Advanced Environmental Dynamics

Specialist Consultants

# RED HILL MINING LEASE PROJECT
# AIR QUALITY ASSESSMENT

## TECHNICAL APPENDICES

**Report # 503001**

Prepared for:

**URS Australia Limited**

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## Abbreviations

| | |
|---|---|
| AED | Advanced Environmental Dynamics Pty Ltd |
| AGD | Australian Geodetic Datum |
| AQCS | Air Quality Control System AQCS |
| AQMP | Air Quality Management Plan |
| AS | Standards Australia |
| bkg | Background |
| BMA | The BHP Billiton Mitsubishi Alliance |
| BoM | Australian Bureau of Meteorology |
| BRM | Broadmeadow Mine |
| c. | Circa, approximately |
| CALMET | California Meteorological Model |
| CALPUFF | California Plume Dispersion Model |
| CRM | Caval Ridge Mine |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DEHP | Department of Environment and Heritage Protection |
| EETM | Emission Estimation Technique Manual |
| EF | Emission Factor |
| EIS | Environmental Impact Statement |
| EPA | Environmental Protection Agency |
| EPP | Environmental Protection Policy |
| EPP(Air) | Environmental Protection (Air) Policy 2008 |
| ESA | European Space Agency |
| FEL | Front End Loader |
| FY | Financial Year |
| GRM | Goonyella Riverside Mine |
| NAAQO | National Ambient Air Quality Objectives |
| NAAQS | National Ambient Air Quality Standards |
| NASA | National Aeronautics and Space Administration |
| NEPC | National Environment Protection Council |

| | |
|---|---|
| NEPM | National Environment Protection Measure |
| NPI | National Pollution Inventory |
| NSW | New South Wales |
| NSW DECCW | New South Wales Department of Environment, Climate Change and Water |
| $PM_{10}$ | Particulate Matter less than 10 micrometres in diameter |
| $PM_{2.5}$ | Particulate Matter less than 2.5 micrometres in diameter |
| QLD | Queensland |
| R | Receptor |
| RHM | Red Hill Mine |
| ROM | Run-of-Mine |
| SRTM | Shuttle Radar Topography Mission |
| TAPM | The Air Pollution Model |
| TEOM | Tapered Element Oscillating Microbalance |
| TPM | Total Particulate Matter |
| TSP | Total Suspended Particulates |
| UTM | Universal Transverse Mercator |
| USEPA | United States Environmental Protection Agency |
| VIC | Victoria |
| WD | Wind Direction |
| WHO | World Health Organisation |
| WS | Wind Speed |
| WSD | Wind Speed Dependent |

# Units

| | |
|---|---|
| #/year | Number(s) per year |
| % | Percentage |
| ºC | Degrees Celsius |
| g/m$^2$/month | Gram per square meter per month |
| g/s | Gram per second |
| hr/ha | Hours per hectare |
| kg | Kilograms |
| kg/ha/yr | Kilograms per hectare per year |
| kg/hr | Kilograms per hour |
| kg/t | Kilogram per tonne |
| kg/vkt | Kilograms per vehicle kilometre travelled |
| kg/year | Kilograms per year |
| km | kilometre |
| km/hr | Kilometres per hour |
| m | Metre |
| m3 | Cubic meters |
| mg/m$^2$/day | Milligrams per square meter per day |
| m/s | Metres per second |
| Mtpa | Million tonnes per annum |
| µg | Micrograms |
| µg/m3 | Micrograms per cubic metre |
| t/y | Tonnes per year |

# Appendix A Introduction

Advanced Environmental Dynamics Pty Ltd (AED) was commissioned by URS Australia Limited (URS) to undertake an air quality assessment of the potential impacts of emission of pollutants associated with BHP Billiton Mitsubishi Alliance's (BMA) Red Hill Mining Lease Project (the Project) on local air quality at receptor locations.

The presentation of the air quality assessment has been separated into two main components: the Red Hill Project Environmental Impact Statement (EIS) Chapter 11: *Air Quality* and this set of technical appendices.

The EIS chapter has been written for a more general audience with a brief summary of the methodology, key inputs and findings presented.

Within these supporting technical appendices are the details of the assessment. These appendices have in general, been designed to be stand-alone with the information provided for the reader interested in the details of (for example) the pollution data analysis, development of the regional meteorological fields, the set-up of the dust dispersion and model results.

## A.1 Project Background

Red Hill Mine (RHM) is a proposed new underground mine to be located adjacent to BMA's Goonyella Riverside and Broadmeadow (GRB) mine complex in the Bowen Basin, Central Queensland (Figure 1).

The Project will increase BMA's local coal production rate by 14 million tonnes per annum (mtpa) to approximately 32.5 mtpa over an estimated life of mine (LOM) of 25 years.

BHP Billiton Mitsubishi Alliance (BMA), through its joint venture manager, BM Alliance Coal Operations Pty Ltd, proposes to convert the existing Red Hill mining lease application (MLA70421) to a mining lease and thus enable the continuation and potential future expansion of existing mining operations associated with the GRB mine complex. Specifically, the mining lease conversion will allow for:

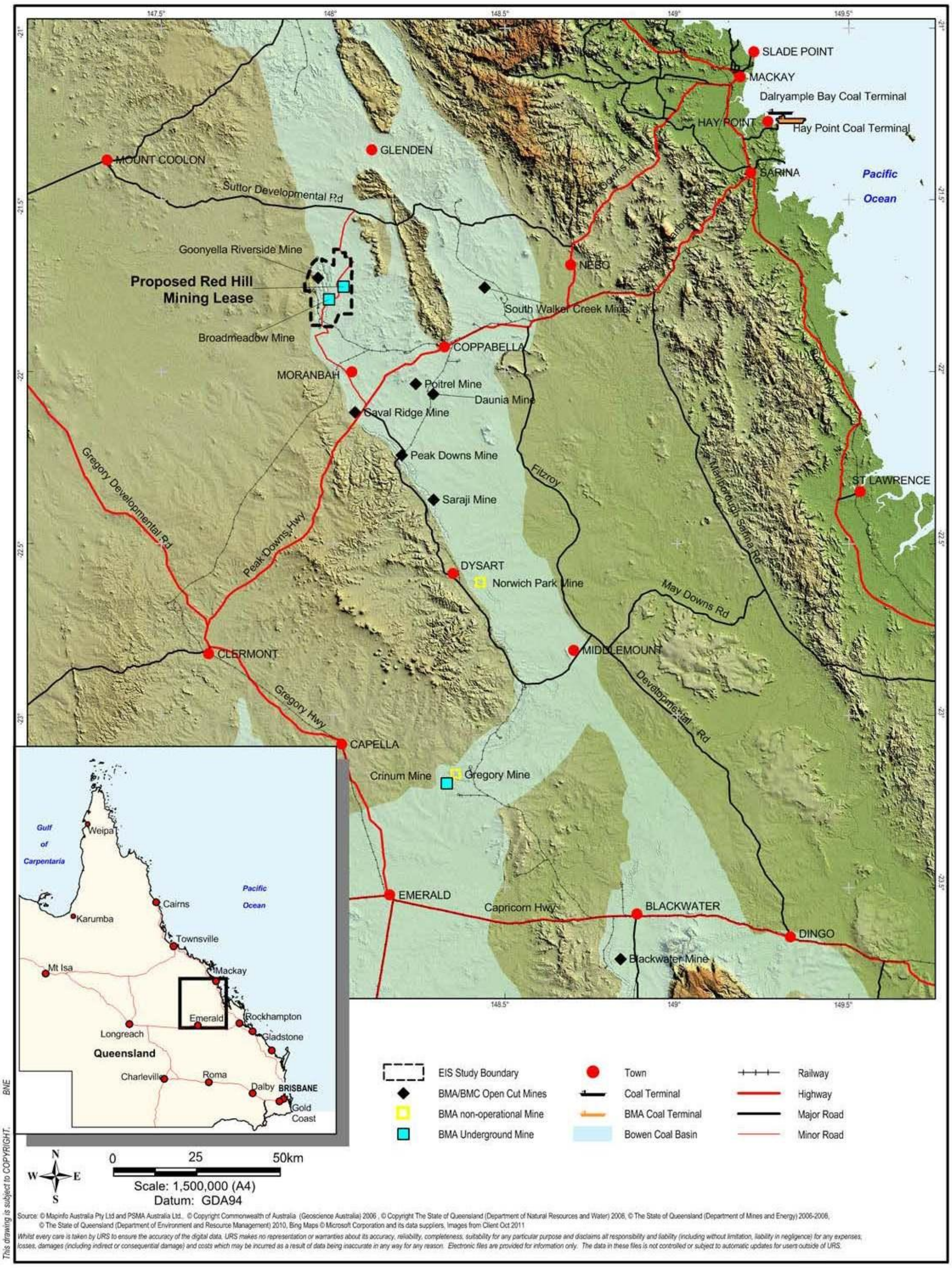
1. An extension of three longwall panels (14, 15 and 16) of the existing Broadmeadow underground mine (BRM).
2. A future incremental expansion option of the existing Goonyella Riverside Mine (GRM).
3. A future Red Hill Mine (RHM) underground expansion option located to the east of the GRB mine complex.

The project includes the following components:

1. The extension of BRM longwall panels 14, 15, and 16 into MLA70421. Key elements include;
   - No new mining infrastructure is proposed other than infrastructure required for drainage of incidental mine gas (IMG) to enable safe and efficient mining.
   - Management of waste and water produced from drainage of IMG will be integrated with the existing BRM waste and water management systems.
   - The mining of the BRM panel extensions is to sustain existing production rates of the BRM mine and will extend the life of mine (LOM) by approximately one year.
   - The existing BRM workforce will complete all work associated with the extensions.
2. The incremental expansion of the Goonyella Riverside Mine including:
   - Underground mining associated with the RHM underground expansion option to target the GMS on ML 1763;
   - A new mine industrial area (MIA);
   - A CHPP adjacent to the Riverside MIA on MLA 1764 and ML 1900 − the Red Hill CHPP will consist of up to three 1,200 tonne per hour (tph) modules;
   - Construction of a drift for mine access;
   - A conveyor system linking RHM to the Red Hill CHPP;
   - Associated coal handling infrastructure and stockpiles;
   - A new conveyor linking product coal stockpiles to a new rail load-out facility located on ML 1900;
   - Means for providing flood protection to the mine access and MIA, potentially requiring a levee along the west bank of the Isaac River.
3. A potential new Red Hill underground mine expansion option to the east of the GRB mine complex, to target the GMS on MLA 70421. Key aspects include:
   - The proposed mine layout consists of a main drive extending approximately west to east with longwall panels ranging to the north and south;
   - A network of bores and associated surface infrastructure over the underground mine footprint for mine gas pre-drainage (IMG) and management of goaf methane drainage to enable the safe extraction of coal;
   - A ventilation system for the underground workings;
   - A bridge across the Isaac River for all-weather access. This will be located above the main headings, and will also provide a crossing point for other mine related infrastructure including water pipelines and power supply;
   - A new accommodation village (Red Hill accommodation village) for the up to 100% remote construction and operational workforces with capacity for up to 3,000 workers;

- Potential production capacity of 14mtpa of high quality hard coking coal over a life of 20 to 25 years.

**Figure 1: Current and Future Mining Operations**



## A.2 Overview of the Assessment Methodology

The air quality assessment for the Project considered the release of dust due to earth moving and mining activities associated with the construction and operation of the GRM incremental expansion and RHM underground expansion option. The BRM panel extensions will not generate any significant dust impacts and is not considered further in this assessment.

In particular, three particle sizes of dust that are of concern for their potential to impact upon human health and amenity were considered namely, total suspended particulates (TSP), particulate matter less than 10 microns in diameter ($PM_{10}$) and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$). Additionally, dust deposition has been estimated in consideration of its potential to impact on environmental amenity.

The existing air quality environment has been described based on estimates of background levels of dust in combination with predicted impacts due to current mining operations at the GRB mine complex.

Meteorology plays an important role in the transport and dispersion of dust away from the Project site and three years of meteorological parameters were developed for use in the dispersion modelling (2007, 2008, 2009).

Dispersion modelling was conducted using the Department of Environment and Heritage Protection (DEHP) approved CALMET/CALPUFF modelling package. A detailed emissions inventory was established using Project information in conjunction with emission factors from both the Australian National Pollutant Inventory (NPI) emission estimation manual for mining and the USEPA AP-42.

Predicted impacts from dust associated with the Project on local air quality that have incorporated BMA's proposed air quality control methods, are presented in this assessment.

Specifically, four scenarios were considered (Table 1):

- **Red Hill Mine Scenario**: Red Hill Mine (RHM) based on a single worst-case dust emissions scenario.
- **Existing Mining Scenario**: Goonyella Riverside Broadmeadow (GRB) mine complex based on current approvals for FY2015, FY2030, FY2040 and FY2050 mining operations. Included in the existing mining scenario is an estimate of naturally occurring dust levels based on continuous monitoring data from BMA's Moranbah Airport monitoring station.
- **Future Mining Scenario**: GRB mine complex, RHM and an estimate of naturally occurring background levels of dust. Results for the four mine configurations for GRB mine complex (i.e. FY2015, FY2030, FY2040, and FY2050) are presented.
- **Cumulative Future Mining Scenario**: GRB mine complex, RHM, and naturally occurring dust levels, have been considered in combination with impacts associated with non-BMA

emission sources: Eaglefield Mine (Peabody Energy), Grosvenor Mine (Anglo Coal), and Moranbah North Mine (Anglo Coal).

**Table 1: Modelled Scenarios**

| Scenario | RHM | GRM | BRM | EFM | Gros & MNM |
|---|---|---|---|---|---|
| Red Hill Mine | √ | x | x | x | x |
| Existing Mining(1) | x | √ | √ | x | x |
| Future Mining(1) | √ | √ | √ | x | x |
| Cumulative Future mining(1) | √ | √ | √ | √ | √ |

Note (1): Consists of 4 scenarios, one each for FY2015, FY2030, FY2040, FY2050.

### A.2.1 Pollutants Considered in the Assessment

Emissions from the Project are generated primarily from activities that move overburden and coal, and to a lesser extent from combustion of diesel fuel in mobile equipment. The emissions and impacts of dust comprising total suspended particulates (TSP), particulate matter with an aerodynamic diameter equal to or less than 10 microns ($PM_{10}$), particulate matter with an aerodynamic diameter equal to or less than 2.5 microns ($PM_{2.5}$), and dust deposition have been assessed in detail.

Air pollutants from diesel combustion may release other air pollutants such as sulphur dioxide, nitrogen dioxide and trace quantities of volatile organic compounds. These substances are not considered to be emitted from Project-related sources in sufficient quantities to affect air quality off-site; therefore impacts from pollutants generated by combustion were not considered in the air quality assessment.

### A.2.2 Air Quality Assessment Components

The air quality assessment consisted of the following key components:

1. **Identification of national and state air quality objectives.** This component of the assessment defines the ambient air quality objectives for dust against which the results of the dispersion modelling at receptor locations will be interpreted. Relevant appendices are summarised in Table 2.
2. **Quantification of background levels of pollutants.** This component of the assessment involved the collection and review of ambient air monitoring data for the purposes of quantifying the current background level of dust. Here background refers to natural background levels i.e. those due to non-anthropogenic dust emission sources. Relevant appendices are summarised in Table 2.
3. **A description of the existing air quality environment.** This component of the assessment provides a description of the existing air quality environment within the local

airshed. The description included a quantification of background creep (i.e. the incremental contribution to the 70th percentile 24-hour concentration of $PM_{10}$ and $PM_{2.5}$) due to operations at the GRB mine complex. Dust dispersion modelling based on three years of regional meteorology was used to predict the temporal and spatial variation in the air quality environment based on four snap-shots of air quality (FY2015, FY2030, F2040 and FY2050) assuming that GRB mine complex operations develop along the lines of their current approval. Relevant appendices are summarised in Table 2.

4. **An estimate of the Project-related impacts on air quality**. This component of the assessment investigated the nature and extent of potential impacts of the emission of dust from Project-related activities on the surrounding environment in isolation from other BMA owned and operated significant dust emission sources. Relevant appendices are summarised in Table 2.

5. **Description of the future air quality environment:** This component of the assessment describes the future air quality environment based on the impacts of the Project in combination with those from the GRB mine complex. Relevant appendices are summarised in Table 2.

6. **Description of the cumulative future air quality environment:** This component of the assessment involved an investigation of cumulative impacts of dust emissions from the Project and other BMA and non-BMA significant sources of dust that operate within the local airshed. Relevant appendices are summarised in Table 2.

**Table 2: Relevant Appendices for each of the Air Quality Assessment Components**

| Appendix | Description | Component | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| Appendix B | Comparison of Ambient Air Quality Goals, Objectives, Standards and Criteria. | √ | | | | | |
| Appendix C | Ambient Air Monitoring Data and Estimate of Background Levels | | √ | | | | |
| Appendix D | Emission Factors and Controls | | | √ | √ | √ | √ |
| Appendix E | Summary of PM10 Emissions Inventories | | | √ | √ | √ | √ |
| Appendix F | Surrounding Land Use and Receptors | | | √ | √ | √ | √ |
| Appendix G | Goonyella Riverside and Broadmeadow Mines Meteorological Monitoring Locations | | | √ | | | |
| Appendix H | Development of Numerically Simulated Meteorological Fields | | | √ | √ | √ | √ |
| Appendix I | Comparison of Observed Site-Specific and Numerically Simulated Wind Fields | | | √ | | | |
| Appendix J | Dispersion Modelling Methodology | | | √ | √ | √ | √ |
| Appendix K | Existing Mining Emission Sources | | | √ | | √ | √ |
| Appendix L | Red Hill Mine Emission Sources | | | | √ | √ | √ |
| Appendix M | Cumulative Future Mining Emission Sources | | | | | | √ |

| Appendix | Description | Component | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| Appendix N | Contour Plots | | | √ | √ | √ | √ |
| Appendix O | Results at Receptor Locations | | | √ | √ | √ | √ |

### A.2.3 Emissions Inventories

Estimates of the quantity of dust that is emitted in association with the Project as well as that associated with the GRB mine complex, Eaglefield Mine, Moranbah North Mine and Grosvenor Mine were based on the following sources of information:

- NPI (2011): *NPI Emission Estimation Technique Manual for Mining,* Version 3, June 2011
- USEPA (1995): *AP-42 - Compilation of Air Pollutant Emission Factors,* Fifth Edition, Volume 1 (Chapter 11) including updates October 1998 and October 2002.
- Peabody (2011): *Eaglefield Expansion Project* EIS Air Quality Appendix
- Anglo Coal ( 2010): *Grosvenor Project EIS* Air Quality Appendix
- Vale Australia (2009): *Ellensfield Coal Mine Project*, EIS Technical Appendix I1: Air Quality.

### A.2.4 Dispersion Modelling

The dispersion modelling was based on the use of the regulatory approved CALMET/CALPUFF modelling system. The CSIRO model TAPM was used to generate upper air and surface files for use as inputs into CALMET.

Three years of three-dimensional hourly meteorological wind fields corresponding to 2007, 2008 and 2009 were produced in order to capture variability in the annual wind fields.

A comparison of CALMET generated wind speed and wind direction data and observed monitoring data at GRM North Meteorological monitor is presented in Appendix I.

### A.2.5 Presentation of Results

The presentation of results focuses on predicted ground-level concentrations for:

- The 15$^{th}$ highest 24-hour average concentration of $PM_{10}$ based on three years of meteorology and is presented as the 5$^{th}$ highest per year.
- The annual average concentration of TSP.
- The maximum 24-hour average concentration of $PM_{2.5}$ based on three years of meteorology. Results for $PM_{2.5}$ were not explicitly modelled but developed from the results for TSP based on the conservative assumption that 10% of TSP is in the form of $PM_{2.5}$. (Note that Table 11.9-2 of the US EPA AP42 Chapter 11 *Western Surface Mining*,

suggests that for a number of activities the ratio of $PM_{2.5}$ to TSP ranges from 1.7% (dragline handling overburden) to 10.5% for dozers operating on overburden.)

- The annual average concentration of $PM_{2.5}$ developed from the results for TSP based on a conservative assumption that 10% of TSP is in the form of $PM_{2.5}$.
- The maximum monthly dust deposition based on 30 day block averages and reported in units of mg/m$^2$/day.

Results are presented both in tabular form and as regional contour plots.

Tabulated results also include the predicted number of exceedences of the relevant EPP(Air) objectives and DEHP criterion for dust deposition.

Estimates of background creep (ie incremental contribution to the 70$^{th}$ percentile concentration) of $PM_{10}$ and $PM_{2.5}$ are presented at receptor locations complementing the contour plots presented in the Red Hill Project EIS Chapter 11: *Air Quality* and highlighting the persistent nature of elevated levels of dust to the west of the GRM mine complex for the Existing and Cumulative Future Mining scenarios.

The contour plots focus on the extent of the area that is proposed to exceed the relevant EPP(Air) objectives with a comparison of the different emissions scenarios.

## A.3 Air Quality Assessment Limitations

This section outlines the limitations associated with the air quality assessment. These include limitations associated with:

- The data sets used as inputs into the assessment such as information provided by the client, third party information and information that is publically available.
- The estimation of emissions associated with the Project as well as those for the GRB mine complex, Eaglefield Mine, Moranbah North Mine and Grosvenor Mine.
- The modelling methodology and the use of numerical tools to simulate physical systems.
- The presentation of results including the use of contour plots.

### A.3.1 Uncertainties Associated with the Information used as Inputs into the Assessment

In addition to the general limitations outlined in Appendix P of this report, uncertainties in the study-specific information include (but may not be limited to) the following:

The accuracy and representativeness of third-party supplied data sets including (but not limited to):

- Land use data from the default TAPM V4.0.5 database which consists of Australian vegetation and soil type data on a longitude/latitude grid at 3-minute grid spacing (approximately 5 km) provided by CSIRO Wildlife and Ecology (Hurley, 2008);
- Terrain data from the default TAPM V4.0.5 database which is derived from Australian terrain height data on a longitude/latitude grid at 9-second grid spacing (approximately 0.3 km) from Geoscience Australia (Hurley, 2008);
- Terrain data for CALMET (Scire, 2000a) from the Shuttle Radar Topography Mission (SRTM) dataset at 3 arc second downloaded from TRC website (SRTM, 2000);
- Land use or land cover data from European Space Agency (ESA, 2010) Globcover land cover map at 300 m resolution; and
- Regulatory supplied meteorological data.

The completeness, accuracy and representativeness of Client-supplied emissions information including (but not limited to):

- Spatial information including 5-yearly pit progression plans and overburden dumping locations;
- Material volumes;
- Material handling methods;
- Engineering controls;
- Pollution and meteorological data from the Moranbah Airport monitoring location.

The completeness, accuracy and representativeness of publically available information including (but not limited to):

- Grosvenor Environmental Impact Statement (Anglo Coal, 2010)
- Moranbah North Mine information contained in the Grosvenor Environmental Impact Statement (Anglo Coal, 2010)
- Eaglefield Expansion Project Environmental Impact Statement (Peabody, 2011)

### A.3.2 Uncertainties Associated with the Emissions Estimation

Uncertainty in the estimated emission factors arise from limitations which include (but may not be limited to):

- The use of default values which are based on a limited number of samples at mines for which representativeness in relation to the Project site is not able to be assessed.

- The use of emission factor formulas which are based on a limited number of samples at mines for which representativeness in relation to the Project site is not able to be assessed.

- The lack of site-specific data for the material properties of percentage silt and moisture content of overburden and haul roads in particular.

### A.3.3 Uncertainties Associated with the Modelling Methodology

With respect to the modelling methodology the following are notes:

- In general, when conducting an air quality assessment a conservative methodology is adopted where inputs are biased towards the higher end of the anticipated range of values. This approach has evolved in part due to the uncertainties associated with the representativeness of the model inputs and in part due to the difficulties in verifying the accuracy of the model output. In general, if the results of the assessment based on a conservative approach do not highlight the potential for significant adverse impacts from a given Project, then the requirement to refine the level of conservatism that has been adopted may not be warranted. However, should potential issues be suggested, a review and refinement of the conservative assumptions that have been incorporated in the assessment should be considered. Following the changes in the EPP(Air) that came into enforcement on 1 January 2009, there has been an increasing pressure on those undertaking air quality assessments to reduce the level of conservatism that is incorporated into the modelling methodology, this must be balanced however by the level of uncertainty and the representativeness of the model inputs on timescales as suggested by the relevant ambient air quality objectives.
- Although very important, model validation and/or calibration is rarely undertaken due to the complexity of the physical system that is being modelled as well as the timeframes and costs associated with the collection of data at a temporal and spatial resolution required to undertake a statistically meaningful study. Thus at best, the model output should be used as a guide to highlight potential air quality issues, provide valuable input into the development of ambient air monitoring programs, and to highlight to the proponent the level of mitigation that may be required in order to protect environmental values.

# Appendix B Comparison of Ambient Air Quality Goals, Objectives, Standards and Criteria.

This appendix defines the relevant ambient air quality objectives that are designed to ensure the protection of national and state recognised environmental values.

## B.1 National Guidelines

National air quality guidelines are specified by the National Environment Protection Council (NEPC). The National Environment Protection Measure (NEPM) (Ambient Air Quality) was released in 1998 (with an amendment in 2003), and sets standards for ambient air quality in Australia.

The NEPM (Ambient Air Quality) specifies national ambient air quality standards and goals for the following common air pollutants: carbon monoxide, nitrogen dioxide, sulphur dioxide, ozone, particulates (as $PM_{10}$ and $PM_{2.5}$), and lead.

Ambient concentrations of $PM_{2.5}$ are addressed only by advisory reporting standards in the NEPM, which are not applied as goals. Potential particulate emissions and impacts are addressed through consideration of the impacts of total suspended particulates and $PM_{10}$.

The NEPM standards are intended to be applied at monitoring locations that represent air quality for a region or sub-region of more than 25,000 people, and are not used as recommendations for locations near industrial facilities (NEPM, Clause 14(1)).

## B.2 Queensland Legislation

In Queensland, air quality is managed under the *Environment Protection Act 1994* (the Act), the *Environmental Protection Regulation 2008* (the Regulation) and the *Environmental Protection (Air) Policy 2008* (EPP (Air)) which came into effect on January 1, 2009.

The Act provides for long-term protection for the environment in Queensland in a manner that is consistent with the principles of ecologically sustainable development. The primary purpose of the EPP(Air) is to achieve the objectives of the Act in relation to Queensland's air environment. This objective is achieved by the EPP (Air) through:

- Identification of environmental values to be enhanced or protected;
- Specification of air quality indicators and goals to protect environmental values; and
- Provision of a framework for making consistent and fair decisions about managing the air environment and involving the community in achieving air quality goals that best protect Queensland's air environment.

The EPP (Air) applies "…to Queensland's air environment" but the air quality objectives specified in the EPP (Air) do not extend to workplaces covered by the Workplace Health and Safety Act (1995) (Section 8 of the EPP (Air)).

The air quality assessment presented in this report addresses off-site ambient air quality impacts only and does not cover workplace health and safety exposure.

Schedule 1 of the EPP (Air) specifies the air quality objectives that are to be (progressively) achieved though no timeframe for achievement of these objectives is specified. The Schedule includes objectives designed to protect the environmental values of:

- Health and well-being;
- Aesthetic environment;
- Health and biodiversity of ecosystems; and
- Agriculture.

DEHP has also adopted a guideline for dust deposition of 120 milligrams per square metre per day ($mg/m^2/day$) to ensure adequate protection from nuisance levels of dust. This level was derived from ambient monitoring of dust conducted in the Hunter Valley, NSW in the 1980's. The former NSW State Pollution Control Commission set the level to avoid a loss of amenity in residential areas, based on the levels of dust fallout that cause complaints (NSW, 2005).

It is noted that the NSW's guideline for dust deposition was based on an annual average of dust deposition reported in $g/m^2/month$. This is in contrast to the application of the dust nuisance guideline adopted by Queensland for which a monthly average is calculated and reported in $mg/m^2/day$.

## B.3 Comparison with Internationally Recognised Ambient Air Quality Criteria

Presented in Table 3 is a summary of regulatory standards, goals and objectives for total suspended particulates (TSP) and particulate matter as $PM_{10}$ and $PM_{2.5}$ from:

- Australia
    - National Environment Protection Measure (NEPM) for ambient air
    - Queensland Environmental Protection (Air) Policy
    - Victorian Environmental Protection Agency

- Canada
  - Province of Ontario
- United States of America
  - National Ambient Air Quality Standards (NAAQS)
  - Texas Commission on Environmental Quality
- World Health Organisation

Information contained in Table 3 highlights the wider range of accepted ambient air criteria for the 24-hour average concentration of $PM_{10}$ (50 µg/m$^3$ compared with 150 µg/m$^3$) than that for $PM_{2.5}$ (25 µg/m$^3$ to 35 µg/m$^3$). With exception of the US EPA NAAQs, all other agencies listed have adopted a criterion for the 24-hour average of $PM_{10}$ of 50 µg/m$^3$.

**Table 3: Comparison of Regulatory Standards, Goals and Objectives (µg/m$^3$)**

| Pollutant | Averaging Period | Environmental Value | Value | Source |
|---|---|---|---|---|
| TSP | 3 minute | amenity | 330 | Vic EPA |
| | annual | health | 90 | Qld EPP(Air) |
| $PM_{10}$ | 1 hour | toxicity | 80 | Vic EPA |
| | 24 hour | health | 150 | US EPA NAAQs |
| | 24 hour | health | 50 | Ontario |
| | 24 hour | health | 50 | Air NEPM |
| | 24 hour | health | 50 | Qld EPP(Air) |
| | 24 hour | health | 50 | WHO |
| | annual | health | 20 | WHO |
| $PM_{2.5}$ | 1 hour | toxicity | 50 | Vic EPA |
| | 24 hour | health | 30 | Ontario |
| | 24 hour | advisory | 25 | Air NEPM |
| | 24 hour | health | 25 | Qld EPP(Air) |
| | 24 hour | health | 35 | US EPA NAAQs |
| | 24 hour | health | 25 | WHO |
| | annual | health | 10 | WHO |
| | annual | health | 15 | US EPA NAAQs |
| | annual | advisory | 8 | Air NEPM |
| | annual | health | 8 | Qld EPP(Air) |

# Appendix C Ambient Air Monitoring Data and Estimate of Background Levels

This appendix presents the results of the data analysis for data collected at BMA's Moranbah airport monitoring location, Moranbah, Central Queensland. Originally sited in an isolated location, more recent land use conflicts has resulted in an increasing contribution to measured levels of dust at this location from localised sources thereby reducing the representativeness of the site's current location as a 'background' monitoring site.

In theory, background levels of pollutants are the concentrations that would occur in the absence of anthropogenic emission sources. In practice, the practicalities and limitations associated with the establishment of an ambient air monitoring stations means that they are rarely sited at locations which are not influenced to some degree by anthropogenic sources.

Additionally, although the Victorian EPA recommend the use of the 70$^{th}$ percentile as an estimate for the background level, in reality the actual background level will be spatially and temporally varying as the emission rate of pollutants from natural sources are often functions of a number of factors including for example, frequency of rain, wind speed, atmospheric stability etc.

For this assessment and with limitations in the data set as noted above, data from the Moranbah Airport monitoring location has been used to estimate background levels. Data for the period January 2011 through January 2013 were analysed to estimate background levels of TSP, particulate matter as $PM_{10}$, and particulate matter as $PM_{2.5}$.

Due to the lack of dust deposition data at this location, a background estimate of dust deposition has been sourced from Caval Ridge Mine Project Environmental Impact Statement (BMA, 2010).

Adopted background levels are summarised in the following table. Details of the data analysis are presented in AED (2013): *Caval Ridge Mine Ambient Air Monitoring Network Baseline Data Summary. Report #101008*. Prepared for BMA and dated 11 March 2013.

**Table 4: Estimate of Background Levels**

| Pollutant | Averaging Period | Project Goal | Estimated Background Level | Source |
|---|---|---|---|---|
| TSP | Annual | 90 µg/m$^3$ | 39.8 µg/m$^3$ | Moranbah Airport |
| $PM_{10}$ | 24 hour$^{(1)}$ | 50 µg/m$^3$ | 29.6 µg/m$^3$ | Moranbah Airport |
| $PM_{2.5}$ | 24 hour$^{(2)}$ | 25 µg/m$^3$ | 7.0 µg/m$^3$ | Moranbah Airport |
| | Annual | 8 µg/m$^3$ | 6.6 µg/m$^3$ | Moranbah Airport |
| Dust deposition | Monthly | 120 mg/m$^2$/day | 50 mg/m$^2$/day | CRM EIS |

Note (1): Based on the 70$^{th}$ percentile 24-hour average concentration.
Note (2): Based on the 70$^{th}$ percentile 24-hour average concentration.

# Appendix D Emission Factors and Controls

Emission factors used to estimate the emission of dust from mining activities were developed from those contained in the National Pollutant Inventory (NPI) Emission Estimation Technique Manual (EETM) for Mining version 3.0, June 2011. The reader is directed to the NPI EETM for Mining (2011) for details.

## D.1 Material Parameters

Presented in Table 5 is a summary of the assumed values for the moisture content, silt content and density of coal, overburden and topsoil as required as input in the development of the emission factors. Note that there was no site-specific data pertaining to the silt and moisture content of overburden at the time of the assessment. Values have been assumed based on information contained in the US EPA AP42. It is acknowledged that the lack of site-specific material parameter information may limit the representativeness of the emission factors developed for this study.

**Table 5: Material Parameters**

| Material | units | Value | Reference |
|---|---|---|---|
| **Moisture Content** | | | |
| Topsoil | % | 3.2 | Assumed based on overburden |
| Overburden | % | 3.2 | Assumed based on US EPA AP42 table 11.9.3 |
| Coal - in situ | % | 3.6 | BMA |
| Coal – ROM (OC) | % | 4 | BMA |
| Coal – ROM (UG) | % | 4 | BMA |
| Coal - Raw | % | 6 | BMA |
| Coal - Product | % | 9 | BMA |
| **Silt Content** | | | |
| Topsoil | % | 6.9 | Assumed based on overburden silt content |
| Overburden | % | 6.9 | Assumed based on US EPA AP42 table 11.9.3 |
| Road | % | 4.3 | Assumed based on US EPA AP42 table 11.9.3 |
| Coal | % | 5 | BMA |
| exposed areas | % | 6.9 | Assumed based on overburden silt content |
| Tailings Dam | % | 60 | URS |
| **Density** | | | |
| Overburden | $g/cm^3$ | 2.2 | BMA |
| Coal | $g/cm^3$ | 1.51 | BMA |

## D.2 Equipment Data

Presented in Table 6 is a summary of the equipment data used to develop the emission factors.

**Table 6: Equipment Data**

| Parameter | units | Value | Reference |
|---|---|---|---|
| **Draglines** | | | |
| Average drop height | m | 15 | Based on information provided by BMA |
| **Graders** | | | |
| Average speed | km/hr | 5 | Based on information provided by BMA |
| **Scrapers** | | | |
| Average speed | km/hr | 20 | Based on information provided by BMA |
| Gross mass (empty) | tonnes | 72 | Based on information provided by BMA |
| Gross mass (full) | tonnes | 115 | Based on information provided by BMA |
| **Water Trucks** | | | |
| Average speed | km/hr | 10 | Assumed |
| Weighted average Mass (empty) | tonnes | 110 | Based on information provided by BMA |
| Weighted average Mass (full) | tonnes | 176 | Based on information provided by BMA |
| **Coal Trucks** | | | |
| Gross mass (empty) | tonnes | 166 | Based on information provided by BMA |
| Gross mass (full) | tonnes | 384 | Based on information provided by BMA |
| **Overburden Trucks** | | | |
| Gross mass (empty) | tonnes | 283 | Based on information provided by BMA |
| Gross mass (full) | tonnes | 610 | Based on information provided by BMA |
| **Rejects Trucks** | | | |
| Gross mass (empty) | tonnes | 132 | Based on information provided by BMA |
| Gross mass (full) | tonnes | 318 | Based on information provided by BMA |

## D.3 Emission Factors

The National Pollutant Inventory (NPI) has a series of Emission Estimation Technique Manuals that are intended to provide data on emissions of air pollutants during typical operations. The NPI Emission Estimation Technique Manual for Mining V3.0 (NPI, 2011) has been used to provide data to estimate the amount of TSP and $PM_{10}$ emitted from the various activities on a mine site, based on the amount of coal and overburden material mined as provided by the Proponent. Emission factors from the NPI EETM for Mining were supplemented with those from the US EPA's AP42 (USEPA, 1995) as required and/or considered appropriate.

### D.3.1 Drilling

The default emission factor for drilling of holes of 0.59 kg/hole (TSP) and 0.31 kg/hole ($PM_{10}$) was used as recommended within table 11.9-4 of the US EPA AP 42 Chapter 11.9 Western *Surface Coal* Mining and Appendix A of the NPI EETM for Mining v 3.0 (July 2011).

### D.3.2 Blasting

The following formula sourced from the NPI EETM V2.3 (2001) has been used to estimate emissions from blasting:

- $EF_{TSP} = 344 \times A^{0.8} \times M^{-1.9} \times D^{-1.8}$ (kg/blast) (A)
- $EF_{PM10} = 0.52 \times 344 \times A^{0.8} \times M^{-1.9} \times D^{-1.8}$ (kg/blast)

where A is the area of the blast, D is the depth of the holes and M is the material moisture content (%).

Note that the area blasted as well as the depth of the holes is dependent on the type of material blasted.

This equation has since been updated as

- $EF_{TSP} = 0.00022 \times A^{1.5}$ (kg/blast) (B)

in latter versions of the NPI EETM for mining, following the findings in the Improvement of NPI fugitive particulate matter emission estimation techniques report by SKM (2005) in which '*it was recommended that Equation 18 (A) be replaced with Equation 19 (B) as it was believed that Equation 18 (A) overestimated the TSP from blasting activities'* (NPI EETM June 2011).

The key disadvantage of (B) is that it no longer differentiates between the nature of the material blasted (in terms of moisture content) nor the manner in which the material will be handled. For example the depth of the holes used in blasting overburden when the handled by dragline is typically deeper than that used when blasting overburden for removal by truck and shovel. Thus equation B predicts the same amount of dust generated per square hectare when blasting either overburden or coal.

Although the approach adopted is potentially conservative, the model results do not highlight dust emissions from blasting as a significant contributor to ground-level impacts at receptor locations during model-predicted adverse meteorological conditions. Thus the conclusions of the assessment are not significantly influenced by the application of the adopted methodology.

### D.3.3 Draglines

The emission factor for dragline activity has been sourced from the US EPA AP 42 Chapter 11.9 *Western Surface Coal* Mining and is given as follows:

- $EF_{TSP} = 0.0046 \times (d^{1.1}) \times (M^{-0.3})$ (kg/bcm)
- $EF_{PM10} = 0.75 \times 0.0029 \times (d^{0.7}) \times (M^{-0.3})$ (kg/bcm)

where d is the dragline drop height (m) and M is the material moisture content (%).

### D.3.4 Excavators/Shovels/Front-End Loaders

For the loading of trucks with overburden the default emission factor for TSP of 0.018 kg/tonne as recommended in table 11.9-4 of the US EPA AP42 has been used. Based on the $PM_{10}$/TSP ratio for dozer activities (Table 11.9-2 *Dozers on overburden*), gives an emission factor for $PM_{10}$ of 0.0135 kg/tonne.

For the loading of coal, the US EPA AP42 and NPI EETM for Mining V3.0 recommended emission factor formulas have been used:

- $EF_{TSP} = 0.58 \times M^{-1.3}$ (kg/tonne)
- $EF_{PM10} = 0.75 \times 0.0596 \times M^{-0.9}$ (kg/tonne)

where M is the material moisture content (%).

### D.3.5 Bulldozers

The TSP and $PM_{10}$ emission factors for dozers on coal were sourced from the US EPA AP42 which is in agreement with that recommended by the NPI EETM for Mining V3.0:

- $EF_{TSP} = 35.6 \times (s^{1.2}) \times (M^{-1.4})$ (kg/hr)
- $EF_{PM10} = 0.75 \times 8.44 \times (s^{1.5}) \times (M^{-1.4})$ (kg/hr)

The TSP and $PM_{10}$ emission factors for dozers on overburden were sourced from the US EPA AP42 which is in agreement with that recommended by the NPI EETM for Mining V3.0:

- $EF_{TSP} = 2.6 \times (s^{1.2}) \times (M^{-1.3})$ (kg/hr)
- $EF_{PM10} = 0.75 \times 0.45 \times (s^{1.5}) \times (M^{-1.4})$ (kg/hr)

where s is the material silt content (%) and M is the material moisture content (%).

### D.3.6 Truck Unloading

The default TSP and $PM_{10}$ emission factor for truck unloading of overburden has been sourced from the NPI EETM for Mining V3.0 (2011)

- $EF_{TSP} = 0.012$ (kg/tonne)
- $EF_{PM10} = 0.0043$ (kg/tonne)

The default TSP and $PM_{10}$ emission factor for truck unloading of coal has been sourced from the NPI EETM for Mining V3.0 (2011)

- $EF_{TSP} = 0.01$ (kg/tonne)
- $EF_{PM10} = 0.0042$ (kg/tonne)

### D.3.7 Wheel Generated Dust

The emission factors for wheel generated dust were taken from the NPI EETM for Mining V3.0 (2011):

- $EF_{TSP} = 1.38 \times (s/12)^{0.9} \times (W/3)^{0.45}$ (kg/vkt)
- $EF_{PM10} = 0.42 \times (s/12)^{0.9} \times (W/3)^{0.45}$ (kg/vkt)

where s is the haul road silt content (%) and W is the vehicle mass (t).

### D.3.8 Graders

The emission factors for grading have been sourced from the US EPA AP42 and the NPI EETM for Mining V3.0 (2011) as:

- $EF_{TSP} = 0.0034 \times S^{2.5}$ (kg/vkt)
- $EF_{TSP} = 0.6 \times 0.0056 \times S^{2.0}$ (kg/vkt)

Where S is the speed of the grader (kph)

### D.3.9 Loading and Unloading Stockpiles

Default emission factors for the loading of coal stockpiles were sourced from the NPI EETM for Mining V3.0 (2011) as:

- $EF_{TSP} = 0.004$ (kg/tonne)
- $EF_{PM10} = 0.0017$ (kg/tonne)

Default emission factors for the unloading of coal stockpiles were sourced from the NPI EETM for Mining V3.0 (2011) as:

- $EF_{TSP} = 0.03$ (kg/tonne)
- $EF_{PM10} = 0.013$ (kg/tonne)

Note that for the unloading of stockpiles by reclaimer the emission factors for miscellaneous transfer points have been used. Also note that reclaiming using dozers has been explicitly accounted for based on dozer hours allocated to CPPs.

### D.3.10 Loading of Trains

Default emission factors for the unloading of trains were sourced from the NPI EETM for Mining V3.0 (2011) as:

- $EF_{TSP} = 0.0004$ (kg/tonne)

- $EF_{PM10}$ = 0.00017 (kg/tonne)

### D.3.11 Miscellaneous Transfer and Conveying Points

Emission factors for miscellaneous transfer points have been sourced from the NPI EETM for Mining V3.0 (2011) as

- $EF_{TSP} = 0.74 \times 0.0016 \times (U/2.2)^{1.3} \times (M/2)^{-1.4}$ (kg/tonne)
- $EF_{PM10} = 0.35 \times 0.0016 \times (U/2.2)^{1.3} \times (M/2)^{-1.4}$ (kg/tonne)

where U is the mean wind speed (m/s) and M is the material moisture content (%).

### D.3.12 Wind Speed Dependent Wind Erosion

Following the recommendations of SKM (2005), for the purposes of estimating wind erosion from stockpiles and exposed areas, the US EPA AP42 formula. In contrast to the default emission factor of 0.4 kg/ha/hr for TSP recommended in the NPI EETM for Mining v 3.0 (2011), Equation 1 has been used in order to account for the climate variations across Australia while it is recognised that there is uncertainty in the representativeness of the equation.

$$E = 1.9\left(\frac{s}{1.5}\right)365\left(\frac{365-p}{235}\right)\left(\frac{f}{15}\right) \quad \text{(Equation 1)}$$

Where: s is the silt content (%), f is the percentage of time that wind speed is greater than 5.4 m/s at the mean height of the stockpile, and p is the number of days when rainfall is greater than 0.25 mm.

Equation 1 is used to provide an estimate for the annual total emissions of dust (TSP) associated with wind erosion. The local meteorological data was then used to distribute the total annual emissions equally to those hours for which the wind speed is greater than a critical wind speed using the methodology outlined in the following sections.

#### *Wind Erosion for Stockpiles*

The annual total emissions of TSP calculated using equation 1 were distributed on an hourly basis in accordance with equation 2 (SKM, 2005)

$$F = ku^3\left(1-\frac{u^2}{u_0^2}\right) \text{ when } u > u_o\text{, otherwise } F = 0 \quad \text{(Equation 2)}$$

Where k is a constant, u is hourly average wind speed at root mean square height of the stockpile (m), $u_0$ is a wind speed threshold velocity.

The critical wind speed $u_0$ is calculated based on a critical wind speed of 5.4 m/s at the root mean square height of the stockpile, corrected to 10 m based on logarithmic wind speed profile as shown in Equation 3.

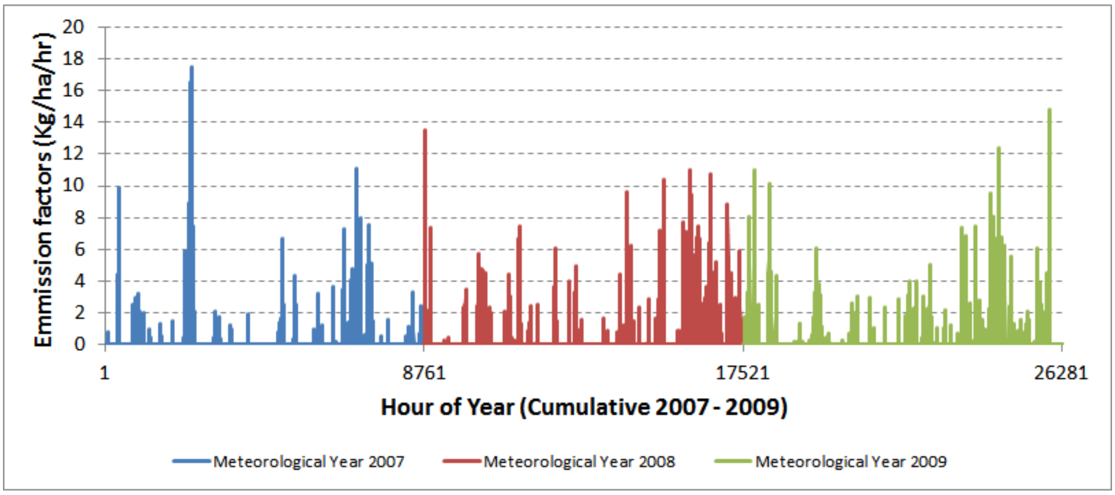
$$u_o = 5.4 ln\left(\frac{10-z_0}{z-z_0}\right) \quad \text{(Equation 3)}$$

Where z is the root mean square height of a stockpile (m), $z_0$ is the surface roughness (0.3 m).

The constant k in Equation 2 is obtained based on the relationship that the cumulative hourly emissions calculated from Equation 2 are equal to the total annual emissions calculated from Equation 1.

Presented in Figure 2 is an example of the wind speed dependent wind erosion emission factors used for a 20 m stockpile for the three year period 2007 through 2009.

**Figure 2: Example – Hourly Wind Speed Dependent Emission Factors for a 20 m Stockpile**




### *Wind Erosion for Exposed Areas*

The methodology for the development of wind speed dependent dust emissions for exposed areas is identical to that for stockpiles with a critical wind speed of 5.4 m/s at 10 m height used in Equation 2.

## D.3.13 Ventilation Outlets

In the absence of site-specific information, emissions from the two Project ventilation outlets were estimated from concentration data provided in the Ellensfield EIS (Vale Australia, 2009) to be 4,520 kg/year/Mtpa of ROM coal for TSP and 2,260 kg/year/Mtpa ROM coal for $PM_{10}$.

## D.4 Activities and Emission Factors

Presented in this section are the emission factors and controls used in the air quality assessment.

### D.4.1 Current Operations

**Table 7: Activity, Uncontrolled Emission Factors and Controls for GRB Mine Complex**

| Activity | Units | TSP | $PM_{10}$ | TSP Control (%) | $PM_{10}$ Control (%) | Nature of Control |
|---|---|---|---|---|---|---|
| **Topsoil** | | | | | | |
| Dozers | kg/hr | 5.82 | 1.21 | 0 | 0 | No control |
| **Drilling and blasting** | | | | | | |
| Holes | kg/hole | 0.59 | 0.31 | 70 | 70 | Water sprays |
| Blasting of OB | kg/blast/(area^0.8) | 0.29 | 0.15 | 0 | 0 | No control |
| Blasting of Coal | kg/blast/(area^0.8) | 0.58 | 0.30 | 0 | 0 | No control |
| **Overburden - T&S** | | | | | | |
| Scrapers | kg/VKT | 8.25 | 2.79 | 0 | 0 | No control |
| Shovel/FEL | kg/t | 0.03 | 0.01 | 0 | 0 | No control |
| WDG Truck: Pit - Dump | kg/VKT | 5.99 | 1.82 | 75 | 75 | Level 2 watering |
| In-Pit Dumping of Overburden | kg/t | 0.01 | 0.00 | 0 | 0 | No controls |
| Out-of-Pit Dumping of Overburden | kg/t | 0.01 | 0.00 | 0 | 0 | No controls |
| WDG Truck: Dump - Pit | kg/VKT | 4.24 | 1.29 | 75 | 75 | Level 2 watering |
| **Overburden - Dragline** | | | | | | |
| Dozers | kg/hr | 5.82 | 1.21 | 50 | 5 | Pit retention |
| Dragline | kg/bcm | 0.06 | 0.01 | 50 | 5 | Pit retention |
| **Coal - in pit activities** | | | | | | |
| Excavator/FEL | kg/t | 0.03 | 0.01 | 50 | 5 | Pit retention |
| Dozers | kg/hr | 35.26 | 10.16 | 50 | 5 | Pit retention |
| **Transport of Coal** | | | | | | |
| WGD Truck: Pit to CPP1 | kg/VKT | 4.86 | 1.48 | 75 | 75 | Level 2 watering |
| Dumping of coal at CPP1 | kg/t | 0.01 | 0.004 | 0 | 0 | No control |
| WGD Truck: CPP1 to Pit | kg/VKT | 3.33 | 1.01 | 75 | 75 | Level 2 watering |
| WGD Truck: Pit to CPP2 | kg/VKT | 4.86 | 1.48 | 75 | 75 | Level 2 watering |
| Dumping of coal at CPP2 | kg/t | 0.01 | 0.004 | 0 | 0 | No control |
| WGD Truck: CPP2 to Pit | kg/VKT | 3.33 | 1.01 | 75 | 75 | Level 2 watering |
| **Road Maintenance** | | | | | | |
| Graders | kg/VKT | 0.19 | 0.09 | 75 | 75 | Level 2 watering |
| Water Trucks | kg/VKT | 3.42 | 1.04 | 75 | 75 | Level 2 watering |

| Activity | Units | TSP | $PM_{10}$ | TSP Control (%) | $PM_{10}$ Control (%) | Nature of Control |
|---|---|---|---|---|---|---|
| **Rehandle** | | | | | | |
| Truck Dumping of Coal | kg/t | 0.01 | 0.004 | 0 | 0 | No controls |
| FEL into Truck | kg/t | 0.11 | 0.13 | 0 | 0 | No controls |
| WGD Truck: Stockpile to CPP | kg/VKT | 4.86 | 1.48 | 75 | 75 | Level 2 watering |
| WGD Truck: CPP to Stockpile | kg/VKT | 3.33 | 1.01 | 75 | 75 | Level 2 watering |
| **Broadmeadow UG Mine** | | | | | | |
| Conveyor - ROM coal from below surface to in-pit conveyor | kg/ha/year | $2.1\times10^{4}$ | $1.0\times10^{4}$ | 50 | 50 | U-shaped conveyor |
| Conveyor - transfer point | kg/t | $6.5\times10^{-4}$ | $3.1\times10^{-4}$ | 75 | 75 | Chute with water sprays |
| Conveyor - ROM coal on in-pit conveyor | kg/ha/year | $2.1\times10^{4}$ | $1.0\times10^{4}$ | 50 | 50 | U-shaped conveyor |
| Conveyor - transfer point | kg/t | $6.5\times10^{-4}$ | $3.1\times10^{-4}$ | 75 | 75 | Chute with water sprays |
| Conveyor - to out-of-pit stockpile | kg/ha/year | $2.1\times10^{4}$ | $1.0\times10^{4}$ | 50 | 50 | U-shaped conveyor |
| Loading of stockpile | kg/t | $4\times10^{-3}$ | $1.7\times10^{-3}$ | 25 | 25 | Variable height stacker |
| FEL loading trucks | kg/t | 0.11 | 0.13 | 0 | 0 | No control |
| WGD: from out-of-pit stockpile to ROMs | kg/VKT | 4.86 | 1.48 | 75 | 75 | Level 2 watering |
| WGD: from ROMs to out-of-pit stockpile | kg/VKT | 3.33 | 1.02 | 75 | 75 | Level 2 watering |
| unloading of ROM coal at CPP1 | kg/t | 0.01 | 0.004 | 0 | 0 | No controls |
| unloading of ROM coal at CPP2 | kg/t | 0.01 | 0.004 | 0 | 0 | No controls |
| **ROM #1 and ROM #2 at CPP #1 (Broadmeadows)** | | | | | | |
| Dozers on ROM coal (Picked up by underground conveyors) | kg/hr | 35.3 | 10.2 | 0 | 0 | No control |
| Conveyor - ROM coal to breaker station | kg/ha/year | $4.2\times10^{3}$ | $2.1\times10^{3}$ | 50 | 50 | U-shaped conveyor |
| Rotary Drum Crushing | kg/tonne | $1.5\times10^{-2}$ | $5.5\times10^{-3}$ | 50 | 50 | Water sprays |
| Conveyor - raw coal from breaker station to raw coal stockpile | kg/ha/year | $4.2\times10^{3}$ | $2.1\times10^{3}$ | 50 | 50 | U-shaped conveyor |
| Loading raw coal stockpiles | kg/t | $4.0\times10^{-3}$ | $1.7\times10^{-3}$ | 25 | 25 | Variable height stacker |
| Dozers on raw coal (picked up by underground conveyors) | kg/hr | 20.0 | 5.8 | 0 | 0 | No control |
| Conveyor - raw coal to CPP #1 | kg/ha/year | $4.2\times10^{3}$ | $2.1\times10^{3}$ | 50 | 50 | U-shaped conveyor |
| Conveyor - product coal from CPP #1 to product stockpile | kg/ha/year | $4.2\times10^{3}$ | $2.1\times10^{3}$ | 100 | 100 | Material sufficiently wet |
| Loading product coal stockpiles - radial stacker | kg/t | $4.0\times10^{-3}$ | $1.7\times10^{-3}$ | 100 | 100 | Material sufficiently wet |
| Dozers on product coal (picked up by underground conveyors) | kg/hr | 11.0 | 3.3 | 100 | 100 | Material sufficiently wet |
| Conveyor - product coal to train load-out hopper | kg/ha/year | $4.2\times10^{3}$ | $2.1\times10^{3}$ | 100 | 100 | Material sufficiently wet |
| Loading of hopper - product coal | kg/t | $2.1\times10^{-4}$ | $9.9\times10^{-5}$ | 100 | 100 | Material sufficiently wet |
| Loading of trains from hopper - product coal | kg/t | $4.0\times10^{-4}$ | $1.7\times10^{-4}$ | 100 | 100 | Material sufficiently wet |

| Activity | Units | TSP | $PM_{10}$ | TSP Control (%) | $PM_{10}$ Control (%) | Nature of Control |
|---|---|---|---|---|---|---|
| **Rejects** | | | | | | |
| Conveyor from CPP #1 to rejects bin | kg/ha/year | $4.2\times10^{3}$ | $2.1\times10^{3}$ | 100 | 100 | Material sufficiently wet |
| Conveyor - transfer point (assumed only 1) | kg/t | $2.1\times10^{-4}$ | $9.9\times10^{-5}$ | 100 | 100 | Material sufficiently wet |
| Dumping of rejects into bin | kg/t | $2.1\times10^{-4}$ | $9.9\times10^{-5}$ | 100 | 100 | Material sufficiently wet |
| Loading of trucks from rejects bin | kg/t | $2.1\times10^{-4}$ | $9.9\times10^{-5}$ | 100 | 100 | Material sufficiently wet |
| WGD: Rejects bin to rejects dump | kg/VKT | 4.5 | 1.4 | 75 | 75 | Level 2 watering |
| Dumping of rejects | kg/t | $1.0\times10^{-2}$ | $4.2\times10^{-3}$ | 100 | 100 | Material sufficiently wet |
| WGD: Rejects dump to rejects bin | kg/VKT | 3.0 | 0.92 | 75 | 75 | Level 2 watering |

## D.4.2 Red Hill Mine

**Table 8: Activity, Uncontrolled Emission Factors and Controls for Red Hill Mine**

| Activity | Units | TSP | $PM_{10}$ | TSP Control (%) | $PM_{10}$ Control (%) | Reason For Control |
|---|---|---|---|---|---|---|
| Primary Breaker Station | kg/tonne | 0.015 | 0.006 | 70 | 70 | Water sprays, partially enclosed |
| Dozers | kg/hour | 35.3 | 10.2 | 0 | 0 | No control |
| Rotary Breaker Station | kg/tonne | 0.015 | 0.006 | 70 | 70 | Water sprays, partially enclosed |
| Surge Bin | kg/tonne | 0.001 | 0.000 | 70 | 70 | Water sprays, partially enclosed |
| Tertiary breaker station | kg/tonne | 0.015 | 0.006 | 70 | 70 | Water sprays, partially enclosed |
| Bin | kg/tonne | 0.001 | 0.000 | 70 | 70 | Water sprays, partially enclosed |
| Transfer points | kg/tonne | 0.001 | 0.000 | 70 | 70 | Water sprays, partially enclosed |
| conveyor | kg/ha/year | $2.1\times10^{4}$ | $1.0\times10^{4}$ | 50 | 50 | Water sprays |
| Stacking | kg/tonne | 0.004 | 0.002 | 50 | 50 | Water sprays |
| Reclaiming | kg/tonne | 0.001 | 0.000 | 50 | 50 | Water sprays |
| WSD Stockpiles | kg/ha/year | 1372.4 | 686.2 | 50 | 50 | Water sprays |
| Ventilation Outlets | kg/year/Mtpa | 4520 | 2260 | 0 | 0 | No control |

### D.4.3 Eaglefield Mine

For the purposes of the cumulative impact assessment dust emission rates were derived from information contained in the Eaglefield EIS (Table 7 of Eaglefield, 2011) which suggested a dust loading of 0.657 kg of TSP per tonne of ROM coal and 0.2409 kg of $PM_{10}$ per tonne of ROM coal.

Presented in Table 9 are the emission rates for dust emission sources for Eaglefiled mine that have been used in this assessment.

**Table 9: Emission Rates for Eaglefield Mine (Source: Table 7, Eaglefield, 2011)**

| Activity | TSP Emission Rate (tonnes/year) | $PM_{10}$ Emission Rate (tonnes/year) |
|---|---|---|
| In pit sources | 6410 | 2354 |
| Out of pit sources | 0 | 0 |
| Above pit sources | 0 | 0 |
| CHPP & Plant | 158 | 54 |
| Conveyor | 2 | 1 |
| Total (tonnes) | 6570 | 2409 |

### D.4.4 Grosvenor and Moranbah North Mines

Emission rates for the dust emission sources associated with Grosvenor Mine (underground mine) and Moranbah North Mine (underground mine) were based on those provided in the Grosvenor EIS Air Quality technical report (Grosvenor, 2011). The dust loading for emissions from both mines was estimated to be 0.0306 kg of TSP per tonne of ROM coal and 0.0153 kg of $PM_{10}$ per tonne of ROM coal.

# Appendix E Summary of $PM_{10}$ Emissions Inventories

## E.1 Current Operations

**Table 10: Emissions Inventory (t/year) for GRB Mine Complex**

| Activity | FY15 | FY30 | FY40 | FY50 | FY15 | FY30 | FY40 | FY50 |
|---|---|---|---|---|---|---|---|---|
| Production - ROM tonnes (Mtpa) | 14.0 | 16.6 | 14.1 | 9.4 | | | | |
| **Pit-Related** | | | | | | | | |
| Topsoil | 3 | 8 | 9 | 2 | 0.0% | 0.1% | 0.1% | 0.0% |
| Drilling & Blasting | 150 | 171 | 155 | 94 | 1.9% | 2.0% | 1.8% | 2.2% |
| Overburden by T&S | 887 | 912 | 911 | 386 | 11.2% | 10.6% | 10.6% | 8.9% |
| Dragline | 548 | 440 | 449 | 426 | 6.9% | 5.1% | 5.2% | 9.9% |
| Dozers on Overburden | 73 | 96 | 93 | 46 | 0.9% | 1.1% | 1.1% | 1.1% |
| Dumping of Overburden | 1,019 | 1,048 | 1,048 | 444 | 12.9% | 12.1% | 12.2% | 10.3% |
| Coaling | 209 | 260 | 238 | 178 | 2.6% | 3.0% | 2.8% | 4.1% |
| | | | | | **36.4%** | **34.0%** | **33.8%** | **36.5%** |
| **Transport of Material** | | | | | | | | |
| Overburden | 2,386 | 2,722 | 2,778 | 1,197 | 30.1% | 31.5% | 32.4% | 27.7% |
| Coal | 389 | 440 | 419 | 287 | 4.9% | 5.1% | 4.9% | 6.6% |
| Rejects | 23 | 95 | 21 | 32 | 0.3% | 1.1% | 0.2% | 0.7% |
| | | | | | **35.3%** | **37.7%** | **37.5%** | **35.1%** |
| **Road Maintenance** | | | | | | | | |
| Road Maintenance | 80 | 136 | 130 | 67 | 1.0% | 1.6% | 1.5% | 1.6% |
| | | | | | **1.0%** | **1.6%** | **1.5%** | **1.6%** |
| **CPP's** | | | | | | | | |
| CPP1 | 167 | 183 | 173 | 143 | 2.1% | 2.1% | 2.0% | 3.3% |
| CPP2 | 267 | 292 | 278 | - | 3.4% | 3.4% | 3.2% | 0.0% |
| | | | | | **5.5%** | **5.5%** | **5.3%** | **3.3%** |
| **Rehandle** | | | | | | | | |
| Rehandle | 36 | 36 | 36 | 13 | 0.5% | 0.4% | 0.4% | 0.3% |
| | | | | | **0.5%** | **0.4%** | **0.4%** | **0.3%** |
| **Underground Mining** | | | | | | | | |
| Broadmeadow | 240 | 122 | - | - | 3.0% | 1.4% | 0.0% | 0.0% |
| | | | | | **3.0%** | **1.4%** | **0.0%** | **0.0%** |
| **Wind Blown Dust** | | | | | | | | |
| Stockpiles | 35 | 38 | 35 | 11 | 0.4% | 0.4% | 0.4% | 0.3% |
| Exposed Areas | 1,138 | 1,355 | 1,536 | 716 | 14.4% | 15.7% | 17.9% | 16.6% |
| Tailings Dams | 278 | 278 | 278 | 278 | 3.5% | 3.2% | 3.2% | 6.4% |
| | | | | | **18.3%** | **19.4%** | **21.5%** | **23.3%** |
| **Total (kg/year)** | **7,929** | **8,631** | **8,586** | **4,321** | **100.0%** | **100.0%** | **100.0%** | **100.0%** |
| **Dust Loading (kg/ROM tonne)** | **0.56** | **0.52** | **0.61** | **0.46** | | | | |

**Figure 3: Breakdown of Emissions Inventory - Current Operations (All of Site)**

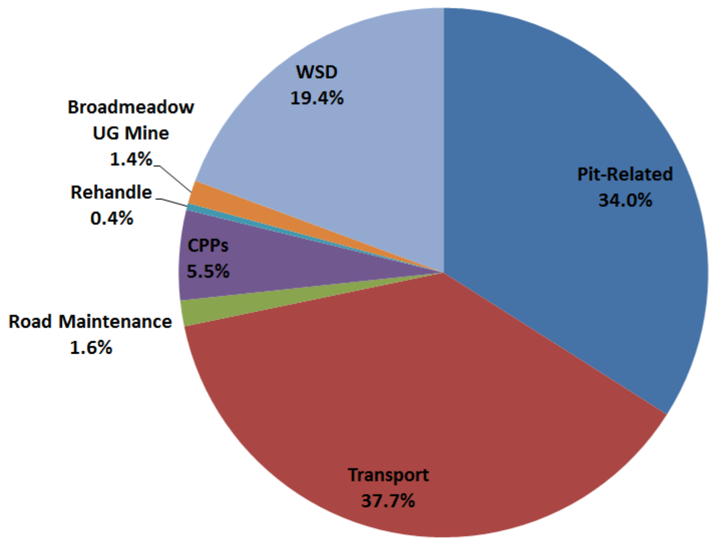
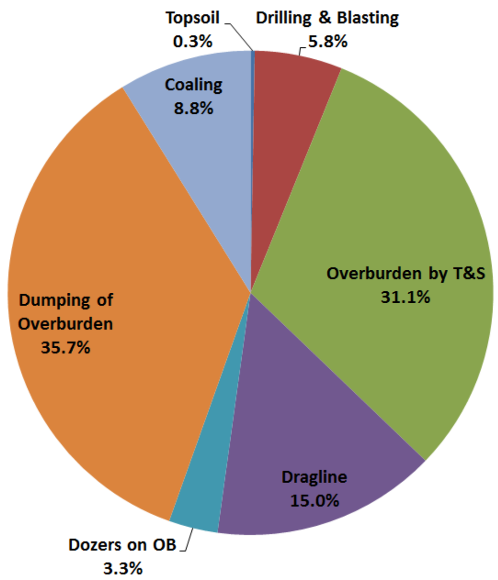
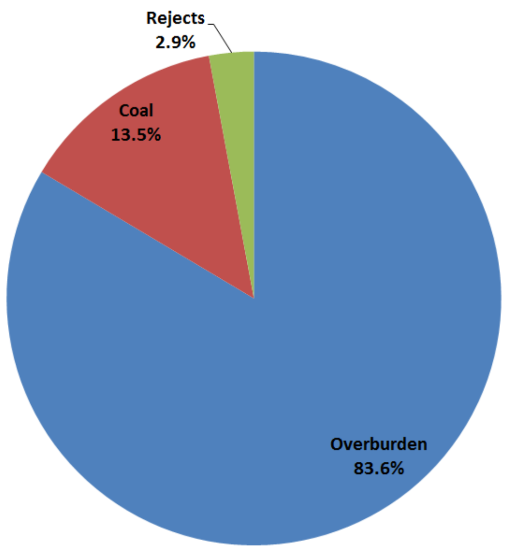



**Figure 4: Breakdown of Emissions Inventory - Pit-Related Activities (left) and Transport of Material (right)**



## E.2 Red Hill Mine

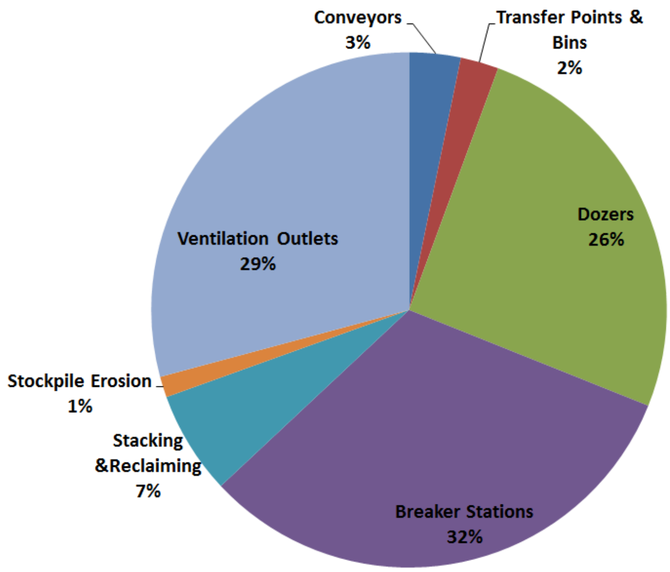
Presented in Table 11 and depicted in Figure 5 is a summary of the $PM_{10}$ emissions inventory for Red Hill Mine based on a worst-case emissions profile corresponding to the maximum production of ROM tonnes of 15.5 Mtpa. As the relative contribution of emissions from Red Hill Mine are small compared with those of the current operations, a worst-case approach to the development of the emissions inventory as opposed to an annual varying emissions profile, was adopted. An annual total of 240 tonnes of $PM_{10}$ corresponds to a dust loading of 0.015 kg of $PM_{10}$ per tonne of ROM coal.

Note that due to the high moisture content of product coal, it has been assumed that the handling of materials post the CPP is not associated with emissions of dust.

**Table 11: Emissions Inventory (kg/year) for Red Hill Mine (Maximum Emissions Scenario)**

| Source | Control | Reason for Control | Emission rate (kg/year) | Percentage of total |
|---|---|---|---|---|
| Conveyors | 50% | Partially enclosed | 7,741 | 3.2% |
| Transfer points & Bins | 70% | Water sprays partially enclosed | 5,744 | 2.4% |
| Dozers | 0% | No control | 60,971 | 25.4% |
| Breaker stations | 70% | Water sprays, partially enclosed | 76,598 | 32.0% |
| Stacking/Reclaiming | 50% | Water Sprays | 15,547 | 6.5% |
| Wind speed erosion | 50% | Water sprays | 3,130 | 1.3% |
| Ventilation Outlets | 0% | No control | 69,947 | 29.2% |
| **Total** | - | - | **239,678** | **100.0%** |

**Figure 5: Breakdown of Emissions Inventory – Red Hill Mine**



# Appendix F Surrounding Land Use and Receptors

## F.1 Surrounding Land Use and Terrain

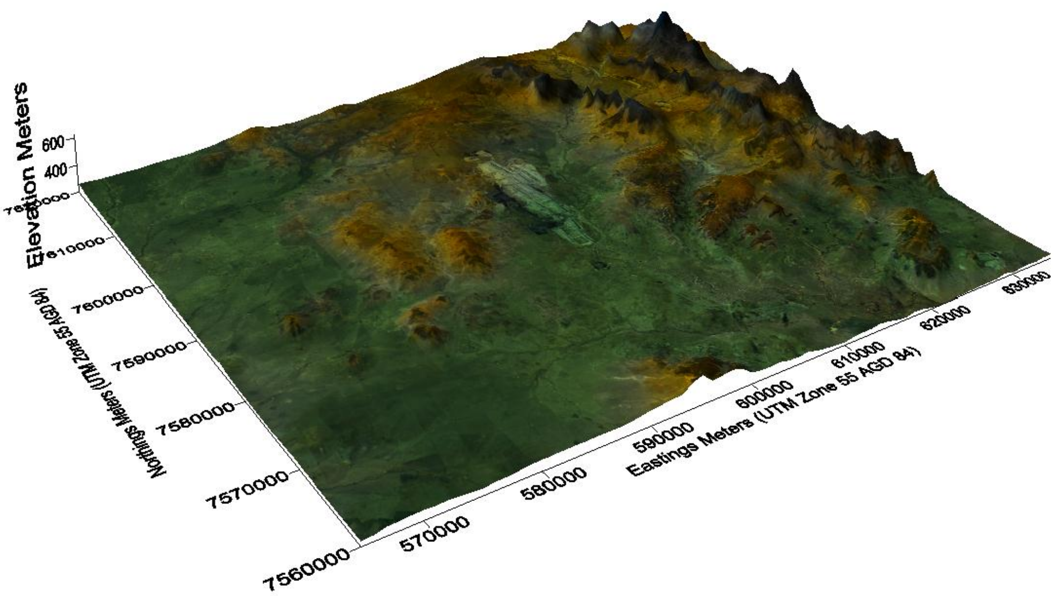
The Project site is located within the northern region of the Bowen basin, approximately 135 kilometres southwest of Mackay. The closet urban centre, Moranbah is approximately 20 kilometres south-southeast of the Project site.

Cattle grazing, agricultural land use, isolated homestead and mining activities constitute the surrounding land use for the Project site.

The region surrounding the Project site has predominantly been a cattle grazing and agricultural area. Coal mining became an important land use in late 1960s and early 1970s with the construction of Goonyella-Riverside and Peak Downs mines. Adjacent to the existing GRM southern boundary is the Moranbah North Mine (underground mine producing hard coking coal). The northern boundary of the GRB mine complex adjoins the North Goonyella Mine and Eaglefield Mine.

Terrain elevation in the vicinity of Project site is shown in Figure 7.

**Figure 6: Terrain Surrounding Project Site**



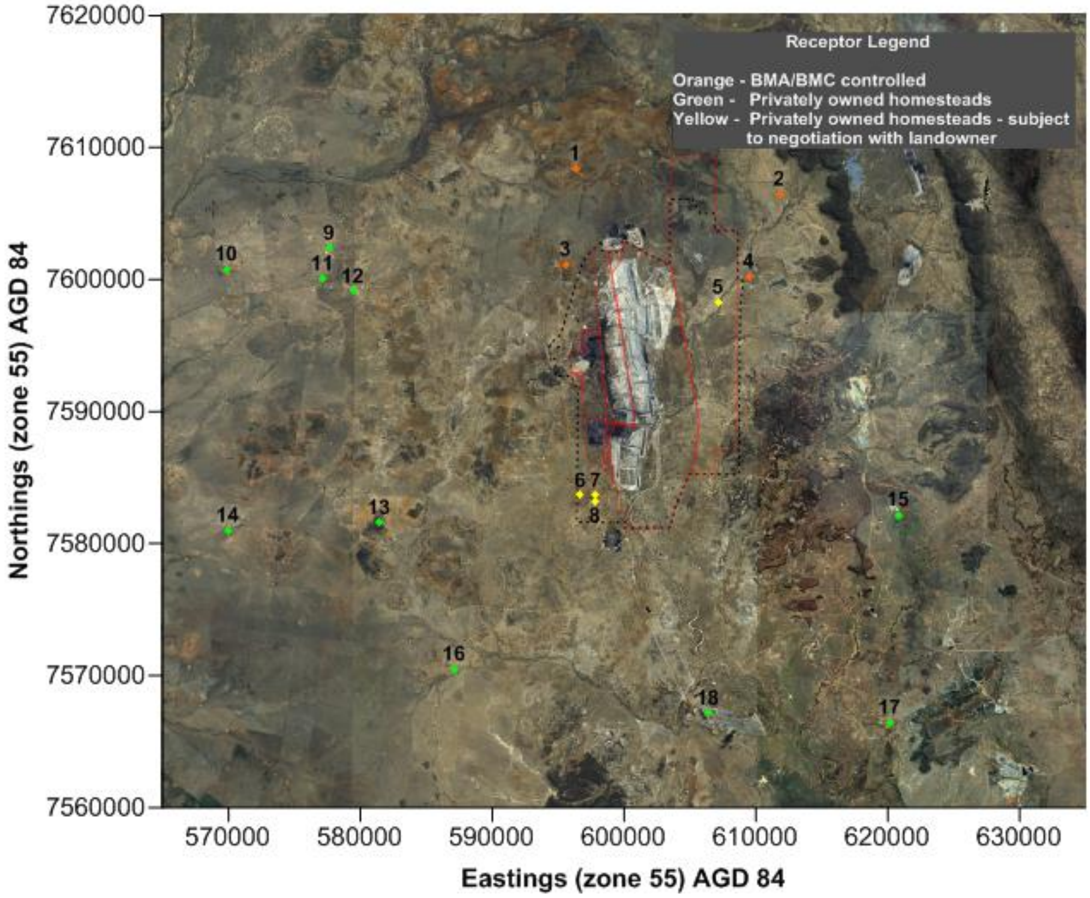
## F.2 Receptors

Sensitive receptors (R) that have been identified in the vicinity (0 km to 10 km) of the Project site include isolated homesteads. The Moranbah Water Treatment Plant (R18) and a few isolated homesteads are located between 10 km and 30 km from the Project boundary. Sensitive receptors are listed in Table 12 and illustrated in Figure 7. The term 'sensitive place' used in the DEHP model conditions do not include places that are within the boundaries of the mining lease, nor places that are owned or leased by the holder of the authority or its related companies . For example, a mining camp operated by the holder of the authority would not be a sensitive place. Note that in accordance with the Department of Environment and Heritage Protection Guideline for Mining *Model Mining Conditions* (130626 EM944 Version 4), BMA's existing accommodation village (Eureka Village) and the proposed Red Hill accommodation village are not considered to be sensitive receptors for the purposes of this air quality assessment.

**Table 12: Receptors**

| Receptor ID | Eastings (AGD 84) | Northings (AGD 84) | Receptor Name |
|---|---|---|---|
| 1 | 596331 | 7608426 | Denham Park |
| 2 | 611792 | 7606475 | Burton Downs |
| 3 | 595590 | 7601155 | Lapunyah |
| 4 | 609497 | 7600256 | Red Hill |
| 5 | 607143 | 7598302 | Riverside Homestead |
| 6 | 596709 | 7583644 | Broadmeadow Cottage 2 |
| 7 | 597877 | 7583646 | Broadmeadow Homestead |
| 8 | 597839 | 7583212 | Broadmeadow Cottage 1 |
| 9 | 577672 | 7602403 | Kimberley |
| 10 | 569879 | 7600794 | Wavering Downs |
| 11 | 577172 | 7600079 | Sondells |
| 12 | 579459 | 7599114 | Nibbereena |
| 13 | 581461 | 7581598 | Pretoria |
| 14 | 569986 | 7580990 | Wyena |
| 15 | 620833 | 7582199 | Broadlea |
| 16 | 587155 | 7570494 | Rugby |
| 17 | 620183 | 7566455 | Watunga |
| 18 | 606409 | 7567155 | Moranbah water treatment plant |

**Figure 7: Receptor Locations**



# Appendix G Goonyella Riverside and Broadmeadow Mines Meteorological Monitoring Locations

AED conducted a site visit on 14 April 2011 to review the existing meteorological stations at the GRB mine complex. The meteorological monitoring network consists of four meteorological stations: Northern Station, Broadmeadow Station, Riverside Station and Southern Station. The location of these four stations is illustrated in Figure 8. Figure 9 through to Figure 12 presents photos of the four stations. Table 13 provides the geographical coordinates and observations recorded for these meteorological stations in terms of siting and location with reference to their surrounding environment.

A comparison of on-site met data with modelled met data including wind rose is provided in Appendix I.

**Table 13: Coordinates and Siting of Site-Specific Meteorological Stations**

| Meteorological Station | Eastings (AGD84) | Northings (AGD84) | Observations during Site Visit | Compliant with AS 2922-1987 for Siting (DEHP, 1997) |
|---|---|---|---|---|
| Northern Weather Station | 600651 | 7601515 | • Height above ground ≅ 3 m<br>• No large obstacles to wind from N, NE,E and SE side, however 30-50 m high stockpiles in NW directions | • Partial |
| Broadmeadow Weather Station | 602764 | 7589718 | • Height above ground ≅ 3 m<br>• Partially surrounded by trees from Southern side, Sparse low height vegetation on all other sides | • No |
| Riverside Weather Station | 597974 | 7593282 | • Height above ground ≅ 2.2 m<br>• Surrounded by high trees (8 m-12 m) from all sides. Separation distance between instrument and trees range from 15 m to 25 m.<br>• Surrounding fencing may shield wind. | • No |
| Southern Weather Station | 599192 | 7585933 | • Height above ground ≅ 3 m<br>• Surrounded by dense high trees from eastern side, low height vegetation on all other sides | • No |

**Figure 8: Location of Site-Specific Meteorological Stations**

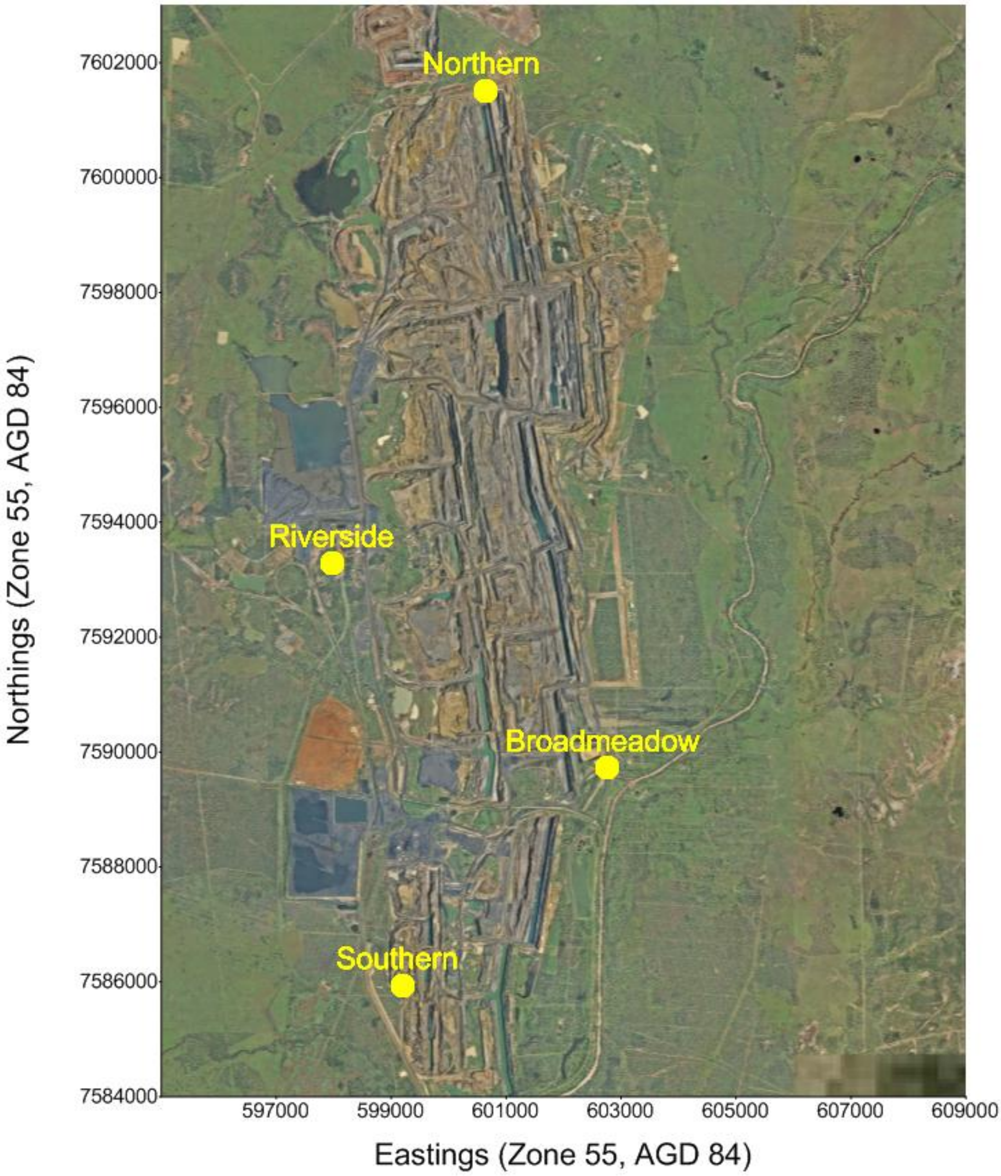


**Figure 9: Broadmeadow Meteorological Station**


**Figure 10: Northern Meteorological Station**

**Figure 11: Riverside Meteorological Station**


**Figure 12: Southern Meteorological Station**

# Appendix H Development of Numerically Simulated Meteorological Fields

Dispersion modelling typically requires a meteorological dataset representative of the local airshed. Parameters required include wind speed, wind direction, temperature, atmospheric stability and mixing height. In general, meteorological observations recorded by weather stations (BoM, DEHP or client operated) include hourly wind speed, wind direction, temperature, rainfall and humidity. However additional parameters like atmospheric stability class and mixing height are difficult to measure and are often generated through the use of meteorological models.

## H.1 TAPM

The meteorological model 'The Air Pollution Model' (TAPM) developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was used to predict initial three-dimensional meteorology for the local airshed. TAPM is a prognostic model used to predict three dimensional meteorological observations, with no local inputs required. The model develops a numerically simulated meteorological dataset consisting of parameters like wind speed, wind direction, temperature, water vapour, cloud, rain, mixing height, atmospheric stability classes etc. that are required for dispersion modelling.

Additionally TAPM includes the option to assimilate local observations (of wind speed and wind direction) in order to nudge the predicted solution towards the observed records. For this assessment, only the upper air data of TAPM is used in CALMET and thus the data assimilation functionality of TAPM was not used.

Technical details of the model equations, parameterisations and numerical methods are described in the technical paper by Hurley (2008).

The details of TAPM configuration are summarised in Table 14.

**Table 14: TAPM Configuration**

| Parameter | Units | Value |
|---|---|---|
| TAPM version | - | v4.0.5 |
| Years modelled | - | 2007, 2008, 2009 |
| Grid centre | Lat.(degrees), Lon. (degrees) | -21.75833, 147.9667 |
| Local centre coordinates | UTM zone 55 S (m) | 599951 , 7593609 |
| Number of nested grids | - | 3 |
| Grid dimensions (nx, ny) | - | 41,41 |
| Number of vertical grid levels (nz) | - | 25 |
| Grid 1 spacing (dx, dy) | km | 30,30 |
| Grid 2 spacing (dx, dy) | km | 10,10 |
| Grid 3 spacing (dx, dy) | km | 3,3 |
| Local hour | - | GMT + 10 |
| Synoptic wind speed maximum | m/s | 30 |
| Local Met Assimilation | - | No |
| Surface vegetation database | - | Default TAPM V4 database at 3-minute grid spacing (Australian vegetation and soil type data provided by CSIRO Wildlife and Ecology. |
| Terrain database | - | Default TAPM V4 database at 9-second grid spacing (Australian terrain height data from Geoscience Australia) |

## H.2 CALMET

CALMET (version 6.326) was used to simulate meteorological conditions for the local airshed. CALMET is a diagnostic three dimensional meteorological pre-processor for the CALPUFF modelling system (developed by Earth Tech, Inc.).

Prognostic output from TAPM was used as an initial guess field for the CALMET model. Using high resolution geophysical datasets CALMET then adjusts the initial guess field for the kinematic effects of terrain, slope flows, blocking effects and 3-dimensional divergence minimisation as well as differential heating and surface roughness associated with different land uses across the modelling domain.

The CALMET model requires three input files along with the control file where the CALMET run parameters are specified and involve:

- Geophysical data
- Upper air meteorological data

- Surface meteorological data

The inputs to these files are discussed in detail in the following.

### H.2.1 Geophysical dataset

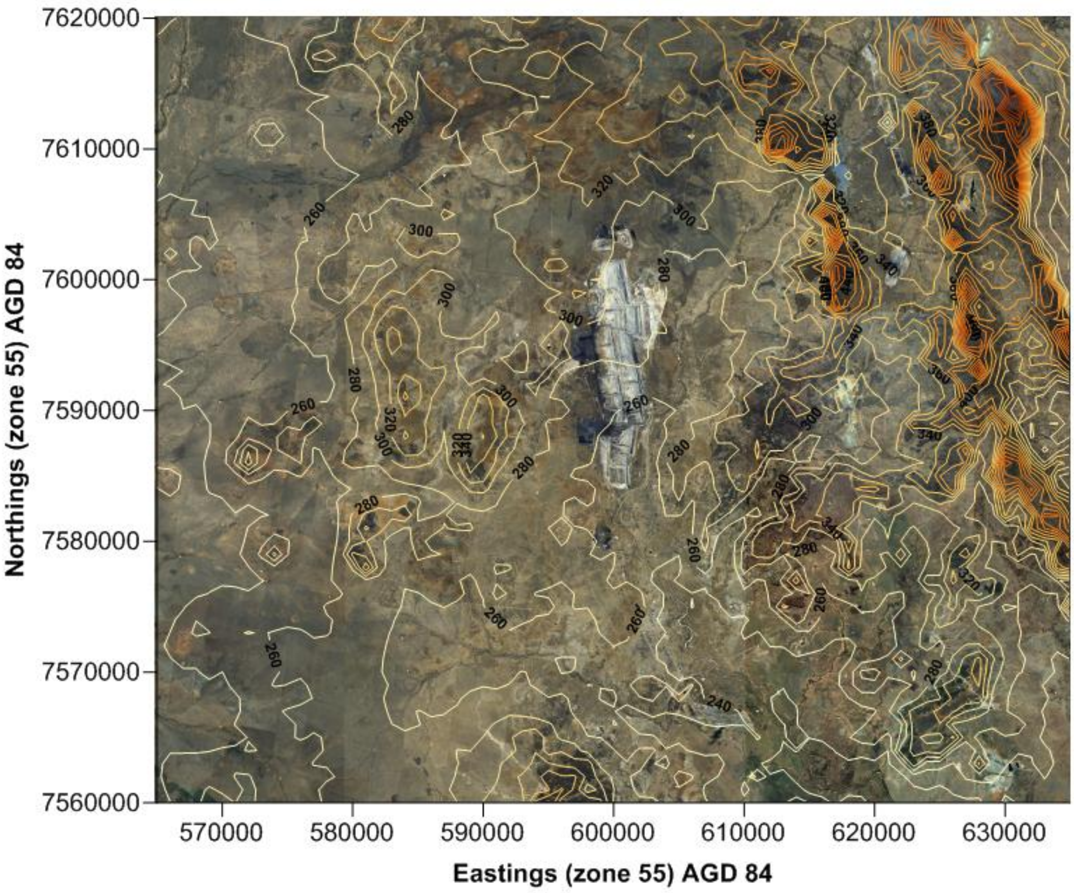
The Geophysical dataset contain terrain and land use information for the modelling domain.

Traditionally, TAPM generated terrain information and land use data are used as an input in CALMET. However TAPM V4 datasets are coarser than other publically available and hence these datasets were replaced by high resolution datasets as input for CALMET.

The terrain information for the Project was extracted from 3-arc second (90m) spaced elevation data obtained via NASA's Shuttle Radar Topography Mission (SRTM) in 2000. (Downloaded from USGS website http://dds.cr.usgs.gov/srtm/version2_1/SRTM3/Australia/)

Final terrain data for Geophysical dataset for CALMET is shown in Figure 13.

**Figure 13: Terrain data for CALMET Geophysical Dataset**



The land use or land cover data for the modelling domain was derived from 300 m resolution Globcover land cover map (© ESA 2010 and UCLouvain, published by European Space science, Dec 2010). Manual edits were performed to take into account the latest mine progressions and urban development within the modelling domain. The ESA classification system was mapped to adopt the user defined CALMET classification system. The Geotechnical parameters for the user defined land use classification were adopted from a combination of closest CALMET and AERMET land use categories.

User defined land use classification and geotechnical parameters used in CALMET are shown in figures below.

**Figure 14: User Defined Land Use Categories for CALMET Modelling domain**

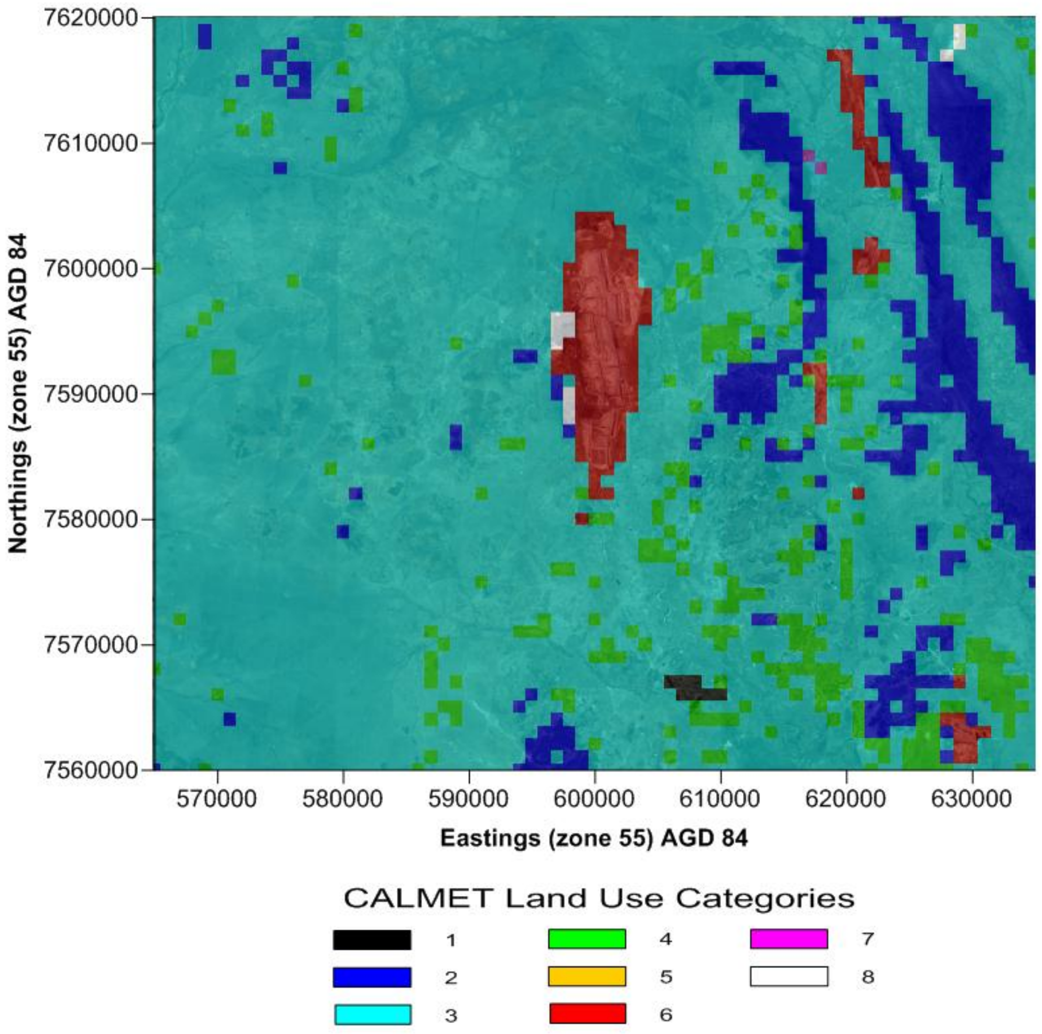


**Figure 15: Geotechnical Parameters for User Defined CALMET Land Use Classification**

| CALMET User defined Category | ESA category | Aermet Category | Surface roughness (a) | Bowen ratio (a) | Albedo (a) | Soil heat flux parameter (b) | Anthropogenic heat flux (b) | Leaf Area Index (b) |
|---|---|---|---|---|---|---|---|---|
| 1 | 17 Artificial surfaces and associated areas (Urban areas >50%) | Low intensity residential | 0.54 | 0.8 | 0.16 | 0.25 (Calmet – Urban) | 0 | 0.2 (Calmet – Urban) |
| 2 | 3 Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)<br>5 Open (15-40%) broadleaved deciduous forest/woodland (>5m) | Mixed Forest | 1.3 | 0.3 | 0.14 | 0.15 (Calmet – Forestland) | 0 | 6 (modified from Calmet – Forestland, 7) |
| 3 | 9 Mosaic forest or shrubland (50-70%) / grassland (20-50%)<br>10 Mosaic grassland (50-70%) / forest or shrubland (20-50%)<br>11 Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m)<br>12 Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)<br>2 Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%) | Shrubland (Non-arid) | 0.3 | 1 | 0.18 | 0.15 (Calmet – Forestland) | 0 | 4.5 (average of modified Calmet forestland (above) and agriland un-irrigated) |
| 4 | 13 Sparse (<15%) vegetation | Grassland / Herbaceous | 0.1 | 0.8 | 0.18 | 0.15 (Calmet – Rangeland) | 0 | 0.5 (Calmet – Rangeland) |
| 5 | 1 Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)<br>0 Rainfed croplands | Small grains | 0.15 | 0.5 | 0.2 | 0.15 ( Calmet – Agri land irrigated) | 0 | 3 ( Calmet – Agri land irrigated) |
| 6 | ------------------------------ | Quarries/strip mine/gravel | 0.3 | 1.5 | 0.2 | 0.15 (Calmet –Barren) | 0 | 0.05 (Calmet –Barren) |
| 7 | Water Bodies | Open water | 0.001 | 0.1 | 0.1 | 1 (Calmet –small water body) | 0 | 0 (Calmet –small water body) |
| 8 | | Bare rock /sand/clay non-arid | 0.05 | 1.5 | 0.2 | 0.15 (Calmet – Barren) | 0.0 | 0.05 (Calmet – Barren) |

(a) EPA ( 2008), *AERSURFACE User's Guide*, developed by the Air Quality Modelling Group, USEPA office of Air Quality Planning and Standards.
(b) CALPUFF version 6, USER guide.

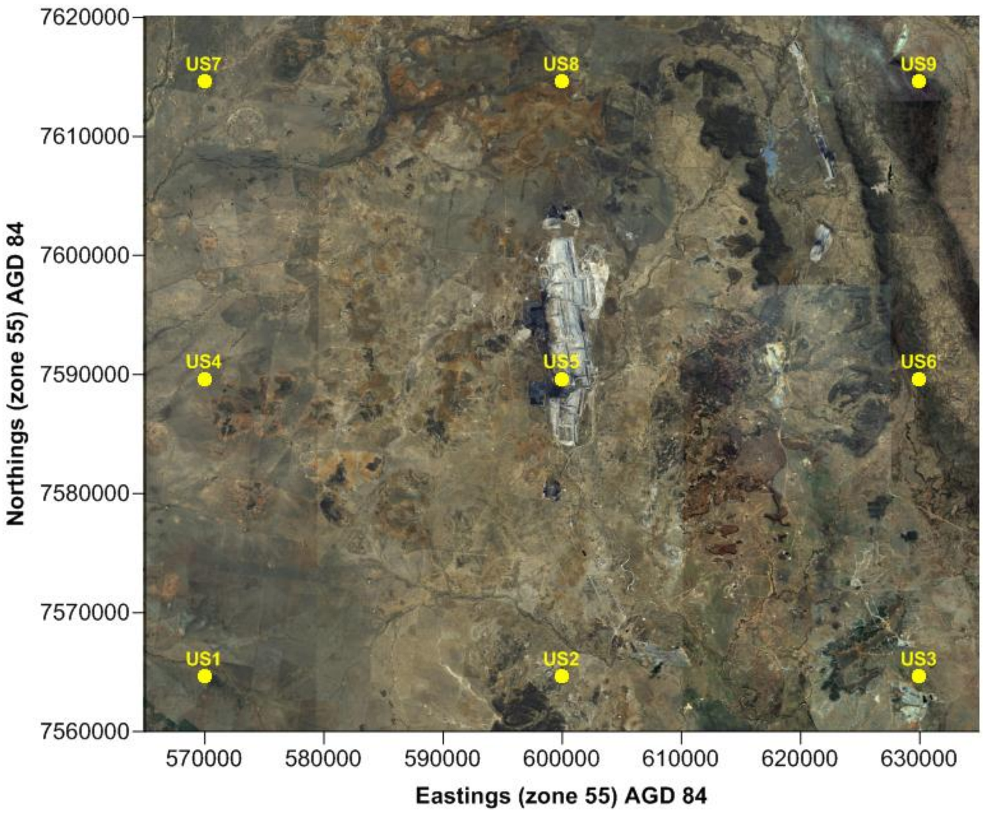
### H.2.2 Upper Air Dataset

Upper air data were extracted from TAPM output for the innermost grid at nine points corresponding to shown in Figure 16. Coordinates of these upper air stations are presented in Table 15.

**Table 15: Coordinates of Upper Air Stations Included in CALMET**

| Station Name | Source | Easting(m) AGD 84 | Northing (m) AGD 84 |
|---|---|---|---|
| US1 | TAPM | 569951 | 7564609 |
| US2 | TAPM | 599951 | 7564609 |
| US3 | TAPM | 629951 | 7564609 |
| US4 | TAPM | 569951 | 7589609 |
| US5 | TAPM | 599951 | 7589609 |
| US6 | TAPM | 629951 | 7589609 |
| US7 | TAPM | 569951 | 7614609 |
| US8 | TAPM | 599951 | 7614609 |
| US9 | TAPM | 629951 | 7614609 |

**Figure 16: Location of Upper Air Stations in Reference to CALMET Modelling Domain**



### H.2.3 Surface Observations Dataset

Surface data were extracted from TAPM output for the innermost grid at thirteen points corresponding to shown in Figure 17. Coordinates of these upper air stations are presented in Table 16.

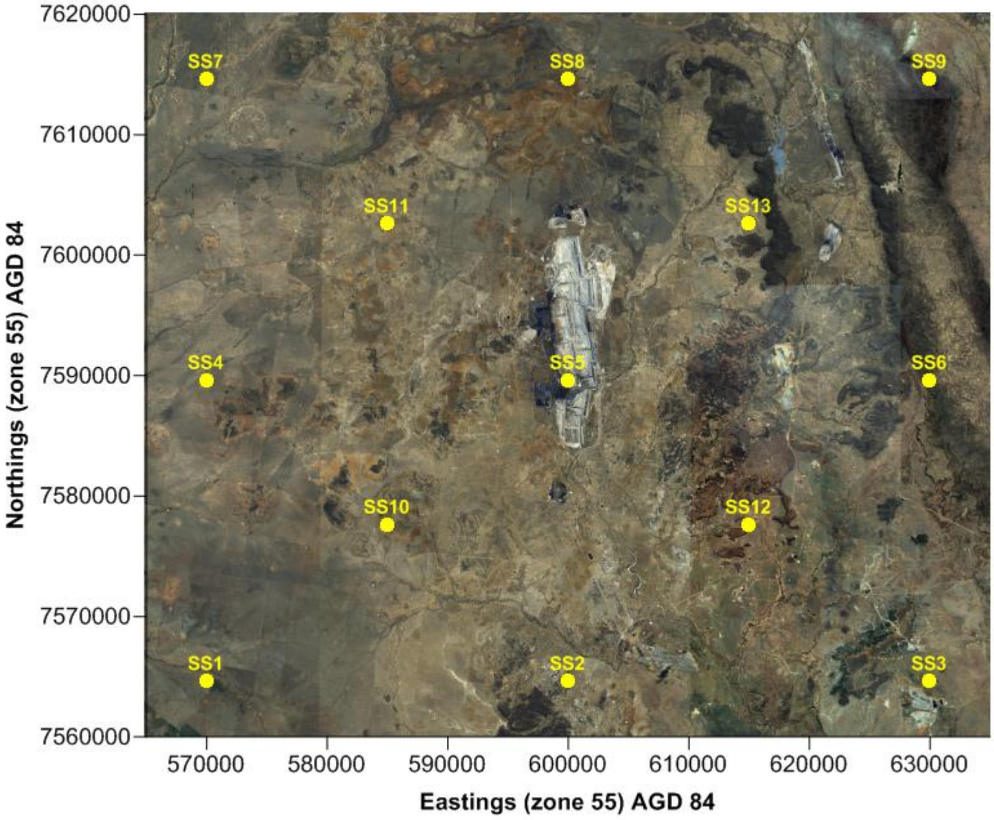
Moranbah water treatment plant records surface observations twice a day. No hourly surface observations were available from BoM or QLD DEHP monitoring stations within CALMET modelling domain for assimilation into CALMET.

Site-specific meteorological observations were available for the Project site. However as discussed in Appendix G the noncompliance of the siting of the meteorological monitoring stations was the main reason that surface observations were not assimilated into CALMET. Additionally, observed data for 2008 highlighted unrealistic inter-annual variability in wind direction compared to 2007 and 2009 (Appendix I).

**Table 16: Coordinates of Surface Observation Stations Included in CALMET**

| Station Name | Source | Easting (m) AGD84 | Northing (m) AGD84 |
|---|---|---|---|
| SS1 | TAPM | 569951 | 7564609 |
| SS2 | TAPM | 599951 | 7564609 |
| SS3 | TAPM | 629951 | 7564609 |
| SS4 | TAPM | 569951 | 7589609 |
| SS5 | TAPM | 599951 | 7589609 |
| SS6 | TAPM | 629951 | 7589609 |
| SS7 | TAPM | 569951 | 7614609 |
| SS8 | TAPM | 599951 | 7614609 |
| SS9 | TAPM | 629951 | 7614609 |
| SS10 | TAPM | 584951 | 7577609 |
| SS11 | TAPM | 584951 | 7602609 |
| SS12 | TAPM | 614951 | 7577609 |
| SS13 | TAPM | 614951 | 7602609 |

**Figure 17: Location of Surface Stations in Reference to CALMET Modelling Domain**



### H.2.4 CALMET Configuration

Details of CALMET configuration are presented in Table 17.

**Table 17: CALMET Configuration**

| Parameter | Units | Value |
|---|---|---|
| CALMET version | - | V6.326 |
| Years modelled | - | 2007, 2008, 2009 |
| No. X grid cells (NX) | - | 71 |
| No. Y grid cells (NY) | - | 61 |
| Grid spacing (DGRIDKM) | km | 1 |
| X coordinate (XORIGKM) | km | 564.500 |
| Y coordinate (YORIGKM) | km | 7559.500 |
| No. of vertical layers (NZ) | - | 10 |
| Number of surface stations | - | 13 |
| Number of upper air stations | - | 9 |
| Maximum radius of influence over land in the surface layer (RMAX1) | km | 3 |
| Maximum radius of influence over land aloft (RMAX2) | km | 30 |
| Maximum radius of influence over water (RMAX3) | km | 10 |
| Radius of influence of terrain features (TERRAD) | km | 1 |
| Land use database | - | Manually edited 300 m resolution Globcover land cover map (© ESA 2010 and UCLouvain, published by European Space science, Dec 2010). |
| Terrain database | - | Manually edited 3-arc second (90m) spaced elevation data obtained via NASA's Shuttle Radar Topography Mission (SRTM) in 2000 |
| Minimum overland mixing height (ZIMIN) | m | 50 |
| Maximum overland mixing height (ZIMAX) | m | 3000 |
| UTC time zone (ABTZ) | Hours | UTC+1000 |

# Appendix I Comparison of Observed Site-Specific and Numerically Simulated Wind Fields

## I.1 Northern Meteorological Monitoring Station

Comparison of observed site-specific meteorological data (wind speed and wind direction) at GRM north meteorological monitoring site and simulated data (extracted from CALMET at nearest location) is shown in figures below.

For all the years observed wind speeds from Northern site-specific monitoring station is generally lower than the simulated CALMET. This could be attributable to the lower height (3 m) of wind anemometer at on-site meteorological station compared to 10 m CALMET data.

Observations for 2007 and 2009 highlight the dominance of winds that are primarily from southeast while CALMET predicts winds from the east-southeast as the dominant direction. Observed site-specific wind direction for the year 2008 shows unrealistically predominant winds from north direction in contrast to 2007 and 2009 highlighting issues with the data during 2008.

**Figure 18: Annual Wind Roses at the Location of the GRM North Meteorological Monitoring Site, 2007. CALMET (left) and Observations (right)**

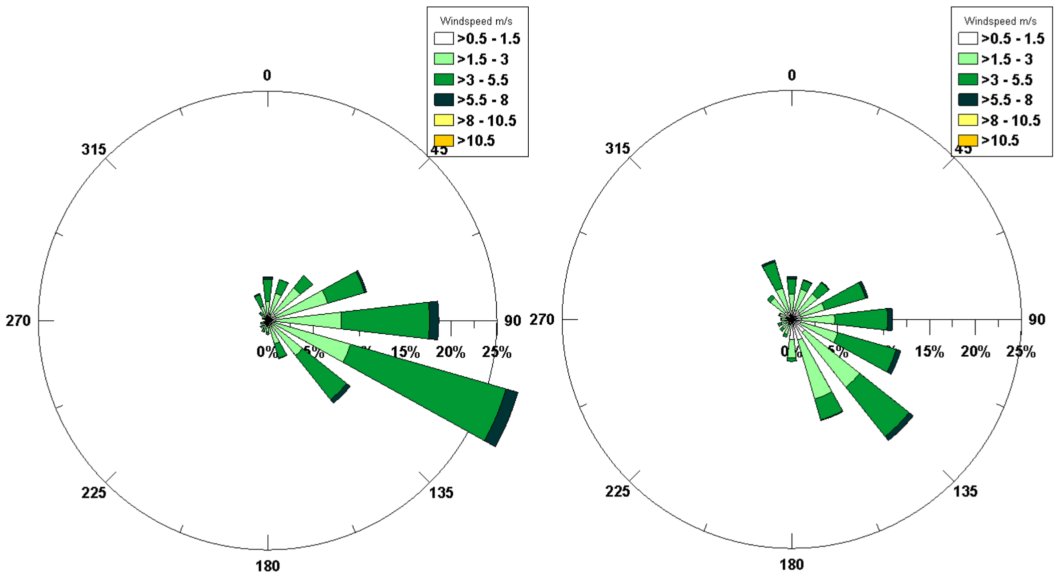


**Figure 19: Annual Wind Roses at the Location of the GRM North Meteorological Monitoring Site, 2008. CALMET (left) and Observations (right)**

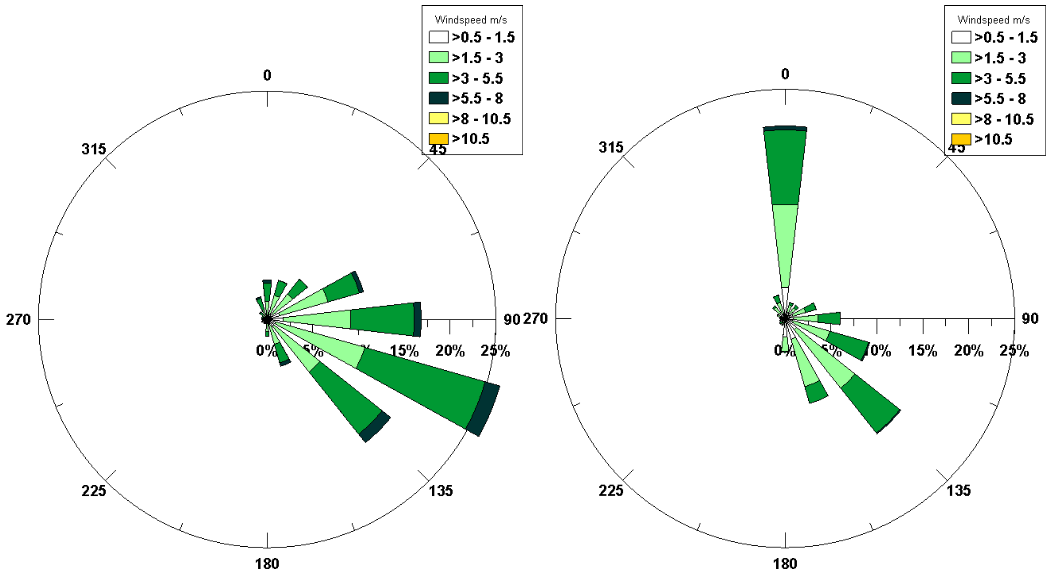



**Figure 20: Annual Wind Roses at the Location of the GRM North Meteorological Monitoring Site, 2009. CALMET (left) and Observations (right)**

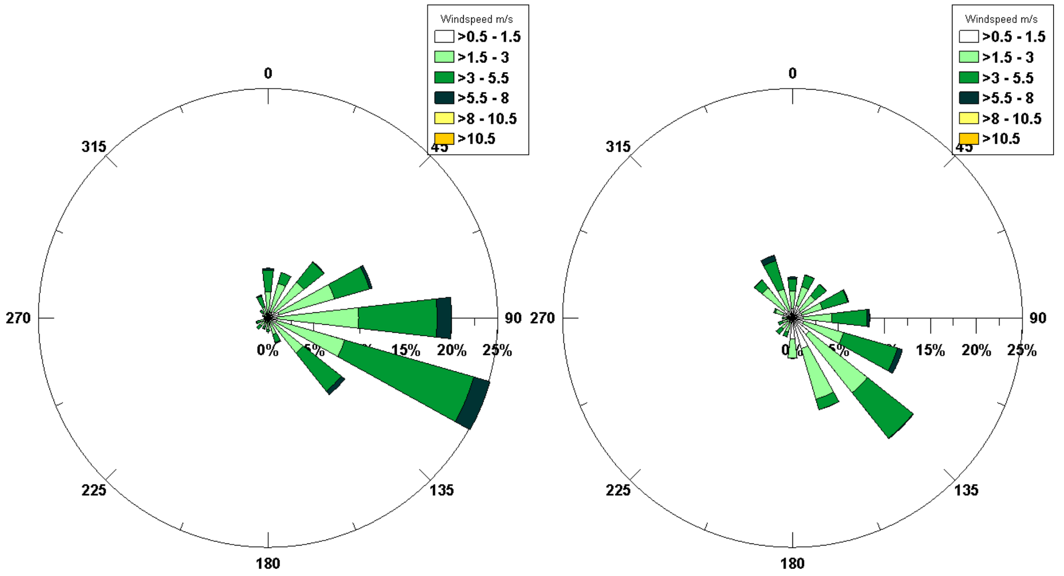
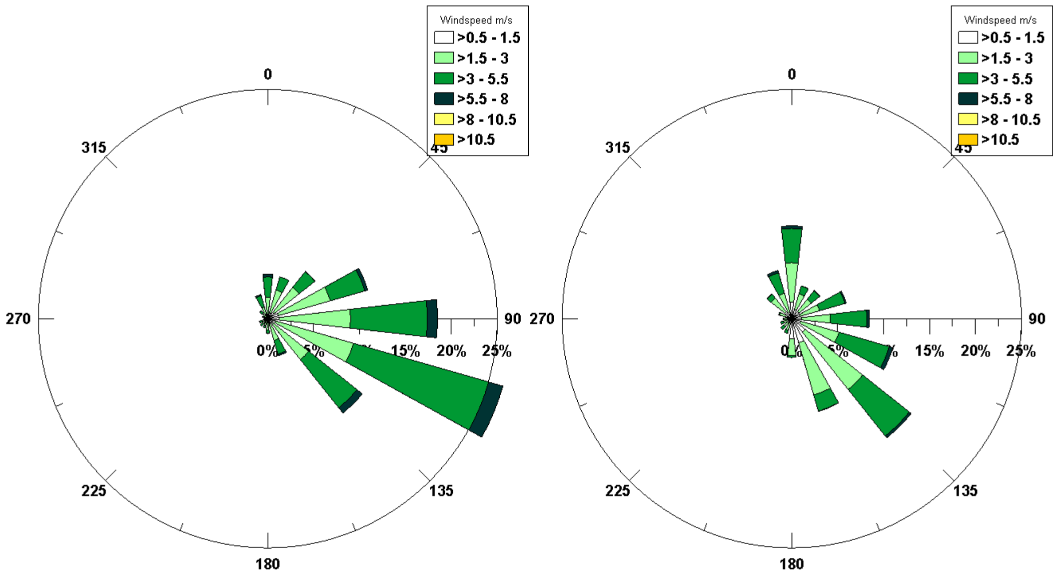


**Figure 21: Annual Wind Roses at the Location of the GRM North Meteorological Monitoring Site, 2007-2009. CALMET (left) and Observations (right)**




## I.2 Broadmeadow, Riverside and Southern Meteorological Monitoring Stations

Observed data for the three meteorological stations (Broadmeadow, Southern and Riverside) were analysed for the years 2005 to 2008 (where available). Analysis showed very low recorded wind speeds at Riverside and Southern monitoring locations. Analysis of the observed wind data for Broadmeadow station showed winds from south and southwest as predominant directions. Due to poor siting of these three on-site meteorological station locations (Broadmeadow, Southern and Riverside) the datasets were not considered reliable and not further analysed and hence excluded from assimilation into CALMET surface dataset.

# Appendix J Dispersion Modelling Methodology

This appendix presents an overview of the dispersion modelling methodology.

## J.1 Dispersion Model

Dust dispersion modelling was undertaken using the US EPA approved CALPUFF model for three years of meteorological conditions at 1 km resolution wind fields developed using CALMET. General run control parameters and technical options that were selected are presented in Table 18. Defaults were used for all other options.

**Table 18: CALPUFF Configuration**

| Parameter | Units | Value |
|---|---|---|
| CALPUFF version | - | V6.263 |
| Years modelled | - | 2007, 2008, 2009 |
| No. X grid cells (NX) | - | 71 |
| No. Y grid cells (NY) | - | 61 |
| Grid spacing (DGRIDKM) | km | 1 |
| X coordinate (XORIGKM) | km | 564.500 |
| Y coordinate (YORIGKM) | km | 7559.500 |
| No. of vertical layers (NZ) | - | 10 |
| UTC time zone (XBTZ) | Hours | UTC+1000 |
| Method used to compute dispersion coefficient (MDISP) | - | 2 (internally calculated sigma v, sigma w using micrometeorology) |
| Computational grid size and resolution | - | Identical to CALMET grid |
| Sampling grid size and resolution | - | Identical to CALMET grid |
| Gridded receptors used (LSAMP) | | False |
| Discrete receptors modelled | - | 21 + 4610 |
| Discrete receptors height above ground | m | 1.5 |
| Wet deposition | | False |
| Dry deposition | | True |

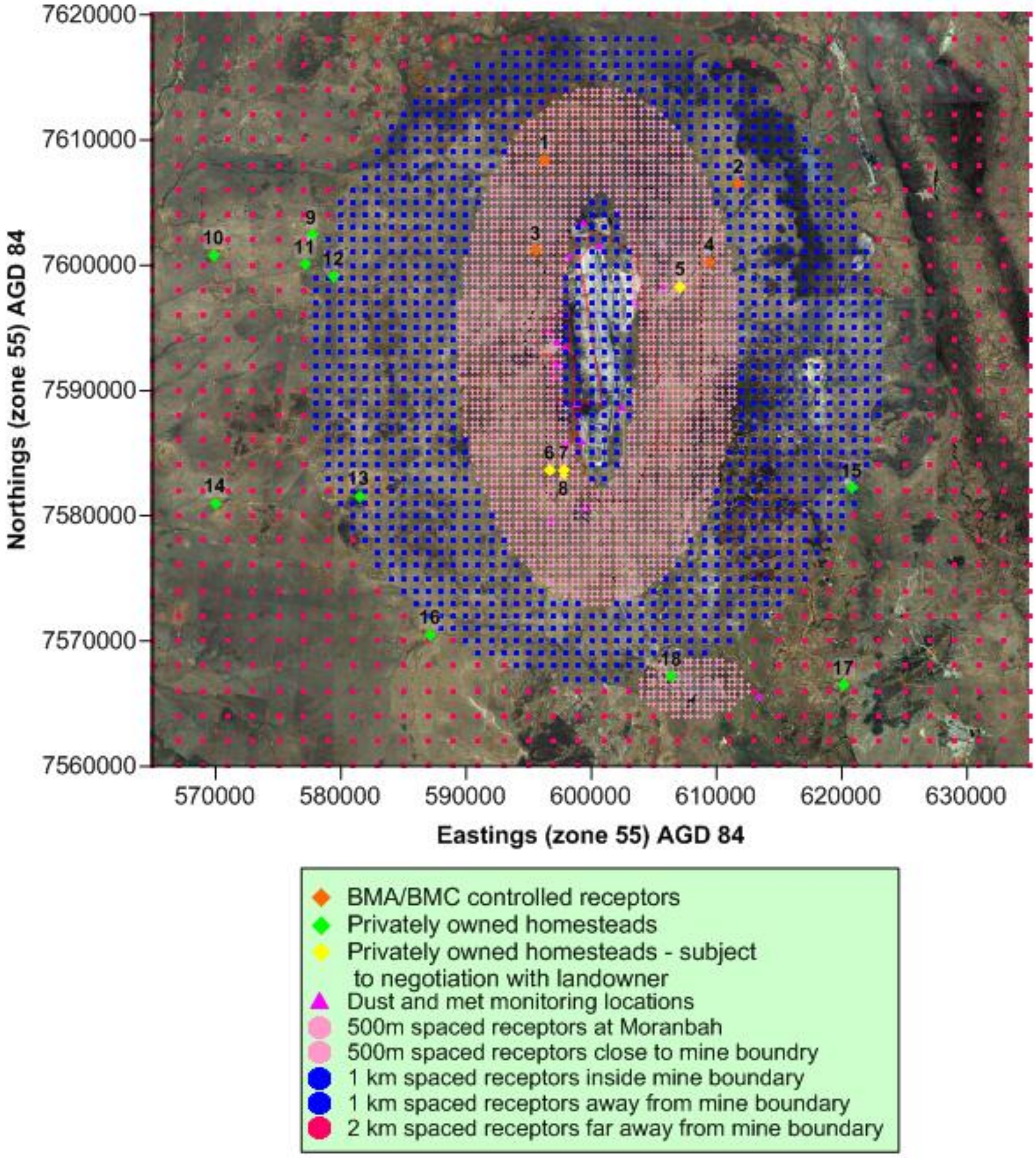
## J.2 Emission Sources

Dust emission sources were identified from the information provided by BMA for the GRM, BRM and Redhill Mine. Dust emission sources for Eaglefield and Grosvenor mine were sourced from their respective EIS.

## J.3 Discrete Receptor Grid

Dispersion model was used to predict 24-hour average and annual average concentrations of pollutants at 21 discrete receptors in the vicinity of Project. An additional 4610 variably spaced discrete receptors were included to generate contour plots showing the predicted impacts on regional scale. The coordinates of the receptors are presented in Table 12 and geographic location with respect to Project site is shown in Figure 7. The geographic location of the variably spaced discrete receptors is shown in Figure 22.

**Figure 22: Location of Discrete Receptors for Regional Contour Plot**



## J.4 Modelled Scenarios

Four scenarios were considered (Table 1):

- **Project-Only Scenario**: Red Hill Mine (RHM) based on a single worst-case dust emissions scenario.
- **Existing Mining Scenario**: Goonyella Riverside Broadmeadow (GRB) mine complex based on current approvals for FY2015, FY2030, FY2040 and FY2050 mining operations. Included in the existing mining scenario is an estimate of naturally occurring dust levels based on continuous monitoring data from BMA's Moranbah Airport monitoring station.
- **Future Mining Scenario**: GRB mine complex, RHM and an estimate of naturally occurring background levels of dust. Results for the four mine configurations for GRB mine complex (i.e. FY2015, FY2030, FY2040, and FY2050) are presented.
- **Cumulative Future Mining Scenario**: GRB mine complex, RHM, and naturally occurring dust levels, have been considered in combination with impacts associated with non-BMA emission sources: Eaglefield Mine (Peabody Energy), Grosvenor Mine (Anglo Coal), and Moranbah North Mine (Anglo Coal).

**Table 19: Modelled Scenarios**

| Scenario | RHM | GRM | BRM | EFM | Gros & MNM |
|---|---|---|---|---|---|
| Red Hill Mine | √ | x | x | x | x |
| Existing Mining(1) | x | √ | √ | x | x |
| Future Mining(1) | √ | √ | √ | x | x |
| Cumulative Future Mining(1) | √ | √ | √ | √ | √ |

Note (1): Consists of 4 scenarios, one each for FY2015, FY2030, FY2040, FY2050.

## J.5 Pollutants Modelled

The pollutants modelled include TSP, $PM_{10}$ and dust deposition. Model results for $PM_{10}$ were used to predict the impact of emissions of $PM_{2.5}$ from mine-related dust generating activities based on a conservative estimate of 10% of TSP as $PM_{2.5}$ (based on US EPA AP42 Table 11.9-2).

## J.6 Particle Size Distribution

In general, dust emitted from an emission source consists of a range of particle sizes that is dependent on the source characteristics.

Dust from overburden and coal handling operations is generated using mechanical means and thus the majority of dust emitted from coal mines consists of larger-sized particles (i.e.

greater than $PM_{2.5}$) when compared with particulate matter generated during combustion processes which contains a higher percentage of particles in the range of $PM_{2.5}$ to ultrafine particles. Dust from roads can be finer than that generated by material handling due to the repeated pulverising of road materials into smaller fragments and the resultant creation of fine particles which can easily become airborne.

For the purposes of the dispersion modelling, two particle size bins were considered. Their ranges and the assumed fraction for the existing and Project dust emission sources is summarised in Table 20.

**Table 20: Geometric Characteristics of Particle Size Intervals used in the Dispersion Modelling**

| Particulate size | Geometric Mass Mean Diameter (µm) | Geometric Standard deviation (µm) |
|---|---|---|
| 1 µm - 10 µm | 3.16 | 2.19 |
| 10 µm – 30 µm | 17.32 | 1.45 |

# Appendix K Existing Mining Emission Sources

## K.1 Goonyella Riverside and Broadmeadow Mine Complex

Key sources of dust emission sources associated with the existing operations at Goonyella Riverside Mine and Broadmeadow Mine include:

- In pit activities
- Coal hauling
- Topsoil stripping
- Transport of overburden to dumps
- Drilling and blasting
- Dozers on ROM stockpiles
- Stacking and reclaiming at raw coal stockpiles
- Stacking and reclaiming at product stockpiles
- Wind erosion from tailing storage facility
- Wind erosion from exposed topsoil
- Wind erosion from exposed overburden dumps
- Wind erosion from ROM, raw and product stockpiles
- Goonyella and Riverside CHPP activities (conveyers, transfer points, breaker stations, processing)

Figure 23 through to Figure 26 illustrate the locations of dust emission sources included in dispersion modelling for the existing mining scenario.

**Figure 23: Calpuff Sources Locations – Haul Roads, In-Pit, Blasting, Topsoil Stripping and Exposed Topsoil**

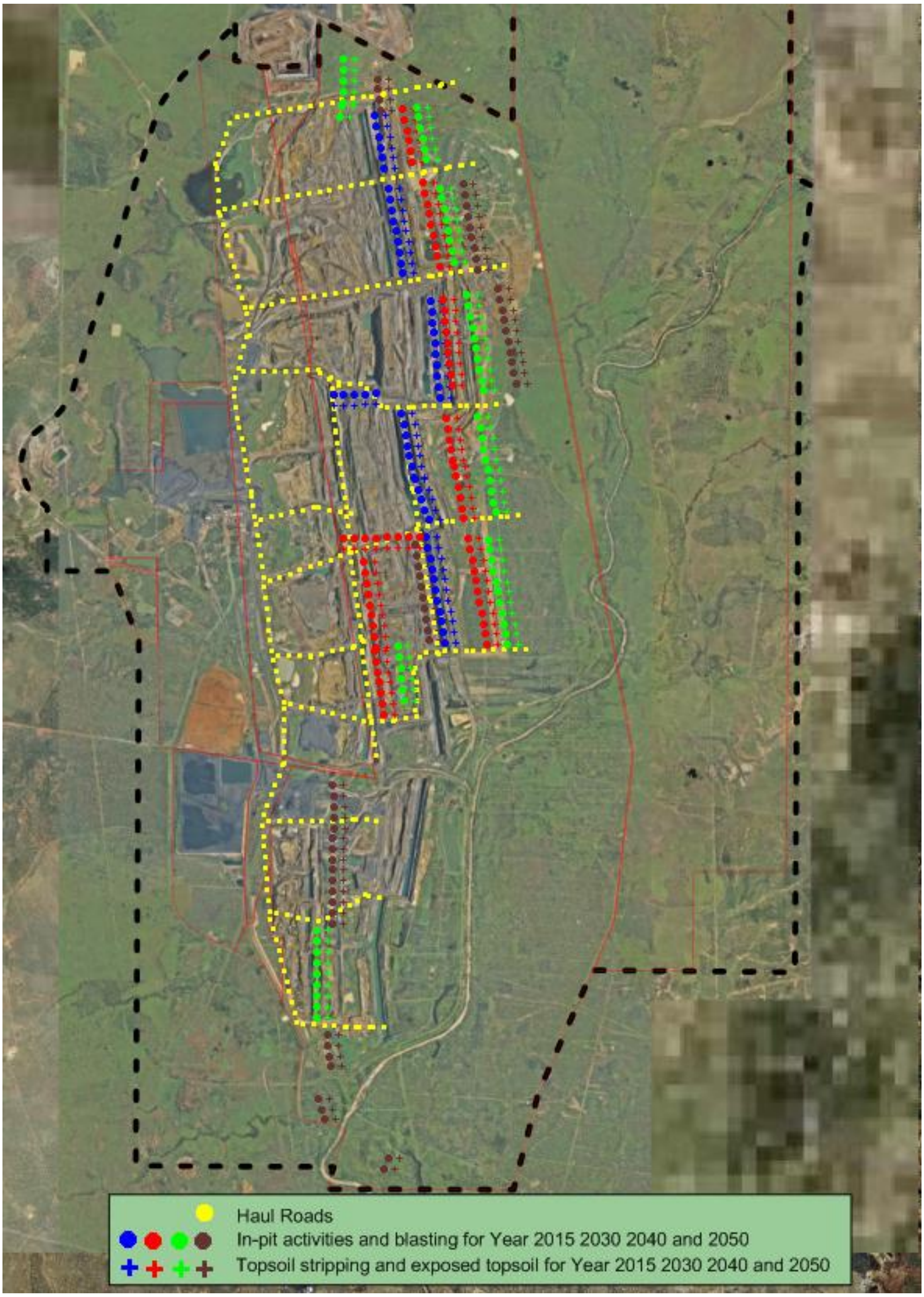


**Figure 24: Calpuff Sources Locations – Constant Emissions Sources for Goonyella CHPP and Riverside CHPP**

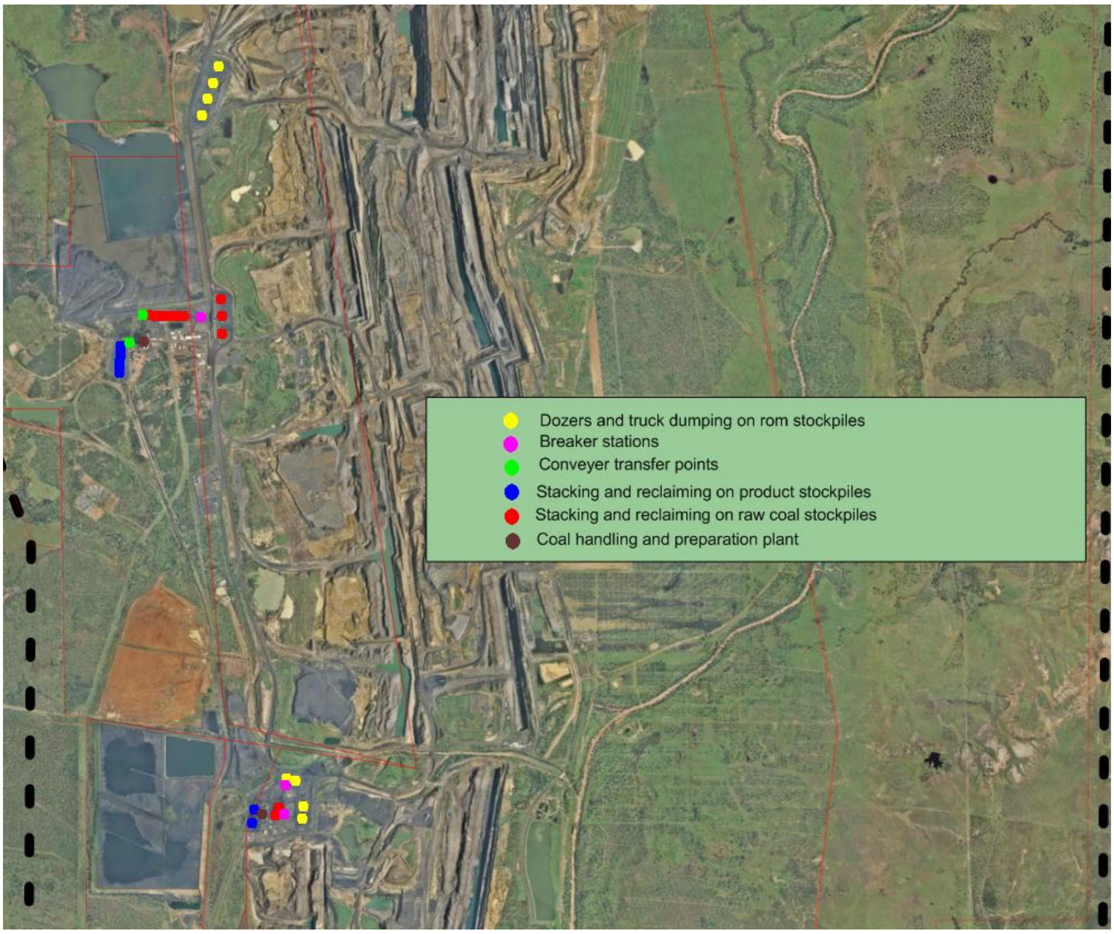


**Figure 25: Calpuff Sources Locations – Wind Speed Dependent Emissions Sources for Goonyella CHPP and Riverside CHPP**

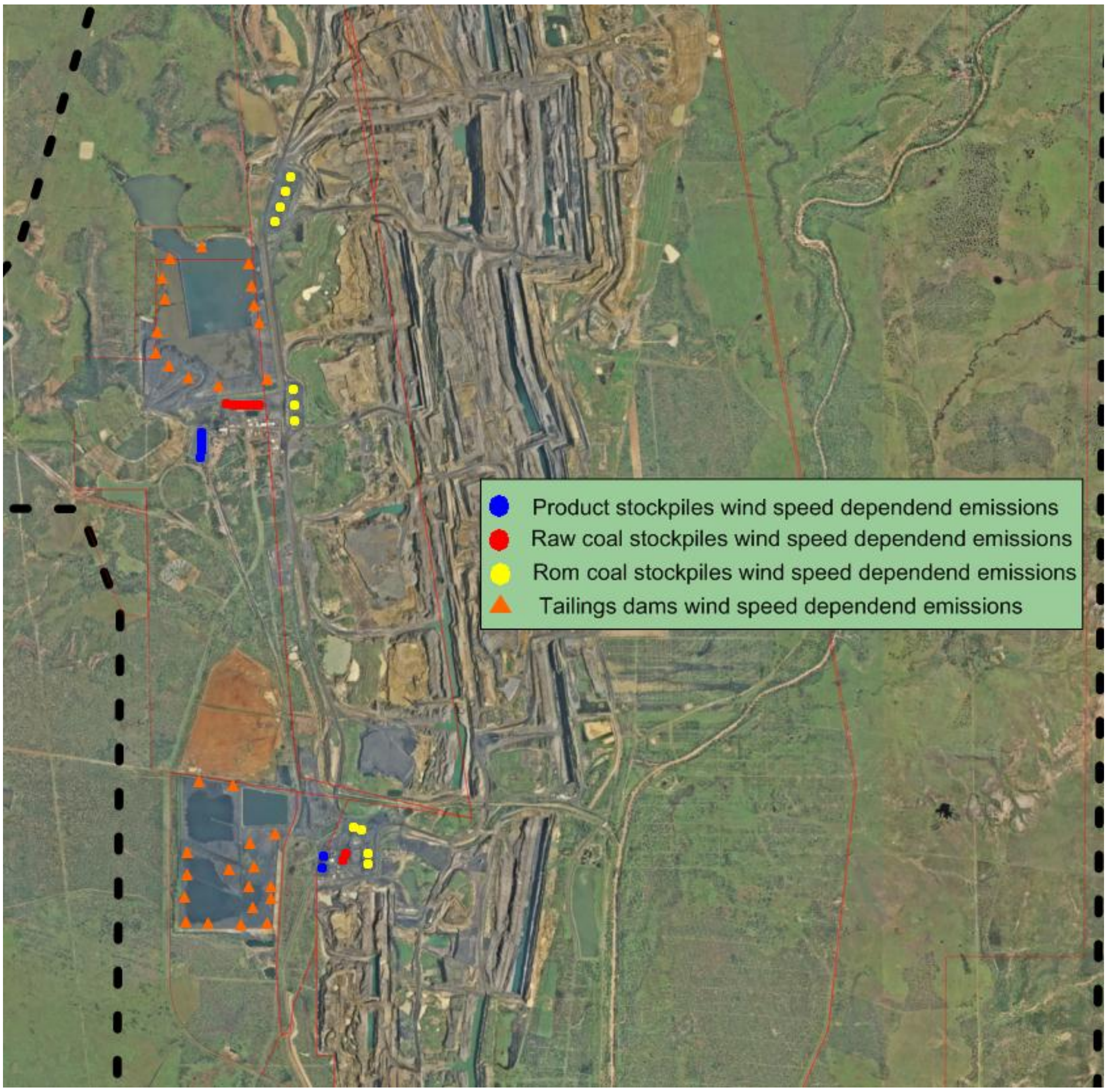
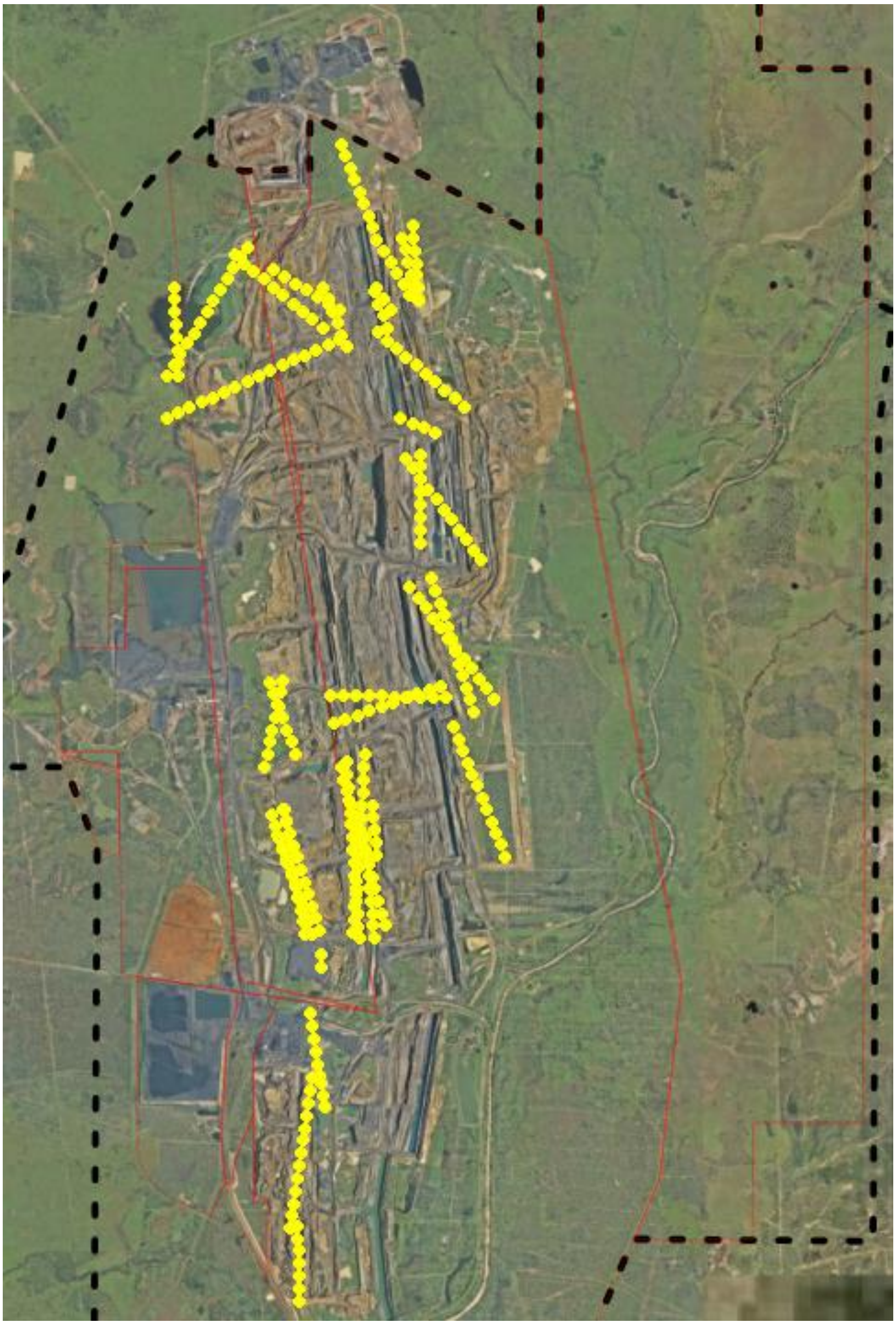


**Figure 26: Calpuff Sources Locations – Wind Speed Dependent Overburden Exposed Areas for a Typical Year (2030) Corresponding to Overburden Dumping Areas**



# Appendix L Red Hill Mine Emission Sources

Key sources of dust associated with Project related operations at Red Hill Mining Lease include:

- Underground ventilation outlets
- Overland conveyers
- Transport of overburden to dumps
- Dozers on ROM stockpiles
- Truck dumping on reject stockpiles
- Stacking and reclaiming at raw coal stockpiles
- Stacking and reclaiming at product stockpiles
- Wind erosion from ROM, raw and product stockpiles
- Redhill CHPP activities (conveyers, transfer points, breaker stations, processing)

Figure 27 and Figure 28 illustrate the locations of dust emission sources included in dispersion modelling for the Project related activities for Red Hill Mining Lease.

**Figure 27: Calpuff Sources Locations – Red Hill CHPP Related 24/7 Emission Sources**

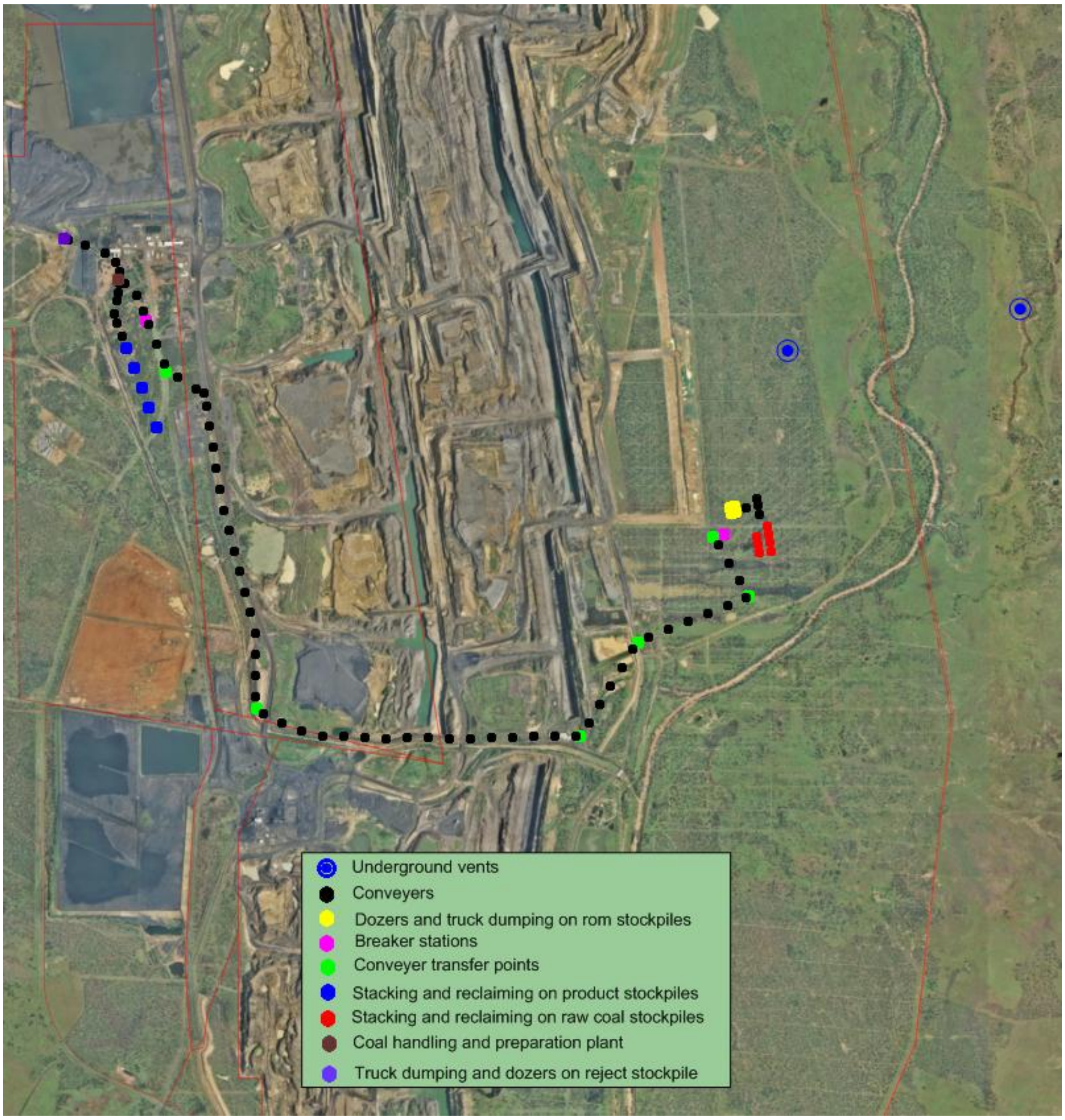
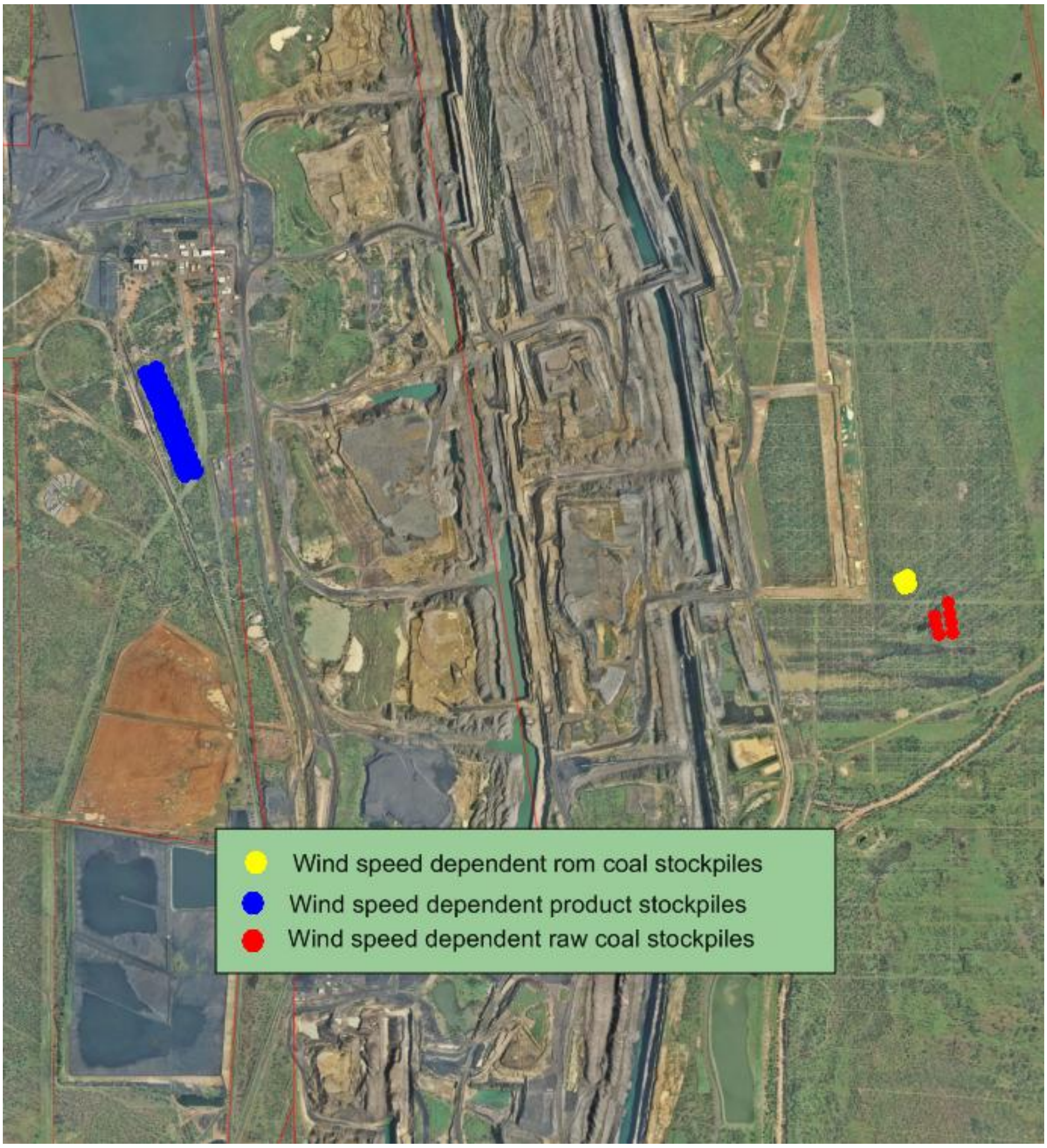


**Figure 28: Calpuff Sources Locations – Red Hill CHPP Related Wind Speed Dependent Emission Sources**

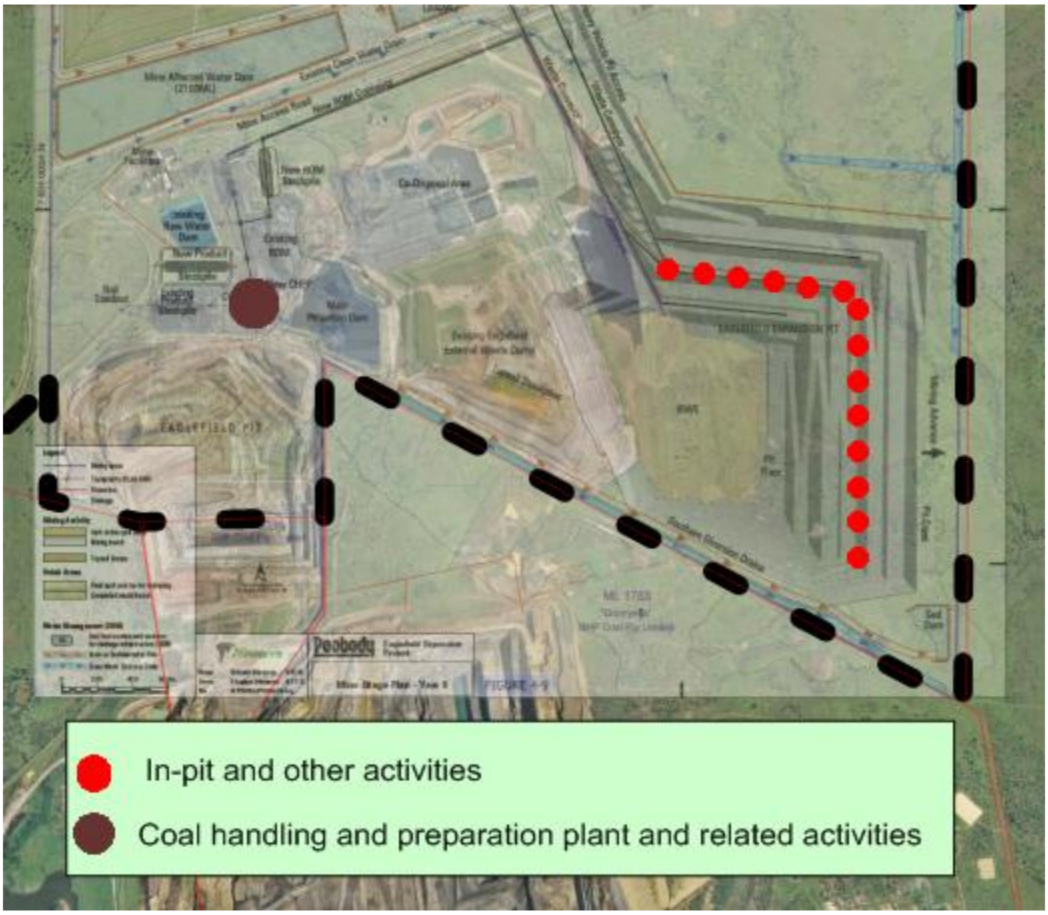


# Appendix M Cumulative Future Mining Emission Sources

## M.1 Eaglefield Expansion Project

Dust emission sources for Eaglefield mine were sourced from Eaglefield Expansion Project EIS (Eaglefield, 2011). Eaglefield Expansion Project proposed mining of up to 10.2 Mtpa of run-of-mine coal, up from the current average of 5 Mtpa. Details of dust emission rates and source characteristics were sourced from the technical air quality appendix of the EIS.

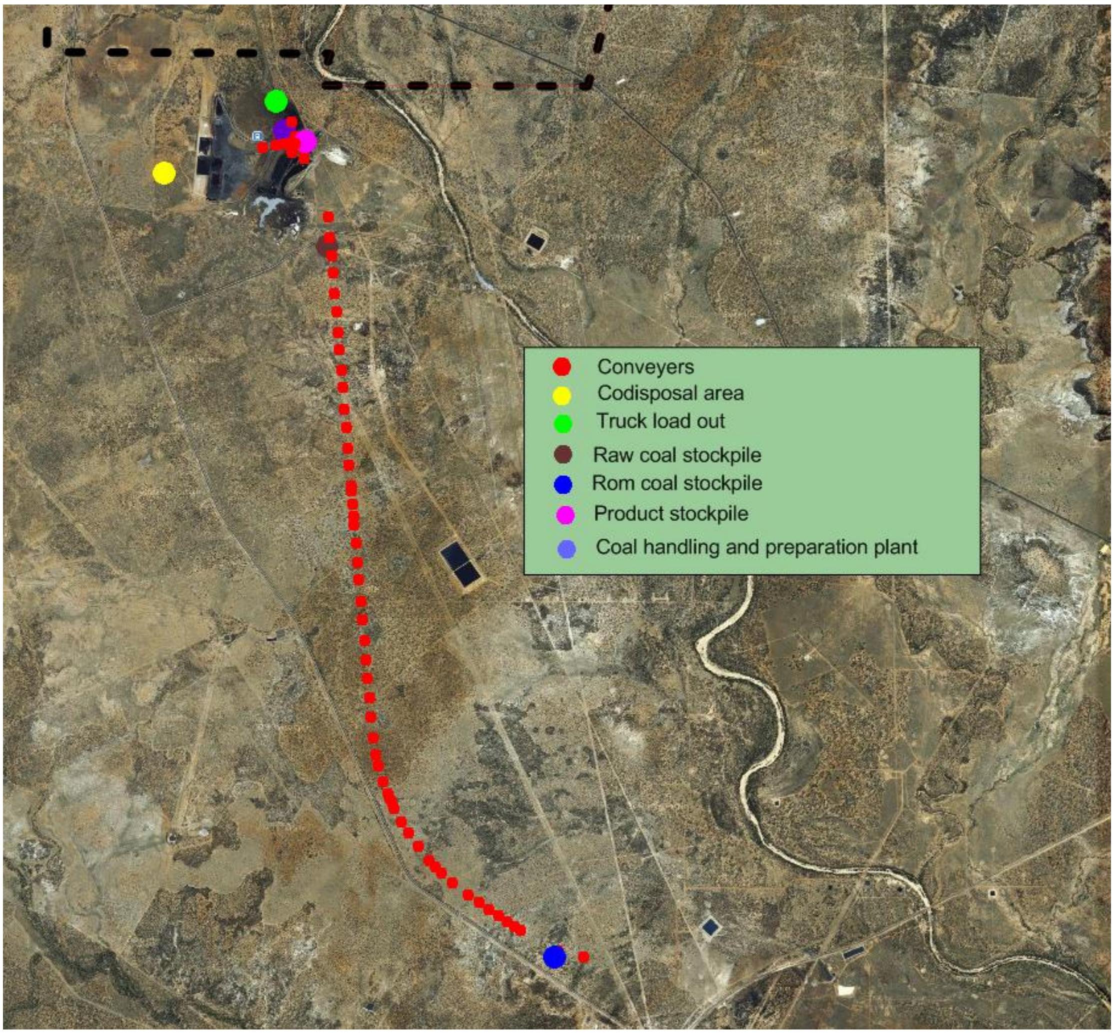
**Figure 29: Representative location of Eaglefield Expansion Project Dust emission Sources**



## M.2 Grosvenor and Moranbah North Mine

Dust emission sources for Grosvenor Project were sourced from Grosvenor Project EIS (Grosvenor, 2010). The proposed Grosvenor Project is a green field underground mine that would produce 7 Mtpa per year of run of mine coal and net 5 Mtpa of coking coal for export. Details of dust emission rates and source characteristics were source from technical air quality appendix of the EIS.

**Figure 30: Representative location of Grosvenor Project Dust emission Sources**



# Appendix N Contour Plots

When interpreting the contour plots presented in this appendix it is important to note that the figures do not represent a snapshot in time but rather a composite of the worst-case conditions at each point within the model domain regardless of when the elevated dust levels occurred. For example, elevated levels to the east of the site will occur at a different date and time than elevated levels to the west of the site.

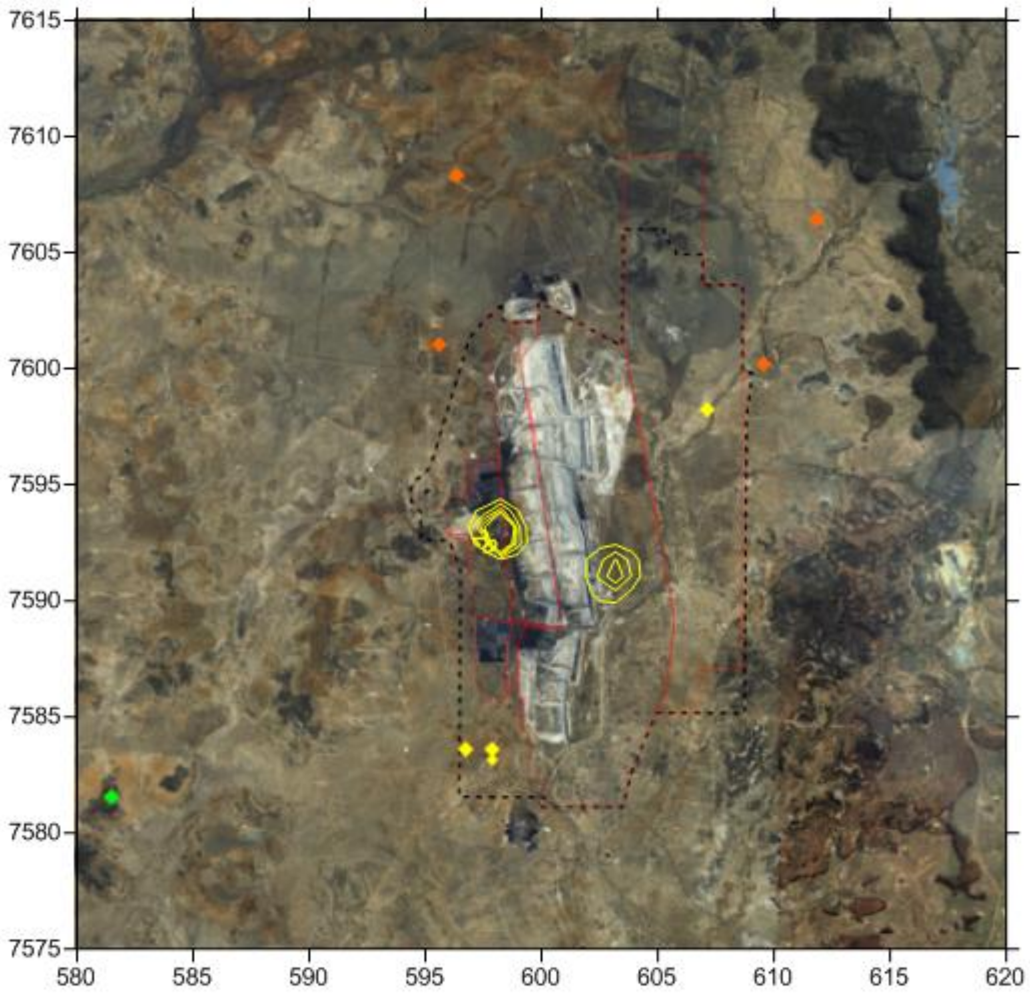
Additionally, it is noted that although the contour plots provided in the following sections provide information pertaining to the distance away from the emission sources that elevated levels are predicted, they do not provide any indication as to the frequency that such elevated levels of dust might occur. The reader is directed to Appendix O for tabulated results highlighting the predicted number of exceedences at the receptor locations.

An interpretation of the results is provided in the RHM EIS Chapter 11: *Air Quality.*

## N.1 Total Suspended Particulates

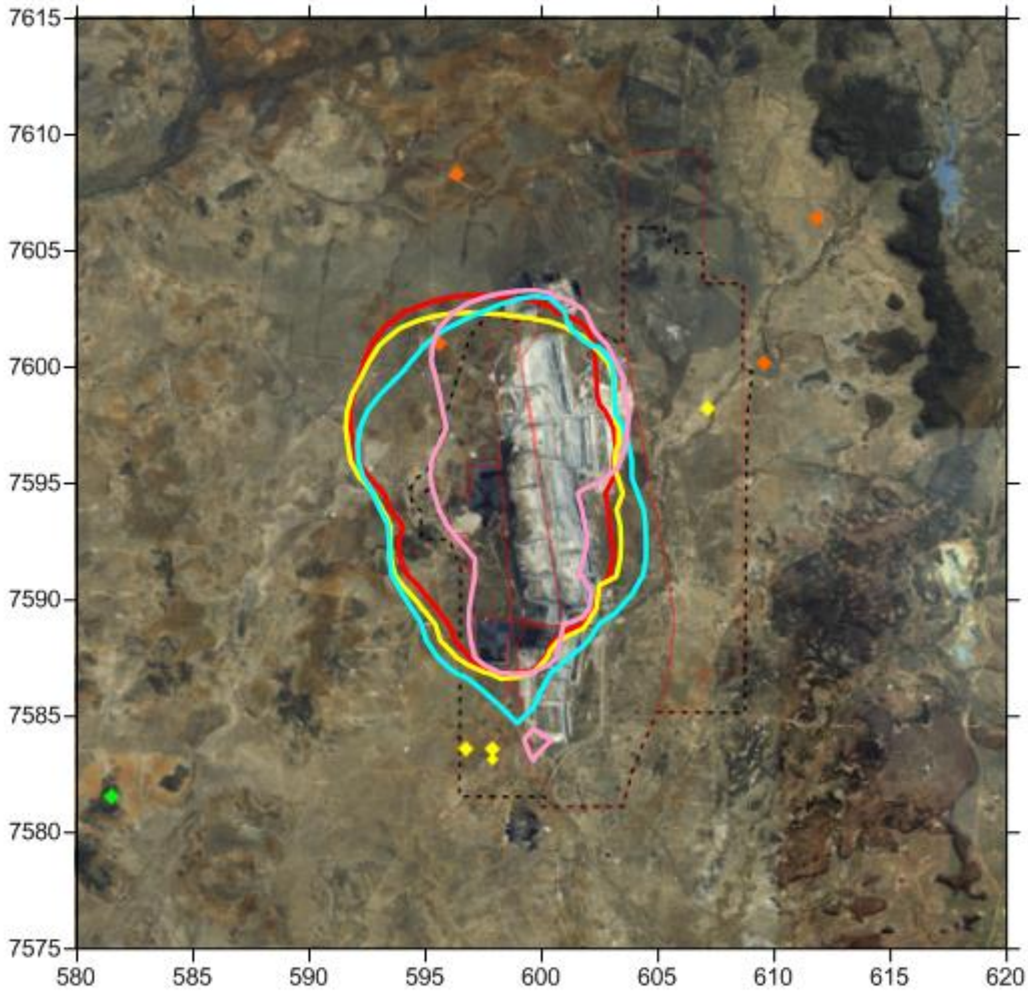
### N.1.1 Annual Average

**Figure 31: Total Suspended Particulates – Red Hill Mine Only Impacts**



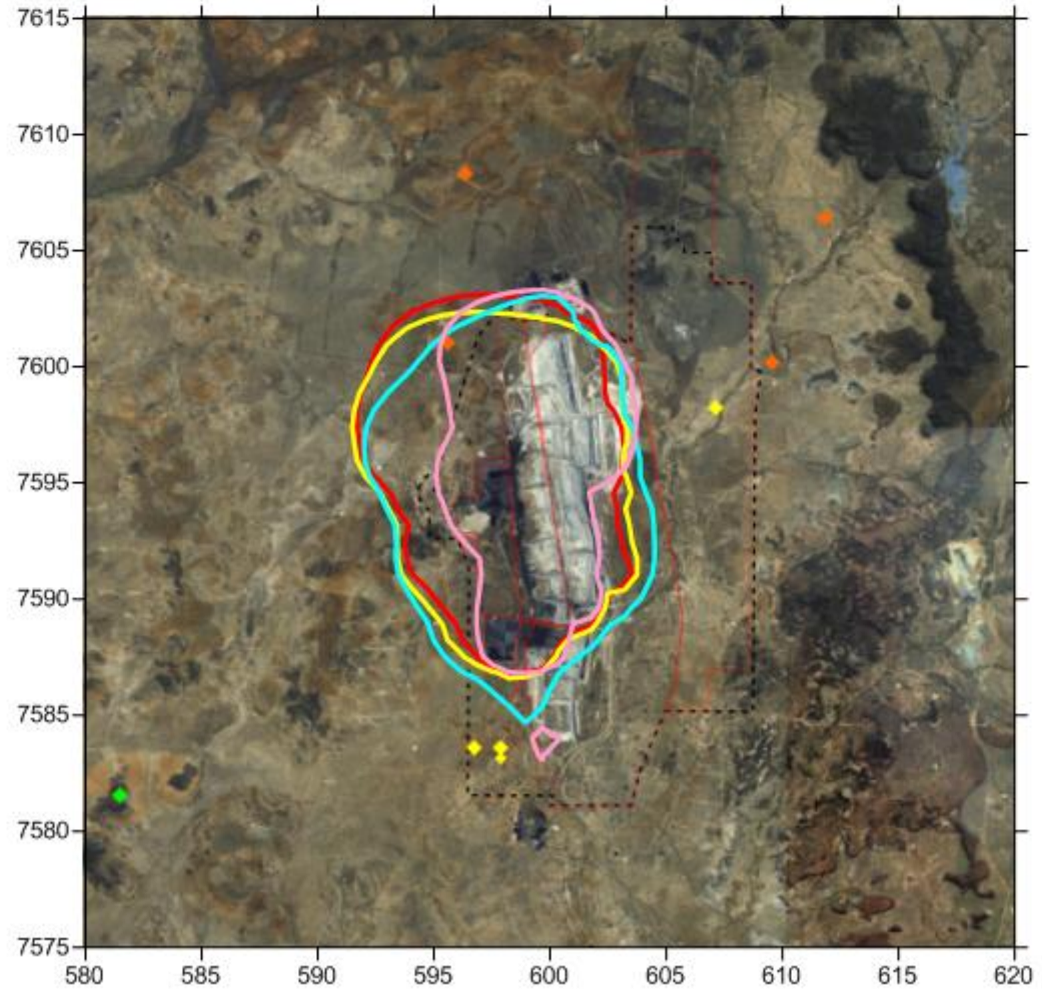

| **Scenario:** Red Hill Mine-only impacts | | **Mines included:** RHM | |
|---|---|---|---|
| **Pollutant:** | TSP | **Averaging Period:** | Annual |
| **Background level:** | Not included | **Rank:** | Maximum |
| **Project Goal:** | 90 µg/m$^3$ | **Contour level(s):** | 10, 20, 30, 40 and 50 µg/m$^3$ |
| **Contour Legend:** Red: 90 µg/m$^3$, Yellow: 10, 20, 30, 40 and 50 µg/m$^3$ | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 32: Total Suspended Particulates - Existing Mining**



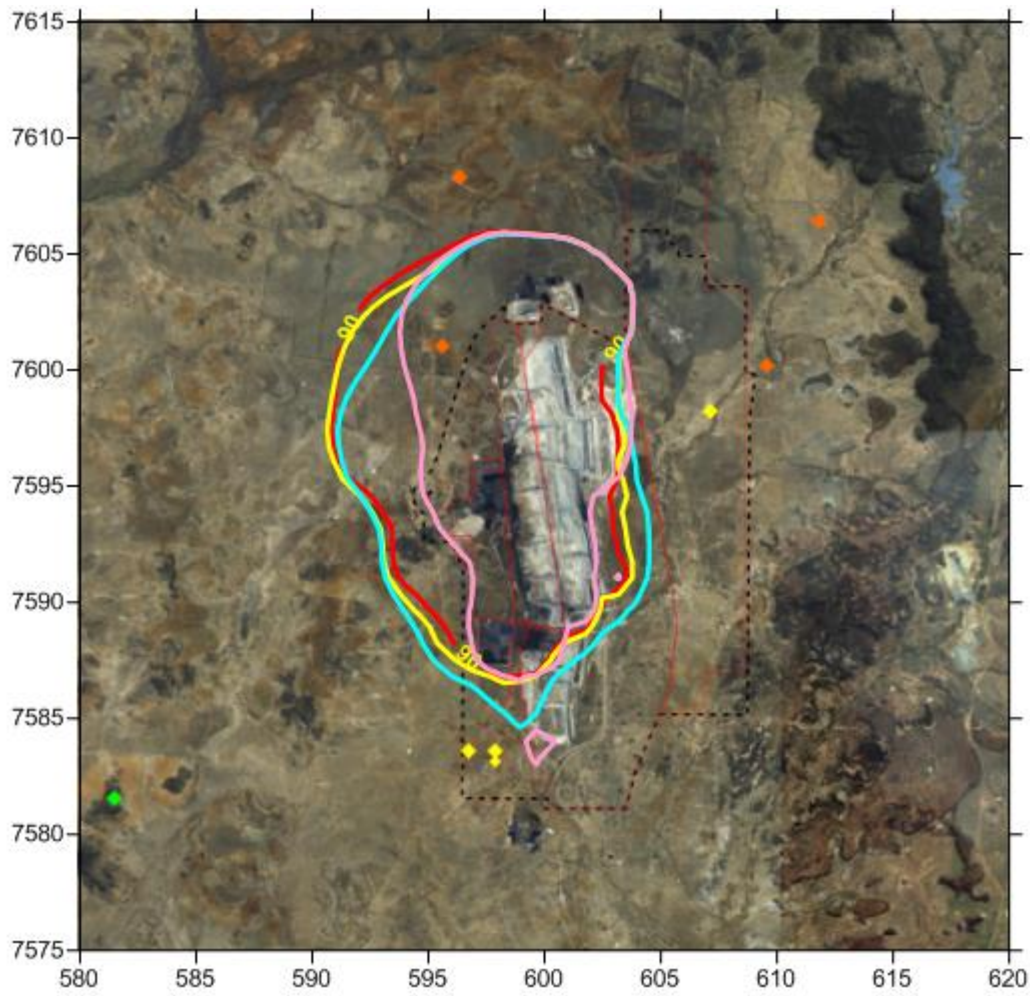

| **Scenario:** Existing Mining | | **Mines included:** GRM, BRM | |
|---|---|---|---|
| **Pollutant:** | TSP | **Averaging Period:** | Annual |
| **Background level:** | 39.8 µg/m$^3$ | **Rank:** | Maximum |
| **Project Goal:** | 90 µg/m$^3$ | **Contour level(s):** | 90 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 33: Total Suspended Particulates - Future Mining**




| | | | |
|---|---|---|---|
| **Scenario:** Future Mining | | **Mines included:** GRM, BRM, RHM | |
| **Pollutant:** | TSP | **Averaging Period:** | Annual |
| **Background level:** | 39.8 µg/m$^3$ | **Rank:** | Maximum |
| **Project Goal:** | 90 µg/m$^3$ | **Contour level(s):** | 90 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 34: Total Suspended Particulates - Cumulative Future Mining**

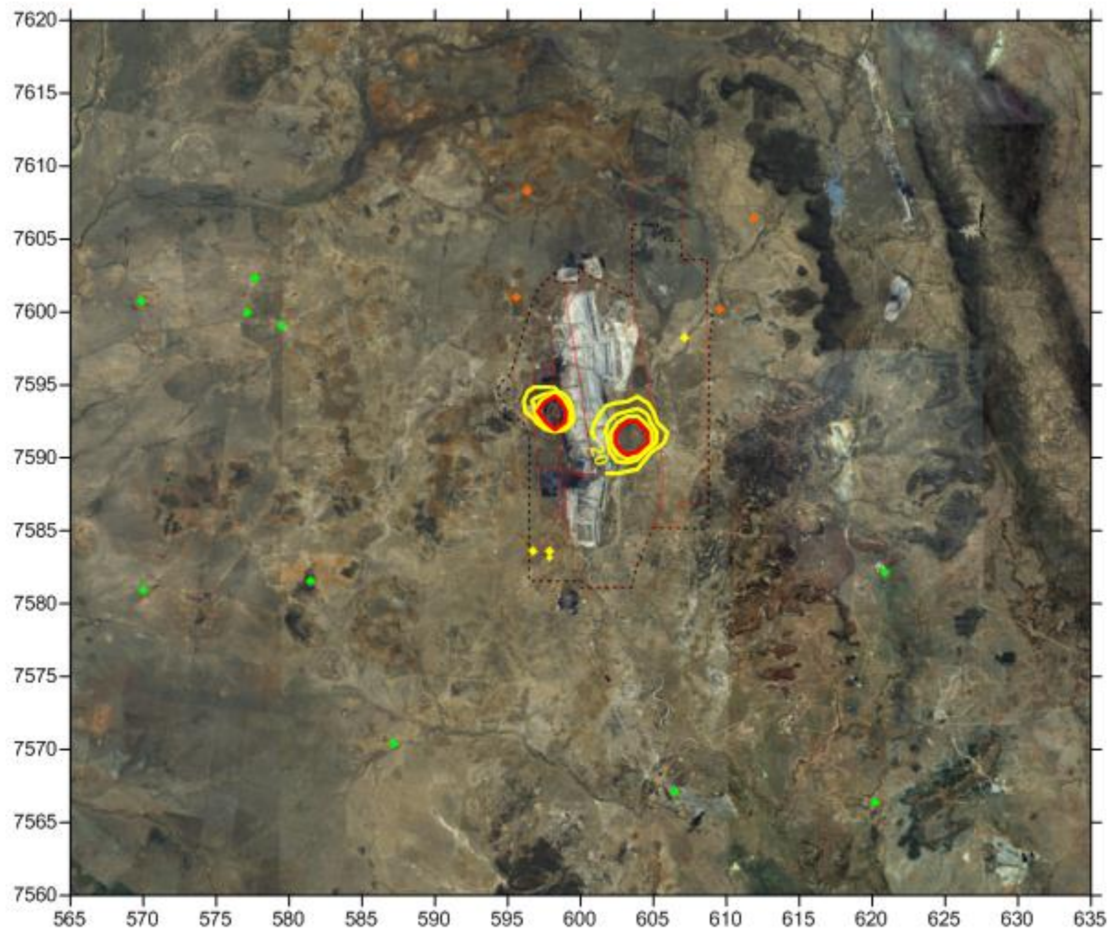



| | | | |
|---|---|---|---|
| **Scenario:** Cumulative Future Mining | | **Mines included:** GRM, BRM, RHM, Eaglefield, Grosvenor, Moranbah North Mine | |
| **Pollutant:** | TSP | **Averaging Period:** | Annual |
| **Background level:** | 39.8 µg/m$^3$ | **Rank:** | Maximum |
| **Project Goal:** | 90 µg/m$^3$ | **Contour level(s):** | 90 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

## N.2 Contour Plots – Particulate Matters as $PM_{10}$

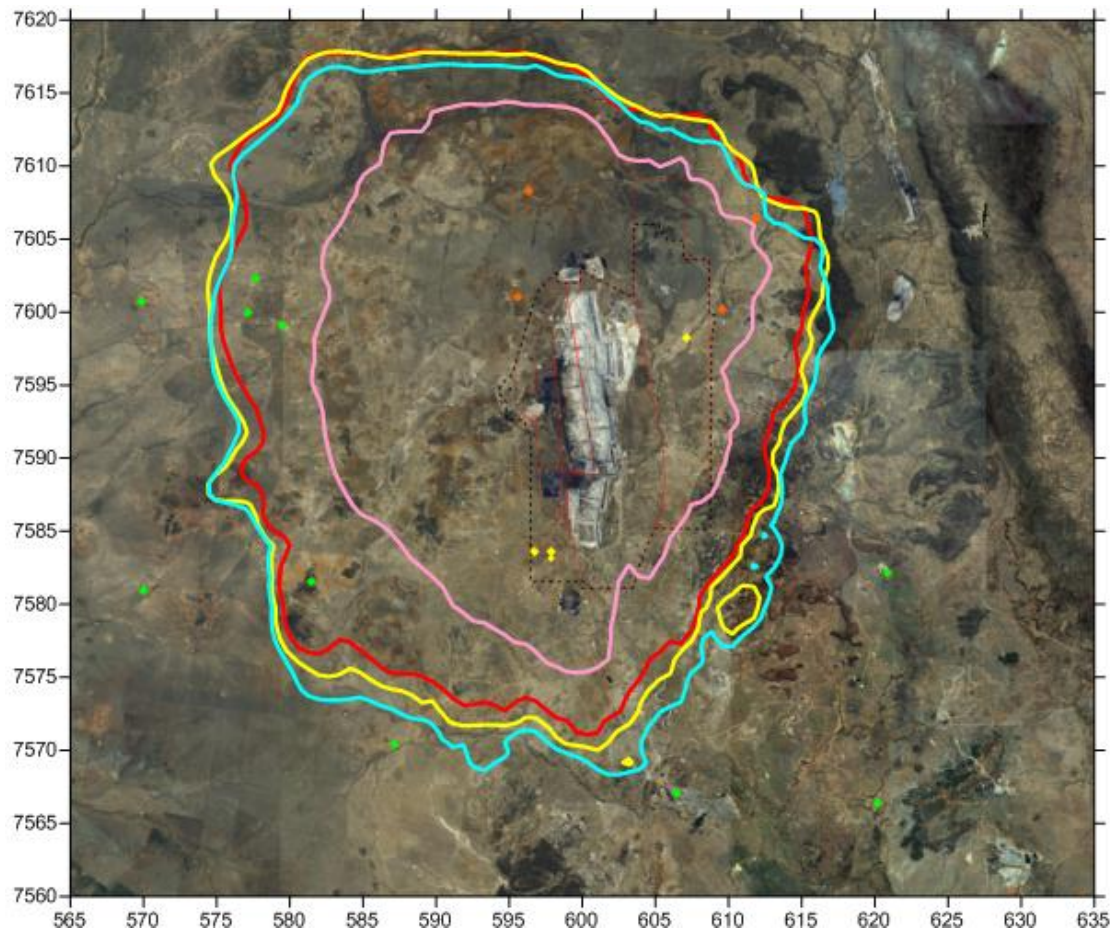
### N.2.1 Maximum 24-Hour Average

**Figure 35: Particulate Matter as $PM_{10}$ – Red Hill Mine Only Impacts**



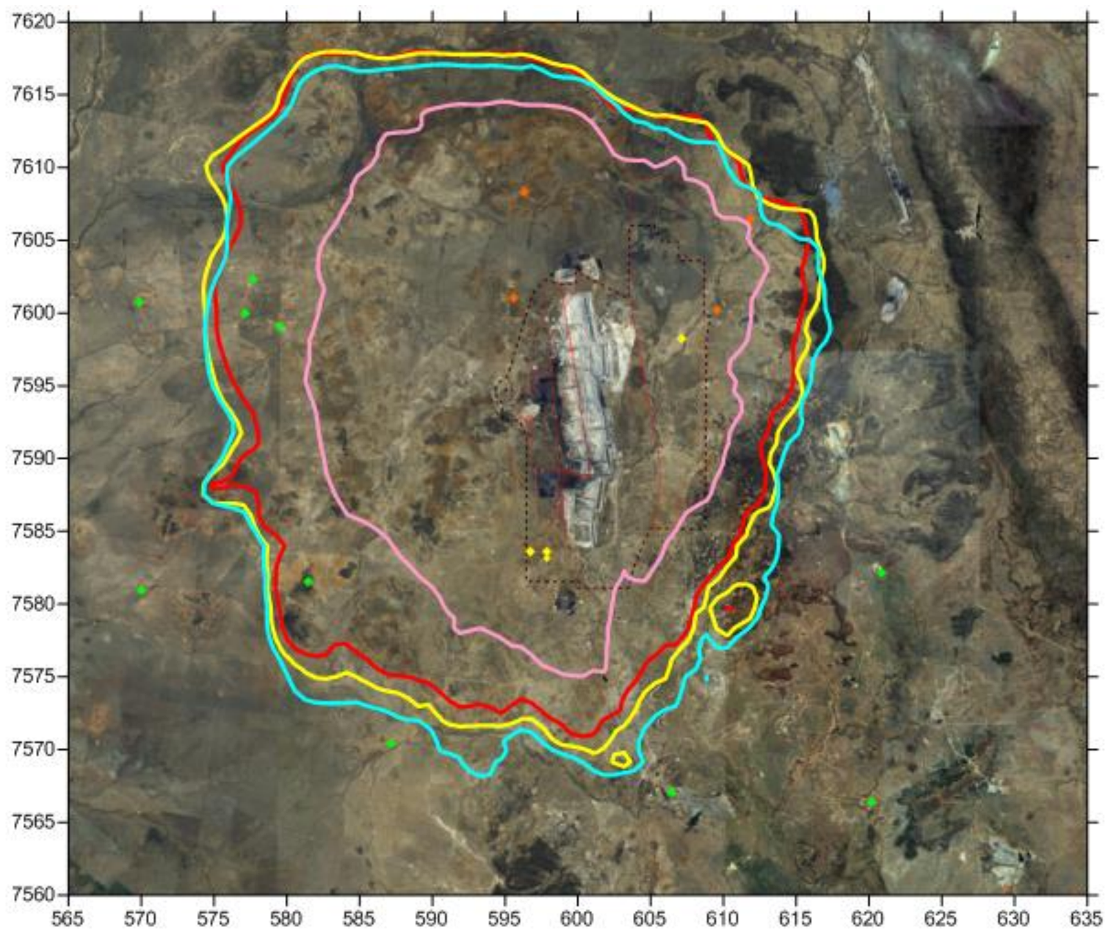

| | | | |
|---|---|---|---|
| **Scenario:** Red Hill Mine only impacts | | **Mines included:** RHM | |
| **Pollutant:** | $PM_{10}$ | **Averaging Period:** | 24-Hour |
| **Background level:** | Not included | **Rank:** | Fifth Highest |
| **Project Goal:** | 50 µg/m$^3$ | **Contour level(s):** | 20, 30, 40 and 50 µg/m$^3$ |
| **Contour Legend:** Red: 50 µg/m$^3$, Yellow: 20, 30 and 40 µg/m$^3$ | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 36: Particulate Matter as $PM_{10}$ - Existing Mining**



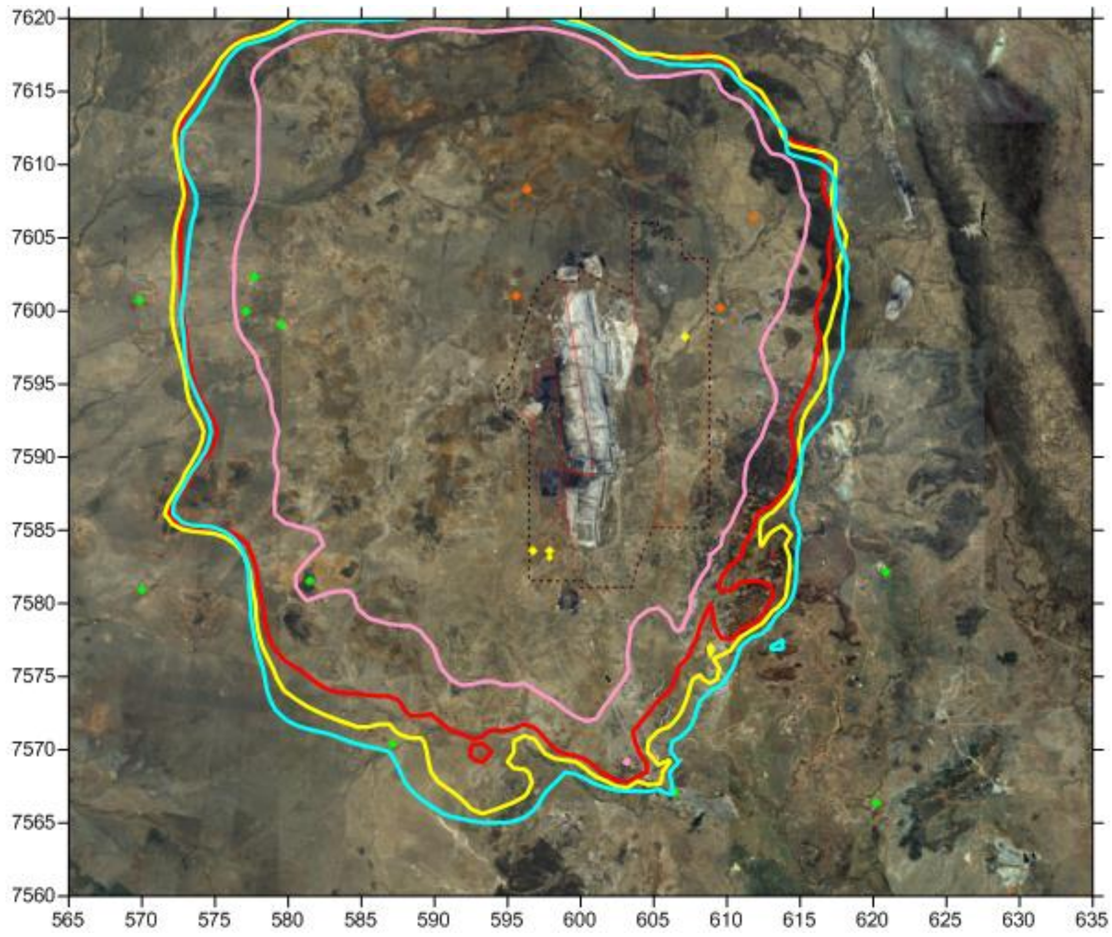

| **Scenario:** Existing Mining | | **Mines included:** GRM, BRM | |
|---|---|---|---|
| **Pollutant:** | $PM_{10}$ | **Averaging Period:** | 24-Hour |
| **Background level:** | 29.6 µg/m$^3$ | **Rank:** | Fifth Highest |
| **Project Goal:** | 50 µg/m$^3$ | **Contour level(s):** | 50 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 37: Particulate Matter as $PM_{10}$ - Future Mining**




| | | | |
|---|---|---|---|
| **Scenario:** Future Mining | | **Mines included:** GRM, BRM, RHM | |
| **Pollutant:** | $PM_{10}$ | **Averaging Period:** | 24-Hour |
| **Background level:** | 29.6 µg/m$^3$ | **Rank:** | Fifth Highest |
| **Project Goal:** | 50 µg/m$^3$ | **Contour level(s):** | 50 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 38: Particulate Matter as $PM_{10}$ - Cumulative Future Mining**

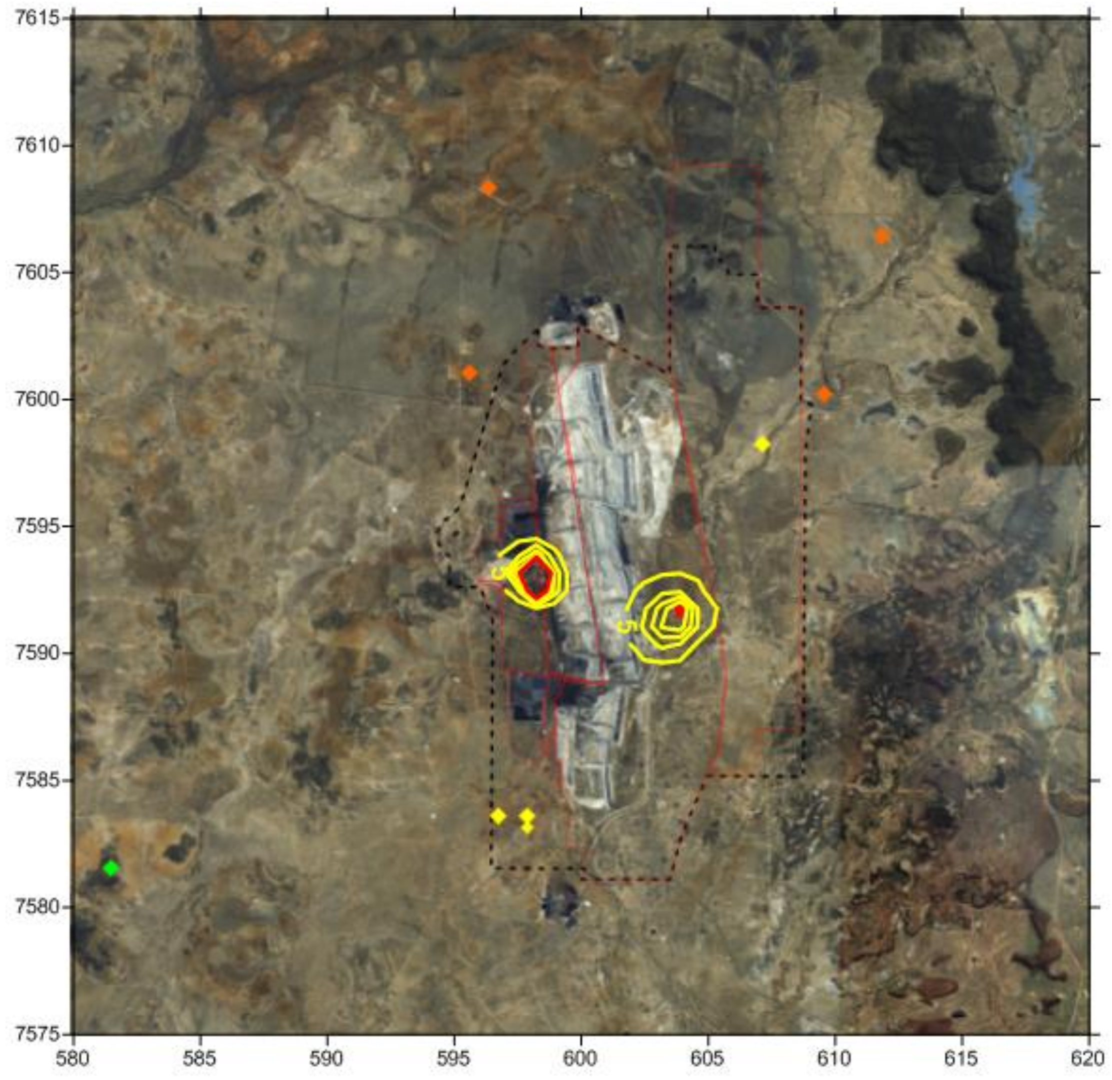



| | | | |
|---|---|---|---|
| **Scenario:** Cumulative Future Mining | | **Mines included:** GRM, BRM, RHM, Eaglefield, Grosvenor, Moranbah North Mine | |
| **Pollutant:** | $PM_{2.5}$ | **Averaging Period:** | 24-Hour |
| **Background level:** | 29.6 µg/m$^3$ | **Rank:** | Fifth Highest |
| **Project Goal:** | 50 µg/m$^3$ | **Contour level(s):** | 50 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

## N.3 Contour Plots – Particulate Matters as $PM_{2.5}$

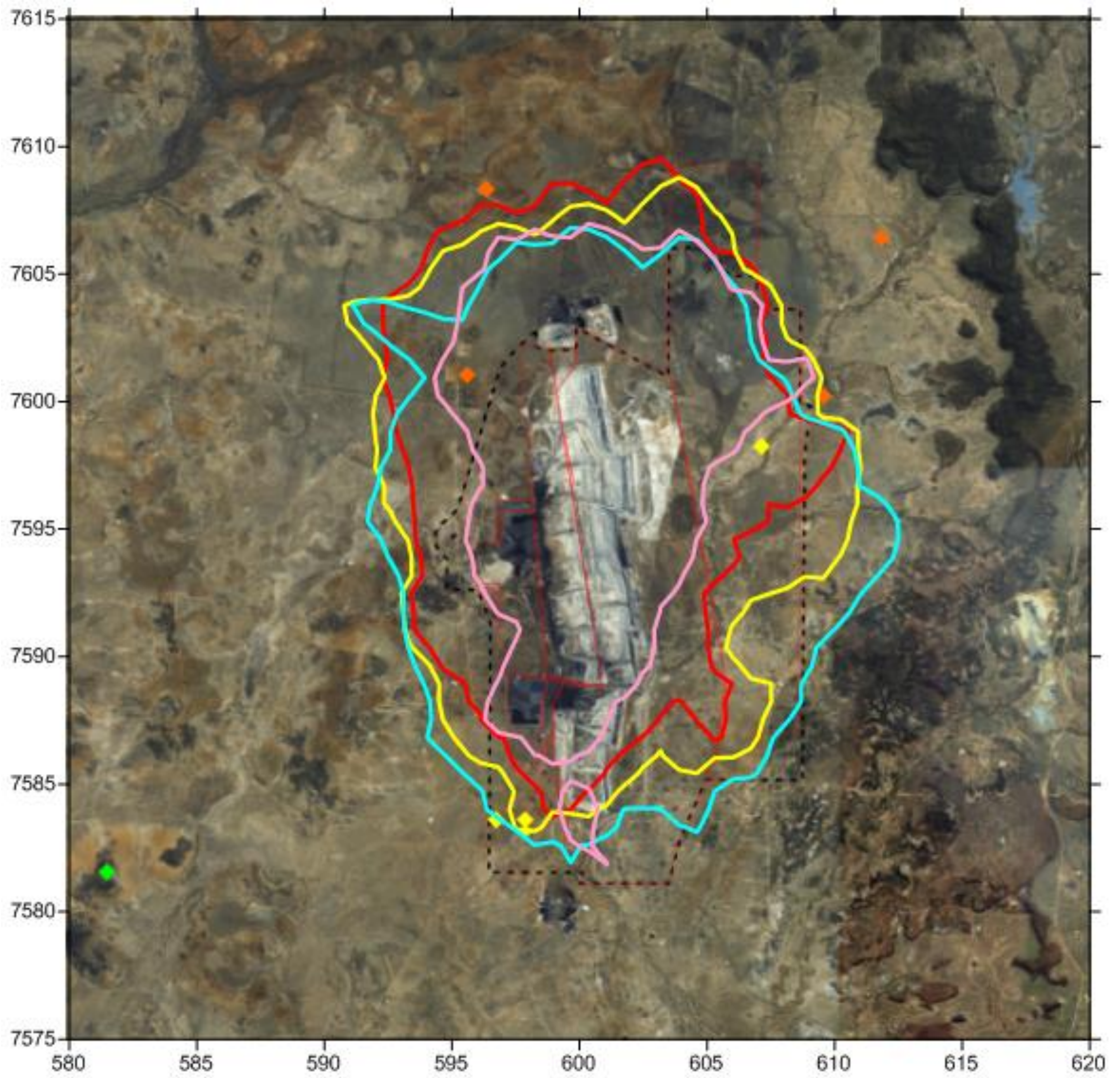
### N.3.1 Maximum 24-Hour Average

**Figure 39: Particulate Matter as $PM_{2.5}$ – Red Hill Mine Only Impacts**



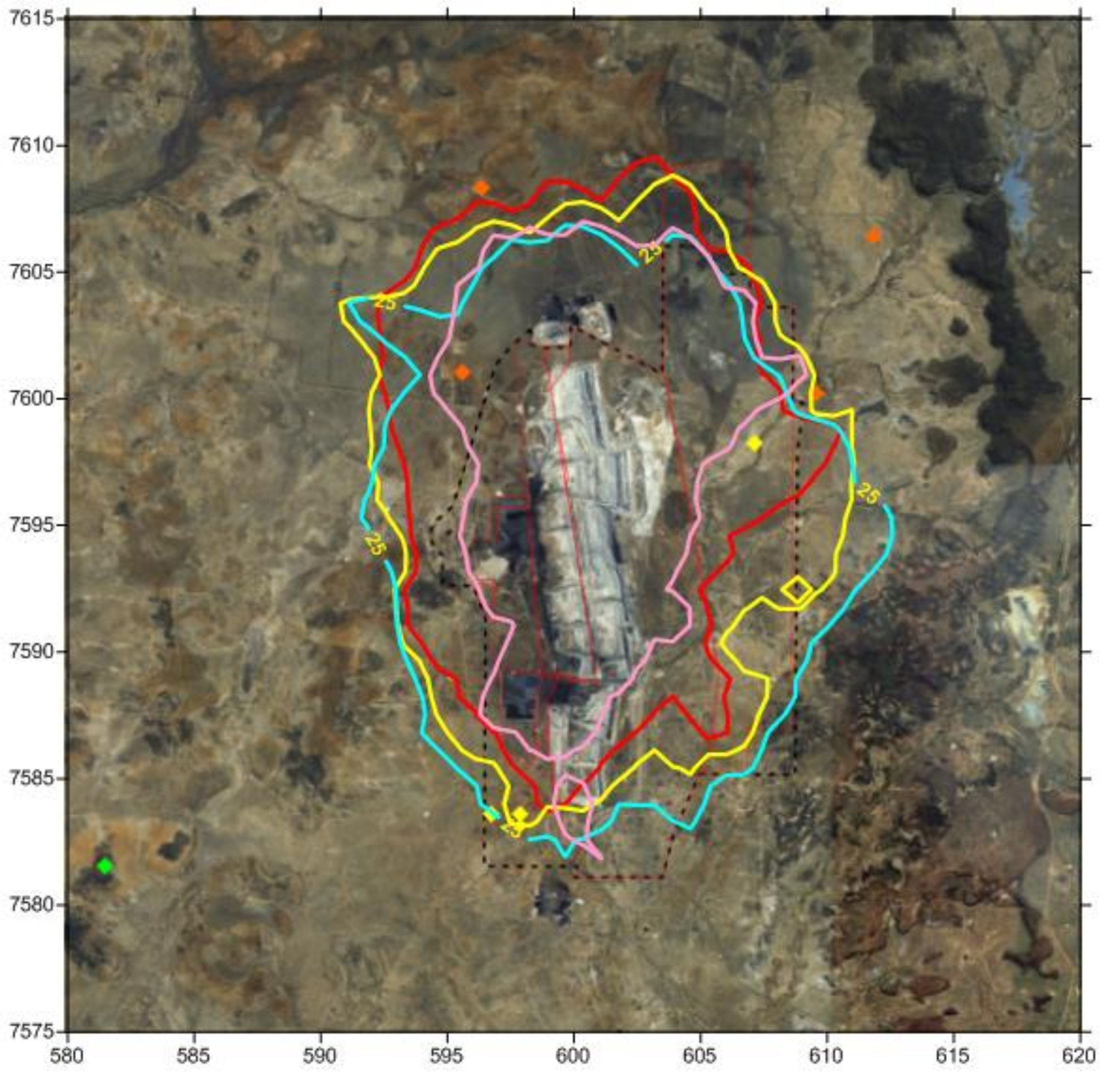

| | | | |
|---|---|---|---|
| **Scenario:** Red Hill Mine only impacts | | **Mines included:** RHM | |
| **Pollutant:** | $PM_{2.5}$ | **Averaging Period:** | 24-Hour |
| **Background level:** | Not included | **Rank:** | Maximum |
| **Project Goal:** | 25 µg/m$^3$ | **Contour level(s):** | 5, 10, 15, 20 and 25 µg/m$^3$ |
| **Contour Legend:** Red: 25 µg/m$^3$, Yellow: 5, 10, 15, and 20 µg/m$^3$ | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 40: Particulate Matter as $PM_{2.5}$ - Existing Mining**



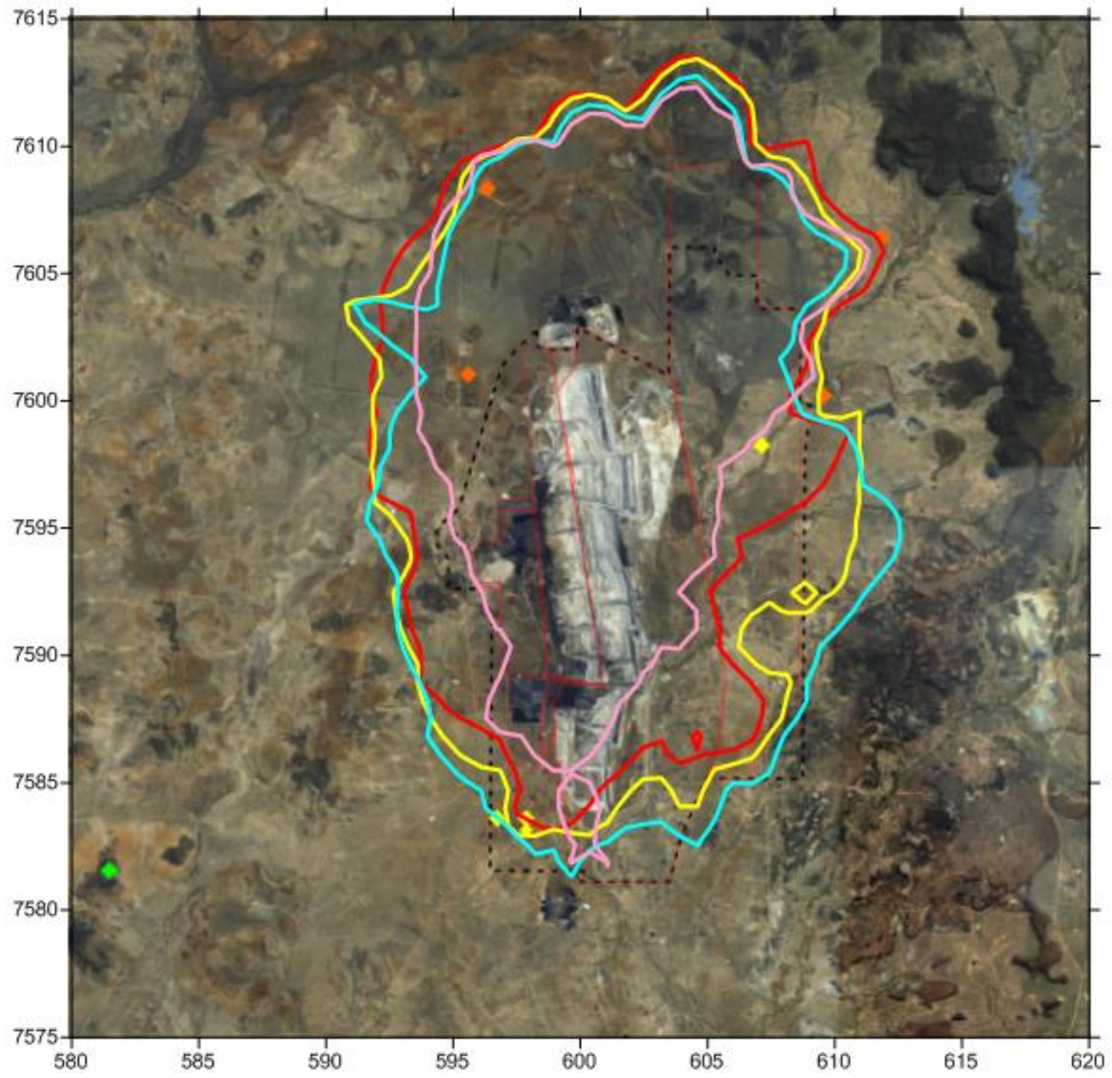

| | | | |
|---|---|---|---|
| **Scenario:** Existing Mining | | **Mines included:** GRM, BRM | |
| **Pollutant:** | $PM_{2.5}$ | **Averaging Period:** | 24-Hour |
| **Background level:** | 7.0 µg/m$^3$ | **Rank:** | Maximum |
| **Project Goal:** | 25 µg/m$^3$ | **Contour level(s):** | 25 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 41: Particulate Matter as $PM_{2.5}$ - Future Mining**




| | | | |
|---|---|---|---|
| **Scenario:** Future Mining | | **Mines included:** GRM, BRM, RHM | |
| **Pollutant:** | $PM_{2.5}$ | **Averaging Period:** | 24-Hour |
| **Background level:** | 7.0 µg/m$^3$ | **Rank:** | Maximum |
| **Project Goal:** | 25 µg/m$^3$ | **Contour level(s):** | 25 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

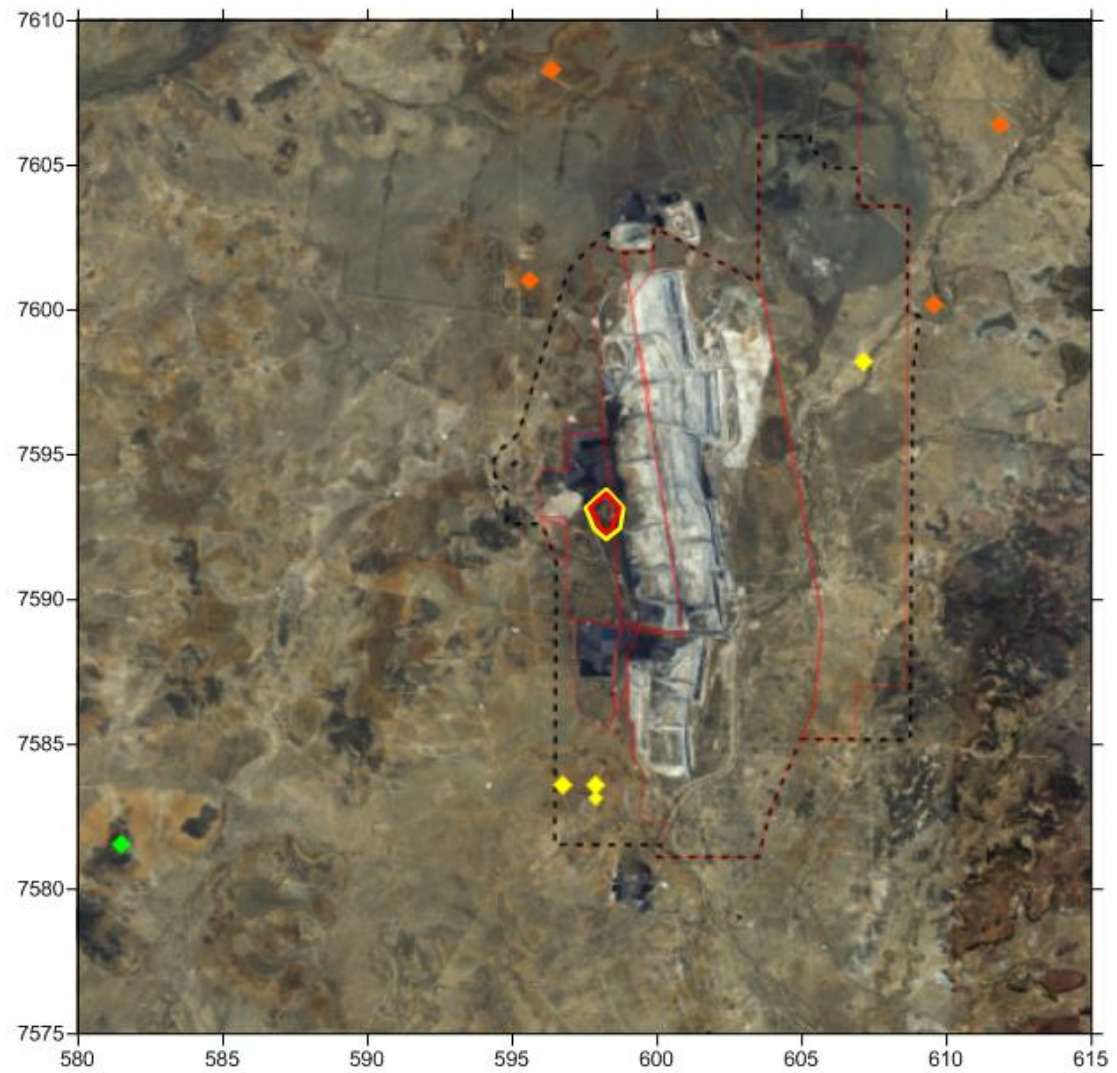
**Figure 42: Particulate Matter as $PM_{2.5}$ - Cumulative Future Mining**




| | | | |
|---|---|---|---|
| **Scenario:** Cumulative Future Mining | | **Mines included:** GRM, BRM, RHM, Eaglefield, Grosvenor, Moranbah North Mine | |
| **Pollutant:** | $PM_{2.5}$ | **Averaging Period:** | 24-Hour |
| **Background level:** | 7.0 µg/m$^3$ | **Rank:** | Maximum |
| **Project Goal:** | 25 µg/m$^3$ | **Contour level(s):** | 25 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

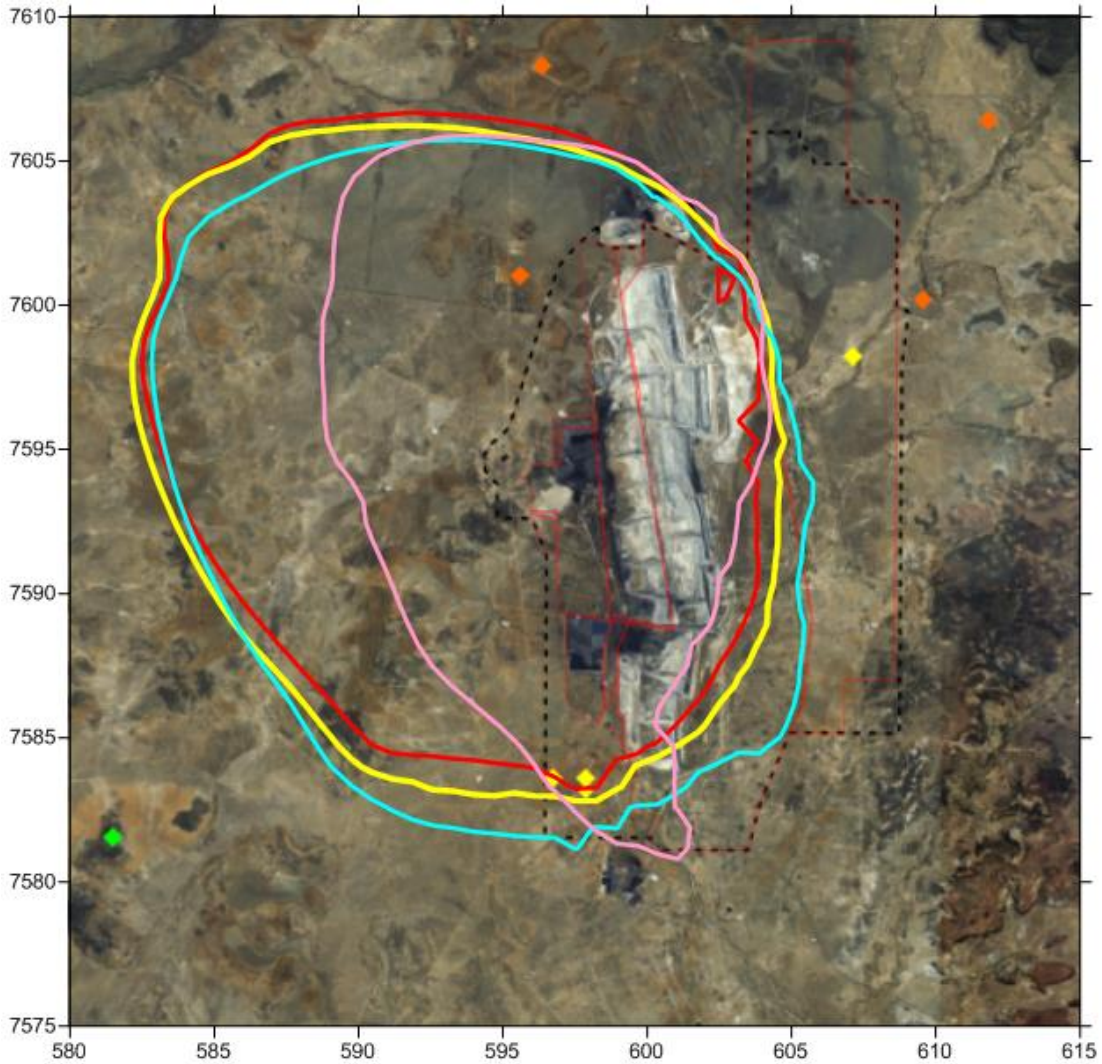
### N.3.2 Annual Average

**Figure 43: Particulate Matter as $PM_{2.5}$ – Red Hill Mine Only Impacts**



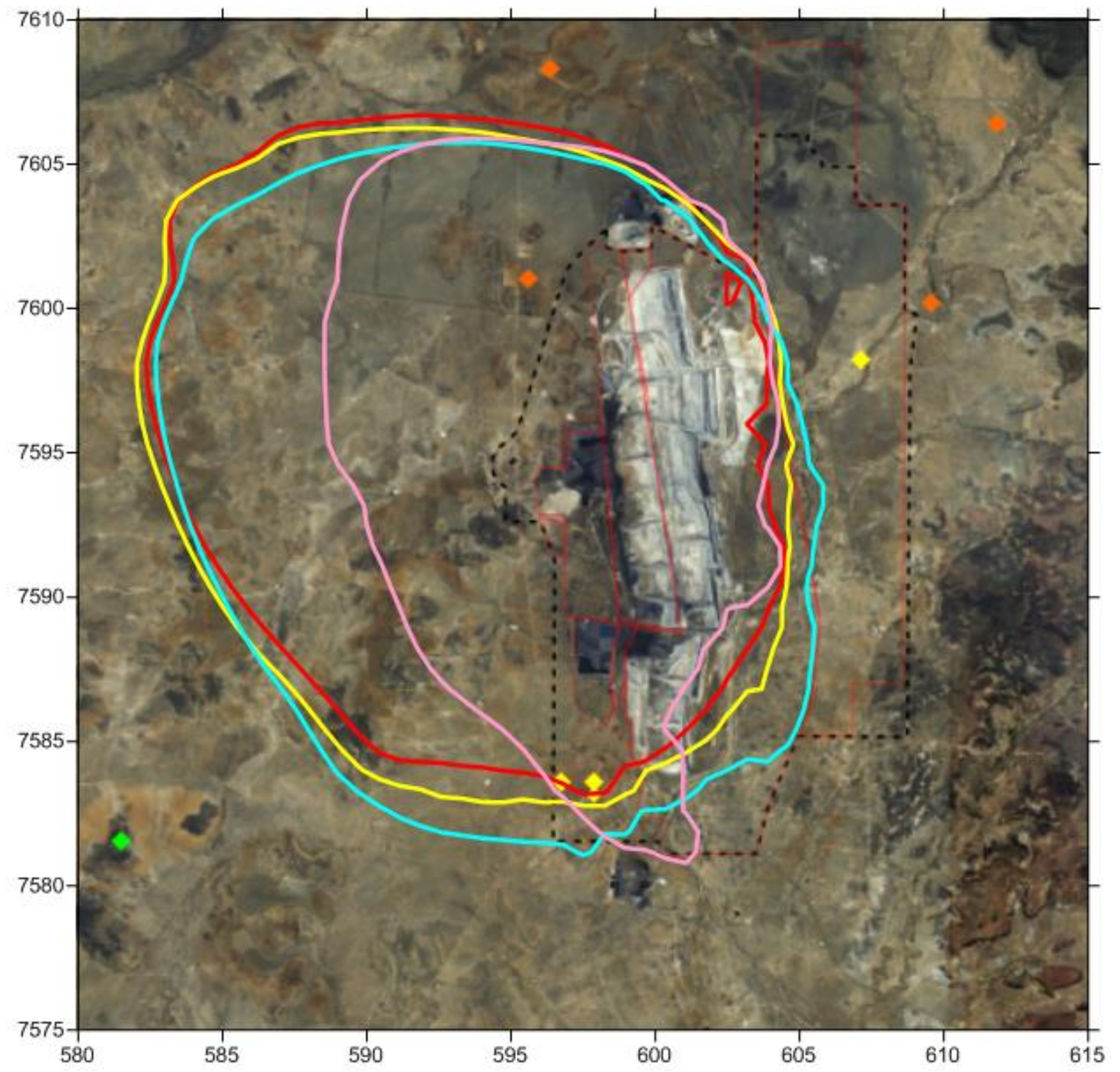

| | | | |
|---|---|---|---|
| **Scenario:** Red Hill Mine only | | **Mines included:** RHM | |
| **Pollutant:** | $PM_{2.5}$ | **Averaging Period:** | Annual |
| **Background level:** | Not included | **Rank:** | Maximum |
| **Project Goal:** | 8 µg/m$^3$ | **Contour level(s):** | 5 µg/m$^3$ and 8 µg/m$^3$ |
| **Contour Legend:** Red: 8 µg/m$^3$, Yellow: 5 µg/m$^3$ | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 44: Particulate Matter as $PM_{2.5}$ - Existing Mining**



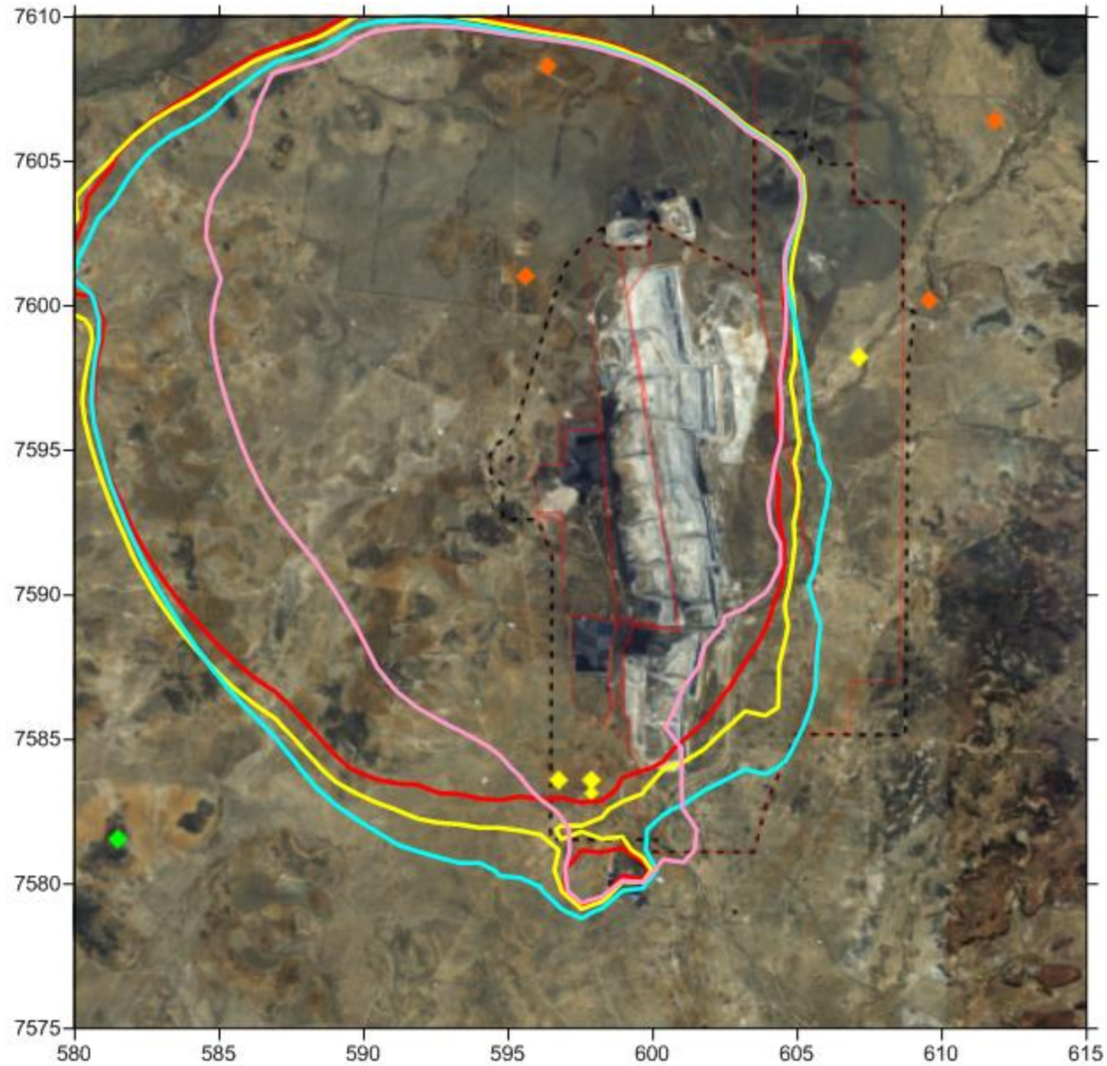

| | | | |
|---|---|---|---|
| **Scenario:** Existing Mining | | **Mines included:** GRM, BRM | |
| **Pollutant:** | $PM_{2.5}$ | **Averaging Period:** | Annual |
| **Background level:** | 6.6 µg/m$^3$ | **Rank:** | Maximum |
| **Project Goal:** | 8 µg/m$^3$ | **Contour level(s):** | 8 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 45: Particulate Matter as $PM_{2.5}$ - Future Mining**




| | | | |
|---|---|---|---|
| **Scenario:** Future Mining | | **Mines included:** GRM, BRM, RHM | |
| **Pollutant:** | $PM_{2.5}$ | **Averaging Period:** | Annual |
| **Background level:** | 6.6 µg/m$^3$ | **Rank:** | Maximum |
| **Project Goal:** | 8 µg/m$^3$ | **Contour level(s):** | 8 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 46: Particulate Matter as $PM_{2.5}$ - Cumulative Future Mining**

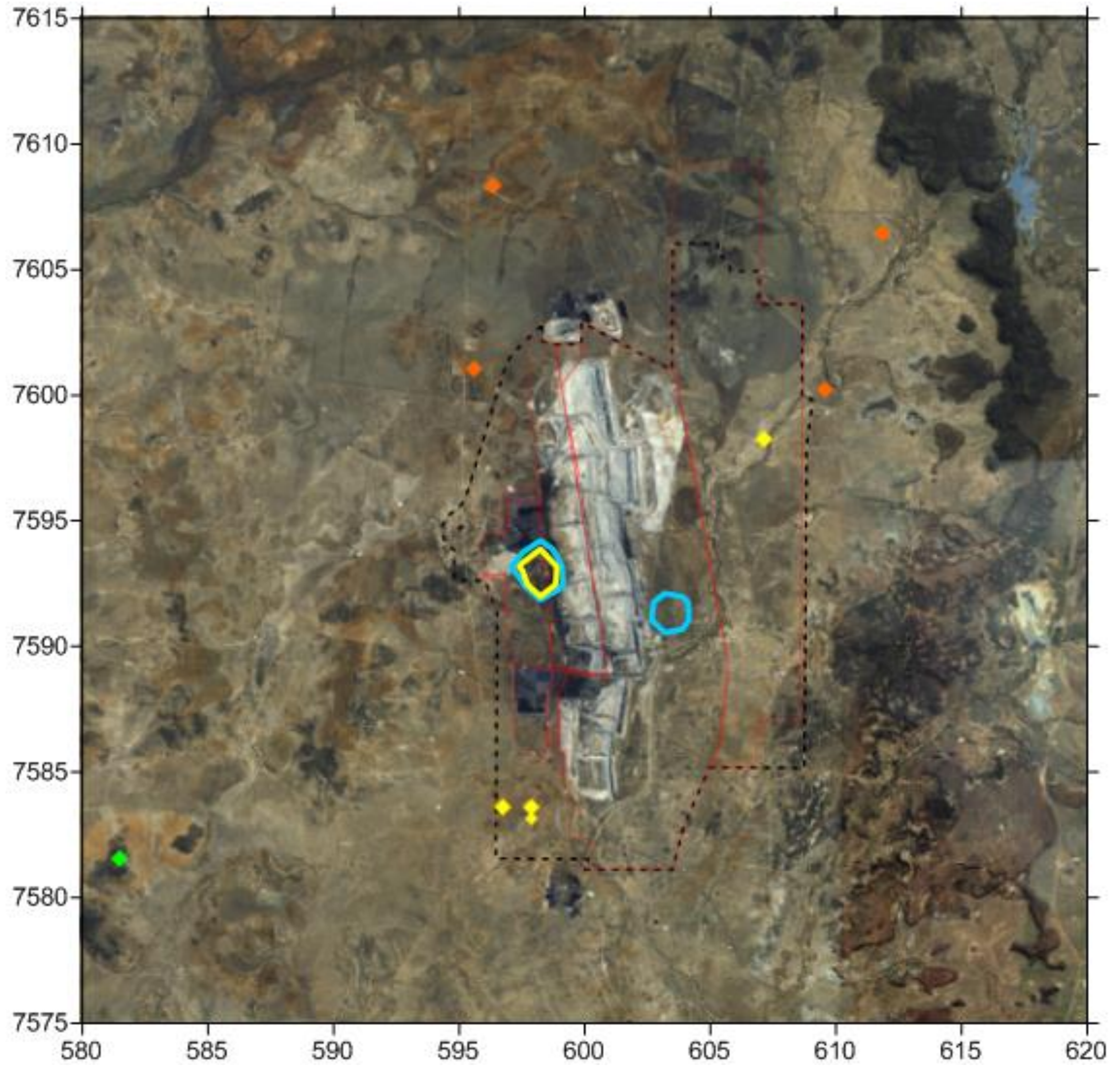



| | | | |
|---|---|---|---|
| **Scenario:** Cumulative Future Mining | | **Mines included:** GRM, BRM, RHM, Eaglefield, Grosvenor, Moranbah North Mine | |
| **Pollutant:** | $PM_{2.5}$ | **Averaging Period:** | Annual |
| **Background level:** | 6.6 µg/m$^3$ | **Rank:** | Maximum |
| **Project Goal:** | 8 µg/m$^3$ | **Contour level(s):** | 8 µg/m$^3$ |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

## N.4 Dust Deposition

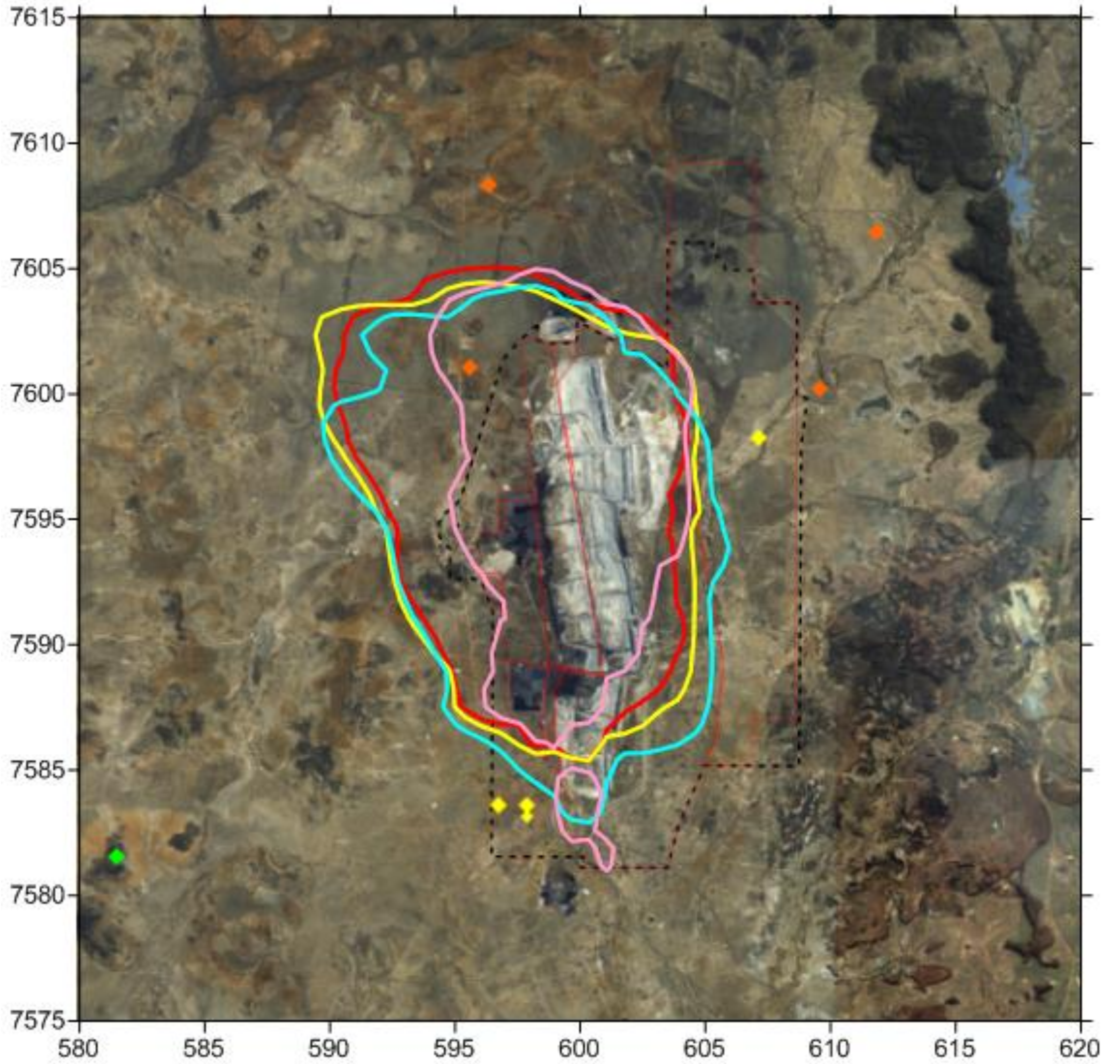
### N.4.1 Monthly Average

**Figure 47: Dust Deposition – Red Hill Mine Only Impacts**



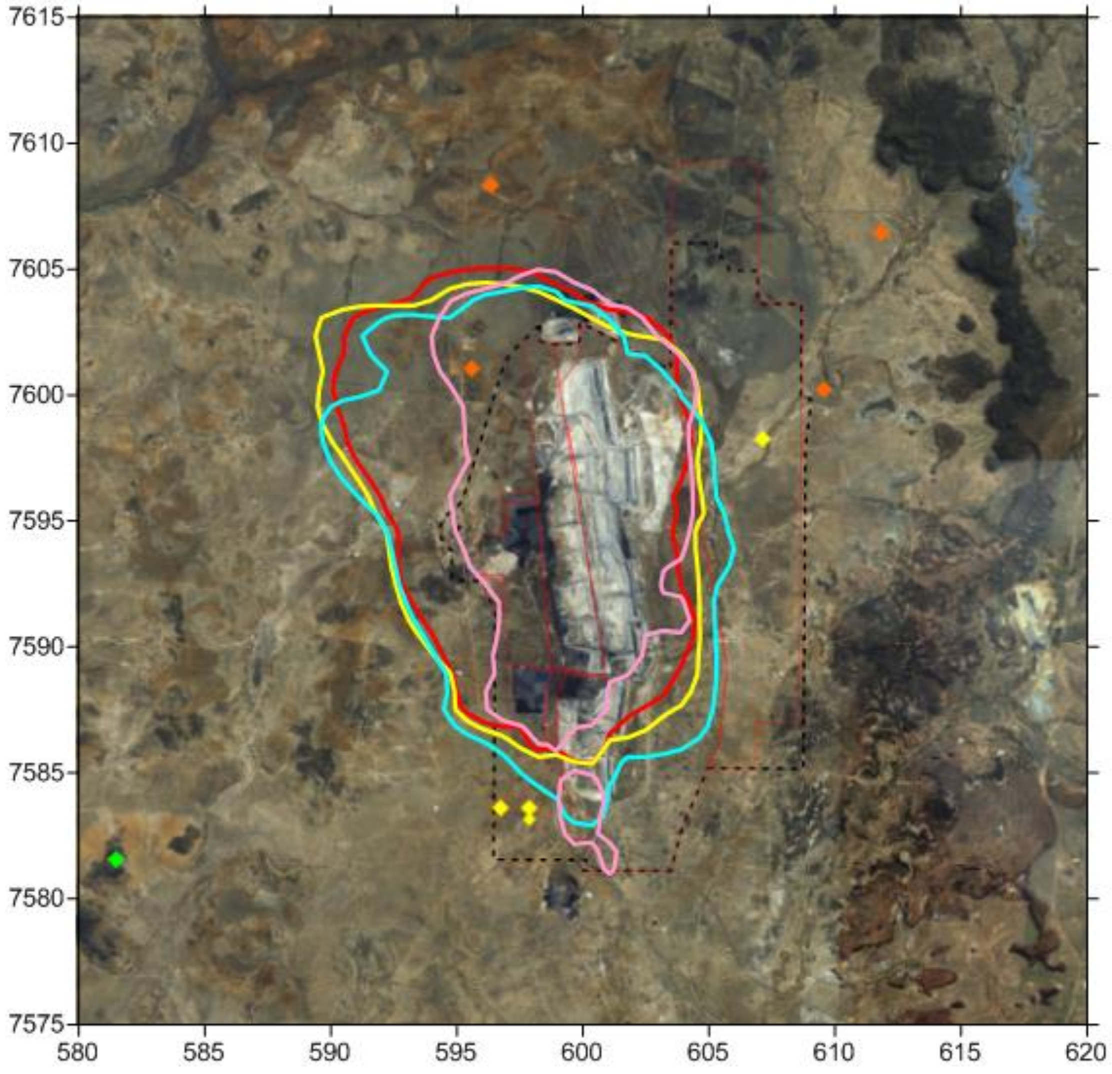

| | | | |
|---|---|---|---|
| **Scenario:** Red Hill Mine only | | **Mines included:** RHM | |
| **Pollutant:** | Dust Deposition | **Averaging Period:** | Monthly |
| **Background level:** | Not included | **Rank:** | Maximum |
| **Project Goal:** | 120 mg/m$^2$/day | **Contour level(s):** | 0.5, 1, 120 mg/m$^2$/day |
| **Contour Legend:** Red: 120 mg/m$^2$/day , Cyan: 0.5 mg/m$^2$/day, Yellow: 1 mg/m$^2$/day | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 48: Dust Deposition - Existing Mining**



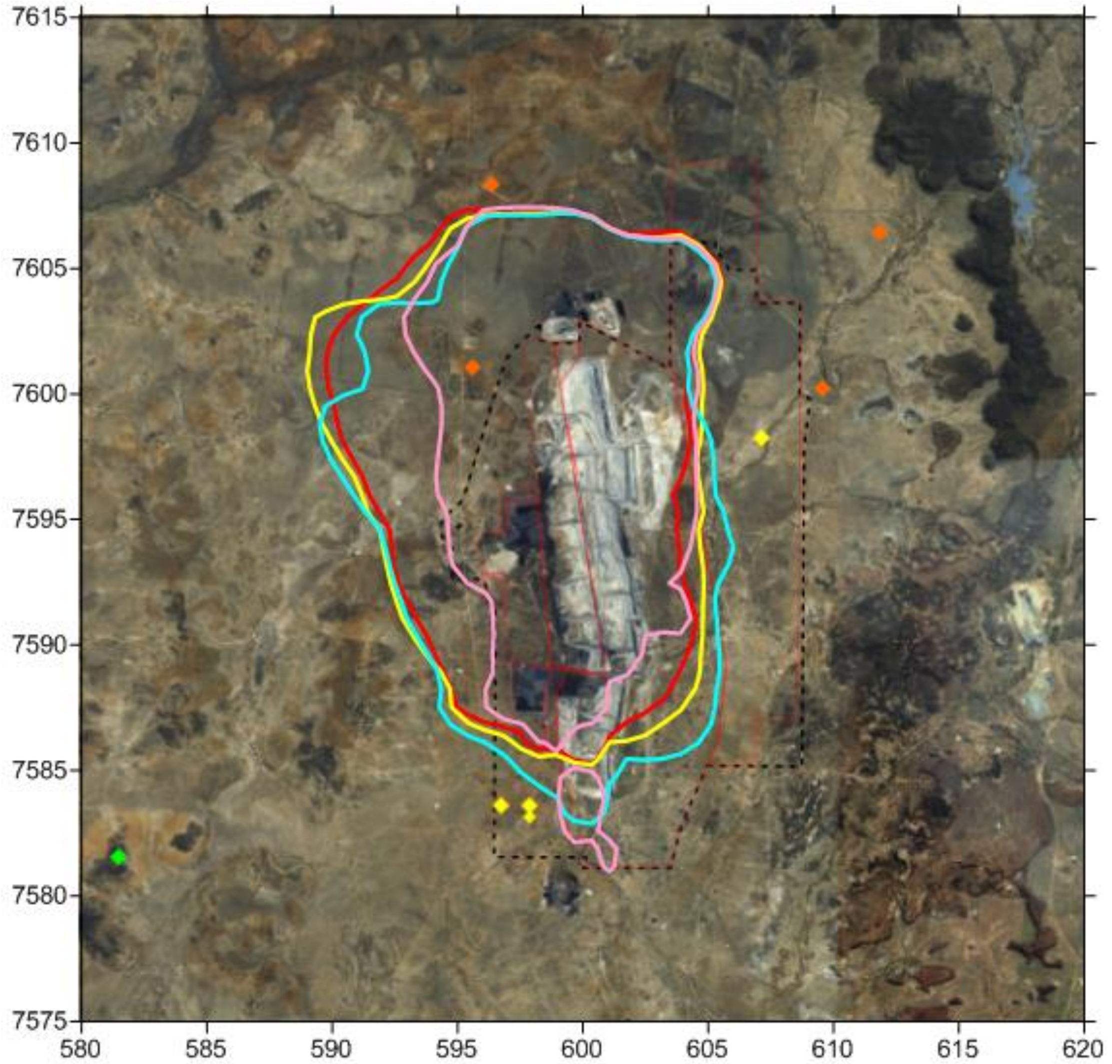

| **Scenario:** Existing Mining | | **Mines included:** GRM, BRM | |
|---|---|---|---|
| **Pollutant:** | Dust Deposition | **Averaging Period:** | Monthly |
| **Background level:** | 50 mg/m$^2$/day | **Rank:** | Maximum |
| **Project Goal:** | 120 mg/m$^2$/day | **Contour level(s):** | 120 mg/m$^2$/day |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 49: Dust Deposition - Future Mining**




| | | | |
|---|---|---|---|
| **Scenario:** Future Mining | | **Mines included:** GRM, BRM, RHM | |
| **Pollutant:** | Dust Deposition | **Averaging Period:** | Monthly |
| **Background level:** | 50 mg/m$^2$/day | **Rank:** | Maximum |
| **Project Goal:** | 120 mg/m$^2$/day | **Contour level(s):** | 120 mg/m$^2$/day |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

**Figure 50: Dust Deposition - Cumulative Future Mining**

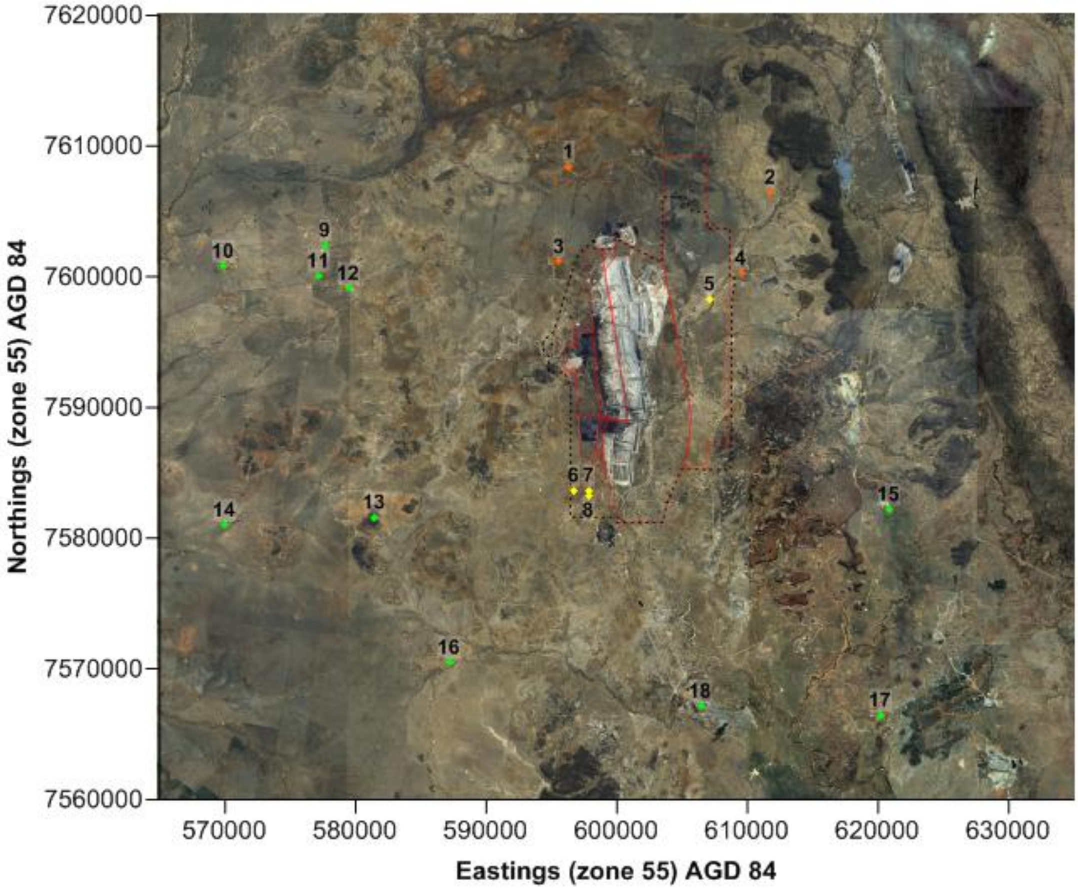



| | | | |
|---|---|---|---|
| **Scenario:** Cumulative Future Mining | | **Mines included:** GRM, BRM, RHM, Eaglefield, Grosvenor, Moranbah North Mine | |
| **Pollutant:** | Dust Deposition | **Averaging Period:** | Monthly |
| **Background level:** | 50 mg/m$^2$/day | **Rank:** | Maximum |
| **Project Goal:** | 120 mg/m$^2$/day | **Contour level(s):** | 120 mg/m$^2$/day |
| **Contour Legend:** Red: FY2015, Yellow: FY2030, Cyan: FY2040, Pink: FY2050 | | | |
| **Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner | | | |

# Appendix O Results at Receptor Locations

Presented in this Appendix are the results of the dispersion modelling at the location of the receptors (Figure 51, see also Appendix E).

**Figure 51: Receptor Locations**




**Receptor Legend:** Orange:- BMA/BMC controlled, Green:- Privately owned homesteads, Yellow:- Privately owned homesteads – subject to negotiation with landowner

Results are presented for the Red Hill Mine only, Existing Mining (FY2015, FY2030, FY2040, FY2050), Future Mining (FY2015, FY2030, FY2040, FY2050) and Cumulative Future Mining (FY2015, FY2030, FY2040, FY2050) for the following:

- A summary of the receptors for which exceedences are predicted
- Annual average ground-level concentration of TSP (maximum and number of exceedences)
- 24-hour average ground-level concentration of $PM_{10}$ (maximum, 5th highest per annum, background creep, and number of exceedences)

- 24-hour average ground-level concentration of $PM_{2.5}$ (maximum, 5th highest per annum, background creep, and number of exceedences per year)
- Annual average ground-level concentration of $PM_{2.5}$ (maximum and number of exceedences per year)
- Monthly average dust deposition (maximum and number of exceedences per year)

Note that background creep is defined here as the incremental contribution to the $70^{th}$ percentile 24-hour average concentration of $PM_{10}$ and/or $PM_{2.5}$.

Note that contour plots for the incremental contribution to the $70^{th}$ percentile 24-hour average concentration of $PM_{10}$ (i.e. background creep) for the Existing Mining Scenario and Cumulative Future Mining Scenario are presented in the Red Hill Mining Lease Project EIS Chapter 11*: Air Quality*.

**Table 21: Receptor Numbers Exceeding Pollutant Criteria**

| Scenario | RHM Only | Existing Mining | | | | Future Mining | | | | Cumulative Future Mining | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pollutant** | **Worst Case** | **2015** | **2030** | **2040** | **2050** | **2015** | **2030** | **2040** | **2050** | **2015** | **2030** | **2040** | **2050** |
| **TSP** Annual average | None | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **$PM_{10}$** 24-hour average | None | 1, 2, 3, 4, 5, 6, 7, 8, 9,11, 12,13, 18 | 1, 2, 3, 4, 5, 6, 7, 8, 9,11, 12,13, 18 | 1, 2, 3, 4, 5, 6, 7, 8, 9,11, 12,13, 16, 18 | 1, 2, 3, 4, 5, 6, 7, 8, 12 | 1, 2, 3, 4, 5, 6, 7, 8, 9,11, 12,13, 18 | 1, 2, 3, 4, 5, 6, 7, 8, 9,11, 12,13, 18 | 1, 2, 3, 4, 5, 6, 7, 8, 9,11, 12,13, 16, 18 | 1, 2, 3, 4, 5, 6, 7, 8, 12 | 1, 2, 3, 4, 5, 6, 7, 8, 9,10, 11, 12,13, 15, 18 | 1, 2, 3, 4, 5, 6, 7, 8, 9,10, 11, 12,13, 15, 16, 18 | 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12,13, 15, 16, 18 | 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13 |
| **$PM_{2.5}$** 24-hour average | None | 3, 5 | 3, 5, 7 | 3, 5, 7, 8 | 3 | 3, 5 | 3, 5, 7 | 3, 5, 7, 8 | 3 | 1, 2, 3, 5 | 1,3, 5, 7, 8 | 1, 3, 5, 6, 7, 8 | 1,3 |
| **$PM_{2.5}$** Annual average | None | 3, 6, 7 | 3, 6, 7, 8 | 3, 6, 7, 8 | 3, 6, 7, 8 | 3, 6, 7, 8 | 3, 6, 7, 8 | 3, 6, 7, 8 | 3, 6, 7, 8 | 1, 3, 6, 7, 8 | 1, 3, 6, 7, 8, 12 | 1, 3, 6, 7, 8 | 1, 3, 6, 7, 8 |
| **Dust Deposition** Monthly average | None | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

## O.1 Total Suspended Particulates Annual Averaging Period

**Table 22: Red Hill Mine**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RHM Only GLC (max) | µg/m³ | 0.1 | 0.0 | 0.2 | 0.0 | 0.1 | 0.4 | 0.4 | 0.4 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total GLC (max) | µg/m³ | 39.9 | 39.8 | 40.0 | 39.8 | 39.9 | 40.2 | 40.2 | 40.2 | 39.9 | 39.9 | 39.9 | 40.0 | 39.9 | 39.8 | 39.8 | 39.8 | 39.8 | 39.8 |
| Exceedences | #/year | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 23: Existing Mining**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | µg/m³ | 47.2 | 41.2 | **128.8** | 42.1 | 43.7 | 54.1 | 55.9 | 53.6 | 48.1 | 43.9 | 48.0 | 50.3 | 45.4 | 41.6 | 40.2 | 41.7 | 40.2 | 41.1 |
| FY2030 | µg/m³ | 46.7 | 41.3 | **111.6** | 42.6 | 44.9 | 57.3 | 59.7 | 57.0 | 48.5 | 44.2 | 48.4 | 50.8 | 46.0 | 41.8 | 40.3 | 42.0 | 40.2 | 41.3 |
| FY2040 | µg/m³ | 45.8 | 41.2 | **94.2** | 42.8 | 45.7 | 64.5 | 69.9 | 65.2 | 48.1 | 44.1 | 48.1 | 50.1 | 46.3 | 41.9 | 40.3 | 42.4 | 40.3 | 41.5 |
| FY2050 | µg/m³ | 45.7 | 40.7 | **93.8** | 41.2 | 42.2 | 55.4 | 63.6 | 60.8 | 44.2 | 42.1 | 44.2 | 45.4 | 42.9 | 40.8 | 40.1 | 41.0 | 40.0 | 40.6 |
| Exceedences FY2015 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2030 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 24: Future Mining**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | µg/m³ | 47.3 | 41.2 | **129.1** | 42.1 | 43.8 | 54.4 | 56.3 | 53.9 | 48.2 | 44.0 | 48.1 | 50.5 | 45.6 | 41.6 | 40.2 | 41.8 | 40.2 | 41.2 |
| FY2030 | µg/m³ | 46.7 | 41.3 | **111.9** | 42.7 | 44.9 | 57.7 | 60.1 | 57.4 | 48.6 | 44.3 | 48.5 | 50.9 | 46.2 | 41.8 | 40.3 | 42.1 | 40.2 | 41.3 |
| FY2040 | µg/m³ | 45.9 | 41.2 | **94.5** | 42.9 | 45.8 | 64.9 | 70.3 | 65.6 | 48.2 | 44.2 | 48.2 | 50.3 | 46.5 | 41.9 | 40.3 | 42.5 | 40.3 | 41.5 |
| FY2050 | µg/m³ | 45.8 | 40.7 | **94.1** | 41.3 | 42.3 | 55.8 | 64.0 | 61.2 | 44.4 | 42.2 | 44.3 | 45.6 | 43.1 | 40.9 | 40.1 | 41.1 | 40.0 | 40.6 |
| Exceedences FY2015 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2030 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 25: Cumulative Future Mining**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | µg/m³ | 59.3 | 41.9 | **152.5** | 42.8 | 45.2 | 56.6 | 58.3 | 56.1 | 50.8 | 45.2 | 50.5 | 53.5 | 46.9 | 42.1 | 40.4 | 42.4 | 40.3 | 41.6 |
| FY2030 | µg/m³ | 58.8 | 42.0 | **135.3** | 43.4 | 46.4 | 59.8 | 62.2 | 59.5 | 51.2 | 45.5 | 50.9 | 53.9 | 47.5 | 42.3 | 40.5 | 42.7 | 40.3 | 41.7 |
| FY2040 | µg/m³ | 57.9 | 41.9 | **117.9** | 43.5 | 47.3 | 67.0 | 72.4 | 67.8 | 50.7 | 45.5 | 50.6 | 53.3 | 47.8 | 42.4 | 40.5 | 43.0 | 40.4 | 41.9 |
| FY2050 | µg/m³ | 57.8 | 41.4 | **117.5** | 42.0 | 43.7 | 57.9 | 66.1 | 63.4 | 46.9 | 43.4 | 46.7 | 48.6 | 44.4 | 41.4 | 40.2 | 41.6 | 40.1 | 41.0 |
| Exceedences FY2015 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2030 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## O.2 Particulate Matter as $PM_{10}$ – Twenty Four-Hour Averaging Period

**Table 26: Red Hill Mine**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Only GLC (max) | µg/m$^3$ | 1.1 | 1.0 | 2.5 | 1.7 | 3.0 | 2.0 | 2.5 | 2.3 | 0.6 | 0.3 | 0.6 | 0.7 | 1.2 | 0.2 | 0.5 | 0.4 | 0.2 | 0.5 |
| Total GLC (max) | µg/m$^3$ | 30.7 | 30.6 | 32.1 | 31.3 | 32.6 | 31.6 | 32.1 | 31.9 | 30.2 | 29.9 | 30.2 | 30.3 | 30.8 | 29.8 | 30.1 | 30.0 | 29.8 | 30.1 |
| Project Only GLC (5th) | µg/m$^3$ | 0.7 | 0.4 | 1.8 | 0.7 | 1.1 | 1.7 | 2.0 | 1.8 | 0.5 | 0.3 | 0.5 | 0.6 | 0.8 | 0.2 | 0.2 | 0.3 | 0.1 | 0.3 |
| Total GLC (5th) | µg/m$^3$ | 30.3 | 30.0 | 31.4 | 30.3 | 30.7 | 31.3 | 31.6 | 31.4 | 30.1 | 29.9 | 30.1 | 30.2 | 30.4 | 29.8 | 29.8 | 29.9 | 29.7 | 29.9 |
| Background Creep | µg/m$^3$ | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.4 | 0.4 | 0.3 | 0.2 | 0.1 | 0.2 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Exceedences | #/year | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 27: Existing Mining**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | µg/m3 | **145** | **104** | **358** | **133** | **159** | **114** | **137** | **126** | **63** | 47 | **66** | **75** | **65** | 44 | **50** | 48 | 39 | **56** |
| FY2030 | µg/m3 | **136** | **106** | **330** | **153** | **193** | **132** | **160** | **143** | **64** | **53** | **68** | **79** | **67** | 46 | **53** | **51** | 40 | **56** |
| FY2040 | µg/m3 | **121** | **95** | **286** | **158** | **224** | **161** | **189** | **170** | **61** | **51** | **64** | **74** | **70** | 45 | **55** | **53** | 41 | **57** |
| FY2050 | µg/m3 | **105** | **80** | **177** | **103** | **120** | **82** | **100** | **91** | 48 | 41 | 48 | **52** | 47 | 39 | 39 | 40 | 34 | 41 |
| Total GLC (5th) FY2015 | µg/m3 | **103** | **58** | **244** | **76** | **95** | **98** | **115** | **105** | **56** | 43 | **58** | **67** | **58** | 38 | 37 | 43 | 34 | 43 |
| FY2030 | µg/m3 | **98** | **55** | **235** | **86** | **112** | **114** | **134** | **122** | **58** | 44 | **59** | **67** | **62** | 39 | 38 | 45 | 34 | 44 |
| FY2040 | µg/m3 | **88** | **53** | **175** | **81** | **119** | **140** | **158** | **144** | **55** | 44 | **57** | **63** | **62** | 39 | 38 | 46 | 35 | 46 |
| FY2050 | µg/m3 | **78** | **50** | **153** | **57** | **64** | **76** | **86** | **80** | 44 | 37 | 44 | 48 | 44 | 34 | 34 | 37 | 32 | 37 |
| Background Creep FY2015 | µg/m3 | 0 | 0 | 66 | 0 | 0 | 6 | 4 | 3 | 9 | 5 | 9 | 12 | 5 | 2 | 0 | 1 | 0 | 0 |
| FY2030 | µg/m3 | 0 | 0 | 56 | 0 | 0 | 7 | 5 | 4 | 10 | 5 | 10 | 12 | 6 | 2 | 0 | 1 | 0 | 0 |
| FY2040 | µg/m3 | 0 | 0 | 42 | 0 | 0 | 17 | 16 | 11 | 10 | 5 | 10 | 12 | 7 | 2 | 0 | 1 | 0 | 0 |
| FY2050 | µg/m3 | 0 | 0 | 39 | 0 | 0 | 11 | 16 | 14 | 5 | 3 | 5 | 6 | 3 | 1 | 0 | 1 | 0 | 0 |
| Exceedences FY2015 | #/year | 36 | 6 | 222 | 9 | 13 | 70 | 69 | 65 | 23 | 0 | 24 | 45 | 29 | 0 | 0 | 0 | 0 | 1 |

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY2030 | #/year | 37 | 7 | 192 | 10 | 15 | 74 | 76 | 71 | 29 | 0 | 28 | 52 | 35 | 0 | 0 | 0 | 0 | 1 |
| FY2040 | #/year | 34 | 6 | 182 | 11 | 19 | 99 | 99 | 91 | 26 | 0 | 25 | 44 | 33 | 0 | 0 | 1 | 0 | 1 |
| FY2050 | #/year | 31 | 5 | 193 | 6 | 9 | 63 | 83 | 76 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 28: Future Mining**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | µg/m3 | **146** | **105** | **359** | **134** | **160** | **116** | **138** | **127** | **64** | 47 | **66** | **76** | **65** | 44 | **50** | 49 | 39 | **56** |
| FY2030 | µg/m3 | **137** | **107** | **331** | **154** | **194** | **134** | **161** | **144** | **64** | **53** | **68** | **79** | **68** | 46 | **53** | **51** | 40 | **56** |
| FY2040 | µg/m3 | **123** | **96** | **286** | **160** | **226** | **163** | **191** | **172** | **61** | **52** | **65** | **74** | **71** | 45 | **55** | **54** | 41 | **57** |
| FY2050 | µg/m3 | **106** | **81** | **177** | **103** | **121** | **84** | **101** | **93** | 48 | 42 | 48 | **53** | 48 | 39 | 39 | 41 | 34 | 42 |
| Total GLC (5th) FY2015 | µg/m3 | **104** | **58** | **245** | **77** | **96** | **99** | **116** | **106** | **56** | 43 | **58** | **67** | **59** | 38 | 37 | 43 | 34 | 43 |
| FY2030 | µg/m3 | **99** | **55** | **236** | **86** | **112** | **115** | **135** | **123** | **58** | 45 | **59** | **68** | **62** | 39 | 38 | 45 | 34 | 44 |
| FY2040 | µg/m3 | **89** | **53** | **177** | **81** | **119** | **141** | **160** | **146** | **56** | 44 | **58** | **64** | **62** | 39 | 39 | 47 | 35 | 46 |
| FY2050 | µg/m3 | **78** | **50** | **153** | **59** | **66** | **77** | **87** | **81** | 44 | 37 | 44 | 48 | 45 | 34 | 34 | 37 | 32 | 37 |
| Background Creep FY2015 | µg/m3 | 0 | 0 | 66 | 0 | 0 | 7 | 5 | 4 | 10 | 5 | 9 | 12 | 5 | 2 | 0 | 1 | 0 | 0 |
| FY2030 | µg/m3 | 0 | 0 | 56 | 0 | 0 | 8 | 5 | 5 | 10 | 5 | 10 | 13 | 6 | 2 | 0 | 1 | 0 | 0 |
| FY2040 | µg/m3 | 0 | 0 | 42 | 0 | 0 | 17 | 16 | 11 | 10 | 5 | 10 | 12 | 7 | 2 | 0 | 1 | 0 | 0 |
| FY2050 | µg/m3 | 0 | 0 | 39 | 0 | 0 | 12 | 16 | 15 | 5 | 3 | 5 | 6 | 3 | 1 | 0 | 1 | 0 | 0 |
| Exceedences FY2015 | #/year | 36 | 6 | 222 | 9 | 13 | 72 | 69 | 66 | 24 | 0 | 25 | 46 | 30 | 0 | 0 | 0 | 0 | 1 |
| FY2030 | #/year | 37 | 7 | 192 | 10 | 16 | 77 | 78 | 72 | 31 | 0 | 29 | 53 | 36 | 0 | 0 | 0 | 0 | 1 |
| FY2040 | #/year | 34 | 6 | 183 | 11 | 19 | 100 | 100 | 92 | 27 | 0 | 26 | 46 | 35 | 0 | 0 | 1 | 0 | 2 |
| FY2050 | #/year | 32 | 5 | 194 | 6 | 9 | 66 | 85 | 79 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 29: Cumulative Future Mining**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | $\mu g/m^3$ | 208 | 174 | 360 | 154 | 177 | 128 | 157 | 144 | 74 | 51 | 73 | 83 | 73 | 46 | 53 | 53 | 41 | 57 |
| FY2030 | $\mu g/m^3$ | 203 | 161 | 332 | 163 | 199 | 144 | 174 | 155 | 75 | 53 | 75 | 85 | 75 | 48 | 56 | 56 | 42 | 58 |
| FY2040 | $\mu g/m^3$ | 194 | 150 | 286 | 160 | 226 | 165 | 201 | 181 | 69 | 52 | 71 | 80 | 73 | 46 | 58 | 57 | 42 | 59 |
| FY2050 | $\mu g/m^3$ | 195 | 164 | 235 | 134 | 137 | 94 | 114 | 105 | 61 | 44 | 58 | 64 | 58 | 41 | 45 | 45 | 36 | 47 |
| Total GLC ($5^{th}$) FY2015 | $\mu g/m^3$ | 153 | 80 | 256 | 87 | 104 | 108 | 127 | 117 | 64 | 47 | 65 | 75 | 66 | 40 | 40 | 47 | 35 | 47 |
| FY2030 | $\mu g/m^3$ | 150 | 82 | 240 | 93 | 121 | 122 | 145 | 131 | 65 | 48 | 67 | 75 | 68 | 41 | 41 | 49 | 36 | 48 |
| FY2040 | $\mu g/m^3$ | 140 | 77 | 193 | 92 | 127 | 144 | 168 | 151 | 62 | 47 | 63 | 70 | 66 | 41 | 41 | 50 | 36 | 50 |
| FY2050 | $\mu g/m^3$ | 143 | 70 | 205 | 67 | 82 | 82 | 97 | 90 | 55 | 41 | 53 | 60 | 52 | 37 | 37 | 41 | 33 | 41 |
| Background Creep FY2015 | $\mu g/m^3$ | 7 | 0 | 89 | 0 | 0 | 7 | 6 | 6 | 13 | 6 | 12 | 16 | 6 | 2 | 0 | 1 | 0 | 0 |
| FY2030 | $\mu g/m^3$ | 7 | 0 | 78 | 0 | 0 | 9 | 7 | 7 | 13 | 7 | 13 | 16 | 7 | 2 | 0 | 1 | 0 | 0 |
| FY2040 | $\mu g/m^3$ | 7 | 0 | 68 | 0 | 0 | 19 | 17 | 13 | 13 | 7 | 13 | 16 | 8 | 3 | 0 | 1 | 0 | 0 |
| FY2050 | $\mu g/m^3$ | 6 | 0 | 61 | 0 | 0 | 13 | 17 | 16 | 8 | 4 | 8 | 10 | 4 | 1 | 0 | 1 | 0 | 0 |
| Exceedences FY2015 | #/year | 75 | 8 | 275 | 12 | 18 | 75 | 72 | 69 | 49 | 1 | 47 | 78 | 41 | 0 | 1 | 0 | 0 | 2 |
| FY2030 | #/year | 75 | 9 | 264 | 13 | 20 | 80 | 79 | 75 | 54 | 2 | 52 | 83 | 46 | 0 | 1 | 2 | 0 | 4 |
| FY2040 | #/year | 74 | 10 | 244 | 14 | 23 | 105 | 102 | 93 | 48 | 0 | 48 | 74 | 48 | 0 | 2 | 5 | 0 | 5 |
| FY2050 | #/year | 73 | 7 | 238 | 9 | 15 | 74 | 91 | 84 | 14 | 0 | 14 | 32 | 9 | 0 | 0 | 0 | 0 | 0 |

## O.3 Particulate Matter as $PM_{2.5}$ – Twenty Four-Hour Averaging Period

**Table 30: Red Hill Mine**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Only GLC (max) | µg/m³ | 0.1 | 0.1 | 0.3 | 0.2 | 0.4 | 0.2 | 0.3 | 0.3 | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 |
| Total GLC (max) | µg/m³ | 7.1 | 7.1 | 7.3 | 7.2 | 7.4 | 7.2 | 7.3 | 7.3 | 7.1 | 7.0 | 7.1 | 7.1 | 7.1 | 7.0 | 7.1 | 7.0 | 7.0 | 7.1 |
| Project Only GLC (5th) | µg/m³ | 0.1 | 0.0 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total GLC (5th) | µg/m³ | 7.1 | 7.0 | 7.2 | 7.1 | 7.1 | 7.2 | 7.2 | 7.2 | 7.1 | 7.0 | 7.1 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| Background Creep | µg/m³ | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Exceedences | #/year | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 31: Existing Mining**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | µg/m³ | 22.6 | 16.2 | **49.1** | 21.9 | **30.2** | 19.5 | 23.7 | 22.0 | 10.8 | 9.7 | 11.0 | 12.1 | 11.0 | 9.0 | 9.1 | 9.3 | 8.2 | 10.6 |
| FY2030 | µg/m³ | 20.6 | 16.4 | **43.3** | 24.9 | **31.6** | 21.0 | **27.6** | **25.6** | 11.3 | 10.6 | 11.7 | 12.4 | 11.4 | 9.2 | 9.4 | 9.7 | 8.3 | 10.6 |
| FY2040 | µg/m³ | 19.0 | 15.9 | **49.7** | 22.5 | **32.2** | **25.2** | **27.8** | **26.5** | 11.0 | 10.3 | 11.2 | 11.8 | 12.0 | 9.2 | 9.6 | 9.8 | 8.3 | 10.8 |
| FY2050 | µg/m³ | 17.8 | 13.6 | **30.4** | 20.3 | 21.5 | 14.0 | 17.2 | 16.3 | 9.2 | 8.8 | 9.2 | 9.6 | 8.9 | 8.3 | 7.9 | 8.3 | 7.5 | 8.5 |
| Total GLC (5th) FY2015 | µg/m³ | 16.7 | 10.6 | **40.6** | 13.5 | 17.1 | 16.6 | 19.1 | 17.9 | 10.1 | 8.7 | 10.3 | 11.1 | 10.2 | 8.0 | 7.9 | 8.7 | 7.6 | 8.8 |
| FY2030 | µg/m³ | 15.9 | 10.2 | **36.8** | 14.8 | 19.6 | 18.6 | 21.4 | 19.7 | 10.3 | 8.8 | 10.3 | 11.3 | 10.5 | 8.1 | 7.9 | 8.8 | 7.6 | 9.0 |
| FY2040 | µg/m³ | 14.6 | 9.9 | **26.4** | 14.4 | 20.0 | 21.1 | 24.6 | 22.8 | 10.0 | 8.8 | 10.2 | 10.8 | 10.6 | 8.2 | 8.0 | 9.0 | 7.7 | 9.2 |
| FY2050 | µg/m³ | 14.2 | 9.6 | **26.4** | 10.6 | 12.4 | 12.9 | 14.5 | 13.8 | 8.7 | 7.9 | 8.7 | 9.1 | 8.6 | 7.5 | 7.5 | 7.9 | 7.3 | 8.0 |
| Background Creep FY2015 | µg/m³ | 0.0 | 0.0 | 12.6 | 0.0 | 0.0 | 0.8 | 0.6 | 0.4 | 1.3 | 0.6 | 1.2 | 1.5 | 0.6 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 |
| FY2030 | µg/m³ | 0.0 | 0.0 | 10.4 | 0.0 | 0.0 | 1.0 | 0.8 | 0.6 | 1.4 | 0.6 | 1.3 | 1.6 | 0.7 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 |
| FY2040 | µg/m³ | 0.0 | 0.0 | 7.5 | 0.0 | 0.0 | 2.6 | 2.7 | 2.0 | 1.3 | 0.6 | 1.3 | 1.5 | 0.8 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 |
| FY2050 | µg/m³ | 0.0 | 0.0 | 7.4 | 0.0 | 0.0 | 1.9 | 3.1 | 2.8 | 0.6 | 0.3 | 0.6 | 0.8 | 0.4 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 |
| Exceedences FY2015 | #/year | 0 | 0 | 64 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY2030 | #/year | 0 | 0 | 40 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 0 | 0 | 10 | 0 | 3 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### Table 32: Future Mining

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | µg/m$^3$ | 22.7 | 16.2 | **49.2** | 22.0 | **30.3** | 19.6 | 23.8 | 22.0 | 10.9 | 9.7 | 11.0 | 12.1 | 11.1 | 9.0 | 9.1 | 9.4 | 8.2 | 10.7 |
| FY2030 | µg/m$^3$ | 20.7 | 16.5 | **43.4** | 24.9 | **31.7** | 21.1 | **27.7** | **25.6** | 11.3 | 10.6 | 11.7 | 12.5 | 11.5 | 9.3 | 9.4 | 9.7 | 8.3 | 10.6 |
| FY2040 | µg/m$^3$ | 19.1 | 16.0 | **49.7** | 22.5 | **32.4** | **25.4** | **28.1** | **26.6** | 11.1 | 10.4 | 11.3 | 11.8 | 12.1 | 9.3 | 9.7 | 9.8 | 8.4 | 10.8 |
| FY2050 | µg/m$^3$ | 17.9 | 13.6 | **30.4** | 20.3 | 21.6 | 14.2 | 17.3 | 16.4 | 9.2 | 8.9 | 9.2 | 9.6 | 8.9 | 8.3 | 8.0 | 8.4 | 7.6 | 8.5 |
| Total GLC (5$^{th}$) FY2015 | µg/m$^3$ | 16.8 | 10.7 | **40.7** | 13.6 | 17.3 | 16.6 | 19.2 | 18.1 | 10.2 | 8.7 | 10.3 | 11.2 | 10.3 | 8.0 | 7.9 | 8.7 | 7.6 | 8.8 |
| FY2030 | µg/m$^3$ | 16.0 | 10.2 | **36.9** | 14.8 | 19.7 | 18.8 | 21.6 | 19.8 | 10.4 | 8.8 | 10.4 | 11.3 | 10.6 | 8.2 | 8.0 | 8.9 | 7.6 | 9.0 |
| FY2040 | µg/m$^3$ | 14.6 | 9.9 | **26.5** | 14.4 | 20.1 | 21.3 | 24.7 | 22.9 | 10.0 | 8.8 | 10.2 | 10.9 | 10.6 | 8.3 | 8.0 | 9.0 | 7.7 | 9.2 |
| FY2050 | µg/m$^3$ | 14.3 | 9.6 | **26.4** | 10.6 | 12.4 | 13.1 | 14.7 | 13.9 | 8.7 | 7.9 | 8.7 | 9.1 | 8.7 | 7.6 | 7.5 | 8.0 | 7.3 | 8.1 |
| Background Creep FY2015 | µg/m$^3$ | 0.0 | 0.0 | 12.6 | 0.0 | 0.0 | 0.8 | 0.6 | 0.5 | 1.3 | 0.6 | 1.2 | 1.6 | 0.6 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 |
| FY2030 | µg/m$^3$ | 0.0 | 0.0 | 10.4 | 0.0 | 0.0 | 1.1 | 0.8 | 0.7 | 1.4 | 0.7 | 1.3 | 1.6 | 0.7 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 |
| FY2040 | µg/m$^3$ | 0.0 | 0.0 | 7.5 | 0.0 | 0.0 | 2.6 | 2.8 | 2.0 | 1.3 | 0.6 | 1.3 | 1.6 | 0.8 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 |
| FY2050 | µg/m$^3$ | 0.0 | 0.0 | 7.5 | 0.0 | 0.0 | 1.9 | 3.1 | 2.8 | 0.7 | 0.3 | 0.7 | 0.8 | 0.4 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 |
| Exceedences FY2015 | #/year | 0 | 0 | 64 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2030 | #/year | 0 | 0 | 40 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 0 | 0 | 10 | 0 | 3 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 33: Cumulative Future Mining**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | µg/m³ | **28.6** | **25.3** | **49.3** | 22.1 | **30.3** | 21.3 | **25.4** | 23.6 | 12.0 | 9.7 | 11.9 | 13.1 | 11.7 | 9.3 | 9.4 | 9.9 | 8.3 | 10.8 |
| FY2030 | µg/m³ | **27.8** | 23.5 | **43.5** | 24.9 | **31.7** | 22.8 | **29.3** | **27.2** | 12.0 | 10.6 | 11.9 | 13.1 | 12.0 | 9.5 | 9.7 | 10.2 | 8.5 | 10.8 |
| FY2040 | µg/m³ | **26.7** | 22.1 | **49.7** | 22.6 | **32.5** | **25.6** | **29.4** | **28.1** | 11.3 | 10.4 | 11.5 | 12.5 | 12.1 | 9.4 | 9.9 | 10.4 | 8.5 | 10.9 |
| FY2050 | µg/m³ | **27.3** | 24.0 | **34.3** | 20.3 | 23.3 | 15.1 | 18.9 | 18.0 | 10.6 | 8.9 | 10.2 | 10.7 | 10.1 | 8.6 | 8.6 | 8.9 | 7.7 | 9.1 |
| Total GLC (5th) FY2015 | µg/m³ | 22.1 | 13.4 | **41.0** | 14.9 | 17.5 | 17.7 | 20.4 | 19.3 | 11.0 | 9.1 | 11.0 | 12.0 | 11.0 | 8.3 | 8.1 | 9.1 | 7.7 | 9.3 |
| FY2030 | µg/m³ | 21.7 | 13.8 | **37.3** | 16.4 | 20.3 | 19.5 | 22.7 | 20.8 | 11.0 | 9.2 | 11.1 | 12.1 | 11.2 | 8.4 | 8.3 | 9.3 | 7.7 | 9.4 |
| FY2040 | µg/m³ | 20.9 | 13.0 | **28.3** | 15.2 | 22.0 | 22.0 | **25.6** | 23.6 | 10.6 | 9.0 | 10.7 | 11.5 | 11.1 | 8.4 | 8.4 | 9.4 | 7.8 | 9.6 |
| FY2050 | µg/m³ | 21.2 | 11.8 | **31.5** | 12.2 | 14.9 | 13.9 | 15.8 | 14.9 | 9.8 | 8.4 | 9.7 | 10.4 | 9.5 | 7.8 | 7.8 | 8.4 | 7.4 | 8.4 |
| Background Creep FY2015 | µg/m³ | 1.1 | 0.0 | 15.5 | 0.0 | 0.0 | 1.0 | 0.8 | 0.8 | 1.6 | 0.8 | 1.6 | 2.0 | 0.7 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 |
| FY2030 | µg/m³ | 1.0 | 0.0 | 12.7 | 0.0 | 0.0 | 1.2 | 1.0 | 0.9 | 1.7 | 0.9 | 1.7 | 2.1 | 0.8 | 0.3 | 0.0 | 0.1 | 0.0 | 0.0 |
| FY2040 | µg/m³ | 1.0 | 0.0 | 10.8 | 0.0 | 0.0 | 2.8 | 2.9 | 2.1 | 1.7 | 0.9 | 1.6 | 2.0 | 1.0 | 0.3 | 0.0 | 0.2 | 0.0 | 0.0 |
| FY2050 | µg/m³ | 1.0 | 0.0 | 10.8 | 0.0 | 0.0 | 2.0 | 3.3 | 2.9 | 1.0 | 0.5 | 1.0 | 1.3 | 0.5 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 |
| Exceedences FY2015 | #/year | 2 | 0 | 86 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2030 | #/year | 1 | 0 | 57 | 0 | 3 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 1 | 0 | 26 | 0 | 4 | 1 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 1 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## O.4 Particulate Matter as $PM_{2.5}$ – Annual Averaging Period

**Table 34: Red Hill Mine**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Only GLC (max) | µg/m³ | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total GLC (max) | µg/m³ | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 | 6.6 |
| Exceedences | #/year | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 35: Existing Mining**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | µg/m³ | 7.3 | 6.7 | **15.5** | 6.8 | 7.0 | **8.0** | **8.2** | 8.0 | 7.4 | 7.0 | 7.4 | 7.7 | 7.2 | 6.8 | 6.6 | 6.8 | 6.6 | 6.7 |
| FY2030 | µg/m³ | 7.3 | 6.7 | **13.8** | 6.9 | 7.1 | **8.4** | **8.6** | **8.3** | 7.5 | 7.0 | 7.5 | 7.7 | 7.2 | 6.8 | 6.6 | 6.8 | 6.6 | 6.8 |
| FY2040 | µg/m³ | 7.2 | 6.7 | **12.0** | 6.9 | 7.2 | **9.1** | **9.6** | **9.1** | 7.4 | 7.0 | 7.4 | 7.6 | 7.3 | 6.8 | 6.7 | 6.9 | 6.6 | 6.8 |
| FY2050 | µg/m³ | 7.2 | 6.7 | **12.0** | 6.7 | 6.8 | **8.2** | **9.0** | **8.7** | 7.0 | 6.8 | 7.0 | 7.2 | 6.9 | 6.7 | 6.6 | 6.7 | 6.6 | 6.7 |
| Exceedences FY2015 | #/year | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2030 | #/year | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### Table 36: Future Mining

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | $\mu g/m^3$ | 7.4 | 6.7 | 15.5 | 6.8 | 7.0 | 8.1 | 8.2 | 8.0 | 7.4 | 7.0 | 7.4 | 7.7 | 7.2 | 6.8 | 6.6 | 6.8 | 6.6 | 6.7 |
| FY2030 | $\mu g/m^3$ | 7.3 | 6.7 | 13.8 | 6.9 | 7.1 | 8.4 | 8.6 | 8.4 | 7.5 | 7.0 | 7.5 | 7.7 | 7.2 | 6.8 | 6.7 | 6.8 | 6.6 | 6.8 |
| FY2040 | $\mu g/m^3$ | 7.2 | 6.7 | 12.1 | 6.9 | 7.2 | 9.1 | 9.7 | 9.2 | 7.4 | 7.0 | 7.4 | 7.6 | 7.3 | 6.8 | 6.7 | 6.9 | 6.6 | 6.8 |
| FY2050 | $\mu g/m^3$ | 7.2 | 6.7 | 12.0 | 6.7 | 6.8 | 8.2 | 9.0 | 8.7 | 7.1 | 6.8 | 7.1 | 7.2 | 6.9 | 6.7 | 6.6 | 6.7 | 6.6 | 6.7 |
| Exceedences FY2015 | #/year | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2030 | #/year | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### Table 37: Cumulative Future Mining

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | $\mu g/m^3$ | 8.6 | 6.8 | 17.9 | 6.9 | 7.1 | 8.3 | 8.5 | 8.2 | 7.7 | 7.1 | 7.7 | 8.0 | 7.3 | 6.8 | 6.7 | 6.9 | 6.6 | 6.8 |
| FY2030 | $\mu g/m^3$ | 8.5 | 6.8 | 16.1 | 7.0 | 7.3 | 8.6 | 8.8 | 8.6 | 7.7 | 7.2 | 7.7 | **8.0** | 7.4 | 6.8 | 6.7 | 6.9 | 6.7 | 6.8 |
| FY2040 | $\mu g/m^3$ | 8.4 | 6.8 | 14.4 | 7.0 | 7.3 | 9.3 | 9.9 | 9.4 | 7.7 | 7.2 | 7.7 | 7.9 | 7.4 | 6.9 | 6.7 | 6.9 | 6.7 | 6.8 |
| FY2050 | $\mu g/m^3$ | 8.4 | 6.8 | 14.4 | 6.8 | 7.0 | 8.4 | 9.2 | 9.0 | 7.3 | 7.0 | 7.3 | 7.5 | 7.1 | 6.8 | 6.6 | 6.8 | 6.6 | 6.7 |
| Exceedences FY2015 | #/year | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2030 | #/year | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## O.5 Dust Deposition – Monthly Average

**Table 38: Red Hill Mine**

| **Parameter** | **Units** | **R1** | **R2** | **R3** | **R4** | **R5** | **R6** | **R7** | **R8** | **R9** | **R10** | **R11** | **R12** | **R13** | **R14** | **R15** | **R16** | **R17** | **R18** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Only GLC (max) | mg/m$^2$/day | 0.2 | 0.1 | 0.5 | 0.2 | 0.3 | 0.5 | 0.6 | 0.5 | 0.3 | 0.2 | 0.3 | 0.4 | 0.2 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 |
| Total GLC (max) | mg/m$^2$/day | 50 | 50 | 51 | 50 | 50 | 51 | 51 | 51 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| Exceedences | #/year | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 39: Existing Mining**

| **Parameter** | **Units** | **R1** | **R2** | **R3** | **R4** | **R5** | **R6** | **R7** | **R8** | **R9** | **R10** | **R11** | **R12** | **R13** | **R14** | **R15** | **R16** | **R17** | **R18** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | mg/m$^2$/day | 75 | 56 | **243** | 60 | 67 | 75 | 79 | 76 | 69 | 63 | 69 | 71 | 60 | 56 | 52 | 54 | 52 | 55 |
| FY2030 | mg/m$^2$/day | 72 | 57 | **227** | 62 | 71 | 79 | 85 | 81 | 73 | 65 | 72 | 75 | 61 | 56 | 52 | 55 | 52 | 56 |
| FY2040 | mg/m$^2$/day | 72 | 56 | **214** | 62 | 75 | 90 | 97 | 90 | 72 | 65 | 71 | 74 | 62 | 56 | 53 | 55 | 52 | 56 |
| FY2050 | mg/m$^2$/day | 77 | 54 | **140** | 56 | 60 | 68 | 74 | 73 | 62 | 58 | 61 | 62 | 55 | 53 | 51 | 53 | 51 | 53 |
| Exceedences FY2015 | #/year | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2030 | #/year | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 40: Future Mining**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | $mg/m^2/day$ | 75 | 56 | **243** | 60 | 67 | 76 | 80 | 77 | 69 | 63 | 69 | 72 | 60 | 56 | 52 | 54 | 52 | 55 |
| FY2030 | $mg/m^2/day$ | 72 | 57 | **227** | 62 | 71 | 79 | 85 | 82 | 73 | 66 | 72 | 75 | 61 | 56 | 52 | 55 | 52 | 56 |
| FY2040 | $mg/m^2/day$ | 72 | 56 | **214** | 63 | 75 | 90 | 97 | 90 | 72 | 65 | 72 | 74 | 62 | 56 | 53 | 55 | 52 | 56 |
| FY2050 | $mg/m^2/day$ | 77 | 54 | **141** | 56 | 60 | 69 | 74 | 74 | 62 | 58 | 61 | 62 | 55 | 53 | 51 | 53 | 51 | 53 |
| Exceedences FY2015 | #/year | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2030 | #/year | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 41: Cumulative Future Mining**

| Parameter | Units | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | R15 | R16 | R17 | R18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total GLC (max) FY2015 | $mg/m^2/day$ | 93 | 58 | **246** | 61 | 69 | 78 | 82 | 79 | 70 | 64 | 70 | 73 | 61 | 56 | 53 | 55 | 52 | 56 |
| FY2030 | $mg/m^2/day$ | 90 | 59 | **231** | 62 | 72 | 82 | 88 | 84 | 74 | 66 | 74 | 76 | 62 | 56 | 53 | 56 | 52 | 57 |
| FY2040 | $mg/m^2/day$ | 90 | 58 | **227** | 63 | 75 | 92 | 99 | 93 | 73 | 66 | 73 | 76 | 63 | 57 | 53 | 56 | 53 | 57 |
| FY2050 | $mg/m^2/day$ | 95 | 56 | **157** | 58 | 66 | 70 | 75 | 75 | 63 | 59 | 62 | 65 | 56 | 54 | 52 | 53 | 52 | 54 |
| Exceedences FY2015 | #/year | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2030 | #/year | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2040 | #/year | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FY2050 | #/year | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# Appendix P Document Limitations

# Appendix Q References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