



Air Quality Impact Assessment for the Manungu Colliery

Project done on behalf of **Environmental Impact Management Services (Pty) Ltd**

Project Compiled by:

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Revision Record

Revision Number	Date	Reason for Revision
Draft	January 2018	For client review
Rev 0.1	February 2018	Incorporation of comments from internal review
Rev 0.2	April 2018	Inclusion of greenhouse gas quantification
Rev 0.3	September 2018	Incorporation of mining layout changes

EXECUTIVE SUMMARY

Introduction

Manungu Colliery is planning to extend their mining area. As such an Environmental Impact Assessment (EIA) is required to assess the impacts associated with the change in the extent of the mining area. The operations at the Manungu Colliery is hereafter referred to as the project. Airshed Planning Professionals (Pty) Ltd was appointed by Environmental Impact Management Services (Pty) Ltd to undertake an Air Quality Impact Assessment for the project.

The aim of the investigation is to quantify the possible impacts resulting from the project activities on the surrounding environment and human health. To achieve this, a good understanding of the local dispersion potential of the site is necessary and subsequently an understanding of existing sources of air pollution in the region and the resulting air quality.

Study Approach and Methodology

The investigation followed the methodology required for a specialist report as prescribed in the Environmental Impact Assessment (EIA) Regulations (Government Gazette 40772 of 7 April 2017).

Baseline Assessment

The baseline study encompassed the analysis of meteorological data. Use was made of the Weather Research and Forecasting mesoscale model (known as WRF) for the period 2013 to 2015

Impact Assessment Criteria

Particulates represent the main pollutants of concern in the assessment of operations from the proposed project. Particulate matter is classified as a criteria pollutant, with ambient air quality guidelines and standards having been established by various countries to regulate ambient concentrations of these pollutants. For the current study, the impacts were assessed against published National Ambient Air Quality Standards (NAAQS) and National Dust Control Regulations (NDCR).

Emissions Inventory

Emissions inventories provide the source input required for the simulation of ambient air concentrations. Fugitive source emissions from drilling and blasting activities, vehicle entrainment, materials handling, crushing activities and wind erosion from stockpiles were quantified.

Impact Prediction Study

Particulate concentrations and dustfall rates due to the proposed operations were simulated using the United States Environmental Protection Agency (US-EPA) approved AERMET/AERMOD dispersion modelling suite. Ambient concentrations were simulated to ascertain highest daily and annual averaging levels occurring as a result of the project operations.

Assumptions, Exclusions and Limitations

The main assumptions, exclusions and limitations consist of the following:

- Meteorological data: As no onsite meteorological data was available, use was made of the Weather Research and Forecasting mesoscale model (known as WRF) for the period 2013 to 2015. An evaluation of the WRF data was undertaken and is provided in Section 3.2. From the evaluation it is concluded that the wind direction may be out by as much as 35°.
- Emissions:
 - The quantification of sources of emission was restricted to the project activities only. Although other background sources were identified in the study area, such sources were not quantified as this did not form part of the scope of this assessment.
 - Information required for the calculation of emissions from fugitive dust sources for the proposed project operations was provided by the client. The assumption was made that this information was accurate and correct.
 - Routine emissions from the proposed operations were estimated and modelled. Atmospheric releases occurring as a result of non-routine operations or accidents were not accounted for.
 - Vehicle exhaust emissions were not quantified as the impacts from these sources are localized and will not exceed NAAQS offsite.
 - Vehicle capacity for hauling was assumed to be 60 t. The capacity for the transport of the product was assumed to be 34 t.
 - Primary and secondary crushing activities were assumed for the current assessment.
 - The access routes for current operations (to the north of the project area) and proposed operations (to the west of the project area) were assumed based on site layouts provided.
- Impact assessment:
 - The construction and closure phases were assessed qualitatively due to the temporary nature of these operations, whilst the operational phase was assessed quantitatively.

Findings

The main findings from the baseline assessment were as follows:

- The main sources likely to contribute to cumulative particulate impact are surrounding agricultural activities, mining and industrial activities as well as vehicle entrainment on unpaved road surfaces and biomass burning.
- The wind field is dominated by winds from the north-north-west and east.
- Numerous individual homesteads are located around the project area. Larger residential areas include Eloff (~9 km to the north-west) and Delmas (~7.5 km to the north).
- Measured PM₁₀ ground level concentrations onsite exceed NAAQS during the sampling period of March to September 2017.

- The dust fallout measured at the Manungu sampling network (single buckets) for the period April to September 2017 were provided for seven sites with the NDCR exceeded at site MAN02.

The main findings from the impact assessment due to project operations were as follows:

- Vehicle entrainment on unpaved surfaces and, to a lesser extent, crushing activities represented the highest impacting particulate sources from the current and proposed project operations.
- The highest simulated ground level PM₁₀ concentrations due to current unmitigated project operations were in non-compliance with daily NAAQS at sensitive receptors within the study area. When activities were mitigated (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities), the impacts reduced significantly with no exceedances of the NAAQS at the closest sensitive receptors. The extent of the PM₁₀ impacts increase with proposed operations with exceedances of the NAAQS (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities) at individual homesteads to the west of the mine.
- The highest simulated PM_{2.5} concentrations due to current unmitigated project operations were in non-compliance with daily NAAQS at the closest sensitive receptor to the north of operations. When activities were mitigated (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities), the impacts reduced significantly with no exceedances of the NAAQS at the closest sensitive receptors. The extent of the PM_{2.5} impacts increase with proposed operations but are within NAAQS at the closest sensitive receptors with mitigated operations (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities).
- Maximum daily dust deposition due to proposed unmitigated operations exceeded the NDCR for the closest sensitive receptor to the west of the mine.

Recommendations

The following recommendations are made:

- It is recommended that ambient sampling, as outlined in Section 6.2.3.2, be undertaken in order to monitor the impacts from the proposed project activities.
- Due to the close proximity of sensitive receptors to the proposed project activities, it is recommended that extensive mitigation measures on the main sources of fugitive dust be implemented to minimise impacts as far as possible. These include:
 - Chemical suppressants applied to unpaved haul and access roads to reduce the impacts from this source by 90% control efficiency.
 - Water sprayers on the crushing activities to control the emission of this source by 50%.

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LIST OF ACRONYMS AND SYMBOLS

APCS	Air pollution control systems
AQA	Air Quality Act
AQM	Air Quality Management
°C	Degrees Celsius
CE	Control efficiency
CH ₄	Methane
CO	Carbon monoxide
CO ₂	Carbon dioxide
CEPA	Canadian Environmental Protection Agency
DEA	Department of Environmental Affairs
EIA	Environmental Impact Assessment
HPA	Highveld priority area
I&AP	Interested and affected parties
IOA	Index of agreement
km	Kilometre
LMo	Monin-Obukhov length
m ³	Cubic metre
m ²	Square metre
NAAQS	National Ambient Air Quality Standards
NACA	National Association for Clean Air
NDCR	National Dust Control Regulations
NH ₃	Ammonia
N ₂ O	Nitrous oxide
NO ₂	Nitrogen dioxide
NO	Nitrogen oxide
NPI	National pollution inventory
O ₃	Ozone
Pb	Lead
PM	Particulate matter
PM ₁₀	Particulate Matter with an aerodynamic diameter of less than 10µm
PM _{2.5}	Particulate Matter with an aerodynamic diameter of less than 2.5µm
QA	Quality assessment
QC	Quality control
RMSE	Root-mean-square error
ROM	Run of Mine
SA	South Africa
SACNASP	South African Council for Natural Scientific Professions
SANS	South African National Standards
SO ₂	Sulfur Dioxide
TSP	Total Suspended Particles
US EPA	United States Environmental Protection Agency
VKT	Vehicle kilometre travelled
VOC	Volatile organic compound
WRF	Weather Research and Forecasting mesoscale model

Note:

1. The spelling of "sulfur" has been standardised to the American spelling throughout the report. The International Union of Pure and Applied Chemistry, the international professional organisation of chemists that operates under the umbrella of UNESCO, in 1990 published a list of standard names for all chemical elements. It was decided that element 16 should be spelled "sulfur". This compromise was to ensure that in future searchable data bases would not be complicated by spelling variants. (IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: <http://goldbook.iupac.org> (2006) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8.doi: 10.1351/goldbook")

Air Quality Impact Assessment for the Manungu Colliery

1 INTRODUCTION

1.1 Purpose/ Objectives

Manungu Colliery (Figure 1-1) is planning to extend their mining area. As such an Environmental Impact Assessment (EIA) is required to assess the impacts associated with the change in the extent of the mining area. The operations at the Manungu Colliery are hereafter referred to as the project. Airshed Planning Professionals (Pty) Ltd was appointed by Environmental Impact Management Services (Pty) Ltd (EIMS) to undertake an Air Quality Impact Assessment for the project.

The main objective of this study is to determine the significance of the predicted impacts from the project operations on the surrounding environment and on human health.

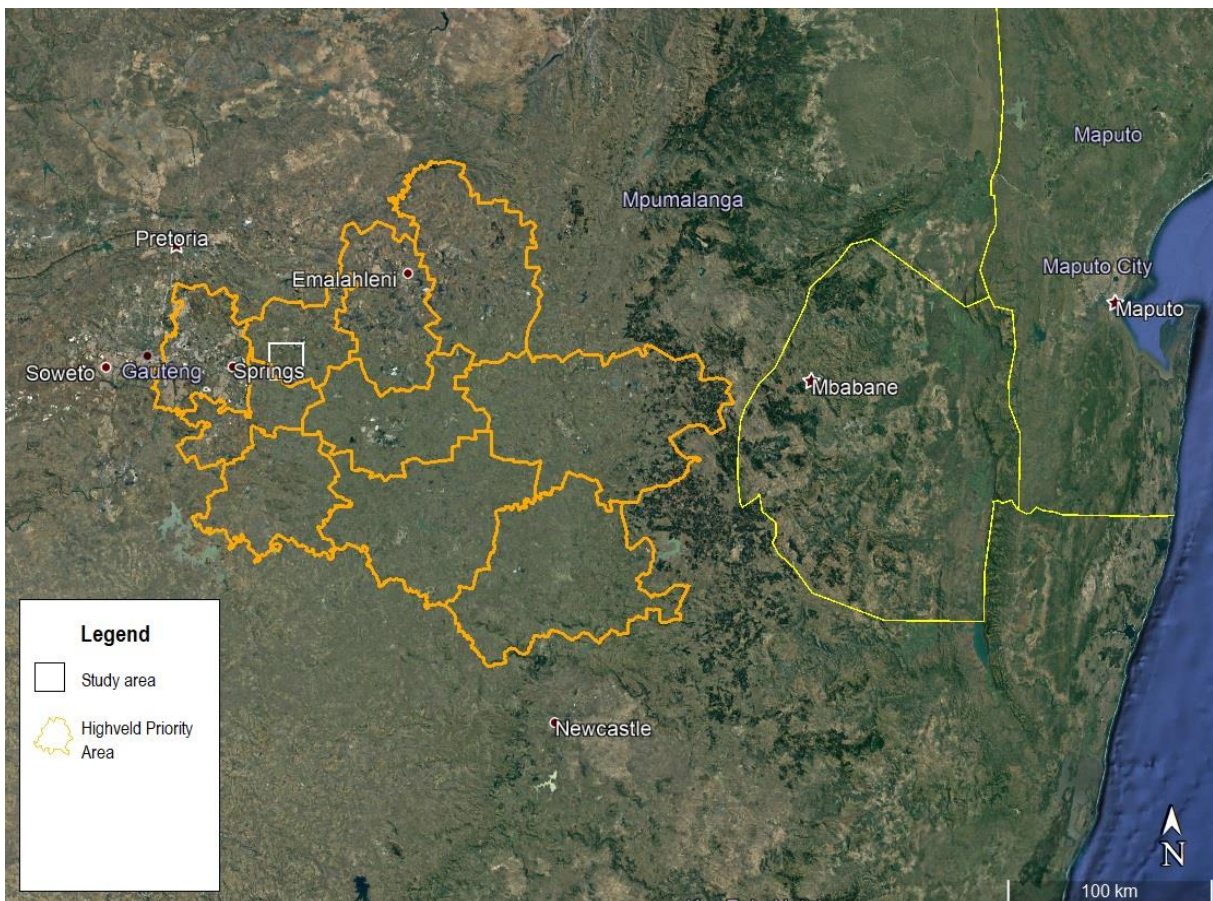


Figure 1-1: Location of study area

1.2 Terms of Reference/Scope of Work

The terms of reference for the assessment are as follows:

1. Scoping Study

- Project kick-off, start-up meeting, site visit and workshop;
- Desktop description of the baseline receiving environment specific to the field of expertise (general surrounding as well as site specific environment);
- Identification and description of any sensitive receptors in terms of air quality that occur in the study area, and the manner in which these sensitive receptors may be affected by the activity;
- Climate and Atmospheric Dispersion Potential within the study area
- Existing Ambient Air Quality within the study area;
- Site visit to verify desktop information;
- Screening to identify any critical issues relating to air quality (potential fatal flaws) that may result in project delays or rejection of the application;
- Provide a map identifying sensitive receptors in the study area, based on available maps, database information & site visit verification;
- Attend project meetings;
- Compile summary report to feed into the Scoping Report
- Attend a Specialist Workshop

2. Impact Assessment

- Generate baseline infrastructure information and maps;
- A detailed Air Quality Impact Assessment based on the proposed activities and the alternatives identified during scoping. Impacts must be calculated for each phase of the project and these phases shall be classified as:
 - Planning and Design;
 - Construction;
 - Operation;
 - Decommissioning;
 - Rehabilitation and Closure.
- Identification and description of site sensitivities (if none, motivate why not);
- Identification and description of site constraints (if none, motivate why not);
- Identified potential impacts must be evaluated in accordance with the agreed methodology to determine significance. Identified potential impacts (cumulative, direct and indirect) must be quantified (where possible) and fully described for each feasible alternative utilising the EIMS Impact Assessment template (EIMS will provide);
- Residual and latent impacts after mitigation must then be evaluated (in accordance with the assessment methodology described above) such that actual implemented results can be measured against those predicted;
- Comparative assessment of the identified alternatives;
- Each specialist will be required to contribute to the preparation of a detailed site specific EMPR relating to the specific field of expertise and impacts identified;
- Provide detailed mitigation / management measures for the management of the identified impacts for inclusion in the EMPR. The mitigation / management measures must be presented in a tabulated format (please see table 2 for example format) for each phase of the project and must include:
 - Detailed description of mitigation measures or management options;
 - Roles and Responsibilities for Implementation;
 - Timeframes for implementation;
 - Means of measuring successful implementation (Targets & Performance Indicators).

- Compilation of an Action Plan for Implementation of the recommended mitigation measures. This plan must, at a minimum, include the following:
 - Management Actions for Implementation;
 - Responsibilities for Implementation, monitoring and review;
 - Timeframes for Implementation.
- Proposed air quality monitoring program. This plan shall, at a minimum, include the following:
 - Conceptual management strategy (Principles & Objectives);
 - Baseline data;
 - Proposed monitoring locations;
 - Recommended Data collection/sampling;
 - Recommended Methods and materials;
 - Applicable Parameters & Standards;
 - Recommended Timeframes & Responsibilities for Implementation where appropriate;
 - Recommended Targets and Key Performance Indicators;
 - Recommended Data Interpretation, Trending and Analysis;
 - Recommended Reporting;
 - Recommendations for audit and review.
- Any other Recommendations;
- Identify any gaps in knowledge, data or information;
 - Report on the adequacy of predictive methods utilised;
 - Report on the adequacy of underlying assumptions;
 - Report on uncertainties in the information provided.
- Anticipated costs to implement mitigation measures and recommendations suggested.

1.3 Deliverables

At the core of the study is the provision of a mathematical tool (i.e. the dispersion model) that credibly describes the fluxes and dispersion of air emissions from the project through the incorporation of meteorological and emission configuration complexities.

The final deliverables are ground level particulate air concentration and total dust deposition predictions provided as isopleths superimposed on base maps of the study area.

1.4 Specialist Details

1.4.1 Statement of Independence

Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.

1.4.2 Competency Profiles

1.4.2.1 RG von Gruenewaldt (MSc (Meteorology), BSc, Pr. Sci Nat.)

Reneé von Gruenewaldt is a Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP) and a member of the National Association for Clean Air (NACA).

Following the completion of her bachelor's degree in atmospheric sciences in 2000 and honours degree (with distinction) with specialisation in Environmental Analysis and Management in 2001 at the University of Pretoria, her experience in air pollution started when she joined Environmental Management Services (now Airshed Planning Professionals) in 2002. Reneé von Gruenewaldt later completed her Master's Degree (with distinction) in Meteorology at the University of Pretoria in 2009.

Reneé von Gruenewaldt became partner of Airshed Planning Professionals in September 2006. Airshed Planning Professionals is a technical and scientific consultancy providing scientific, engineering and strategic air pollution impact assessment and management services and policy support to assist clients in addressing a wide variety of air pollution related risks and air quality management challenges.

She has extensive experience on the various components of air quality management including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Reneé has been the principal air quality specialist and manager on several Air Quality Impact Assessment projects between 2006 to present and her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality.

A comprehensive curriculum vitae of Reneé von Gruenewaldt is provided in Appendix A.

The declaration of independence for Reneé von Gruenewaldt is provided in Appendix B.

1.5 Approach and Methodology

The air quality study includes both baseline and predicted impact assessment. The approach and methodology for tasks are provided in the following section.

1.5.1 Project Kick-Off, Start-Up Meeting, Site Visit and Workshop

The kick-off, start-up meeting and workshop was held at Manungu Colliery on 12 October 2017. No further workshops have been held for the project. The site visit was conducted on 3 October 2018 to verify sensitive receptors, understand operations and inspect dustfall sampling locations.

1.5.2 Receiving Environment

1.5.2.1 Air Quality Sensitive receptors

Air quality sensitive receptors are identified based on human exposure where the public is exposed to ambient air quality impacts from the project. This included the identification of all dwellings including farmsteads and residential areas as identified from available satellite imagery (Google Earth, 2018). The closest sensitive receptors to the project were verified during a site visit conducted on 3 October 2018. No database for sensitive receptors in the study area was available for the assessment. A geo-referenced map providing the location of all identified sensitive receptors were provided in order to generate sensitivity maps for the study area.

1.5.2.2 Climate and Atmospheric Dispersion Potential

It is important to have a good understanding of the meteorological parameters governing the rate and extent of dilution and transportation of air pollutants that are generated by the proposed project. The primary meteorological parameters to obtain from measurement include wind speed, wind direction and ambient temperature. Other meteorological parameters that influence the air concentration levels include rainfall (washout) and a measure of atmospheric stability. The latter quantities are normally not measured and are derived from other parameters such as the vertical height temperature difference or the standard deviation of wind direction. The depth of the atmosphere in which the pollutants are able to mix is similarly derived from other meteorological parameters by means of mathematical parameterizations.

The first step was therefore to source any on-site meteorological observations. As a minimum this data had to include hourly averaged wind speed, wind direction and ambient air temperature. No on-site meteorological observations, however, are available. For this assessment use was made of modelled WRF meteorological data for the period 2013 to 2015. This data was used to construct wind roses, general climatic information such as diurnal temperature variations, atmospheric stability estimates and for dispersion modelling.

1.5.2.3 Existing Sources of Emissions and Ambient Air Quality

Existing sources of emission surrounding the project were identified and ambient air quality for particulate matter and dustfall levels in the study area were reported.

1.5.2.4 Summary Report

A summary report of the baseline was not required for the Scoping Report.

1.5.3 Impact Assessment

The impact assessment followed with the tasks below:

- The dispersion modelling was executed as per The Regulations Regarding Air Dispersion Modelling (Gazette No 37804 vol. 589; published 11 July 2014). Three Levels of Assessment are defined in the Regulations. Level 2 was deemed adequate.

- Preparation of the model control options and input files for the AERMOD dispersion modelling suite. This included the compilation of:
 - terrain information (land use, albedo and surface roughness);
 - source layout; and
 - grid definitions.
- Preparation of hourly average meteorological data for the wind field and atmospheric dispersion model.
- Preparation of an emissions inventory (particulates) for the existing (current) and proposed (future) operations., including. Current and proposed project operations result in fugitive particulate emissions. Fugitive emissions refer to emissions that are spatially distributed over a wide area and not confined to a specific discharge point as would be the case for process related emissions (IFC, 2007). In the quantification of fugitive dust, use was made of emission factors which associate the quantity of a pollutant with the activity associated with the release of that pollutant. Emissions were calculated using a comprehensive set of emission factors and equations as published by the United States Environmental Protection Agency (US EPA) and Australian National Pollutant Inventory (NPI).
- Using the emissions inventory where the emissions were quantified for both current and future operations, simulations were conducted using the AERMOD dispersion modelling suite, which allowed the calculations of the current ambient inhalable concentrations (PM₁₀ and PM_{2.5}) and dustfall rates as well as the predicted future impacts. The second highest daily and highest annual average concentrations as well as average daily dust deposition were calculated.
- The legislative and regulatory context, including emission limits and guidelines, ambient air quality guidelines and dustfall classifications were used to assess the impact and recommend additional emission controls, mitigation measures and air quality management plans to maintain the impact of air pollution to acceptable limits in the study area. The model results were analysed against the national ambient air quality standards (NAAQS) and national dust control regulations (NDCR).

1.5.3.1 Data Gathering

All project information required to calculate emissions for proposed operations were provided by EIMS via electronic mail and at the kick-off meeting conducted in on 12 October 2017.

Dustfall rates data was acquired from EIMS and analysed for inclusion in this report. WRF data (2013-2015) was obtained for the meteorological parameters including wind speed, wind direction, ambient air temperature and rainfall data.

1.5.4 Alternatives Considered for the Assessment

The following alternatives are looked at in terms of air quality:

- The footprint from the proposed waste material stockpiles assuming a height of 6m.
- The footprint from the proposed waste material stockpiles assuming a height of 45m.

The emissions from these alternatives would result from windblown dust due to the nature of the material. These alternatives are assessed quantitatively, and their significance rated in Section 5.

1.5.4.1 Data Analysis for Air Dispersion Modelling

As per the National Code of Practice for Air Dispersion Modelling use was made of the US EPA approved AERMOD atmospheric dispersion modelling suite for the simulation of ambient air pollutant concentrations and dustfall rates. AERMOD is a gaussian plume model, which are best used for near-field applications where the steady-state meteorology assumption is most likely to apply. The AERMOD model is one of the most widely used gaussian plume model. AERMOD is a Gaussian plume model best used for near-field applications where the steady-state meteorology assumption is most likely to apply. AERMOD is a model developed with the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective has been to include state-of-the-art science in regulatory models (Hanna, Egan, Purdum, & Wagler, 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

AERMOD is an advanced new-generation model. It is designed to predict pollution concentrations from continuous point, flare, area, line, and volume sources. AERMOD offers new and potentially improved algorithms for plume rise and buoyancy, and the computation of vertical profiles of wind, turbulence and temperature. However, retains the single straight-line trajectory limitation. AERMET is a meteorological pre-processor for AERMOD. Input data can come from hourly cloud cover observations, surface meteorological observations and twice-a-day upper air soundings. Output includes surface meteorological observations and parameters and vertical profiles of several atmospheric parameters. AERMAP is a terrain pre-processor designed to simplify and standardise the input of terrain data for AERMOD. Input data includes receptor terrain elevation data. The terrain data may be in the form of digital terrain data. The output includes, for each receptor, location and height scale, which are elevations used for the computation of air flow around hills. A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Input data types required for the AERMOD model include: source data, meteorological data (pre-processed by the AERMET model), terrain data and information on the nature of the receptor grid.

The dispersion of PM₁₀, PM_{2.5} and total suspended particulates (TSP) was modelled for an area covering 16 km (north-south) by 16 km (east-west). These areas were divided into a grid with a resolution of 160 m (north-south) by 160 m (east-west). AERMOD simulates ground-level concentrations for each of the receptor grid points. AERMOD executable version 09292 was used for the assessment.

1.5.4.2 Dispersion Results

The dispersion model uses the specific input data to run various algorithms to estimate the dispersion of pollutants between the source and receptor. The model output is in the form of a simulated time-averaged concentration at the receptor. These simulated concentrations are added to suitable background concentrations and compared with the relevant ambient air quality standard or guideline. The post-processing of air concentrations at discrete receptors as well as the regular grid points include the calculation of various percentiles, specifically the 99th percentile, which corresponds to the requirements of the NAAQS.

Ground level concentration (GLC) isopleths plots presented in this report depict interpolated values from the concentrations simulated by AERMOD for each of the receptor grid points specified. Plots reflecting daily averaging periods contain only the 99.73th percentile of simulated ground level concentrations, for those averaging periods, over the entire period for which simulations were undertaken. It is therefore possible that even though a high daily average concentration is simulated at certain locations, this may only be true for one day during the period. Typically, NAAQS apply to areas where the Occupational Health and Safety regulations do not apply, thus outside the mine property or lease area. Ambient air quality

guidelines and standards are therefore not occupational health indicators but applicable to areas where the general public has access i.e. off-site.

1.5.4.3 Uncertainty of Modelled Results

There will always be some error in any geophysical model; however, modelling is recognised as a credible method for evaluating impacts, but it is desirable to structure the model in such a way to minimise the total error. A model represents the most likely outcome of an ensemble of experimental results. The total uncertainty can be thought of as the sum of three components: the uncertainty due to errors in the model physics; the uncertainty due to data errors; and the uncertainty due to stochastic processes (turbulence) in the atmosphere.

The stochastic uncertainty includes all errors or uncertainties in data such as source variability, observed concentrations, and meteorological data. Even if the field instrument accuracy is excellent, there can still be large uncertainties due to unrepresentative placement of the instrument (or taking of a sample for analysis). Model evaluation studies suggest that the data input error term is often a major contributor to total uncertainty. Therefore, accurate input data is essential.

A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. The model has been shown to be an improvement on the ISC model, especially for short-term predictions. The accuracy improves with fairly strong wind speeds and during neutral atmospheric conditions.

1.5.4.4 Mitigation and Management Recommendations

Practical mitigation and optimisation measures that can be implemented effectively to reduce or enhance the significance of impacts were identified.

1.5.5 Atmospheric Dispersion Modelling

In the calculation of ambient air pollutant concentrations and dustfall rates use was made of the US EPA AERMOD atmospheric dispersion modelling suite. AERMOD is a Gaussian plume model best used for near-field applications where the steady-state meteorology assumption is most likely to apply. AERMOD is a model developed with the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective has been to include state-of-the-art science in regulatory models (Hanna, Egan, Purdum, & Wagler, 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

The dispersion of PM₁₀, PM_{2.5} and total suspended particulates (TSP) was modelled for an area covering 16 km (north-south) by 16 km (east-west). These areas were divided into a grid with a resolution of 160 m (north-south) by 160 m (east-west). AERMOD simulates ground-level concentrations for each of the receptor grid points. AERMOD executable version 09292 was used for the assessment.

1.5.6 Management and Mitigation

The findings of the above components informed recommendations of air quality management measures, including mitigation and monitoring.

1.6 Assumptions and Limitations

The main assumptions, exclusions and limitations are summarised below:

- Meteorological data: As no onsite meteorological data was available, use was made of the Weather Research and Forecasting mesoscale model (known as WRF) for the period 2013 to 2015. An evaluation of the WRF data was undertaken and is provided in Section 3.2. From the evaluation it is concluded that the wind direction may be out by as much as 35°.
- Emissions:
 - The quantification of sources of emission was restricted to the project activities only. Although other background sources were identified in the study area, such sources were not quantified as this did not form part of the scope of this assessment.
 - Information required for the calculation of emissions from fugitive dust sources for the proposed project operations was provided by the client. The assumption was made that this information was accurate and correct.
 - Routine emissions from the proposed operations were estimated and modelled. Atmospheric releases occurring as a result of non-routine operations or accidents were not accounted for.
 - Vehicle exhaust emissions were not quantified as the impacts from these sources are localized and will not exceed NAAQS offsite.
 - Vehicle capacity for hauling was assumed to be 60 t. The capacity for the transport of the product was assumed to be 34 t.
 - Primary and secondary crushing activities were assumed for the current assessment.
 - The access routes for current operations (to the north of the project area) and proposed operations (to the west of the project area) were assumed based on site layouts provided.
- Impact assessment:
 - The simulated impacts are screened against NAAQS and NDCR and is not a health risk assessment.
 - The impact assessment is confined to the quantification of impacts on human health due to exposures via the inhalation pathway only and not through the ingestion and dermal absorption pathways for humans and animals.
 - The construction and closure phases were assessed qualitatively due to the lack of detailed information available for these phases and the temporary nature of these operations, whilst the operational phase was assessed quantitatively.
 - The assessment is based on current operations as provided. Operations prior to this assessment has not been accounted for as this is not a retrospective assessment.

1.7 Outline of Report

Assessment criteria applicable to the proposed project are presented in Section 2. The study area, atmospheric dispersion potential and the existing air quality for the area are discussed in Section 3. Dispersion model results are presented, and the main findings of the air quality impact assessments documented in Section 4. The significance ranking for the proposed project is provided in Section 5. A dust management plan is provided in Section 6 and findings and recommendations provided in Section 7. The quantification of greenhouse gasses (GHG) emissions is provided in Section 8. Comments raised from interested and affected parties were addressed in Section 9.

2 REGULATORY REQUIREMENTS AND ASSESSMENT CRITERIA

The environmental regulations and guidelines governing the emissions and impact of the project need to be considered prior to potential impacts and sensitive receptors being identified.

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality standards are intended to indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging periods. These averaging periods refer to the time-span over which the air concentration of the pollutant was monitored at a location. Generally, five averaging periods are applicable, namely an instantaneous peak, 1-hour average, 24-hour average, 1-month average, and annual average.

2.1 National Ambient Air Quality Standards

NAAQS are available for PM_{2.5} (gazetted on 29 June 2012 (Government Gazette no. 35463)) as well as, PM₁₀, SO₂, NO₂ ozone (O₃), CO, lead (Pb) and benzene gazetted on 24 December 2009 (Government Gazette 32816). The NAAQS are provided in Table 2-1 with the pollutants of concern for the project provided in bold text.

Table 2-1: South African National Ambient Air Quality Standards

Substance	Molecular formula / notation	Averaging period	Concentration limit (µg/m ³)	Frequency of exceedance	Compliance date
Sulfur dioxide	SO ₂	10 minutes	500	526	Immediate
		1 hour	350	88	Immediate
		24 hours	125	4	Immediate
		1 year	50	0	Immediate
Nitrogen dioxide	NO ₂	1 hour	200	88	Immediate
		1 year	40	0	Immediate
Particulate matter	PM₁₀	24 hour	75	4	Immediate
		1 year	40	0	Immediate
Fine particulate matter	PM_{2.5}	24 hour	40	4	Immediate
			25	4	1 Jan 2030
		1 year	20	0	Immediate
			15	0	1 Jan 2030
Ozone	O ₃	8 hours (running)	120	11	Immediate
Benzene	C ₆ H ₆	1 year	5	0	1 Jan 2015
Lead	Pb	1 year	0.5	0	Immediate
Carbon monoxide	CO	1 hour	30 000	88	Immediate
		8 hour (calculated on 1 hour averages)	10 000	11	Immediate

2.2 National Regulations for Dust Deposition

South Africa's Draft National Dust Control Regulations were published on the 27 May 2011 with the dust fallout standards passed and subsequently published on the 1st of November 2013 (Government Gazette No. 36974). These are called the NDCR. The purpose of the regulations is to prescribe general measures for the control of dust in all areas including residential and light commercial areas. South African (SA) NDCRs that were published on the 1st of November 2013. Acceptable dustfall rates according to the regulation are summarised in Table 2-2. These regulations are only applicable to a facility (including mining) that has been identified as a potential source of nuisance dust by a local air quality officer.

Table 2-2: Acceptable dustfall rates

Restriction Area	Dustfall rate (D) ($\text{mg m}^{-2} \text{day}^{-1}$, 30-day average)	Permitted frequency of exceeding dust fall rate
Residential	$D < 600$	Two within a year, not sequential months.
Non-residential	$600 < D < 1\ 200$	Two within a year, not sequential months

The regulation also specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be ASTM D1739 (1970), or equivalent method approved by any internationally recognized body. It is important to note that dustfall is assessed for nuisance impact and not inhalation health impact.

2.3 Effect of Dust on Vegetation, Animals and Susceptible Human Receptors

2.3.1 Effects of Particular Matter on Vegetation

Since plants are constantly exposed to air, they are the primary receptors for both gaseous and particulate pollutants of the atmosphere. In terrestrial plant species, the enormous foliar surface area acts as a natural sink for pollutants especially the particulate ones. Vegetation is an effective indicator of the overall impact of air pollution particularly in context of PM (Rai, 2016).

There are two main types of direct injury that PM pollution can cause on plants: acute and chronic injury. Acute injury results from exposure to a high concentration of gas for a relatively short period and is manifested by clear visible symptoms on the foliage, often in the form of necrotic lesions. While this type of injury is very easy to detect (although not necessarily to diagnose), chronic injury is subtler: it results from prolonged exposure to lower gas concentrations and takes the form of growth and/or yield reductions, often with no clear visible symptoms. Plants that are constantly exposed to environmental pollutants absorb, accumulate and integrate these pollutants into their systems. It reported that depending on their sensitivity level, plants show visible changes which would include alteration in the biochemical processes or accumulation of certain metabolites (Rai, 2016). Pollutants can cause leaf injury, stomatal damage (Ricks and Williams, 1974, Hirano et al., 1995; Naidoo and Chirkoot; 2004; Harmens et al., 2005), premature senescence, decrease photosynthetic activity, disturb membrane permeability (Ernst, 1981; Naidoo and Chirkoot, 2004; Harmens et al., 2005) and reduce growth and yield in sensitive plant species. The long term, low-concentration exposures of air pollution produces harmful impacts on plant leaves without visible injury. Several studies have been conducted to assess the effects of pollution on different aspects of plant life such as overall growth and development, foliar morphology, anatomy, and bio chemical changes (Rai, 2016).

Plant leaves are the primary receptors for both gaseous and PM pollutants of the atmosphere. Before these pollutants enter the leaf tissue, they interact with foliar surface and modify its configuration. Dust deposition on leaf surface, consisting of ultra-fine and coarse particles, showed reduction in plant growth through its effect on leaf gas exchange, flowering and reproduction of plants, number of leaves and leaf area, one of the most common driving variables in growth analyses. Reduction in leaf area and leaf number may be due to decreased leaf production rate and enhanced senescence (Rai, 2016).

The chemical composition of the dust particles can also affect exposed plant tissue and have indirect effects on the soil pH (Spencer, 2001).

To determine the impact of dust deposition on vegetation, two factors are of importance: (i) Does dust accumulate on vegetation surfaces and if it does, what are the factors influencing the rate of deposition (ii) Once the dust has been deposited, what is the impact of the dust on the vegetation? Regarding the first question, there is adequate evidence that dust does accumulate on all types of vegetation. Any type of vegetation causes a change in the local wind fields, increasing turbulence and enhancing the collection efficiency. Vegetation structure alters the rate of dust deposition such that the larger the “collecting elements” (branches and leaves), the lower the impaction efficiency per element. Therefore, for the same volume of tree/shrub canopy, finer leaves will have better collection efficiencies. However, the roughness of the leaves themselves, in particularly the presence of hairs on the leaves and stems, plays a significant role, with venous surfaces increasing deposition of 1-5 μm particles by up to seven-times compared to smooth surfaces. Collection efficiency rises rapidly with particle size; wind tunnel studies show a relationship of deposition velocity on the fourth power of particle size for moderate wind speeds (Tiwarly and Colls, 2010). Wind tunnel studies also show that windbreaks or “shelter belts” of three rows of trees have a decrease of between 35 and 56% of the downwind mass transport of inorganic particles.

After deposition onto vegetation, the effect of particulate matter depends on the composition of the dust. South African ambient standards are set in terms of $\text{PM}_{2.5}$ and PM_{10} (particulate matter smaller than 2.5 μm and 10 μm aerodynamic diameter) but internationally it is recognised that there are major differences in the chemical composition of the fine particulate matter (PM) (the fraction between 0 and 2.5 μm in aerodynamic diameter) and coarse PM (the fraction between 2.5 μm and 10 μm in aerodynamic diameter). The former is often the result of chemical reactions in the atmosphere and may have a high proportion of black carbon, sulfate and nitrate; whereas the latter often consists of primary particles as a result of abrasion, crushing, soil disturbances and wind erosion (Grantz et al., 2003). Sulfate is however often hygroscopic and may exist in significant fractions in coarse PM. This has been shown at the Elandsfontein Eskom air quality monitoring station where the PM_{10} has been shown to vary between 15% (winter) and 49% (spring) sulfate (Alade, 2010). Grantz et al. (op. cit.) however indicate that sulfate is much less phototoxic than gaseous sulfur dioxide and that “it is unusual for injurious levels of particular sulfate to be deposited upon vegetation”.

Naidoo and Chirkoot (2004) conducted a study to investigate the effects of coal dust on mangrove trees at two sites in the Richards Bay harbour. Mature fully-exposed sun leaves of 10 trees (*Avicennia marina*) were tagged as being covered or uncovered with coal dust and photosynthetic rates were measured. It was concluded that coal dust significantly reduced photosynthesis of upper and lower leaf surfaces and reduction in growth and productivity was expected. In addition, trees in close proximity to the coal stockpiles were in poorer health than those further away. Coal dust particles, which are composed predominantly of carbon, were not toxic to the leaves; neither did they occlude stomata as they were larger than fully open stomatal apertures (Naidoo and Chirkoot, 2004).

According to the Canadian Environmental Protection Agency (CEPA), generally air pollution adversely affects plants in one of two ways. Either the quantity of output or yield is reduced, or the quality of the product is lowered. The former (invisible) injury results from pollutant impacts on plant physiological or biochemical processes and can lead to significant loss of

growth or yield in nutritional quality (e.g. protein content). The latter (visible) may take the form of discolouration of the leaf surface caused by internal cellular damage. Such injury can reduce the market value of agricultural crops for which visual appearance is important (e.g. lettuce and spinach). Visible injury tends to be associated with acute exposures at high pollutant concentrations whilst invisible injury is generally a consequence of chronic exposures to moderately elevated pollutant concentrations. However, given the limited information available, specifically the lack of quantitative dose-effect information, it is not possible to define a reference level for vegetation and particulate matter (CEPA, 1998).

Exposure to a given concentration of airborne PM may therefore lead to widely differing phytotoxic responses, depending on the mix of the deposited particles. The majority of documented toxic effects indicate responses to the chemical composition of the particles. Direct effects have most often been observed around heavily industrialised point sources, but even there, effects are often associated with the chemistry of the particulate rather than with the mass of particulate. A review of European studies has shown the potential for reduced growth and photosynthetic activity in sunflower and cotton plants exposed to dust fall rates greater than 400 mg/m²/day. Little direct evidence of the effects of dust-fall on South African vegetation, including crops, exists.

2.3.2 *Effects of Particulate Matter on Animals*

As presented by the Canadian Environmental Protection Agency (CEPA, 1998) studies using experimental animals have not provided convincing evidence of particle toxicity at ambient levels. Acute exposures (4-6 hour single exposures) of laboratory animals to a variety of types of particles, almost always at concentrations well above those occurring in the environment have been shown to cause:

- decreases in ventilatory lung function;
- changes in mucociliary clearance of particles from the lower respiratory tract (front line of defence in the conducting airways);
- increased number of alveolar macrophages and polymorphonuclear leukocytes in the alveoli (primary line of defence of the alveolar region against inhaled particles);
- alterations in immunologic responses (particle composition a factor, since particles with known cytotoxic properties, such as metals, affect the immune system to a significantly greater degree);
- changes in airway defence mechanisms against microbial infections (appears to be related to particle composition and not strictly a particle effect);
- increase or decrease in the ability of macrophages to phagocytize particles (also related to particle composition);
- a range of histologic, cellular and biochemical disturbances, including the production of proinflammatory cytokines and other mediators by the lungs alveolar macrophages (may be related to particle size, with greater effects occurring with ultrafine particles);
- increased electrocardiographic abnormalities (an indication of cardiovascular disturbance); and
- increased mortality.

Bronchial hypersensitivity to non-specific stimuli, and increased morbidity and mortality from cardio-respiratory symptoms, are most likely to occur in animals with pre-existing cardio-respiratory diseases. Sub-chronic and chronic exposure tests involved repeated exposures for at least half the lifetime of the test species. Particle mass concentrations to which test animals were exposed were very high (> 1 mg m⁻³), greatly exceeding levels reported in the ambient environment. Exposure resulted in significant compromises in various lung functions similar to those seen in the acute studies, but including also:

- reductions in lung clearance;

- induction of histopathologic and cytologic changes (regardless of particle types, mass, concentration, duration of exposure or species examined);
- development of chronic alveolitis and fibrosis; and
- development of lung cancer (a particle and/or chemical effect).

The epidemiological finding of an association between 24-hour ambient particle levels below 100 µg/m³ and mortality has not been substantiated by animal studies as far as PM₁₀ and PM_{2.5} are concerned. At ambient concentrations, none of the other particle types and sizes used in animal inhalation studies result in acute effects, including high mortality, with exception of ultrafine particles (0.1 µm). The lowest concentration of PM_{2.5} reported that caused acute death in rats with acute pulmonary inflammation or chronic bronchitis was 250 g/m³ (3 days, 6 hour day⁻¹), using continuous exposure to concentrated ambient particles.

Most of the literature regarding air quality impacts on cattle refers to the impacts from feedlots on the surrounding environment, hence where the feedlot is seen as the source of pollution. This mainly pertains to odours and dust generation. The US EPA recently focussed on the control of air pollution from feed yards and dairies, primarily regulating coarse particulate matter. However, the link between particulates and public health is considered to be understudied (Sneeringer, 2009).

A study was conducted by the State University of Iowa on the effects of air contaminants and emissions on animal health in swine facilities. Air pollutants included gases, particulates, bioaerosols, and toxic microbial by-products. The main findings were that ammonia is associated with lowered average number of pigs weaned, arthritis, porcine stress syndrome, muscle lesions, abscesses, and liver ascarid scars. Particulates are associated with the reduction in growth and turbine pathology, and bioaerosols could lower feed efficiency, decrease growth, and increase morbidity and mortality. The authors highlighted the general lack of information on the health effects and productivity-problems of air contaminants on cattle and other livestock. Ammonia and hydrogen sulfide are regarded the two most important inorganic gases affecting the respiratory system of cattle raised in confinement facilities, affecting the mucociliary transport and alveolar macrophage functions. Holland et al., (2002) found that the fine inhalable particulate fraction is mainly derived from dried faecal dust.

Inhalation of confinement-house dust and gases produces a complex set of respiratory responses. An individual's response depends on characteristics of the inhaled components (such as composition, particle size and antigenicity) and of the individual's susceptibility, which is tempered by extant respiratory conditions (Davidson et al., 2005). Most studies concurred that the main implication of dusty environments is the stress caused to animals which is detrimental to their general health. However, no threshold levels exist to indicate at what levels these are having a negative effect. In this light it was decided to use the same screening criteria applied to human health, i.e. the South African Standards and SANS limit values.

2.3.3 Effect of Particulate Matter on Susceptible Human Receptors

The impact of particles on human health is largely depended on (i) particle characteristics, particularly particle size and chemical composition, and (ii) the duration, frequency and magnitude of exposure. The potential of particles to be inhaled and deposited in the lung is a function of the aerodynamic characteristics of particles in flow streams. The aerodynamic properties of particles are related to their size, shape and density. The deposition of particles in different regions of the respiratory system depends on their size.

The nasal openings permit very large dust particles to enter the nasal region, along with much finer airborne particulates. These larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal

passages. The smaller particles (PM₁₀) pass through the nasal region and are deposited in the tracheobronchial and pulmonary regions. Then particles are removed by impacting with the wall of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles are removed by Brownian motion, which pushes them to the alveolar membrane (CEPA, 1998; Dockery and Pope, 1994).

The air quality guidelines for particulates are given for various particle size fractions, including TSP, thoracic particulates or PM₁₀, and respirable particulates or PM_{2.5}. Although TSP is defined as all particulates with an aerodynamic diameter of less than 100 µm, and effective upper limit of 30 µm aerodynamic diameter is frequently assigned. The PM₁₀ and PM_{2.5} are of concern due to their health impact potentials. As indicated previously, such fine particles are able to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung.

The World Health Organization states that the evidence on airborne particulates and public health consistently shows adverse health effects at exposures experienced by urban populations throughout the world. The range of effects is broad, affecting the respiratory and cardiovascular systems and extending from children to adults including a number of large, susceptible groups within the general population. Long-term exposure to particulate matter has been found to have adverse effects on human respiratory health (Abbey et al., 1995). Respiratory symptoms in children resident in an industrialised city were found not to be associated with long-term exposure to particulate matter; however non-asthmatic symptoms and hospitalizations did increase with increased total suspended particulate concentrations (Hruba et al., 2001). The epidemiological evidence shows adverse effects of particles after both short-term and long-term exposures. However, current scientific evidence indicates that guidelines cannot be proposed that will lead to complete protection against adverse health effects as thresholds have not been identified.

Many scientific studies have linked inhaled particulate matter to a series of significant health problems, including:

- aggravated asthma;
- increases in respiratory symptoms like coughing and difficult or painful breathing;
- chronic bronchitis;
- decreased lung function; and,
- premature death.

PM₁₀ is the standard measure of particulate air pollution used worldwide and studies suggest that asthma symptoms can be worsened by increases in the levels of PM₁₀, which is a complex mixture of particle types. PM₁₀ has many components and there is no general agreement regarding which component(s) could exacerbate asthma. However, pro-inflammatory effects of transition metals, hydrocarbons, ultrafine particles (due to combustion processes) and endotoxins - all present to varying degrees in PM₁₀ - could be important.

Exposure to motor traffic emissions can have a significant effect on respiratory function in children and adults. Studies show that children living near heavily travelled roadways have significantly higher rates of wheezing and diagnosed asthma. Epidemiologic studies suggest that children may be particularly susceptible to diesel exhaust. The adverse health effects from particulate matter exposure and susceptible populations is summarised in Table 2-3.

Table 2-3: Summary of adverse health effects from particulate matter exposure and susceptible populations

Health Effects	Susceptible Groups	Notes
Acute (short-term) exposure		

Health Effects	Susceptible Groups	Notes
Mortality	Elderly, infants, persons with chronic cardiopulmonary disease, influenza or asthma	Uncertainty regarding how much life shortening is involved and how much is due to short-term mortality displacement.
Hospitalisation / other health care visits	Elderly, infants, persons with chronic cardiopulmonary disease, pneumonia, influenza or asthma	Reflects substantive health impacts in terms of illness, discomfort, treatment costs, work or school time lost, etc.
Increased respiratory symptoms	Most consistently observed in people with asthma, and children	Mostly transient with minimal overall health consequences, although for a few there may be short-term absence from work or school due to illness.
Decreased lung function	Observed in both children and adults	For most, effects seem to be small and transient. For a few, lung function losses may be clinically relevant.
Chronic (long-term) exposure		
Increased mortality rates, reduced survival times, chronic cardiopulmonary disease, reduced lung function, lung cancer	Observed in broad-based cohorts or samples of adults and children (including infants). All chronically exposed are potentially affected.	Long-term repeated exposure appears to increase the risk of cardiopulmonary disease and mortality. May result in lower lung function. Average loss of life expectancy in highly polluted cities may be as much as a few years.

Source: Adopted from Pope (2000) and Pope et al. (2002)

2.4 Regulations Regarding Air Dispersion Modelling

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Regulations regarding Air Dispersion Modelling were promulgated in Government Gazette No. 37804 vol. 589; 11 July 2014, (DEA, 2014) and recommend a suite of dispersion models to be applied for regulatory practices as well as guidance on modelling input requirements, protocols and procedures to be followed. The Regulations regarding Air Dispersion Modelling are applicable –

- (a) in the development of an air quality management plan, as contemplated in Chapter 3 of the Air Quality Act (AQA);
- (b) in the development of a priority area air quality management plan, as contemplated in section 19 of the AQA;
- (c) in the development of an atmospheric impact report, as contemplated in section 30 of the AQA; and,
- (d) in the development of a specialist air quality impact assessment study, as contemplated in Chapter 5 of the AQA.

The Regulations have been applied to the development of this report. The first step in the dispersion modelling exercise requires a clear objective of the modelling exercise and thereby gives direction to the choice of the dispersion model most suited for the purpose. Chapter 2 of the Regulations present the typical levels of assessments, technical summaries of the prescribed models (SCREEN3, AERSCREEN, AERMOD, SCIPUFF, and CALPUFF) and good practice steps to be taken for modelling applications. The proposed operation falls under a Level 2 assessment – described as follows;

- The distribution of pollutants concentrations and depositions are required in time and space.
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. The model specifically to be used in the air quality impact assessment of the proposed operation is AERMOD.
- Emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km) downwind.

Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Chapter 3 of the Regulations prescribe the source data input to be used in the models. Dispersion modelling can typically be used in the:

- Apportionment of individual sources for installations with multiple sources. In this way, the individual contribution of each source to the maximum ambient predicted concentration can be determined. This may be extended to the study of cumulative impact assessments where modelling can be used to model numerous installations and to investigate the impact of individual installations and sources on the maximum ambient pollutant concentrations.
- Analysis of ground level concentration changes as a result of different release conditions (e.g. by changing stack heights, diameters and operating conditions such as exit gas velocity and temperatures).
- Assessment of variable emissions as a result of process variations, start-up, shut-down or abnormal operations.
- Specification and planning of ambient air monitoring programs which, in addition to the location of sensitive receptors, are often based on the prediction of air quality hotspots.

The above options can be used to determine the most cost-effective strategy for compliance with the NAAQS. Dispersion models are particularly useful under circumstances where the maximum ambient concentration approaches the ambient air quality limit value and provide a means for establishing the preferred combination of mitigation measures that may be required including:

- Stack height increases;
- Reduction in pollutant emissions through the use of air pollution control systems (APCS) or process variations;
- Switching from continuous to non-continuous process operations or from full to partial load.

Chapter 4 of the Regulations prescribe meteorological data input from onsite observations to simulated meteorological data. The chapter also gives information on how missing data and calm conditions are to be treated in modelling applications. Meteorology is fundamental for the dispersion of pollutants because it is the primary factor determining the diluting effect of the atmosphere. Therefore, it is important that meteorology is carefully considered when modelling.

Topography is also an important geophysical parameter. The presence of terrain can lead to significantly higher ambient concentrations than would occur in the absence of the terrain feature. In particular, where there is a significant relative difference in elevation between the source and off-site receptors, large ground level concentrations can result. Thus, the accurate determination of terrain elevations in air dispersion models is very important.

The modelling domain would normally be decided on the expected zone of influence; the latter extent being defined by the predicted ground level concentrations from initial model runs. The modelling domain must include all areas where the ground level concentration is significant when compared to the air quality limit value (or other guideline). Air dispersion models require a receptor grid at which ground-level concentrations can be calculated. The receptor grid size should include the entire modelling domain to ensure that the maximum ground-level concentration is captured and the grid resolution (distance between grid points) sufficiently small to ensure that areas of maximum impact adequately covered. No receptors however should be located within the property line as health and safety legislation (rather than ambient air quality standards) is applicable within the site.

Chapter 5 provides general guidance on geophysical data, model domain and coordinates system required in dispersion modelling, whereas Chapter 6 elaborates more on these parameters as well as the inclusion of background air concentration

data. The chapter also provides guidance on the treatment of NO₂ formation from NO_x emissions, chemical transformation of sulfur dioxide into sulfates and deposition processes.

Chapter 7 of the Regulations outline how the plan of study and modelling assessment reports are to be presented to authorities.

2.5 Regulations Regarding Report Writing

This report complies with the requirements of the National Environmental Management Act, 1998 (NEMA, No 107 of 1998) and the environmental impact assessment (EIA) regulations (GNR 982 of 2014), as amended. The table below provides a summary of the requirements, with cross references to the report sections where these requirements have been addressed.

Table 2-4: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (2014), as amended

A specialist report prepared in terms of the Environmental Impact Regulations of 2014 must contain:	Relevant section in report
Details of the specialist who prepared the report	Section 1.4
The expertise of that person to compile a specialist report including a curriculum vitae	Section 1.4.2 Appendix A
A declaration that the person is independent in a form as may be specified by the competent authority	Section 1.4.1 Appendix B
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.2
An indication of the quality and age of base data used for the specialist report;	Section 3.2 Section 3.3
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 4
The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 3.2 Section 4.2
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 1.5
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternative;	Section 3.1
An identification of any areas to be avoided, including buffers	Section 3.1
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 4.2
A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.6
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	Section 4.2
Any mitigation measures for inclusion in the EMPr	Section 4.1.2 Section 4.2.3 Section 4.3.2
Any conditions for inclusion in the environmental authorisation	Section 6.2 Section 7.2
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 6.2.3
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 7.2

A specialist report prepared in terms of the Environmental Impact Regulations of 2014 must contain:	Relevant section in report
Regarding the acceptability of the proposed activity or activities; and	Section 4.2
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 4.1.2 Section 4.2.3 Section 4.3.2 Section 6.2.2 Section 7.2
A description of any consultation process that was undertaken during the course of carrying out the study	Not applicable
A summary and copies if any comments that were received during any consultation process	Section 9
Any other information requested by the competent authority.	Not applicable

2.6 Highveld Priority Area

The Highveld Airshed Priority Area (HPA) was declared by the Minister of Environmental Affairs at the end of 2007, requiring the development of an Air Quality Management Plan for the area. The plan (HPA, 2011) includes the establishment of emissions reduction strategies and intervention programmes based on the findings of a baseline characterisation of the area. The implication of this is that all contributing sources in the area will be assessed to determine the emission reduction targets to be achieved over the following few years.

The project is within the footprint of the Highveld Priority Area. Emission reduction strategies are included for the numerous operations in the area with specific associated targets. Included in this management plan are seven goals, each of which has a further list of objectives that has to be met. The seven goals for the Highveld Priority Area are as follows:

- **Goal 1:** By 2015, organisational capacity in government is optimised to efficiently and effectively maintain, monitor and enforce compliance with ambient air quality standards
- **Goal 2:** By 2020, industrial emissions are equitably reduced to achieve compliance with ambient air quality standards and dust fallout limit values
- **Goal 3:** By 2020, air quality in all low-income settlements is in full compliance with ambient air quality standards
- **Goal 4:** By 2020, all vehicles comply with the requirements of the National Vehicle Emission Strategy
- **Goal 5:** By 2020, a measurable increase in awareness and knowledge of air quality exists
- **Goal 6:** By 2020, biomass burning, and agricultural emissions will be 30% less than current
- **Goal 7:** By 2020, emissions from waste management are 40% less than current.

Goal 2 applies directly to the proposed project, the objectives associated with this goal include:

- Emissions are quantified from all sources.
- Gaseous and particulate emissions are reduced.
- Fugitive emissions are minimised.
- Emissions from dust generating activities are reduced.
- Incidences of spontaneous combustion are reduced.
- Abatement technology is appropriate and operational.
- Industrial Air Quality Management (AQM) decision making is robust and well-informed, with necessary information available.

- Clean technologies and processes are implemented.
- Adequate resources are available for AQM in industry.
- Ambient air quality standard and dust fallout limit value exceedances as a result of industrial emissions are assessed.
- A line of communication exists between industry and communities.

Each of these objectives is further divided into activities, each of which has a timeframe, responsibility and indicator. Refer to the Highveld Priority Management Plan for further details (HPA, 2011).

3 RECEIVING ENVIRONMENT

3.1 Air Quality Sensitive Receptors

The NAAQS (Section 2.1) are based on human exposure to specific criteria pollutants and as such, possible sensitive receptors were identified where the public is likely to be unwittingly exposed. NAAQS are enforceable where Occupational Health and Safety Standards are not applicable and therefore a number of sensitive receptors have been identified in the study area (Figure 3-1). These sensitive receptors are small residential communities, individual residences, and farmsteads in the vicinity of the project. Potential impacts from the project will be assessed at these sensitive receptors and screened against NAAQS.

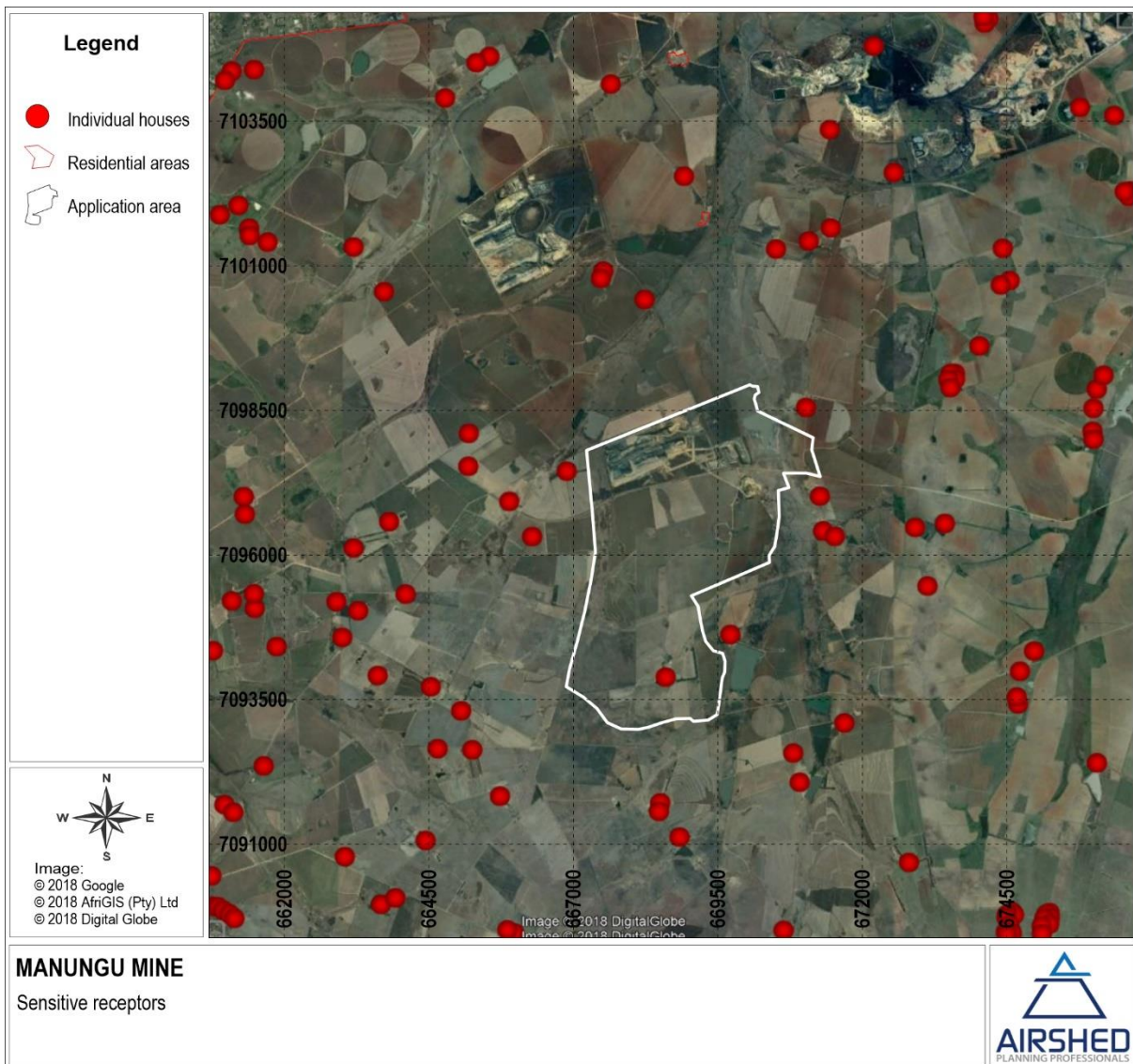


Figure 3-1: Location of potentially sensitive receptors in relation to the project

3.2 Climate and Atmospheric Dispersion Potential

Meteorological mechanisms direct the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. This dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction, and the variability in wind direction, determines the general path pollutants will follow, and the extent of crosswind spreading. The pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field (Tiwary and Colls, 2010).

The spatial variations, and diurnal and seasonal changes, in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich and Tyson, 1988). The atmospheric processes at macro- and meso-scales need therefore be taken into account in order to accurately parameterise the atmospheric dispersion potential of a particular area. A qualitative description of the synoptic systems determining the macro-ventilation potential of the region may be provided based on the review of pertinent literature. These meso-scale systems may be investigated through the analysis of meteorological data observed for the region.

Since no weather measurements are available from the proposed project site, meteorological information was obtained from the Weather Research and Forecasting mesoscale model (known as WRF).

The WRF Model is a next-generation mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting needs. It features two dynamical cores, a data assimilation system, and a software architecture facilitating parallel computation and system extensibility. The model serves a wide range of meteorological applications across scales from tens of meters to thousands of kilometres. WRF can generate atmospheric simulations using real data (observations, analyses) or idealized conditions. WRF offers operational forecasting a flexible and computationally-efficient platform, while providing recent advances in physics, numeric, and data assimilation contributed by developers across the very broad research community.

WRF data for the period 2013 to 2015 was used. An evaluation of the WRF data is provided in Table 3-1 with the benchmark for the WRF data provided in Table 3-2. This evaluation was undertaken for a point extracted at OR Tambo. OR Tambo was selected for the evaluation as it is expected that the data quality at this weather station is of high standard. From the evaluation, the daily average WRF results for the period 2013 to 2015 were within the benchmarks for model evaluation, with the exception of the gross error for the wind direction (WRF providing value of 35 degrees where benchmark is at ≤ 30 degrees) and index of agreement for humidity (WRF providing value of 0.55 where benchmark is at ≥ 0.6). A comparison of wind roses from measured meteorological data at OR Tambo (Figure 3-2) to WRF data (extracted at OR Tambo) (Figure 3-3) is provided below. The wind roses, which illustrate and summarise wind field information, comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below reflect the different categories of wind speeds; the yellow area, for example, representing winds in between 4 and 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated. The measured wind direction at OR Tambo has a higher frequency of winds from the north than the WRF data. The gross error for wind direction could influence the simulated pollutant concentrations by up to 35 degrees.

Table 3-1: Benchmarks for WRF Model Evaluation

	Wind Speed	Wind Direction	Temperature	Humidity
IOA	≥ 0.6		≥ 0.8	≥ 0.6
RMSE	≤ 2 m/s			
Mean Bias	≤ ± 0.5 m/s	≤ ± 10 deg	≤ ± 0.5 K	≤ ± 1 g/kg
Gross Error		≤ 30 deg	≤ 2 K	≤ 2 g/kg

Table 3-2: Daily evaluation results for the WRF simulations for the 2013-2015 extracted at OR Tambo

	Wind Speed	Wind Direction	Temperature	Humidity
IOA	0.61		0.91	0.55
RMSE	1.54			
Mean Bias	-0.09	-1.48	-0.46	-0.14
Gross Error		34.97	1.6	1.01

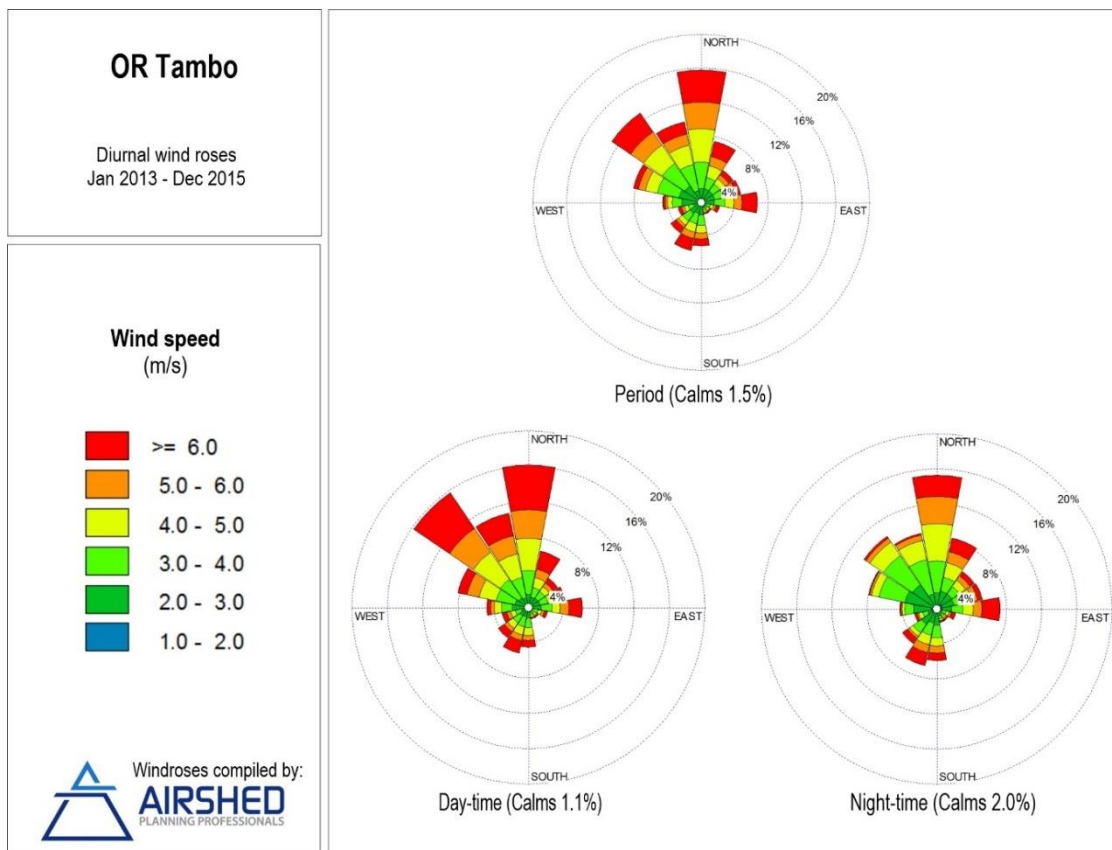


Figure 3-2: Period, day- and night-time wind rose measured at OR Tambo for the period 2013 - 2015

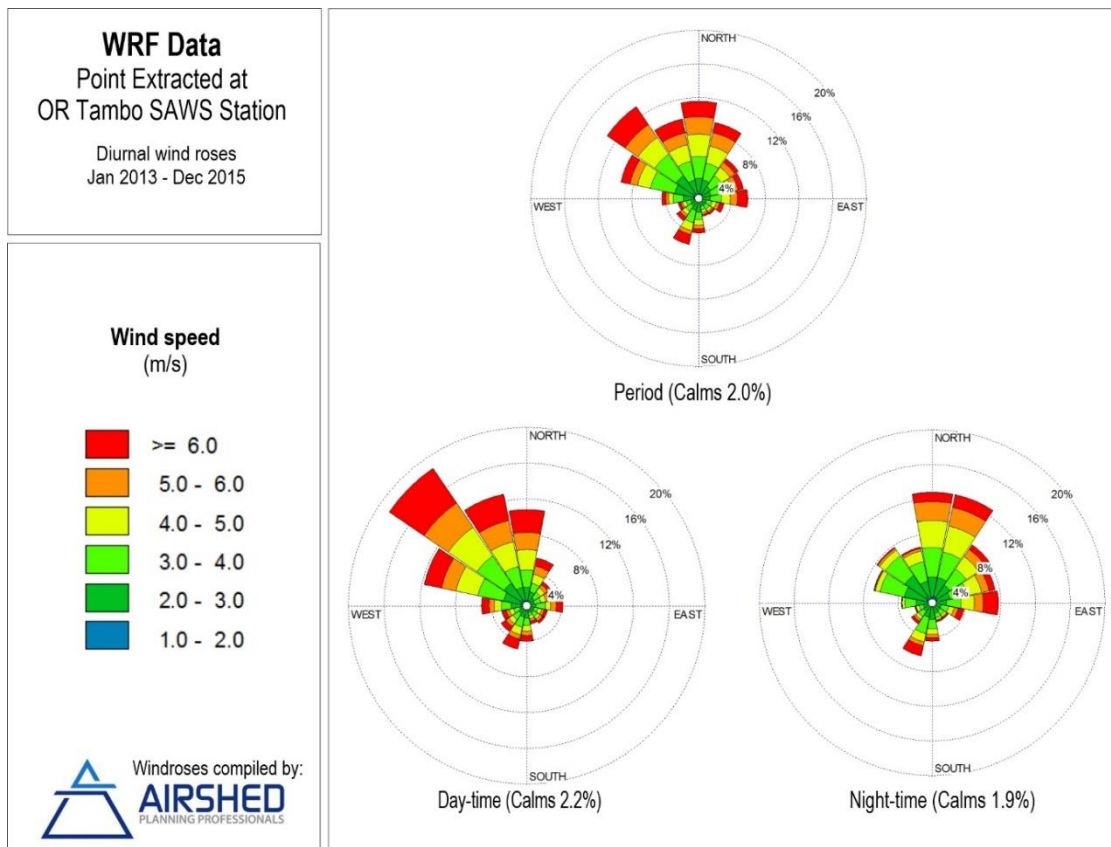


Figure 3-3: Period, day- and night-time wind rose for WRF data as extracted at OR Tambo for the period 2013 - 2015

3.2.1 Local Wind Field

The vertical dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness (Tiway and Colls, 2010).

The co-dominant wind directions (Figure 3-4), during the period under investigation, are north-north-west and east with a frequency of occurrence of approximately 12%. Winds from the south and south-south-east occur relatively infrequently (<3% of the total period). Calm conditions (wind speeds <1 m/s) occur 3.87% of the time. A frequent north-north-westerly flow dominates day-time conditions with >15% frequency of occurrence. At night, an increase in easterly flow is observed (>15% frequency).

During summer months, winds from the east become more frequent (Figure 3-5). There is an increase in the frequency of calm periods (i.e. wind speeds <1 m/s) during the autumn (5.19%) and winter months (4.26%). The predominant wind direction in winter is from the north-west and south-west. During spring-time, winds are more likely to exceed 5.0 m/s, with calm conditions only 2% of the time.

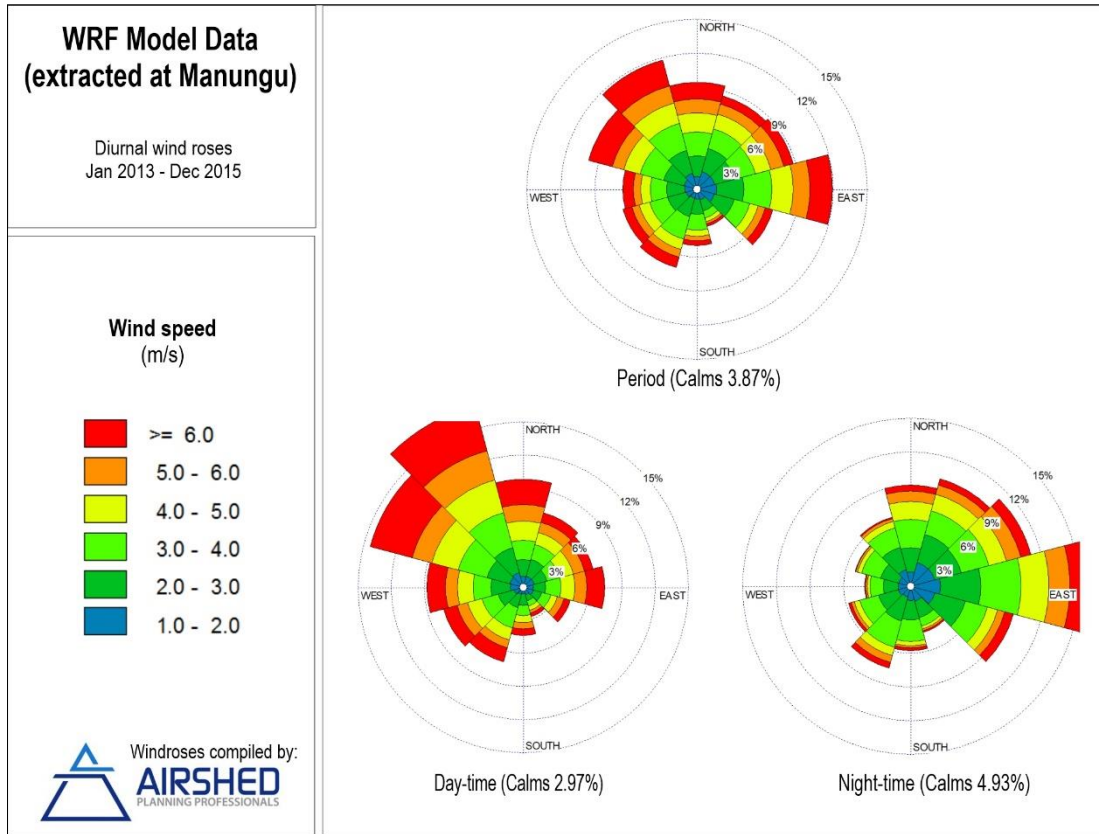


Figure 3-4: Period average, day-time and night-time wind roses (WRF data; 2013 to 2015)

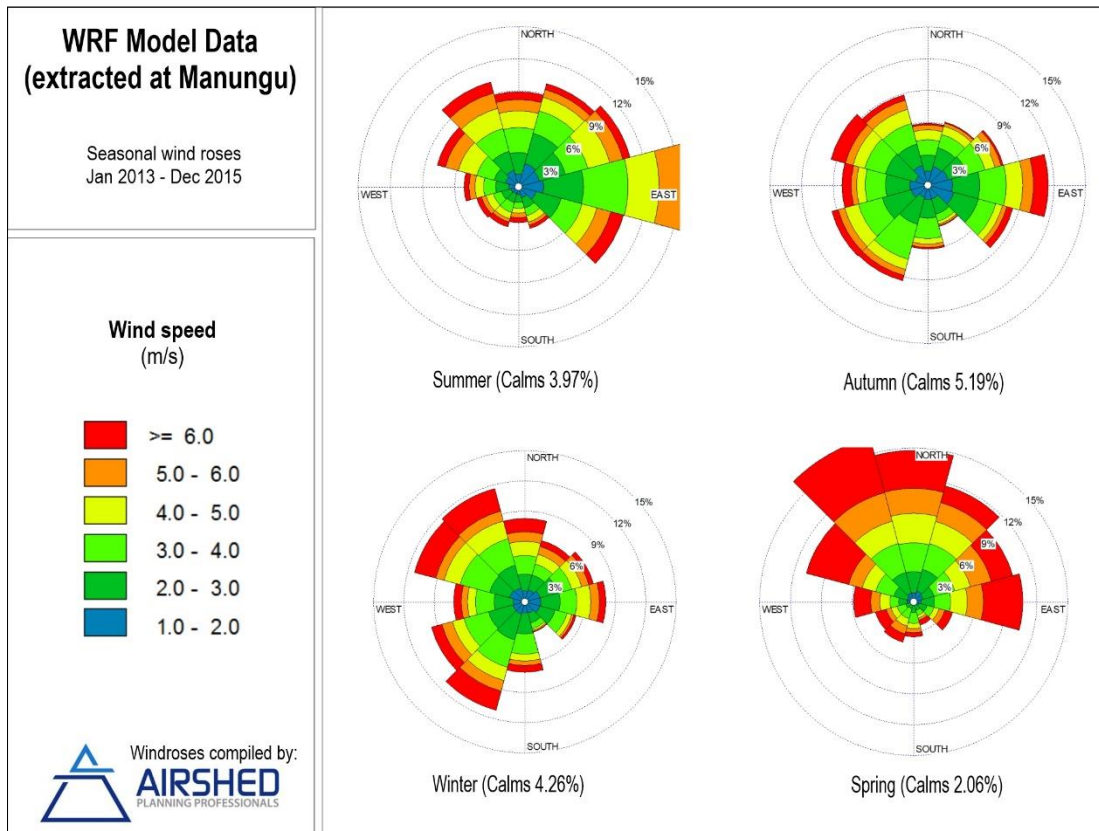


Figure 3-5: Seasonal wind roses (WRF data; 2013 to 2015)

3.2.2 Ambient Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher a pollution plume rises), and determining the development of the mixing and inversion layers. The monthly temperature pattern is shown in Figure 3-6. Average daily maximum, minimum and mean temperatures for the site are given as 26.6°C, 4.9°C and 16.7°C, respectively, based on the modelled WRF data for the project area for the period 2013 to 2015. Maximum temperatures range from 26.6°C in February to 17.9°C in July, with daily minima ranging from 15.0°C in January to 4.9°C in June.

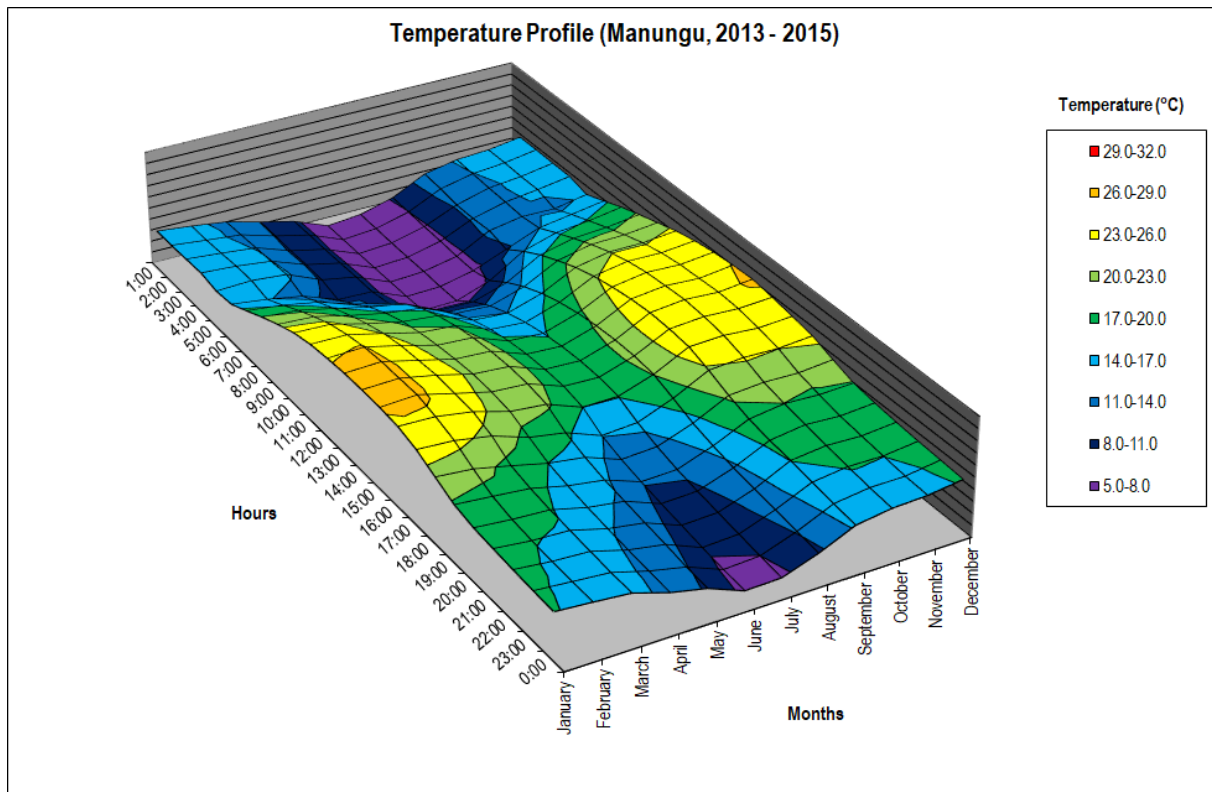


Figure 3-6: Monthly temperature profile (WRF data; 2013 to 2015)

3.2.3 Atmospheric Stability and Mixing Depth

The new generation air dispersion models differ from the models traditionally used in a number of aspects, the most important of which is the description of atmospheric stability as a continuum rather than discrete classes. The atmospheric boundary layer properties are therefore described by two parameters; the boundary layer depth and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill Class. The Monin-Obukhov length (L_{Mo}) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and less dilution potential. During windy and/or cloudy conditions, the atmosphere is normally neutral. For low level releases, the highest ground level concentrations would occur during weak wind speeds and stable (night-time) atmospheric conditions.

3.3 Ambient Air Quality within the Region

3.3.1 *PM_{2.5} and PM₁₀ Sampling*

PM_{2.5} and PM₁₀ sampling is undertaken at the Manungu Colliery by means of a Minivol. The sampler was setup near the offices in March 2017. For the current assessment, measured PM_{2.5} and PM₁₀ has been provided for the period March to September 2017 (Figure 3-7).

PM₁₀ daily concentrations ranged from 2 µg/m³ to 304 µg/m³ during the months of March to September 2017 (average concentration 144 µg/m³). The NAAQ Limit of 75 µg/m³ was exceeded 13 times (the regulations allow for 4 days in a calendar year).

PM_{2.5} daily concentrations ranged from 2 µg/m³ to 327 µg/m³ during the months of March to September 2017 (average concentration 105 µg/m³). The NAAQ Limit of 40 µg/m³ was exceeded 14 times (the regulations allow for 4 days in a calendar year).

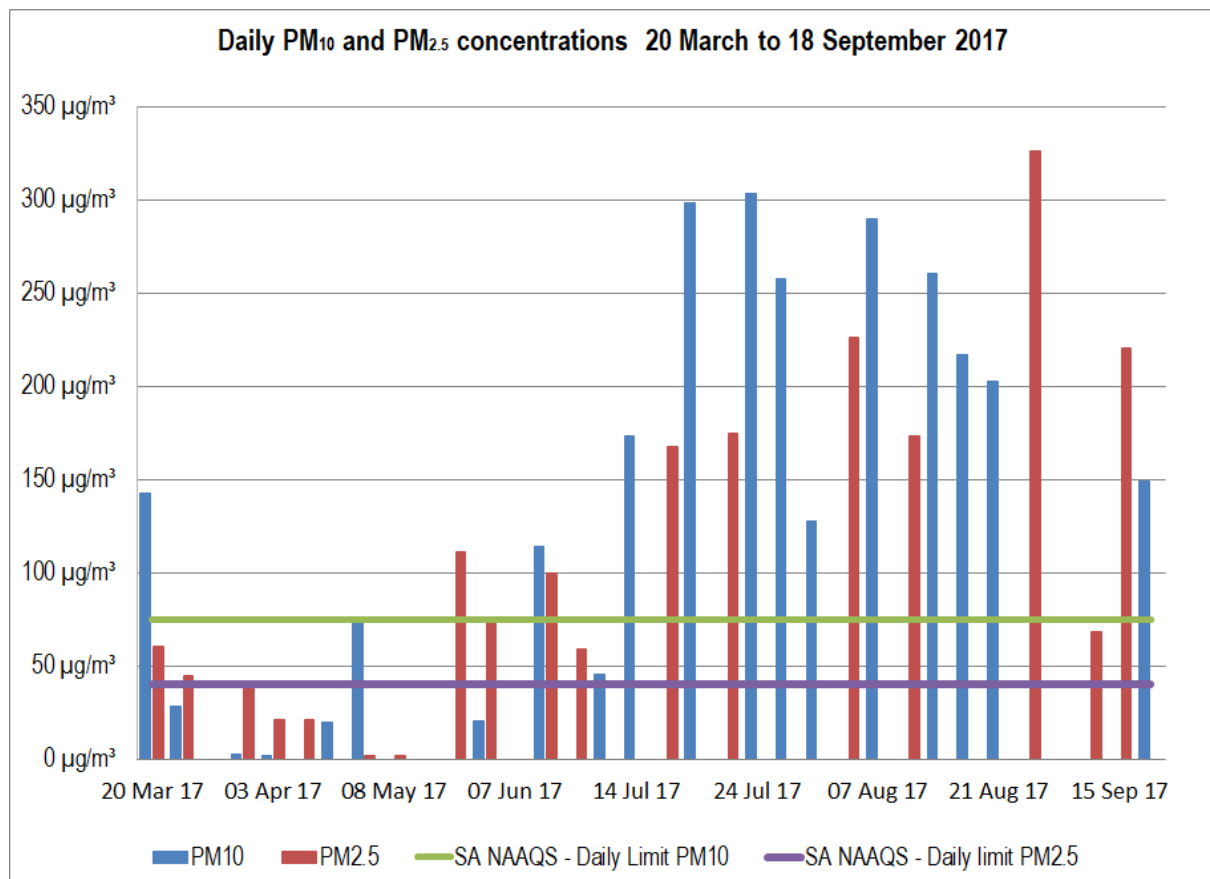


Figure 3-7: Measured daily PM_{2.5} and PM₁₀ at the sampling location for the period March to September 2017

3.3.2 Dust Fallout Monitoring

The Manungu Colliery have a dust fallout monitoring network onsite consisting of 7 single buckets and 4 directional buckets (Figure 3-8 and Table 3-3). The dust deposition levels for the period May 2017 to April 2018 were provided for the current assessment and is summarised in Table 3-4.

It should be noted that the NDCR specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be ASTM D1739 (1970), or equivalent method approved by any internationally recognized body. The method uses a simple non-directional bucket of at least 150 mm diameter and at least twice as deep as the diameter with the top of the bucket at 2 m above ground level. Samples are exposed for 30 ± 3 days, and results reported as a dustfall rate in units ($\text{mg}/\text{m}^2/\text{day}$), 30-day average. For this reason, only measurements from single dustfall buckets have been discussed in this section.

The dustfall rates as specified in the NDCR (600 $\text{mg}/\text{m}^2/\text{day}$ for residential areas and 1200 $\text{mg}/\text{m}^2/\text{day}$ for non-residential areas) are applicable for dust fallout measured by the ASTM D1739 method.

The measured dust fallout for the period May 2017 to April 2018 exceeded the NDCR for non-residential areas at MAN01 during November 2017, MAN02 during August and September 2017, MAN03 during July 2017 and February and March 2018, MAN04 during September and November 2017 and March 2018 and MAN05 during September 2017. The NDCR stipulates that the rate for non-residential areas can be exceeded two months in the year but not consecutive months. This condition is not met at site MAN02, MAN03 and MAN04. It should be noted, however, that MAN03 and MAN04 are onsite sampling locations for internal management purposes and should not form part of the reporting network to the Department of Environmental Affairs.

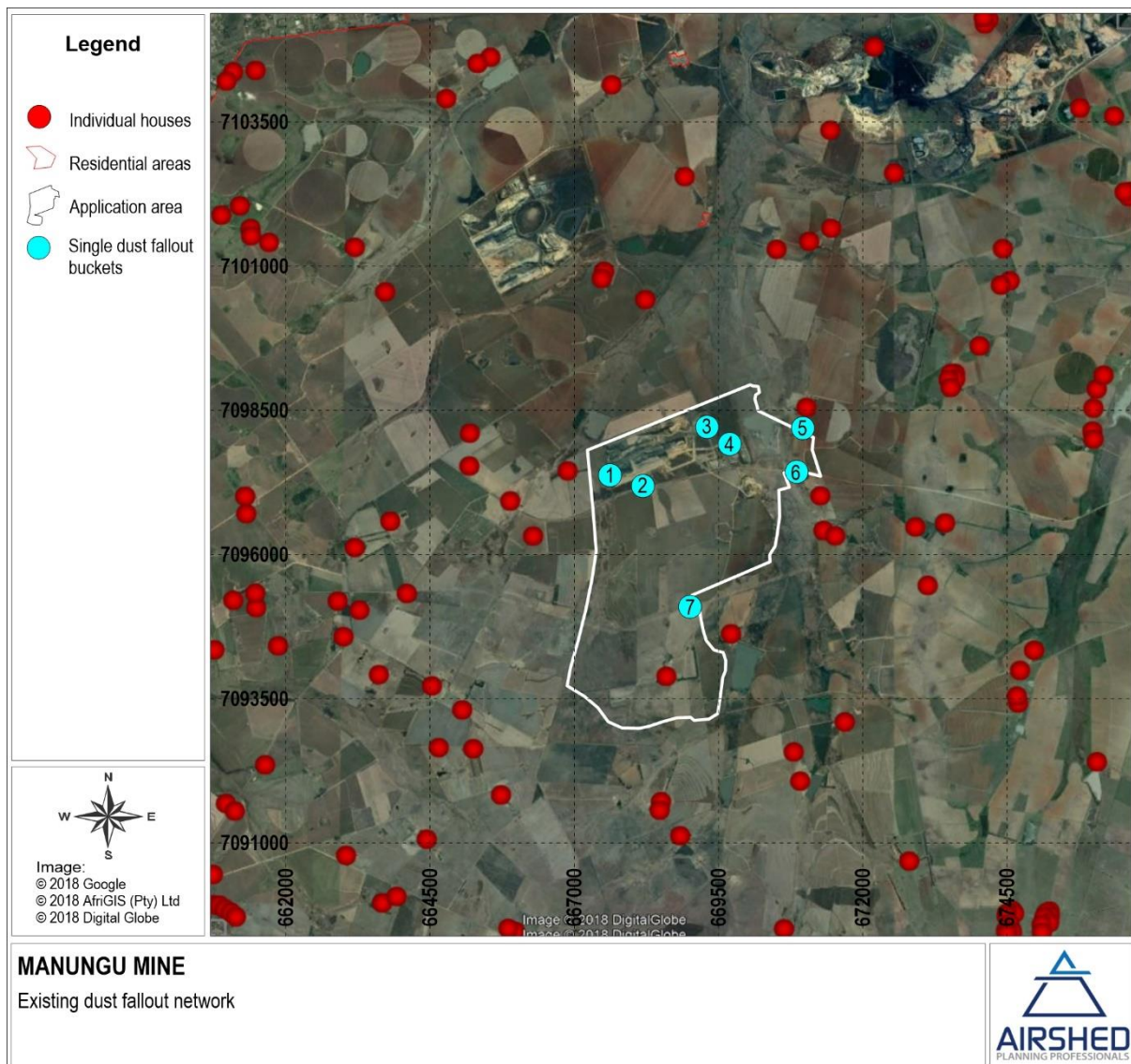


Figure 3-8: The position of the current dust fallout network for the Manungu Colliery

Table 3-3: The co-ordinates of the current dust fallout network for the Manungu Colliery

Description	Latitude	Longitude
MAN01	-26.2331	28.6783
MAN02	-26.2353	28.6842
MAN03	-26.2261	28.6953
MAN04	-26.2286	28.6989
MAN05	-26.2264	28.7114
MAN06	-26.2331	28.7103
MAN07	-26.2542	28.6919

Table 3-4: The measured dust fallout rates for the period April to September 2017

Period	Man 01	Man 02	Man 03	Man 04	Man 05	Man 06	Man 07
May-17	1 009	397	200	697	57	262	411
Jun-17	269	634	387	186	785	135	69
Jul-17	770	686	1 299	717	510	57	667
Aug-17	745	1 748	412	838	71	546	611
Sep-17	601	1 289	1 111	6 042	1 503	287	302
Oct-17	726	1 064	987	2 969	285	149	674
Nov-17	1 836	940	852	2 457	98	191	392
Dec-17	397	615	1 060	1 086	70	276	404
Jan-18		439	911	1 027	111	142	303
Feb-18	213	605	1 230	1 140	108	67	475
Mar-18	584	395	1 320	3 600	12	132	419
Apr-18	102	456	836	995	230	129	

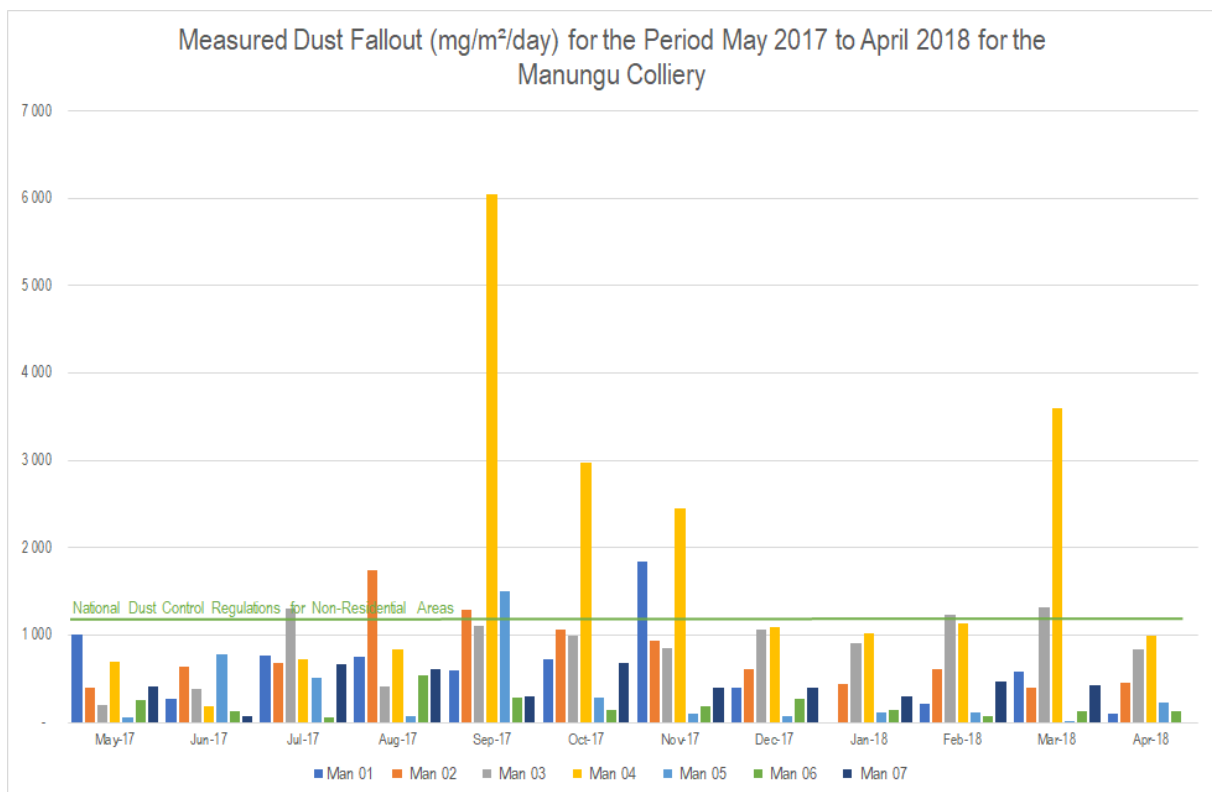


Figure 3-9: The measured dust fallout rates for the period May 2017 to April 2018

3.4 Existing Sources of Emissions near the Project

3.4.1 Vehicle Tailpipe Emissions

Emissions resulting from motor vehicles can be grouped into primary and secondary pollutants. While primary pollutants are emitted directly into the atmosphere, secondary pollutants form in the atmosphere as a result of chemical reactions. Significant primary pollutants emitted by internal combustion engines include carbon dioxide (CO₂), CO, carbon (C), SO₂, oxides of nitrogen (mainly nitrogen monoxide (NO)) and particulates. Secondary pollutants include NO₂, photochemical oxidants such as ozone, sulfur acid, sulfates, nitric acid, and nitrate aerosols (particulate matter). Vehicle (i.e. model-year, fuel delivery system), fuel (i.e. type, oxygen content), operating (i.e. vehicle speed, load), and environmental parameters (i.e. altitude, humidity) influence vehicle emission rates (Onursal & Gautam, 1997). The release of volatile organic compounds (VOCs) via vehicle emissions is likely to have localised impacts and be within ambient air quality standards and are considered to be a minor contributor to an emissions inventory.

3.4.2 Agricultural Sources

Crop farming occurs in the area. Crop farming activities that may result in atmospheric emissions include land tilling operations, fertiliser and pesticide applications, and harvesting. By applying fertiliser and pesticides use are typically made of vehicles (tractors) driving on unpaved roads and exposed soil. Land tilling include dust entrainment on exposed surfaces, wind-blown dust and scraping and grading type activities resulting in fugitive dust releases. Both PM and gaseous air emissions (mainly NO, NO₂, ammonia (NH₃), SO₂ and VOCs) are generated from the application of nutrients as fertilizers or manures. There are primarily three harvesting operations resulting in particulate emissions: (1) crop handling by the harvest machine, (2) loading of the harvested crop into trucks, and (3) transport by trucks in the field. Particulate matter, composed of soil dust and plant tissue fragments (chaff), may be entrained by wind (US EPA, 1995).

3.4.3 Fugitive Dust Sources

These sources are termed fugitive because they are not discharged to the atmosphere in a confined flow stream. Sources of fugitive dust identified to potentially occur in the study area include mining operations, paved and unpaved roads; agricultural tilling operations; and wind erosion of sparsely vegetated surfaces.

Unpaved and paved roads

Emissions from unpaved roads can constitute a substantial source of emissions to the atmosphere in the South African context. The force of the wheels of a vehicle traveling on an unpaved road, results in the pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong turbulent air shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. Dust emissions from unpaved roads vary in relation to the vehicle traffic (including average vehicle speed, mean vehicle weight, average number of wheels per vehicle) and the silt loading on the roads.

Emissions from paved roads are significantly less than those originating from unpaved roads; however, they do contribute to the particulate load of the atmosphere. Particulate emissions occur whenever vehicles travel over a paved surface. The fugitive dust emissions are due to the re-suspension of loose material on the road surface.

Wind erosion of open areas

Emissions generated by wind erosion are dependent on the frequency of disturbance of the erodible surface. Every time a surface is disturbed, its erosion potential is restored. Erodible surfaces may occur as a result of agriculture and/or grazing activities, or as a result of drying of fine material such as slimes.

3.4.4 Biomass Burning

Biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Within the project vicinity, wild fires (locally known as veld fires) may represent significant sources of combustion-related emissions (Maenhaut, Salma, Cafmeyer, Annegarn, & Andreae, 1996) (Galpin & Turner, 1999). The frequency of wildfires varies between annual and triennial (Tainton & Mentis, 1984).

Biomass burning is an incomplete combustion process (Cachier, 1992), with carbon monoxide, methane and nitrogen dioxide gases being emitted. Approximately 40% of the nitrogen in biomass is emitted as nitrogen, 10% is left in the ashes, and it may be assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds (Held et al., 1996). The visibility of the smoke plumes is attributed to the aerosol (particulate matter) content. In addition to the impact of biomass burning within the vicinity of the proposed mining activity, long-range transported emissions from this source can be expected to impact on the air quality between the months August to October. It is impossible to control this source of atmospheric pollution loading; however, it should be noted as part of the background or baseline condition before considering the impacts of other local sources.

3.4.5 Domestic Fuel Burning

Domestic fuel burning contributes to gaseous and particulate ambient concentrations. Coal burning emits a large amount of gaseous and particulate pollutants including SO₂, NO₂, heavy metals, total and respirable particulates including heavy metals and inorganic ash, carbon monoxide, polycyclic aromatic hydrocarbons, and benzo(a)pyrene (EPA, 1996). Polyaromatic hydrocarbons are recognised as carcinogens. Pollutants arising due to the combustion of wood include respirable particulates, SO₂, NO₂, carbon monoxide, polycyclic aromatic hydrocarbons, particulate benzo(a)pyrene and formaldehyde (EPA, 1996). The main pollutants emitted from the combustion of paraffin are NO₂, particulates carbon monoxide and polycyclic aromatic hydrocarbons (EPA, 2010).

3.4.6 Industrial Emissions

The proposed project is within the Mpumalanga province which consists of several industrial activities:

- Emissions from coal combustion by power generation, metallurgical and petrochemical industries represent the largest contribution to total emissions from the industrial / institutional / commercial fuel use sector within the Mpumalanga region.
- The metallurgical group is estimated to be responsible for at least ~50% of the particulate emissions from this sector. This group includes iron and steel, ferro-chrome, ferro-alloy and stainless-steel manufacturers (includes Ferrometals, Columbus Stainless, Transalloys, Middelburg Ferrochrome).
- Petrochemical and chemical industries are primarily situated in Secunda (viz. Sasol Synfuels). The use of coal for power generation and the coal gasification process represent significant sources of sulphur dioxide emissions. (Particulate emissions are controlled through the implementation of stack gas cleaning equipment.)
- Other industrial sources include: brick manufacturers which use coal (e.g. Witbank Brickworks, Quality Bricks, Corobrik, Hoeveld Stene, Middelwit Stene) and woodburning and wood drying by various sawmills (Bruply, Busby,

M&N Sawmills) and other heavy industries (using coal and to a lesser extent heavy fuel oil (HFO) for steam generation). The contribution of fuel combustion (primarily coal) by institutions such as schools and hospitals to total emissions is relatively minor due to the extent of emissions from other groups.

4 IMPACTS FROM THE PROPOSED PROJECT ON THE RECEIVING ENVIRONMENT

4.1 Planning/Design and Construction Phase

4.1.1 Identification of Environmental Aspects

The construction phase will comprise a series of different operations including land clearing, topsoil removal, material loading and hauling, stockpiling, grading, bulldozing, compaction, (etc.). Each of these operations has its own duration and potential for dust generation. It is anticipated therefore that the extent of dust emissions would vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions. This is in contrast to most other fugitive dust sources where emissions are either relatively steady or follow a discernible annual cycle.

A list of all the potential dust generation activities expected during the construction phase is provided in Table 4-1. Unmitigated construction activities provide the potential for impacts on local communities, primarily due to nuisance and aesthetic impacts associated with fugitive dust emissions. On-site dustfall may also represent a nuisance to employees.

Impact due to the construction phase was not assessed as detailed information was not provided for this phase. The emission sources for this phase, however, would be of a relatively short-term duration and the impact would be near to site.

Table 4-1: Typical sources of fugitive particulate emission associated with construction

Impact	Source	Activity
Gasses	Vehicle tailpipe	Transport and general construction activities
PM ₁₀ and PM _{2.5}	Stockpile areas and open areas	Clearing of groundcover
		Levelling of area
		Wind erosion from open areas
		Materials handling
	Transport infrastructure	Clearing of vegetation and topsoil
		Levelling of areas

4.1.2 Mitigation Measures Recommended

Incremental PM₁₀ and PM_{2.5} concentrations and deposition rates due to the Construction Phase of the proposed project will be of relatively short-term and of local impact. The implementation of effective controls, however, during this phase would also serve to set the precedent for mitigation during the operational phase.

Dust control measures which may be implemented during the construction phase are outlined in Table 4-2. Control techniques for fugitive dust sources generally involve watering, chemical stabilization, and the reduction of surface wind speed through the use of windbreaks and source enclosures.

Table 4-2: Dust control measures that may be implemented during construction activities

Construction Activity	Recommended Control Measure(s)
Materials storage, handling and transfer operations	Wet suppression where feasible on stockpiles and materials handling activities
Open areas (windblown emissions)	Minimise extent of disturbed areas. Reduction of frequency of disturbance. Early re-vegetation Stabilisation (chemical, rock cladding or vegetative) of disturbed soil

4.2 Operational Phase

4.2.1 Identification of Environmental Aspects

In terms of air quality, atmospheric emissions represent the environmental aspects of concern for the assessment of the proposed project. The sources of these emissions were determined by first identifying the inputs and outputs to the various processes and secondly considering the disturbance to the environment by the proposed operations. Possible aspects associated with the proposed operations of relevance in terms of air quality impacts are listed in Table 4-3. Particulates present the main pollutant of concern from mining operations. Fugitive dust from vehicle entrainment, materials handling operations, wind erosion and crushing and screening are classified as routine emissions and are fairly constant throughout the year.

Table 4-3: Potential air pollutants emitted from the proposed project

Operational phase		
Aspects	Source	Activities
Vehicle Entrainment		
Gaseous and particulate emissions; fugitive dust	Vehicle activity on paved and unpaved roads	Transportation of Run of Mine (ROM) from underground and opencast mines to crusher plant Transportation of overburden Transportation of product
Material handling		
Fugitive dust	Materials handling operations	Remove ROM from underground and opencast mining areas Tip ROM at crusher Tip from crusher to product stockpile Reclaim from stockpile Tipping of product at load-out area Primary and secondary crushing
In-pit mining operations		
Fugitive dust	Mining operations within open pit	Topsoil removal Drilling and blasting of seam and overburden Removal of ROM by excavator and loading of haul trucks Overburden replacement Grading of covered pit areas
Storage piles		
Fugitive dust	Wind erosion	Windblown dust from storage piles

4.2.2 Quantification of Environmental Aspects and Impact Classification

4.2.2.1 Emissions Inventory

The operation phase is assessed quantitatively with the emissions provided in the current section. The emission factors and calculated emission rates are provided in Table 4-4.

Table 4-4: Emission factors used to qualify the routine emissions from the operational phase for the project

Activity	Emission Equation	Source	Information assumed/provided
Vehicle entrainment on unpaved surfaces	$E = k(s/12)^a(W/3)^b$ <p>Where, E = size-specific emission factor (lb/VKT) s = surface material silt content (%) W = mean vehicle weight (tons)</p> <p>The particle size multiplier (k) is given as 0.15 for PM_{2.5}, 1.5 for PM₁₀, and as 4.9 for TSP. A is given as 0.9 for PM_{2.5} and PM₁₀ and 0.7 for TSP. A is given as 0.45 for PM_{2.5}, PM₁₀ and TSP.</p>	US-EPA AP42 Section 13.2.2	<p>In the absence of site specific silt data, use was made of US EPA default mean silt loading of 8.4 % for haul roads.</p> <p>The capacity of the haul trucks to be used was assumed to be 60t. It was assumed that the product will be transported by 34 t interlink trucks.</p> <p>The throughput of the ROM material and overburden was provided for current and proposed operations. A throughput for the period 2017 and 2018 was assumed for current operations. The life of mine (LOM) throughput was provided for proposed operations and the maximum throughput year selected for the proposed impact assessment.</p> <p><i>75% and 90% control efficiency were assumed for the mitigated scenario.</i></p>
Materials handling	$E = 0.0016 \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$ <p>Where, E = Emission factor (kg dust / t transferred) U = Mean wind speed (m/s) M = Material moisture content (%)</p> <p>The PM_{2.5}, PM₁₀ and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively.</p>	US-EPA AP42 Section 13.2.4	<p>An average wind speed of 3.6 m/s was used based on the modelled WRF data for the period 2013 to 2015.</p> <p>The throughput of the material was provided.</p>
Crushing and screening	<p><u>Primary (for high moisture ore):</u></p> $E_{TSP} = 0.01 \text{ kg/t material processed}$ $E_{PM10} = 0.004 \text{ kg/t material processed}$ $E_{PM2.5} = 0.00074 \text{ kg/t material processed}$ <p><u>Secondary (for high moisture ore):</u></p> $E_{TSP} = 0.03 \text{ kg/t material processed}$ $E_{PM10} = 0.012 \text{ kg/t material processed}$ $E_{PM2.5} = 0.00222 \text{ kg/t material processed}$	NPI Section: Mining	<p>It was assumed that primary and secondary crushing takes places.</p> <p><i>50% control efficiency was assumed for the mitigated scenario.</i></p>

Activity	Emission Equation	Source	Information assumed/provided
	Fraction of PM _{2.5} taken from US-EPA crushed stone emission factor ratio for tertiary crushing		
Drilling	$E_{TSP} = 0.59 \text{ kg of dust /drill hole}$ PM ₁₀ is given as 52% of TSP emissions and PM _{2.5} is assumed to be 3% of TSP emissions	NPI Section: Mining	A blast area of 40 m x 120 m was provided. <i>99% control efficiency was assumed for the mitigated scenario.</i>
Blasting	$E_{TSP} = 0.00022 \times A^{1.5}$ Where, A = area blasted in m ² PM ₁₀ is given as 52% of TSP emissions and PM _{2.5} is assumed to be 3% of TSP emissions	NPI Section: Mining	A blast area of 4750 m ² was assumed based on the previous air quality impacts assessment completed for the site (Akinshipe and Bird, 2016). <i>As blasting activities are intermittent and not a continuous operation, the emissions from this activity was quantified but not modelled.</i>
Wind Erosion	$E(i) = G(i)10^{(0.134(\%clay)-6)}$ For $G(i) = 0.261 \left[\frac{P_a}{g} \right] u^{*3} (1 + R)(1 - R^2)$ And $R = \frac{u_*^t}{u^*}$ where, E _(i) = emission rate (g/m ² /s) for particle size class i P _a = air density (g/cm ³) G = gravitational acceleration (cm/s ³) u ^{*t} = threshold friction velocity (m/s) for particle size i u [*] = friction velocity (m/s)	Marticorena & Bergametti, 1995	Particle size distribution was obtained from similar processes (Table 4-5). Layout of all storage piles were provided. Hourly emission rate file was calculated and simulated.

Table 4-5: Particle size distribution (provided as a fraction) for the storage pile material

Size Distribution (µm)	Fraction			
	Product	ROM	Discard	Topsoil
5000-4750	0.234	0.188		
4750-3375	0.352	0.205		
3375-2850	0.092	0.144		
2850-2000			0.8	
2000-477.01		0.001	0.0004	
477-409.45	0.002	0.002	0.0009	
2000-355				0.034
409-351.46	0.004	0.002	0.0009	
351-301.68	0.007	0.004	0.002	
301-258.95	0.005	0.004	0.002	
258-222.28	0.003	0.004	0.002	
355-212				0.077
222-190.8	0.003	0.005	0.002	

Size Distribution (µm)	Fraction			
	Product	ROM	Discard	Topsoil
190-163.77	0.004	0.004	0.002	
163-140.58	0.007	0.005	0.002	
212-125				0.056
140-120.67	0.009	0.006	0.003	
120-103.58	0.007	0.005	0.002	
103-88.91	0.005	0.004	0.002	
89-76.32	0.006	0.005	0.002	
125-75				0.099
76-65.51	0.009	0.006	0.003	
65-56.23	0.01	0.006	0.003	
56-48.27	0.009	0.005	0.002	
75-45				0.117
48-41.43	0.008	0.003	0.001	
41-35.56	0.008	0.003	0.001	
35-30.53	0.008	0.003	0.001	
45-30				0.179
30-26.2	0.008	0.003	0.001	
26-22.49	0.007	0.003	0.001	
22-19.31	0.007	0.003	0.001	
19-16.57	0.006	0.003	0.001	
30-15				0.076
16-14.22	0.006	0.003	0.001	
14-12.21	0.005	0.003	0.001	
12-10.48	0.005	0.002	0.0009	
15-10				0.117
10-9	0.005	0.002	0.0009	
9-7.72	0.005	0.003	0.001	
7.7-6.63	0.005	0.004	0.002	
6.9-5.69	0.005	0.004	0.002	
10-5				0.081
5.7-4.88	0.004	0.002	0.0009	
4.9-4.19	0.002			
4.2-3.6	0.002	0.001	0.0004	
3.6-3.09	0.002	0.001	0.0004	
5-3				0.107
3.1-2.65	0.002	0.001	0.0005	
2.6-2.28	0.001	0.001	0.0005	
2.3-1.95		0.001	0.0005	
1.9-1.68		0.002	0.0018	
1.7-1.44		0.003	0.001	
1.4-1.24		0.003	0.001	
3-1				0.057
1.2-0.42		0.003	0.002	
0.4-0.36		0.038	0.016	
0.36-0.31		0.128	0.055	
0.31-0.27		0.128	0.055	
0.27-0.23		0.038	0.016	
0.23-0.2		0.003	0.002	
2.28-0.13	0.002			
0.13-0.11	0.005			

Size Distribution (µm)	Fraction			
	Product	ROM	Discard	Topsoil
0.11-0.09	0.013			
0.09-0.08	0.025			
0.08-0.07	0.039			
0.07-0.06	0.048			

4.2.2.2 Synopsis of Particulate Emissions from Various Sources at the Project due to Current and Proposed Operational Activities

Particulate emissions calculated for various source types are given in Table 4-6. Both unmitigated and mitigated (applying 75% control efficiency on unpaved road surfaces and 50% control efficiency on crushing activities (control efficiency documented by Australia's National Pollution Inventory as being achievable through water sprayers)) conditions were assessed. A further mitigated scenario was assessed where 90% control efficiency on unpaved roads (achieved through chemical suppressants or paving surfaces) and 50% control efficiency on crushing activities was assumed. For unmitigated operations, vehicle entrainment on unpaved surfaces represents the most significant source of particulate emissions. The second largest source of unmitigated TSP emissions for mining operations is due to crushing activities (Figure 4-1 and Figure 4-2).

Table 4-6: Particulate emissions due to routine operations for the project

ACTIVITY	Emissions (tpa)			% Contribution			Rank
	TSP	PM ₁₀	PM _{2.5}	TSP	PM ₁₀	PM _{2.5}	TSP
Current Manungu operations							
<i>Unmitigated</i>							
Vehicle entrainment	1 746.38	497.80	49.78	89.13	82.38	55.07	1
Drilling and blasting	30.62	15.92	0.92	1.56	2.63	1.02	5
Materials handling	42.23	19.97	3.02	2.16	3.31	3.35	4
Crushing and screening	81.14	32.46	6.00	4.14	5.37	6.64	2
Wind erosion	59.08	38.09	30.67	3.02	6.30	33.93	3
TOTAL	1 959.44	604.24	90.40	100.00	100.00	100.00	
<i>Mitigated: control efficiency of 75% applied to unpaved roads; 50% applied to crushing activities</i>							
Vehicle entrainment	436.59	124.45	12.44	71.68	57.98	24.86	1
Drilling and blasting	30.62	15.92	0.92	5.03	7.42	1.83	5
Materials handling	42.23	19.97	3.02	6.93	9.30	6.04	3
Crushing and screening	40.57	16.23	3.00	6.66	7.56	6.00	4
Wind erosion	59.08	38.09	30.67	9.70	17.74	61.27	2
TOTAL	609.09	214.66	50.06	100.00	100.00	100.00	
<i>Mitigated: control efficiency of 90% applied to unpaved roads; 50% applied to crushing activities</i>							
Vehicle entrainment	174.64	49.78	4.98	50.31	35.56	11.69	1
Drilling and blasting	30.62	15.92	0.92	8.82	11.37	2.16	5
Materials handling	42.23	19.97	3.02	12.16	14.27	7.10	3
Crushing and screening	40.57	16.23	3.00	11.69	11.59	7.05	4
Wind erosion	59.08	38.09	30.67	17.02	27.21	72.01	2
TOTAL	347.13	139.99	42.59	100.00	100.00	100.00	
Proposed Manungu operations							
<i>Unmitigated</i>							
Vehicle entrainment	6 915.96	1 971.37	197.14	95.32	92.45	80.70	1
Drilling and blasting	30.62	15.92	0.92	0.42	0.75	0.38	5

ACTIVITY	Emissions (tpa)			% Contribution			Rank
	TSP	PM ₁₀	PM _{2.5}	TSP	PM ₁₀	PM _{2.5}	TSP
Materials handling	53.48	25.29	3.83	0.74	1.19	1.57	4
Crushing and screening	156.12	62.45	11.55	2.15	2.93	4.73	2
Wind erosion	99.03	57.24	30.83	1.36	2.68	12.62	3
TOTAL	7 255.21	2 132.27	244.27	100.00	100.00	100.00	
Mitigated: control efficiency of 75% applied to unpaved roads; 50% applied to crushing activities							
Vehicle entrainment	1 728.99	492.84	49.28	86.88	79.17	54.37	1
Drilling and blasting	30.62	15.92	0.92	1.54	2.56	1.01	5
Materials handling	53.48	25.29	3.83	2.69	4.06	4.23	4
Crushing and screening	78.06	31.22	5.78	3.92	5.02	6.37	3
Wind erosion	99.03	57.24	30.83	4.98	9.19	34.01	2
TOTAL	1 990.18	622.52	90.64	100.00	100.00	100.00	
Mitigated: control efficiency of 90% applied to unpaved roads; 50% applied to crushing activities							
Vehicle entrainment	691.60	197.14	19.71	72.59	60.32	32.28	1
Drilling and blasting	30.62	15.92	0.92	3.21	4.87	1.50	5
Materials handling	53.48	25.29	3.83	5.61	7.74	6.27	4
Crushing and screening	78.06	31.22	5.78	8.19	9.55	9.46	3
Wind erosion	99.03	57.24	30.83	10.39	17.51	50.48	2
TOTAL	952.78	326.82	61.07	100.00	100.00	100.00	

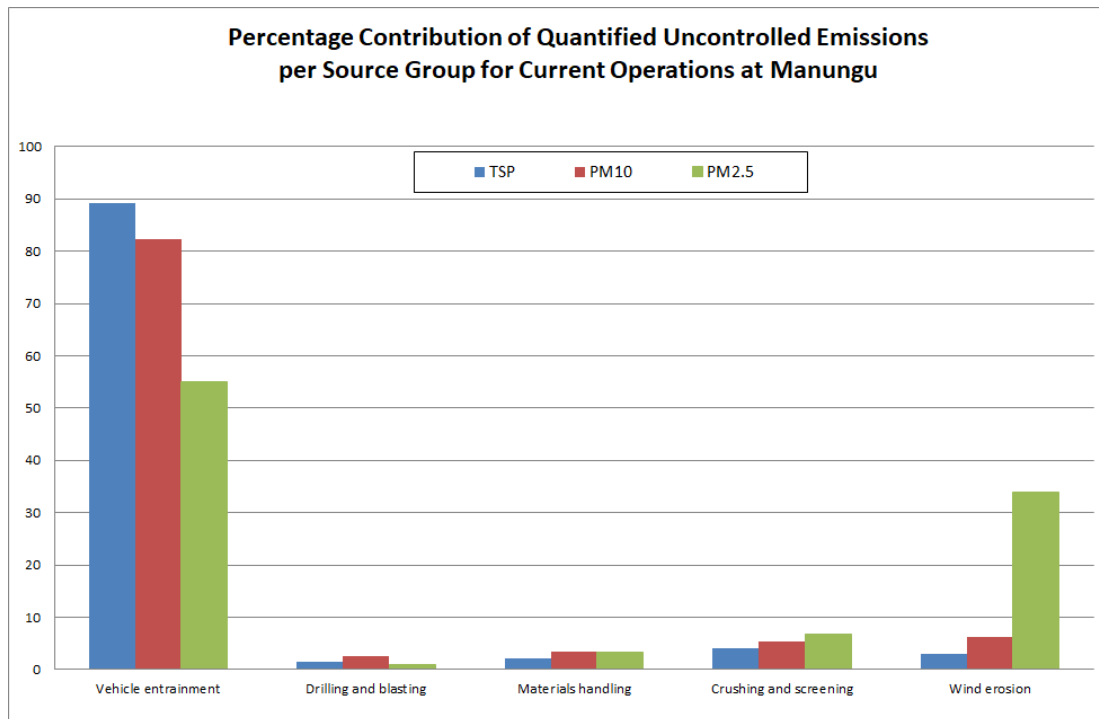


Figure 4-1: Percentage contribution of particulate emissions due to current routine unmitigated operations for the project

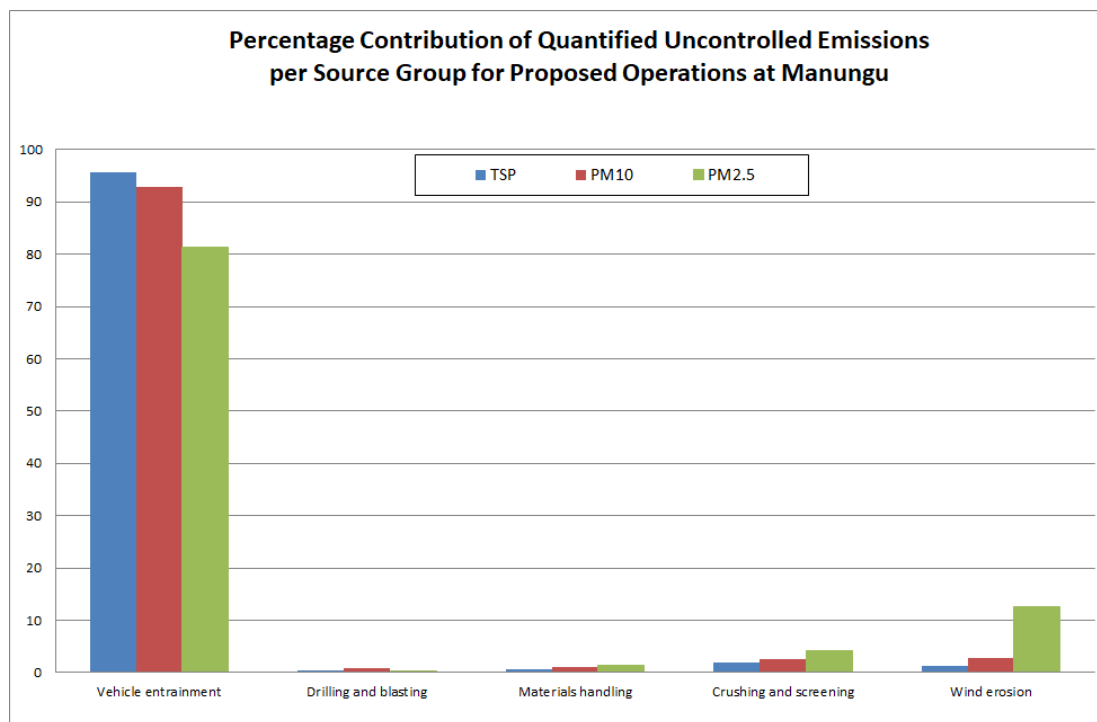


Figure 4-2: Percentage contribution of particulate emissions due to proposed routine unmitigated operations for the project

4.2.2.3 Dispersion Simulation Results and Compliance Assessment

Simulations were undertaken to determine particulate matter (PM₁₀ and PM_{2.5}) concentrations and total daily dust deposition from project activities. For compliance, reference was made to NAAQS and NDCR. The plots provided for the relevant pollutants of concern during the operational phase are given in Table 4-7.

With regard to wind erosion, two scenarios were assessed for proposed operations: (a) the footprint from the waste material stockpiles assuming a height of 6m; (b) the smaller footprints from the waste material stockpiles assuming a height of 45m. The daily particulate concentrations obtained from simulations for the two scenarios were similar in magnitude and spatial distribution. Option (a) was therefore only displayed in the current section. It should be noted, however, that although the daily particulate impacts would be similar, the incidental hourly and sub-hourly impacts from the smaller footprint (assuming a storage pile height of 45m) would be lower than for a larger footprint area (assuming a storage pile height of 6m).

Table 4-7: Isopleth plots presented in the current section

Pollutant	Scenario	Operating Conditions	Figure
PM ₁₀	Current operations	Unmitigated operations	4-3
		Mitigated operations (assuming 75% control efficiency (CE) on unpaved roads and 50% CE on crushing activities)	4-4
		Mitigated operations (assuming 90% CE on unpaved roads and 50% CE on crushing activities)	4-5
	Proposed operations	Unmitigated operations	4-6
		Mitigated operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)	4-7

Pollutant	Scenario	Operating Conditions	Figure
		Mitigated operations (assuming 90% CE on unpaved roads and 50% CE on crushing activities)	4-8
PM _{2.5}	Current operations	Unmitigated operations	4-9
		Mitigated operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)	4-10
		Mitigated operations (assuming 90% CE on unpaved roads and 50% CE on crushing activities)	4-11
	Proposed operations	Unmitigated operations	4-12
		Mitigated operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)	4-13
		Mitigated operations (assuming 90% CE on unpaved roads and 50% CE on crushing activities)	4-14
TSP	Current operations	Unmitigated operations	4-15
		Mitigated operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)	4-16
		Mitigated operations (assuming 90% CE on unpaved roads and 50% CE on crushing activities)	4-17
	Proposed operations	Unmitigated operations	4-18
		Mitigated operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)	4-19
		Mitigated operations (assuming 90% CE on unpaved roads and 50% CE on crushing activities)	4-20

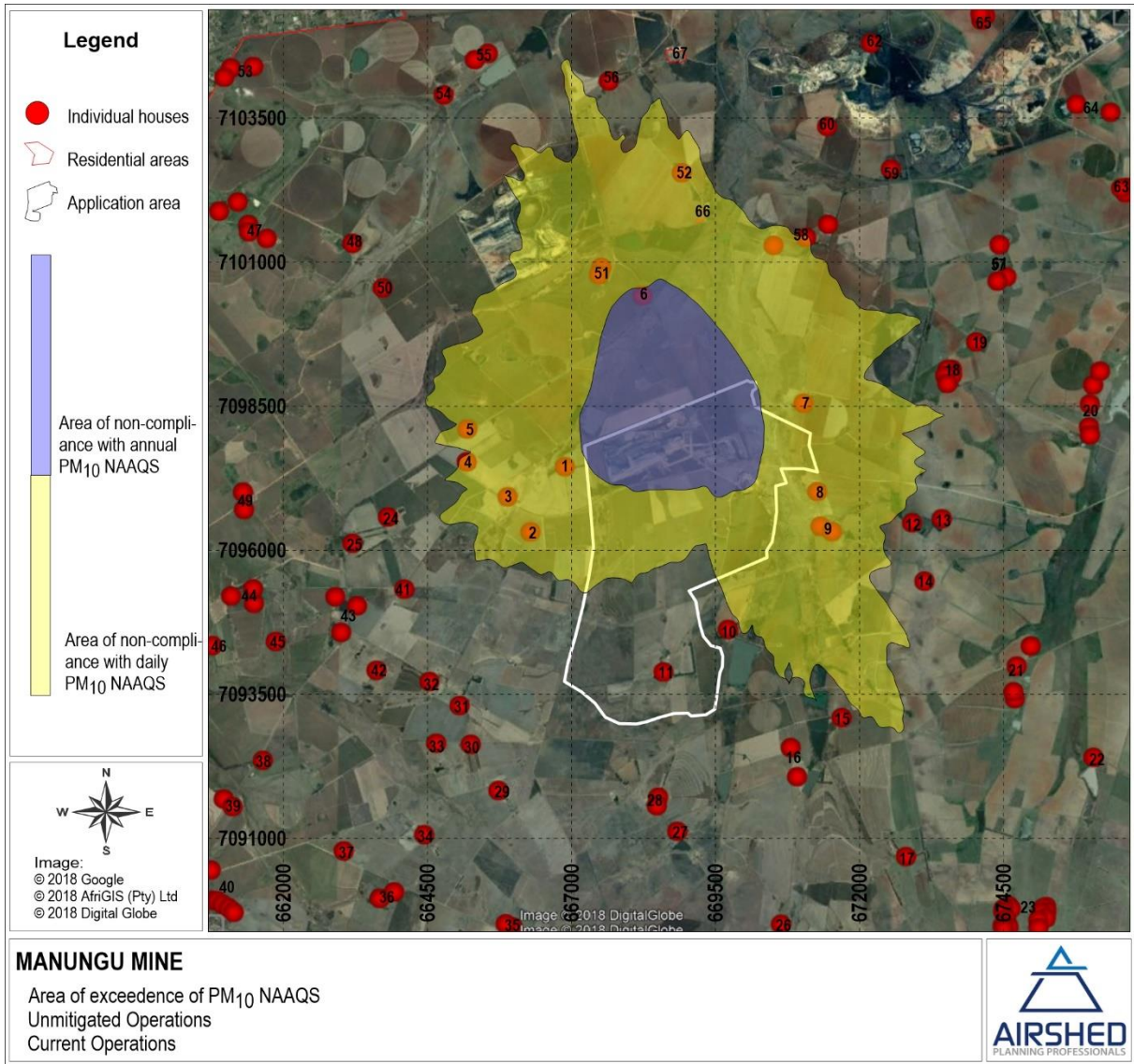


Figure 4-3: Area of non-compliance of PM₁₀ NAAQS due to current unmitigated project operations

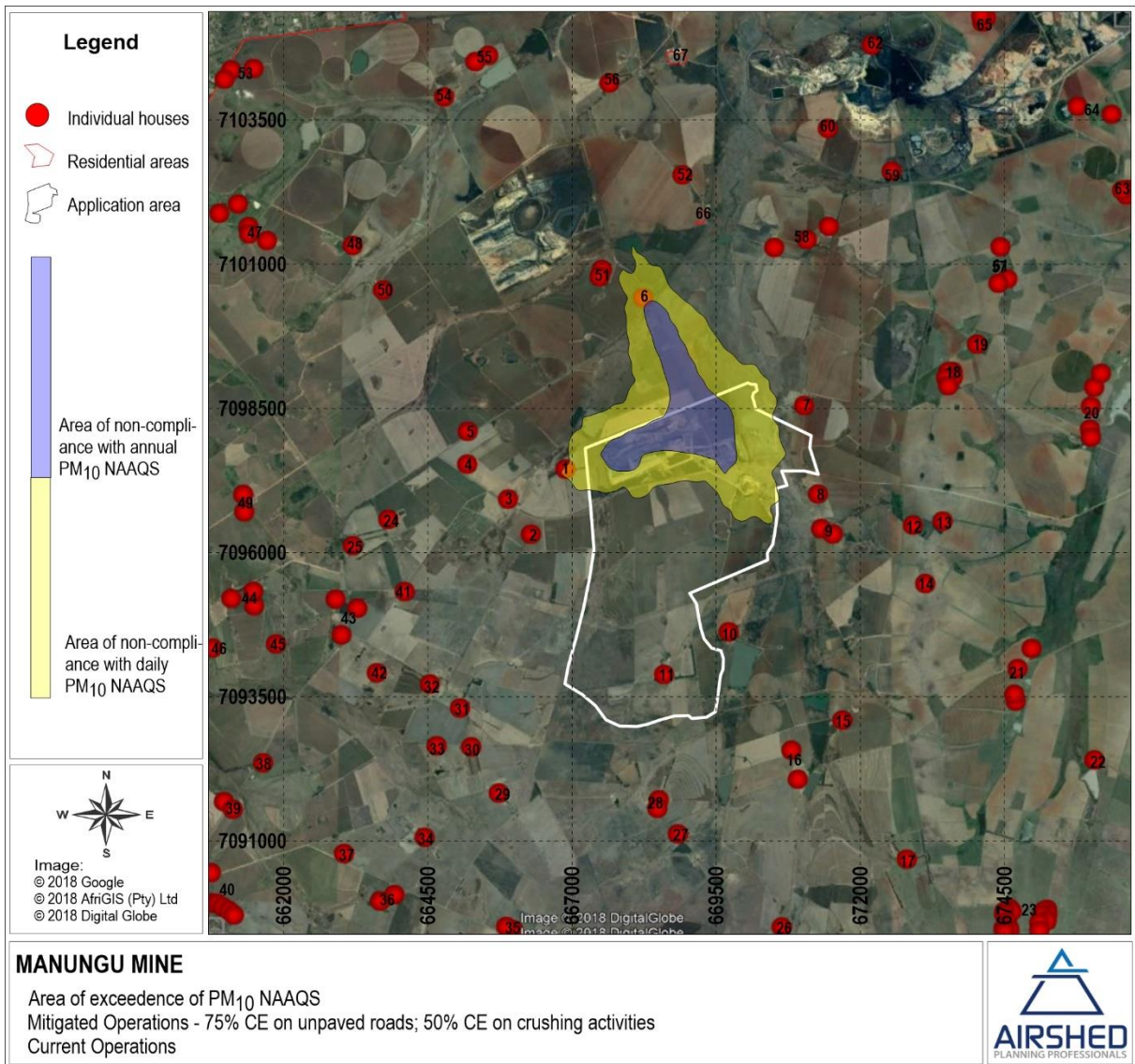


Figure 4-4: Area of non-compliance of PM₁₀ NAAQS due to current mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

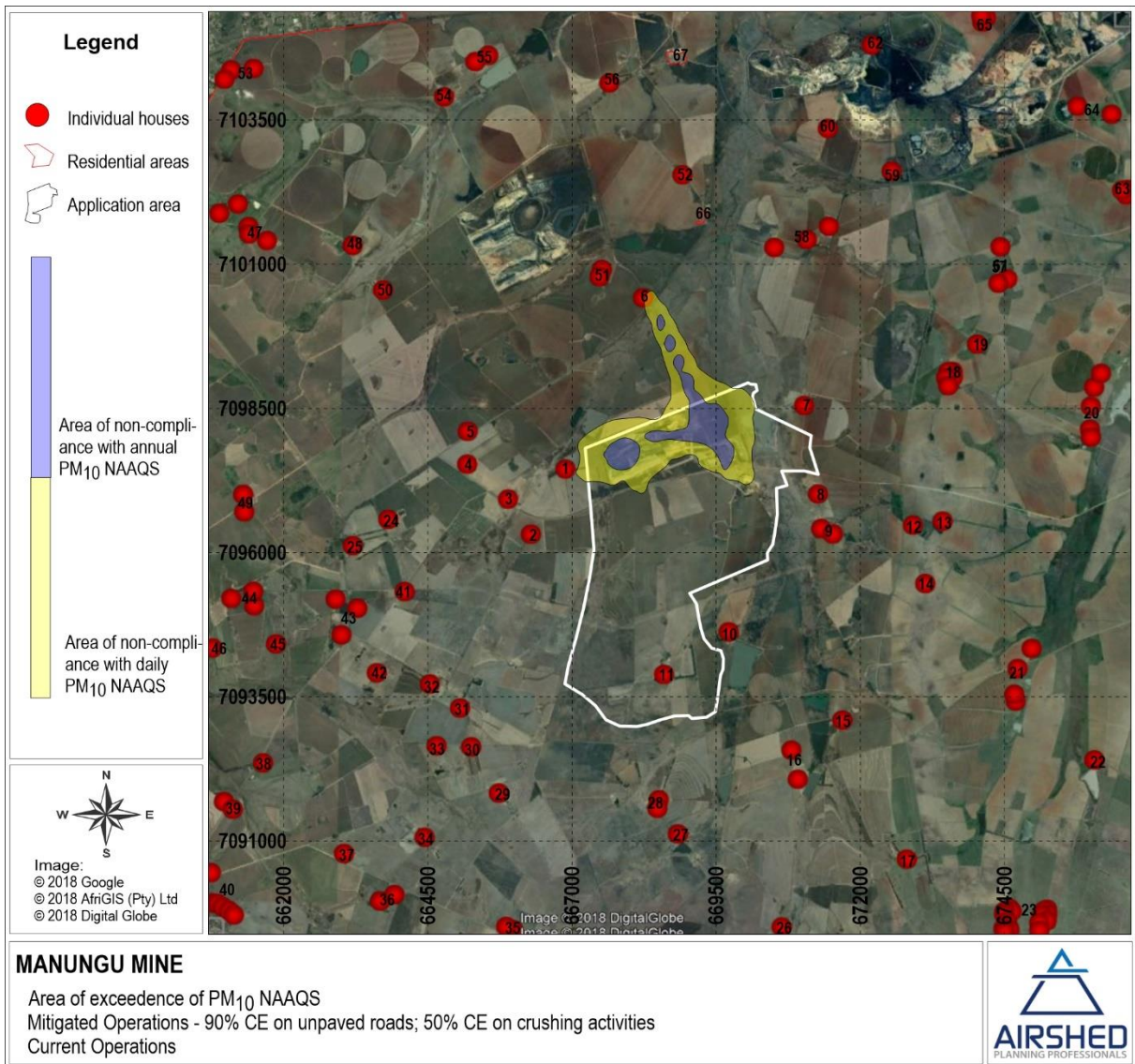


Figure 4-5: Area of non-compliance of PM₁₀ NAAQS due to current mitigated project operations (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

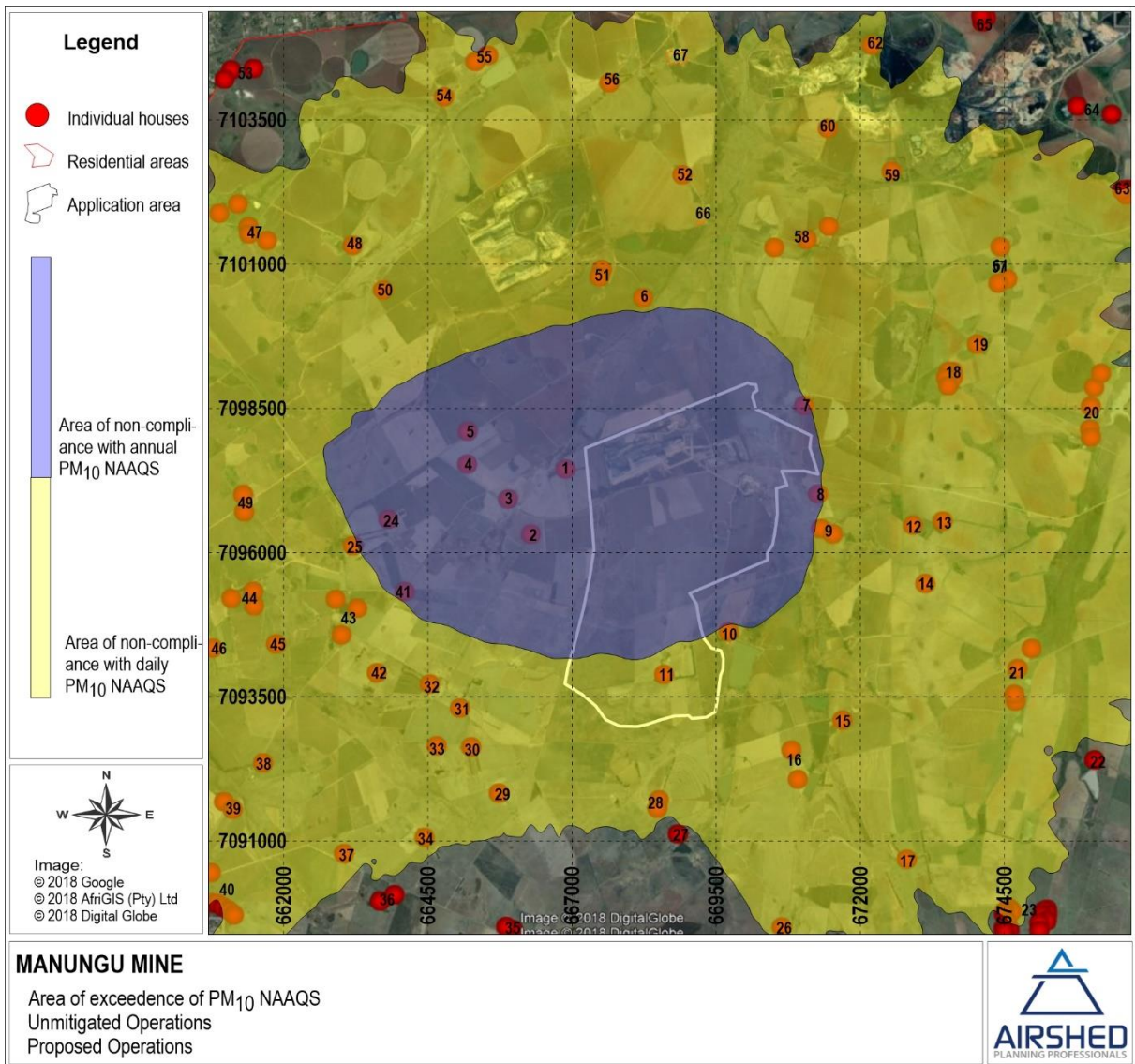


Figure 4-6: Area of non-compliance of PM₁₀ NAAQS due to proposed unmitigated project operations

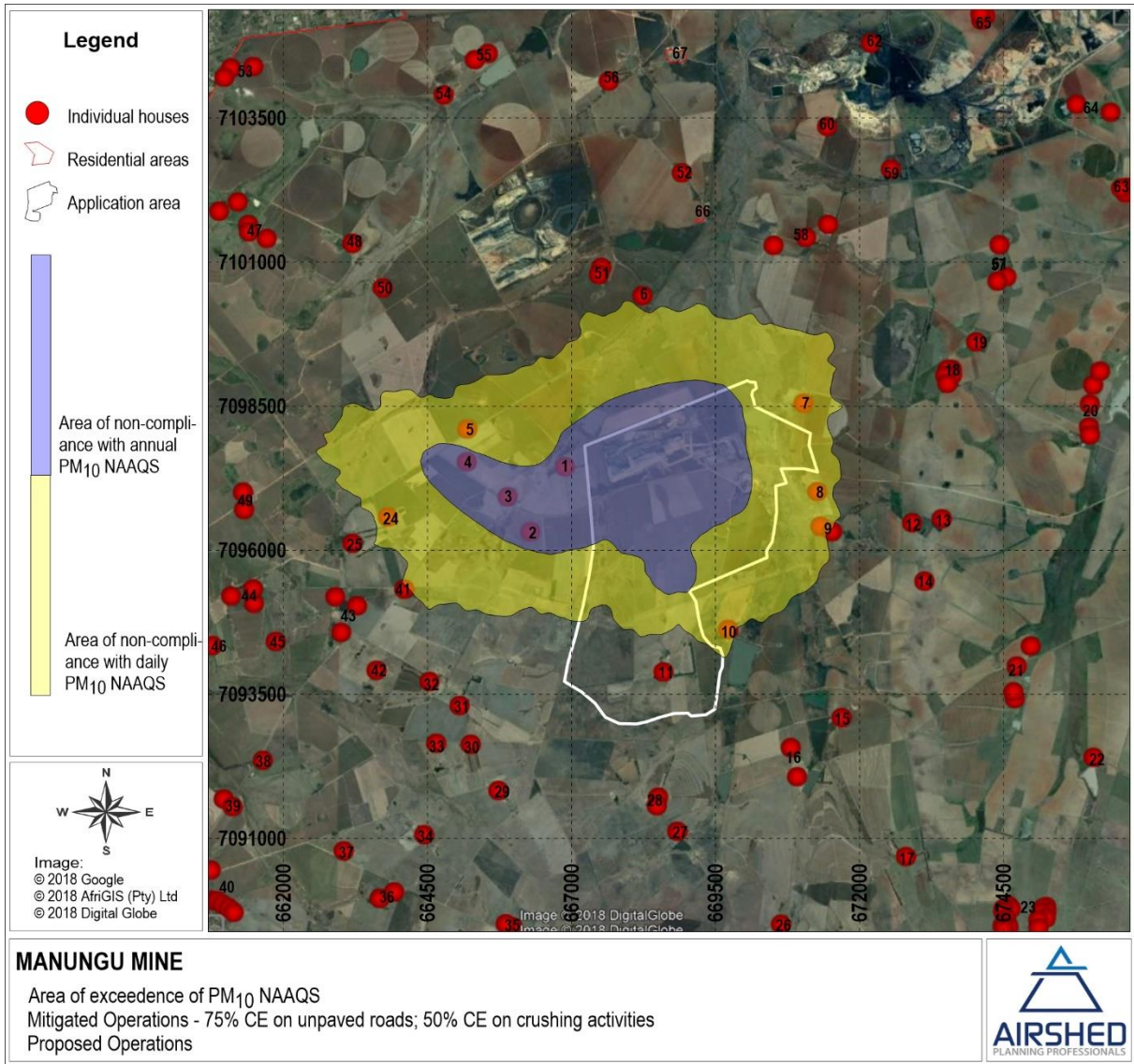


Figure 4-7: Area of non-compliance of PM₁₀ NAAQS due to proposed mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

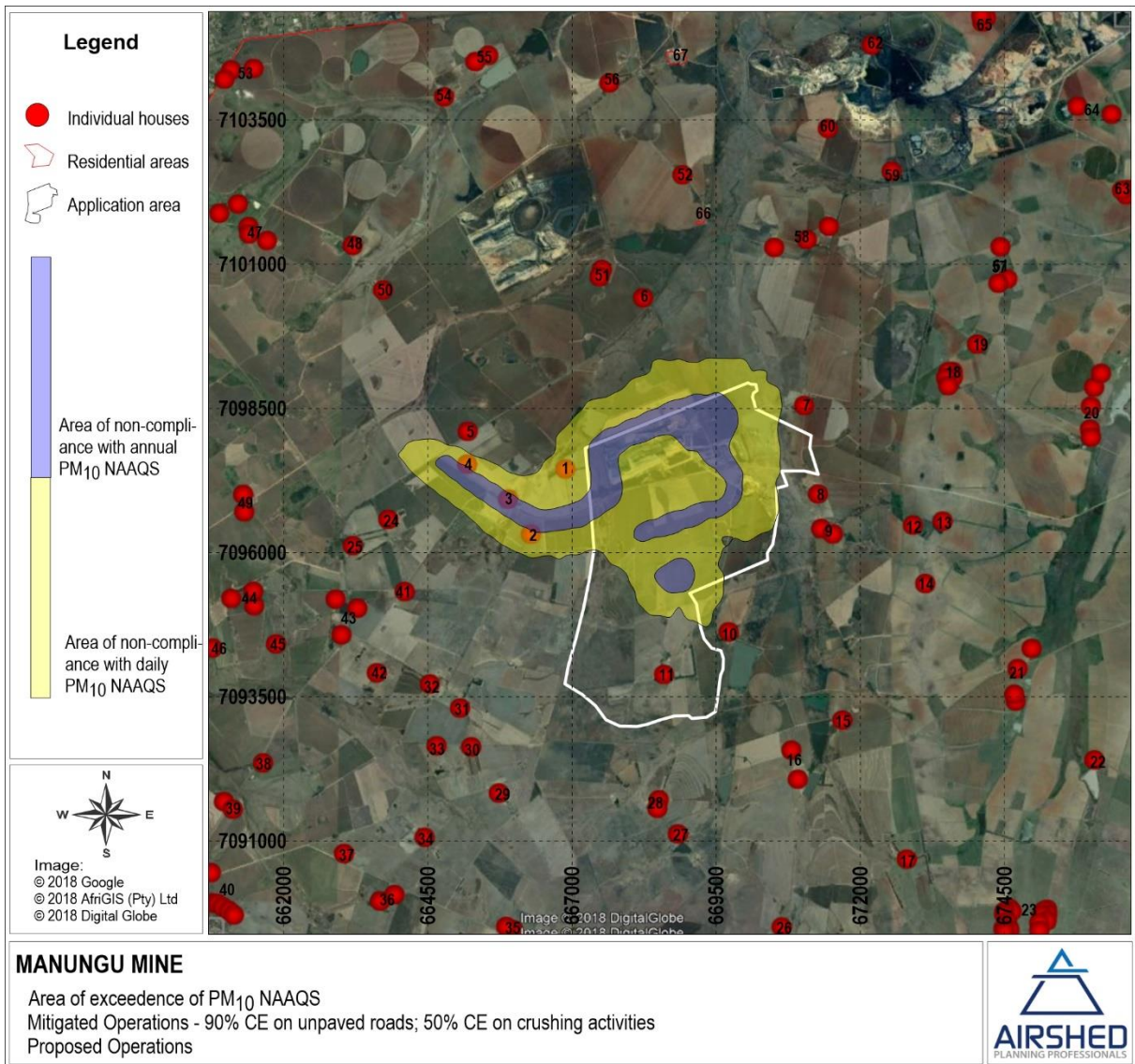


Figure 4-8: Area of non-compliance of PM₁₀ NAAQS due to proposed mitigated project operations (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

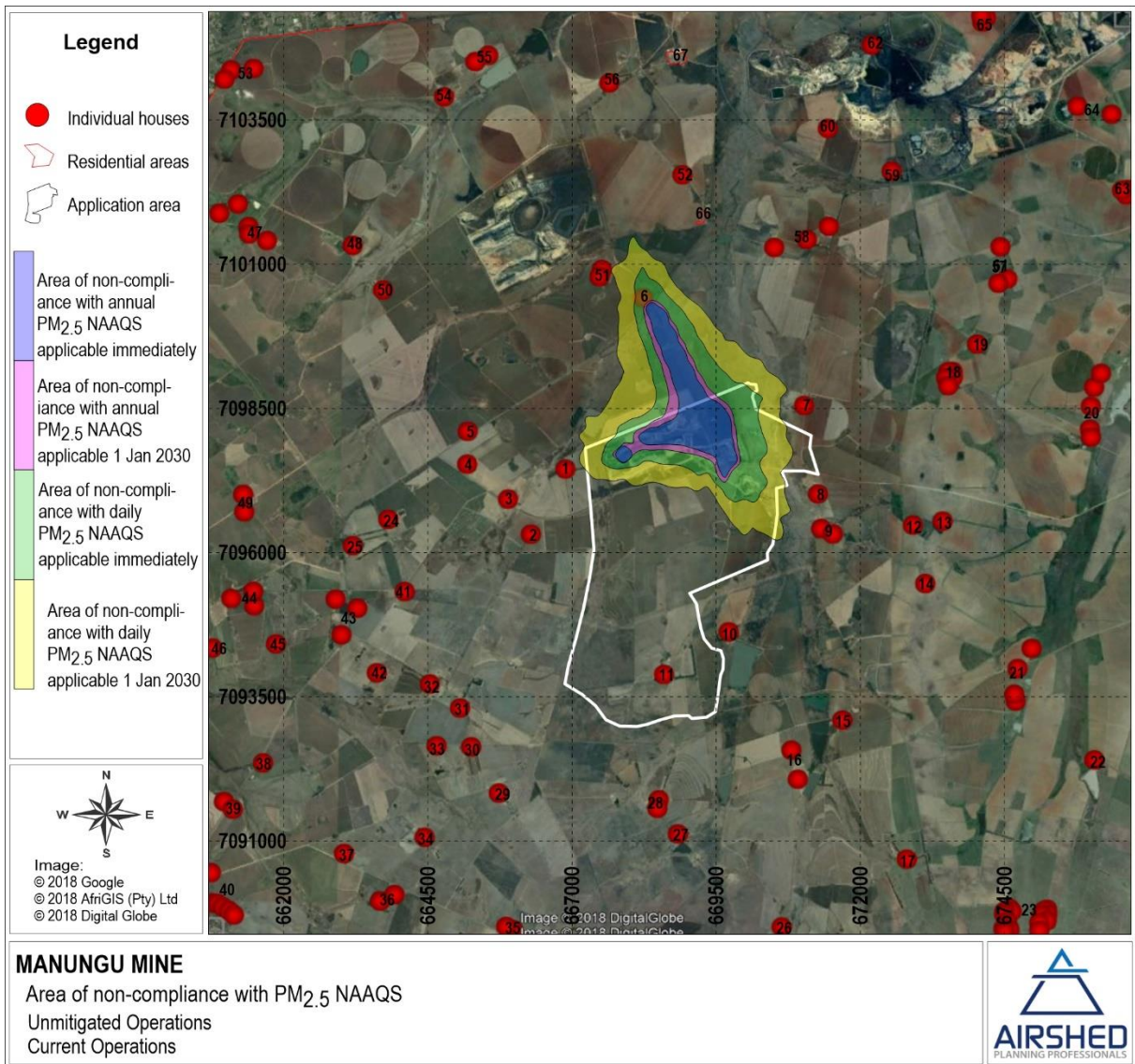


Figure 4-9: Area of non-compliance of PM_{2.5} NAAQS due to current unmitigated project operations

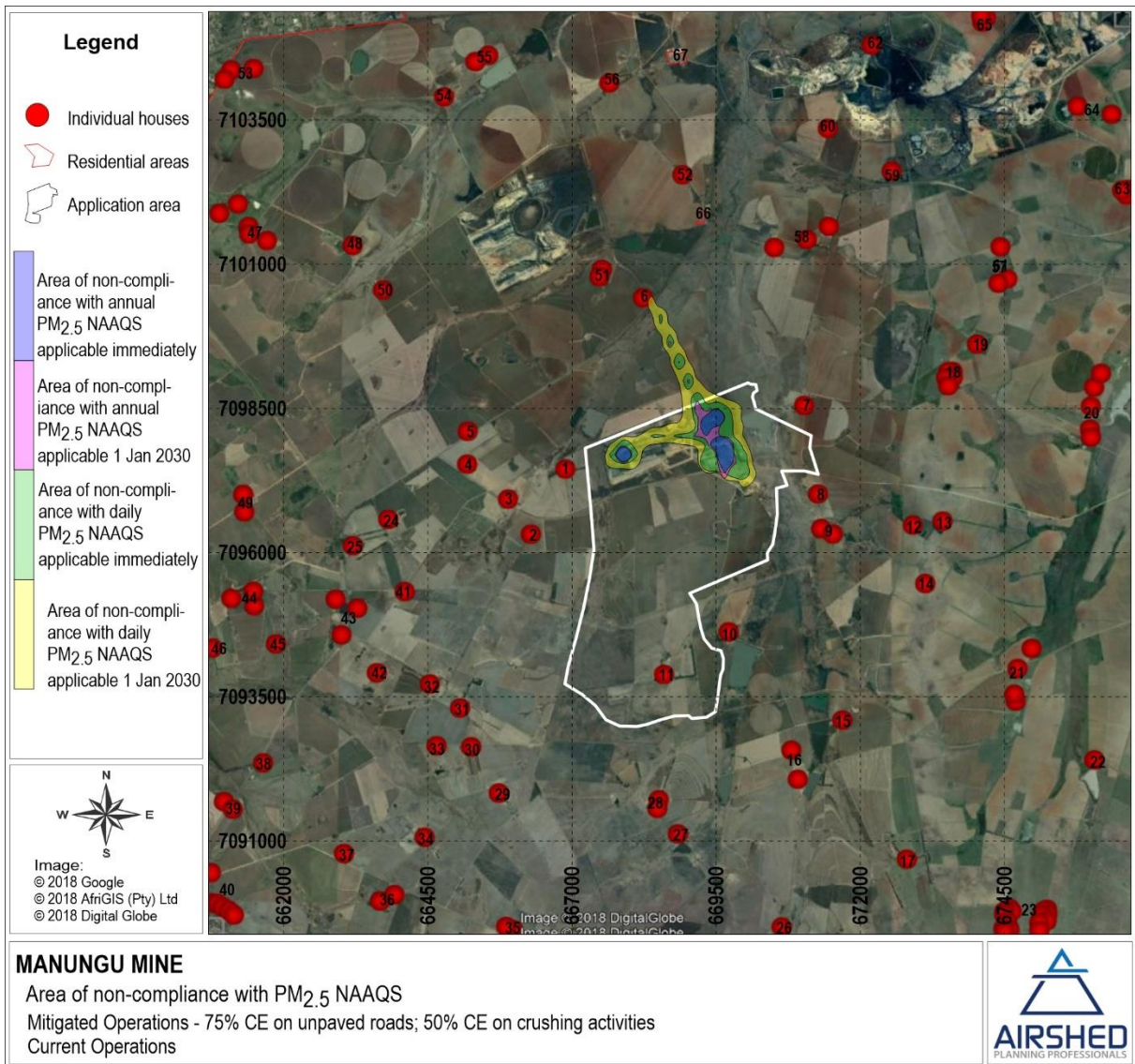


Figure 4-10: Area of non-compliance of PM_{2.5} NAAQS due to current mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

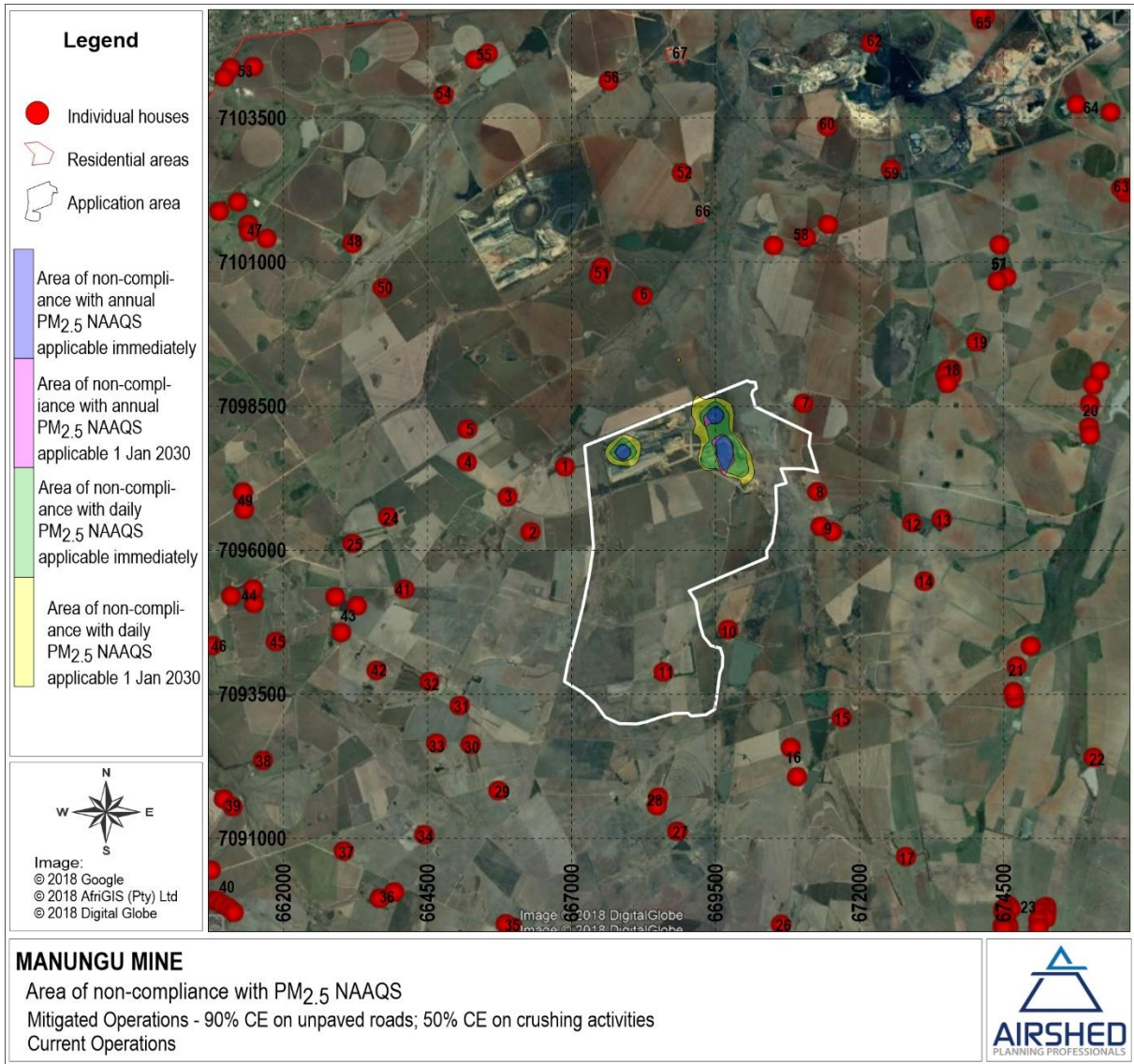


Figure 4-11: Area of non-compliance of PM_{2.5} NAAQS due to current mitigated project operations (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

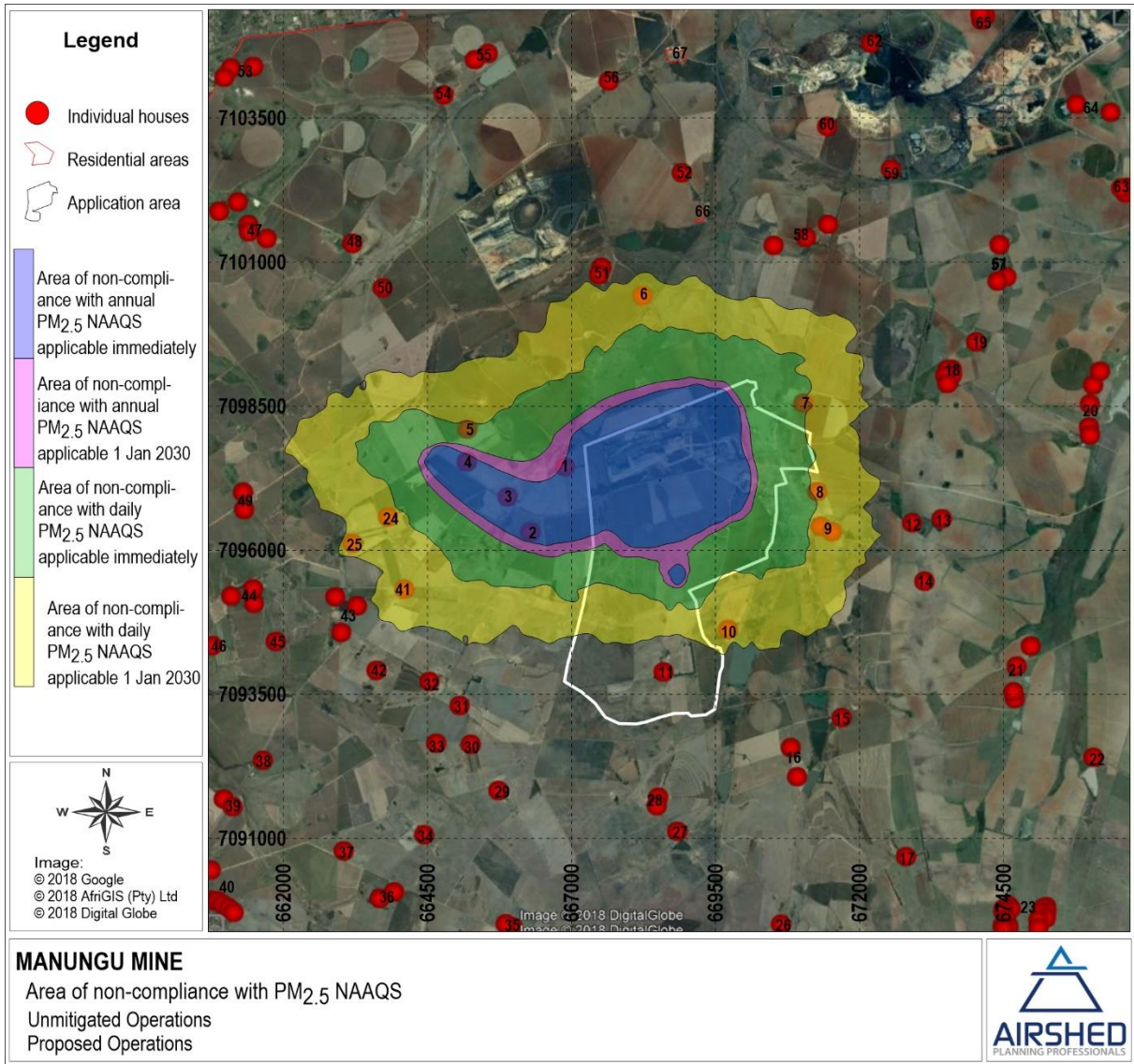


Figure 4-12: Area of non-compliance of PM_{2.5} NAAQS due to proposed unmitigated project operations

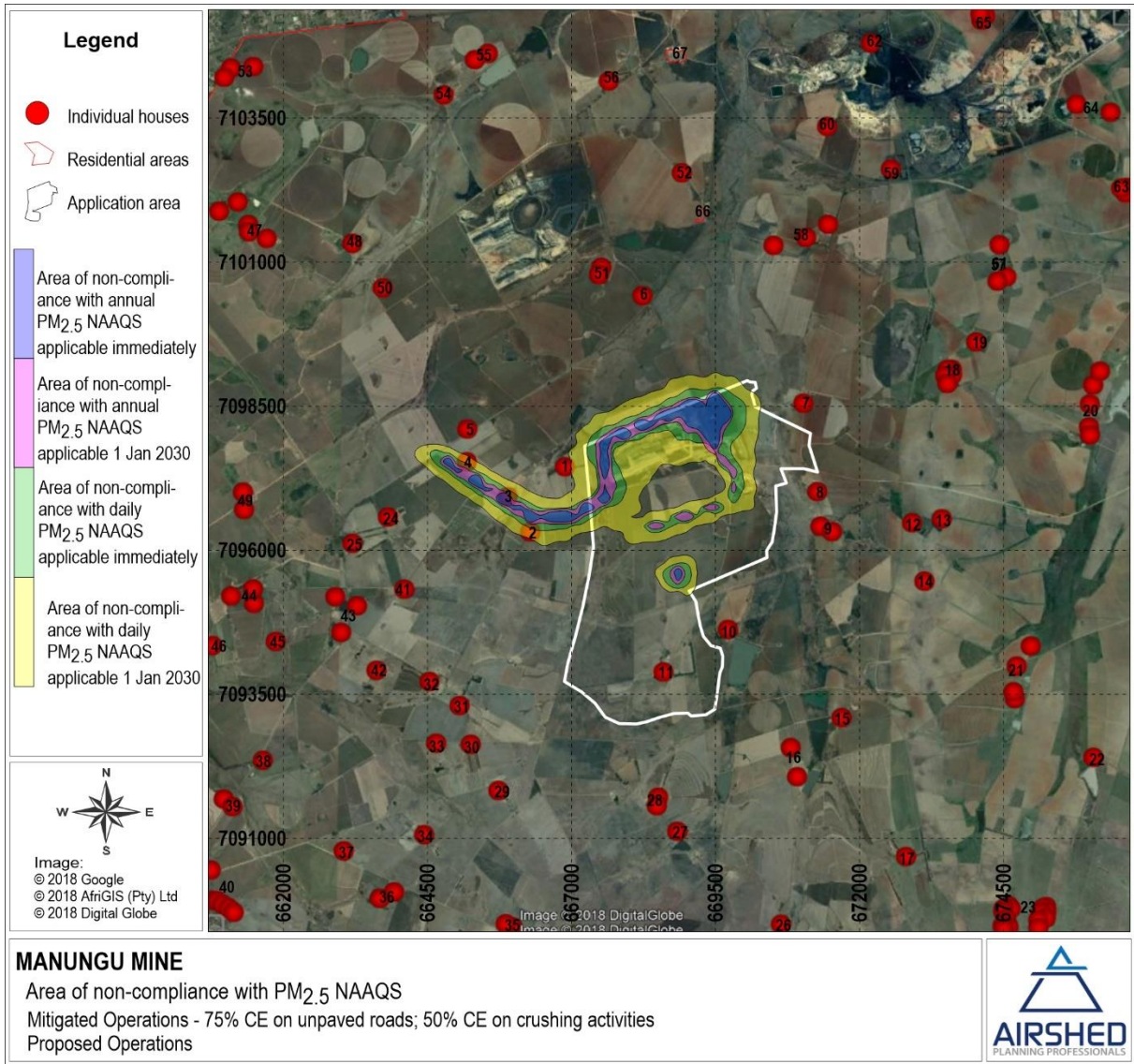


Figure 4-13: Area of non-compliance of PM_{2.5} NAAQS due to proposed mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

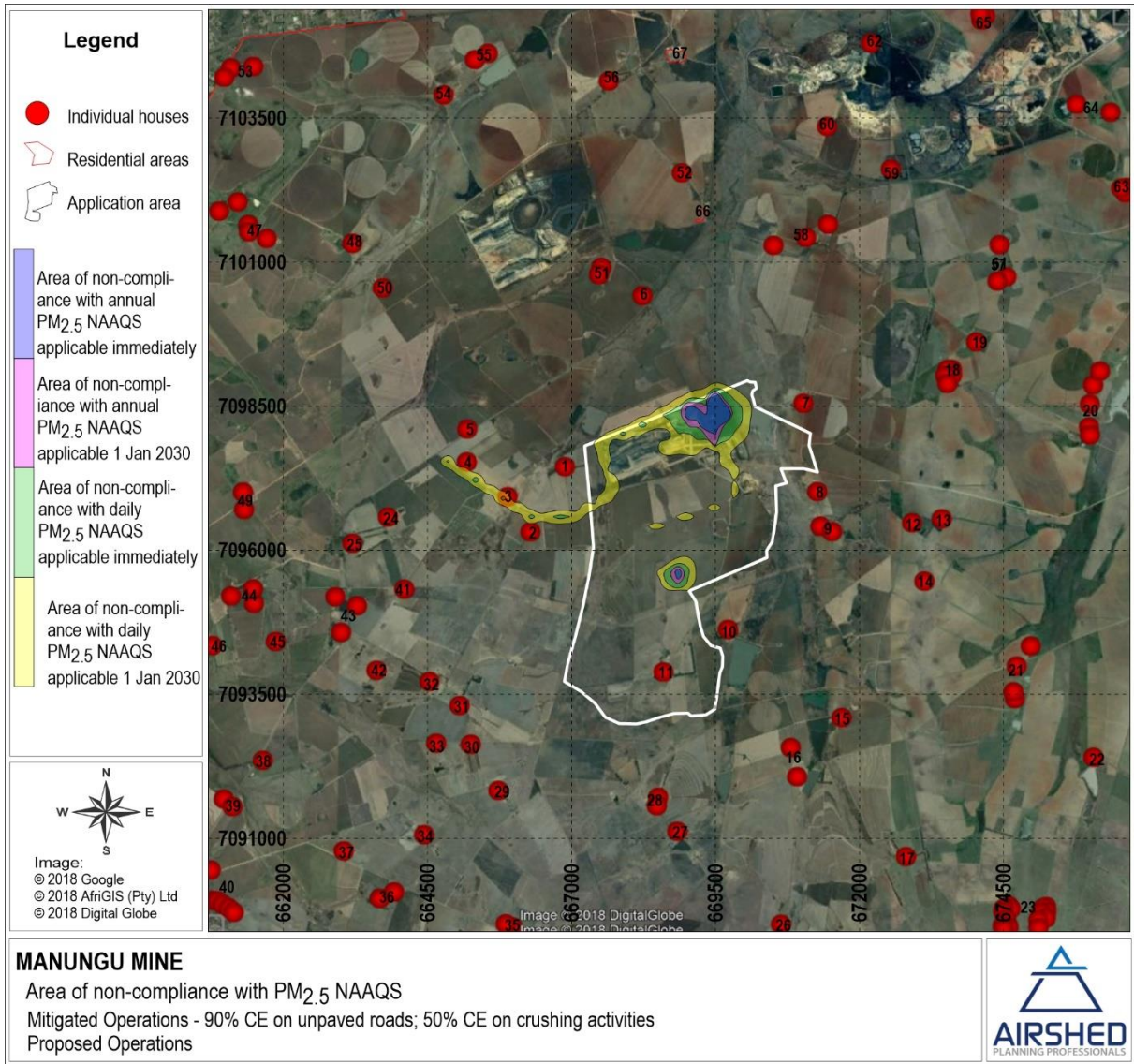


Figure 4-14: Area of non-compliance of PM_{2.5} NAAQS due to proposed mitigated project operations (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

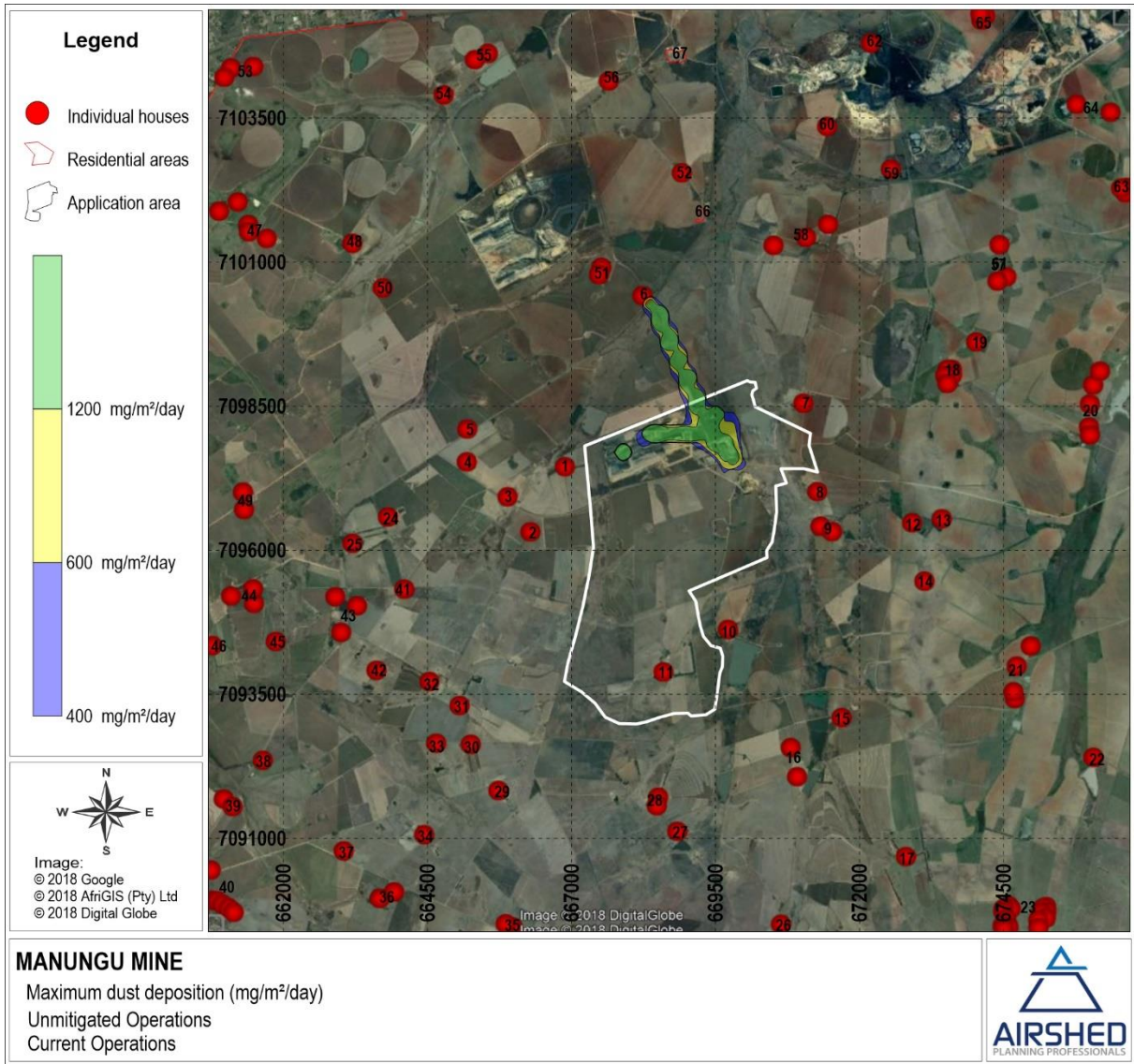


Figure 4-15: Total particulate deposition due to current unmitigated project operations

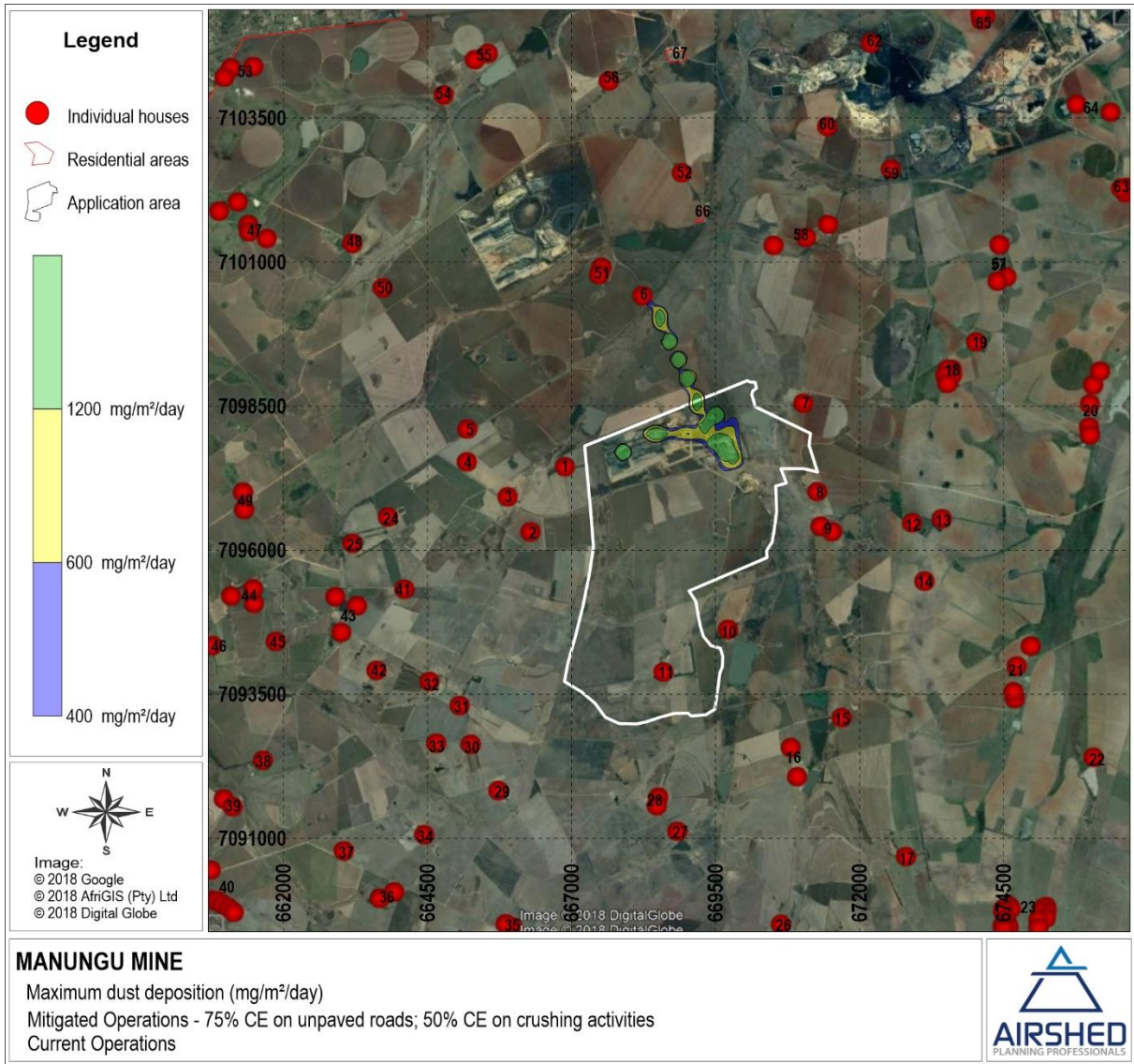


Figure 4-16: Total particulate deposition due to current mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

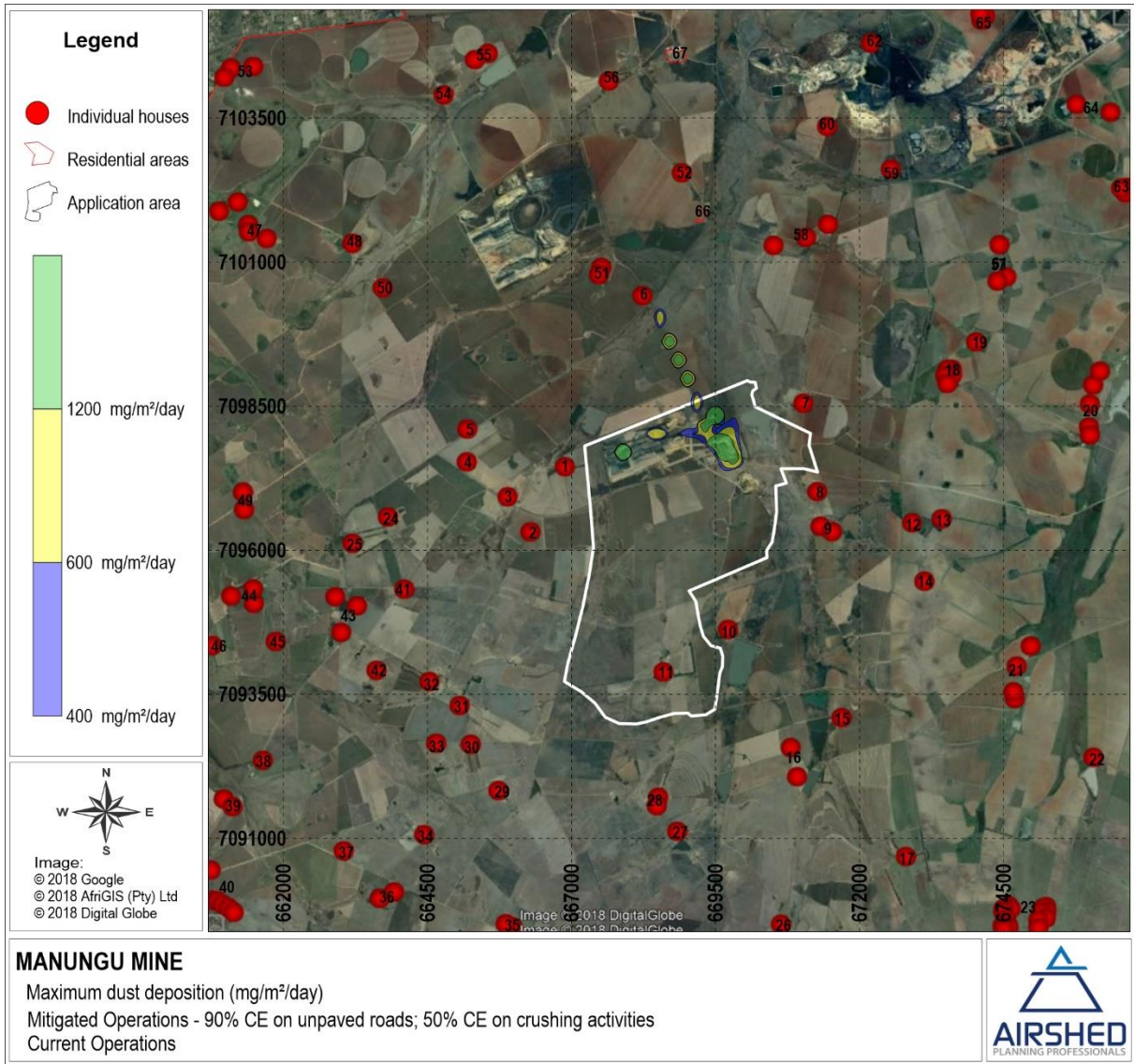


Figure 4-17: Total particulate deposition due to current mitigated project operations (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

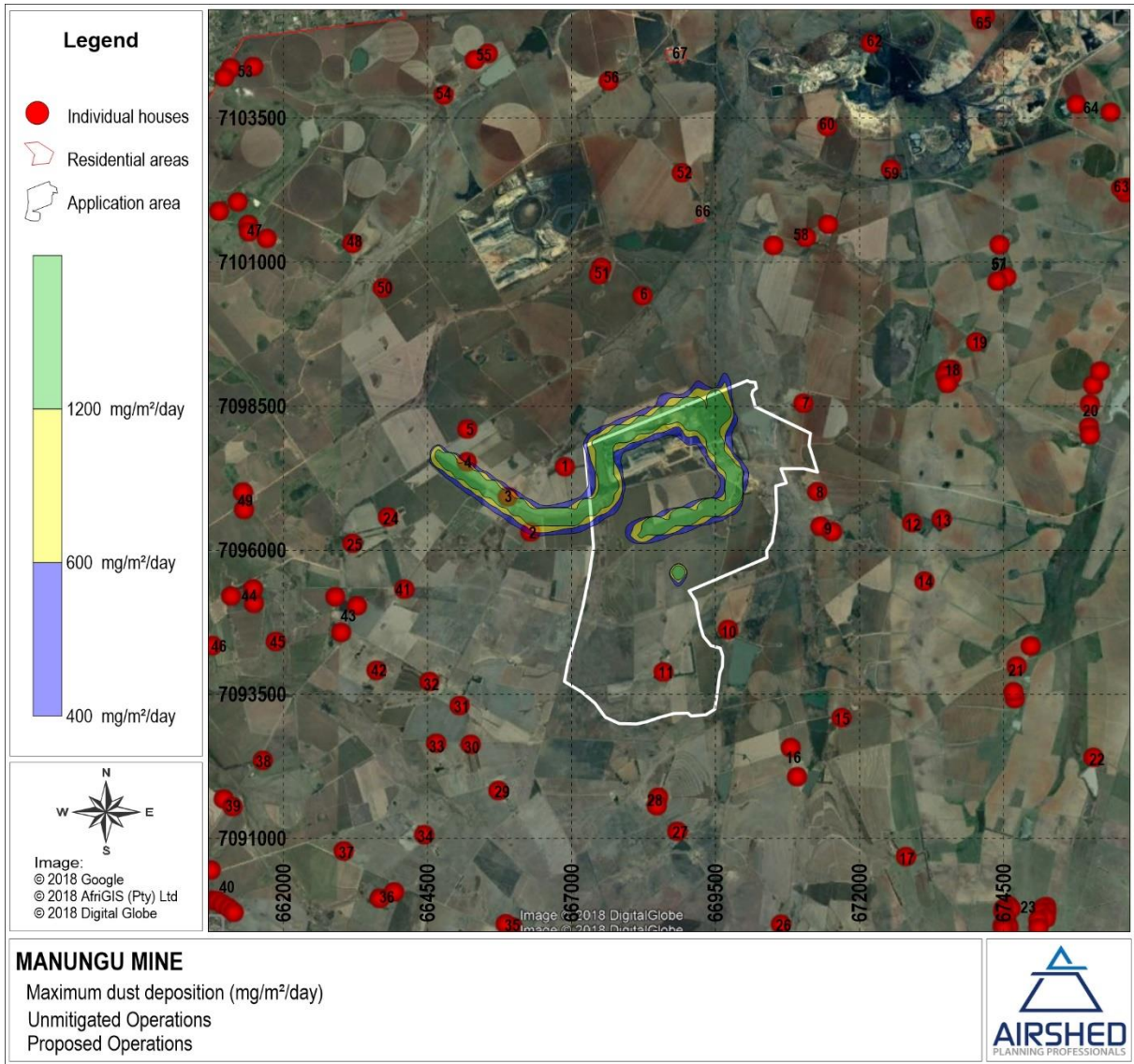


Figure 4-18: Total particulate deposition due to proposed unmitigated project operations

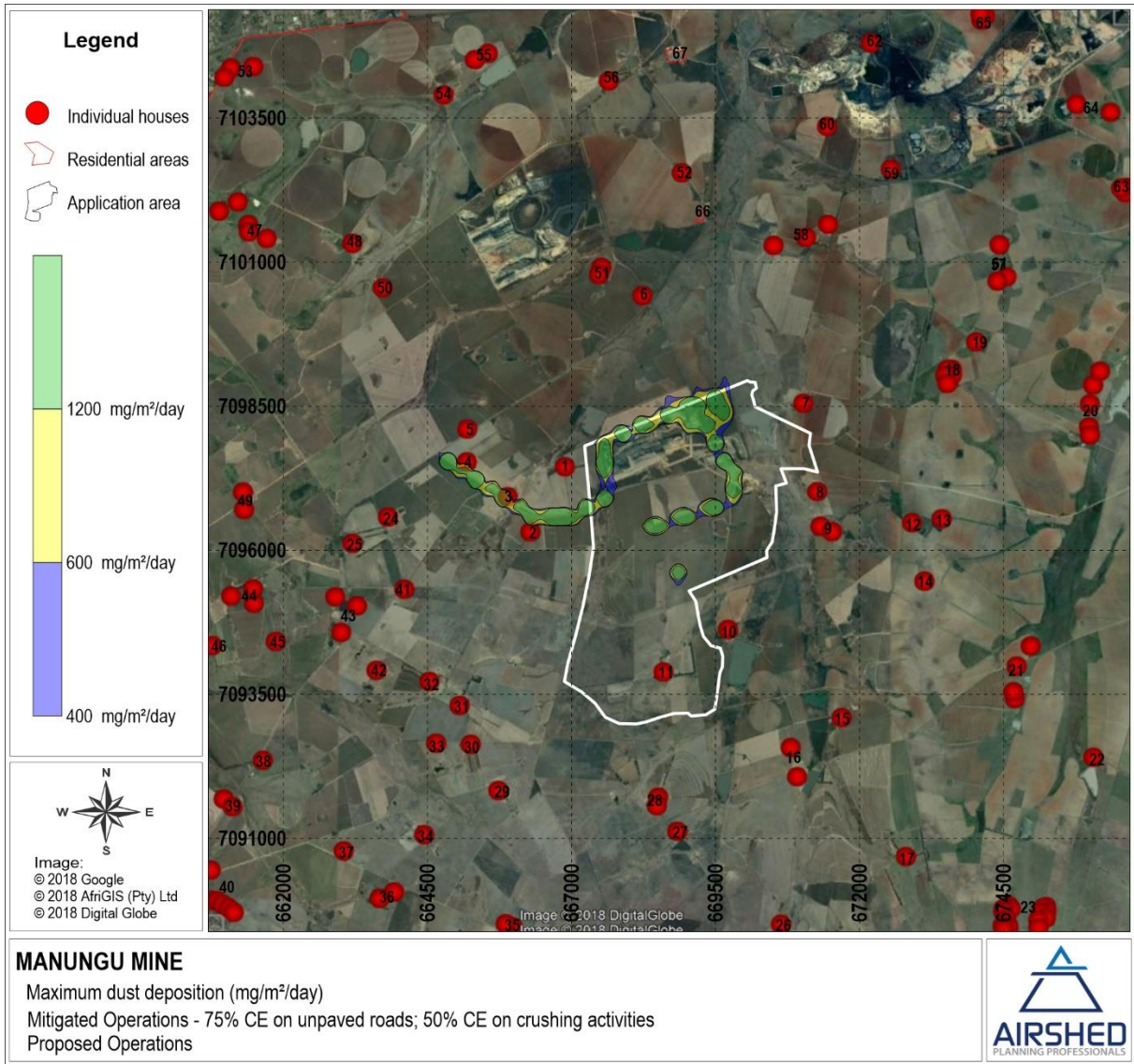


Figure 4-19: Total particulate deposition due to proposed mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

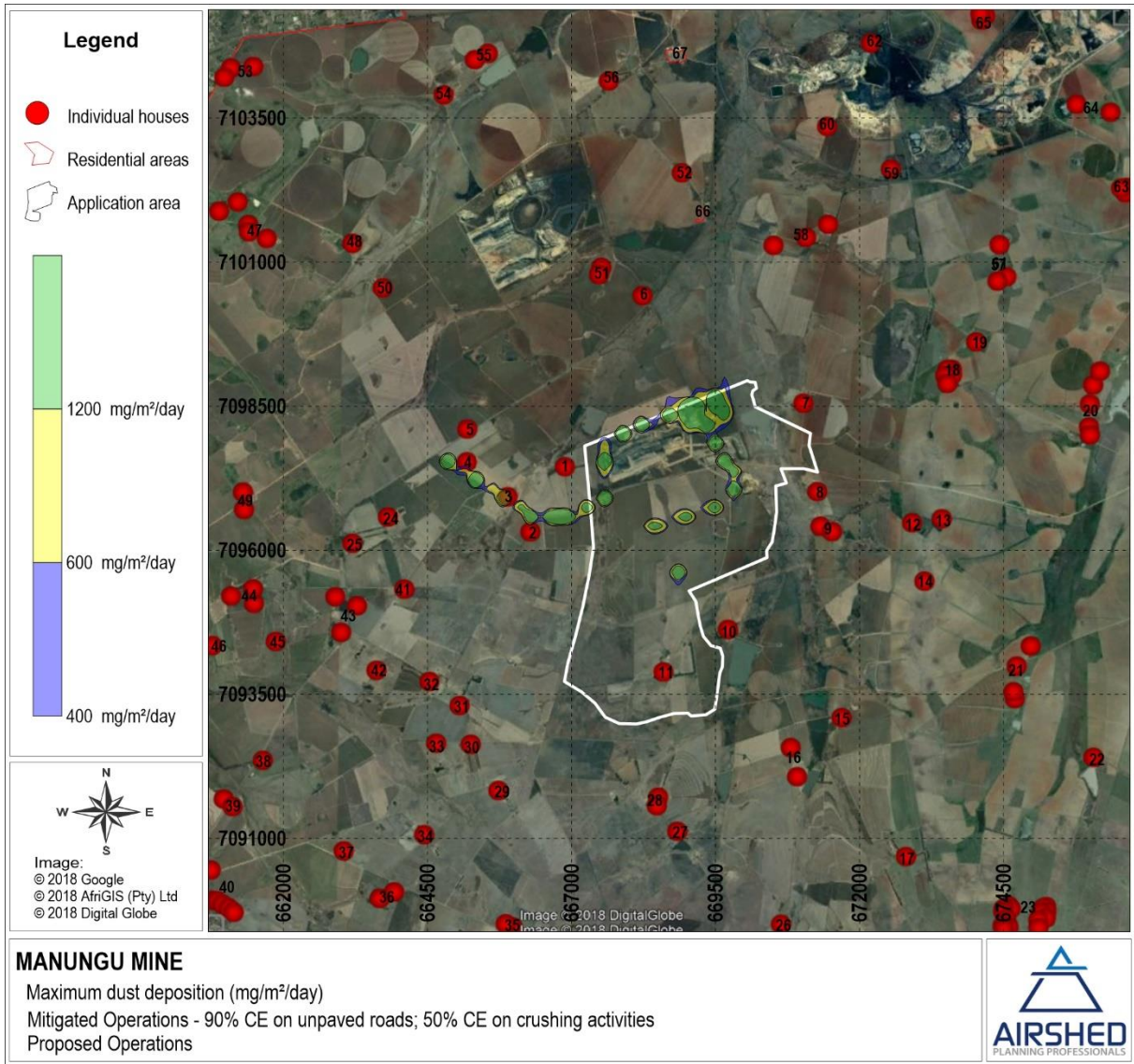


Figure 4-20: Total particulate deposition due to proposed mitigated project operations (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities)

Compliance of PM_{2.5} and PM₁₀ concentrations with NAAQS and total particulate deposition with NDCR at selected sensitive receptors in the study area, is provided in Table 4-8 and Table 4-9 for current and proposed operations respectively.

Table 4-8: Compliance of simulated PM_{2.5} and PM₁₀ ground level concentrations due to current operations with NAAQS and dust deposition with NDCR for residential areas at the closest sensitive receptors within the study area

Receptor	Current Unmitigated Operations					Current Mitigated Operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)					Current Mitigated Operations (assuming 90% CE on unpaved roads and 50% CE on crushing activities)				
	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)
R1	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R2	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R3	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R4	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R5	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R6	x	x	x	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓
R7	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R8	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R9	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R11	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R13	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R14	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R15	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R17	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R18	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R19	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R20	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R21	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R22	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R23	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R24	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R25	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R26	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R27	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R28	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R29	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R30	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R31	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R32	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R33	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R34	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R35	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Receptor	Current Unmitigated Operations					Current Mitigated Operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)					Current Mitigated Operations (assuming 90% CE on unpaved roads and 50% CE on crushing activities)				
	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)
R36	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R37	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R38	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R39	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R40	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R41	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R42	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R43	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R44	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R45	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R46	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R47	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R48	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R49	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R51	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R52	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R53	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R54	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R55	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R56	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R57	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R58	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R59	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R60	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R61	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R62	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R63	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R64	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R65	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R66	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R67	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 4-9: Compliance of simulated PM_{2.5} and PM₁₀ ground level concentrations due to proposed operations with NAAQS and dust deposition with NDCR for residential areas at the closest sensitive receptors within the study area

Receptor	Proposed Unmitigated Operations					Proposed Mitigated Operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)					Proposed Mitigated Operations (assuming 90% CE on unpaved roads and 50% CE on crushing activities)				
	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)
R1	x	x	x	x	✓	x	x	✓	✓	✓	x	✓	✓	✓	✓
R2	x	x	x	x	✓	x	x	✓	✓	✓	x	✓	✓	✓	✓
R3	x	x	x	x	x	x	x	x	✓	✓	x	x	✓	✓	✓
R4	x	x	x	x	✓	x	x	✓	✓	✓	x	✓	✓	✓	✓
R5	x	x	x	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓
R6	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R7	x	✓	x	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓
R8	x	x	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓
R9	x	✓	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓
R10	x	✓	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓
R11	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R12	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R13	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R14	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R15	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R16	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R17	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R18	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R19	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R20	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R21	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R22	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R23	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R24	x	x	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓
R25	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R26	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R27	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R28	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R29	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R30	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R31	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R32	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R33	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R34	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R35	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Receptor	Proposed Unmitigated Operations					Proposed Mitigated Operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)					Proposed Mitigated Operations (assuming 90% CE on unpaved roads and 50% CE on crushing activities)				
	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)	Compliance with daily PM ₁₀ NAAQS	Compliance with annual PM ₁₀ NAAQS	Compliance with daily PM _{2.5} NAAQS	Compliance with annual PM _{2.5} NAAQS	Within Daily dust deposition of 600 mg/m ² /day (for residential areas)
R36	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R37	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R38	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R39	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R40	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R41	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R42	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R43	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R44	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R45	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R46	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R47	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R48	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R49	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R50	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R51	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R52	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R53	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R54	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R55	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R56	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R57	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R58	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R59	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R60	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R61	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R62	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R63	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R64	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R65	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R66	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R67	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

The highest simulated PM₁₀ concentrations due to current unmitigated project operations are in non-compliance with daily NAAQS at sensitive receptors within the study area (Figure 4-3). The area of non-compliance extends ~6km north-west to ~4km south-east from the mine boundary. When activities are mitigated (assuming 50% control efficiency on crushing activities and 75% control efficiency on unpaved roads) the PM₁₀ concentrations reduce notably in magnitude and spatial distribution with exceedances of daily NAAQS at the closest sensitive receptors surrounding the mine (i.e. R6) (Figure 4-4). When further mitigation is applied (90% control efficiency on unpaved roads), the impacts reduce further with no exceedances of the NAAQS at the closest sensitive receptors (Figure 4-5).

The highest simulated ground level PM₁₀ concentrations due to proposed unmitigated project operations are in non-compliance with daily NAAQS at sensitive receptors within the study area extending ~7.5km north and ~6km southeast (Figure 4-6). When activities are mitigated (assuming 50% control efficiency on crushing activities and 75% control efficiency on unpaved roads) the PM₁₀ concentrations reduce notably in magnitude and spatial distribution with exceedances of daily NAAQS at the closest sensitive receptors surrounding the mine (i.e. R1, R2, R3, R4, R5, R7, R8, R9, R10, R24) (Figure 4-7). When further mitigation is applied (90% control efficiency on unpaved roads), the impacts reduce further with exceedances of the NAAQS only at the closest sensitive receptors directly west of the mine (i.e. R1, R2, R3 and R4) (Figure 4-8).

The highest PM_{2.5} concentrations due to current unmitigated project operations are in non-compliance with daily NAAQS at sensitive receptors north of the mine (i.e. R6) (Figure 4-9). When activities are mitigated (assuming 50% control efficiency on crushing activities and 75% control efficiency on unpaved roads) the PM_{2.5} concentrations reduce notably in magnitude and spatial distribution with no exceedances of daily NAAQS at the closest sensitive receptors surrounding the mine (Figure 4-10).

The highest PM_{2.5} concentrations due to proposed unmitigated project operations are in non-compliance with daily NAAQS at sensitive receptors west of the mine (i.e. R1, R2, R3, R4, R5) and east of the mine (i.e. R7) (Figure 4-12). When activities are mitigated (assuming 50% control efficiency on crushing activities and 75% control efficiency on unpaved roads) the PM_{2.5} concentrations reduce notably in magnitude and spatial distribution with exceedances of daily NAAQS at the closest sensitive receptors to the west of the mine (i.e. R3) (Figure 4-13). When further mitigation is applied (90% control efficiency on unpaved roads), the impacts reduce further with no exceedances of the NAAQS at the closest sensitive receptors within the study area (Figure 4-14).

Maximum daily dust deposition due to unmitigated and mitigated current and proposed operations are within the NDCR for residential areas at all sensitive receptors within the study area with the exception of R3 to the west of mining operations for proposed activities (Figure 4-15 to Figure 4-20).

4.2.2.4 Cumulative Impacts

Literature states that by adding the peak model concentrations to the background concentrations, this can result in severe overestimation of the source contribution and that a more realistic method is to add twice the annual mean background concentrations to the peak (or 99.9th percentile) (Ministry for the Environment, 2004). PM_{2.5} and PM₁₀ have been sampled at Manungu Colliery for the period March to September 2017. The sampling station is onsite, however, and is not representative of background concentrations but rather Manungu Colliery operations. If the background PM₁₀ concentrations for Kendal (57.6 µg/m³ annual average for the period 2012 to 2014) are assumed to be representative of the project area, the annual and daily cumulative ground level concentrations may increase with a further 57.6 µg/m³ and 115 µg/m³ respectively.

4.2.2.5 Predicted Impacts on Vegetation and Animals

No national ambient air quality standards or guidelines are available for the protection of animals and vegetation. In the absence of national ambient standards for animals, the standards used for the protection of human beings may be used to assess the impacts on animals. Areas of non-compliance of PM₁₀ and PM_{2.5} NAAQS due to the project operations are provided in Section 4.2.2.3.

While there is little direct evidence of what the impact of dustfall on vegetation is under a South African context, a review of European studies has shown the potential for reduced growth and photosynthetic activity in Sunflower and Cotton plants exposed to dust fall rates greater than 400 mg/m²/day (Farmer, 1991). The simulated dustfall rates due to the proposed project operations are provided in Section 4.2.2.3.

If more detailed information is required on the impact of particulate matter on vegetation and animals, it is recommended that the predicted PM concentrations and dust depositions be used in a more detailed biodiversity and/or health risk assessment study.

4.2.3 Mitigation Measures Recommended

Based on literature surveys, air pollution abatement measures were identified to be implemented at the main sources of fugitive dust. These mitigation measures are discussed in more detail in the following section. From the impact assessment for the Operation Phase it was predicted that impacts from the unpaved road surface and, to a lesser extent, crushing and screening activities was significant.

The modelled impacts from materials handling activities and windblown dust from the storage piles did not exceed the relevant particulate NAAQS at sensitive receptors in the study area. Although there will be incidences of high particulate concentrations during high wind speed episodes from these sources (duration from a few minutes to hours), the NAAQS for particulate matter is for daily and annual averages.

4.2.3.1 Dust Control Options for Unpaved Roads

Three types of measures may be taken to reduce emissions from unpaved roads: (a) measures aimed at reducing the extent of unpaved roads, e.g. paving, (b) traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds, and (c) measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilization (Cowhert et al., 1988; APCD, 1995).

The main dust generating factors on unpaved road surfaces include:

- Vehicle speeds
- Number of wheels per vehicle
- Traffic volumes
- Particle size distribution of the aggregate
- Compaction of the surface material
- Surface moisture
- Climate

According to research conducted by the Desert Research Institute at the University of Nevada, an increase in vehicle speed of 10 miles per hour resulted in an increase in PM₁₀ emissions of between 1.5 and 3 times. A similar study conducted by Flocchini et.al. (1994) found a decrease in PM₁₀ emissions of 42±35% with a speed reduction from 40 km/hr to 24 km/hr (Stevenson, 2004). The control efficiency obtained by speed reduction can be calculated by varying the vehicle speed input parameter in the predictive emission factor equation given for unpaved roads. An evaluation of control efficiencies resulting from reductions in traffic volumes can be calculated due to the linear relationship between traffic volume, given in terms of vehicle kilometres travelled, and fugitive dust emitted. Similar affects will be achieved by reducing the truck volumes on the roads.

Water sprays on unpaved roads is the most common means of suppressing fugitive dust due to vehicle entrainment at mines, but it is not necessarily the most efficient means (Thompson and Visser, 2000). Thompson and Visser (2000) developed a model to determine the cost and management implications of dust suppression on haul roads using water or other chemical palliatives. The study was undertaken at 10 mine sites in Southern Africa. The model was first developed looking at the re-application frequency of water required for maintaining a specific degree of dust palliation. From this the cost effectiveness of water spray suppression could be determined and compared to other strategies. Factors accounted for in the model included climate, traffic, vehicle speed and the road aggregate material. A number of chemical palliative products, including hygroscopic salts, lignosulphonates, petroleum resins, polymer emulsions and tar and bitumen products were assessed to benchmark their performance and identify appropriate management strategies. Cost elements taken into consideration included amongst others capital equipment, operation and maintenance costs, material costs and activity related costs. The main findings were that water-based spraying is the cheapest dust suppression option over the short term. Over the longer term however, the polymer-emulsion option is marginally cheaper with added benefits such as improved road surfaces during wet weather, reduced erosion and dry skid resistance (Thompson and Visser, 2000).

An empirical model, developed by the US EPA (EPA, 1996), can be used to estimate the average control efficiency of certain quantities of water applied to a road. The model takes into account rainfall, evaporation rates and traffic.

Chemical suppressant has been proven to be effective due to the binding of fine particulates in the road surface, hence increasing the density of the surface material. In addition, dust control additives are beneficial in the fact that it also improves the compaction and stability of the road. The effectiveness of a dust palliative include numerous factors such as the application rate, method of application, moisture content of the surface material during application, palliative concentrations, mineralogy of aggregate and environmental conditions. Thus, for different climates and conditions you need different chemicals, one chemical might not be as effective as another under the same conditions and each product comes with various advantages and limitations of each own. In general, chemical suppressants are given to achieve a PM₁₀ control efficiency of 80% to 90% when applied regularly on the road surfaces (Stevenson, 2004).

There is however no cure-all solution but rather a combination of solutions. A cost-effective chemical control programme may be developed through establishing the minimum control efficiency required on a particular roadway, and evaluating the costs and benefits arising from various chemical stabilization practices. Appropriate chemicals and the most effective relationships between application intensities, reapplication frequencies, and dilution ratios may be taken into account in the evaluation of such practices.

Spillage and track-on from the surrounding unpaved areas may result in the deposition of materials onto the chemically treated or watered road resulting in the need for periodic "housekeeping" activities (Cowherd et al., 1988; EPA, 1996). In addition, the gradual abrasion of the chemically treated surface by traffic will result in loose material on the surface which would have to be controlled. The minimum frequency for the reapplication of watering or chemical stabilizers thus depends not only on the control efficiency of the suppressant but also on the degree of spillage and track-on from adjacent areas, and

the rate at which the treated surface is abraded. The best way to avoid dust generating problems from unpaved roads is to properly maintain the surface by grading and shaping for cross sectional crowing to prevent dust generation caused by excessive road surface wear (Stevenson, 2004).

One of the main benefits of chemical stabilisation in conjunction with wet suppression is the management of water resources (MFE, 2001).

In the assessment of mitigated operations, proposed project activities were simulated assuming 75% and 90% control efficiency for vehicle entrainment.

4.2.3.2 Crushing

Enclosure of crushing operations is very effective in reducing dust. The Australian NPI indicates that a telescopic chute with water sprays would ensure 75% control efficiency and enclosure of storage piles where tipping occur would reduce the emissions by 99%. According to the Australian NPI, water sprays can have up to 50% control efficiency and hoods with scrubbers up to 75%. If in addition, the scrubbers and screens were to be enclosed; up to 100% control efficiency can be achieved. Hooding with fabric filters can result in control efficiencies of 83%. It is important that this control equipment be maintained and inspected on a regular basis to ensure that the expected control efficiencies are met.

In the assessment of mitigated operations, proposed project activities were simulated assuming 50% control efficiency on the crushing activities.

4.3 Decommissioning and Closure Phase

4.3.1 Identification of Environmental Aspects

It is assumed that all the operations will have ceased by the closure phase of the project. The potential for impacts during this phase will depend on the extent of rehabilitation efforts during closure. Aspects and activities associated with the decommissioning phase of the proposed operations are listed in Table 4-10. The same mitigation measures for construction phase can be implemented for the decommissioning phase. For long-term rehabilitation, mitigation measures are provided in Section 4.3.2. Simulations of the decommissioning and closure phases were not included in the current study due to its temporary impacting nature.

Table 4-10: Activities and aspects identified for the decommissioning phase

Impact	Source	Activity
Generation of PM _{2.5} and PM ₁₀	Open surfaces	Dust generated during rehabilitation activities
Generation of PM _{2.5} and PM ₁₀	Offices and buildings	Demolition of the structure
Gas emissions	Vehicles	Tailpipe emissions from vehicles utilised during the closure phase

4.3.2 *Mitigation Measures Recommended*

Dust control measures for open areas can consist of wet suppression, chemical suppressants, vegetation, wind breaks, etc. Wet suppressants and chemical suppressants are generally applied for short storage pile durations. For long-term control measures vegetation frequently represents the most cost-effective and efficient control.

Vegetation cover retards erosion by binding the soil with a root network, by sheltering the soil surface and by trapping material already eroded. Sheltering occurs by reducing the wind velocity close to the surface, thus reducing the erosion potential and volume of material removed. The trapping of the material already removed by wind and in suspension in the air is an important secondary effect. Vegetation is also considered the most effective control measure in terms of its ability to also control water erosion. In investigating the feasibility of vegetation types, the following properties are normally taken into account: indigenous plants; ability to establish and regenerate quickly; proven effective for reclamation elsewhere; tolerant to the climatic conditions of the area; high rate of root production; easily propagated by seed or cuttings; and nitrogen-fixing ability. The long-term effectiveness of suitable vegetation selected for the site will be dependent on the nature of the cover.

5 SIGNIFICANCE RANKING

2014 EIA Regulations require that impacts be assessed in terms of the nature, significance, consequence, extent, duration and probability of the impacts including the degree to which these impacts can be reversed, may cause irreplaceable loss of resources, and can be avoided, managed or mitigated. The significance ranking methodology used in this scoping report is provided in Appendix C.

With regard to wind erosion, two scenarios were assessed for proposed operations: (Alternative a) the footprint from the waste material stockpiles assuming a height of 6m; (Alternative b) the smaller footprints from the waste material stockpiles assuming a height of 45m.

The decline in ambient air quality was the same for all alternatives assessed. The significance ranking for all alternatives (including proposed project operations) is provided in Table 5-1 to Table 5-4 and provides a low significance ranking for decommissioning and closure phases and a moderate significance ranking for construction and operation phases.

Table 5-1: Significance ranking due to proposed project construction activities

Impact Name	Decline in Ambient Air Quality: Construction				
Alternative	Alternative a and b				
Phase	Construction				
Environmental Risk					
Attribute	Pre-mitigation	Post-mitigation	Attribute	Pre-mitigation	Post-mitigation
Nature of Impact	-1	-1	Magnitude of Impact	3	3
Extent of Impact	2	2	Reversibility of Impact	2	1
Duration of Impact	2	2	Probability	4	4
Environmental Risk (Pre-mitigation)					-9.00
Mitigation Measures					
See Section 4.1.2					
Environmental Risk (Post-mitigation)					-8.00
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
<i>Issue has received a meaningful and justifiable public response</i>					
Cumulative Impacts					2
<i>Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.</i>					
Degree of potential irreplaceable loss of resources					1
<i>The impact is unlikely to result in irreplaceable loss of resources.</i>					
Prioritisation Factor					1.33
Final Significance					-10.67

Table 5-2: Significance ranking due to proposed project operation activities

Impact Name	Decline in Ambient Air Quality: Operation				
Alternative	Alternative a and b				
Phase	Operation				
Environmental Risk					
Attribute	Pre-mitigation	Post-mitigation	Attribute	Pre-mitigation	Post-mitigation
Nature of Impact	-1	-1	Magnitude of Impact	3	3
Extent of Impact	4	3	Reversibility of Impact	3	1
Duration of Impact	4	4	Probability	4	4
Environmental Risk (Pre-mitigation)					-14.00
Mitigation Measures					
See Section 4.2.3					
Environmental Risk (Post-mitigation)					-11.00
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					3
<i>Issue has received an intense meaningful and justifiable public response</i>					
Cumulative Impacts					2
<i>Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.</i>					
Degree of potential irreplaceable loss of resources					1
<i>The impact is unlikely to result in irreplaceable loss of resources.</i>					
Prioritisation Factor					1.50
Final Significance					-16.50

Table 5-3: Significance ranking due to proposed project decommissioning activities

Impact Name	Decline in Ambient Air Quality				
Alternative	Alternative a and b				
Phase	Decommissioning				
Environmental Risk					
Attribute	Pre-mitigation	Post-mitigation	Attribute	Pre-mitigation	Post-mitigation
Nature of Impact	-1	-1	Magnitude of Impact	3	3
Extent of Impact	3	2	Reversibility of Impact	3	1
Duration of Impact	2	2	Probability	4	4
Environmental Risk (Pre-mitigation)					-11.00
Mitigation Measures					
See Section 4.1.2					
Environmental Risk (Post-mitigation)					-8.00
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
<i>Low: Issue not raised in public responses</i>					
Cumulative Impacts					1
<i>Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.</i>					
Degree of potential irreplaceable loss of resources					1
<i>The impact is unlikely to result in irreplaceable loss of resources.</i>					
Prioritisation Factor					1.17
Final Significance					-9.33

Table 5-4: Significance ranking due to proposed project closure and rehabilitation activities

Impact Name	Decline in Ambient Air Quality: Closure				
Alternative	Alternative a and b				
Phase	Rehab and closure				
Environmental Risk					
Attribute	Pre-mitigation	Post-mitigation	Attribute	Pre-mitigation	Post-mitigation
Nature of Impact	-1	-1	Magnitude of Impact	3	3
Extent of Impact	2	2	Reversibility of Impact	3	1
Duration of Impact	2	2	Probability	4	4
Environmental Risk (Pre-mitigation)					-10.00
Mitigation Measures					
See Section 4.3.2					
Environmental Risk (Post-mitigation)					-8.00
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
<i>Issue has received a meaningful and justifiable public response</i>					
Cumulative Impacts					1
<i>Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.</i>					
Degree of potential irreplaceable loss of resources					1
<i>The impact is unlikely to result in irreplaceable loss of resources.</i>					
Prioritisation Factor					1.17
Final Significance					-9.33

6 DUST MANAGEMENT PLAN

An air quality impact assessment was conducted for the project operations. The main objective of this study was to determine the significance of the predicted impacts from the current and proposed operations on the surrounding environment and on human health.

6.1 Site Specific Management Objectives

The main objective of Air Quality Management measures for the proposed project is to ensure that all operations are within ambient air quality criteria. In order to define site specific management objectives, the main sources of pollution needed to be identified. Sources can be ranked based on source strengths (emissions) and impacts. Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

Particulates were identified as the main pollutant of concern from the proposed project operations.

The ranking of sources serves to confirm or, where necessary revise, the current understanding of the significance of specific sources, and to evaluate the emission reduction potentials required for each. Sources of emissions for the proposed project may be ranked based on:

- emissions - based on the comprehensive emissions inventory established for the operations, and,
- impacts - based on the predicted dustfall levels and ambient inhalable and respirable particulate concentrations.

Source ranking based on emissions was undertaken for source groups reflecting proposed operations with no control measures. Ranking of uncontrolled sources provides an indication of the relative significance of each source. This also allows the assessment of the suitability of controls. Ranking according to emissions and impacts facilitates the identification of sources requiring further controls.

6.1.1 Ranking of Sources by Emissions

Quantified particulate emissions due to the proposed project operations were provided in Section 4.2.2.2. The emissions were divided into TSP, PM₁₀ and PM_{2.5} per operation category.

The largest contribution of total particulate emissions due to proposed unmitigated operations is vehicle entrainment and then crushing activities.

6.1.2 Ranking of Sources by Impact

In the assessment of the significance of the main source categories in terms of their impacts, reference is made to the inhalable particulate concentrations and dustfall results. NAAQS are applicable to the assessment of community exposures.

Prior to the analysis of these results, careful consideration should be given to the assumptions with regard to the temporal variations in emissions for the purpose of the dispersion modelling. Constant emissions were assumed for material handling operations and vehicle entrainment. Wind-blown dust was, however, calculated for each hour on the basis of wind speed and

atmospheric stabilities occurring during that hour. Peaks in wind-blown emissions were therefore accounted for in the dispersion simulations, whereas peaks in materials handling emissions due to intermittent high tonnage handling periods were not accounted for.

From the impact assessment, the main sources of concern were identified to be the vehicle entrainment and, to a lesser extent, crushing operations.

6.2 Project-Specific Management Measures

The proposed operations have been assessed during this study with all emissions quantified and dispersion simulations executed. As a result of the air quality assessment, it is found that the acceptability of proposed operations in terms of NAAQS and NDCR necessitates the implementation of an effective local dust management plan.

Given the potential dust impacts from operations it is considered “good practice” that dust control measures be implemented throughout the life of the project and it is recommended that the project proponent commit itself to dust management planning.

The main contributing sources of particulate emissions have been identified and quantified. Due to the focus of the current section on the potential expansion of the monitoring system for the project, the dust management plan will focus on the proposed sources.

6.2.1 Estimation of Dust Control Efficiencies

The main sources of fugitive dust emissions from the proposed project were identified to be:

- Vehicle entrainment on unpaved road surfaces
- Crushing and screening activities

The impacts from vehicle entrainment are directly linked to the vehicle activity. The impacts from unpaved road surfaces may be mitigated with water sprayers (assuring ~75% control efficiency). However, due to the close proximity of sensitive receptors to the proposed activities, it is recommended that chemical suppressants be applied to unpaved haul roads and access roads to reduce the impacts from this source with **90% control efficiency**.

The crushing operations are shown to be a potentially significant source of emissions if unmitigated. It is recommended that mitigation by means of **water sprayers (50% control efficiency)** at the crushing and screening plant be implemented to minimise impacts from this source.

6.2.2 Identification of Suitable Pollution Abatement Measures

Suitable abatement measures have been discussed in detail in Section 4.2.3.

6.2.3 Performance Indicators

Key performance indicators against which progress may be assessed form the basis for all effective environmental management practices. In the definition of key performance indicators careful attention is usually paid to ensure that progress towards their achievement is measurable, and that the targets set are achievable given available technology and experience.

Performance indicators are usually selected to reflect both the source of the emission directly and the impact on the receiving environment. Ensuring that no visible evidence of wind erosion exists represents an example of a source-based indicator, whereas maintaining off-site dustfall levels to below 600 mg/m²/day represents an impact- or receptor-based performance indicator. The NAAQS for particulate matter and NDCR represent receptor-based objectives.

6.2.3.1 Specification of Source Based Performance Indicators

Source based performance indicators for proposed routine operations for the project would include the following:

- Dustfall immediately downwind of the product storage piles to be < 1200 mg/m²/day and dustfall at sensitive receptors to be < 600 mg/m²/day.
- Crushing and screening plant: The absence of visible dust plume at all tipping points and outside the crushers during crushing operations would be the best indicator of effective control equipment in place. In addition, the dustfall in the immediate vicinity of various sources should be <1 200 mg/m²/day and dustfall at sensitive receptors to be <600 mg/m²/day.

6.2.3.2 Receptor Based Performance Indicators

Dustfall Network

The current dust fallout network consists of 7 single buckets and 4 directional buckets. The placement of the network, as established from the satellite imagery, is provided in Table 6-1.

Table 6-1: The placement for the current dust fallout network

Description	Single/ directional bucket	Placement of bucket	Rational of placement
MAN01	Single	Downwind of the current opencast mining operations	To monitor the dust fallout rates due to current mining operations
MAN02	Single	Along a public road to the south of operations	To monitor the dust fallout rates due to current operations at the southern boundary of current operations
MAN03	Single	Along the access road	To monitor the dust fallout rates due to plant and vehicle entrainment activities
MAN04	Single	At the current product storage piles	To monitor the dust fallout rates due to current product storage pile operations
MAN05	Single	At the eastern boundary	To monitor the dust fallout rates due to current operations at the eastern boundary of current operations

Description	Single/ directional bucket	Placement of bucket	Rational of placement
MAN06	Single	At the eastern boundary	To monitor the dust fallout rates due to current operations at the eastern boundary of current operations
MAN07	Single	At the southern boundary	To monitor the dust fallout rates due to current operations at the southern boundary of current operations
MAN-OP	Directional	At the western boundary	To determine the proportional contribution of dust from the mining operations to the east and other sources to the west
MAN-MG	Directional	At the northern boundary	To determine the proportional contribution of dust from the mining operations to the south and other sources to the north
MAN-MF	Directional	At the eastern boundary	To determine the proportional contribution of dust from the mining operations to the west and other sources to the east
MAN-GR	Directional	South of current operations	To determine the proportional contribution of dust from the mining operations to the north and other sources to the south

Based on the impacts from the proposed project it is recommended that the current dust fallout sampling undertaken at the mine be continued during proposed operations to ensure management measures implemented are effective and ambient air quality levels are not significantly different to baseline levels.

Recommendations on a change in placement of the current dust fallout network is provided for proposed operating conditions and is provided in Table 6-2. Suggested locations for the directional dust buckets are also provided. It should be noted that directional buckets can be used to understand the source apportionment from the area but should not be used for comparison to NDCR. In addition, only boundary and off-site single dust bucket samples should be reported to the authorities, this excludes MAN03 and MAN06 as well as the directional dust bucket samples. The recommended performance assessment and reporting programme for ambient air sampling is given in Table 6-3.

Table 6-2: Recommended dust fallout and PM₁₀ sampling for the proposed project

Description	Latitude	Longitude	Placement of bucket
MAN01	-26.2330	28.6710	To the west of operations, co-located with the closest sensitive receptor (R1). The directional bucket MAN-OP can be co-located at this site.
MAN02	-26.2377	28.6609	Along access road, co-located with sensitive receptor R3.
MAN03	-26.2234	28.6982	At the product and crusher area.
MAN04	-26.2225	28.6925	At the northern boundary, co-located with the directional bucket MAN-MG .
MAN05	-26.2235	28.7113	At the eastern boundary (same location as current sampler but can be moved to co-locate site with closest sensitive receptor (R7).
MAN06	-26.2391	28.6947	Along the proposed haul road.
MAN07	-26.2542	28.6919	At the southern boundary (same location as current sampler). The directional bucket MAN-GR can be co-located at this site.
MAN08	-26.2358	28.7131	Co-located with the directional bucket MAN-MF .

Table 6-3: Ambient air monitoring, performance assessment and reporting programme

Monitoring Strategy Criteria	Dustfall Monitoring
<i>Monitoring objectives</i>	<ul style="list-style-type: none"> - Assessment of compliance with dustfall limits within the main impact zone of the operation. - Facilitate the measurement of progress against environmental targets within the main impact zone of the operation. - Temporal trend analysis to determine the potential for nuisance impacts within the main impact zone of the operation. - Tracking of progress due to pollution control measure implementation within the main impact zone of the operation. - Informing the public of the extent of localised dust nuisance impacts occurring in the vicinity of the mine operations.
<i>Monitoring location(s)</i>	It is recommended that the current dust fallout network comprising of 8 single dust buckets, be continued with some of the samplers moved to capture the dust fallout due to proposed activities (Figure 6-1).
<i>Sampling techniques</i>	<p><i>Single Bucket Dust Fallout Monitors</i></p> <p>Dust fallout sampling measures the fallout of windblown settle able dust. Single bucket fallout monitors to be deployed following the American Society for Testing and Materials standard method for collection and analysis of dustfall (ASTM D1739). This method employs a simple device consisting of a cylindrical container exposed for one calendar month (30 days, ± 2 days).</p>
<i>Accuracy of sampling technique</i>	Margin of accuracy given as ± 200 mg/m ² /day.
<i>Sampling frequency and duration</i>	On-going, continuous monitoring to be implemented facilitating data collection over 1-month averaging period.
<i>Commitment to Quality Assessment/ Quality Control (QA/QC) protocol</i>	Comprehensive QA/QC protocol implemented.
<i>Interim environmental targets (i.e. receptor-based performance indicator)</i>	Maximum total daily dustfall (calculated from total monthly dustfall) of not greater than 600 mg/m ² /day for residential areas. Maximum total daily dustfall to be less than 1 200 mg/m ² /day on-site (non-residential areas).
<i>Frequency of reviewing environmental targets</i>	Annually (or may be triggered by changes in air quality regulations).
<i>Action to be taken if targets are not met</i>	<ul style="list-style-type: none"> (i) Source contribution quantification. (ii) Review of current control measures for significant sources (implementation of contingency measures where applicable).
<i>Procedure to be followed in reviewing environmental targets and other elements of the monitoring strategy (e.g. sampling technique, duration, procedure)</i>	Procedure to be drafted in liaison with I&APs through the proposed community liaison forum. Points to be taken into account will include, for example: (i) trends in local and international ambient particulate guidelines and standards and/or compliance monitoring requirements, (ii) best practice with regard to monitoring methods, (iii) current trends in local air quality, i.e. is there an improvement or deterioration, (iv) future development plans within the airshed (etc.)
<i>Progress reporting</i>	At least annually to the necessary authorities and community forum.

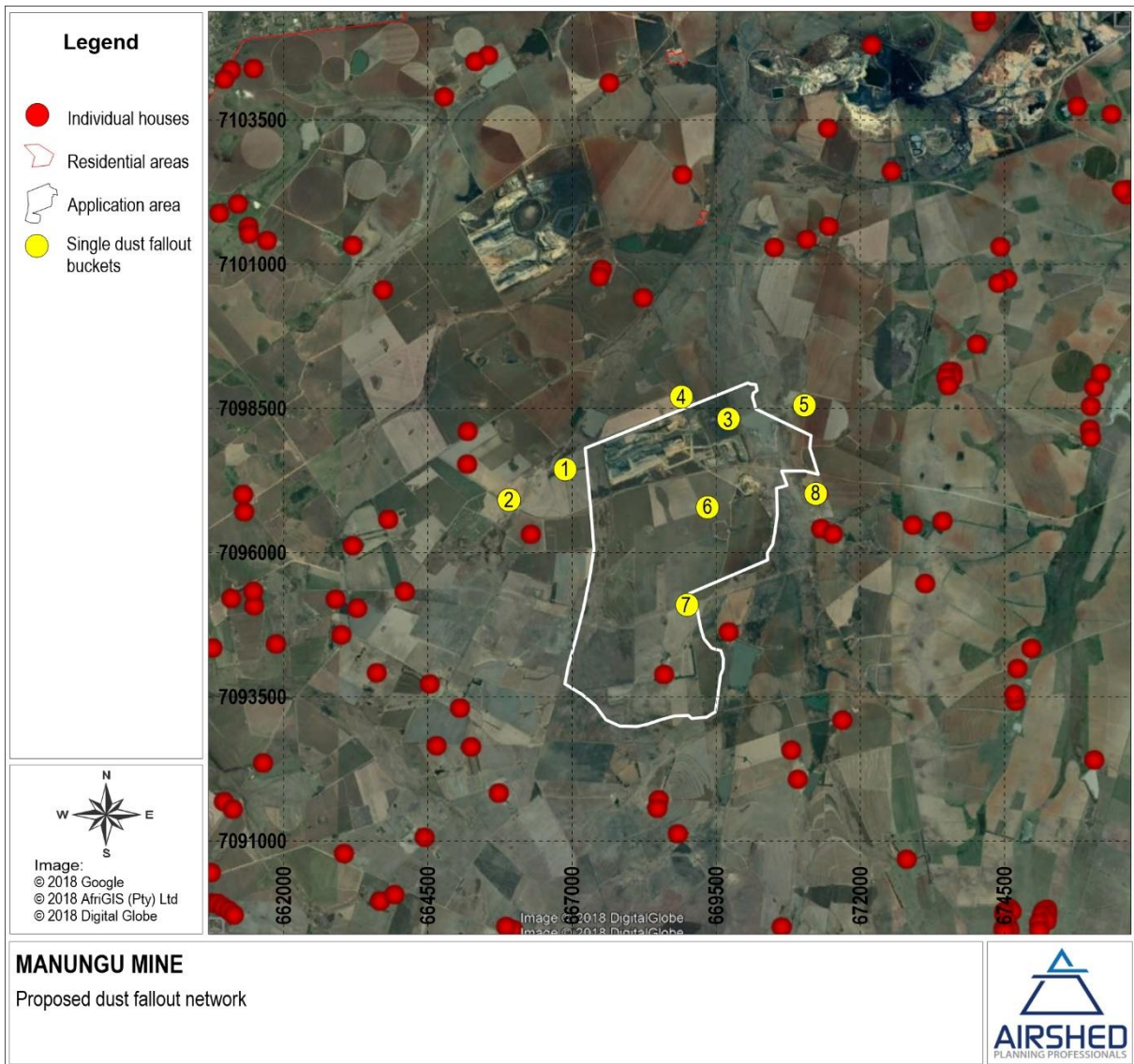


Figure 6-1: Proposed dust fallout network for the proposed project operations

PM₁₀ Sampling

It is recommended that PM₁₀ sampling be continued but that the placement of the sampler be carefully considered to understand impacts at the closest sensitive receptor. The sampler can thus be co-located with the sensitive receptors R1, R3 or perhaps R7. This should be done prior to commencement of proposed activities to understand the baseline ambient levels. Once proposed mitigated operations commence, a PM₁₀ sampling campaign of 12 months needs to be undertaken in order to ensure that baseline levels are not further compromised by the projects proposed operations and if possible, to reduce ambient particulate concentrations to within NAAQS. The PM₁₀ sampling can be undertaken by inexpensive sampling equipment such as a MiniVol or EBam or more expensive equipment such as a TEOM.

Various factors can severely affect the validity of data from a monitoring site. The following issues should be thoroughly considered before selecting a site.

- 1) Sites with restricted air flows in the vicinity of the monitor: Sites should not be adjacent to walls, buildings or trees that impede or distort the air flow. In general, the site should be in an open area, free of structures higher than 1 m within a 20 m radius of the container stand.
- 2) Obstacles between source to be monitored and monitor itself: In addition, if the monitor is to measure the effects from a specific operation, there should not be tall trees, buildings, etc. between the monitor and the source of impact.
- 3) Sources of pollution that affect the sampler: The site should be away from local sources of pollution and objects that could affect the settling of particulate matter, such as trees, and air exhausts and intakes. This also applies to bird nests in the sampling structure or stands which should be kept clear of any debris.
- 4) Security: Accessibility and security from vandalism are major considerations in the selection of a site.

6.2.4 Record-keeping, Environmental Reporting and Community Liaison

6.2.4.1 Periodic Inspections and Audits

Periodic inspections and external audits are essential for progress measurement, evaluation and reporting purposes. It is recommended that site inspections and progress reporting be undertaken at regular intervals (at least quarterly) during rehabilitation, with annual environmental audits being conducted. Annual environmental audits should be continued at least until closure. Results from site inspections and monitoring efforts should be combined to determine progress against source- and receptor-based performance indicators. Progress should be reported to all interested and affected parties, including authorities and persons affected by pollution.

The criteria to be taken into account in the inspections and audits must be made transparent by way of minimum requirement checklists included in the Environmental Management Plan.

Corrective action or the implementation of contingency measures must be proposed to the stakeholder forum in the event that progress towards targets is indicated by the quarterly/annual reviews to be unsatisfactory.

6.2.4.2 Liaison Strategy for Communication with Interested and Affected Parties (I&APs)

Stakeholder forums provide possibly the most effective mechanisms for information dissemination and consultation. EMPs should stipulate specific intervals at which forums will be held, and provide information on how people will be notified of such meetings. For operations for which un-rehabilitated or partly rehabilitated impoundments are located in close proximity (within 3 km) from residential areas, it is recommended that such meetings be scheduled and held at least on a bi-annual basis.

6.2.4.3 Financial Provision (Budget)

The budget should provide a clear indication of the capital and annual maintenance costs associated with dust control measures and dust monitoring plans. It may be necessary to make assumptions about the duration of aftercare prior to

obtaining closure. This assumption must be made explicit so that the financial plan can be assessed within this framework. Costs related to inspections, audits, environmental reporting and interested and affected parties (I&AP) liaison should also be indicated where applicable. Provision should also be made for capital and running costs associated with dust control contingency measures and for security measures.

The financial plan should be audited by an independent consultant, with reviews conducted on an annual basis.

The costs to implement mitigation measures will be dependent on the solutions selected and the engineering designs. A detailed cost can therefore not be provided in this assessment.

6.3 Summary of Dust Management Plan

Based on the evaluation of the proposed project, a summary of the air quality management objectives is provided in Table 6-4. The management and monitoring of all operations at the mine is provided in Table 6-4 with the action plan provided in Table 6-5.

Table 6-4: Air Quality Management Plan for the proposed project operations

No.	Mitigation Measures	Phase	Timeframe	Responsible party for implementation	Monitoring Party (frequency)	Target	Performance Indicators (Monitoring Tool)
Vehicle entrainment on unpaved road surfaces							
A	<p>Various management measures may be implemented including: Water sprayers providing ~75% control efficiency Chemical suppressants providing 80%-90% control efficiency.</p> <p><i>Due to the proximity of sensitive receptors to the proposed project activities, it is recommended that chemical suppressants be applied to unpaved haul and access roads to reduce the impacts from this source by 90% control efficiency.</i></p>	Operational Phase	Duration of operations	Applicant Environmental Manager	Environmental Manager (Monthly)	Ensure compliance with NAAQS and NDCR.	The ambient air quality is within NAAQS for PM ₁₀ and PM _{2.5} and that the dust fallout levels at residential areas are less than 600 mg/m ³ /day.
Crushing operations							
A	<p>Various management measures may be implemented including:</p> <ul style="list-style-type: none"> Telescopic chute with water sprays providing ~75% control efficiency Water sprayers on crushing activities providing ~50% control efficiency Hoods with scrubbers providing up to 75% control efficiency Enclosure of scrubbers and screens would provide up to 100% control efficiency Hooding with fabric filters can result in control efficiencies of 83%. <p><i>Water sprayers on the crushing activities should be implemented to</i></p>	Operational Phase	Duration of operations	Applicant Environmental Manager	Environmental Manager (Weekly)	Ensure compliance with NAAQS and NDCR.	The ambient air quality is within NAAQS for PM ₁₀ and PM _{2.5} and that the dust fallout levels at residential areas are less than 600 mg/m ³ /day.

No.	Mitigation Measures	Phase	Timeframe	Responsible party for implementation	Monitoring Party (frequency)	Target	Performance Indicators (Monitoring Tool)
	<i>control the emission of this source by 50%.</i>						
Ambient Monitoring							
A	A proposed dust fallout sampling network (comprising of eight single dust buckets), as provided in Section 6.2.3, is recommended. Dust fallout rates to be below 1200 mg/m ² /day in non-residential areas and 600 mg/m ² /day in residential areas, averaged over 30 days.	Construction, operation and closure phases	Duration of construction, operations and closure	Applicant Environmental Manager	Environmental Manager (Monthly)	Ensure compliance with NDCR.	Eight single dust fallout buckets.
B	Two PM ₁₀ sampling campaigns are recommended at the closest sensitive receptors (west or east of operations) before proposed operations commence and once proposed mitigated operations take place in order to ensure minimum impacts from the project on the surrounding communities.	Planning phase and proposed operational phase.	12-month sampling campaign before operations and during operations	Applicant Environmental Manager	Environmental Manager (Daily)	Ensure compliance with NAAQS.	PM ₁₀ sampler.

Table 6-5: Action Plan

Phase	Management Action	Timeframe for Implementation	Responsible Party for Implementation (frequency)	Responsible Party for Monitoring/Audit/Review (frequency)
Planning Phase	Undertake a 12-month PM ₁₀ sampling campaign	1 year prior to construction	Consultant to be appointed	Consultant Environmental Manager (internal review)
Planning Phase	Relocate dust fallout sampling units as recommended in the Section 6.2.3.2	1 month prior to construction	Consultant	Consultant Environmental Manager (internal review)
Construction Phase	Ongoing dust fallout sampling	Throughout construction	Consultant	Consultant Environmental Manager (internal review)
Operational Phase	Undertake a 12-month PM ₁₀ sampling campaign	During maximum LOM throughput year	Consultant to be appointed	Consultant Environmental Manager (internal review)
	Ongoing dust fallout sampling	Throughout operation	Consultant	Consultant Environmental Manager (internal review)
	Dust suppression on unpaved roads	Throughout operation	Service company	Service company Environmental Manager (onsite monitoring)
	Dust suppression on crusher	Throughout operation	Environmental Manager	Environmental Manager (onsite monitoring)
Closure Phase	Ongoing dust fallout sampling (locations at sensitive receptors)	Throughout closure	Consultant	Consultant Environmental Manager (internal review)
Post Closure Phase	Ongoing dust fallout sampling (locations at sensitive receptors)	1 year after closure	Consultant	Consultant Environmental Manager (internal review)

7 FINDINGS AND RECOMMENDATIONS

7.1 Findings

An air quality impact assessment was conducted for the project operations. The main objective of this study was to determine the significance of the predicted impacts from the project operations on the surrounding environment and on human health. Emission rates were quantified for the current and proposed activities and dispersion modelling executed.

The main findings from the baseline assessment were as follows:

- The main sources likely to contribute to cumulative particulate impact are surrounding agricultural activities, mining and industrial activities as well as vehicle entrainment on unpaved road surfaces and biomass burning.
- The wind field is dominated by winds from the north-north-west and east.
- Numerous individual homesteads are located around the project area. Larger residential areas include Eloff (~9 km to the north-west) and Delmas (~7.5 km to the north).
- Measured PM₁₀ ground level concentrations onsite exceed NAAQS during the sampling period of March to September 2017.
- The dust fallout measured at the Manungu sampling network (single buckets) for the period April to September 2017 were provided for seven sites with the NDCR exceeded at site MAN02.

The main findings from the impact assessment due to project operations were as follows:

- Vehicle entrainment on unpaved surfaces and, to a lesser extent, crushing activities represented the highest impacting particulate sources from the current and proposed project operations.
- The highest simulated ground level PM₁₀ concentrations due to current unmitigated project operations were in non-compliance with daily NAAQS at sensitive receptors within the study area. When activities were mitigated (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities), the impacts reduced significantly with no exceedances of the NAAQS at the closest sensitive receptors. The extent of the PM₁₀ impacts increase with proposed operations with exceedances of the NAAQS (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities) at individual homesteads to the west of the mine.
- The highest simulated PM_{2.5} concentrations due to current unmitigated project operations were in non-compliance with daily NAAQS at the closest sensitive receptor to the north of operations. When activities were mitigated (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities), the impacts reduced significantly with no exceedances of the NAAQS at the closest sensitive receptors. The extent of the PM_{2.5} impacts increase with proposed operations but are within NAAQS at the closest sensitive receptors with mitigated operations (assuming 90% control efficiency on unpaved roads and 50% control efficiency on crushing activities).

- Maximum daily dust deposition due to proposed unmitigated operations exceeded the NDCR for the closest sensitive receptor to the west of the mine.

7.2 Recommendations

It is of the authors opinion that the project be authorised provided that the following recommendations are followed:

- It is recommended that ambient sampling, as outlined in Section 6.2.3.2, be undertaken in order to monitor the impacts from the proposed project activities.
- Due to the close proximity of sensitive receptors to the proposed project activities, it is recommended that extensive mitigation measures on the main sources of fugitive dust (as recommended in Table 6-4) be implemented to minimise impacts as far as possible.

8 GREENHOUSE GAS QUANTIFICATION

The South African mandatory reporting guidelines for GHG focus on the reporting of Scope 1 emissions only. The three broad scopes for estimating GHG are:

- Scope 1: All direct GHG emissions.
- Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.
- Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc.

The National Air Quality Act, 2004 (Act No.39 of 2004) and the National Greenhouse Gas Emissions Reporting Regulations (NGERs) under that Act establish the legislative framework for a national GHG reporting system.

The South African Technical Guidelines (Department Environmental Affairs, 2017b) embody the latest methods for estimating emissions and are based on the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for compilation of National Greenhouse Gas inventories.

Sources of GHGs at the Manungu Mine include the liberation of carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) during fossil fuel combustion from mining. This section will include the following:

- Detail and determine the direct carbon footprint of the mine;
- Determination of the type and volumes GHG emissions arising from the mines direct operations; and
- Determination of the carbon tax to be levied on the mine as a result of its direct operations once the carbon emissions tax is promulgated.

8.1 Greenhouse Gas Emissions Inventory

The Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry (Department Environmental Affairs, 2017b) state methods for determining greenhouse gas emissions as required by the IPCC. The following methods are given:

- Tier 1: A bare minimum method using readily available statistical data on the intensity of processes (activity data) and default emission factors. This method is the simplest method and has the highest level of uncertainty;
- Tier 2: Similar to Tier 1 but uses technology or country specific emission factors. Tier 2 methods reduce the level of uncertainty;
- Tier 3: Defined as any methodology more detailed than Tier 2 and might include amongst others, process models and direct measurements. Tier 3 methods have the lowest level of uncertainty.

Mining is a key category for South Africa and thus reporting of emissions on either Tier 2 or Tier 3 is required. For diesel emissions, only tier 1 emission factors are available. The categories that are triggered by Manugu Colliery include 1A1cii, 1B1ai and 1B1aai. A summary of all direct GHG emissions from the Manungu Colliery for current and proposed operations (based on diesel usage provided and ROM throughput) is given in Table 8-1 and Table 8-2 for current and proposed operations respectively.

A summary of all direct GHG emissions is given in Table 8-3 and Table 8-4 for current and proposed operations respectively. CO₂eq is a term for describing different GHG in a common unit. For any quantity and type of GHG, CO₂eq signifies the amount of CO₂ which would have the equivalent global warming impact. A quantity of GHG can be expressed as CO₂eq by multiplying the amount of the GHG by its global warming potential (GWP). E.g. if 1kg of CH₄ is emitted, this can be expressed as 23kg of CO₂eq (1kg CH₄ * 23 = 23kg CO₂eq). GWP for CH₄ and N₂O were obtained from the technical guidelines document (Department Environmental Affairs, 2017b).

The "Declaration of Greenhouse Gases as Priority Air Pollutants" in the Government Gazette of 40996 in July 2017 (Department of Environmental Affairs, 2017c) states processes that emit GHG in excess of 0.1 Megatonnes (109 kg) (Mt) or more annually or measured as CO₂eq are required to submit a pollution prevention plan. Manungu Colliery currently does not therefore require the submission of a pollution prevention plan as they emit less than 100 000 tCO₂eq. However, for proposed operations (at maximum ROM throughput from underground mining operations) Manungu Colliery will emit more than 100 000 tCO₂eq and will therefore require a pollution prevention plan.

Table 8-1: Annual reporting as per Annexure 3 of the National Greenhouse Gas Emissions Reporting Regulations of 2017 for current operations at Manungu Colliery

Name of Data Provider		Manungu Colliery											
Data Provider ID													
Date of Submission		October 2018											
Year of data:		2017											
Comments:		All diesel usage is assumed to be for transportation onsite.											
IPPC Code	Sub category (disaggregated by fuel/ product type/ production process)	Activity data			Emissions (tonnes/year)								
		Name of activity data	Value of activity data	Units of activity data	GHG-CO ₂			GHG-CH ₄			GHG-N ₂ O		
					Value	Tier	Ref	Value	Tier	Ref	Value	Tier	Ref
1A1cii	Diesel	Transportation	9 455 851	litres/year	22 558.00	1	IPPC	1.26	1	IPPC	8.71	1	IPPC
1B1aii	Coal mined	Opencast mining	2 028 500	tonnes/year	0	2	DEA, 2017	0	2	DEA, 2017			

Table 8-2: Annual reporting as per Annexure 3 of the National Greenhouse Gas Emissions Reporting Regulations of 2017 for proposed operations at Manungu Colliery

Name of Data Provider		Manungu Colliery											
Data Provider ID													
Date of Submission		October 2018											
Year of data:		Proposed operations											
Comments:		All diesel usage is assumed to be for transportation onsite.											
IPPC Code	Sub category (disaggregated by fuel/ product type/ production process)	Activity data			Emissions (tonnes/year)								
		Name of activity data	Value of activity data	Units of activity data	GHG-CO ₂			GHG-CH ₄			GHG-N ₂ O		
					Value	Tier	Ref	Value	Tier	Ref	Value	Tier	Ref
1A1cii	Diesel	Transportation	15 122 458	litres/year	36 076.32	1	IPPC	2.02	1	IPPC	13.92	1	IPPC
1B1ai	Coal mined	Underground mining	1 620 000	tonnes/year	12 828 634.78	2	DEA, 2017	29 505 859.99	2	DEA, 2017			
1B1aii	Coal mined	Opencast mining	1 970 000	tonnes/year	0	2	DEA, 2017	0	2	DEA, 2017			

Table 8-3: Greenhouse Gas Emissions Inventory at the Manungu Mine for current operations (2017)

Energy Consumption (2017)	CO ₂ equivalent emissions (tpa)			TOTAL
	CO ₂	CH ₄	N ₂ O	
Diesel	22 558.00	29.06	2 577.15	25 164.21
Total				25 164.21

Table 8-4: Greenhouse Gas Emissions Inventory at the Manungu Mine for proposed operations

Energy Consumption (proposed)	CO ₂ equivalent emissions (tpa)			TOTAL
	CO ₂	CH ₄	N ₂ O	
Diesel	36 076.32	46.47	4 121.56	40 244.36
Coal mining (underground)	12 828 634.78	29 505 859.99		42 334 494.77
Total				42 374 739.13

9 COMMENTS/ISSUES RAISED

Comments and issues related to air quality that have been raised is provided in Table 9-1.

Table 9-1: Comments/issues raised

Origin	Complaint	Complainant	Response
Letter received from Barnard Inc. Attorneys	The release of the methane gasses into the air as a result of the coal mining will negatively impact the living condition of the nearby environment of the proposed coal processing facility and will have severe health implications for the workers of our client and livestock.	Couwenburg Boerdery	The quantification of methane gasses has been provided in Section 8
	The livestock, agriculture as well as the persons living within the surrounding area of the facility which includes our clients farm will be severely effected by the air pollution as a result of the stock piles height amendments. As a result of the higher stockpile there will be more dust and which will further negatively impact the surrounding livestock, agriculture and heath of workers on our clients farm.	Couwenburg Boerdery	The impacts due to operations (including windblown dust from the stockpiles) has been provided in Section 4. From an air quality perspective, impacts due to windblown dust will be lower for a smaller footprint stockpile with a higher height than for a larger footprint stockpile with a lower height.
Public meeting held 14 March 2018	Mr Nel asked, with regards to vegetation, if the stockpile does go higher than 6m, which it already is, how are they going to control the dust if they are not going to vegetate it and put topsoil over it? Mr Whitfield advised that the issue of dust, specifically relating to 6m vs 45m high stockpiles, would be assessed in more detail and the findings presented in the next phase of this EIA process.	Mr Nel	The impacts due to operations (including windblown dust from the stockpiles) has been provided in Section 4. From an air quality perspective, impacts due to windblown dust will be lower for a smaller footprint stockpile with a higher height than for a larger footprint stockpile with a lower height. The waste stockpiles will be backfilled into the mined opencast areas. The topsoil stockpiles are naturally self-vegetating (as observed during the site visit).
	Mr Nel asked who was going to be doing the air studies. Mr Whitfield advised that Airshed Planning Professionals will be conducting the air quality specialist study. Mr Nel stated that Airshed has done work for the mine already. Mr Whitfield clarified that the previous work was not undertaken as part of this current application process. Mr Nel questioned if the specialist is not meant to be independent. Mr Whitfield clarified that Airshed is independent as they are not directly employed by the mine. Mr Nel questioned if Airshed has not been employed by anyone else around the mine. Mr Whitfield stated that Airshed has been appointed by the Nel family as part of the study on the Fournel Factory. Mr Nel asked if the information that Airshed has for Fournel will be shared and how would Airshed know if the dust Fournel is getting is from the mine? Mr Whitfield advised that Airshed would consult with the Nel's and furthermore that any historic information Airshed may have for the mine or for the Fournel Factory would be beneficial to them assessing the impact of dust.	Mr Nel	Airshed have been sub-contracted by EIMS to provide an independent assessment of the potential air quality impacts due to Manungu Colliery's current and proposed mining operations. Any studies that have been conducted for Fournel Factory are the property of Fournel and will not be discussed or included into this assessment unless requested and information provided by Fournel themselves.

Origin	Complaint	Complainant	Response
	<p>Mr Nel requested clarification that should the dust specialist study find that there is too much dust, how will this be dealt with? Mr Whitfield responded that the air quality study would assess the impact of dust and identify sources, reasons and possible mitigation measures. Mr Proburst added that wind needs to be included as a factor. Mr Nel asked when the study will be done and if it will consider the windy season. Mr Whitfield advised that the study will consider all available data including previous seasonal dust monitoring data.</p>	<p>Mr Nel Mr Proburst</p>	<p>The impacts due to operations has been provided in Section 4. The sources of emissions and impacts have been ranked and potential mitigation measures recommended in Section 4.3.2. The impacts are quantified with the aid of the AERMOD dispersion model and 3 years of meteorological data that assists in the calculation of the dispersion potential of the impacts. The three years of meteorological data used for the modelling will capture all meteorological conditions during the year (i.e. dry season, wet season, windy season, etc.) and provide a simulated impact for the worst meteorological condition for varying simulated periods.</p>
	<p>Mr Nel raised the issue of conflict of interest in terms of the proposed air quality specialist for the EIA, namely Airshed Planning Professionals, as they had previously undertaken a dust assessment for the Fournel Factory as well as for the mine. Mr Whitfield advised that the specialist must sign a disclaimer stating that they are independent and impartial. It was further stated that the fact that Airshed had previously assessed the impact of dust on the factory is beneficial in that they have this data to feed into their study for the mine expansion project.</p>	<p>Mr Nel</p>	<p>Airshed have been sub-contracted by EIMS to provide an independent assessment of the potential air quality impacts due to Manungu Colliery's current and proposed mining operations.</p> <p>Any studies that have been conducted for Fournel Factory are the property of Fournel and will not be discussed or included into this assessment unless requested and information provided by Fournel themselves.</p> <p>In addition, Fournel were contacted when Airshed were approached to provide a proposal for the current assessment, to ask whether there was any objection. No response was provided by the Fournel's to Airshed. This was taken as a sign of no objection. Similarly, EIMS were notified that Airshed had undertaken a study for Fournel. EIMS did not have any objections that Airshed conduct the air quality assessment for the current study.</p> <p>In order to remain fully objective, Dr Burger did not form part of the consulting team for the current assessment and has not discussed or provided any information on the Fournel assessment to the Airshed team working on this assessment.</p> <p>The declaration of independence for the assessment is signed and provided in Appendix B.</p>

Origin	Complaint	Complainant	Response
	<p>Mr Nel asked how can they trust the previous dust study? Mr Whitfield responded that the mine may appoint the specialists to undertake dust monitoring however the specialists must maintain independence and report truthfully.</p>	<p>Mr Nel</p>	<p>No reference has been provided as to which dust study is under question. Airshed have been involved in a PM₁₀ sampling campaign undertaken from March to September 2017. The samples were sent to an independent laboratory for analysis and the results were provided to Airshed for reporting.</p> <p>For the current assessment Airshed provide an independent assessment of the impacts based on the LOM throughputs and operations. All information used in the assessment is documented and the declaration of independence provided in Appendix B.</p>
	<p>Mr Nel asked for confirmation that the dust specialists will come to them. Mr Whitfield confirmed that the air quality specialist would consult with them.</p>	<p>Mr Nel</p>	<p>Airshed will address all comments from I&APs with written responses that are received from their client (EIMS). Concerns raised during public meetings, if Airshed are present, will also be addressed verbally. Airshed will not consult directly with I&APs in any other setting not listed above that does not conform to the proper channels of communication for such assessments.</p>

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FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	Reneé von Gruenewaldt (<i>nee</i> Thomas)
Profession	Air Quality Scientist
Date of Birth	13 May 1978
Years with Firm	More than 15 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP)
- Member of the National Association for Clean Air (NACA)

KEY QUALIFICATIONS

Reneé von Gruenewaldt (Air Quality Scientist): René joined Airshed Planning Professionals (Pty) Ltd (previously known as Environmental Management Services cc) in 2002. She has, as a Specialist, attained over fifteen (15) years of experience in the Earth and Natural Sciences sector in the field of Air Quality and three (3) years of experience in the field of noise assessments. As an environmental practitioner, she has provided solutions to both large-scale and smaller projects within the mining, minerals, and process industries.

She has developed technical and specialist skills in various modelling packages including the AMS/EPA Regulatory Models (AERMOD and AERMET), UK Gaussian plume model (ADMS), EPA Regulatory puff based model (CALPUFF and CALMET), puff based HAWK model and line based models. Her experience with emission models includes Tanks 4.0 (for the quantification of tank emissions), WATER9 (for the quantification of waste water treatment works) and GasSim (for the quantification of landfill emissions). Noise propagation modelling proficiency includes CONCAWE, South African National Standards (SANS 10210) for calculating and predicting road traffic noise.

Having worked on projects throughout Africa (i.e. South Africa, Mozambique, Malawi, Kenya, Angola, Democratic Republic of Congo, Namibia, Madagascar and Egypt) René has developed a broad experience base. She has a good understanding

of the laws and regulations associated with ambient air quality and emission limits in South Africa and various other African countries, as well as the World Bank Guidelines, European Community Limits and World Health Organisation.

RELEVANT EXPERIENCE

Mining and Ore Handling

Reneé has undertaken numerous air quality impact assessments and management plans for coal, platinum, uranium, copper, cobalt, chromium, fluorspar, bauxite, manganese and mineral sands mines. These include: compilation of emissions databases for Landau and New Vaal coal collieries (SA), impact assessments and management plans for numerous mines over Mpumalanga (viz. Schoonoord, Belfast, Goedgevonden, Mbila, Evander South, Driefontein, Hartogshoop, Belfast, New Largo, Geluk, etc.), Mmamabula Coal Colliery (Botswana), Moatize Coal Colliery (Mozambique), Revuboe Coal Colliery (Mozambique), Toliera Sands Heavy Minerals Mine and Processing (Madagascar), Corridor Sands Heavy Minerals Mine monitoring assessment, El Burullus Heavy Minerals Mine and processing (Egypt), Namakwa Sands Heavy Minerals Mine (SA), Tenke Copper Mine and Processing Plant (DRC), Rössing Uranium (Namibia), Lonmin platinum mines including operations at Marikana, Baobab, Dwaalkop and Doornvlei (SA), Impala Platinum (SA), Pilannesburg Platinum (SA), Aquarius Platinum, Hoogland Platinum Mine (SA), Tamboti PGM Mine (SA), Sari Gunay Gold Mine (Iran), chrome mines in the Steelpoort Valley (SA), Mecklenburg Chrome Mine (SA), Naboom Chrome Mine (SA), Kinsenda Copper Mine (DRC), Kassinga Mine (Angola) and Nokeng Fluorspar Mine (SA), etc.

Mining monitoring reviews have also been undertaken for Optimum Colliery's operations near Hendrina Power Station and Impunzi Coal Colliery with a detailed management plan undertaken for Morupule (Botswana) and Glencor (previously known as Xstrata Coal South Africa).

Air quality assessments have also been undertaken for mechanical appliances including the Durban Coal Terminal and Nacala Port (Mozambique) as well as rail transport assessments including BHP-Billiton Bauxite transport (Suriname), Nacala Rail Corridor (Mozambique and Malawi), Kusile Rail (SA) and WCL Rail (Liberia).

Metal Recovery

Air quality impact assessments have been carried out for Highveld Steel, Scaw Metals, Lonmin's Marikana Smelter operations, Saldanha Steel, Tata Steel, Afro Asia Steel and Exxaro's Manganese Pilot Plant Smelter (Pretoria).

Chemical Industry

Comprehensive air quality impact assessments have been completed for NCP (including Chloorkop Expansion Project, Contaminated soils recovery, C3 Project and the 200T Receiver Project), Revertex Chemicals (Durban), Stoppani Chromium Chemicals, Foskor (Richards Bay), Straits Chemicals (Coega), Tenke Acid Plant (DRC), and Omnia (Sasolburg).

Petrochemical Industry

Numerous air quality impact assessments have been completed for Sasol (including the postponement/exemption application for Synfuels, Infracem, Natref, MIBK2 Project, Wax Project, GTL Project, re-commissioning of boilers at Sasol Sasolburg and Ekandustria), Engen Emission Inventory Functional Specification (Durban), Sapref refinery (Durban), Sasol

(at Elrode) and Island View (in Durban) tanks quantification, Petro SA and Chevron (including the postponement/exemption application).

Pulp and Paper Industry

Air quality studies have been undertaken on the expansion of Mondi Richards Bay, Multi-Boiler Project for Mondi Merebank (Durban), impact assessments for Sappi Stanger, Sappi Enstra (Springs), Sappi Ngodwana (Nelspruit) and Pulp United (Richards Bay).

Power Generation

Air quality impact assessments have been completed for numerous Eskom coal fired power station studies including the ash expansion projects at Kusile, Kendal, Hendrina, Kriel and Arnot; Fabric Filter Plants at Komati, Grootvlei, Tutuka, Lethabo and Kriel Power Stations; the proposed Kusile, Medupi (including the impact assessment for the Flue Gas Desulphurization) and Vaal South Power Stations. René was also involved in the cumulative assessment of the existing and return to service Eskom power stations assessment and the optimization of Eskom's ambient air quality monitoring network over the Highveld.

In addition to Eskom's coal fired power stations, various Eskom nuclear power supply projects have been completed including the air quality assessment of Pebble Bed Modular Reactor and nuclear plants at Duynefontein, Bantamsklip and Thyspunt.

Apart from Eskom projects, power station assessments have also been completed in Kenya (Rabai Power Station) and Namibia (Paratus Power Plant).

Waste Disposal

Air quality impact assessments, including odour and carcinogenic and non-carcinogenic pollutants were undertaken for the Waste Water Treatment Works in Magaliesburg, proposed Waterval Landfill (near Rustenburg), Tutuka Landfill, Mogale General Waste Landfill (adjacent to the Leipardsvlei Landfill), Cape Winelands District Municipality Landfill and the Tsoeneng Landfill (Lesotho). Air quality impact assessments have also been completed for the BCL incinerator (Cape Town), the Ergo Rubber Incinerator and the Ecorevert Pyrolysis Plant.

Cement Manufacturing

Impact assessments for ambient air quality have been completed for the Holcim Alternative Fuels Project (which included the assessment of the cement manufacturing plants at Ulco and Dudfield as well as a proposed blending platform in Roodepoort).

Management Plans

René undertook the quantification of the baseline air quality for the first declared Vaal Triangle Airshed Priority Area. This included the establishment of a comprehensive air pollution emissions inventory, atmospheric dispersion modelling, focusing on impact area "hotspots" and quantifying emission reduction strategies. The management plan was published in 2009 (Government Gazette 32263).

René has also been involved in the Provincial Air Quality Management Plan for the Limpopo Province.

Other Experience (2001)

Research for B.Sc Honours degree was part of the “Highveld Boundary Layer Wind” research group and was based on the identification of faulty data from the Majuba Sodar. The project was THRIP funded and was a joint venture with the University of Pretoria, Eskom and Sasol (2001).

EDUCATION

M.Sc Earth Sciences	University of Pretoria, RSA, Cum Laude (2009) Title: <i>An Air Quality Baseline Assessment for the Vaal Airshed in South Africa</i>
B.Sc Hons. Earth Sciences	University of Pretoria, RSA, Cum Laude (2001) Environmental Management and Impact Assessments
B.Sc Earth Sciences	University of Pretoria, RSA, (2000) Atmospheric Sciences: Meteorology

ADDITIONAL COURSES

CALMET/CALPUFF	Presented by the University of Johannesburg, RSA (March 2008)
Air Quality Management	Presented by the University of Johannesburg, RSA (March 2006)
ARCINFO	GIMS, Course: Introduction to ARCINFO 7 (2001)

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Malawi, Liberia, Kenya, Angola, Democratic Republic of Congo, Namibia, Madagascar, Egypt, Suriname and Iran.

EMPLOYMENT RECORD

January 2002 - Present

Airshed Planning Professionals (Pty) Ltd, (previously known as Environmental Management Services cc until March 2003), Principal Air Quality Scientist, Midrand, South Africa.

2001

University of Pretoria, Demi for the Geography and Geoinformatics department and a research assistant for the Atmospheric Science department, Pretoria, South Africa.

Department of Environmental Affairs and Tourism, assisted in the editing of the Agenda 21 document for the world summit (July 2001), Pretoria, South Africa.

1999 - 2000

The South African Weather Services, vacation work in the research department, Pretoria, South Africa.

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- Topographical Effects on Predicted Ground Level Concentrations using AERMOD, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2011.
- Emission Factor Performance Assessment for Blasting Operations, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2009.
- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007.
- A High Resolution Diagnostic Wind Field Model for Mesoscale Air Pollution Forecasting, R.G. Thomas, L.W. Burger, and H Rautenbach. National Association for Clean Air (NACA) conference, September 2005.
- Emissions Based Management Tool for Mining Operations, R.G. Thomas and L.W. Burger. National Association for Clean Air (NACA) conference, October 2004.
- An Investigation into the Accuracy of the Majuba Sodar Mixing Layer Heights, R.G. Thomas. Highveld Boundary Layer Wind Conference, November 2002.

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Fair	Good	Good

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications, and my experience.



Signature of staff member

10/05/2017

Date (Day / Month / Year)

Full name of staff member:

René Georgeinna von Gruenewaldt

APPENDIX B - DECLARATION OF INDEPENDENCE

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: René von Gruenewaldt

Name of Registration Body: South African Council for Natural Scientific Professions

Professional Registration No.: 400304/07

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, René von Gruenewaldt, declare that I am independent of the applicant. I have the necessary expertise to conduct the assessments required for the report and will perform the work relating the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. I will disclose to the applicant and the air quality officer all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the air quality officer. The additional information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at Midrand on this 15th of October 2018



SIGNATURE

Principal Air Quality Scientist

CAPACITY OF SIGNATORY

APPENDIX C – EIMS ENVIRONMENTAL IMPACT ASSESSMENT SIGNIFICANCE RATING METHODOLOGY

THE IMPACT ASSESSMENT METHODOLOGY

Method of Assessing Impacts:

The impact assessment methodology is guided by the requirements of the NEMA EIA Regulations (2010). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/likelihood (P) of the impact occurring. This determines the environmental risk. In addition, other factors, including cumulative impacts, public concern, and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S). Please note that the impact assessment must apply to the identified Sub Station alternatives as well as the identified Transmission line routes.

Determination of Environmental Risk:

The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER).

The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$C = (E+D+M+R) \times N$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 1.

Table 1: Criteria for Determining Impact Consequence

Aspect	Score	Definition
Nature	-1	Likely to result in a negative/ detrimental impact
	1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary),
	3	Local (i.e. the area within 5 km of the site),
	4	Regional (i.e. extends between 5 and 50 km from the site)
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years),
	3	Medium term (6-15 years),
	4	Long term (the impact will cease after the operational life span of the project),

Aspect	Score	Definition
	5	Permanent (no mitigation measure of natural process will reduce the impact after construction).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact

Once the C has been determined the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/scored as per Table 2.

Table 2: Probability Scoring

Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur - > 75% probability), or
	5	Definite (the impact will occur)

The result is a qualitative representation of relative ER associated with the impact. ER is therefore calculated as follows:

$$ER = C \times P$$

Table 3: Determination of Environmental Risk

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
Probability						

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 4.

Table 4: Significance Classes

Environmental Risk Score	
Value	Description
< 9	Low (i.e. where this impact is unlikely to be a significant environmental risk),
≥9; <17	Medium (i.e. where the impact could have a significant environmental risk),
≥ 17	High (i.e. where the impact will have a significant environmental risk).

The impact ER will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/mitigated.

Impact Prioritisation:

In accordance with the requirements of Regulation 31 (2)(l) of the EIA Regulations (GNR 543), and further to the assessment criteria presented in the Section above it is necessary to assess each potentially significant impact in terms of:

- Cumulative impacts; and
- The degree to which the impact may cause irreplaceable loss of resources.

In addition it is important that the public opinion and sentiment regarding a prospective development and consequent potential impacts is considered in the decision making process.

In an effort to ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact ER (post-mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the ER score based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table 5: Criteria for Determining Prioritisation

Public response (PR)	Low (1)	Issue not raised in public response.
	Medium (2)	Issue has received a meaningful and justifiable public response.
	High (3)	Issue has received an intense meaningful and justifiable public response.
Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable loss of resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 7. The impact priority is therefore determined as follows:

$$\text{Priority} = \text{PR} + \text{CI} + \text{LR}$$

The result is a priority score which ranges from 3 to 9 and a consequent PF ranging from 1 to 2 (refer to Table 6).

Table 6: Determination of Prioritisation Factor

Priority	Ranking	Prioritisation Factor
3	Low	1
4	Medium	1.17
5	Medium	1.33
6	Medium	1.5
7	Medium	1.67
8	Medium	1.83
9	High	2

In order to determine the final impact significance the PF is multiplied by the ER of the post mitigation scoring. The ultimate aim of the PF is to be able to increase the post mitigation environmental risk rating by a full ranking class, if all the priority attributes are high (i.e. if an impact comes out with a medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential, significant public response, and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

Table 7: Final Environmental Significance Rating

Environmental Significance Rating	
Value	Description
< 10	Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
≥10 <20	Medium (i.e. where the impact could influence the decision to develop in the area),
≥ 20	High (i.e. where the impact must have an influence on the decision process to develop in the area).