is a representative year for modelling (Figure 8-9 to Figure 8-11).

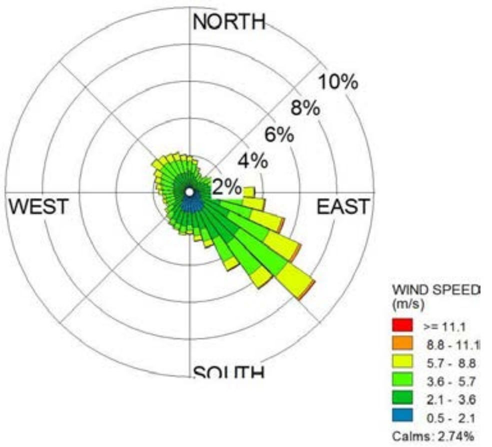

Figure 8-9: *Annual wind rose recorded at BoM Marble Bar (2005-2015)*

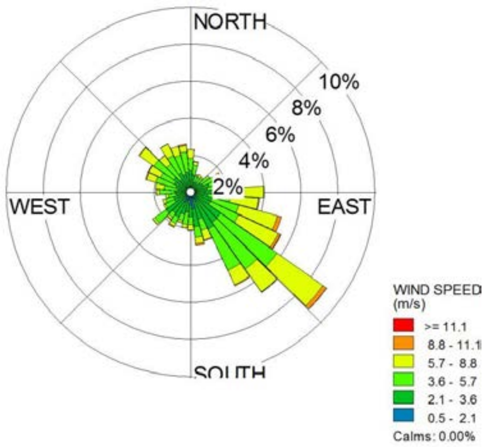

Figure 8-10: *Annual wind rose recorded at BoM Marble Bar (2009)*

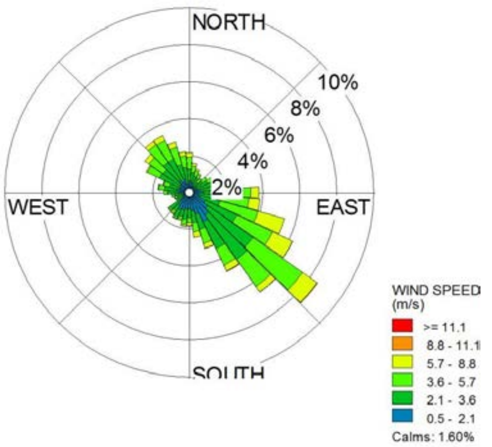

Figure 8-11: *Annual wind rose recorded at BoM Marble Bar (2015)*

Appendix B

AERMET – Quality Assurance

B1 AERMET Output

Quality assurance was performed on AERMET output. Attention was focused on internally-derived variables such as mixing height and Monin-Obukhov length.

Figure 8-12 shows the diurnal statistics of mixing height where the classic diurnal profile is seen, with a gradual increase during the day followed by a rapid decrease after the transition from a convective to a mechanical mixing regime. Average minimum mixing heights of approximately 230 m occurs at night with average maximum mixing heights of 3084 m occurring during the late afternoon. A rapid decrease in mixing height after sunset is consistent with the transition from a convective to a mechanical regime.

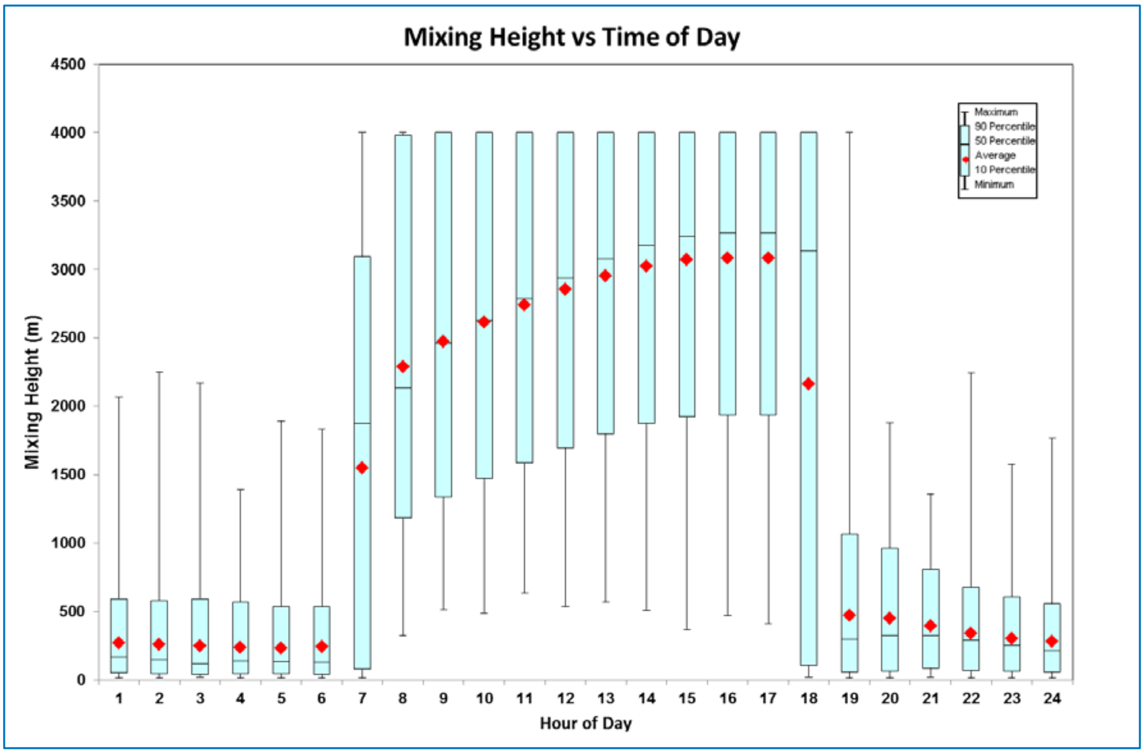

Figure 8-12: *Mixing height – generated by AERMET*.

The diurnal profile of atmospheric stability (derived from Monin-Obukhov length) is shown in the Golder plot in Figure 8-13 and Figure 8-14 . The profile follows an expected pattern, with slightly unstable and unstable conditions confined to the daytime and stable conditions confined to the night-time. Slightly unstable conditions occur for approximately 18 % of the time in a year.

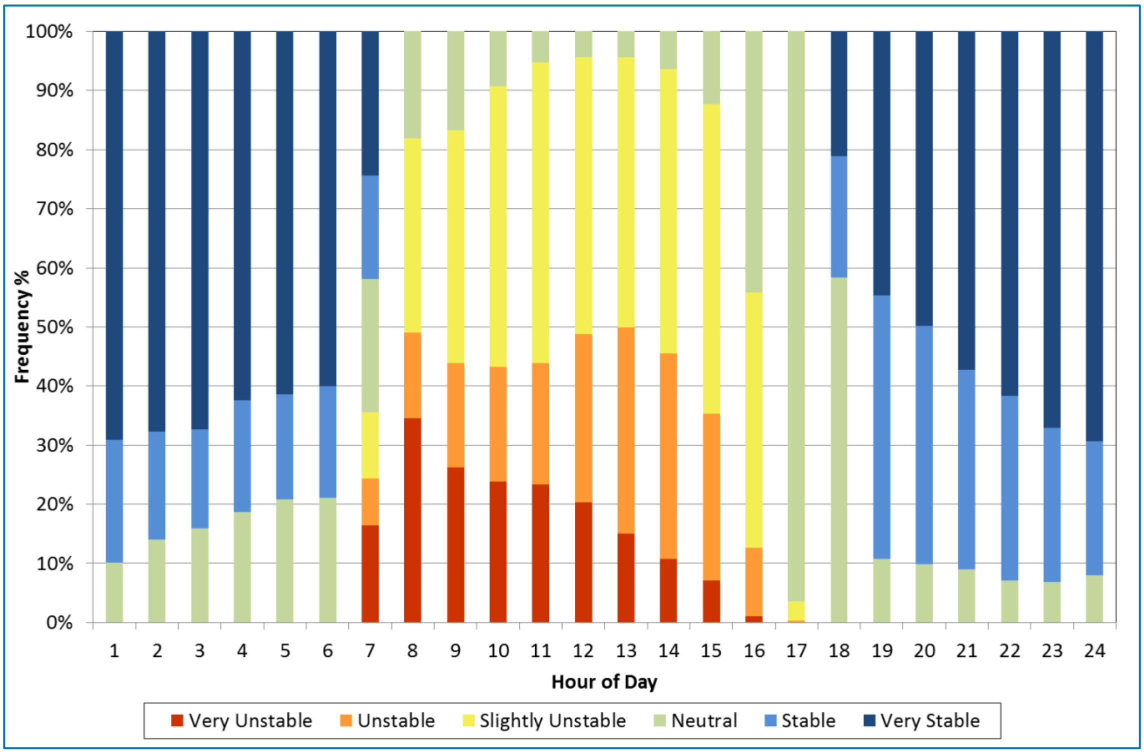

Figure 8-13: *Stability – by time of day (Golder plot)*.

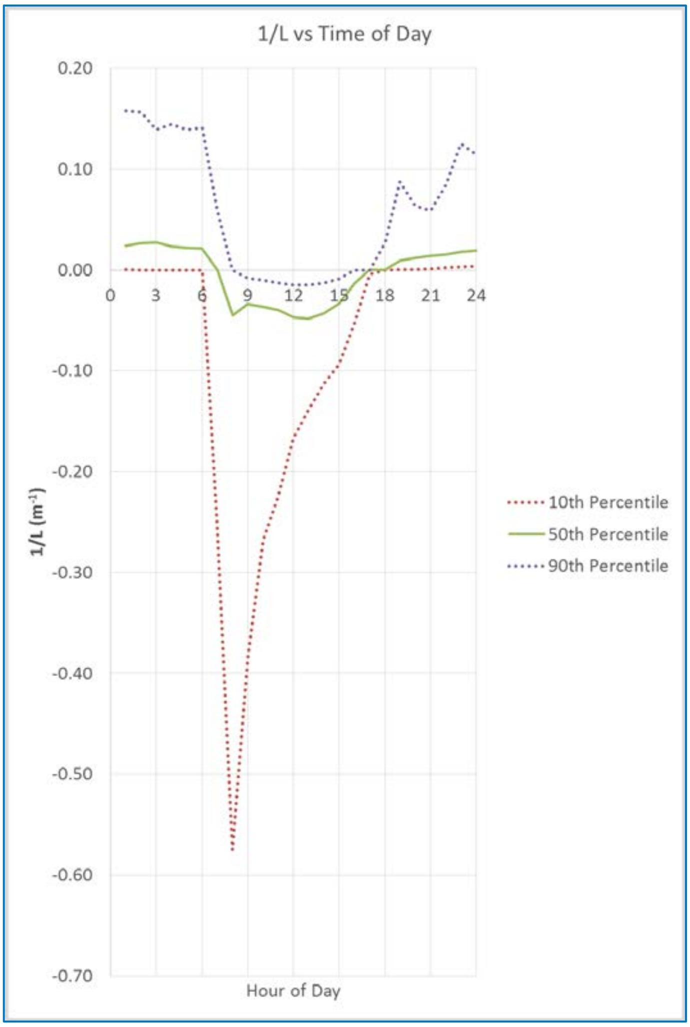

Figure 8-14: *Statistics of 1/L – by time of day*

Appendix C

Emission Estimation

C1 Emissions - Mining

The following tables list the site specific data used in emission estimation for mining.

Table 8.1: *Mining – Site Specific Data for Operational Phase*.

Item	Value	Unit
Area per blast	26,316	m^2
Blast hole depth (ore and waste)	6	m
Average volume displaced per blast	150,000	m^3/blast
No. of holes per blast	3,348	holes
No. of blast per year	16	holes
No. of blast per year -RW	8.68	holes
No. of blast per year - SG	7.32	holes
No. of blast per year - SR	n/a	
No. of blast per year - RB	n/a	
No of holes drilled (Total)	53,571	holes
No of holes drilled - RW	29,057	holes
No of holes drilled - SG	24,515	
No of holes drilled - SR	n/a	
No of holes drilled - RB	n/a	
Tonnage of Ore - RW	2,045,033	tonnes/year
Tonnage of Ore -SG	1,895,843	tonnes/year
Tonnage of Ore -SR	n/a	tonnes/year
Tonnage of Ore -RB	n/a	
Tonnage of Waste - RW	1,178,313	tonnes/year
Tonnage of Waste -SG	823,690	tonnes/year
Tonnage of Waste -SR	n/a	
Tonnage of Waste -RB	n/a	
Tonnage of Rehandle - RW	267,383	tonnes/year
Tonnage of Rehandle -SG	35,180	tonnes/year
Tonnage of Rehandle -SR	n/a	
Tonnage of Rehandle -RB	n/a	
Total Tonnage of ore	3,940,876	tonnes/year
Total Tonnage of waste	2,002,003	tonnes/year
Total Tonnage of material moved	5,942,879	tonnes/year
Moisture content of ore/waste	2	%
Silt content of haul road	10	%
Density of ore	2595	kg/m3
Haul truck empty weight	105.0	tonnes
Haul truck Payload	145	tonnes
Haul truck loaded weight	250	tonnes
Haul truck average weight (loaded+unloaded)	177.5	tonnes

Item	Value	Unit
Water carts average weight	102.74	tonnes
No of haul truck trips per year - waste (total)	27,614	Trips/year
No of haul truck trips per year - ore (total)	54,357	Trips/year
No of haul truck trips per year - waste (RW)	16,253	Trips/year
No of haul truck trips per year - ore (RW)	28,207	Trips/year
No of haul truck trips per year - waste (SG)	11,361	Trips/year
No of haul truck trips per year - ore (SG)	26,150	Trips/year
No of water cart trips per year	730	Trips/year
Hours of Operation	24	hours/day
Hourly rate of primary crusher	529	Tonnes\ hour
Hourly rate of grinder	529	Tonnes\ hour

Emissions were estimated using the equations detailed in Table 8.2, for the following sources:

- Blasting
- Wheel generated dust from unpaved roads
- Drilling
- Bulldozer
- Conveying
- Loading and unloading haul trucks
- Primary crushing

Table 8.2: *Mining – Emission Equations*.

Eq.No	Emission Source	Equations	Reference
1	Blasting	$EF_{PM10} = 0.000114 \times A^{1.5}$ Where EF_{PM10} is emission factor for PM_{10} (kg/blast) A is area per blast in m^2	NPI EET Manual for Mining v3.1, Table 2, p15
2	Wheel generated dust from unpaved roads	$EF_{PM10} = 0.282 \times 1.5 \times (s/12)^{0.9} \times (W/3)^{0.45}$ Where EF_{PM10} is emission factor for PM_{10} (kg/VKT) s is silt content of haul road % W is average weight of vehicles in tonnes	Pitts and Hibberd 2009; Pitts, R.O. and Hibberd, M. 2009. Workshop Report. ModSIG Workshop, Sydney 7th November 2008. Air Quality And Climate Change. Volume 43, No. 3, August 2009, page 14

Eq.No	Emission Source	Equations	Reference
3	Bulldozer	$EF_{PM10} = 0.34 \times (s)^{1.5}/M^{1.4}$ Where, EF_{PM10} is emission factor for PM_{10} (kg/hour) s is silt content % M is moisture content of material in %	NPI EET Manual for Mining v3.1, Section 1.1.5
4	Drilling	0.31 kg/hole	NPI EET Manual for Mining v3.1, Table 2, p15
5	Loading of trucks with ore/waste	0.012 kg/tonne	NPI EET Manual for Mining v3.1, Appendix A 1.1.2
6	Unloading of trucks with ore/waste	0.0043 kg/tonne	NPI EET Manual for Mining v3.1, Appendix A 1.1.6
7	Conveying / Stacking	0.002 kg/tonne	NPI EET Manual for Mining v3.1, Table 3, p20; High Moisture Ore
8	Primary Crushing	0.004 kg/tonne	NPI EET Manual for Mining v3.1, Table 3, p20; Primary Crusher; High Moisture Ore
9	Secondary Crushing	0.012 kg/tonne	NPI EET Manual for Mining v3.1, Table 3, p20; Secondary Crusher; High Moisture Ore

Wind erosion emissions were estimated using the equations detailed in ***Equation 1*** and ***Equation 2***.

Equation 1

$EF_{PM10} = k\,[WS^3 \times (1 - WS_0^2/WS^2)$ $\quad$ *when* $WS > WS_0$

$EF_{PM10} = 0$ $\quad$ *when* $WS < WS_0$

Where:

EF_{PM10}	=	Emission factor for PM_{10}	($g/m^2/s$)
WS	=	Wind speed	(m/s)
WS_0	=	Threshold for dust lift off	(m/s)
k	=	A constant	

Equation 2

$E_{PM10\,(g/s)} = EF_{PM10} \times A \times (100 - CE_{PM10})/100$

Where:

E_{PM10}(g/s)	=	Emission factor for PM_{10}	(g/s)
EF_{PM10}	=	Emission factor for PM_{10}	(g/m²/s)
A	=	Total exposed	(m²)
CE	=	Overall control efficiency of PM_{10}	(%)

Appendix D

AERMOD – Sample File

D1 AERMOD Sample Input File

```
**
****************************************
**
** AERMOD Input Produced by:
** AERMOD View Ver. 9.2.0
** Lakes Environmental Software Inc.
** Date: 19/12/2016
** File: C:\Jobs\21675\Corruna\PM10\Corunna_pm10\Corunna_pm10.ADI
**
****************************************
**
**
****************************************
** AERMOD Control Pathway
****************************************
**
**
CO STARTING
   TITLEONE C:\Jobs\21675\Corruna\PM10\Corunna_pm10\Corunna_pm10.isc
   TITLETWO PM10
   MODELOPT CONC DRYDPLT BETA LOWWIND2
   AVERTIME 1 24 ANNUAL
   POLLUTID PM_10
   RUNORNOT RUN
   ERRORFIL Corunna_pm10.err
CO FINISHED
**
****************************************
** AERMOD Source Pathway
****************************************
**
**
SO STARTING
** Source Location **
** Source ID - Type - X Coord. - Y Coord. **
   LOCATION DR_RW       VOLUME     777781.660  7628750.660      392.160
** DESCRSRC Drilling at RW
   LOCATION DR_SG       VOLUME     776445.610  7625503.650      453.280
** DESCRSRC Drilling at SG pit
   LOCATION BLA_RW      VOLUME     777773.570  7629131.230      395.480
** DESCRSRC Blasting at RW
   LOCATION BLA_SG      VOLUME     776526.590  7625584.630      461.310
** DESCRSRC Blasting at SG pit
   LOCATION LO_OR_RW    VOLUME     777765.470  7628507.740      408.410
** DESCRSRC Loading ore inpit at RW
   LOCATION LO_OR_SG    VOLUME     776648.040  7625706.090      468.940
** DESCRSRC Loading ore inpit at SG
   LOCATION LO_WA_RW    VOLUME     778008.390  7628880.220      403.010
** DESCRSRC Loading waste inpit at RW
   LOCATION LO_WA_SG    VOLUME     776801.890  7625762.770      475.110
** DESCRSRC Loading waste inpit at SG
   LOCATION UN_OR_RW    VOLUME     779116.920  7630682.990      240.540
** DESCRSRC Unloading ore from RW onto RoM pad
   LOCATION UN_OR_SG    VOLUME     779275.140  7630656.610      245.130
** DESCRSRC Unloading ore from SG onto RoM pad
   LOCATION UN_OR       VOLUME     779117.710  7630540.160      244.860
** DESCRSRC unloading ore into dump hoppers
   LOCATION UN_WA_RW    VOLUME     777959.800  7628378.190      379.780
** DESCRSRC Unloading waste at RW dumps
   LOCATION UN_WA_SG    VOLUME     776818.090  7626378.160      460.130
** DESCRSRC Unloading waste at SG dumps
   LOCATION DOZER1      VOLUME     777822.150  7628693.980      395.050
** DESCRSRC Dozer inpit at RW
   LOCATION DOZER2      VOLUME     776607.560  7625503.650      465.390
```

```
** DESCRSRC dozer inpit at SG
   LOCATION DOZER3       VOLUME     778048.870  7628386.280      377.470
** DESCRSRC Dozer on waste dumps at RW
   LOCATION DOZER4       VOLUME     776874.770  7626548.200      448.080
** DESCRSRC Dozer on waste dumps at SG
   LOCATION LO_OR        VOLUME     779279.660  7630669.720      245.000
** DESCRSRC Loading ore from ROM Pad onto dump hoppers
   LOCATION PC           VOLUME     779133.910  7630750.690      240.230
** DESCRSRC Primary Crusher
   LOCATION CNV1         VOLUME     779263.460  7630523.960      247.950
** DESCRSRC Conveyor from PC to SC
   LOCATION SC           VOLUME     779133.910  7630685.910      240.300
** DESCRSRC Secondar Crusher
   LOCATION CNV2         VOLUME     779303.950  7630515.870      246.520
** DESCRSRC Conveyor from SC to PRocessing plant
   LOCATION STK1         VOLUME     779373.830  7630561.130      252.710
** DESCRSRC Stackers
   LOCATION STK2         VOLUME     779343.970  7630785.040      242.500
** DESCRSRC Stackers
   LOCATION LO_OR2       VOLUME     779396.220  7630747.720      243.270
** DESCRSRC Loading ore into Road trains
   LOCATION WE_ROM       VOLUME     779248.770  7630788.470      241.980
** DESCRSRC Wind erosion from ROM
   LOCATION WE_WA_RW     VOLUME     778062.100  7628546.990      389.380
** DESCRSRC Wind erosion from RW waste dumps
   LOCATION WE_WA_SG     VOLUME     776769.960  7626331.880      463.340
** DESCRSRC wind erosion from SG waste dumps
** Source Parameters **
   SRCPARAM DR_RW              1.0     1.000    37.674     0.465
   SRCPARAM DR_SG              1.0     1.000    37.674     0.465
   SRCPARAM BLA_RW             1.0    10.000    37.674     4.651
   SRCPARAM BLA_SG             1.0    10.000    37.674     4.651
   SRCPARAM LO_OR_RW           1.0     5.000     0.847     2.326
   SRCPARAM LO_OR_SG           1.0     5.000     0.847     2.326
   SRCPARAM LO_WA_RW           1.0     5.000     0.847     2.326
   SRCPARAM LO_WA_SG           1.0     5.000     0.847     2.326
   SRCPARAM UN_OR_RW           1.0     7.000     0.847     3.256
   SRCPARAM UN_OR_SG           1.0     7.000     0.847     3.256
   SRCPARAM UN_OR              1.0     1.000     0.847     0.465
   SRCPARAM UN_WA_RW           1.0     7.000     0.847     3.256
   SRCPARAM UN_WA_SG           1.0     7.000     0.847     3.256
   SRCPARAM DOZER1             1.0     1.800     0.969     0.837
   SRCPARAM DOZER2             1.0     1.800     0.969     0.837
   SRCPARAM DOZER3             1.0     1.800     0.969     0.837
   SRCPARAM DOZER4             1.0     1.800     0.969     0.837
   SRCPARAM LO_OR              1.0     5.000     0.847     2.326
   SRCPARAM PC                 1.0    10.000     4.000     4.651
   SRCPARAM CNV1               1.0     2.000     2.790     0.930
   SRCPARAM SC                 1.0    10.000     4.000     4.651
   SRCPARAM CNV2               1.0     2.000     2.790     0.930
   SRCPARAM STK1               1.0     5.000     1.000     2.326
   SRCPARAM STK2               1.0     5.000     1.000     2.326
   SRCPARAM LO_OR2             1.0     2.500     0.847     1.163
   SRCPARAM WE_ROM             1.0     2.000    28.581     0.930
   SRCPARAM WE_WA_RW           1.0     2.000    26.124     0.930
   SRCPARAM WE_WA_SG           1.0     2.000    27.280     0.930
   PARTDIAM BLA_RW 1.25 3.75 7.5
   PARTDIAM BLA_SG 1.25 3.75 7.5
   PARTDIAM CNV1 1.25 3.75 7.5
   PARTDIAM CNV2 1.25 3.75 7.5
   PARTDIAM DOZER1 1.25 3.75 7.5
   PARTDIAM DOZER2 1.25 3.75 7.5
   PARTDIAM DOZER3 1.25 3.75 7.5
   PARTDIAM DOZER4 1.25 3.75 7.5
   PARTDIAM DR_RW 1.25 3.75 7.5
   PARTDIAM DR_SG 1.25 3.75 7.5
   PARTDIAM LO_OR 1.25 3.75 7.5
   PARTDIAM LO_OR_RW 1.25 3.75 7.5
   PARTDIAM LO_OR_SG 1.25 3.75 7.5
```

```
PARTDIAM LO_WA_RW 1.25 3.75 7.5
PARTDIAM LO_WA_SG 1.25 3.75 7.5
PARTDIAM PC 1.25 3.75 7.5
PARTDIAM SC 1.25 3.75 7.5
PARTDIAM UN_OR 1.25 3.75 7.5
PARTDIAM UN_OR_RW 1.25 3.75 7.5
PARTDIAM UN_OR_SG 1.25 3.75 7.5
PARTDIAM UN_WA_RW 1.25 3.75 7.5
PARTDIAM UN_WA_SG 1.25 3.75 7.5
PARTDIAM WE_WA_RW 1.25 3.75 7.5
PARTDIAM WE_WA_SG 1.25 3.75 7.5
PARTDIAM STK1 1.25 3.75 7.5
PARTDIAM STK2 1.25 3.75 7.5
PARTDIAM LO_OR2 1.25 3.75 7.5
PARTDIAM WE_ROM 1.25 3.75 7.5
MASSFRAX BLA_RW 0.15 0.36 0.48
MASSFRAX BLA_SG 0.15 0.36 0.48
MASSFRAX CNV1 0.15 0.36 0.48
MASSFRAX CNV2 0.15 0.36 0.48
MASSFRAX DOZER1 0.15 0.36 0.48
MASSFRAX DOZER2 0.15 0.36 0.48
MASSFRAX DOZER3 0.15 0.36 0.48
MASSFRAX DOZER4 0.15 0.36 0.48
MASSFRAX DR_RW 0.15 0.36 0.48
MASSFRAX DR_SG 0.15 0.36 0.48
MASSFRAX LO_OR 0.15 0.36 0.48
MASSFRAX LO_OR_RW 0.15 0.36 0.48
MASSFRAX LO_OR_SG 0.15 0.36 0.48
MASSFRAX LO_WA_RW 0.15 0.36 0.48
MASSFRAX LO_WA_SG 0.15 0.36 0.48
MASSFRAX PC 0.15 0.36 0.48
MASSFRAX SC 0.15 0.36 0.48
MASSFRAX UN_OR 0.15 0.36 0.48
MASSFRAX UN_OR_RW 0.15 0.36 0.48
MASSFRAX UN_OR_SG 0.15 0.36 0.48
MASSFRAX UN_WA_RW 0.15 0.36 0.48
MASSFRAX UN_WA_SG 0.15 0.36 0.48
MASSFRAX WE_WA_RW 0.15 0.36 0.48
MASSFRAX WE_WA_SG 0.15 0.36 0.48
MASSFRAX STK1 0.15 0.36 0.48
MASSFRAX STK2 0.15 0.36 0.48
MASSFRAX LO_OR2 0.15 0.36 0.48
MASSFRAX WE_ROM 0.15 0.36 0.48
PARTDENS BLA_RW 1 1 1
PARTDENS BLA_SG 1 1 1
PARTDENS CNV1 1 1 1
PARTDENS CNV2 1 1 1
PARTDENS DOZER1 1 1 1
PARTDENS DOZER2 1 1 1
PARTDENS DOZER3 1 1 1
PARTDENS DOZER4 1 1 1
PARTDENS DR_RW 1 1 1
PARTDENS DR_SG 1 1 1
PARTDENS LO_OR 1 1 1
PARTDENS LO_OR_RW 1 1 1
PARTDENS LO_OR_SG 1 1 1
PARTDENS LO_WA_RW 1 1 1
PARTDENS LO_WA_SG 1 1 1
PARTDENS PC 1 1 1
PARTDENS SC 1 1 1
PARTDENS UN_OR 1 1 1
PARTDENS UN_OR_RW 1 1 1
PARTDENS UN_OR_SG 1 1 1
PARTDENS UN_WA_RW 1 1 1
PARTDENS UN_WA_SG 1 1 1
PARTDENS WE_WA_RW 1 1 1
PARTDENS WE_WA_SG 1 1 1
PARTDENS STK1 1 1 1
PARTDENS STK2 1 1 1
```

```
   PARTDENS LO_OR2 1 1 1
   PARTDENS WE_ROM 1 1 1
   HOUREMIS MINE_SOURCE_PM10.TXT DR_RW DR_SG BLA_RW
   HOUREMIS MINE_SOURCE_PM10.TXT BLA_SG LO_OR_RW LO_OR_SG
   HOUREMIS MINE_SOURCE_PM10.TXT LO_WA_RW LO_WA_SG UN_OR_RW
   HOUREMIS MINE_SOURCE_PM10.TXT UN_OR_SG UN_OR UN_WA_RW
   HOUREMIS MINE_SOURCE_PM10.TXT UN_WA_SG DOZER1 DOZER2
   HOUREMIS MINE_SOURCE_PM10.TXT DOZER3 DOZER4 LO_OR
   HOUREMIS MINE_SOURCE_PM10.TXT PC CNV1 SC
   HOUREMIS MINE_SOURCE_PM10.TXT CNV2 STK1 STK2
   HOUREMIS MINE_SOURCE_PM10.TXT LO_OR2 WE_ROM WE_WA_RW
   HOUREMIS MINE_SOURCE_PM10.TXT WE_WA_SG
   SRCGROUP ALL
SO FINISHED
**
****************************************
** AERMOD Receptor Pathway
****************************************
**
**
RE STARTING
   INCLUDED Corunna_pm10.rou
RE FINISHED
**
****************************************
** AERMOD Meteorology Pathway
****************************************
**
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ME STARTING
   SURFFILE Corunna.SFC
   PROFFILE Corunna.PFL
   SURFDATA 0 2015
   UAIRDATA 54321 2015
   SITEDATA 4106 2015
   PROFBASE 182.0 METERS
ME FINISHED
**
****************************************
** AERMOD Output Pathway
****************************************
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**
OU STARTING
   RECTABLE ALLAVE 1ST
   RECTABLE 1 1ST
   RECTABLE 24 1ST
   POSTFILE 1 ALL PLOT CORUNNA_PM10.AD\01_GALL.POS 31
   POSTFILE 24 ALL PLOT CORUNNA_PM10.AD\24_GALL.POS 32
   POSTFILE ANNUAL ALL PLOT CORUNNA_PM10.AD\AN_GALL.POS 33
** Auto-Generated Plotfiles
   PLOTFILE 1 ALL 1ST CORUNNA_PM10.AD\01H1GALL.PLT 34
   PLOTFILE 24 ALL 1ST CORUNNA_PM10.AD\24H1GALL.PLT 35
   PLOTFILE ANNUAL ALL CORUNNA_PM10.AD\AN00GALL.PLT 36
   SUMMFILE Corunna_pm10.sum
OU FINISHED
**
****************************************
** Project Parameters
****************************************
** PROJCTN  CoordinateSystemUTM
** DESCPTN  UTM: Universal Transverse Mercator
** DATUM    World Geodetic System 1984
** DTMRGN   Global Definition
** UNITS    m
** ZONE     -50
** ZONEINX  0
**
```

Appendix E

Source Parameters

E1 Source Parameters

The modelled volume source parameters are listed in Table 8.3 and Table 8.4.

Table 8.3: Source characteristics for mining operations

Source ID	Description	Easting (m)	Northing (m)	Sigma Y (m)	Sigma Z (m)	Release Height (m)
DR_RW	Drilling at RW	777,782	7,628,751	37.67	0.47	1.0
BLA_RW	Blasting at RW	77,774	7,629,131	37.67	4.65	10.0
LO_OR_RW	Loading ore inpit at RW	777,765	7,628,508	0.85	2.33	5.0
LO_WA_RW	Loading waste inpit at RW	778,008	7,628,880	0.85	2.33	5.0
UN_WA_RW	Unloading waste at RW dumps	777,960	7,628,378	0.85	3.26	7.0
DOZER1	Dozer inpit at RW	777,822	7,628,694	0.97	0.84	1.8
DOZER3	Dozer on waste dumps at RW	778,049	7,628,386	0.97	0.84	1.8
DR_SG	Drilling at SG pit	776,446	7,625,504	37.67	0.47	1.0
BLA_SG	Blasting at SG pit	776,527	7,625,585	37.67	4.65	10.0
LO_OR_SG	Loading ore inpit at SG	776,648	7,625,706	0.85	2.33	5.0
LO_WA_SG	Loading waste inpit at SG	776,802	7,625,763	0.85	2.33	5.0
UN_WA_SG	Unloading waste at SG dumps	776,818	7,626,378	0.85	3.26	7.0
DOZER2	dozer inpit at SG	776,608	7,625,504	0.97	0.84	1.8
DOZER4	Dozer on waste dumps at SG	776,875	7,626,548	0.97	0.84	1.8
UN_OR	unloading ore into dump hoppers	779,118	7,630,540	0.85	0.47	1.0
LO_OR	Loading ore from ROM Pad onto dump hoppers	779,280	7,630,670	0.85	2.33	5.0
PC	Primary Crusher	779,134	7,630,751	4.00	4.65	10.0
SC	Secondar Crusher	779,134	7,630,686	4.00	4.65	10.0
CNV1	Conveyor from PC to SC	779,263	7,630,524	2.79	0.93	2.0
CNV2	Conveyor from SC to Processing plant	779,304	7,630,516	2.79	0.93	2.0

Source ID	Description	Easting (m)	Northing (m)	Sigm a Y (m)	Sigma Z (m)	Release Height (m)
UN_OR_RW	Unloading ore from RW onto RoM pad	779,117	7,630,683	0.85	3.26	7.0
UN_OR_SG	Unloading ore from SG onto RoM pad	779,275	7,630,657	0.85	3.26	7.0
STK1	Stackers	779,374	7,630,561	1.00	2.33	5.0
STK2	Stackers	779,344	7,630,785	1.00	2.33	5.0
LO_OR2	Loading ore into Road trains	779,396	7,630,748	0.85	1.16	2.5
WR_ROM	Wind erosion from ROM	779,249	7,630,788	28.58	0.93	2.0
WR_RW	Wind erosion from RW waste dumps	778,062	7,628,547	26.12	0.93	2.0
WR_SG	wind erosion from SG waste dumps	776,770	7,626,332	27.28	0.93	2.0

Table 8.4: Source characteristics for Haul Roads

Source ID	Route	Easting (m)	Northing (m)	Sigm a Y (m)	Sigma Z (m)	Release Height (m)
V1_1	SG Pit to RW Pit	776,418	7,625,290	1.05	2.09	4.5
V1_2		776,979	7,625,667	1.05	2.09	4.5
V1_3		776,579	7,626,196	1.05	2.09	4.5
V1_4		776,817	7,626,671	1.05	2.09	4.5
V1_5		777,011	7,627,135	1.05	2.09	4.5
V1_6		777,216	7,627,577	1.05	2.09	4.5
V1_7		777,238	7,628,074	1.05	2.09	4.5
V1_8		777,400	7,628,559	1.05	2.09	4.5
V1_9		777,658	7,628,991	1.05	2.09	4.5
V2_1	SG Pit to Waste dump	776,417	7,625,277	1.05	2.09	4.5
V2_2		776,970	7,625,713	1.05	2.09	4.5
V2_3		776,604	7,626,150	1.05	2.09	4.5
V2_4		776,845	7,626,477	1.05	2.09	4.5
V3_1	RW Pit to Waste Dump	777,820	7,628,691	1.05	2.09	4.5
V3_2		778,077	7,628,270	1.05	2.09	4.5
V4_1	SG Pit, RW Pit to ROM	777,668	7,628,994	1.05	2.09	4.5
V4_2		778,138	7,629,126	1.05	2.09	4.5
V4_3		778,430	7,629,510	1.05	2.09	4.5
V4_4		778,470	7,630,034	1.05	2.09	4.5
V4_5		778,874	7,630,365	1.05	2.09	4.5
V4_6		779,245	7,630,591	1.05	2.09	4.5