HASTINGS
Technology Metals Limited

APPENDIX 6-3

Air Quality Assessment

Final Report

Yangibana Rare Earths Project – Air Quality Assessment

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Executive summary

Project description

Hastings Technology Metals Limited (Hastings) is seeking environmental approvals for the Yangibana Rare Earths Project (YREP). The project is located approximately 270 kilometres (km) east-northeast of Carnarvon, in the Gascoyne region of Western Australia. The YREP will include open pit mining and processing of mineralised monazite ore, including transport of product to port.

Mining is anticipated to occur over an eight-year period. The on-site beneficiation plant will treat up to 1 million tonnes per annum (Mtpa) of mineralised monazite, producing approximately 30,000 tonnes per annum (tpa) of mineral concentrate. The concentrate will pass through a hydrometallurgical process, producing an estimated average of 12,000 (tpa) of final product. Power for the plant will be supplied from an onsite diesel generation plant.

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

Overview of assessment

For the purpose of the air quality assessment, the YREP comprises the mine and processing facilities, including power supply, the 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 and the natural environment).

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 YREP, as well as the cumulative impact (ie in conjunction with the existing air quality of 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.

Key findings of the assessment

YREP impact in isolation of other emission sources

The YREP was modelled to estimate the contribution of emissions from the project under a single operating design scenario; mining and processing associated with handling approximately 15 Mtpa of material.

Particles as TSP, PM_{10}, $PM_{2.5}$, dust deposition as well as nitrogen dioxide (NO_2) were modelled to represent the potential impact of the operations on the environment (ie, human health and the natural environment).

The modelling results for YREP in isolation of other emission sources in the region indicates that the predicted ground level concentrations of TSP, PM_{10} , $PM_{2.5}$, dust deposition and NO_2 are not significant, by comparison to the relevant criterion at receptor locations.

Cumulative impact with other emission sources

The YREP was modeled in conjunction with an estimate of background emissions, to estimate the potential cumulative impact on the environment following the introduction of the project. The YREP included emissions from the project under a single design scenario.

In the absence of site specific background monitoring information, conservative background levels have been adopted for pollutants and the cumulative impact should be read in conjunction with background levels adopted. Given the remoteness of the YREP operations, background levels for NO_2 are assumed negligible.

Both short term impacts (24-hour timeframe) and longer term impacts (1-year) were considered. The modelling results for the YREP project indicate that the maximum predicted ground level concentrations for:

- Cumulative 24-hour TSP can be expected to be around 36.4µg/m^3 (44% of the criteria)
- Cumulative 24-hour PM_{10} can be expected to be around 20.3µg/m^3 (44% of the criteria)
- Cumulative annual average PM_{10} can be expected to be around 19.2µg/m^3 (70% of the criteria) – of which the majority is accounted for in the background data used
- Cumulative 24-hour $PM_{2.5}$ can be expected to be around 3.1µg/m^3 (14% of the criteria)
- Cumulative annual average $PM_{2.5}$ can be expected to be around 2.9µg/m^3 (41% of the criteria) – of which the majority is accounted for in the background data used
- Project only dust deposition levels can be expected to be less than 0.7% of the criteria.
- Cumulative 1-hour NO_2 can be expected to be less than 2% of the criteria
- Cumulative annual average NO_2 can be expected to be around 13% of the criteria

In summary, no significant air quality impact is expected during the operational phase of the YREP project.

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1 Introduction

Hastings Technology Metals Limited (Hastings) is seeking environmental approvals for the Yangibana Rare Earths Project (YREP).

Hastings 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 YREP (as it is currently defined) in areas surrounding the project (as determined at selected sensitive receptors).

1.1 Project description

The YREP is located approximately 270 kilometres (km) east-northeast of Carnarvon, in the Gascoyne region of Western Australia. The YREP will include open pit mining and processing of mineralised monazite ore, including transport of product to port. The site location, in a regional context, is shown in Figure 1-1.

Mining is anticipated to occur over an eight-year period. The on-site beneficiation plant will treat up to 1 million tonnes per annum (Mtpa) of mineralised monazite, producing approximately 30,000 tpa of mineral concentrate. The concentrate will pass through a hydrometallurgical process, producing an estimated average of 12,000 tpa of final product. Power for the plant will be supplied from an onsite diesel generation plant.

Infrastructure and support facilities for the YREP include the administration and site office, maintenance workshop, and power supply. The workforce for the site will be accommodated on site.

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

- Mines –open pits.
- Processing plant
- Tailings facility – secure storage of residue from the processing facility
- Associated infrastructure – includes –
  - Power supply (initially diesel fuel power plant)
  - Road network from the mine pits to the processing plant
  - Buildings and support facilities including administration, waste water treatment and worker accommodation.

Ambient air quality and potential impacts are assessed in terms of the following pollutants:

- Particles, as PM_{10}, $PM_{2.5}$,TSP and dust deposition
- Oxides of nitrogen (NO_x) as nitrogen dioxide (NO_2).

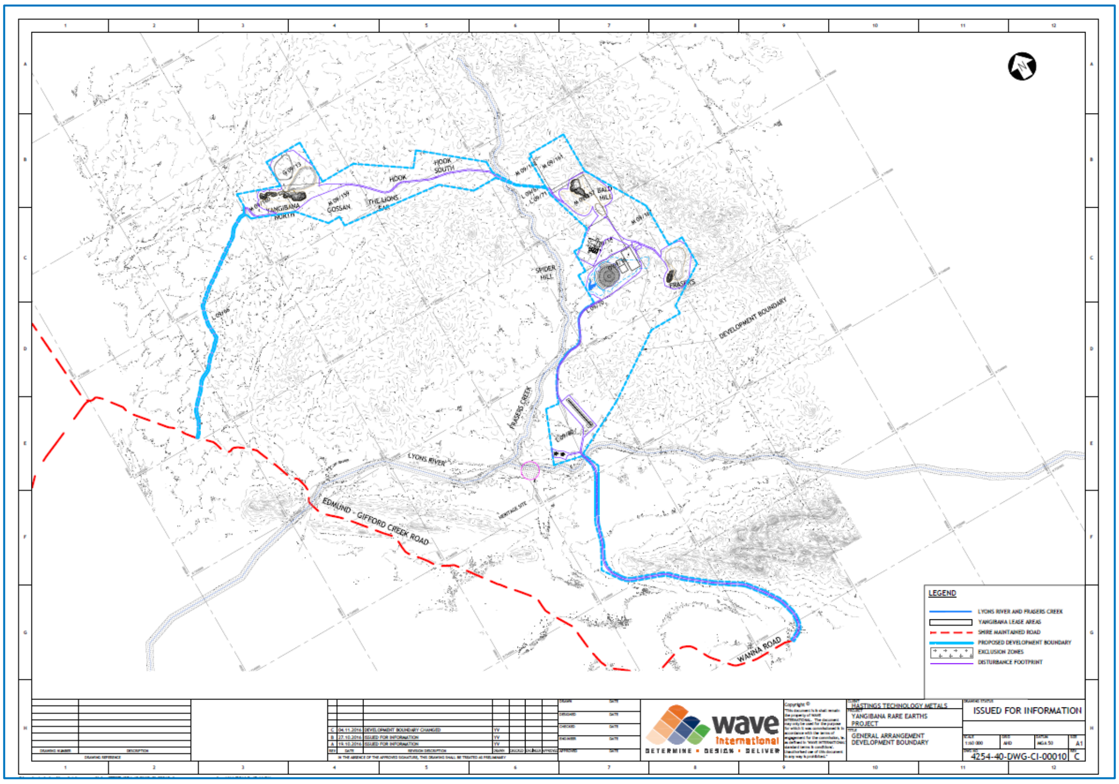

Figure 1-1: Site location in regional context (Hastings, 2016)

1.2 Report structure

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

- Study methodology (Section 2)
- Emission estimation (Section 3)
- Atmospheric dispersion modelling results (Section 4)
- 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). Hastings operates an onsite meteorological station with this station recording wind speed and wind direction data close to a year. Further investigation identified that this station was not subject to regular maintenance and the data was invalidated.

Reference was made to the closed BoM station at Paraburdoo Airport (180km from YREP) that records hourly wind speed and wind direction amongst other parameters. Analysis of 10-year of historical surface observations at the BoM Paraburdoo Airport identified 2011 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 YREP 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 15 Mtpa of material moved from quarter 10 to 13. 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 in the Shire of Kalgoorlie. This approach is considered extremely conservative for reasons stated in Section 4.2.1.5.

2.3.3 Modelled operating scenarios and assumptions

The air quality assessment has taken into account only the operational phase impacts of the YREP. 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
- On site power generation

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 YREP, 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.

2.4.2 Sensitive receptors

The key sensitive receptor located closest to the operations was identified as the accommodation facility. Modelled ambient air quality concentrations were determined at this location. The key sensitive receptor is listed in Table 2.1 and shown in Figure 2-1.

Table 2.1: Sensitive receptor locations

Receptor ID	Easting (m)	Northing (m)
Accommodation facility	421700.31	7346593.39

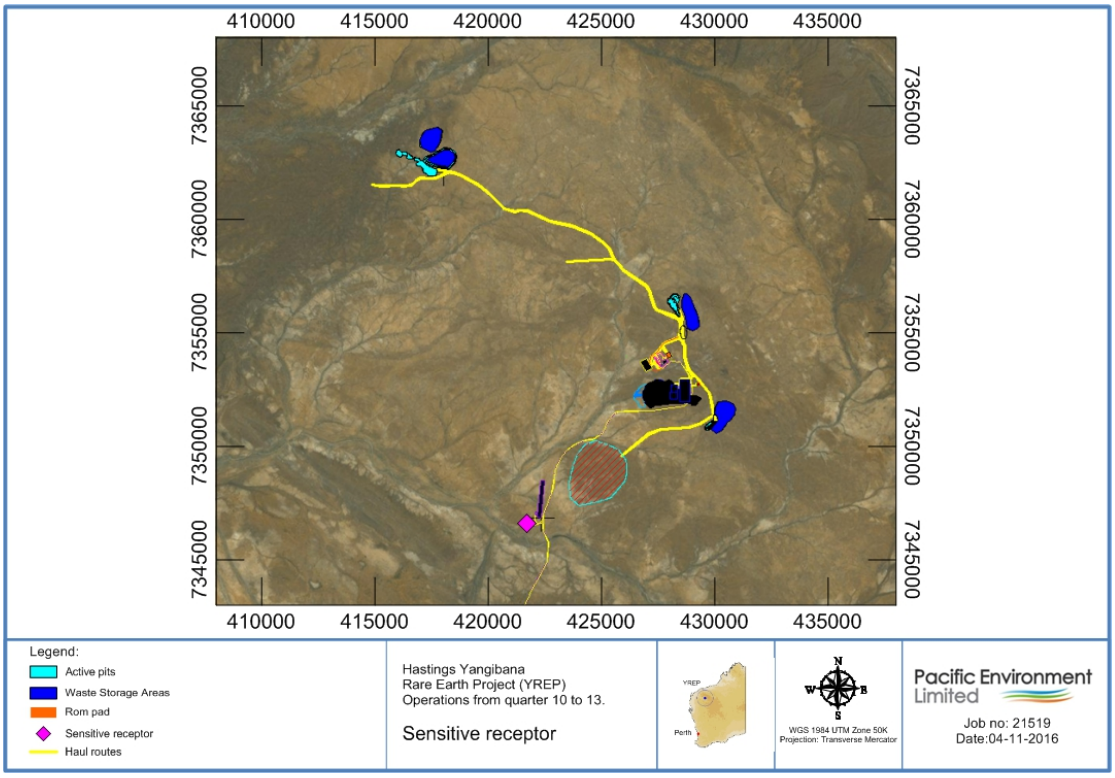

Figure 2-1: Sensitive receptor locations

3 Emission Estimation

This section outlines the emission estimation process used to develop the emission inventory for the YREP (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 YREP 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
- On site power generation

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 Hastings has been used.

Mining will occur at a maximum rate of 15 Mtpa (ore and waste) with approximately14 Mtpa of waste and 1Mtpa of ore.

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. The annual estimated emissions from the processing facilities and power generation are shown in Table 3.3.

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

Activity	PM_{10} (kg/year)	Controls
Drilling	25,439	In pit retention
Blasting	267	In pit retention
Loading	195,302	In pit retention
Unloading	68,872	In pit retention
Bulldozers	34,797	In pit retention (Ore)
Conveying	4,035	No control
Wheel generated emission	462,040	Water sprays
Primary Crusher	4,035	No control
Wind Erosion	1,039	Water sprays
Power generation	10,899	No control
Carbon Regeneration kiln	0.22	No control

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)

Table 3.3: *Gaseous emissions – operational phase*

Activity	Pollutant	Emission Rate (kg/year)
Power generation	NO_x	166,987
Carbon regeneration kiln	NO_x	3

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

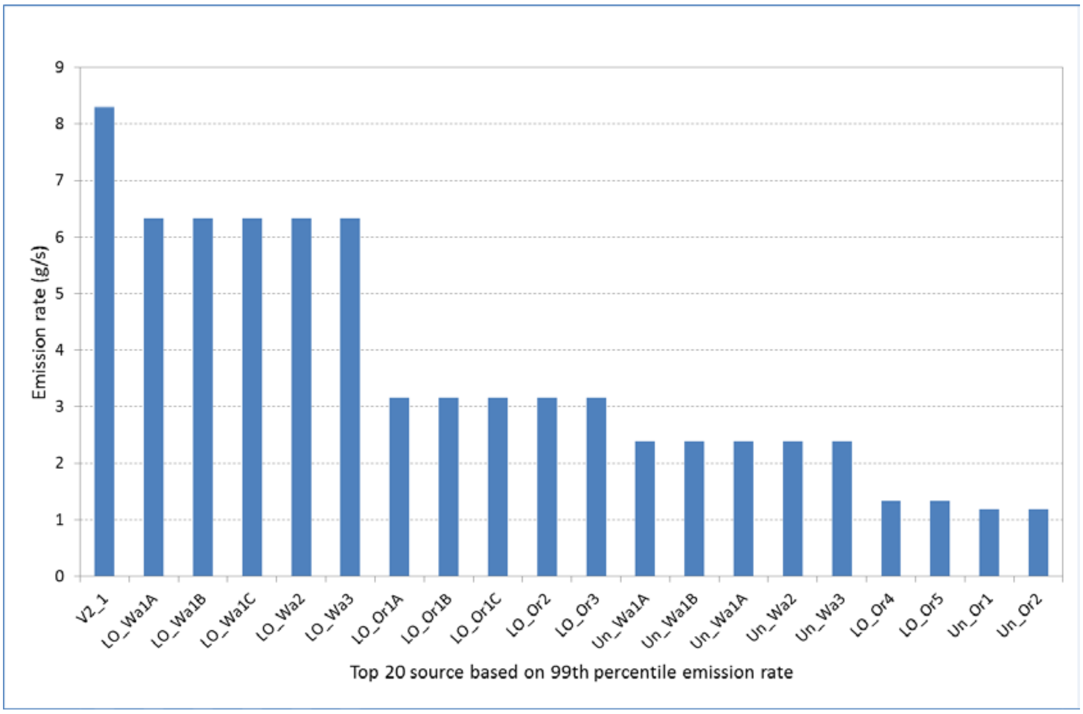

Figure 3-1: Top 20 calculated PM_{10} emission rates with emission controls

Further details including the emission equations used, stack parameters 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, 2011. 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 (2011) with four nested domains (30 km, 10 km, 3 km and 1 km) centred at 23.96S and 116.030E. 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 were 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
- Cloud cover
- Ceiling height
- Mixing height.

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 a 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 v9.1.0 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.

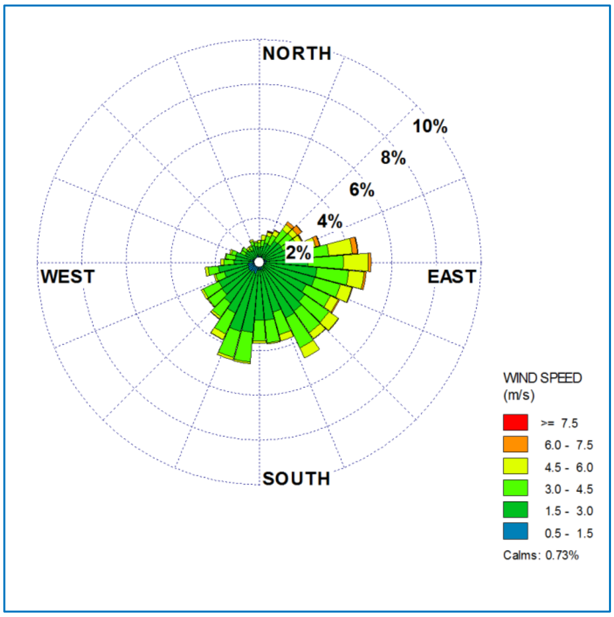

Figure 4-1: *Annual windrose generated by AERMET (2011)*

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 3 arc, 90m resolution
- PM_{10} were modelled as gas accounting for dry depletion. Depositional parameters are provided in Section 4.2.1.1
- pollutant concentrations were modelled across one discrete receptor (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.

4.2.1.2 Source Characteristics

A total of 73 volume sources were used to represent emissions: 45 sources to represent operational emissions from mining including wind erosion and 28 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 25 km in the north–south direction and 30 km in the east-west direction and has its southwest corner at 408000, 7343000 m (50K UTM). This grid approach was chosen to restrict the duration of model runs while using the particle deposition algorithms. An additional one discrete receptor was 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 Gascoyne Mid-West region is bushfire prone with these generally occurring between October and February. 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 within Newman as used by BHP Billiton Iron Ore (BHPBIO) in their Pilbara Strategic Environmental Assessment – Cumulative Air Quality Assessment (PEL, 2015). This assessment details the statistics of both PM_{10} and TSP from 2009 to 2012 from their background station. These statistics are reproduced in this report with TSP in Table 4.3 and PM_{10} in Table 4.4.

It is noted in the PEL report that 2009 recorded concentrations, especially TSP, that were extremely high with a possible causes being wildfires. It is further noted that 2009 and 2012 had only moderate data recovery and that these two years were not considered representative of background concentrations.

For this assessment the background concentrations will be chosen based on the 70^{th} percentile of either 2010 or 2011 from the BHPBIO BG2 monitoring station. Based on the information contained in Table 4.3 and Table 4.4 this equates to:

- A TSP background of 35 µg/m^3
- A PM_{10} background of 19 µg/m^3

Table 4.3: Statistics for TSP at BHPBIO BG2 Monitoring Station (µg/m^3)

	2009	2010	2011	2012
Maximum	722	288	119	146
99^{th} percentile	448	163	95	97
95^{th} percentile	236	82	68	68
90^{th} percentile	168	59	54	55
70^{th} percentile	93	33	35	35
Average	90.1	31.7	29.8	29.9

Table 4.4: Statistics for PM_{10} at BHPBIO BG2 Monitoring Station (µg/m^3)

	2009	2010	2011	2012
Maximum	153	590	92	194
99th percentile	99	63	70	77
95th percentile	67	37	34	55
90th percentile	54	30	28	35
70th percentile	31	18	19	21
Average	28.5	18.3	16.5	20.4

As there is no publically available $PM_{2.5}$ monitoring data the background levels are assumed to be 15% of the PM_{10} used for the assessment, which equates to 2.9 µg/m^3.

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

Considering the very remote nature of the project, background NO_2 levels are assumed negligible.

4.2.1.6 Conversion of NO_x to NO_2

At the exhaust from combustion sources, NO_x is primarily released as NO with 5 to 40% of NO_x released as NO_2. After release, NO is converted to NO_2 primarily due to chemical reactions involving the presence of ozone and sunlight.

There are a number of models and empirical relationships for estimating the conversion of NO to NO_2 for plumes from stacks. The most commonly used is the Ozone Limiting Method and is also the approved method for use in NSW (NSW EPA, 2005). This method requires an estimate of NO_2/NO_x ratio and background NO_2 and ozone concentrations.

Given the remote location of the site and presence of negligible background sources, a simple method was used for estimating NO_2: a conversion of 30% was assumed as was used by Air Assessment (2014). The Browns Range Rare Earths Project is also in a relatively remote locality (Carnarvon region) with no major industrial sources in its vicinity.

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 4.5.

Table 4.5: 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 nominated sensitive receptor location. The cumulative results for the YREP are also presented. Modelled results are presented in tables (statistics) and as contour maps showing the cumulative ground level concentrations for each pollutant 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, the maximum 24-hour average TSP is expected to be significantly below the criteria (Table 5.1).
- Including background, the maximum 24-hour average TSP is predicted to be around 44% of the criteria with the YREP project contributing less than 2%. (Table 5.2).
- Contour plots of maximum 24-hour average TSP concentrations both 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 accommodation facility excluding background (µg/m^3)

Statistics	Value
Maximum	1.4
99th Percentile	1.0
95th Percentile	0.7
90th Percentile	0.6
70th Percentile	0.4
Average	0.3

Table 5.2: Predicted 24-hour TSP concentrations at the accommodation facility including background (µg/m^3)

Statistics	Value
Maximum	36.4
99th Percentile	36.0
95th Percentile	35.7
90th Percentile	35.6
70th Percentile	35.4
Average	35.3
Criteria	82

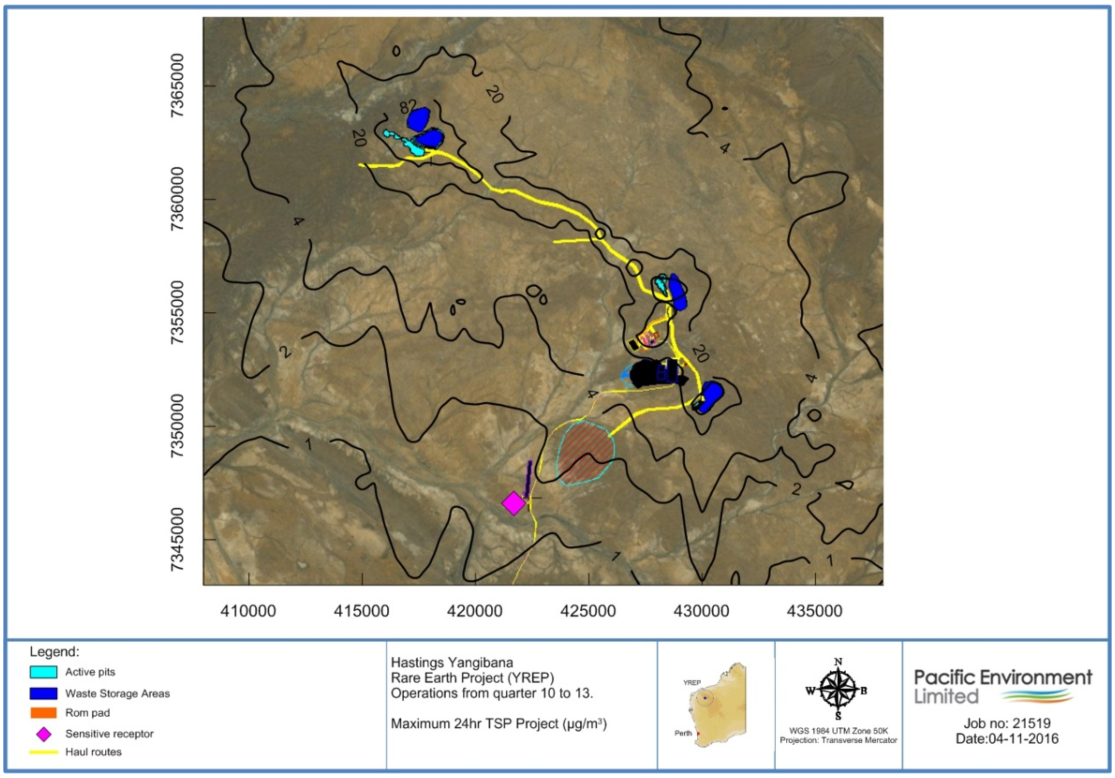

Figure 5-1: Contour plot of m*aximum 24-hour TSP concentrations (excluding background)*

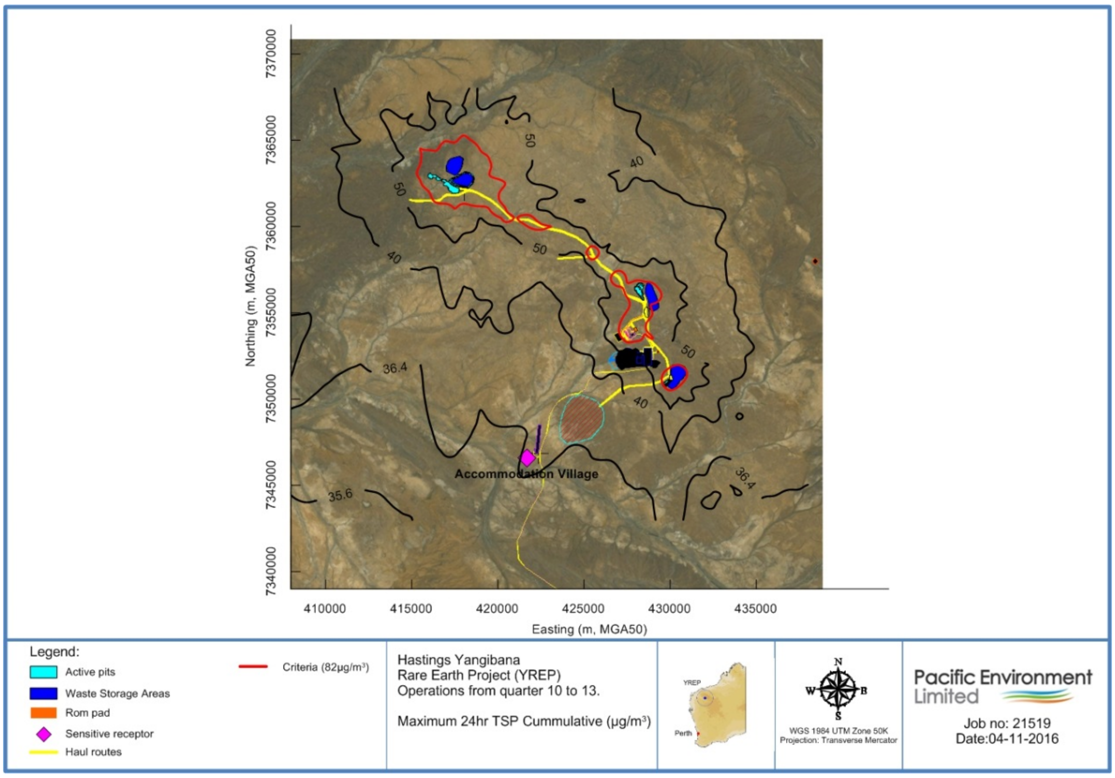

Figure 5-2: Contour plot of m*aximum 24-hour TSP concentrations (including background)*

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, the maximum 24-hour average PM_{10} is expected to be significantly below the criteria (Table 5.3).
- Including background, the maximum 24-hour average PM_{10} levels is predicted to be 20.3µg/m³ (44%) of the criteria (Table 5.4).
- Contour plots of maximum 24-hour average PM_{10} concentrations both 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 accommodation facility excluding background (µg/m³)

Statistics	Value
Maximum	1.3
99th Percentile	0.7
95th Percentile	0.5
90th Percentile	0.4
70th Percentile	0.2
Average	0.2

Table 5.4: Predicted 24-hour PM_{10} concentrations at the accommodation facility including background (µg/m³)

Statistics	Value
Maximum	20.3
99th Percentile	19.7
95th Percentile	19.5
90th Percentile	19.4
70th Percentile	19.2
Average	19.2
Criteria	46

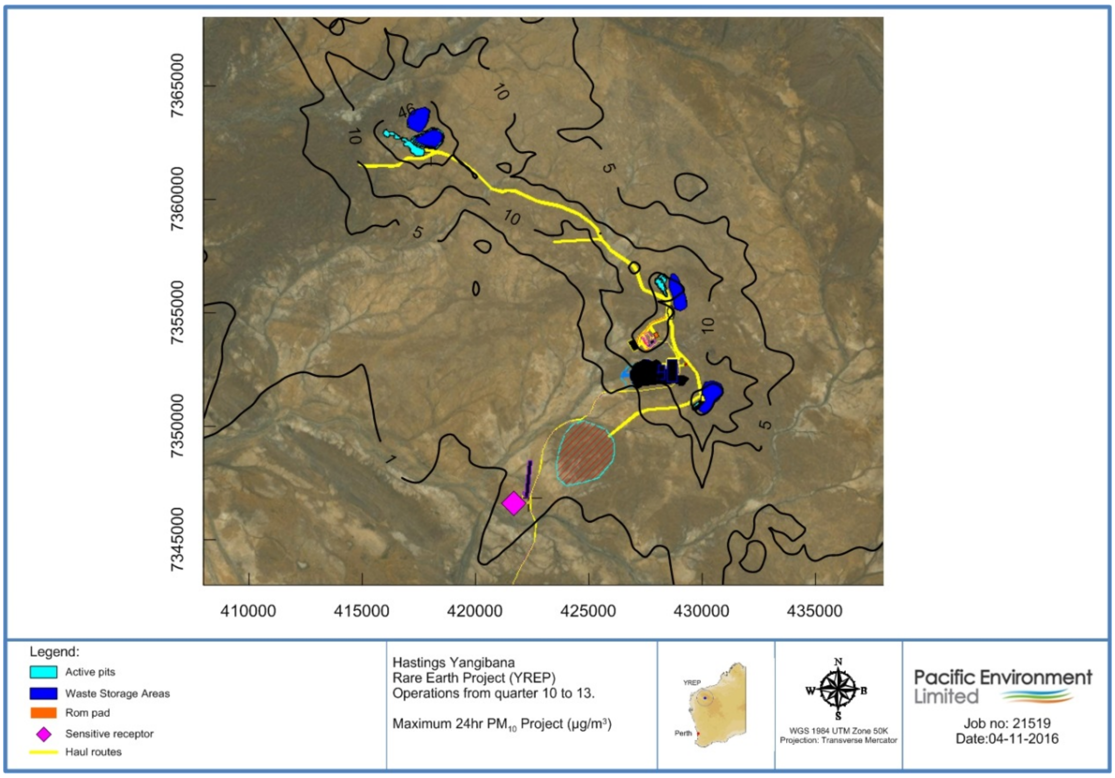

Figure 5-3: Contour plot of m*aximum 24-hour PM_{10} concentrations (excluding background)*

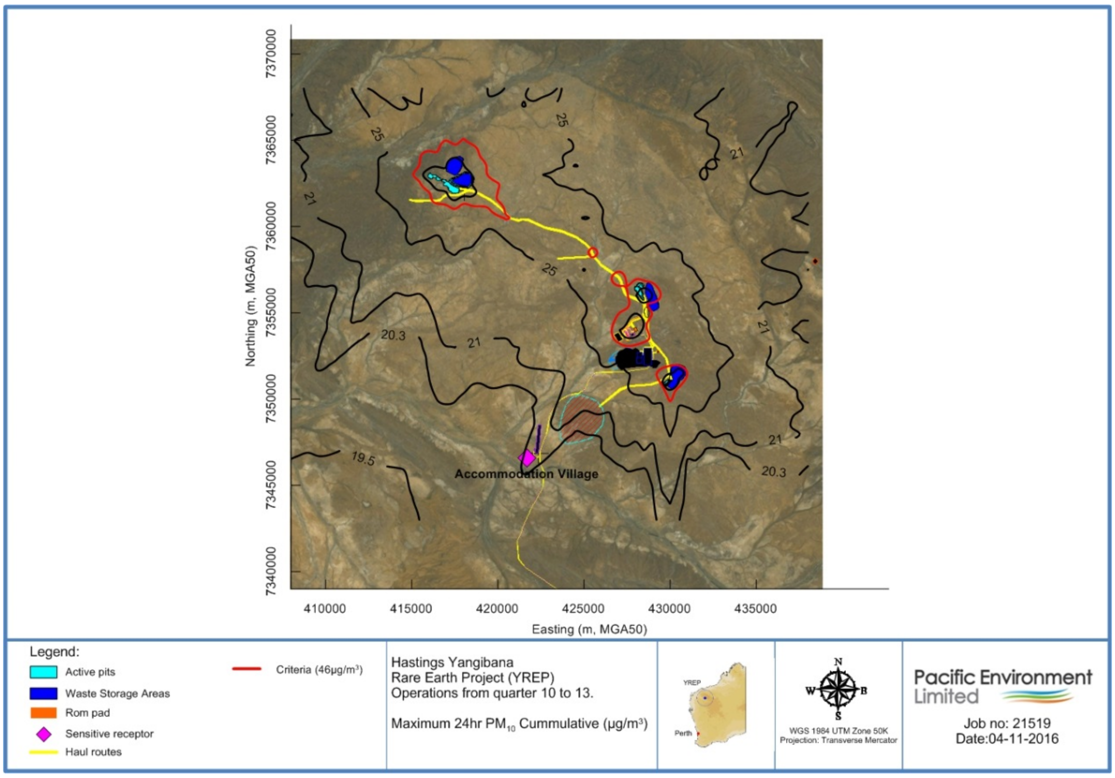

Figure 5-4: Contour plot of m*aximum 24-hour PM_{10} concentrations (including background)*

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). As observed from Table 5.5, including background, the annual average PM_{10} concentrations at the accommodation facility is predicted to be around 70% of the criteria, with less than 1% of this level contributed by the YREP project.

Contour plot of cumulative annual average PM_{10} is presented in Figure 5-5.

Table 5.5: Predicted annual average PM_{10} concentrations at the accommodation facility including background (µg/m^3)

Item	Value
Annual average	19.2
Criteria	27.5
Background	19

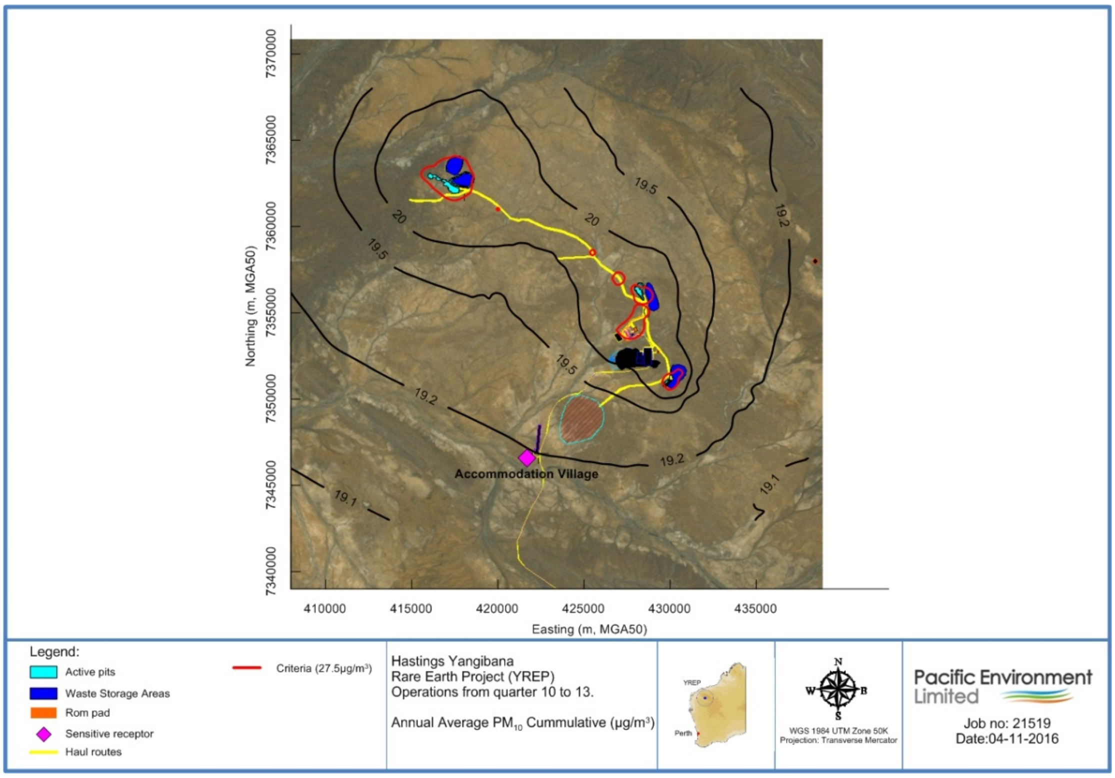

Figure 5-5: *Annual average PM_{10} concentrations (including background)*

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). The model results indicate the following:

- Excluding background, the maximum 24-hour average $PM_{2.5}$ is expected to be significantly below the criteria (Table 5.6).
- Including background, the maximum 24-hour average $PM_{2.5}$ is predicted to be significantly below (14%) the criterion (Table 5.6).
- Contour plots of maximum 24-hour average $PM_{2.5}$ concentrations both excluding and including background are presented in Figure 5-6 and Figure 5-7 respectively.

Table 5.6: Predicted 24-hour $PM_{2.5}$ concentrations at the accommodation facility (µg/m^3)

Statistics	Excluding background	Including background
Maximum	0.27	3.1
99th Percentile	0.15	3.0
95th Percentile	0.10	3.0
90th Percentile	0.09	2.9
70th Percentile	0.05	2.9
Average	0.04	2.9
Criteria	n/a	23

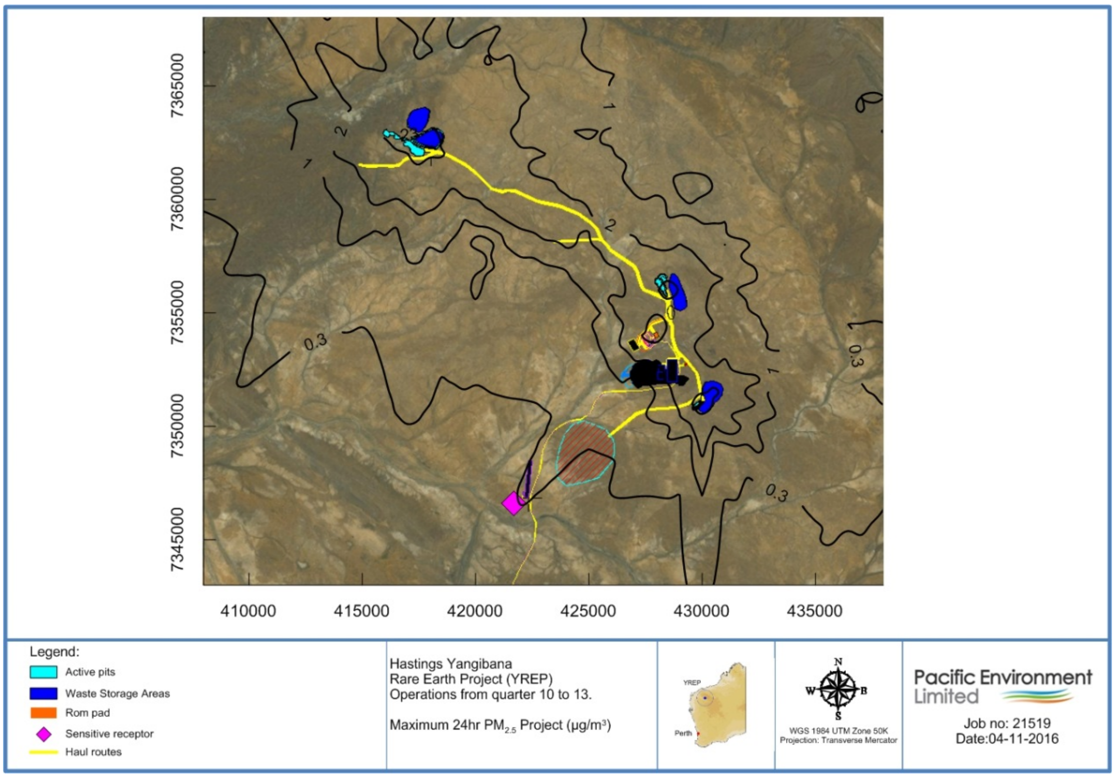

Figure 5-6: Contour plot of m*aximum 24-hour $PM_{2.5}$ concentrations (excluding background)*

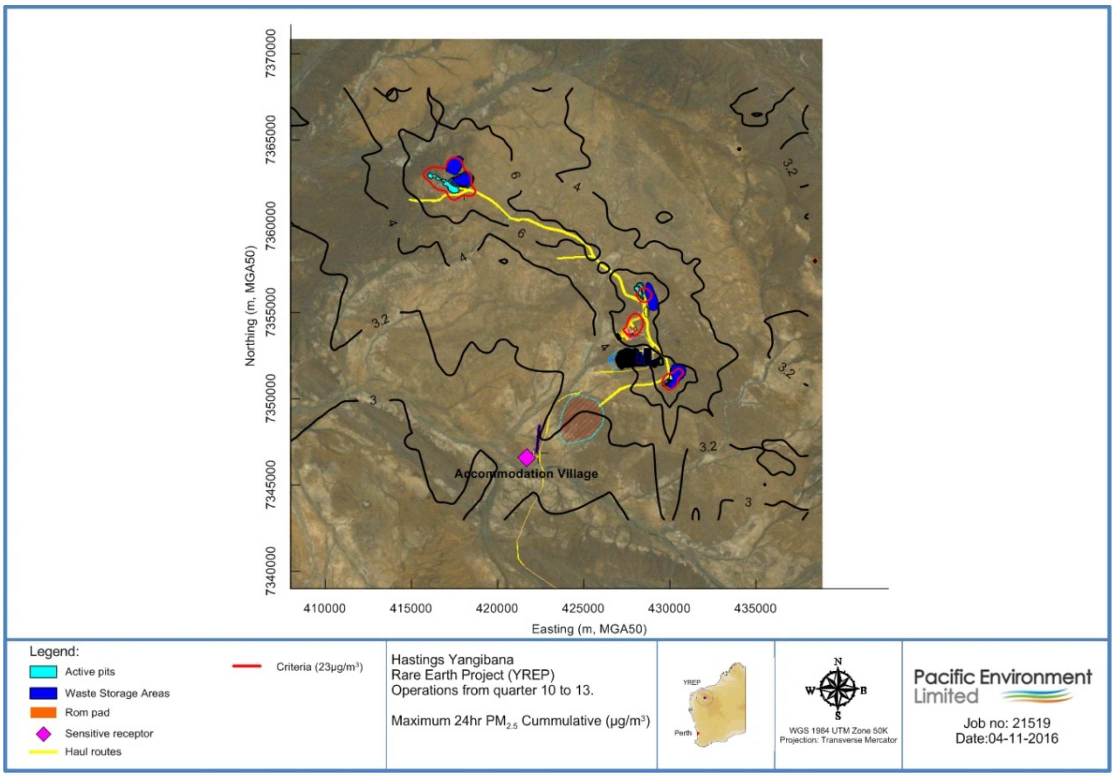

Figure 5-7: Contour plot of m*aximum 24-hour $PM_{2.5}$ concentrations (including background)*

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). It can be observed from Table 5.7 that including background, the annual average PM_{10} concentrations at the accommodation facility is predicted to be around 41% of the criteria, and less than 1% of this level is contributed by the YREP project.

Contour plot of cumulative annual average $PM_{2.5}$ is presented in Figure 5-8.

Table 5.7: Predicted annual average $PM_{2.5}$ concentrations at the accommodation facility including background (µg/m^3)

Item	Value
Annual average	2.9
Criteria	7
Background	2.9

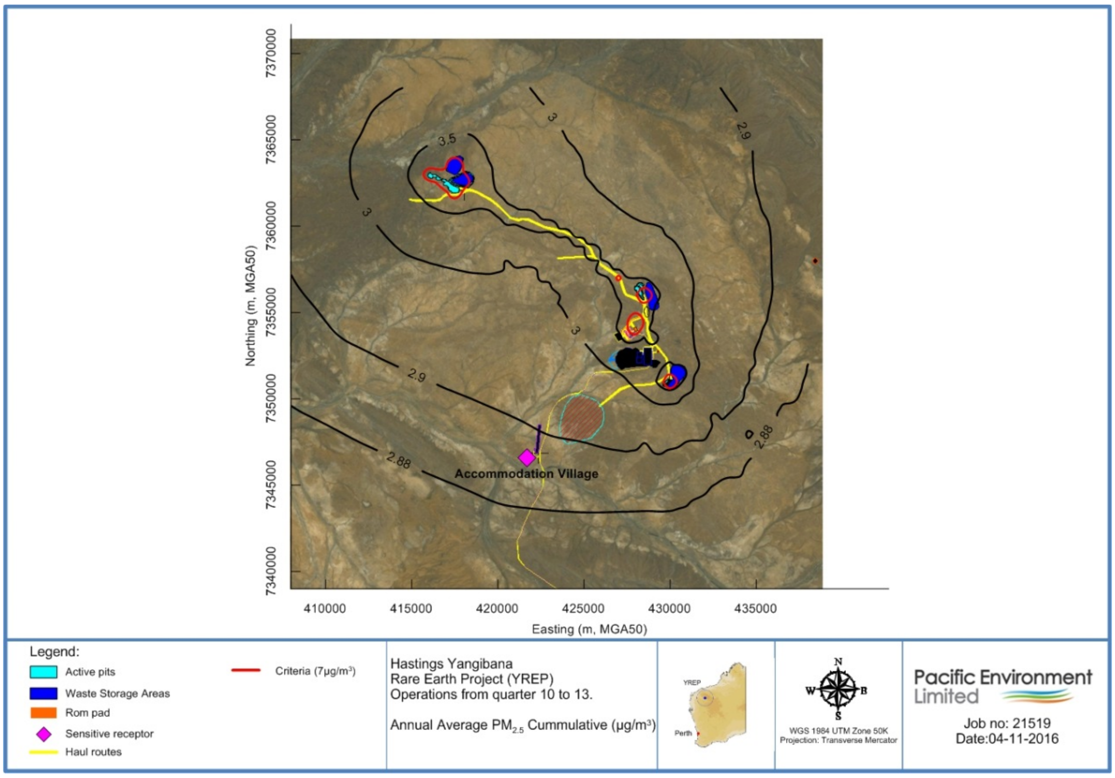

Figure 5-8: *Annual average $PM_{2.5}$ concentrations (including background)*

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, the maximum monthly dust deposition is predicted to be 0.014g/m^2/month, at less than 0.7% of the criteria (Table 5.6).
- Contour plot of maximum monthly dust deposition levels (excluding background) is presented in Figure 5-6.

Table 5.8: Predicted maximum monthly dust deposition levels at the accommodation facility – excluding background (g/m^2/30days)

Statistics	Excluding background
Maximum	0.014
Criteria	2

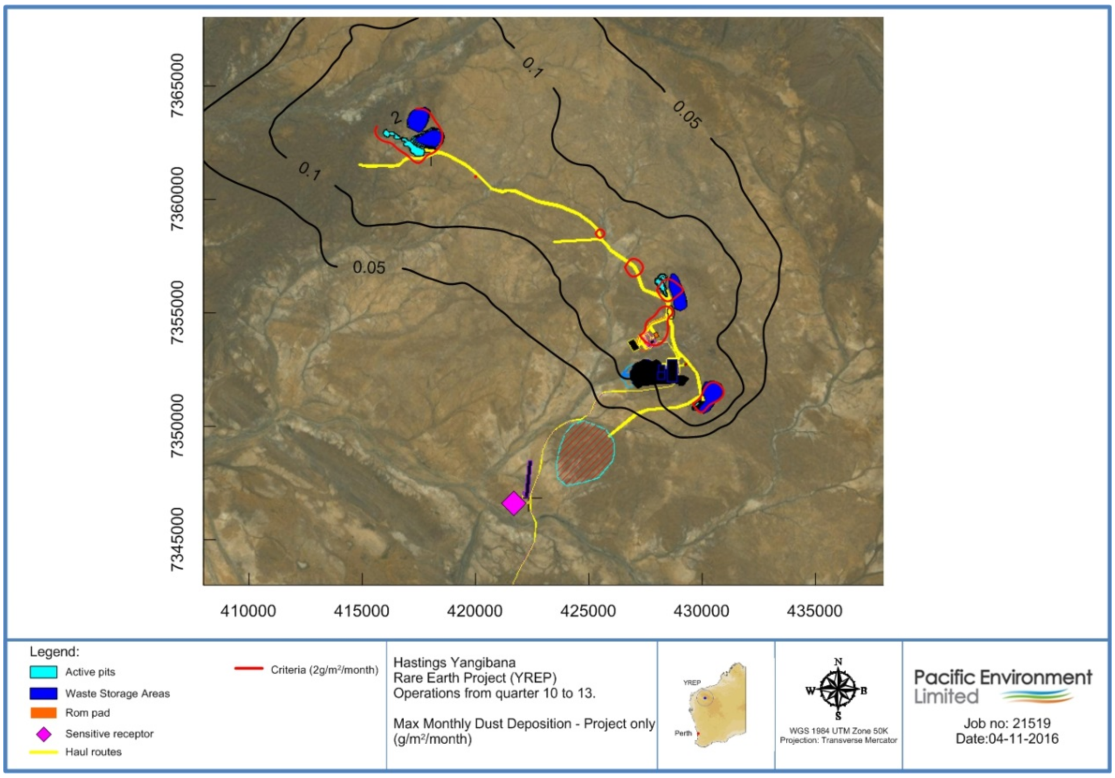

Figure 5-9: *Maximum monthly dust deposition levels at receptors - excluding background (g/m²/month)*

5.5 Assessment of NO_2

A summary of the predicted 1-hour maximum and annual average concentrations, for the cumulative scenario, is presented in Table 5.9. The model results indicate that:

- The maximum predicted cumulative 1-hour average NO_2 is about 13% of the criteria.
- Including background, the annual average NO_2 concentrations is expected to be less than 2% of the criteria.

Table 5.9: *Maximum predicted NO_2 concentrations at the* accommodation facility *(including background (µg/m³))*

Item	1-hour average	Annual average
Value	29.4	1.1
Criteria	226	56

Contour plots showing the cumulative 1-hour and annual average NO_2 concentrations are presented in Figure 5-10 and Figure 5-11 respectively.

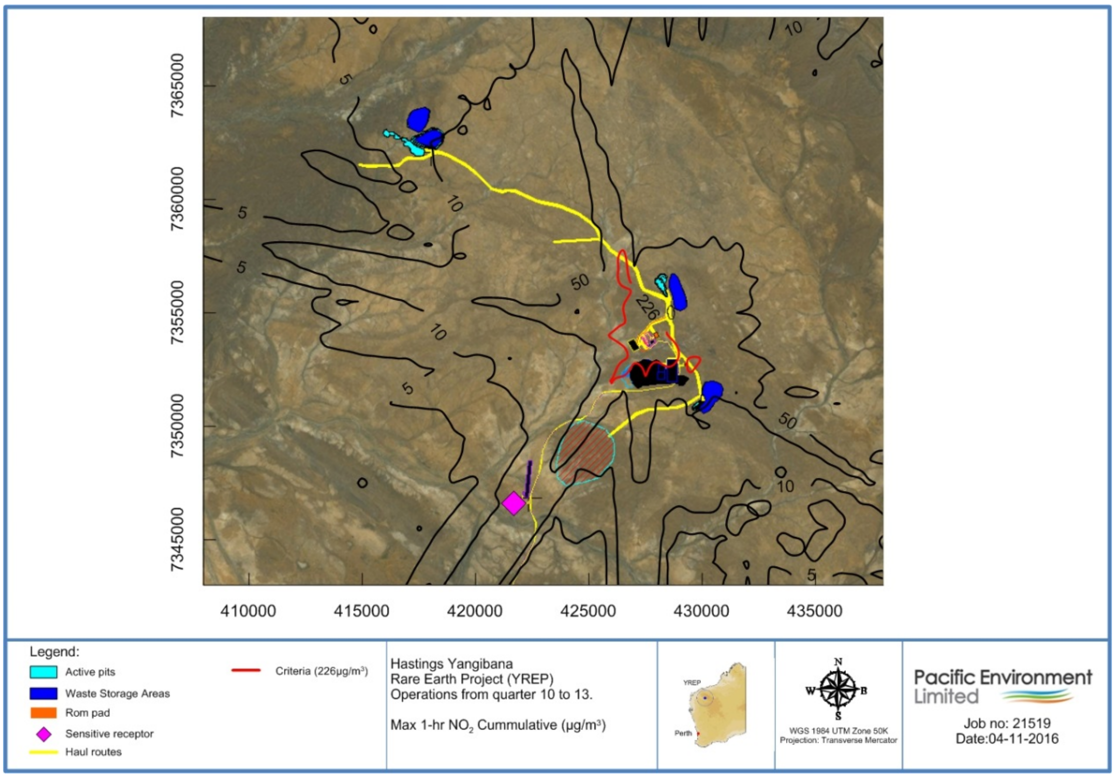

Figure 5-10: *Maximum 1-hour NO_2 concentrations – cumulative*

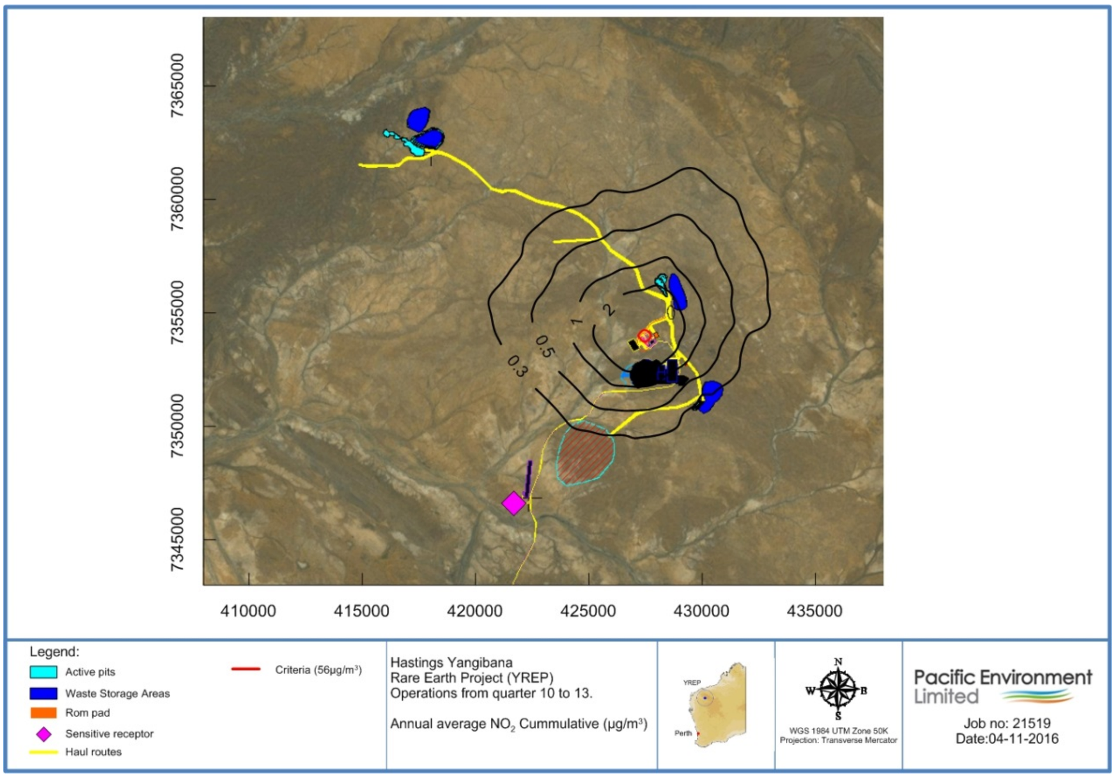

Figure 5-11: *Annual average NO_2 concentrations – cumulative*

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 over a period of 10 years (2005-2015) was analysed.

The review identified 2011 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 cumulative NO_2 concentrations for this assessment have been compared to the following criteria:

- Draft WA DER 1-hour criteria of 226 µg/m³
- Draft WA DER annual average criteria of 56 µg/m^3.

6.3 Modelled Results and Potential Impact

The maximum 24-hour TSP, PM_{10} and $PM_{2.5}$ concentrations (including background) can be expected to be well within the DER criteria at the accommodation facility. It is noted that the background concentrations have been adopted from the BHP Billiton Iron background monitoring in Newman and it is possible that the concentrations can vary at the Project area.

The annual average PM_{10} and $PM_{2.5}$ concentrations (including background) can be expected to be met at the sensitive receptor.

The maximum monthly dust deposition levels predicted from the YREP (project only) is expected to be significantly below the criteria.

At the identified receptor, the cumulative NO_2 concentrations are within the criteria for both 1-hour and annual averaging periods.

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8 Appendices

Appendix A
Climate and representative meteorological year

A1.1 Climate of the region

Hastings operates a meteorological station. This station records wind speed and wind direction and has been operational close to a year. Further investigation revealed that the sensors had been hit by a lightning strike and as a result data quality had been compromised and was not fit for use in this report.

There is a BoM climate station at Gascoyne Junction (station no 6022). However, the closest BoM station that records hourly wind speed and wind direction is Paraburdoo Airport (station no 7185), at around 180 kilometres from the project location. Where available, preference will be given to data recorded at the BoM Gascoyne Junction.

Data obtained from the BoM Gascoyne Junction included long term statistics of rainfall, temperature and relative humidity. Long-term hourly meteorological parameters (wind speed, wind direction and temperature and humidity) from BoM Paraburdoo Airport are also presented. This data analysis provides a general description and understanding of the local climate and supports the emission estimations and selection of representative meteorological year dispersion model set-up. Analysis of meteorological data is also used in the analysis to identify or determine a representative year for dispersion modelling.

A1.1.1 Wind Speed and Wind Direction

The seasonal wind rose for Paraburdoo Airport, 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 north-easterly to east-north-easterly.

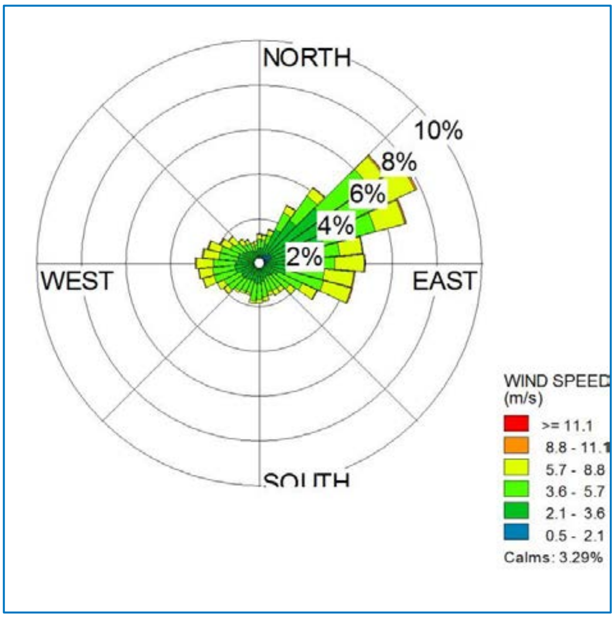

Figure 8-1: *Annual wind rose recorded at Paraburdoo Airport station (2005-2015)*

A1.2.1 Rainfall

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 the late summer through to winter, with very little rainfall occurring between late winter and early summer. The average number of rainy days in the year range between 0.6 and 3.6 days. The mean annual rainfall (1907 to 2016) is around 215.5mm. Rainfall statistics are illustrated in Figure 8-2 . The figure shows the average monthly rainfall and average days of rain per month measured between 1907 and 2016 (BoM, 2016).

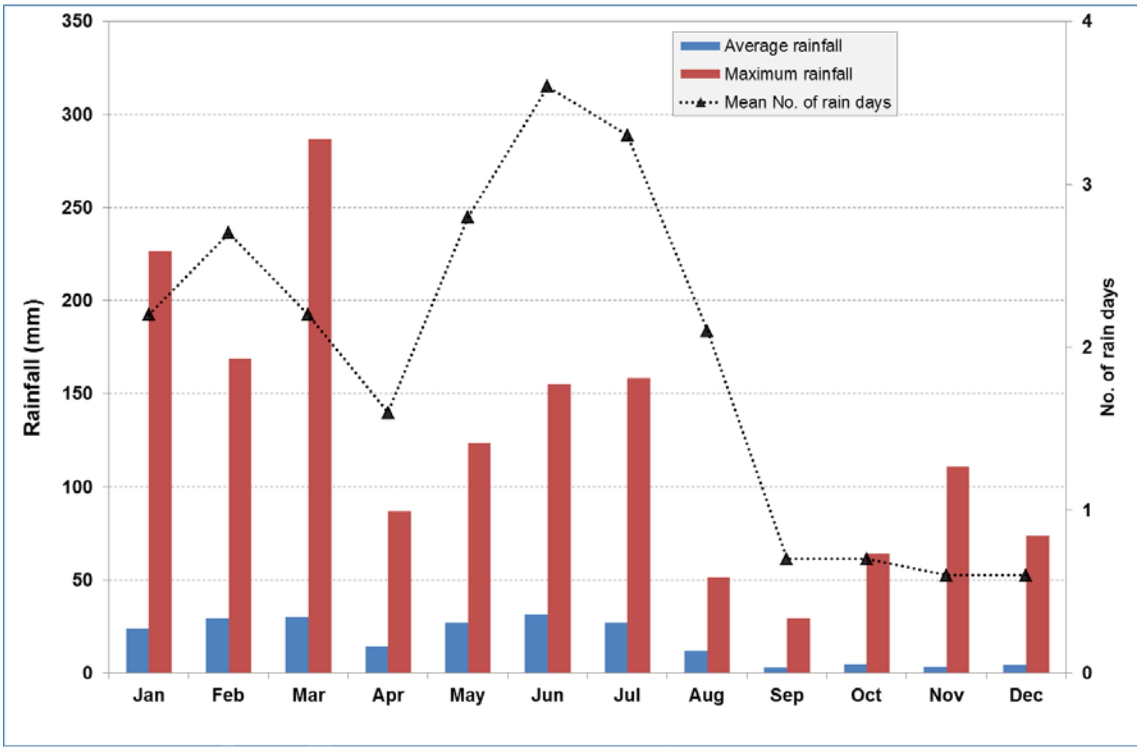

Figure 8-2: Monthly *rainfall data for Gascoyne Junction (1907-2016) (BoM, 2016)*

A1.3.1 Temperature

Air temperature, in the context of dispersion modelling, is important for understanding the development of mixing and inversion layers in the model domain.

The long term monthly temperature statistics for BoM Gascoyne Junction 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 1961 to 2016.

Average temperatures in Gascoyne Junction range from 18.1°C to 38.7°C during summer, with maximum recorded temperatures of up to 48.8°C. During winter the temperature typically varies from 9.5°C to 24.9°C, with lowest minimum temperature of 1.3°C.

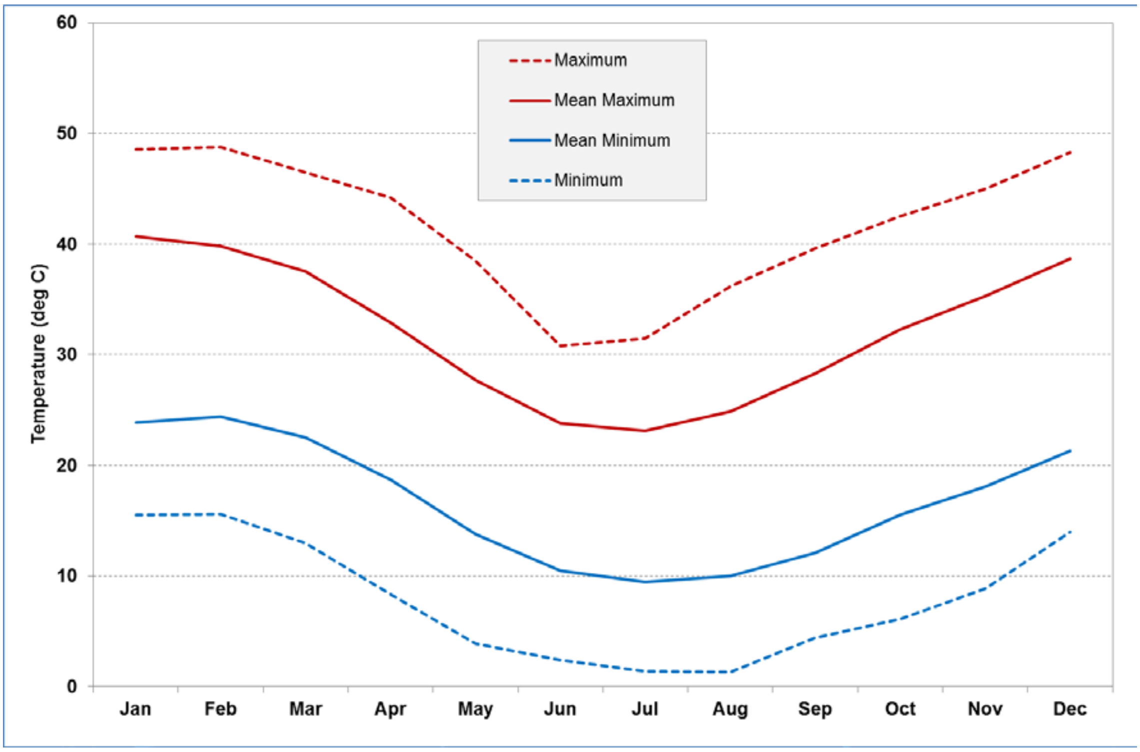

Figure 8-3: *Monthly temperature data for Gascoyne Junction (1961-2016) (BoM, 2016)*

A1.4.1 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 could potentially accumulate water through condensation and grow to sizes at which they are more efficient at scattering light, thereby reducing visibility.

The long term humidity statistics in Gascoyne Junction at 9 am and 3 pm is presented in Figure 8-4. It shows the humidity is typically high during the winter period and is generally low during the summer period. This reflects the arid nature of the region.

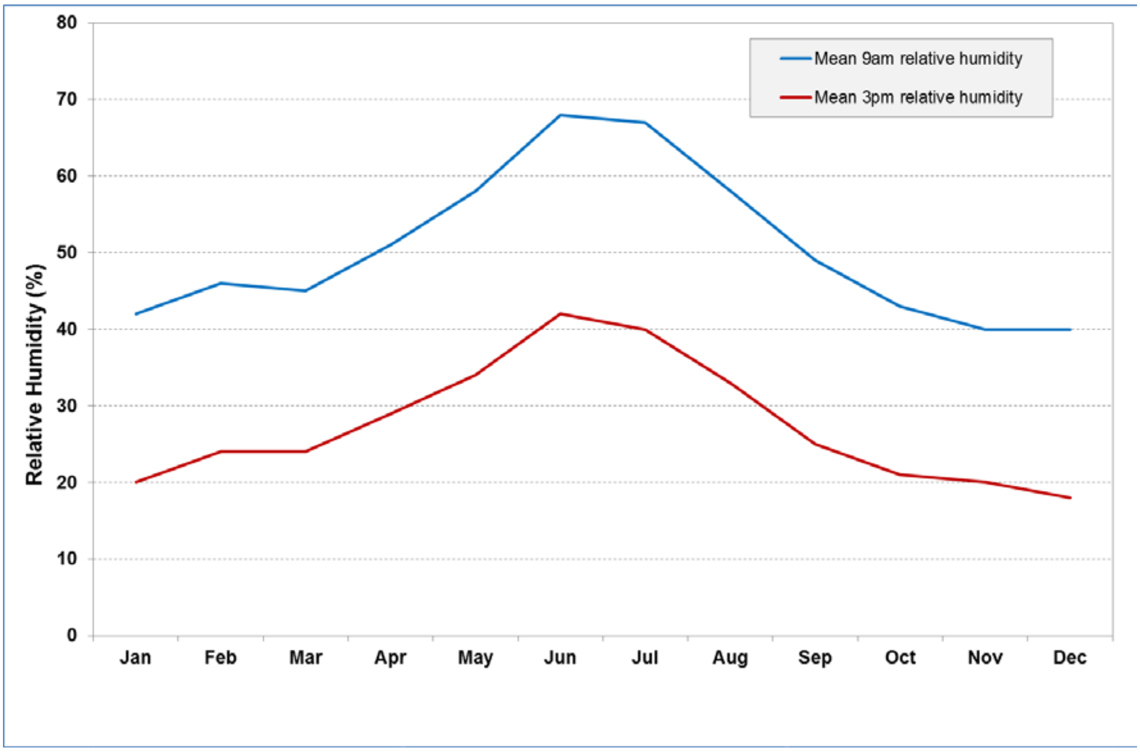

Figure 8-4: *Monthly relative humidity data for Gascoyne Junction (1940-2010) (BoM, 2016)*

A2.1 Representative year

In order to determine the most applicable meteorological year for use in dispersion modelling, 10-year historical surface observations from the BoM Paraburdoo Airport for the period 2005 to 2015 inclusive were reviewed. Statistical analysis was performed to determine the representative year.

A plot of annual rainfall for the period 1999 to 2015 is presented in Figure 8-5. Over the 16-year period, 2003 and 2010 recorded rainfall below the 10th percentile value while 1999 and 2006 recorded rainfall above the 90th percentile value. Of the remaining 12 year period, year 2002, 2008, 2009, 2001, 2011, 2005, 2014, 2007, 2015, 2012, 2004 and 2000 (in order of preference) provide the closest representation of long-term conditions expected in the region.

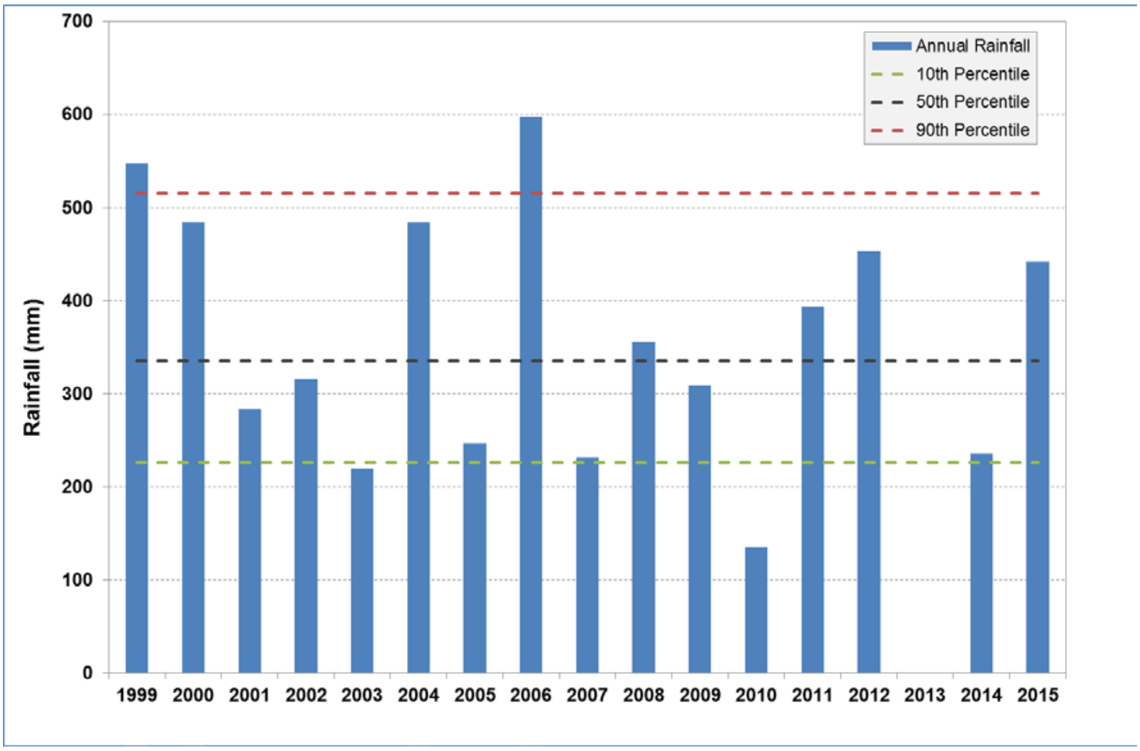

Figure 8-5: Annual rainfall data for Paraburdoo Airport (1999-2015) (BoM, 2016)

A2.1.1 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 Paraburdoo Airport 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. If values fall within the vertical lines (at 5% Confidence Interval, two tailed), then accept the null hypothesis (Figure 8-6). It is noted that only scalars were assessed (i.e. temperature, relative humidity and wind speed).

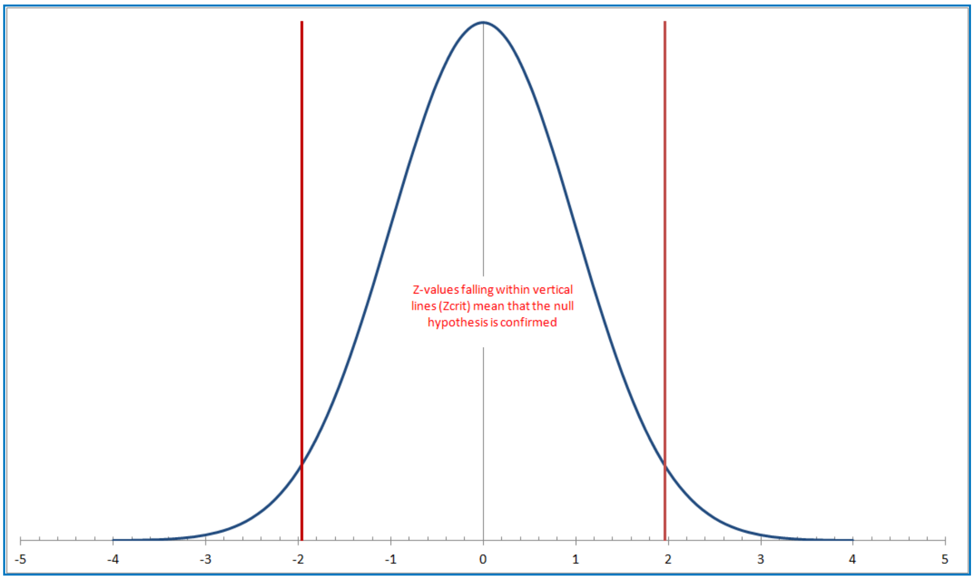

Figure 8-6: *Null Hypothesis for Mann-Whitney U test*

A2.2.1 Wind Speed

Mann-Whitney U test results for wind speed indicate that 2011 is the most representative of the 10-year mean conditions followed by 2010, 2013, 2012, 2007, 2015 and 2008 in order of preference (Figure 8-7). From 2009 to 2015, 2011 is the most suitable followed by 2010, 2013, 2012 and 2015 in the order of preference.

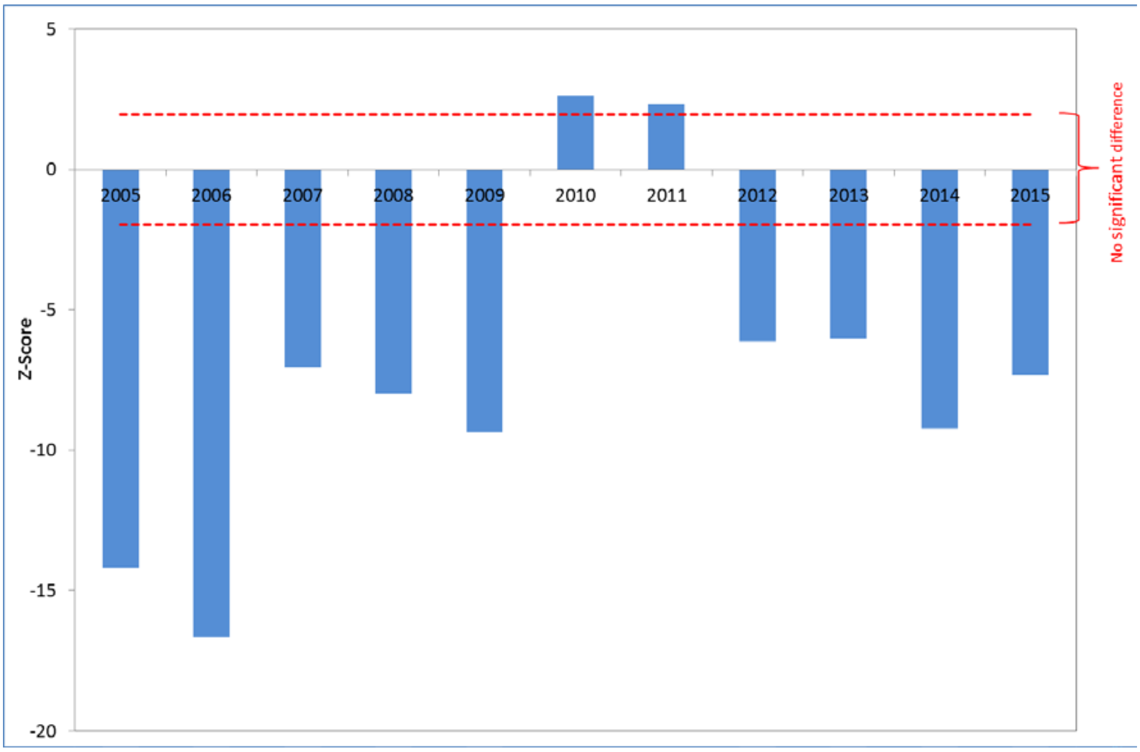

Figure 8-7: *Mann-Whitney U test result for wind speed*

A2.3.1 Temperature

Mann-Whitney U test results for temperature indicate that years 2015, 2013 and 2007 are the most representative followed by 2009, 2005, 2008, 2014 and 2011 in order of preference (Figure 8-8). For meteorological data from 2009 to 2015, 2015 is the most suitable followed by 2013, 2009, 2014 and 2011 in order of preference.

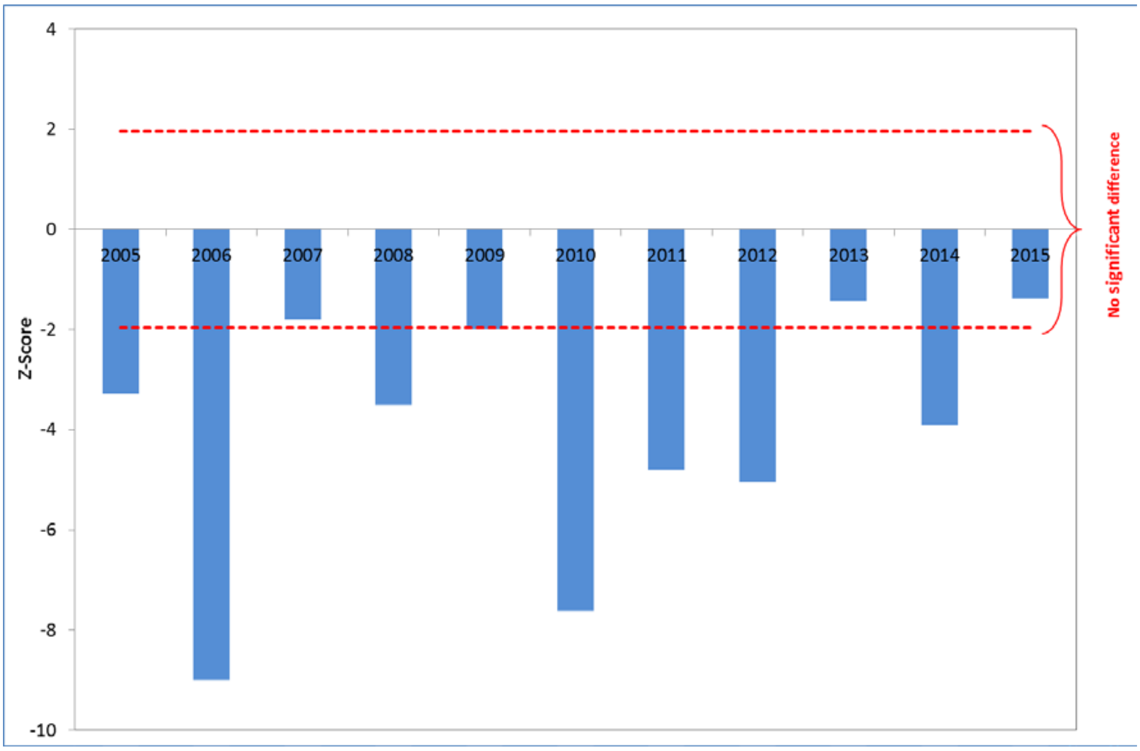

Figure 8-8: *Mann-Whitney U test result for temperature*

A3.1 Selection of Representative Year

The analysis of meteorological parameters indicated that a number of years were suitably representative of the long term average conditions:

- Rainfall – 2009, 2011, 2014, 2015 and 2012 (in order of preference)
- Wind - 2011, 2010, 2013, 2012 and 2015 (in the order of preference)
- Temperature - 2015, 2013, 2009, 2014 and 2011 (in the order of preference)

The meteorological conditions highlight that the most representative year in terms of rainfall, wind speed and temperature was considered to be 2011 followed by 2015. Further analysis was conducted based on 1-hour wind speed and wind direction to confirm 2011 is the most representative year for modelling (Figure 8-9 to Figure 8-11).

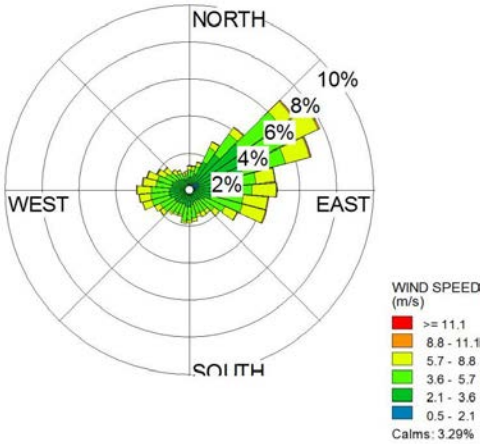

Figure 8-9: *Annual wind rose recorded at Paraburdoo Airport (2005-2015)*

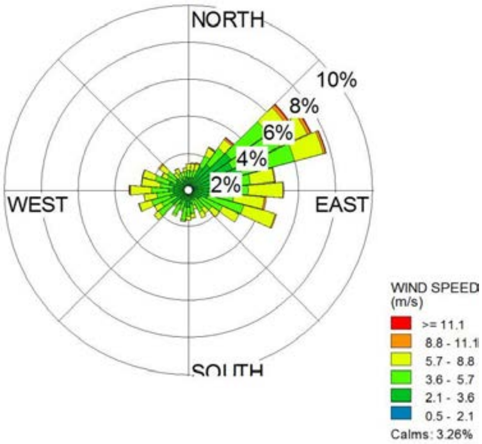

Figure 8-10: *Annual wind rose recorded at Paraburdoo Airport (2011)*

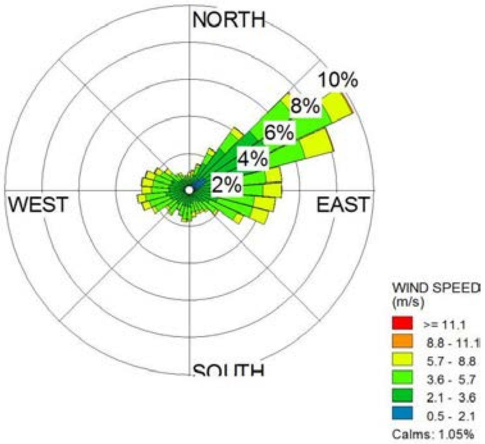

Figure 8-11: *Annual wind rose recorded at Paraburdoo Airport (2015)*

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 500 m occurs at night with average maximum mixing heights of 2800 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.

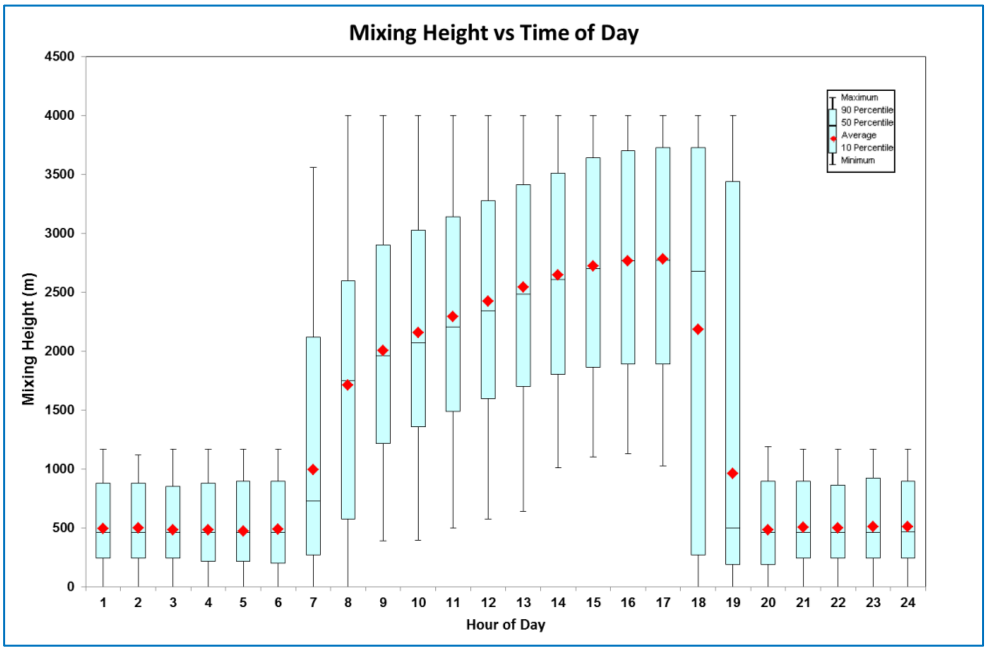

Figure 8-12: *Mixing height – generated by AERMET*.

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 10 % of the time in a year.

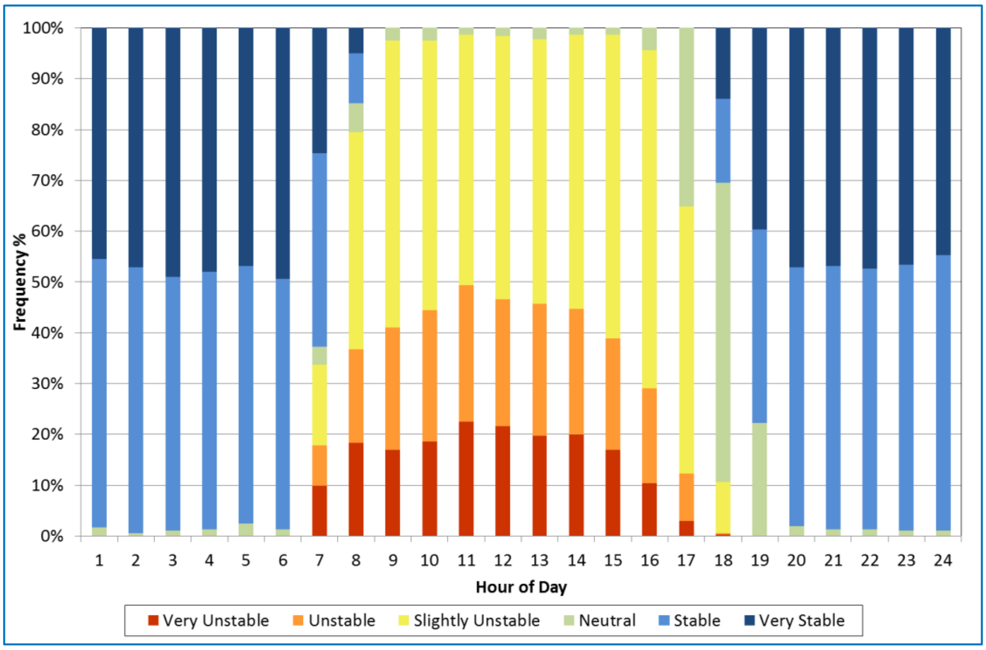

Figure 8-13: *Stability – by time of day (Golder plot)*.

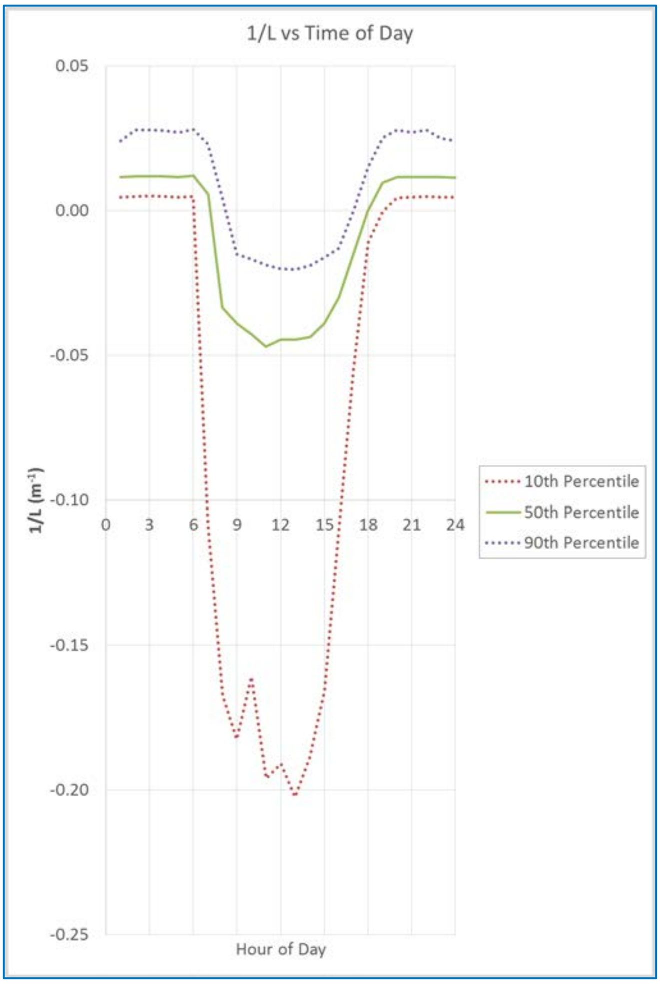

Figure 8-14: *Statistics of 1/L – by time of day*

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	930	m^2
Blast hole depth (ore and waste)	30	m
Average volume displaced per blast	27,900	m^3/blast
No. of holes per blast	1,000	holes
No. of blast per year	105	holes
No. of blast per year -YN	79	holes
No. of blast per year - BH	6	holes
No. of blast per year - FR	1	holes
No of holes drilled (Total)	105,000	holes
No of holes drilled - YN	79,466	holes
No of holes drilled - BH	5,901	holes
No of holes drilled - FR	997	holes
Tonnage of Ore - YN	526,000	t/yr
Tonnage of Ore -BH	291,000	t/yr
Tonnage of Ore -FR	182,000	t/yr
Tonnage of Waste - YN	10,827,000	t/yr
Tonnage of Waste -BH	823,000	t/yr
Tonnage of Waste -FR	2,352,000	t/yr
Total Tonnage of ore	999,000	t/yr
Total Tonnage of waste	14,002,000	t/yr
Total Tonnage of material moved	15,001,000	t/yr
Moisture content of ore/waste	2	t/yr
Silt content of haul road	10	%
Density of ore	5150	kg/m^3
Haul truck empty weight	64.7	tonnes
Haul truck Payload	90	tonnes
Haul truck loaded weight	163.36	tonnes
Haul truck average weight (loaded+unloaded)	114.0	tonnes
Water carts average weight	102.74	tonnes
No of haul truck trips per year - waste (total)	311,156	Trips/yr
No of haul truck trips per year - ore (total)	22,200	Trips/yr
No of haul truck trips per year - waste (YN)	240,600	Trips/yr
No of haul truck trips per year - ore (YN)	11,689	Trips/yr
No of haul truck trips per year - waste (BH)	18,289	Trips/yr
No of haul truck trips per year - ore (BH)	6,467	Trips/yr
No of haul truck trips per year - waste (FR)	52,267	

Item	Value	Unit
No of haul truck trips per year - ore (FR)	4,044	
No of water cart trips per year	730	Trips/yr
No. of haul truck trips per year	22,200	Trips/yr
Hourly rate of primary crusher	400	tph
Hourly rate of grinder	400	tph

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
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

Eq.No	Emission Source	Equations	Reference
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	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

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

Equation 1

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

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

Where:

EF_{PM10}	=	Emission factor for PM_{10}	(g/m²/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}	(%)

The following tables detail the emission rates and parameters used for modelling PM_{10} and NO_x from power plant and carbon regeneration kilns.

Table 8.3: *Emission – Diesel Power generation*

Item	NO_x	PM_{10}	Unit
Emission Rate for 2MW plant[a]	9.2	0.54	g/KW-hr
Normal Operating Load	2072		KW

a) Reference temperature of 25ºC, 100kPa, 10.7g/kg of dry air

Table 8.4: *Emissions – Carbon Regeneration Kiln*

Item	Value	Unit
Natural Gas Fuel Consumption per burner	84	kg/hr
No of burners	2	
Operating hours	8073	Hours/ year

Table 8.5: *Power Generation – Stack Parameters*

Parameters	Value	Unit
No. of units	5	
Exhaust Temperature	350	degree
Stack diameter	0.301	m
Velocity	22.8	m/s
Release height	16.5	m

Appendix D

AERMOD – Sample File

D1 AERMOD Sample Input File

```
**
*****************************************
**
** AERMOD Input Produced by:
** AERMOD View Ver. 9.1.0
** Lakes Environmental Software Inc.
** Date: 7/11/2016
** File: C:\Jobs\21519\Mine\PM10\PM10.ADI
**
*****************************************
**
**
*****************************************
** AERMOD Control Pathway
*****************************************
**
**
CO STARTING
   TITLEONE C:\Jobs\21519\Mine\PM10\PM10.isc
   TITLETWO Haul Road
   MODELOPT CONC DDEP DRYDPLT BETA LOWWIND2
   AVERTIME 1 24 PERIOD
   POLLUTID TSP
   RUNORNOT RUN
   ERRORFIL PM10.err
CO FINISHED
**
*****************************************
** AERMOD Source Pathway
*****************************************
**
**
SO STARTING
** Source Location **
** Source ID - Type - X Coord. - Y Coord. **
   LOCATION DR01A      VOLUME     416318.600  7362907.000      334.510
   LOCATION DR01B      VOLUME     417046.000  7362446.000      338.490
   LOCATION DR01C      VOLUME     417413.700  7362117.000      345.030
   LOCATION DR02       VOLUME     428174.100  7356227.000      351.680
   LOCATION DR03       VOLUME     429805.900  7350909.000      353.010
   LOCATION BLA01      VOLUME     417228.400  7362278.000      342.220
   LOCATION BLA02      VOLUME     428105.700  7356329.000      355.220
   LOCATION BLA03      VOLUME     429879.400  7350964.000      354.590
   LOCATION LO_OR1A    VOLUME     416148.700  7362844.000      338.000
   LOCATION LO_OR1B    VOLUME     416956.600  7362586.000      333.800
   LOCATION LO_OR1C    VOLUME     417507.500  7362036.000      343.410
   LOCATION LO_OR2     VOLUME     428057.900  7356417.000      357.410
   LOCATION LO_OR3     VOLUME     429747.200  7350863.000      351.270
   LOCATION LO_WA1A    VOLUME     416508.600  7362755.000      334.380
   LOCATION LO_WA1B    VOLUME     417140.200  7362381.000      340.730
   LOCATION LO_WA1C    VOLUME     417595.600  7362080.000      343.960
   LOCATION LO_WA2     VOLUME     428285.600  7356098.000      348.870
   LOCATION LO_WA3     VOLUME     429945.500  7351030.000      351.980
   LOCATION UN_OR1     VOLUME     427944.100  7354045.000      342.370
   LOCATION UN_OR2     VOLUME     427979.000  7353992.000      342.350
   LOCATION UN_OR3     VOLUME     428023.000  7353938.000      340.170
   LOCATION UN_WA1A    VOLUME     417485.400  7363475.000      339.720
   LOCATION UN_WA1B    VOLUME     417742.500  7362638.000      341.130
   LOCATION UN_WA1C    VOLUME     418175.800  7362770.000      343.120
   LOCATION UN_WA2     VOLUME     428913.600  7355859.000      352.480
   LOCATION UN_WA3     VOLUME     430261.300  7351052.000      348.920
   LOCATION DOZER1     VOLUME     416053.200  7362968.000      339.800
   LOCATION DOZER2     VOLUME     417316.500  7362183.000      344.560
   LOCATION DOZER3A    VOLUME     428230.500  7356175.000      350.650
```

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   LOCATION DOZER3B      VOLUME     429839.000  7350993.000      352.070
   LOCATION DOZER4       VOLUME     417610.300  7363629.000      341.010
   LOCATION DOZER5       VOLUME     418028.900  7362550.000      344.660
   LOCATION DOZER6A      VOLUME     428840.100  7356050.000      354.870
   LOCATION DOZER6B      VOLUME     430481.600  7351449.000      352.000
   LOCATION LO_OR4       VOLUME     427906.100  7353942.000      341.740
   LOCATION PC           VOLUME     427761.500  7353862.000      335.950
   LOCATION CNV1         VOLUME     427694.600  7353768.000      334.020
   LOCATION UN_OR4       VOLUME     427637.600  7353832.000      333.170
   LOCATION LO_OR5       VOLUME     427670.800  7353895.000      334.310
   LOCATION CNV2         VOLUME     427604.300  7353919.000      333.120
   LOCATION WE_ROM       VOLUME     427984.300  7354011.000      341.840
   LOCATION WE_WASTE_YN1 VOLUME     417416.000  7363432.000      338.900
   LOCATION WE_WASTE_YN2 VOLUME     417942.200  7362669.000      343.040
   LOCATION WE_WASTE_BH  VOLUME     428958.400  7355886.000      352.830
   LOCATION WE_WASTE_FR  VOLUME     430361.600  7351259.000      348.060
** Source Parameters **
   SRCPARAM DR01A             1.0     1.000      0.242     0.465
   SRCPARAM DR01B             1.0     1.000      0.242     0.465
   SRCPARAM DR01C             1.0     1.000      0.242     0.465
   SRCPARAM DR02              1.0     1.000      0.242     0.465
   SRCPARAM DR03              1.0     1.000      0.242     0.465
   SRCPARAM BLA01             1.0    10.000     16.994     4.651
   SRCPARAM BLA02             1.0    10.000     16.994     4.651
   SRCPARAM BLA03             1.0    10.000     16.994     4.651
   SRCPARAM LO_OR1A           1.0     5.000      0.847     2.326
   SRCPARAM LO_OR1B           1.0     5.000      0.847     2.326
   SRCPARAM LO_OR1C           1.0     5.000      0.847     2.326
   SRCPARAM LO_OR2            1.0     5.000      0.847     2.326
   SRCPARAM LO_OR3            1.0     5.000      0.847     2.326
   SRCPARAM LO_WA1A           1.0     5.000      0.847     2.326
   SRCPARAM LO_WA1B           1.0     5.000      0.847     2.326
   SRCPARAM LO_WA1C           1.0     5.000      0.847     2.326
   SRCPARAM LO_WA2            1.0     5.000      0.847     2.326
   SRCPARAM LO_WA3            1.0     5.000      0.847     2.326
   SRCPARAM UN_OR1            1.0     7.000      0.847     2.326
   SRCPARAM UN_OR2            1.0     7.000      0.847     2.326
   SRCPARAM UN_OR3            1.0     7.000      0.847     2.326
   SRCPARAM UN_WA1A           1.0     7.000      0.847     2.326
   SRCPARAM UN_WA1B           1.0     7.000      0.847     2.326
   SRCPARAM UN_WA1C           1.0     7.000      0.847     2.326
   SRCPARAM UN_WA2            1.0     7.000      0.847     2.326
   SRCPARAM UN_WA3            1.0     7.000      0.847     2.326
   SRCPARAM DOZER1            1.0     1.800      0.969     0.837
   SRCPARAM DOZER2            1.0     1.800      0.969     0.837
   SRCPARAM DOZER3A           1.0     1.800      0.969     0.837
   SRCPARAM DOZER3B           1.0     1.800      0.969     0.837
   SRCPARAM DOZER4            1.0     1.800      0.969     0.837
   SRCPARAM DOZER5            1.0     1.800      0.969     0.837
   SRCPARAM DOZER6A           1.0     1.800      0.969     0.837
   SRCPARAM DOZER6B           1.0     1.800      0.969     0.837
   SRCPARAM LO_OR4            1.0     5.000      0.847     2.326
   SRCPARAM PC                1.0    10.000      4.000     4.000
   SRCPARAM CNV1              1.0     1.500      2.790     0.700
   SRCPARAM UN_OR4            1.0     7.000      0.847     3.256
   SRCPARAM LO_OR5            1.0     5.000      0.847     3.256
   SRCPARAM CNV2              1.0     1.500      2.790     0.700
   SRCPARAM WE_ROM            1.0     4.000     14.480     2.000
   SRCPARAM WE_WASTE_YN1      1.0     2.000     61.230     1.000
   SRCPARAM WE_WASTE_YN2      1.0     2.000     64.420     1.000
   SRCPARAM WE_WASTE_BH       1.0     2.000     61.590     1.000
   SRCPARAM WE_WASTE_FR       1.0     2.000     63.460     1.000
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   PARTDIAM WE_WASTE_YN1 1.25 3.75 7.5
   PARTDIAM WE_WASTE_FR 1.25 3.75 7.5
   PARTDIAM WE_WASTE_BH 1.25 3.75 7.5
   PARTDIAM WE_ROM 1.25 3.75 7.5
   PARTDIAM UN_WA3 1.25 3.75 7.5
   PARTDIAM UN_WA2 1.25 3.75 7.5
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PARTDIAM UN_WA1C 1.25 3.75 7.5
PARTDIAM UN_WA1B 1.25 3.75 7.5
PARTDIAM UN_WA1A 1.25 3.75 7.5
PARTDIAM UN_OR4 1.25 3.75 7.5
PARTDIAM UN_OR3 1.25 3.75 7.5
PARTDIAM UN_OR2 1.25 3.75 7.5
PARTDIAM UN_OR1 1.25 3.75 7.5
PARTDIAM PC 1.25 3.75 7.5
PARTDIAM LO_WA3 1.25 3.75 7.5
PARTDIAM LO_WA2 1.25 3.75 7.5
PARTDIAM LO_WA1C 1.25 3.75 7.5
PARTDIAM LO_WA1B 1.25 3.75 7.5
PARTDIAM LO_WA1A 1.25 3.75 7.5
PARTDIAM LO_OR5 1.25 3.75 7.5
PARTDIAM LO_OR4 1.25 3.75 7.5
PARTDIAM LO_OR3 1.25 3.75 7.5
PARTDIAM LO_OR2 1.25 3.75 7.5
PARTDIAM LO_OR1C 1.25 3.75 7.5
PARTDIAM LO_OR1B 1.25 3.75 7.5
PARTDIAM LO_OR1A 1.25 3.75 7.5
PARTDIAM DR03 1.25 3.75 7.5
PARTDIAM DR02 1.25 3.75 7.5
PARTDIAM DR01C 1.25 3.75 7.5
PARTDIAM DR01B 1.25 3.75 7.5
PARTDIAM DR01A 1.25 3.75 7.5
PARTDIAM DOZER6B 1.25 3.75 7.5
PARTDIAM DOZER6A 1.25 3.75 7.5
PARTDIAM DOZER5 1.25 3.75 7.5
PARTDIAM DOZER4 1.25 3.75 7.5
PARTDIAM DOZER3B 1.25 3.75 7.5
PARTDIAM DOZER3A 1.25 3.75 7.5
PARTDIAM DOZER2 1.25 3.75 7.5
PARTDIAM DOZER1 1.25 3.75 7.5
PARTDIAM CNV2 1.25 3.75 7.5
PARTDIAM CNV1 1.25 3.75 7.5
PARTDIAM BLA03 1.25 3.75 7.5
PARTDIAM BLA02 1.25 3.75 7.5
PARTDIAM BLA01 1.25 3.75 7.5
MASSFRAX WE_WASTE_YN2 0.15 0.36 0.48
MASSFRAX WE_WASTE_YN1 0.15 0.36 0.48
MASSFRAX WE_WASTE_FR 0.15 0.36 0.48
MASSFRAX WE_WASTE_BH 0.15 0.36 0.48
MASSFRAX WE_ROM 0.15 0.36 0.48
MASSFRAX UN_WA3 0.15 0.36 0.48
MASSFRAX UN_WA2 0.15 0.36 0.48
MASSFRAX UN_WA1C 0.15 0.36 0.48
MASSFRAX UN_WA1B 0.15 0.36 0.48
MASSFRAX UN_WA1A 0.15 0.36 0.48
MASSFRAX UN_OR4 0.15 0.36 0.48
MASSFRAX UN_OR3 0.15 0.36 0.48
MASSFRAX UN_OR2 0.15 0.36 0.48
MASSFRAX UN_OR1 0.15 0.36 0.48
MASSFRAX PC 0.15 0.36 0.48
MASSFRAX LO_WA3 0.15 0.36 0.48
MASSFRAX LO_WA2 0.15 0.36 0.48
MASSFRAX LO_WA1C 0.15 0.36 0.48
MASSFRAX LO_WA1B 0.15 0.36 0.48
MASSFRAX LO_WA1A 0.15 0.36 0.48
MASSFRAX LO_OR5 0.15 0.36 0.48
MASSFRAX LO_OR4 0.15 0.36 0.48
MASSFRAX LO_OR3 0.15 0.36 0.48
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MASSFRAX LO_OR1C 0.15 0.36 0.48
MASSFRAX LO_OR1B 0.15 0.36 0.48
MASSFRAX LO_OR1A 0.15 0.36 0.48
MASSFRAX DR03 0.15 0.36 0.48
MASSFRAX DR02 0.15 0.36 0.48
MASSFRAX DR01C 0.15 0.36 0.48
MASSFRAX DR01B 0.15 0.36 0.48
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MASSFRAX DOZER6A 0.15 0.36 0.48
MASSFRAX DOZER5 0.15 0.36 0.48
MASSFRAX DOZER4 0.15 0.36 0.48
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MASSFRAX DOZER2 0.15 0.36 0.48
MASSFRAX DOZER1 0.15 0.36 0.48
MASSFRAX CNV2 0.15 0.36 0.48
MASSFRAX CNV1 0.15 0.36 0.48
MASSFRAX BLA03 0.15 0.36 0.48
MASSFRAX BLA02 0.15 0.36 0.48
MASSFRAX BLA01 0.15 0.36 0.48
PARTDENS WE_WASTE_YN2 1 1 1
PARTDENS WE_WASTE_YN1 1 1 1
PARTDENS WE_WASTE_FR 1 1 1
PARTDENS WE_WASTE_BH 1 1 1
PARTDENS WE_ROM 1 1 1
PARTDENS UN_WA3 1 1 1
PARTDENS UN_WA2 1 1 1
PARTDENS UN_WA1C 1 1 1
PARTDENS UN_WA1B 1 1 1
PARTDENS UN_WA1A 1 1 1
PARTDENS UN_OR4 1 1 1
PARTDENS UN_OR3 1 1 1
PARTDENS UN_OR2 1 1 1
PARTDENS UN_OR1 1 1 1
PARTDENS PC 1 1 1
PARTDENS LO_WA3 1 1 1
PARTDENS LO_WA2 1 1 1
PARTDENS LO_WA1C 1 1 1
PARTDENS LO_WA1B 1 1 1
PARTDENS LO_WA1A 1 1 1
PARTDENS LO_OR5 1 1 1
PARTDENS LO_OR4 1 1 1
PARTDENS LO_OR3 1 1 1
PARTDENS LO_OR2 1 1 1
PARTDENS LO_OR1C 1 1 1
PARTDENS LO_OR1B 1 1 1
PARTDENS LO_OR1A 1 1 1
PARTDENS DR03 1 1 1
PARTDENS DR02 1 1 1
PARTDENS DR01C 1 1 1
PARTDENS DR01B 1 1 1
PARTDENS DR01A 1 1 1
PARTDENS DOZER6B 1 1 1
PARTDENS DOZER6A 1 1 1
PARTDENS DOZER5 1 1 1
PARTDENS DOZER4 1 1 1
PARTDENS DOZER3B 1 1 1
PARTDENS DOZER3A 1 1 1
PARTDENS DOZER2 1 1 1
PARTDENS DOZER1 1 1 1
PARTDENS CNV2 1 1 1
PARTDENS CNV1 1 1 1
PARTDENS BLA03 1 1 1
PARTDENS BLA02 1 1 1
PARTDENS BLA01 1 1 1
HOUREMIS MINE_SOURCE_PM10.TXT DR01A DR01B DR01C
HOUREMIS MINE_SOURCE_PM10.TXT DR02 DR03 BLA01
HOUREMIS MINE_SOURCE_PM10.TXT BLA02 BLA03 LO_OR1A
HOUREMIS MINE_SOURCE_PM10.TXT LO_OR1B LO_OR1C LO_OR2
HOUREMIS MINE_SOURCE_PM10.TXT LO_OR3 LO_WA1A LO_WA1B
HOUREMIS MINE_SOURCE_PM10.TXT LO_WA1C LO_WA2 LO_WA3
HOUREMIS MINE_SOURCE_PM10.TXT UN_OR1 UN_OR2 UN_OR3
HOUREMIS MINE_SOURCE_PM10.TXT UN_WA1A UN_WA1B UN_WA1C
HOUREMIS MINE_SOURCE_PM10.TXT UN_WA2 UN_WA3 DOZER1
HOUREMIS MINE_SOURCE_PM10.TXT DOZER2 DOZER3A DOZER3B
```

```
   HOUREMIS MINE_SOURCE_PM10.TXT DOZER4 DOZER5 DOZER6A
   HOUREMIS MINE_SOURCE_PM10.TXT DOZER6B LO_OR4 PC
   HOUREMIS MINE_SOURCE_PM10.TXT CNV1 UN_OR4 LO_OR5
   HOUREMIS MINE_SOURCE_PM10.TXT CNV2 WE_ROM WE_WASTE_YN1
   HOUREMIS MINE_SOURCE_PM10.TXT WE_WASTE_YN2 WE_WASTE_BH WE_WASTE_FR
   SRCGROUP ALL
SO FINISHED
**
****************************************
** AERMOD Receptor Pathway
****************************************
**
**
RE STARTING
   INCLUDED PM10.rou
RE FINISHED
**
****************************************
** AERMOD Meteorology Pathway
****************************************
**
**
ME STARTING
   SURFFILE Hastings_new.SFC
   PROFFILE Hastings.PFL
   SURFDATA 0 2011
   UAIRDATA 54321 2011
   SITEDATA 54321 2011
   PROFBASE 300.0 METERS
ME FINISHED
**
****************************************
** AERMOD Output Pathway
****************************************
**
**
OU STARTING
   RECTABLE ALLAVE 1ST
   RECTABLE 1 1ST
   RECTABLE 24 1ST
   POSTFILE 1 ALL PLOT PM10.AD\01_GALL.POS 31
   POSTFILE 24 ALL PLOT PM10.AD\24_GALL.POS 32
   POSTFILE PERIOD ALL PLOT PM10.AD\PE_GALL.POS 33
** Auto-Generated Plotfiles
   PLOTFILE 1 ALL 1ST PM10.AD\01H1GALL.PLT 34
   PLOTFILE 24 ALL 1ST PM10.AD\24H1GALL.PLT 35
   PLOTFILE PERIOD ALL PM10.AD\PE00GALL.PLT 36
   SUMMFILE PM10.sum
OU FINISHED
**
****************************************
** Project Parameters
****************************************
** PROJCTN  CoordinateSystemUTM
** DESCPTN  UTM: Universal Transverse Mercator
** DATUM    Geocentric Datum of Australia (1994)
** DTMRGN   Australia
** UNITS    m
** ZONE     -50
** ZONEINX  0
**
```

Appendix E

Source Parameters

E1 Source Parameters

The modelled volume source parameters are listed in Table 8.6 and Table 8.7.

Table 8.6: Source characteristics for mining operations

Source ID	Description	Easting (m)	Northing (m)	Sigma Y (m)	Sigma Z (m)	Release Height (m)
DR01A	Drilling at Yangibana North	416319	7362907	0.24	0.47	1.00
DR01B	Drilling at Yangibana North	417046	7362446	0.24	0.47	1.00
DR01C	Drilling at Yangibana North	417414	7362117	0.24	0.47	1.00
DR02	Drilling at Bald Hill	428174	7356227	0.24	0.47	1.00
DR03	Drilling at Frasers	429806	7350909	0.24	0.47	1.00
BLA01	Blasting at Yangibana North	417228	7362278	16.99	4.65	10.00
BLA02	Blasting at Bald Hill	428106	7356329	16.99	4.65	10.00
BLA03	Blasting at Frasers	429879	7350964	16.99	4.65	10.00
LO_Or1A	Loading of ore into trucks at Yangibana North	416149	7362844	0.85	2.33	5.00
LO_Or1B	Loading of ore into trucks at Yangibana North	416957	7362586	0.85	2.33	5.00
LO_Or1C	Loading of ore into trucks at Yangibana North	417507	7362036	0.85	2.33	5.00
LO_Or2	Loading of ore into trucks at Bald Hill	428058	7356417	0.85	2.33	5.00
LO_Or3	Loading of ore into trucks at Frasers	429747	7350863	0.85	2.33	5.00
LO_Wa1A	Loading of waste into trucks at Yangibana North	416509	7362755	0.85	2.33	5.00
LO_Wa1B	Loading of ore into trucks at Yangibana North	417140	7362381	0.85	2.33	5.00
LO_Wa1C	Loading of ore into trucks at Yangibana North	417596	7362080	0.85	2.33	5.00
LO_Wa2	Loading of ore into trucks at Bald Hill	428286	7356098	0.85	2.33	5.00
LO_Wa3	Loading of ore into trucks at Frasers	429945	7351030	0.85	2.33	5.00
Un_Or1	Trucks dumping ore onto RoM	427944	7354045	0.85	2.33	7.00
Un_Or2	Trucks dumping ore onto RoM	427979	7353992	0.85	2.33	7.00

Source ID	Description	Easting (m)	Northing (m)	Sigma Y (m)	Sigma Z (m)	Release Height (m)
Un_Or3	Trucks dumping ore onto RoM	428023	7353938	0.85	2.33	7.00
Un_Wa1A	Trucks dumping waste at Yangibana North	417485	7363475	0.85	2.33	7.00
Un_Wa1B	Trucks dumping waste at Yangibana North	417742	7362638	0.85	2.33	7.00
Un_Wa1C	Trucks dumping waste at Yangibana North	418176	7362770	0.85	2.33	7.00
Un_Wa2	Trucks dumping waste at Bald Hill	428914	7355859	0.85	2.33	7.00
Un_Wa3	Trucks dumping waste at Frasers	430261	7351052	0.85	2.33	7.00
DOZER1	Dozer on ore at Yangibana North	416053	7362968	0.97	0.84	1.80
DOZER2	Dozer on ore at Yangibana North	417316	7362183	0.97	0.84	1.80
DOZER3A	Dozer on ore at Bald Hill	428231	7356175	0.97	0.84	1.80
DOZER3B	Dozer on ore at Frasers	429839	7350993	0.97	0.84	1.80
DOZER4	Dozer on waste at Yangibana North	417610	7363629	0.97	0.84	1.80
DOZER5	Dozer on waste at Yangibana North	418029	7362550	0.97	0.84	1.80
DOZER6A	Dozer on waste at Bald Hill	428840	7356050	0.97	0.84	1.80
DOZER6B	Dozer on waste at Frasers	430482	7351449	0.97	0.84	1.80
LO_Or4	Loading of ore onto trucks near ROM pad	427906	7353942	0.85	2.33	5.00
PC	Primary Crusher	427762	7353862	4.00	4.00	10.00
Cnv1	Conveyor from PC to Stockpile	427695	7353768	2.79	0.70	1.50
Un_Or4	Unloading of ore to Stockpile	427638	7353832	0.85	3.26	7.00
LO_Or5	Loading of ore from Stockpile	427671	7353895	0.85	3.26	5.00
Cnv2	Conveyor from stockpile to wet processing facility	427604	7353919	2.79	0.70	1.50
WE_ROM	Wind erosion from ROM Pad	427984	7354011	14.48	2.00	4.00
WE_Waste_YN1	Yangibana North	417416	7363432	61.23	1.00	2.00
WE_Waste_YN2	Yangibana North	417942	7362669	64.42	1.00	2.00
WE_Waste_BH	Wind erosion from Bald Hill	428958	7355886	61.59	1.00	2.00

Source ID	Description	Easting (m)	Northing (m)	Sigma Y (m)	Sigma Z (m)	Release Height (m)
WE_Waste_FR	Wind erosion from Frasers	430362	7351259	63.46	1.00	2.00

Table 8.7: Source characteristics for Haul Roads

Source ID	Description	Easting (m)	Northing (m)	Sigma Y (m)	Sigma Z (m)	Release Height (m)
V1_1	Yangibana North to processing facility - Ore	418265	7362075	25	0.25	0.5
V1_2		419209	7361712	25	0.25	0.5
V1_3		420000	7361128	25	0.25	0.5
V1_4		420668	7360584	25	0.25	0.5
V1_5		421374	7360317	25	0.25	0.5
V1_6		421984	7360236	25	0.25	0.5
V1_7		422762	7359948	25	0.25	0.5
V1_8		423761	7359642	25	0.25	0.5
V1_9		424754	7359142	25	0.25	0.5
V1_10		425492	7358356	25	0.25	0.5
V1_11		426198	7357632	25	0.25	0.5
V1_12		426931	7356940	25	0.25	0.5
V1_13		427384	7356242	25	0.25	0.5
V1_14		428042	7355712	25	0.25	0.5
V1_15		428480	7355104	25	0.25	0.5
V1_16		427989	7354521	25	0.25	0.5
V2_1	Yangibana North to waste dump	417393	7362768	25	0.25	0.5
V3_1	Bald Hill to processing facility - Ore	428309	7355664	25	0.25	0.5
V3_2		428060	7354851	25	0.25	0.5
V3_3		427680	7354245	25	0.25	0.5
V4_1	Bald Hill to waste dump	428551	7355996	25	0.25	0.5
V5_1	Frasers to processing facility - Ore	428060	7354634	25	0.25	0.5
V5_2		428618	7354264	25	0.25	0.5
V5_3		428902	7353395	25	0.25	0.5
V5_4		429425	7352676	25	0.25	0.5
V5_5		429814	7351896	25	0.25	0.5
V5_6		429990	7351249	25	0.25	0.5
V6_1	Frasers to waste dump	430108	7351304	25	0.25	0.5