Air Quality Specialist Report for the Bakubung Platinum Mine TSF Project near Ledig, North West Province

Project done for **Knight Piésold (Pty) Ltd**

Report Compiled by
N Shackleton

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Report Details

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Report Title	Air Quality Specialist Report for the Bakubung Platinum Mine TSF Project near Ledig, North West Province
Date	May 2021
Client	Knight Piésold (Pty) Ltd
Prepared by	Natasha Shackleton, Pr. Sci. Nat., BSc Hons (Meteorology) (University of Pretoria)
Reviewed by	Terri Bird, Pr. Sci. Nat., PhD (University of Witwatersrand)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	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. I, Natasha Anne Shackleton as the appointed independent air quality specialist for the “Air Quality Specialist Report for the Bakubung Platinum Mine TSF Project near Ledig, North West Province”, hereby declare that I: • acted as the independent specialist in this scoping assessment; • performed the work relating to the study in an objective manner; • regard the information contained in this report as it relates to my specialist input/study to be true and correct, • do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment; • declare that there are no circumstances that may compromise my objectivity in performing such work; • have expertise in conducting the specialist report relevant to this application; • have no, and will not engage in, conflicting interests in the undertaking of the activity; • have no vested interest in the proposed activity proceeding; • undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing the decision of the competent authority; and • all the particulars furnished by me in this specialist input/study are true and correct.
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Revision Record

Revision Number	Date	Section Revised	Reason for Revision
Draft	13 May 2020		Original for client comment
Final v0	7 June 2020		Incorporation of client comments.
		Section 7	Additional simulations for proposed operations.
		Section 19	Approved results discussion moved to Appendix E.
Final v1	14 May 2021	Section 4	Discussion of applicability of: Environmental Impact Assessment Regulations; Waterberg-Bojanala Priority Area Air Quality Management Plan; North West Environmental Implementation Plan 2015 - 2020; Bojanala Platinum District Air Quality Management By-Law; Rustenburg Local Municipality Air Pollution By-Law; and Moses Kotane Local Municipality Environmental By-Law.
		Section 11	Discussion of: North West Environmental Management Framework; North West Air Quality Management Plan.
		Section 13	Discussion of: Bojanala Platinum District Municipality Climate Change Vulnerability and Response Plan.

Competency Profiles

Report author: N A Shackleton (née Gresse), Pr. Sci. Nat., BSc Hons - Meteorology (University of Pretoria)

Natasha Shackleton started her professional career in Air Quality in April 2011 when she joined Airshed Planning Professionals (Pty) Ltd after completing her Undergraduate Degree at the University of Pretoria in Science. In 2011 she completed her Honours Degree at the University of Pretoria in Meteorology. Natasha is a registered Professional Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) (registration no. 116335) and a member of the South African Society for Atmospheric Sciences (SASAS) as well as a member of the National Association for Clean Air (NACA). Natasha has worked on several air quality specialist studies between 2011 and 2021. She has experience in the various components including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. 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. Whilst most of his working experience has been in South Africa, a number of investigations were made in countries elsewhere, including Burkina Faso, Guinea, Ghana, Madagascar, Mozambique, Namibia, Suriname, Tanzania, Zimbabwe and Zambia.

Report reviewer: Dr Theresa (Terri) Bird, Pr. Sci. Nat., PhD (University of the Witwatersrand)

Dr Terri Bird holds a PhD from the School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Johannesburg. The focus of her doctoral research was on the impact of sulphur and nitrogen deposition on the soil and waters of the Mpumalanga Highveld. Since March 2012 she has been employed at Airshed Planning Professionals (Pty) Ltd. In this time, she has been involved in air quality impact assessments for various mining operations (including coal, mineral sand, diamond and platinum mines) as well as coal-fired power station ash disposal facilities. She has been a team member on the development of Air Quality Management Plans, both provincial and for specific industries. Recent projects include assessing the impact of Postponement and/or Exemption of Emission Standards for various Listed Activities.

NEMA EIA Regulation (2014, as amended), Appendix 6

NEMA Regulations (2017) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report.	Report Details (page i)
The expertise of that person to compile a specialist report including curriculum vitae.	Competency Profiles (page iii) Section 15: Appendix A: Authors' Curriculum Vitae (page 104)
A declaration that the person is independent in a form as may be specified by the competent authority.	Report Details (page i)
An indication of the scope of, and the purpose for which, the report was prepared.	Section 1.1: Background (page 1) Section 1.2: Terms of Reference (page 6)
An indication of quality and age of base data used.	Section 2.1: Data Gathering (page 9) Section 5.2: Atmospheric Dispersion Potential (page 25) Section 5.3: Existing Air Quality (page 31)
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change.	Section 5.3: Existing Air Quality (page 31) Section 7.3: Assessment of Impact – Proposed Operation (page 45) Section 9: Impact Assessment: Cumulative (page 72) Section 4: Legislation (page 17)
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Section 2.1: Data Gathering (page 9) Description of the current land use in the region, simulations undertaken for the current operations and meteorological data included used in the study are considered representative of all seasons. Section 5.2: Atmospheric Dispersion Potential (page 25) Section 5.3: Existing Air Quality (page 31)
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 2: Methodology (page 8)
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 5: Air Quality Baseline (page 25)
An identification of any areas to be avoided, including buffers.	Not applicable
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.	Figure 1 and Section 5.1: Affected Environment (page 25)
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 2.5: Managing Uncertainties (page 13)
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 6: Impact Assessment: Construction Phase (page 33) Section 7: Impact Assessment: Operational Phase (page 38)
Any mitigation measures for inclusion in the EMPr.	Section 11: Management of Atmospheric Emissions and Air Quality Impacts (page 74)
Any conditions for inclusion in the environmental authorisation	Section 11: Management of Atmospheric Emissions and Air Quality Impacts (page 74)

NEMA Regulations (2017) - Appendix 6	Relevant section in report
Any monitoring requirements for inclusion in the EMPr or environmental authorisation.	Section 11: Management of Atmospheric Emissions and Air Quality Impacts (page 74)
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Section 12: Findings and Recommendations (page 79)
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 12: Findings and Recommendations (page 79)
A description of any consultation process that was undertaken during the course of carrying out the study.	Provided as part of the EIA documents
A summary and copies if any comments that were received during any consultation process.	Provided as part of the EIA documents
Any other information requested by the competent authority.	None

Executive Summary

Wesizwe Platinum Limited (Wesizwe) is the owner of Bakubung Platinum Mine (BPM), currently shaft sinking on the farm Frischgewaagd 96JQ (Portions 3, 4 and 11). Bakubung Minerals (Pty) Ltd holds the mining right for BPM. The mine is located near Ledig, 2 kilometres (km) south of the Pilanesberg Game Reserve and Sun City in the North West Province. Two reefs will be mined for Platinum Group Elements -platinum, palladium, rhodium and gold, with copper and nickel as by-products. The mine falls within the Rustenburg and Moses Kotane Local Municipalities of the Bojanala Platinum District Municipality.

BPM is now proposing to make changes to cater for the ore processing capacity, as well as additional support infrastructure; these include another Tailings Storage Facility (TSF), conveyor from the plant to the TSF and storm water infrastructure. The proposed TSF will have a capacity to contain an average tonnage profile of 1 Mtpa for a maximum period of 7 years. The proposed TSF covers an approximate 24 ha area. The mine process plant infrastructure is located 250 m north-east of the site and an electricity sub-station is adjacent to the north-eastern boundary of the footprint. A waste rock stockpile is located 100 m north of the TSF footprint. A 11 kV overhead Eskom powerline forms the eastern boundary of the TSF.

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Knight Piésold (Pty) Ltd (Knight Piésold) to undertake an Air Quality Impact Assessment (AQIA) and Climate Change Impact Assessment (CCIA) as part of the Environmental Impact Assessment (EIA) to identify key aspects that may have significant air quality impacts during the various project phases. As such the report conforms to the amended regulated format requirements for specialist reports as per Appendix 6 of the EIA Regulations (Government Notice [GN] R982 as amended by GN 326, 7 April 2017 and GN 706, 13 July 2018). This report covers the impact assessment for the TSF project (the project).

The scope of work had to include the following:

- Identify and describe the existing air quality of the project area, as well as climatic patterns and features (i.e. the baseline);
- Assess (model) the impact on air quality (specifically particulate matter [PM] with reference to Total Particulate Matter [TSP], PM_{10} [Particulate matter with an aerodynamic dimeter less than 10 µm] and $PM_{2.5}$ [particulate matter with an aerodynamic dimeter less than 2.5 µm]), human health and biota resulting from the proposed TSF project (including impacts associated with the construction, operations, decommissioning and post-closure phases of the project);
- Identify and describe potential cumulative air quality impacts resulting from the proposed project in relation to proposed and existing developments in the surrounding area;
- Recommend mitigation measures to minimise impacts and/or optimise benefits associated with the project;
- Recommend a monitoring campaign to ensure the correct implementation and adequacy of recommenced mitigation measures, if applicable;
- Estimate the greenhouse gas (GHG) emissions during construction, operation and decommissioning of the project compared to the global and national emission inventory; and compared to international benchmarks for the project;

- Determine the robustness of the project with the impact of climate change over the lifetime of the project considered; and
- Ascertain the vulnerability to climate change of communities in the immediate vicinity of the project.

The main findings of the baseline assessment are:

- The significant Air Quality Sensitive Receptors (AQSRs) are those of Ledig, Sun City, Chaneng, Phatsima, along with isolated homesteads and the Sundown Ranch Hotel.
- The main sources likely to contribute to baseline PM emissions include mining and processing operations, industrial operations, vehicle entrained dust from local roads, vehicle exhaust and windblown dust from exposed areas.
- Other sources of PM include farm activities, occasional biomass burning and household fuel burning in the residential areas of Ledig, Chaneng and Phatsima.
- The area is dominated by winds from the east. These westerly winds are associated with strong winds of above 6 m/s. According to the US EPA wind speeds exceeding 5 m/s are likely to result in windblown dust emissions.
- A fallout dust measurements dataset was provided for the area from September 2008 to December 2019. The National Dust Control Regulations (NDCR) limit for residential areas of 600 mg/m^2-day were exceeded at some of the residential sites. SA NDCR limit for non-residential areas of 1 200 mg/m^2-day were exceeded at some of the non-residential sites. However, there were not more than two exceedances or consecutive exceedances in a year at any of the sites.

The main findings of the impact assessment are as follows:

- Construction phase:
  - The significance of construction related inhalation health and nuisance impacts are likely to have a "low" rating without and with mitigation.
- Operational phase:
  - PM (TSP, PM_{10} and $PM_{2.5}$) emissions and impacts were quantified.
  - PM_{10} and $PM_{2.5}$ concentrations are within compliance off-site and at all the AQSRs over the short- and long-term for the proposed TSF operations. PM_{10} and $PM_{2.5}$ concentrations are within compliance off-site and at all the AQSRs over the short- and long-term for the approved and proposed and future operations; however they exceed the short-term NAAQS at a portion of the mine housing.
  - Dustfall rates are below the NDCR limits for residential areas at all AQSRs and 400 mg/m^2-day at all agricultural areas.
  - The significance of operations related inhalation health and nuisance impacts are likely to be "low" without and with mitigation.
- Decommissioning and closure phases:
  - The significance of decommissioning operations related inhalation health and nuisance impacts are likely "low".
  - The significance of closure operations related inhalation health and nuisance impacts are likely "low".

To ensure the lowest possible impact on AQSRs and environment it is recommended that the air quality management plan as set out in this report should be adopted. This includes:

- Management of the proposed TSF; resulting in the mitigation of associated air quality impacts;
- Ambient air quality monitoring; and
- Record keeping and community liaison procedures.

The findings and recommendations of the greenhouse gases and climate change assessment are:

- The Carbon Dioxide-equivalent (CO_2-e) (scope 1) emissions for construction is approximately 4 676 tonnes per annum (tpa) therefore contributing less than 0.001% to the total of South Africa's GHG emissions and 0.01% of the total "manufacturing industry and construction" sector.
- The CO_2-e (scope 1) emissions for approved operations is approximately 305 tpa therefore contributing less than 0.0001% to the total of South Africa's GHG emissions and 0.0007% of the total "manufacturing industry and construction" sector.
- The GHG emissions from the project are low and will not likely result in a noteworthy contribution to climate change on their own.
- The project and the community are likely to be negatively impacted by climate change due to increased temperatures and possible water shortages (decreased rainfall and possible increased evaporation).
- The following is recommended to reduce the impacts of climate change on the project and the community:
    - Additional support infrastructure can reduce the climate change impact on the staff and project, for example ensuring adequate water supply for staff and reducing on-site water usage as much as possible.
    - Wesizwe could initiate a community development program if one is not already in place.
- The following is recommended to reduce the GHG emissions from project:
    - Ensuring the vehicles and equipment are maintained through an effective inspection and maintenance program.
    - Limiting the removal or vegetation and ensuring adequate re-vegetation or addition of vegetation surrounding the project. Vegetation acts as a carbon sink.

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List of Abbreviations

ABEC	AB Enviro-Consult T/A
Airshed	Airshed Planning Professionals (Pty) Ltd
APPA	Atmospheric Pollution Prevention Act
BPM	Bakubung Platinum Mine
CO	Carbon monoxide
DEFF	Department of Environment, Forestry and Fisheries
DoE	Department of Energy
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
g	Gram
g/s	Gram per second
IPCC	Intergovernmental Panel on Climate Change
Knight Piésold	Knight Piésold Consulting
m	Metre
m^2	Metre squared
m^3	Metre cubed
m/s	Metres per second
MM5	Fifth-Generation Penn State/NCAR Mesoscale Model
MPRDA	Mineral and Petroleum Resources Development Act (No. 28 of 2002)
NMES	National Minimum Emission Standards
NAAQ Limit	National Ambient Air Quality Limit concentration
NAAQS	National Ambient Air Quality Standards (as a combination of the NAAQ Limit and the allowable frequency of exceedance)
NEMA	National Environmental Management Act (No. 107 of 1998)
NEM:AQA	National Environmental Management: Air Quality Act (No. 39 of 2004)
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NWA	National Water Act (No 36 of 1998)
O_3	Ozone
PM	Particulate matter
PM_{10}	Particulate matter with diameter of less than 10 µm
$PM_{2.5}$	Particulate matter with diameter of less than 2.5 µm
SO_2	Sulphur dioxide
TSF	Tailings Storage Facility
US EPA	United States Environmental Protection Agency
Wesizwe	Wesizwe Platinum Limited
WUL	Water Use Licence
µ	micro
°C	Degrees Celsius

Glossary

Air-shed	An area, bounded by topographical features, within which airborne contaminants can be retained for an extended period
Albedo[1]	The ratio of reflected flux density to incident flux density, referenced to some surface. Albedos commonly tend to be broadband ratios, usually referring either to the entire spectrum of solar radiation, or just to the visible portion. More precise work requires the use of spectral albedos, referenced to specific wavelengths. Visible albedos of natural surfaces range from low values of ~0.04 for calm, deep water and overhead sun, to > 0.8 for fresh snow or thick clouds. Many surfaces show an increase in albedo with increasing solar zenith angle.
Algorithm	A mathematical process or set of rules used for calculation or problem-solving, which is usually undertaken by a computer
Atmospheric dispersion model	A mathematical representation of the physics governing the dispersion of pollutants in the atmosphere
Atmospheric stability	A measure of the propensity for vertical motion in the atmosphere
Baseline	Information gathered at the beginning of a study which describes the environment prior to development of a project and against which predicted changes (impacts) are measured.
Calm / stagnation	A period when wind speeds of less than 0.5 m/s persist
Cartesian grid	A co-ordinate system whose axes are straight lines intersecting at right angles
Causality	The relationship between cause and effect
Closure Phase	This stage of the project includes the period of aftercare and maintenance after the decommissioning phase
Configuring a model	Setting the parameters within a model to perform the desired task
Construction Phase	The stage of project development comprising site preparation as well as all construction activities associated with the development.
Cumulative Impacts	Direct and indirect impacts that act together with current or future potential impacts of other activities or proposed activities in the area/region that affect the same resources and/or receptors.
Dispersion	The lowering of the concentration of pollutants by the combined processes of advection and diffusion
Environment	The external circumstances, conditions and objects that affect the existence of an individual, organism or group. These circumstances include biophysical, social, economic, historical and cultural aspects.
Environmental Authorisation	Permission granted by the competent authority for the applicant to undertake listed activities in terms of the NEMA EIA Regulations, 2014.
Environmental Impact Assessment	A process of evaluating the environmental and socio-economic consequences of a proposed course of action or project.
Environmental Impact Assessment Report	The report produced to relay the information gathered and assessments undertaken during the Environmental Impact Assessment.
Environmental Management Programme	A description of the means (the environmental specification) to achieve environmental objectives and targets during all stages of a specific proposed activity.

[1] Definition from American Meteorological Society's glossary of meteorology

Impact	A change to the existing environment, either adverse or beneficial, that is directly or indirectly due to the development of the project and its associated activities.
Mitigation measures	Design or management measures that are intended to minimise or enhance an impact, depending on the desired effect. These measures are ideally incorporated into a design at an early stage.
Operational Phase	The stage of the works following the Construction Phase, during which the development will function or be used as anticipated in the Environmental Authorisation.
Specialist study	A study into a particular aspect of the environment, undertaken by an expert in that discipline.
Stakeholders	All parties affected by and/or able to influence a project, often those in a position of authority and/or representing others.

Air Quality Specialist Report for the Bakubung Platinum Mine TSF Project near Ledig, North West Province

1 INTRODUCTION

1.1 Background

Wesizwe Platinum Limited (Wesizwe) is the owner of Bakubung Platinum Mine (BPM), currently shaft sinking on the farm Frischgewaagd 96JQ (Portions 3, 4 and 11). Bakubung Minerals (Pty) Ltd holds the mining right for BPM. The mine is located near Ledig, 2 kilometres (km) south of the Pilanesberg Game Reserve and Sun City in the North West Province (Figure 1 and Figure 2). Two reefs will be mined for Platinum Group Elements -platinum, palladium, rhodium and gold, with copper and nickel as by-products. The mine falls within the Rustenburg and Moses Kotane Local Municipalities of the Bojanala Platinum District Municipality.

In 2008, BPM conducted an Environmental Impact Assessment (EIA) process for the development of the BPM. The mine received Environmental Authorisation in 2009, in terms of both the National Environmental Management Act (No. 107 of 1998) (NEMA) and Mineral and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA). A Water Use Licence (WUL) was issued in terms of the National Water Act (No 36 of 1998) (NWA) in 2010. In 2014 a Basic Assessment process was conducted for the development of mine housing on site. Authorisation for Phase 1 of the Gabonewe Estate mine housing was received in 2015. The Basic assessment was conducted by AB Enviro-Consult T/A (ABEC).

While construction at the mine has commenced, certain facilities have yet to be constructed. BPM is now proposing to make changes to the approved mine following refinement of the operational plan. The changes are required to cater for an ore processing capacity; these include another Tailings Storage Facility (TSF), conveyor from the plant to the TSF and storm water infrastructure. The TSF is proposed on the farm Frischgewaagd 96 JQ, and that the authorised TSF (which was the focus of the 2016 study) is located on the farm Mimosa 81 JQ.

The proposed TSF will have a capacity to contain an average tonnage profile of 1 Mtpa for a maximum period of 7 years. The proposed TSF covers an approximate 24 ha area. The mine process plant infrastructure is located 250 m north-east of the site and an electricity sub-station is adjacent to the north-eastern boundary of the footprint. A waste rock stockpile is located 100 m north of the TSF footprint. A 11 kV overhead Eskom powerline forms the eastern boundary of the TSF. The locality of proposed TSF, in relation to approved operations and surrounding residential areas and topography, is shown in Figure 3.

Specialist studies have been commissioned to assess the impacts of the TSF project on all aspects of biophysical and socio-economic receptors within the area. Mitigation, management, and rehabilitation designs are informed by a team of specialists and engineers.

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Knight Piésold (Pty) Ltd (Knight Piésold) to undertake an Air Quality Impact Assessment (AQIA) and Climate Change Impact Assessment (CCIA) as part of the Environmental Impact Assessment (EIA) to identify key aspects that may have significant air quality impacts during the various project phases. As such the report conforms to the amended regulated format requirements for specialist reports as per Appendix 6 of the EIA Regulations (Government Notice [GN] R982 as amended by GN 326, 7 April 2017 and GN 706, 13 July 2018). This report covers the impact assessment for the TSF project (the project).

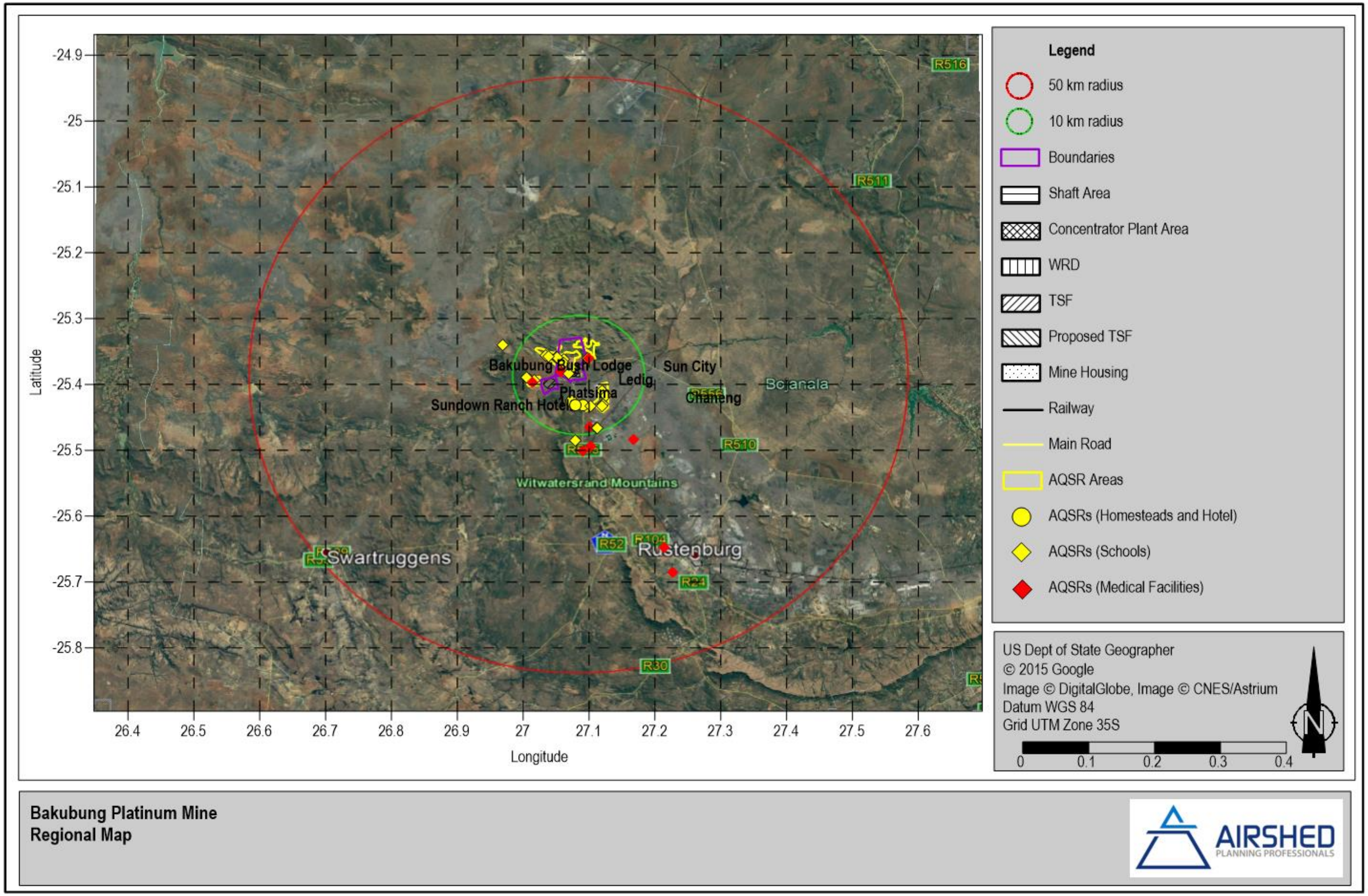

Figure 1: Regional locality map

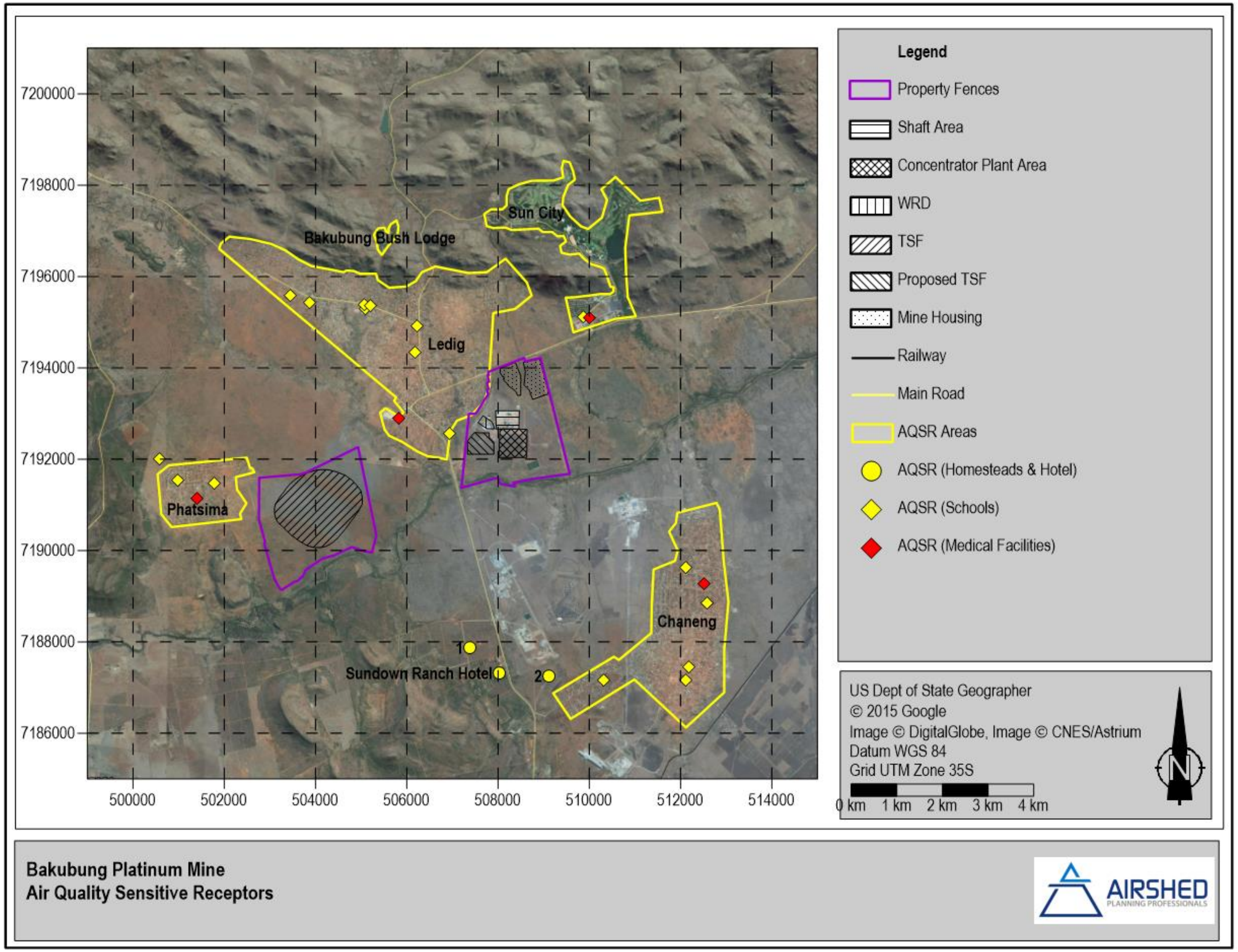

Figure 2: Location of BPM and proposed TSF and sensitive receptors included in the simulations

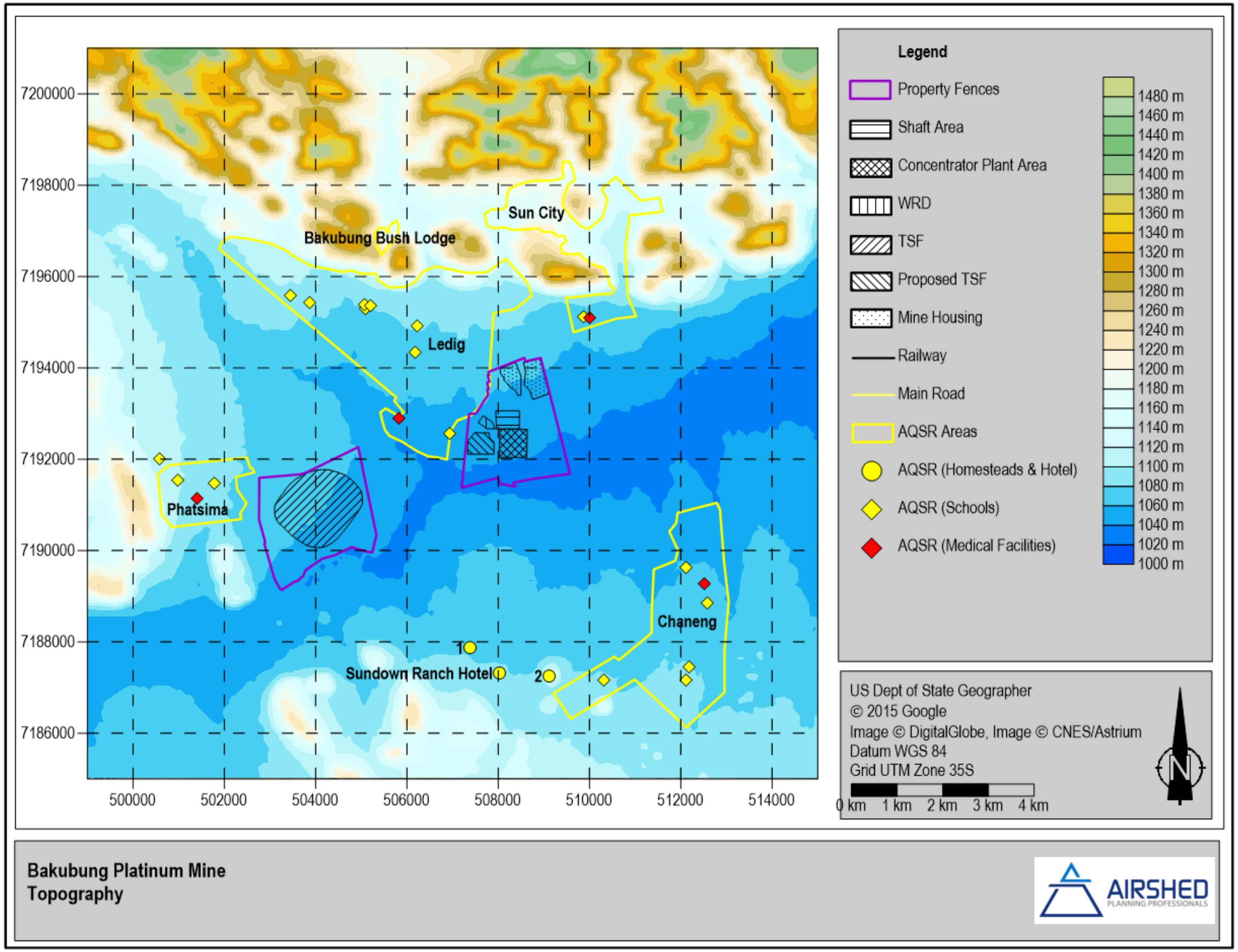

Figure 3: Location of BPM approved operations, proposed TSF, sensitive receptors included in the simulations and topography

1.2 Terms of Reference

The specific terms of reference for the overall project are as follows:

- Identify and describe the existing air quality of the project area, as well as climatic patterns and features (i.e. the baseline);
- Assess (model) the impact on air quality (specifically particulate matter with reference to Total Particulate Matter [TSP], PM_{10} ([Particulate matter with an aerodynamic dimeter less than 10 µm] and $PM_{2.5}$ [particulate matter with an aerodynamic dimeter less than 2.5 µm]), human health and biota resulting from the proposed TSF project (including impacts associated with the construction, operations, decommissioning and post-closure phases of the project);
- Identify and describe potential cumulative air quality impacts resulting from the proposed project in relation to proposed and existing developments in the surrounding area;
- Recommend mitigation measures to minimise impacts and/or optimise benefits associated with the project;
- Recommend a monitoring campaign to ensure the correct implementation and adequacy of recommenced mitigation measures, if applicable;
- Estimate the greenhouse gas (GHG) emissions during construction, operation and decommissioning of the project compared to the global and national emission inventory; and compared to international benchmarks for the project;
- Determine the robustness of the project with the impact of climate change over the lifetime of the project considered; and
- Ascertain the vulnerability to climate change of communities in the immediate vicinity of the project.

1.3 Report Structure

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2 METHODOLOGY

The air quality study includes both baseline and predicted impact assessment. The baseline characterisation includes the following enabling tasks:

- Identification of existing sources of emission and characterization of ambient air quality and dustfall levels in the study area;
    - A quantitative assessment of baseline air quality was not possible due to the availability of ambient data within the area; thus, the baseline air quality is qualitative.
- 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.
    - Daily data was available for the one on-site weather station. This data collected is not adequate to undertake dispersion modelling.
    - The South Africa Weather Service (SAWS) Pilansberg weather stations are located 10 km west-north-west and 20 km north-west of the project site. These stations measure wind speed, wind direction, temperature, rainfall, relative humidity, and barometric pressure. These parameters are current but taking into consideration the topography (landforms) and land-use surrounding the operations, both stations may not provide an accurate representation of the meteorology at the site.
    - Since none of the closest measured stations would be suitable for the site, MM5 (short for Fifth-Generation Penn State/NCAR Mesoscale Model) data was used to construct wind roses, general climatic information such as diurnal temperature variations, atmospheric stability estimates and used for dispersion modelling.
- Potential air pollution sensitive receptors within the study area were identified and georeferenced for detailed analysis of the impact assessment calculations.

The impact assessment followed with the tasks below:

- The dispersion modelling was executed as per *The Regulations Regarding Air Dispersion Modelling* (GN 533 in Gazette No 37804, 11 July 2014) (Republic of South Africa, 2014). Three *Levels of Assessment* are defined in the Regulations. Level 2 was deemed adequate. These are described under Section 4.3.
- Preparation of the model control options and input files for the AERMOD dispersion modelling suite. This included the compilation of:
    - terrain information (topography, land use, albedo and surface roughness);
    - source layout; and
    - grid and receptor definitions.

- Preparation of hourly average meteorological data for the wind field and atmospheric dispersion model.
- Preparation of an emissions inventory (particulates) for the approved and proposed operations, including fugitive sources[2]. Ideally, the emission rates should be based on actual measurements, but since this is not possible for the project, emission factors are used.
- For the study, simulations were conducted using the AERMOD dispersion modelling suite, which allowed the calculations of the current ambient inhalable concentrations (PM_{10} and $PM_{2.5}$) and dust fallout. The daily and annual concentrations and total daily dust deposition were calculated. Dispersion modelling was completed for "approved" which includes all operations associated with the approved BPM operations; "proposed" which includes the wind-blown dust from the proposed TSF area and additional materials handling; and "future" which includes all operations associated with the approved BPM operations and the wind-blown dust from the proposed TSF.
- 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).

2.1 Data Gathering

All project information required to calculate emissions for proposed operations was provided by Wesizwe and Knight Piésold via electronic mail and at the site visit conducted in March 2020.

Measured dustfall rates data was acquired from Wesizwe and included in this report and for simulation results verification. The following data sources were consulted, primarily for their observations of meteorological parameters including wind speed, wind direction, ambient air temperature and rainfall data:

- On-site station (2015-2019);
- SAWS Pilansberg Weather station data provided by Wesizwe (2019); and
- MM5 model data (2017-2019).

2.2 Data Analysis for Air Dispersion Modelling

2.2.1 AERMOD Modelling Suite

The US EPA approved AERMOD atmospheric dispersion modelling suite was used for the simulation of ambient air pollutant concentrations and dustfall rates. AERMOD is a Gaussian plume model, 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 model developed with the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective was to include state-of the-art science in

[2] Fugitive particulate matter (PM) emissions will be released to atmosphere during these activities. 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).

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 which 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 spatially varying wind fields, due to topography or other factors cannot be included. Input data types required for the AERMOD model includes source data, meteorological data (pre-processed by the AERMET model), terrain data (pre-processed by the AERMAP model) and information on the nature of the receptor grid.

The components of the AERMOD modelling suite are summarised in Table 1; however, only AERMOD contain the simulation engines to calculate the dispersion and removal mechanisms of pollutants released into this boundary layer. The other codes are mainly used to assist with the preparation of input and output data. Table 1 also includes the development versions of each of the codes used in the investigation.

Table 1: Summary description of AERMOD model suite with versions used in the investigation

Module	Interface Version	Executable	Description
AERMOD	Breeze v9.0.0.23	(US) EPA 19191	Gaussian plume dispersion model.
AERMET	Breeze v7.9.0.3	(US) EPA 18081	Meteorological pre-processor for creating AERMOD compatible formats.
AERMAP	Breeze v9.0.0.23	(US) EPA 18081	Topographical pre-processor for creating digital elevation data in a format compatible with the AERMOD control file.

The execution phase (i.e. dispersion modelling and analyses) involves gathering specific information regarding the emission source(s) and site(s) to be assessed, and subsequently the actual simulation of the emission sources and determination of impact significance. The information gathering included:

- Source information: emission rate, source extents and release height;
- Site information: site layout, terrain information, and land use data;
- Meteorological data: a minimum of wind speed, wind direction, temperature, and sensible heat flux or Monin-Obukhov length; and
- Receptor information: locations using discrete receptors and/or gridded receptors.

2.2.1 Meteorological Requirements

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. MM5 modelled meteorological data was used. The MM5 model domain covered a 50 km (east-west) by 50 km (north-south) area with a 12 km resolution. The modelled meteorological data for a point on-site was extracted for the period from January 2017 to December 2019.

2.2.2 Topographical and Land Use Data

For operational scenario with current topography readily available terrain and land use data was obtained from the United States Geological Survey (USGS) via the Earth Explorer website (U.S. Department of the Interior, U.S. Geological Survey, 2018). Use was made of Shuttle Radar Topography Mission (SRTM) (30 m, 1 arc-sec) data and Global Land Cover Characterisation (GLCC) data for Africa.

2.2.3 Receptor Grid

The dispersion of pollutants expected to arise from approved, proposed, and future operations was simulated for an area covering 16 km (east-west) by 16 km (north-south). The area was divided into a grid matrix with a resolution of 100 m. AERMOD calculates ground-level concentrations and dustfall rates at each grid point. The grid details used in dispersion modelling are given in Table 2. The discrete receptors data included in the dispersion model input is shown in Table 3.

Table 2: Simulation domain

Simulation domain	
South-western corner of simulation domain	499 000 m (Easting); 7 185 000 m (Northing)
Domain size	16 x 16 km
Projection	Grid: UTM Zone 35S, Datum: WGS-84
Resolution	100 m

Table 3: Individual air quality sensitive receptors included as discrete receptors points

Receptor name	Easting (m)	Northing (m)
Bafokeng Rasimone Platinum Mine Clinic	510097.95	7183531.85
Bakgofa Primary School	503447.80	7195596.75
Bakubung Primary School D50	505093.75	7195297.08
Bonwakgogo Primary School	512183.93	7187442.77
Bothibelo Primary School	500986.88	7191539.40
Chaneng Clinic	512524.53	7189278.78
Chaneng Primary School	512112.93	7189625.37
Charora High School	512103.58	7187159.33
Cornerstone Academy Primary School	509862.32	7195112.81
Impala North Clinic	516837.40	7181472.83
Itumeleng Middle School	506225.95	7194915.04
Khayalethu High School	501771.97	7191477.82
Mafenya Primary School	510315.28	7187153.88
Medi Care Private Hospital	522746.25	7159124.06

Receptor name	Easting (m)	Northing (m)
Medi Smart	509129.41	7179628.36
Molefe to Tlhage Primary School	511200.23	7183443.38
Moreteletsi Community Hospital	510297.59	7180408.79
Moses Kotane Hospital	505814.48	7192895.54
Motlhatlhedi Secondary School	500573.36	7192010.91
Mperebere Primary School	506188.96	7194341.01
Mphuphuthe School	505065.37	7195379.39
Naomi's Ark Pre School	512589.25	7188848.10
Netcare Ferncrest Hospital	521449.08	7163312.75
Phatsima Clinic	501398.11	7191147.12
Rasimone Primary School	511332.06	7183398.84
Ratheo Primary School	505212.06	7195370.26
Sun Village Medical Centre	510003.76	7195097.69
Tshose Primary School	496917.28	7197450.83
Tswaidi High School	503866.69	7195424.85
Vuka Primary Farm School	507913.16	7181358.08
School	506929.93	7192562.81

2.2.4 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 includes the calculation of various percentiles, specifically the 99th percentile, which corresponds to the requirements of the NAAQS.

Ground level concentration (GLC) isopleth 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 99.73rd 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 public has access i.e. off-site.

2.2.5 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. 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. Even in the best tracer studies, the source emissions are known only with an accuracy of ±5%, which translates directly into a minimum error of that magnitude in the model predictions. It is also well known that wind direction errors are the major cause of poor agreement, especially for relatively short-term predictions (minutes to hours) and long downwind distances. All the above factors contribute to the inaccuracies not associated with the mathematical models themselves.

A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Although the model has been shown to be an improvement on the ISC model, especially short-term predictions, the range of uncertainty of the model predictions is -50% to 200%. The accuracy improves with fairly strong wind speeds and during neutral atmospheric conditions.

In quantifying the uncertainty of the modelled results for this assessment, measured ambient data was required which was not available for this study.

2.3 Impact Assessment

Potential impacts of the proposed project were identified based on the dispersion simulations, review of other studies for similar projects and professional experience. The significance of the impacts was assessed using the prescribed Knight Piésold impact rating methodology provided. The impact significance was rated for unmitigated project operations and assuming the effective implementation of design mitigation measures for the approved operations.

2.4 Mitigation and Management Recommendations

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

2.5 Managing Uncertainties

The study is based on a few assumptions and is subject to certain limitations, which should be borne in mind when considering information presented in this report. The validity of the findings of the study is not expected to be affected by these assumptions and limitations:

1. All project information required to calculate emissions for proposed operations was provided by Wesizwe and Knight Piésold; it is assumed that all this information is the most recent data and correct.

2. The EIA will be completed by Knight Piésold on behalf of Wesizwe. For this reason, the impact significance of the project was determined based on the Knight Piésold impact significance methodology.
3. No ambient air quality data is available thus a qualitative assessment of sources in the area is included.
4. The approved operations air quality modelling is based on the emissions data and source locations included in the previous study (Shackleton & von Reiche, 2016) except for an update of the windblown dust sources' emissions as this is dependent on the meteorological data.
5. The impact of the construction and decommissioning phase impacts are expected to be similar or somewhat less significant than operational phase impacts. Mitigation and management measures recommended for the construction phase are also applicable to the decommissioning phase. No impacts are expected post-closure provided the rehabilitation of final landforms is successful.
6. Meteorology:
    a. Based on the distance of the site in relation to the SAWS Pilansberg station; as well as considering the topography (landforms) and land-use in the area (see Figure 2 and Figure 3) which can all affect the local meteorology, it was decided to use the MM5 modelled meteorological data for a point on-site. The data for the period January 2017 to December 2019 was used in the dispersion modelling.
    b. The National Code of Practice for Air Dispersion Modelling described in the Regulations regarding air dispersion modelling (GN 533; 11 July 2014) (Republic of South Africa, 2014) prescribes the use of a minimum of one year of on-site data or at least three years of appropriate off-site data for use in Level 2 and 3 assessments. It also states that the meteorological data must be for a period no older than five years to the year of assessment. The dataset period is within the timeframe recommended by the National Code of Practice for Air Dispersion as the meteorological data is for three years (modelled data) and less than five years old during the assessment period (2020).
7. Greenhouse gas (GHG):
    a. Scope 1 and Scope 2, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions were calculated for the construction phase and operational phase;
    b. Scope 1 and Scope 2 emissions were converted to CO_2 equivalent (CO_2-e) emissions for the construction phase and operational phase; and
    c. Modelling was not included in the scope of work.
8. Particulate matter, with reference to TSP, PM_{10} and $PM_{2.5}$ is the main pollutant of concern from the approved operations and proposed TSF project.
9. Emissions:
    a. The impact assessment was limited to airborne particulates (including TSP, PM_{10} and $PM_{2.5}$). These pollutants are regulated under NAAQS and considered key pollutants released by the operations associated with the proposed TSF project.
    b. The quantification of sources of emission was restricted to the approved operations and the proposed TSF project operations (erosion of the TSF by wind and materials handling at the plant and TSF). Other existing sources of emission within the area including other companies' mining and processing operations, industrial activities, farming activities, domestic fires, vehicle exhaust emissions and dust entrained by vehicles on public roads were not quantified as part of the Project's emissions inventory and simulations.

c. Site specific particle size, moisture and silt content data were available.
d. For the estimation of windblown dust emissions, use was made of the Airborne Dust Dispersion Model from Area Sources (ADDAS) (Burger, Held, & Snow, 1997).

Other assumptions made in the report are explicitly stated in the relevant sections.

3 PROJECT DESCRIPTION

The proposed project will make use of some of the approved facilities included in the previous assessment (Shackleton & von Reiche, 2016) as well as the proposed additional supporting infrastructure which includes a conveyor from the plant to the proposed TSF, a spreader on the TSF and the proposed TSF. In the future operations the use of the proposed TSF and its associated infrastructure will cease; however, the proposed TSF will remain as a landform and will result in windblown dust.

Air emissions during the proposed and future activities will result from a variety of air emission sources, from which airborne particulates are the most significant emissions. Airborne particulate may contain sizes up to about 100 micron in diameter. Particles of sizes larger than about 75 micron tend to deposit out of the plume relatively nearby their source of emission. Particles less than about 20 micron, on the other hand, can be carried for considerable distances before depositing out. Dust emissions are produced from the mechanical movement of large volumes of material, as well as by the movement of mobile equipment and trucks, both within the stockpile, dump and proposed TSF areas and along the unsealed roadways on the property. Dust particles, especially the very fine particles, will potentially be harmful to human health, may create amenity issues and might result in soiling of buildings, structures and other objects at nearby residences. Particle fallout in significant quantities can also negatively impact vegetation due to the reduction in photosynthesis.

4 LEGISLATION

Prior to assessing the impact of proposed activities on human health and the environment, reference needs to be made to the air quality regulations governing the calculation and impact of such operations i.e. reporting requirements, emission standards, ambient air quality standards and dust control regulations.

Emission standards are generally provided for point sources, specify the amount of the pollutant acceptable in an emission stream and are often based on proven efficiencies of air pollution control equipment. 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 and guideline values 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 or exposure periods.

This section summarises legislation from the National Environmental Management Act, 1998 (NEMA) (Republic of South Africa, 1998) and the National Environmental Management: Air Quality Act, 2004 NEM:AQA (Republic of South Africa, 2005). A portion of the NEMA EIA Regulations, the Listed Activities and Minimum National Emission Standards (MES) Regulations, National Atmospheric Emission Reporting Regulations, Waterberg-Bojanala Priority Area (WBPA) Air Quality Management Plan (AQMP), Regulations regarding Air Dispersion Modelling, National Ambient Air Quality Standards (NAAQS) and National Dust Control Regulations (NDCR) are discussed below.

4.1 National Environmental Management Act, 1998 (NEMA) Environmental Impact Assessment (EIA) Regulations

In terms of the National Environmental Management Act (NEMA) (Act No. 107 of 1998) (Republic of South Africa, 1998) Environmental Impact Assessment (EIA) Regulations (Republic of South Africa, 2014) (GN R982 as amended by GN 326 of 7 April 2017; GN 706 of 13 July 2018 and GN 320 of 20 March 2020) a specialist report must contain certain information (see table on page iv for full list of information required). A site environmental sensitivity screening must also be conducted for the specialist assessment using the Department screening tool to determine among other information the development incentives, restrictions, exclusions or prohibitions that apply to the proposed development site as well as the most environmental sensitive features on the site based on the site sensitivity screening results for the application classification that was selected. Based on the site sensitivity screening the only requirements is that the study considers the requirements set out in the Waterberg-Bojanala Priority Area (WBPA) Air Quality Management Plan and Threat Assessment (Republic of South Africa, 2015), and that the report fulfils the NEMA EIA Regulations Appendix 6 Specialist Report requirements.

4.2 Emissions Standards

In terms of Section 21 of NEM:AQA the Minister [of Environment] must publish a list of activities which result in atmospheric emissions which have or may cause a significant detrimental effect on the environment, human health and social welfare, economic conditions, ecological conditions or cultural heritage. The list of activities and associated minimum emission standards were established in March 2010 (Republic of South Africa, 2010) and the updated list of activities and associated minimum emission standards were published in 2013 (Republic of South Africa, 2013). The Department of Environmental Affairs (DEA) now the Department of Forestry, Fisheries Environment (DFFE) published amendments to certain categories in June 2015 (Republic of South Africa, 2015), and further amendments were made in October 2018 (Rebuplic of South Africa, 2018). In March 2020, the minister of DEFF published amendments to Category 1 (Republic of South Africa, 2020). None of the approved or proposed operations would fall under any listed activities nor require an Atmospheric Emissions Licences (AEL) thus national Minimum Emission Standards (MES), AELs and Atmospheric Impact Reports (AIRs) are not discussed in this section.

4.3 Atmospheric Emissions Reporting Regulations

The National Atmospheric Emission Reporting Regulations (NAERR) was published in 2015 by the Minister of Environmental Affairs (Republic of South Africa, 2015). The regulation aims to standardise the reporting of data and information from an identified point, non-point and mobile sources of atmospheric emissions to an internet-based National Atmospheric Emissions Inventory System (NAEIS), towards the compilation of atmospheric emission inventories. The NAEIS is a component of the South African Air Quality Information System (SAAQIS). Its objective is to provide all stakeholders with relevant, up to date and accurate information on South Africa's emissions profile for informed decision making.

Annexure 1 of the NAERR classifies **mines** (holders of a mining right or permit in terms of the MPRDA) as a data provider under **Group C**. As per the regulations, BPM and/or their data provider should be registered on the NAEIS system as they are currently operating. Data providers must inform the relevant authority of changes if there are any:

- Change in registration details;
- Transfer of ownership; or
- Activities being discontinued.

A data provider must submit the required information for the preceding calendar year to the NAEIS by 31 March of each year. Records of data submitted must be kept for a period of 5 years and must be made available for inspection by the relevant authority. The relevant authority must request a data provider, in writing to verify the information submitted if the information is incomplete or incorrect. The data provider then has 60 days to verify the information. If the verified information is incorrect or incomplete the relevant authority must instruct a data provider, in writing, to submit supporting documentation prepared by an independent person. The relevant authority cannot be held liable for cost of the verification of data. A person guilty of an offence in terms of section 13 of these regulations is liable for penalties.

4.4 Industry Requirements as part of the Waterberg-Bojanala Priority Area (WBPA) Air Quality Management Plan (AQMP)

There are a few requirements listed in the Waterberg-Bojanala Priority Area (WBPA) Air Quality Management Plan (AQMP) (Republic of South Africa, 2015) that would be applicable to the BPM operations, these are:

- Appointment of an Environmental Control Officer.

- Appointment of industry representatives who will be the official mandated to agree on emission control and reduction initiatives.
- Annual reporting of operational emissions (minimum of listed activities emissions) on the NAEIS.
- To make ambient monitoring data accessible to the authorities.
- To make ambient monitoring data accessible to the public (not compulsory).

4.5 Atmospheric Dispersion Modelling Regulations

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. Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Regulations regarding Air Dispersion Modelling were promulgated in GN 533, in Government Gazette No. 37804; 11 July 2014, (Republic of South Africa, 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 NEM:AQA;
(b) in the development of a priority area air quality management plan, as contemplated in *Section 19* of the NEM:AQA;
(c) in the development of an AIR, as contemplated in *Section 30* of the NEM:AQA; and,
(d) in the development of a specialist air quality impact assessment study, as contemplated in *Chapter 5* of the NEMAQA.

Three *Levels of Assessment* are defined in the Regulations. The three levels are:

- Level 1: where worst-case air quality impacts are assessed using simpler screening models
- Level 2: for assessment of air quality impacts as part of license application or amendment processes, where impacts are the greatest within a few kilometres downwind (less than 50km)
- Level 3: require more sophisticated dispersion models (and corresponding input data, resources and model operator expertise) in situation:
    - where a detailed understanding of air quality impacts, in time and space, is required;
    - where it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types & chemical transformations;
    - when conducting permitting and/or environmental assessment process for large industrial developments that have considerable social, economic and environmental consequences;
    - when evaluating air quality management approaches involving multi-source, multi-sector contributions from permitted and non-permitted sources in an air-shed; or,
    - when assessing contaminants resulting from non-linear processes (e.g. deposition, ground level ozone [O_3], particulate formation, visibility).

The first step in the dispersion modelling exercise requires a clear objective of the modelling exercise and thereby gives clear direction to the choice of the dispersion model most suited for the purpose. Accordingly, Level 2 was deemed appropriate for the current study.

4.6 South African National Ambient Air Quality Standards

Criteria pollutants are considered those pollutants most commonly found in the atmosphere, that have proven detrimental health effects when inhaled and are regulated by ambient air quality criteria. These generally include carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), PM_{10}, $PM_{2.5}$, and O_3.

The initial NAAQS were published for comment in the Government Gazette on 9 June 2007. The revised NAAQS were subsequently published for comment in the Government Gazette on the 13th of March 2009. The final revised NAAQS were published in the Government Gazette on the 24th of December 2009 (GN 1210, Government Gazette 32816) (Republic of South Africa, 2009) and additional standards for $PM_{2.5}$ were published on the 29th June 2012 (GN 486, Government Gazette no. 35463) (Republic of South Africa, 2012). NAAQS for the criteria pollutants assessed in this study are listed in Table 4.

Table 4: National Ambient Air Quality Standards

Pollutant	Averaging Period	Concentration (µg/m³)	Permitted Frequency of Exceedance	Compliance Date
$PM_{2.5}$	24-hour	40	4	1 January 2016 till 31 December 2029 (currently enforceable)
	24-hour	25	4	1 January 2030
	1 year	20	-	1 January 2016 till 31 December 2029 (currently enforceable)
	1 year	15	-	1 January 2030
PM_{10}	24-hour	75	4	Currently enforceable
	1 year	40	-	Currently enforceable

4.7 National Dust Control Regulations

National Dust Control Regulations (NDCR) were published by DEA, now DFFE in 2013 (Republic of South Africa, 2013). The purpose of the regulations is to prescribe general measures for the control of dust in all areas including residential and non-residential areas. The standard for acceptable dustfall rates for residential and non-residential areas is set out in Table 5. According to these regulations the dustfall at the boundary or beyond the boundary of the premises where it originates cannot exceed 600 mg/m²- day in residential and light commercial areas; or 1 200 mg/m²-day in areas other than residential and light commercial areas more than twice a year or in sequential months. Acceptable dustfall rates per the regulations are summarised in Table 5.

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. Dustfall is assessed for nuisance impact and not inhalation health impact.

Table 5: Acceptable dustfall rates

Restriction areas	Dustfall rate (D) in mg/m²-day over a 30-day average	Permitted frequency of exceedance
Residential areas	D < 600	Two within a year, not sequential months
Non-residential areas	600 < D < 1 200	Two within a year, not sequential months

4.8 Screening criteria for animals and vegetation

Limited information is available on the impact of dust on vegetation and grazing quality. While there is little direct evidence of the impact of dustfall on vegetation in the 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, 1993). In addition, there is anecdotal evidence to indicate that over extended periods, high dustfall levels in grazing lands can soil vegetation and this can impact the teeth of livestock (Farmer, 1993).

4.9 North West Environmental Implementation Plan

On 15 May 2015 the North West Environmental Implementation Plan 2015 – 2020 (EIP) was published in Extraordinary Provincial Gazette No. 7443 (North West Provincial Government, 2015). This document includes some information of the air quality within the North West Province and the main issues with regards to air quality in the region. Including the statement "Although the ambient air quality is good, regional circulation patterns are likely to impact the situation negatively. The main issue facing North West, however, is the air quality in settlements where domestic fuel is used as an energy source. Elevated levels of pollution in the immediate proximity of main pollution sources are also of concern. Poor air quality, especially as elevated levels of particulate matter, increases morbidity and mortality."

It also states that the North West AQMP is under review and the Bojanala Platinum District Municipality AQMP is in the implementation phase. The Municipal Provincial Air Quality Officers' Forum is an ongoing institution without a limited lifespan. In summary, it notes the following as needs to be undertaken to guarantee Air Quality Management:

- Enforcement of licence conditions and air quality standards;
- The enhancement of air quality management systems including monitoring and Governments' capacity to implement the systems and maintain the monitoring stations;
- Ensuring that monitoring data is fed through onto the SAAQIS;
- Public awareness of air quality in general (and likely the current situation within the area) through educational campaigns,
- Compilation and implementation of AQMPs
- In areas of poor air quality, to undertake health risk assessments.

4.10 Bojanala Platinum District Municipality Air Quality Management By-Law

The Bojanala Platinum District Municipality Air Quality Management By-Law published on 15 November 2013 (Extraordinary Provincial Gazette No.: 7191) (North West Provincial Government, 2013) contains the following relevant definitions:

- Disturbing noise means a specific noise level that exceeds either the outdoor equivalent continuous day/night rating level, the outdoor equivalent continuous day rating level and/or the outdoor equivalent continuous night rating level for the particular neighbourhood indicated as the outdoor ambient noise in various districts in SANS 10103.
- Integrated sound level meter means a device integrating a function of sound pressure over a period of time and indicating the result in dB(A) indicating is a function of both the sound level and the duration of exposure to the sound during the period of measurement".
- Noise nuisance means any sound which disturbs or impairs or may disturb or impair the convenience or peace of any reasonable person".

Chapter 9 (Noise Pollution Management) of this Gazette includes the matters that are most relevant to this study; it should be noted that 25 are tasks that would be undertaken by the municipality but should be noted by the operations as these are enforcement measures for this By-law. The most relevant points are:

22. Prohibition of noise nuisance

(1) No person shall –

(a) Make, produce or cause a disturbing noise, or allow it to be made, produces or caused by any person, animal, machine, device and apparatus or any combination thereof.

(d) Build, make, construct, repair, rebuild, modify, operate or test a vehicle, vessel, aircraft, or object including construction vehicles on or near residential premises, or allow it to be built, made, constructed, repaired, rebuilt, modified, operated or tested, if this may cause a noise nuisance.

24. General prohibitions on noise pollution management

(1) A person is guilty of an offence when she or he –

(a) Fails to comply with a written condition, instruction or notice issued by the municipality in terms of the noise pollution management of this By-law;

(c) In respect of a duly authorised person of the municipality –

(i) Fails or refuses to grant admission to such official to enter and to inspect the premises;

(ii) Fails or refuses to give information which may lawfully be required of him or her to such official;

(iii) Hinders or obstruct such official in the execution of his or her duties; or

(iv) Gives false or misleading information to such official knowing that it is false or misleading.

25. Right of entry and inspection

(2) The municipality –

(a) For the purpose of applying the noise pollution management section of this By-law, at any reasonable time enter premises upon hearing noise or receiving a complaint –

(i) To conduct any appropriate examination, injury or inspection thereon as it may deem expedient; and

(ii) To take steps it may deem necessary.

(b) If a noise emanating from a building, premises, vehicle, recreational vehicle or private area is a disturbing noise or noise nuisance or may in the opinion of the authorised person be a disturbing noise or noise nuisance, instruct in writing the person causing such noise or who is responsible for the infringement, or the owner or occupant os such building, premises, vehicle, reacreational vehicle or private area from which or from where sauch noise emanates or may emanat, or all such persons to discontinue or cause to be discontinued such noise or to take steps to lower the level of such noise to a level conforming to the requirements of this By-law within the period stipulated in the instruction: Provided that the provision of this By-law shall not apply in respect of a disturbing noise or noise nuisance caused by rail, vehicles or air traffic or on a public road, by vehicles that are not used as recreational vehicle.

(e) Subject to the applicable provisions of any other law or cause to be placed measuring instruments or similar devices, road traffic signs or notices at any place within the municipality's jurisdiction for the enforcement of the provisions of this By-law: Provided that road traffic sign and notice shall be placed on private only with the permission of the owner.

4.11 Rustenburg Local Municipality Air Pollution By-Law

On 12 December 2014, the Rustenburg Local Municipality Council adopted the Air Pollution By-law (North West: Provincial Gazette Extraordinary 7383) (North West Provincial Government, 2014). This by-law is in place to ensure air quality is correctly managed and reasonable measures are undertaken to prevent air pollution or minimise air pollution where it cannot be avoided. This by-law includes the following critical sections to ensure the objective of the by-law is achieved:

1. clarification of duty of care, the obligations of Council in enforcing "duty of care" and authority of Council to ensure air pollution matters are dealt with (Chapter 1 Section 6 Overarching Principles);
2. how conflicts with other legislation should be treated (Chapter 1 Section 7 Conflict with other Legislation);
3. designation of the Air Quality Officer (AQO) and Environmental Management Inspectors as well as duties and functions of the AQO (Chapter 2);
4. provisions for the establishment of local emissions norms and standards (Chapter 3 Section 14);
5. prohibition of dark smoke emissions from compression ignition powered vehicles (Chapter 3 Section 15);
6. guidelines for dust emissions (Chapter 3 Section 16);
7. guidelines on open burning (Chapter 3 Section 17);
8. prohibition of domestic or garden waste burning (Chapter 3 Section 18);
9. prohibition of spray painting without a permit (Chapter 3 Section 19);
10. prohibition of tyre and rubber products burning in open spaces (Chapter 3 Section 20);
11. prohibition of pesticide spraying without the permission of Council (Chapter 3 Section 21);
12. prohibition of emissions that cause a nuisance including the abatement notice requirements to be issued by Council and nuisance abatement steps (Chapter 3 Section 22);
13. the requirements for Listed Activities (Chapter 4);
14. offences and penalties (Chapter 5); and,
15. general matters and miscellaneous (Chapter 6 and 7).

Relevant to the project are section 6 (duty of care); section 15 (emissions from compression ignition powered vehicles); section 16 (dust emissions); section 22 (emissions that cause a nuisance); chapter 5 (offences and penalties); section 35 (appeals); and section 36 (exemptions). According to this by-law, the project operator is legally required to undertake reasonable measures to prevent air pollution, is not permitted to install listed activities without environmental authorisation and is not permitted to emit black smoke from vehicles and must not cause any unreasonable interference or likely interference through air pollution (adversely affect the health of any persons or living organisms or reduce the amenity of a place or the environment).

4.12 Moses Kotane Local Municipality Environmental By-Law

The Moses Kotane Local Municipality Environmental By-Law was published on 30 August 2016 (North West Provincial Government, 2016). Chapter 6 (Air Quality and Noise Pollution Control) of this Gazette includes similar matters to that of the Rustenburg Local Municipality Air Pollution By-Law including point 3, points 6 to 12. The most relevant sections to the project contained within the MKLM Environmental By-Law are:

73. Any person causing dust emissions shall take full responsibility to prevent excessive emissions into the atmosphere that may be harmful to public, safety and health;

74. Any person who produces excessive emission of dust must adopt control measures before starting the activity;

75. Any person who carries out or plans to carry out any construction activity must notify, in writing, owners and occupiers; of all adjacent properties about the details of the proposed construction activity, an also, of their right to lodge written objections to the proposed construction activity.

Section 76 is not applicable as the quantity of vehicles per day that will travel on the unpaved roads is below the threshold.

5 AIR QUALITY BASELINE

5.1 Affected Environment

AQSRs generally include places of residence and areas where members of the public may be affected by air pollution generated by the BPM activities. AQSRs within an 8 km radius (Figure 3) of the operations include Ledig to the north, northwest and west as well as Sun City to the northeast, Chaneng to the southeast and Phatsima to the southwest, along with isolated homesteads and the Sundown Ranch Hotel to the south.

The topography is uneven and ranges from 1 000 mamsl near the project site to 1 480 mamsl north of the site (Figure 2). The land use in the area comprises primarily of mining, industries, residential and agriculture (Figure 3). Aside from the residential areas, individual homesteads and the Sundown Ranch Hotel near the BPM, agricultural areas were identified as environmentally sensitive areas. Table 3 is a summary of the nearby schools and medical facilities that may be influenced by air pollution emissions from the proposed Project. These receptors are also depicted in Figure 1.

5.2 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 because of plume 'stretching'. The generation of mechanical turbulence is similarly a function of wind speed, in combination with surface roughness. The wind direction, and 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 & 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 & Tyson, 1988). The atmospheric processes at macro- and meso-scales need therefore be considered 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.

Use was made of MM5 model data for a point on-site where three years of hourly sequential data was acquired. This data was used to construct wind roses, general climatic information such as diurnal temperature variations, atmospheric stability estimates and for dispersion modelling.

5.2.1 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 wind speed, in combination with surface roughness (Tiwary & Colls, 2010).

The wind roses 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 between 5 and 6 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.

To avoid the overly conservative concentration estimates being made by AERMOD, it is recommended in the Regulations Regarding Dispersion Modelling (Government Gazette No. 37804; 11 July 2014) (Republic of South Africa, 2014) that all wind speeds greater than/equal to the anemometer starting threshold (AST) and less than 1 m/s be replaced with the value of 1 m/s. This approach was undertaken and 18% of the wind speeds were replaced with 1 m/s.

The period wind field and diurnal variability in the wind field are shown in Figure 4, while the seasonal variations are shown in Figure 5. The wind field is dominated by winds from the east. The strongest winds (>6 m/s) occurred mostly from the west. Calm conditions occurred 1.5% of the time, with the average wind speed over the period of 2.74 m/s. Wind from the west having greater speeds were greater during the day with a higher frequency of calm conditions (1.6% during the day) than during the night (1.3% during the night). Day-time shows a dominant easterly component to the wind field and during the night winds from the east decrease and the east-north-easterly winds dominate but only slightly in comparison to the easterly winds. Strong winds in excess of 6 m/s occurred most frequently during spring followed by summer. Calm conditions occurred most frequently during the autumn and winter months.

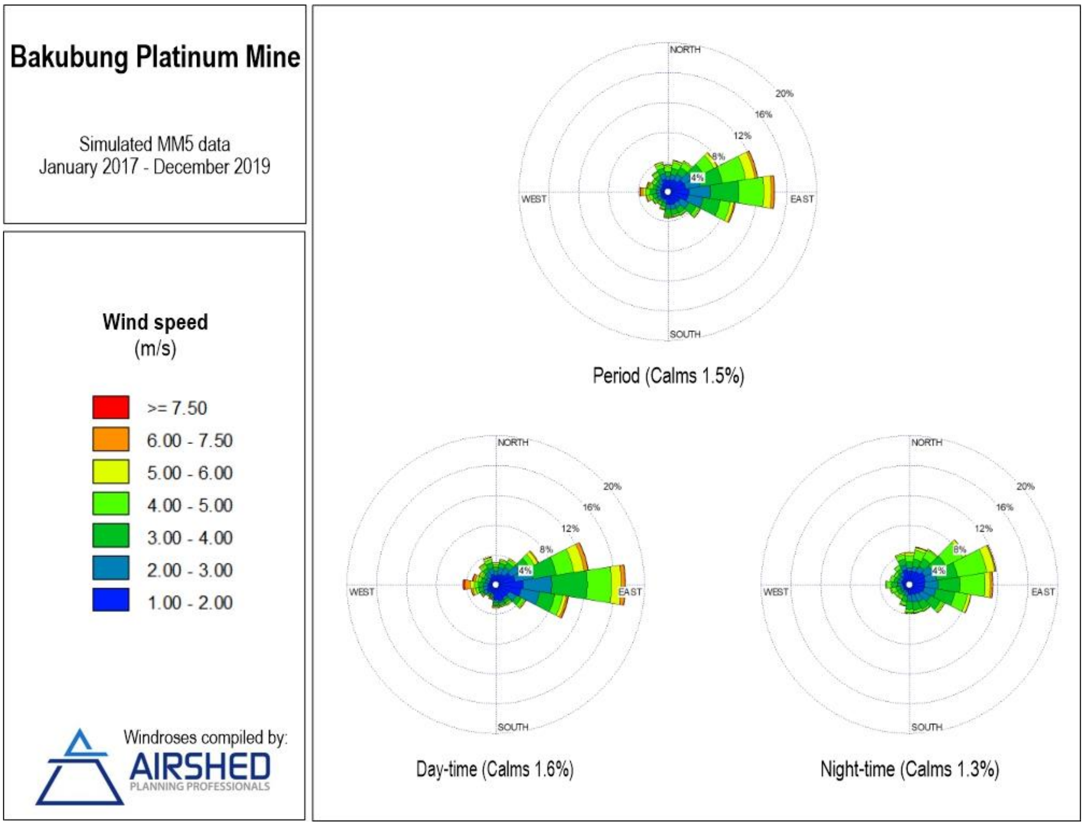


Figure 4: Period, day- and night-time wind roses (AERMET processed MM5 data, January 2017 to December 2019)

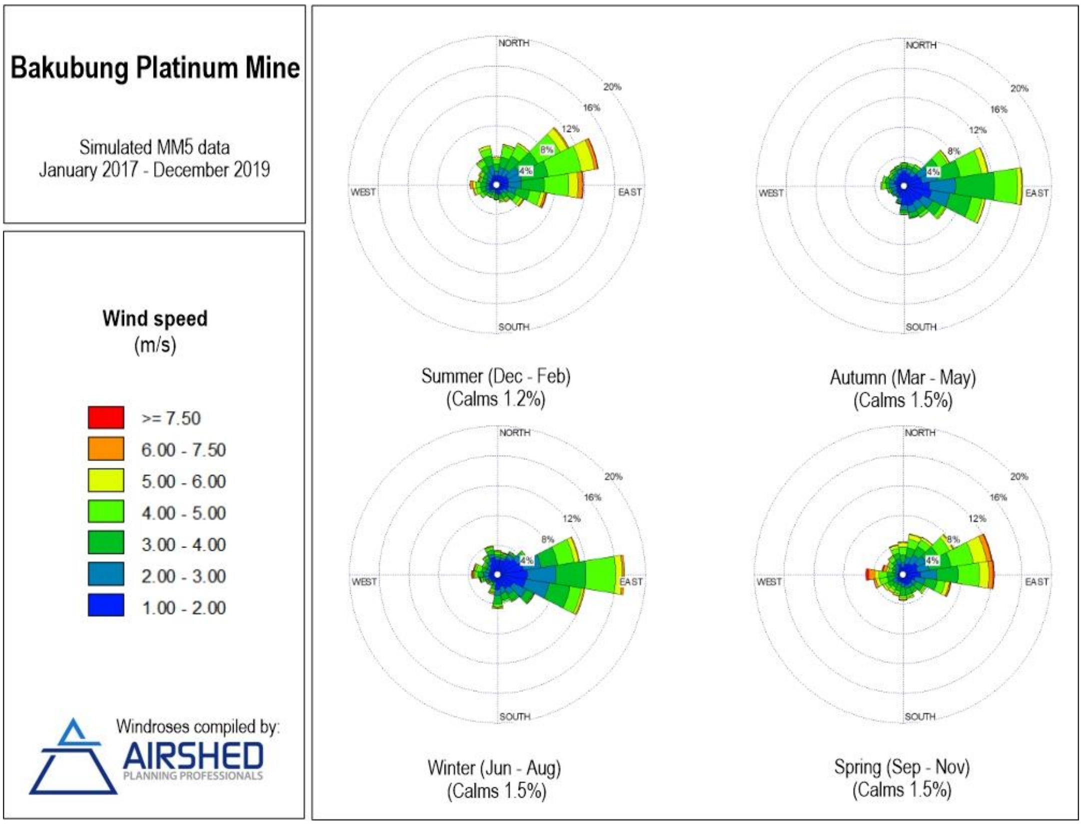


Figure 5: Seasonal wind roses (AERMET processed MM5 data, January 2017 to December 2019)

5.2.2 Ambient Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the emissions plume and the ambient air, the higher the plume can rise), and determining the development of the mixing and inversion layers.

Monthly mean, maximum and minimum temperatures are given in Table 6. Diurnal temperature variability is presented in Figure 6. Temperatures ranged between 2°C and 34°C. The highest temperatures occurred in December and January and the lowest in June and July. During the day, temperatures increase to reach maximum at around 14:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 06:00 i.e. just before sunrise.

Table 6: Monthly temperature summary (AERMET processed MM5 data, January 2017 to December 2019)

Minimum, Average and Maximum Temperatures (°C)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Hourly Minimum	12	15	12	10	5	2	2	3	4	9	8	14
Monthly Average	24	24	23	19	15	12	12	15	19	21	23	25
Hourly Maximum	34	33	33	30	24	21	22	26	30	33	32	34

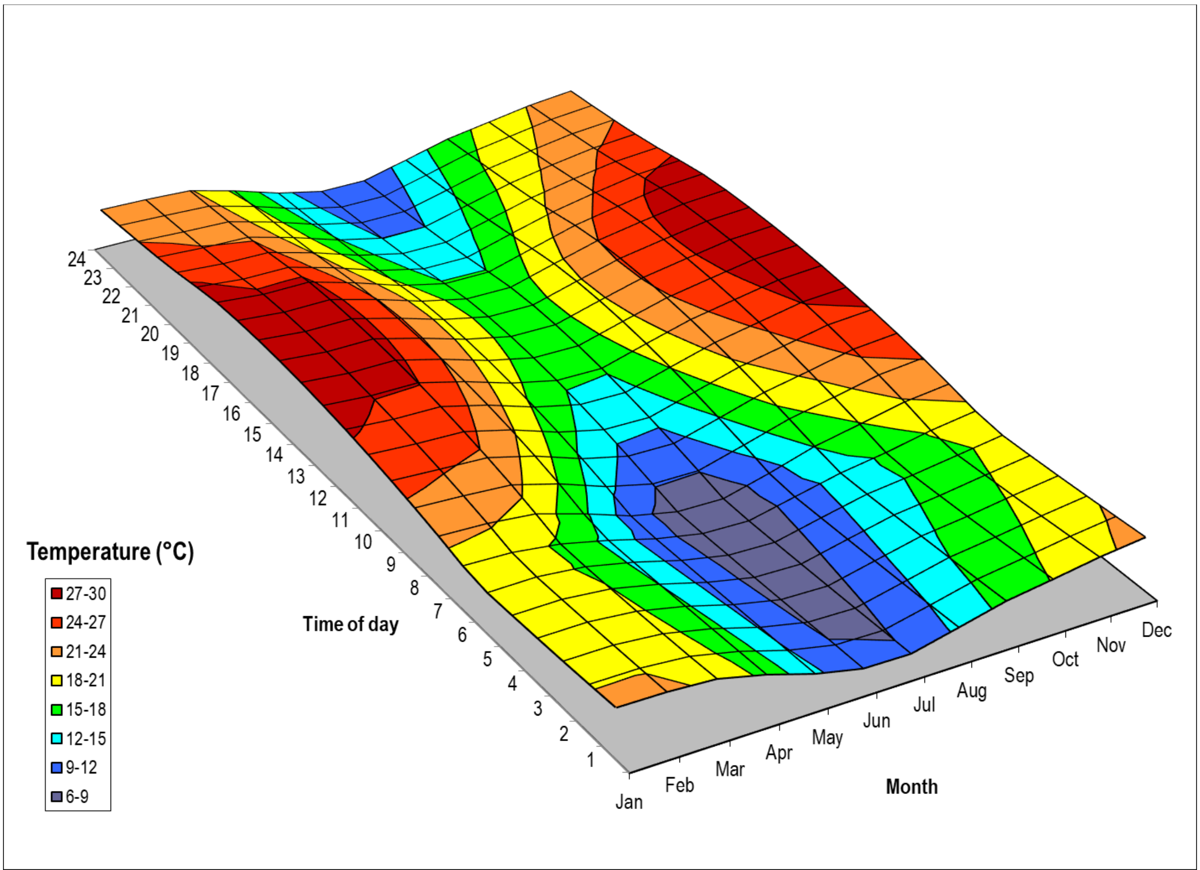


Figure 6: Diurnal temperature profile (AERMET processed MM5 data, January 2017 to December 2019)

5.2.3 *Atmospheric Stability*

The new generation air dispersion models differ from the models traditionally used in a number of aspects, the most important of which are 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 Obukhov length (often referred to as the Monin-Obukhov length).

The 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 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 lower dilution potential.

Diurnal variation in atmospheric stability, as calculated from measured data, and described by the inverse Obukhov length and the boundary layer depth is provided in Figure 7. The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions. For elevated releases, unstable conditions can result in very high concentrations of poorly diluted emissions close to the stack. This is called *looping* (Figure 7(c)) and occurs mostly during daytime hours. Neutral conditions disperse the plume fairly equally in both the vertical and horizontal planes and the plume shape is referred to as *coning* (Figure 7(b)). Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called *fanning* (Figure 7(a)) (Tiwary & Colls, 2010). For ground level releases such as fugitive dust the highest ground level concentrations will occur during stable night-time conditions.

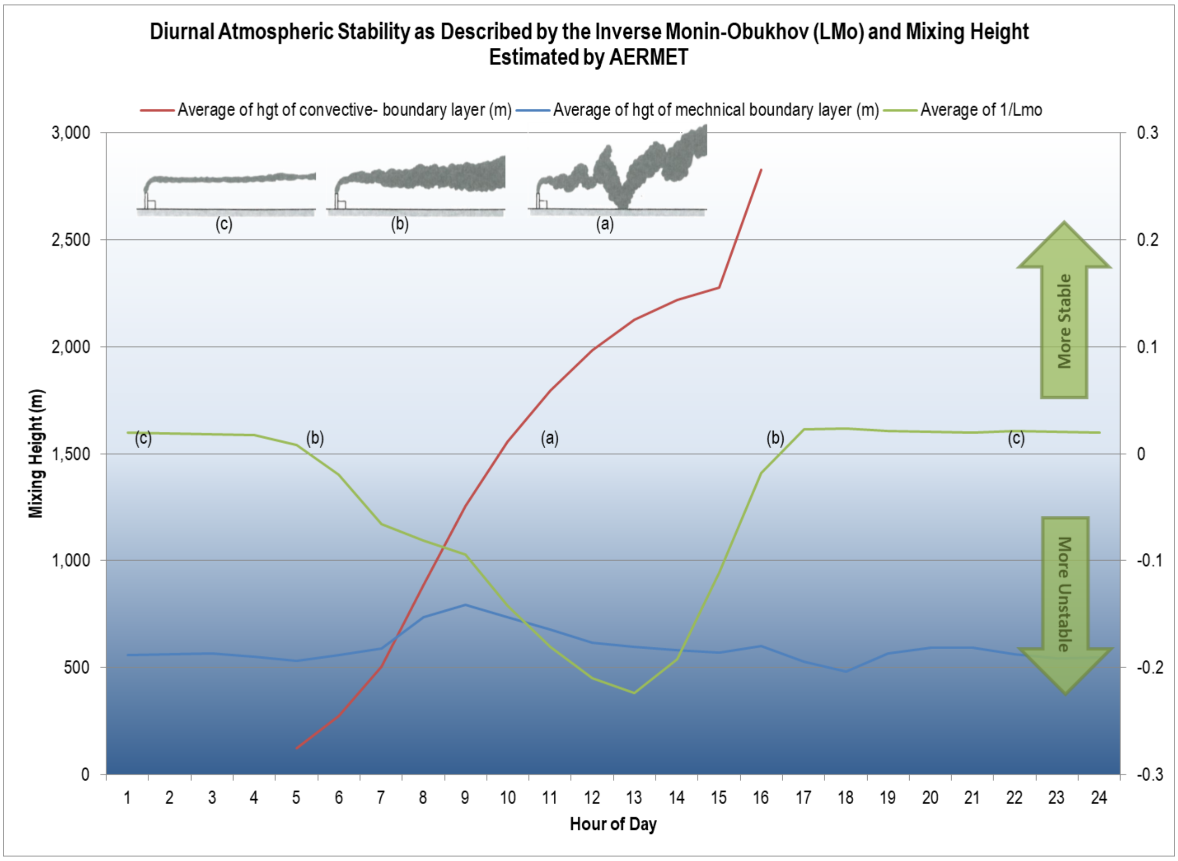
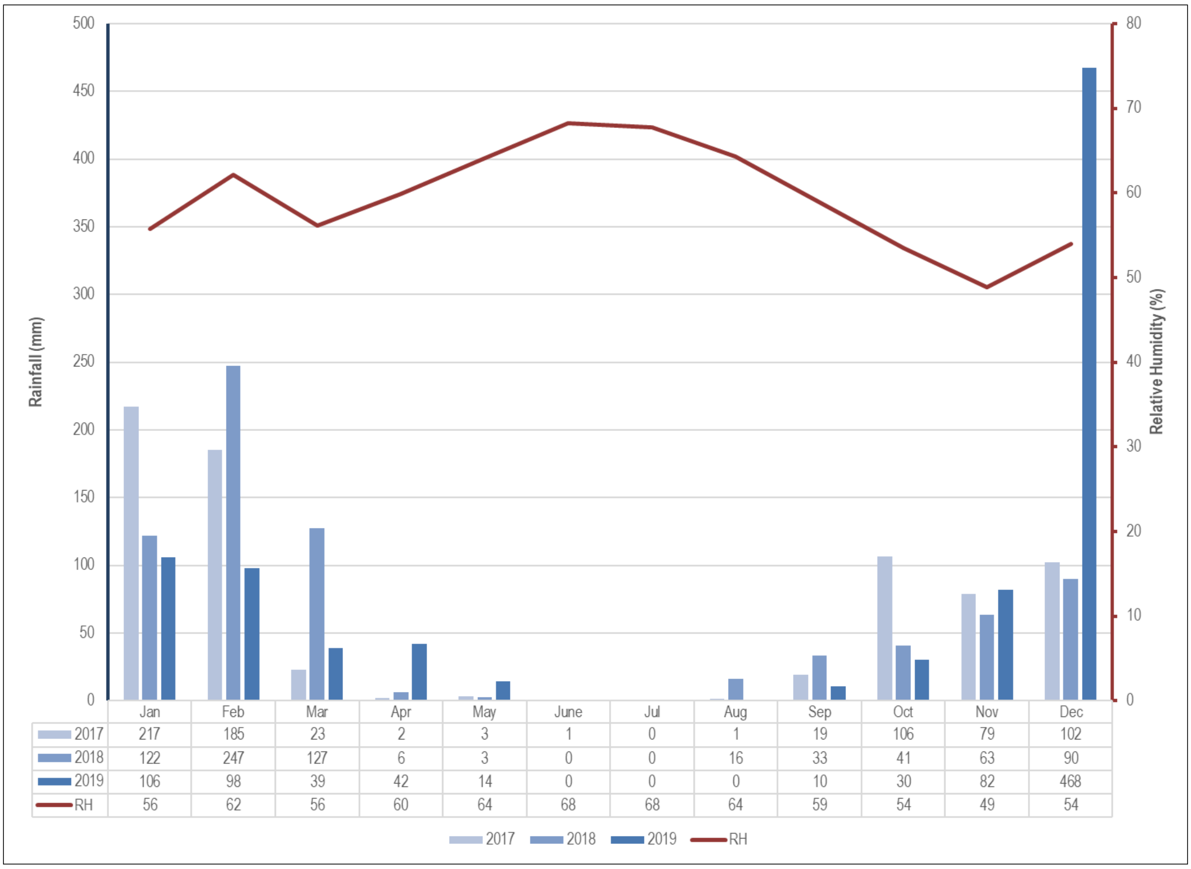


Figure 7: Diurnal atmospheric stability (AERMET processed MM5 data, January 2017 to December 2019)

5.2.4 Precipitation

Rainfall is important to air pollution studies since it represents an effective removal mechanism of atmospheric pollutants. Monthly rainfall obtained from the MM5 data is presented in Figure 8. Total average annual rainfall from January 2017 to December 2019 is 792 mm. The rainfall for 2017, 2018 and 2019 was 738 mm, 750 mm, and 890 mm, respectively. Rainfall in this area occurs mostly during the summer months although it also rains during spring and autumn while the winter months are dry even through the relative humidity is greater during the winter period than other seasons. Colder air can hold less moisture than warmer air and thus the percentage saturation is higher at a lower moisture quantity resulting in higher relative humidity during colder periods than warmer periods.



	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
2017	217	185	23	2	3	1	0	1	19	106	79	102
2018	122	247	127	6	3	0	0	16	33	41	63	90
2019	106	98	39	42	14	0	0	0	10	30	82	468
RH	56	62	56	60	64	68	68	64	59	54	49	54

Figure 8: Monthly rainfall and relative humidity (AERMET processed MM5 data, January 2017 to December 2019)

5.3 Existing Air Quality

The current air quality in the study area is mostly influenced by mining, processing and industrial activities at other companies' operations, as well as farming activities, domestic fires, vehicle exhaust emissions and dust entrained by vehicles. These emission sources vary from activities that generate relatively course airborne particulates (such as farmland preparation, dust from paved and unpaved roads, and the mine sites) to fine PM such as that emitted by vehicle exhausts, diesel power generators and processing operations. Other sources of PM include occasional fires in the residential areas and farm activities. Emissions from unpaved roads constitute a major source of emissions to the atmosphere in South Africa. When a vehicle travels on an unpaved road, the force of the wheels on the road surface causes 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 are a function of vehicle traffic 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. Emissions generated by wind erosion are dependent on the frequency of disturbance of the erodible surface. Every time that a surface is disturbed e.g. by mining, agriculture and/or grazing activities, its erosion potential is restored.

5.3.1 Sampled Dustfall Rates

Dust fallout sampling is being undertaken at the site. The current network includes at 16 locations (8 non-residential sites and 8 residential sites) in accordance with ASTM D1739 (1970). Figure 9 acquired from the 2019 dustfall report created by Skyside and shows the locations of the units. Results of the sampling campaign available to date are summarised in Table 7, based on the data in the Skyside report for 2019. Although there were exceedances of the limits, the operations dustfall rates shown by the sampling complies in terms of the NDCR as there were no exceedances of more than two times per year at a site or for consecutive months at a site.

Table 7: Summary of dustfall rates

Pollutant	Data source	Compliance Assessment
Dustfall	Results of dustfall sampling at 16 locations for the period September 2008 to December 2019.	SA NDCR limit for residential areas of 600 mg/m^2-day was exceeded at the following residential sites: • Bakgofa Primary School – October 2008 • Bakgofa Primary School – July 2009 • Lekwadi Section – November 2012 • Lekwadi Section – December 2014 • Lekwadi Section – October 2015 • Kayalethu High School – September 2018 SA NDCR limit for non-residential areas of 1 200 mg/m^2-day was exceeded at the following non-residetial sites: • Explosives magazine – January 2012 • Tailings North – January 2012 • Tailings Dam – July 2012 • Tailings North – November 2012

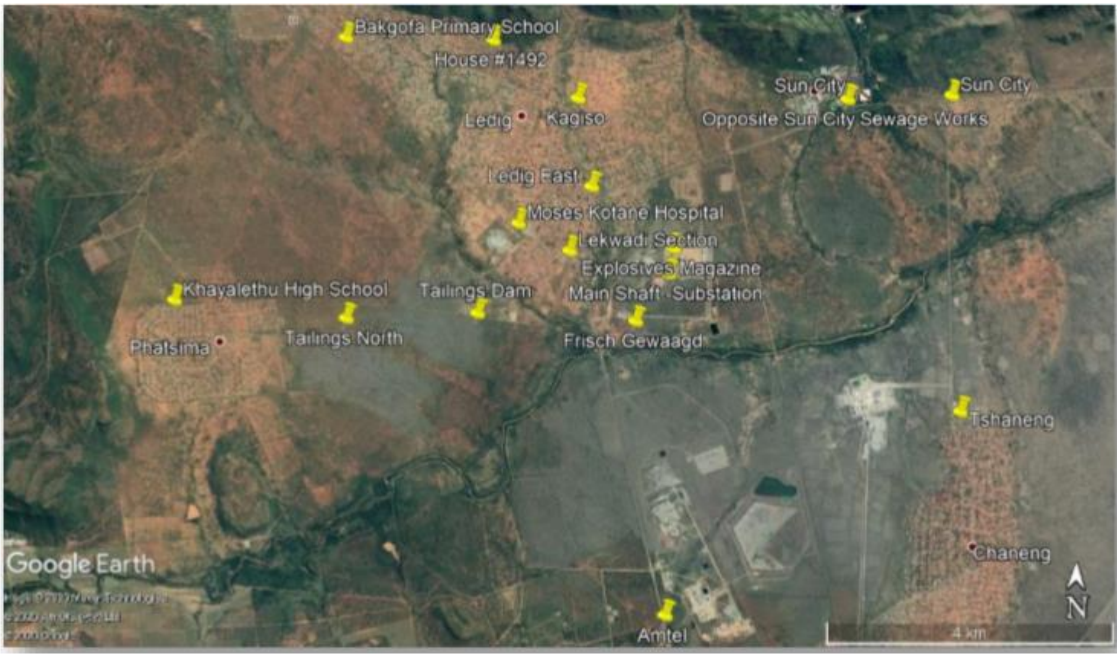


Figure 9: Bakubung Platinum Mine dustfall monitoring network

6 IMPACT ASSESSMENT: CONSTRUCTION PHASE

6.1 Emissions Inventory for Construction Phase

During the construction phase several facilities need to be added including storm water infrastructure, TSF liner, conveyor to the TSF and TSF service roads. The following activities will take place:

- Site establishment of construction phase facilities;
- Clearing of vegetation;
- Stripping and stockpiling of soil resources and earthworks;
- Collection, storage and removal of construction related waste;
- Construction of all infrastructure required for the operational phase; and
- Operation of mechanical equipment.

A summary of sources quantified, emissions estimation techniques applied, and source input parameters are summarised in Table 8 and the summary of estimated particulate emissions is provided in Table 9.

Table 8: Emission estimation techniques and parameters for construction

Source Group	Emission Estimation Technique	Input Parameters/Notes
General construction	US EPA emission factor (US EPA, 1995) $$EF = k \cdot 2.69$$ Where EF is the emission factor in t/ha-month k is the particle size multiplier (k_{TSP} – 1, k_{PM10} – 0.35, $k_{PM2.5}$ – 0.18)	A total infrastructure/disturbed area of ~40.5 ha was estimated from the site layout map. It was assumed that 25% of this area would be under construction at any given point in time. It is assumed that roads will likely be unpaved for most of the construction period. **Hours of operation:** 5 days per week (6 days when required), 12-hours per day (06H00 – 18H00) **Design mitigation:** None **Additional mitigation:** Dust management and water sprays (assumed 50% control efficiency)
Construction equipment	NPI single valued emission factors (ADE, 2008) for: Excavator Bulldozer Tractor Crane Front End Loader	**Operating power:** Excavator – 304 kW Bulldozer – 114 kW Tractor – 60.8 kW Crane – 76 kW Front End Loader – 57 kW **Hours of operation:** 5 days per week (6 days when required), 12-hours per day (06H00 – 18H00) **Design Mitigation:** None

Table 9: Summary of estimated particulate emissions in tons per annum for construction

Source Group	Estimated UNMITIGATED Particulate Emissions (tpa)			Estimated MITIGATED Particulate Emissions (tpa)		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
General Construction	0.581	1.16	3.32	0.290	0.581	1.66
Mobile Construction Equipment	1.75	1.75	1.75	-	-	-

6.2 Assessment of Impact – Construction

Dispersion modelling for the construction phase was considered to be unrepresentative of the actual activities that will result in dust and gaseous emissions. It is not anticipated that the various construction activities will result in higher $PM_{2.5}$ and PM_{10} GLCs and dustfall rates than the operational phase activities. The temporary nature of the construction activities will likely reduce the significance of the potential impacts. The main pollutants of concern are PM. A qualitative assessment of the PM_{10}, $PM_{2.5}$ and TSP impacts during construction operations is discussed below.

6.2.1 Impact A1: Potential for Impacts on Human Health from Increased Pollutant Concentrations Associated with General Construction Activities

The sources of emissions would include site establishment in proposed additional operating areas; vegetation clearing; stripping and stockpiling of topsoil and other earthworks; collection, storage and removal of construction related waste; the construction of all required infrastructure; and the operation of mechanical equipment. It is unlikely that the long-term and short-term NAAQS will be exceeded at AQSRs (with and without mitigation). The construction operations are likely to last for less than a year. The rating is LOW without and with mitigation applied (Table 10).

6.2.2 Impact A2: Increased Nuisance Dustfall Rates Associated with General Construction Activities

The sources of emissions would include site establishment in proposed additional operating areas; vegetation clearing; stripping and stockpiling of topsoil and other earthworks; collection, storage and removal of construction related waste; the construction of all required infrastructure; and the operation of mechanical equipment. It is unlikely that the NDCR limit for residential areas will be exceeded at AQSRs (with and without mitigation). The construction operations are likely to last for less than a year. The rating is LOW without and with mitigation applied (Table 11).

Table 10: Health risk impact significance summary table for the construction operations

Air Quality	Description	Rating
Project activity or issue	Construction	N/A
Potential impact	Increased health risk at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in PM_{10} and $PM_{2.5}$ concentrations at AQSRs	-
Direct/Indirect/Cumulative	Direct	D
	Significance Before Mitigation	
Severity / magnitude (M)	Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %	2
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**6**
	Significance After Mitigation	
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1

Air Quality	Description	Rating
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**4**
Potential mitigation measures (construction)	• Reduction of fugitive PM emissions through the watering of roads, stockpiles and inactive open areas and the use of screens. • Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	N/A

Table 11: Nuisance impact significance summary table for the construction operations

Air Quality	Description	Rating
Project activity or issue	Construction	N/A
Potential impact	Nuisance dustfall rates at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in dustfall rates at AQSRs	-
Direct/Indirect/Cumulative	Direct	D
	Significance Before Mitigation	
Severity / magnitude (M)	Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %	2
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**6**
	Significance After Mitigation	

Air Quality	Description	Rating
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**4**
Potential mitigation measures (construction)	• Reduction of fugitive PM emissions through the watering of roads, stockpiles and inactive open areas and the use of screens. • Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	N/A

7 Impact Assessment: Operational Phase

The following scenarios were included in the dispersion modelling:

1. The proposed TSF operations only;
2. The approved operations and proposed TSF operations excluding the approved TSF operations; and
3. The future operations including all the approved operations and the windblown dust from the proposed TSF.

All the approved operation dispersion modelling has been included in Appendix E. This is to allow a comparison of the impacts of all operations associated with the proposed TSF operational period in comparison to all the approved operations.

7.1 Emissions Inventory

Expected sources of atmospheric emissions during the operational phase associated with the proposed project include:

- Particulate emissions from vehicle entrainment along the unpaved service roads;
- Particulate emissions from vehicles' exhaust; and
- Particulate emissions from materials handling at the plant;
- Particulate emissions from materials handling at the proposed TSF; and
- Particulate emissions from wind-blown dust from proposed TSF area.

The volume and frequency of vehicles travelling along the service roads is not expected to be significant during the proposed operations, thus they have not been quantified.

Wind erosion is a complex process, including three different phases of particle entrainment, transport and deposition. It is primarily influenced by atmospheric conditions (e.g. wind, precipitation and temperature), soil properties (e.g. soil texture, composition and aggregation), land-surface characteristics (e.g. topography, moisture, aerodynamic roughness length, vegetation and non-erodible elements) and land-use practice (e.g. farming, grazing and mining) (Shao, 2008).

Windblown dust (WBD) generates from natural and anthropogenic sources. For wind erosion to occur, the wind speed needs to exceed a certain threshold, called the friction velocity. This relates to gravity and the inter-particle cohesion that resists removal. Surface properties such as soil texture, soil moisture and vegetation cover influence the removal potential. Conversely, the friction velocity or wind shear at the surface is related to atmospheric flow conditions and surface aerodynamic properties. Thus, for particles to become airborne the wind shear at the surface must exceed the gravitational and cohesive forces acting upon them, called the threshold friction velocity (Shao, 2008). Thus, the likelihood exists for wind erosion to occur from open and exposed surfaces, with loose fine material, when the wind speed exceeds at least the friction velocity.

Sources of emissions generally associated with these TSFs include wind erosion and materials handling. A summary of emission sources quantified, estimation techniques applied, and source input parameters is included in Table 12. Windblown dust emissions quantification was done using the in-house modelled ADDAS (Burger, Held, & Snow, 1997; Burger L. W., 2010). This model is based on the dust emission scheme of Marticorena & Bergametti (1995) and Shao et al. (2011). For the purpose of this study, the Marticorena & Bergametti (1995) dust flux model was used. The model inputs include material particle density, moisture content, particle size distribution and site-specific surface characteristics such as whether the source is active or undisturbed. A summary of estimated particulate emissions in tonnes per annum (tpa) associated with the approved TSF, WRD and proposed TSF operations is provided in Table 13.

Table 12: Emission estimation techniques and parameters

Source Group	Emission Estimation Technique	Input Parameters and Activities
Proposed TSF wind erosion	The calculation of a windblown dust emission rate for every hour of 2017, 2018 and 2019 was carried out using the ADDAS model, which is based on the dust emission model proposed by Marticorena & Bergametti (1995). A literature review on the model is provided in Appendix C.	The exposed area was included in emission estimations based on project layouts; this was 24 ha for the proposed TSF. Mitigation: None Post operations mitigation: Capping and vegetation (40% control efficiency)
Proposed materials handling	US EPA miscellaneous transfer and conveying emission factor equation (US EPA, 2006) $\mathrm{EF} = \mathrm{k} \cdot 0.0016 \cdot \left(\frac{\mathrm{U}}{2.3}\right)^{1.3} \cdot \left(\frac{\mathrm{M}}{2}\right)^{-1.4}$ (1) EF is the emission factor in kg/tonne material handled k is the particle size multiplier (k_{PM10} – 0.35, $k_{PM2.5}$ – 0.053) U is the average wind speed in m/s M is the material moisture content in %	Handling of materials and at the TSF. 114 tonnes per hour (tph); moisture content of 12.5% and average wind speed of 2.74 m/s. Mitigation: None

Table 13: Summary of estimated particulate emissions in tonnes per annum

Source Group	Estimated UNMITIGATED Particulate Emissions (tpa)			Estimated MITIGATED Particulate Emissions (tpa)[(a)]		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Proposed TSF wind erosion	1.24	3.77	16.8	0.670	2.04	9.07
Proposed materials handling	0.009	0.057	0.121	-	-	-

Note: (a) This is applicable during part of the future operations but not during the worst-case operations where the vegetation of the TSF is initiated and vegetation is sparse; this accounts for when the TSF is fully vegetated

7.2 Assessment of Impact – Proposed TSF Operations Only

Simulation results of windblown dust emissions for proposed TSF and materials handling only are discussed in this section.

7.2.1 *Inhalable particulate matter (PM_{10})*

Simulated annual average PM_{10} concentrations do not exceed the NAAQS of 40 µg/m^3 (Figure 10). The 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) are not exceeded off-site or at any AQSRs (Figure 11). Since the simulated results show that the NAAQS are not exceeded, there is not a significant risk to human health at these receptors as a result of the proposed operations.

7.2.2 *Respirable particulate matter ($PM_{2.5}$)*

Simulated annual average $PM_{2.5}$ concentrations do not exceed the NAAQS of 20 µg/m^3 (Figure 16). The 24-hour NAAQS (4 days of exceedance of 40 µg/m^3) are not exceeded. Since the simulated results show that the NAAQS are not exceeded, there is not a significant risk to human health at these receptors as a result of the proposed operations.

7.2.3 *Fallout Dust*

Based on the highest monthly simulated dustfall rates, the daily average dustfall rate does not exceed the NDCR residential limit of 600 mg/m²-day at any AQSRs and are below 400 mg/m²-day at all agricultural areas (Figure 13).

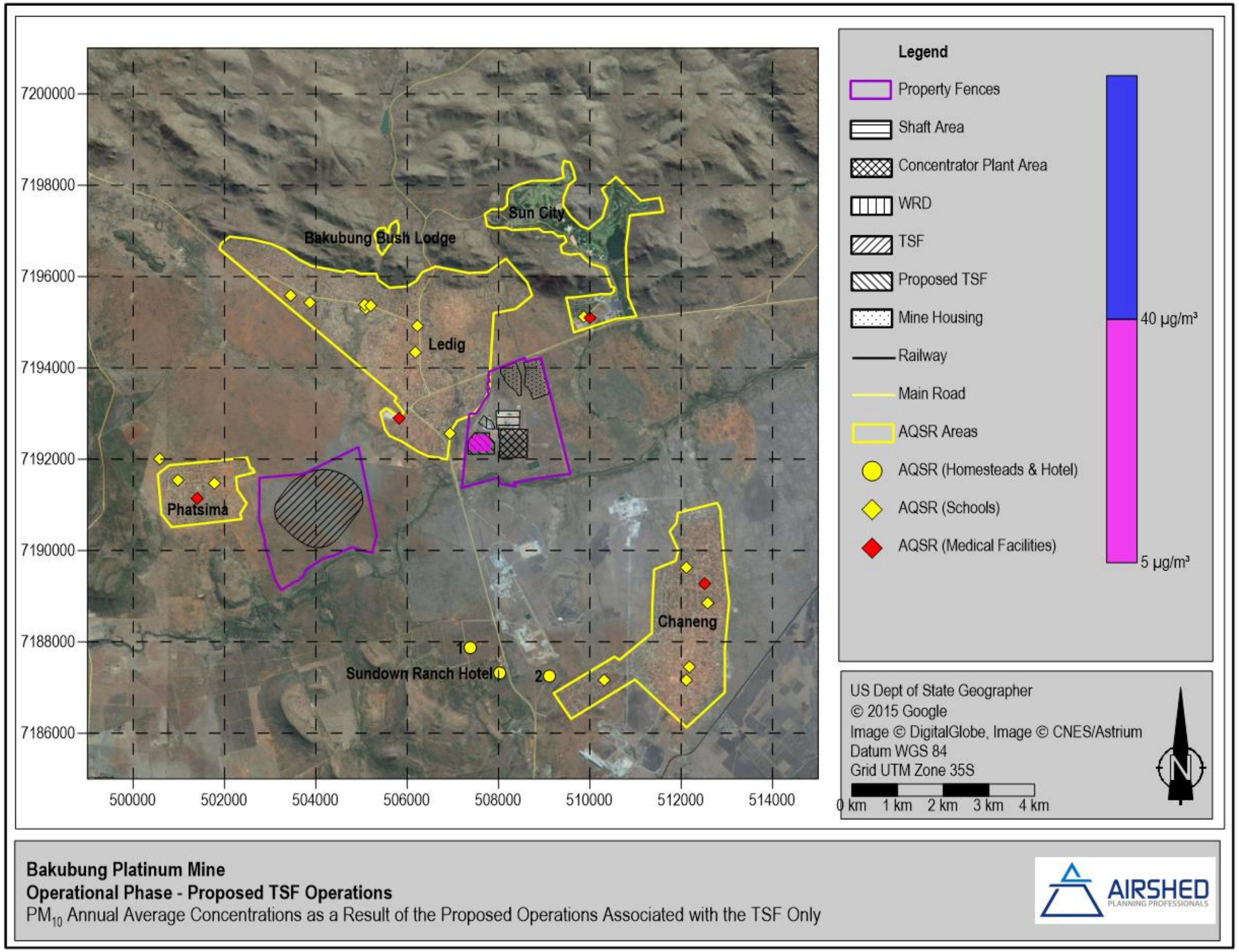


Figure 10: Proposed TSF - simulated annual average PM_{10} concentrations

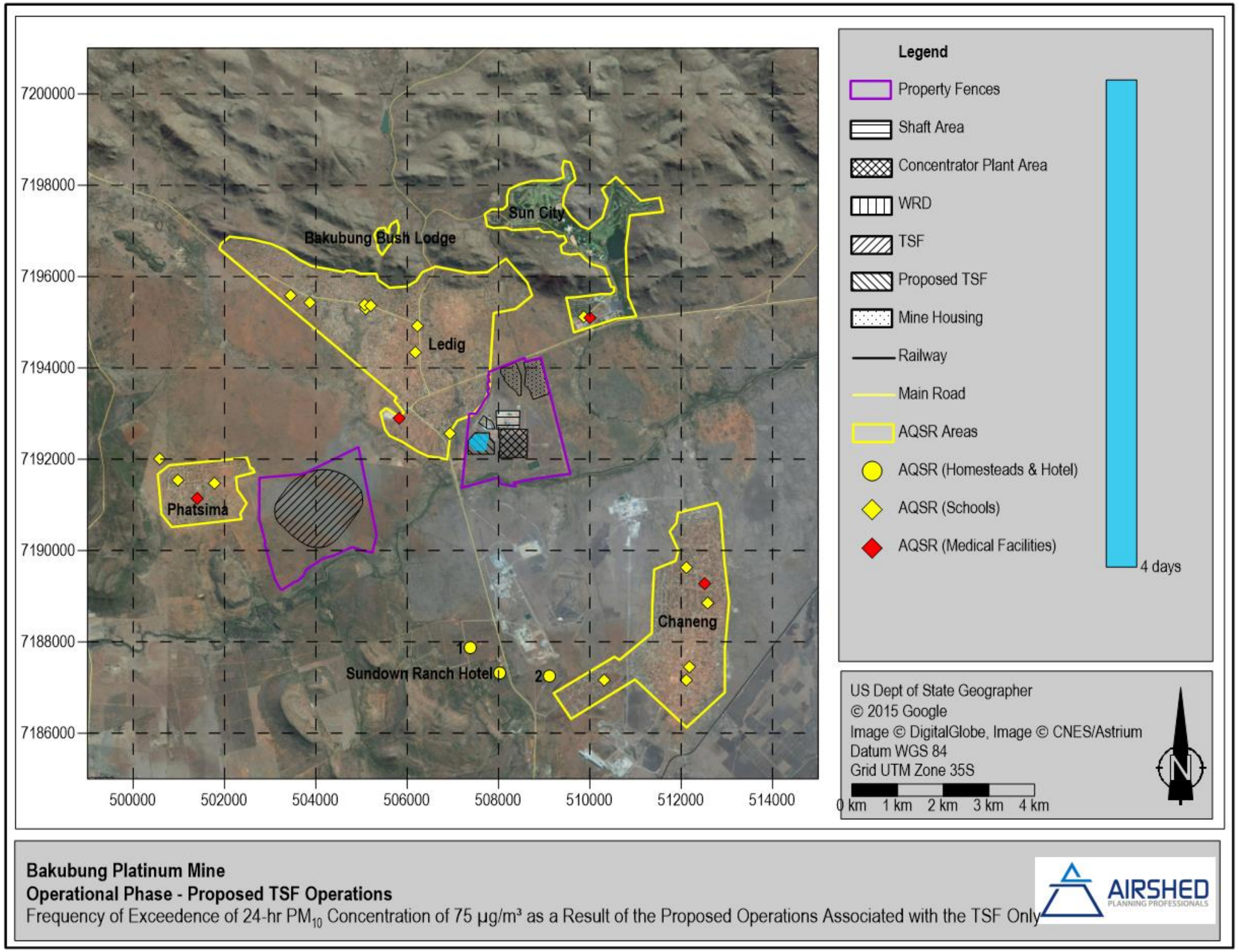


Figure 11: Proposed TSF - simulated area of exceedance of the 24-hour PM_{10} NAAQS

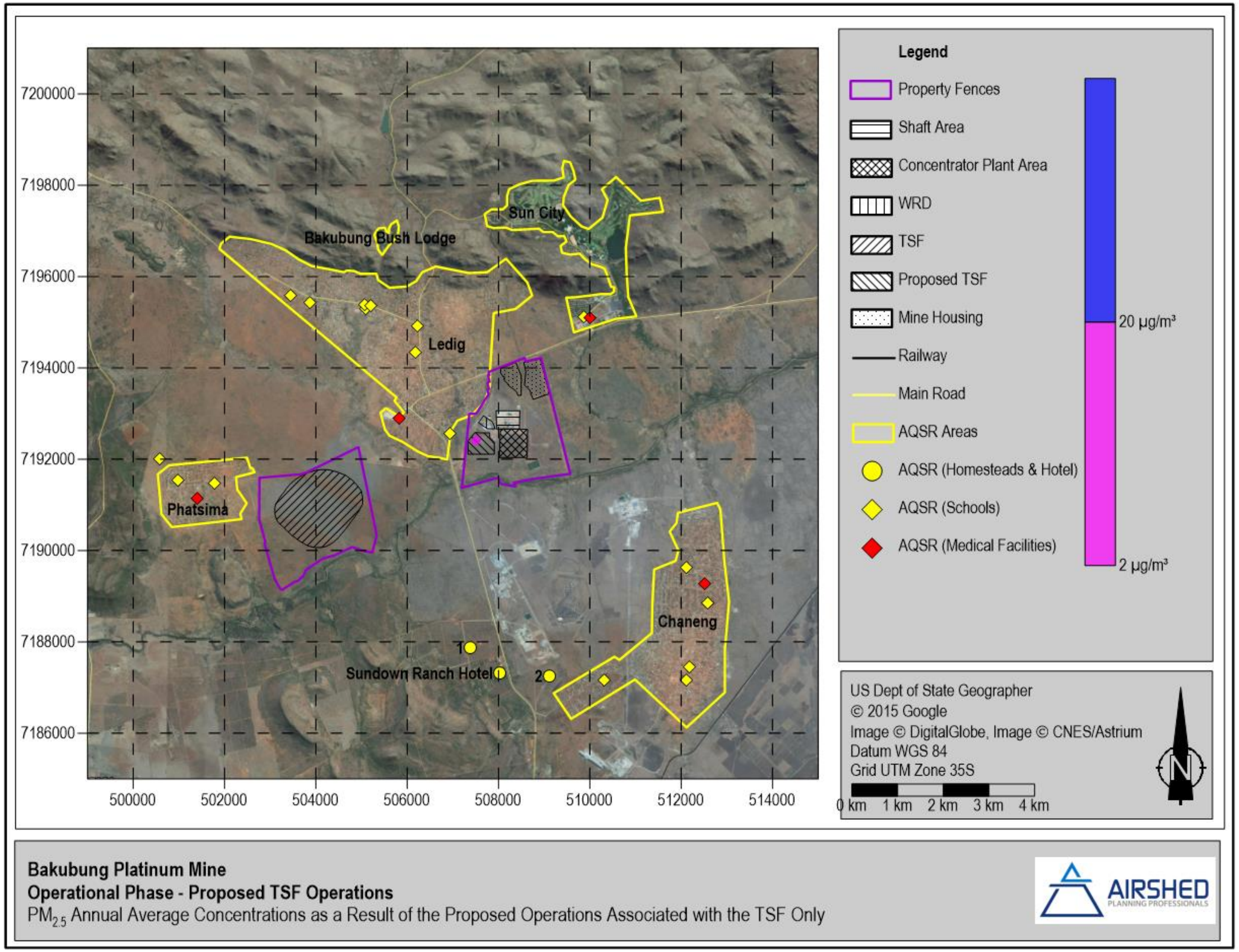


Figure 12: Proposed TSF - simulated annual average $PM_{2.5}$ concentrations

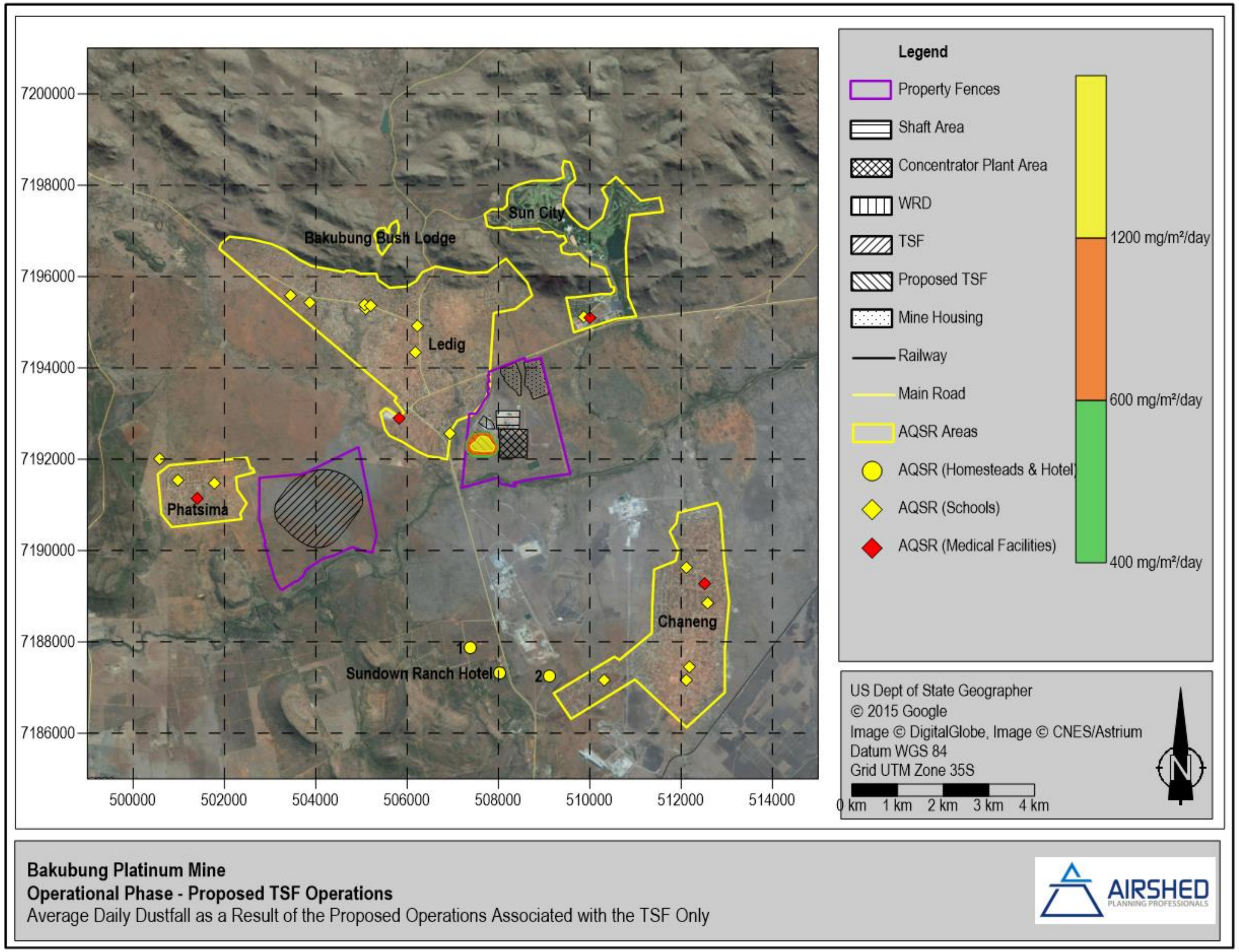


Figure 13: Proposed TSF - average daily dustfall rates based on simulated highest monthly dust fallout

7.3 Assessment of Impact – Proposed Operations

Simulation results of the approved operations and proposed TSF operations excluding the approved TSF are discussed in this section. The simulation results are for the proposed operational phase only and do not include any other sources contributions in the area, as is common practice when assessing an individual facility.

7.3.1 Inhalable particulate matter (PM_{10})

Simulated annual average PM_{10} concentrations do not exceed the NAAQS of 40 µg/m^3 off-site or at and AQSRs or at the mine housing (Figure 14). The 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) are not exceeded off-site or at any AQSRs; however, the 24-hour NAAQS is exceeded at a portion of the mine housing (Figure 15). The NAAQS 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. Simulated results show that only the short-term NAAQS are exceeded at the mine housing but at no off-site AQSRs, thus the simulated operations are unlikely to be a significant risk to human health at the surrounding receptors.

7.3.2 Respirable particulate matter ($PM_{2.5}$)

Simulated annual average $PM_{2.5}$ concentrations do not exceed the NAAQS of 20 µg/m^3 off-site or at any of the AQSRs (Figure 16). The 24-hour NAAQS (4 days of exceedance of 40 µg/m^3) are exceeded only at a portion of the mine housing and not at any off-site AQSRs (Figure 17). Simulated results show that only the short-term NAAQS are exceeded at the mine housing but no off-site AQSRs, thus the simulated operations are unlikely to be a significant risk to human health at the surrounding receptors.

7.3.3 Fallout Dust

Based on the highest monthly simulated dustfall rates, the daily average dustfall rate does not exceed the NDCR residential limit of 600 mg/m²-day of site or at any AQSRs and are below 400 mg/m²-day at all agricultural areas (Figure 18). Dust fallout is associated with nuisance impacts and not human health impacts; however, it could also compromise photosynthetic rates depending on species sensitivity.

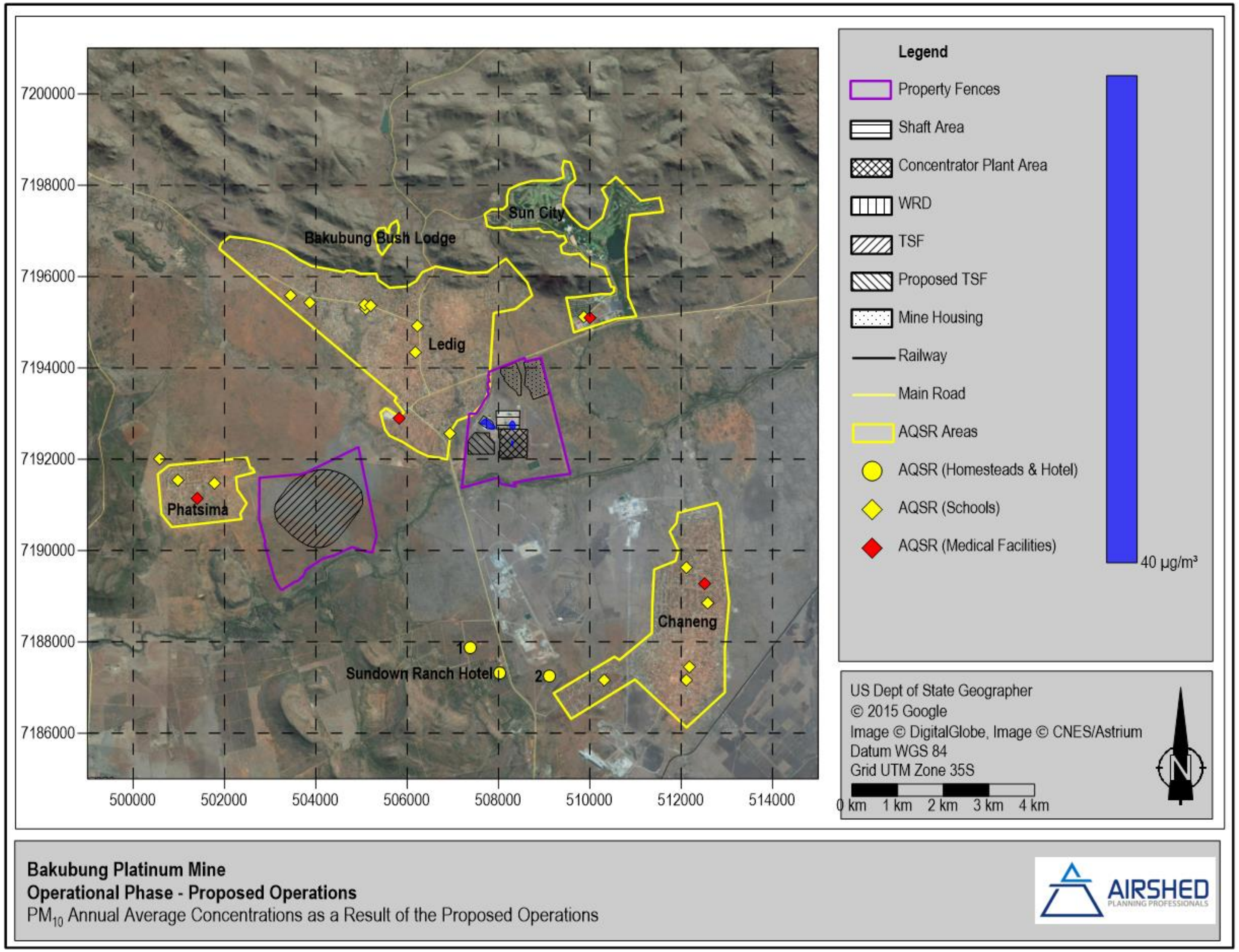


Figure 14: Proposed – simulated area of exceedance of the annual average PM_{10} NAAQS

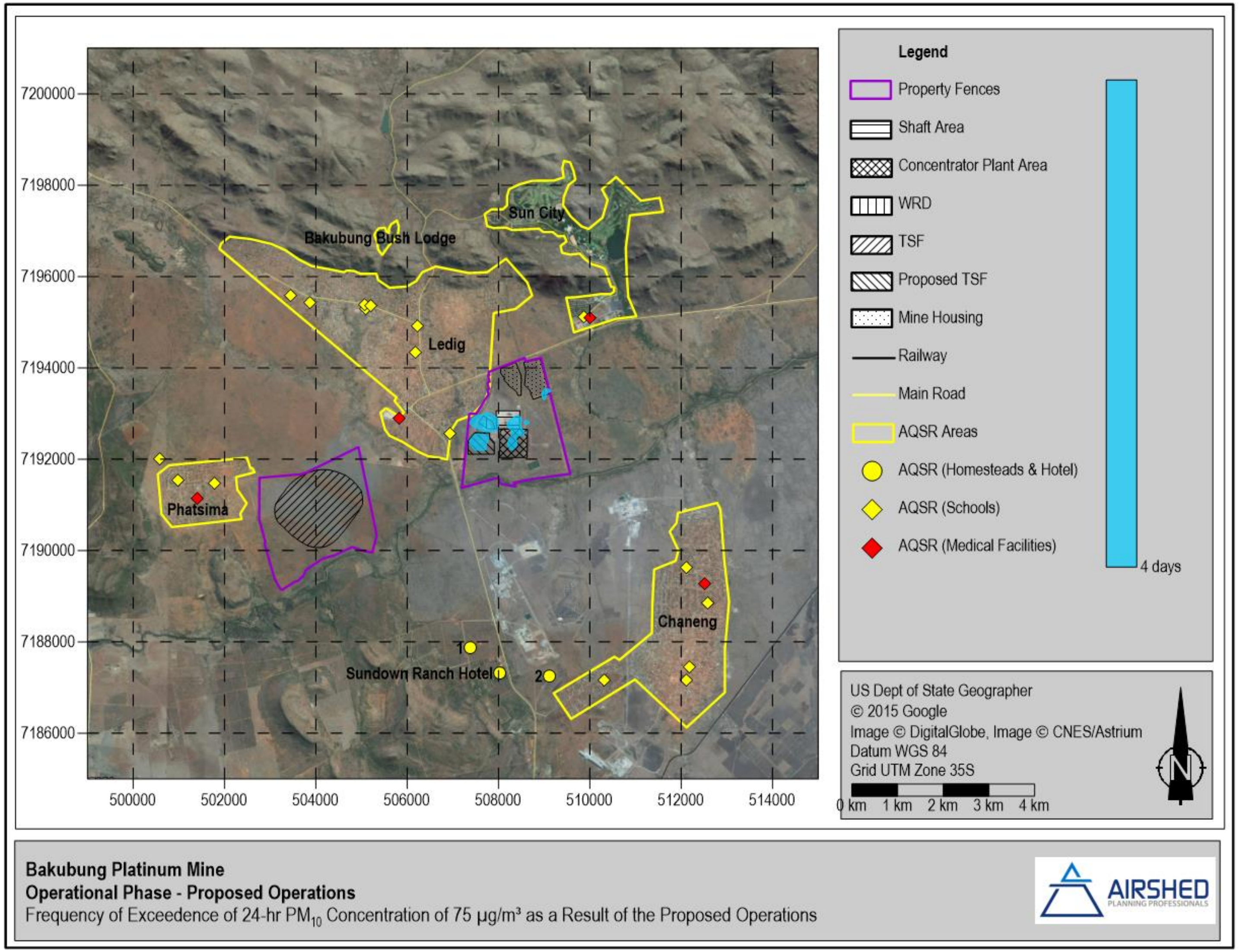


Figure 15: Proposed – simulated area of exceedance of the 24-hour PM_{10} NAAQS

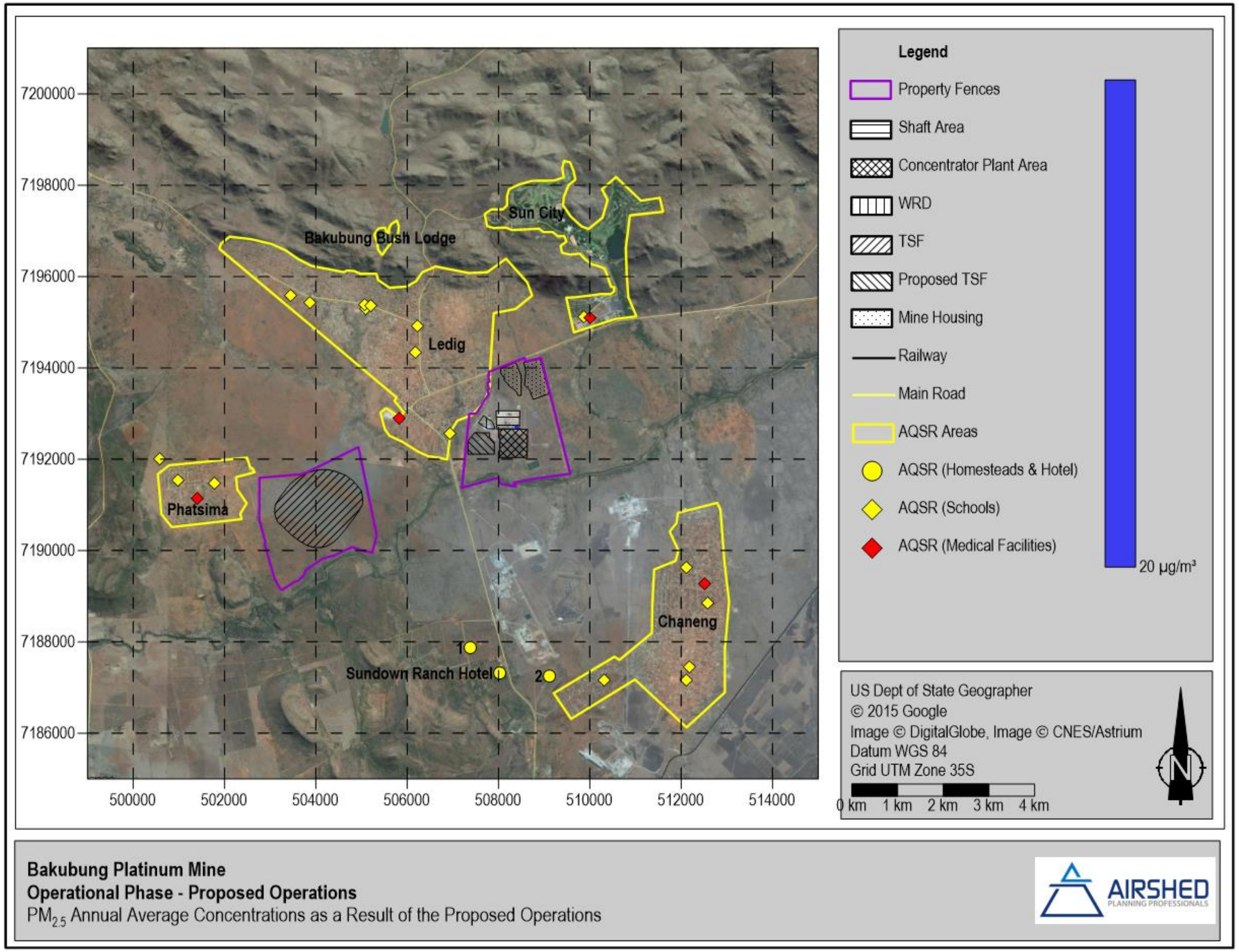


Figure 16: Proposed – simulated area of exceedance of the annual average $PM_{2.5}$ NAAQS

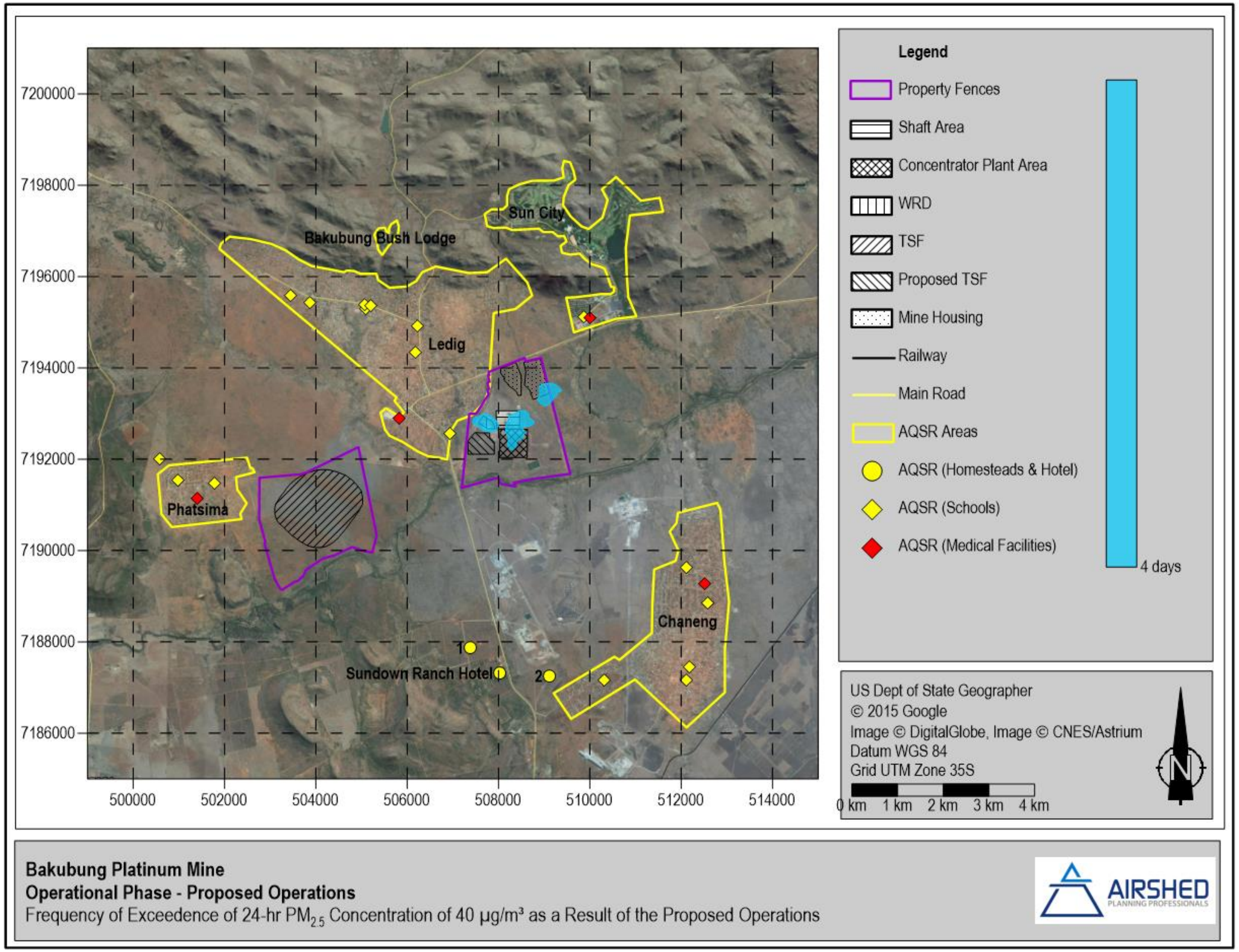


Figure 17: Proposed – simulated area of exceedance of the 24-hour $PM_{2.5}$ NAAQS

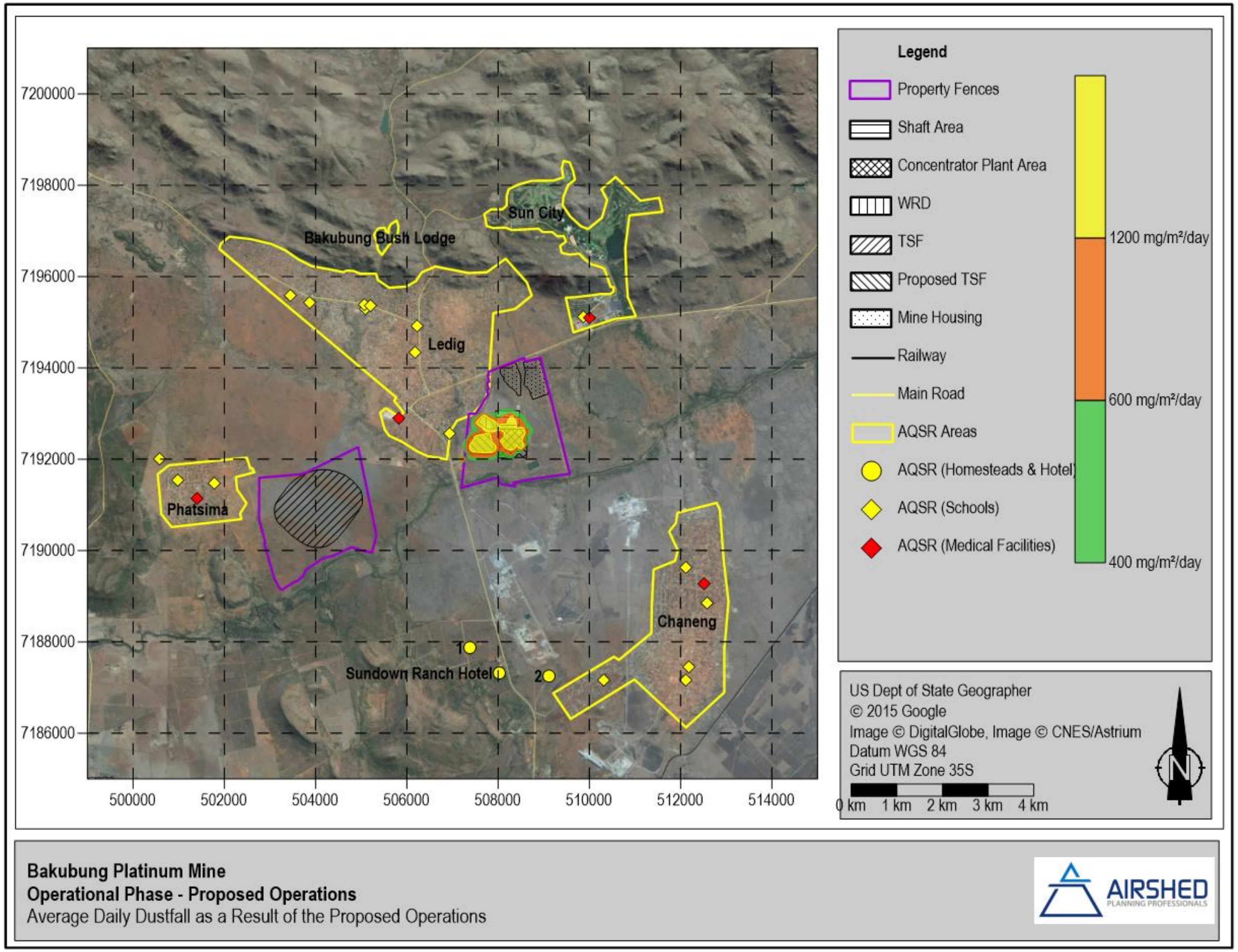


Figure 18: Proposed - average daily dustfall rates based on simulated highest monthly dust fallout

7.4 Assessment of Impact – Future Operations (Approved Operations and Windblown Dust from Proposed TSF)

Simulation results of the approved operations and windblown dust emissions for the proposed TSF are discussed in this section.

7.4.1 Inhalable Particulate Matter (PM_{10})

Simulated annual average PM_{10} concentrations do not exceed the NAAQS of 40 µg/m^3 off-site or at any AQSRs (Figure 19). The 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) at a portion of the mine housing but not at any of the AQSRs (Figure 20). Simulated results show that only the short-term NAAQS are exceeded at the mine housing but at no off-site AQSRs, thus the simulated operations are unlikely to be a significant risk to human health at the surrounding receptors.

7.4.2 Respirable Particulate Matter ($PM_{2.5}$)

Simulated annual average $PM_{2.5}$ concentrations do not exceed the NAAQS of 20 µg/m^3 or the future NAAQS of 15 µg/m^3 off-site or at any AQSRs (Figure 21). The 24-hour NAAQS (4 days of exceedance of 40 µg/m^3) are only exceeded at a portion of the mine housing but not at any of the AQSRs (Figure 22). The future 24-hour NAAQS (4 days of exceedance of 25 µg/m^3) are only exceeded at a portion of the mine housing but not at any of the AQSRs (Figure 22). Simulated results show that only the short-term NAAQS are exceeded at the mine housing but no off-site AQSRs, thus the simulated operations are unlikely to be a significant risk to human health at the surrounding receptors.

7.4.3 Fallout Dust

Based on the highest monthly simulated dustfall rates, the daily average dustfall rate does not exceed the NDCR residential limit of 600 mg/m^2-day of site or at any AQSRs and are below 400 mg/m^2-day at all agricultural areas (Figure 23).

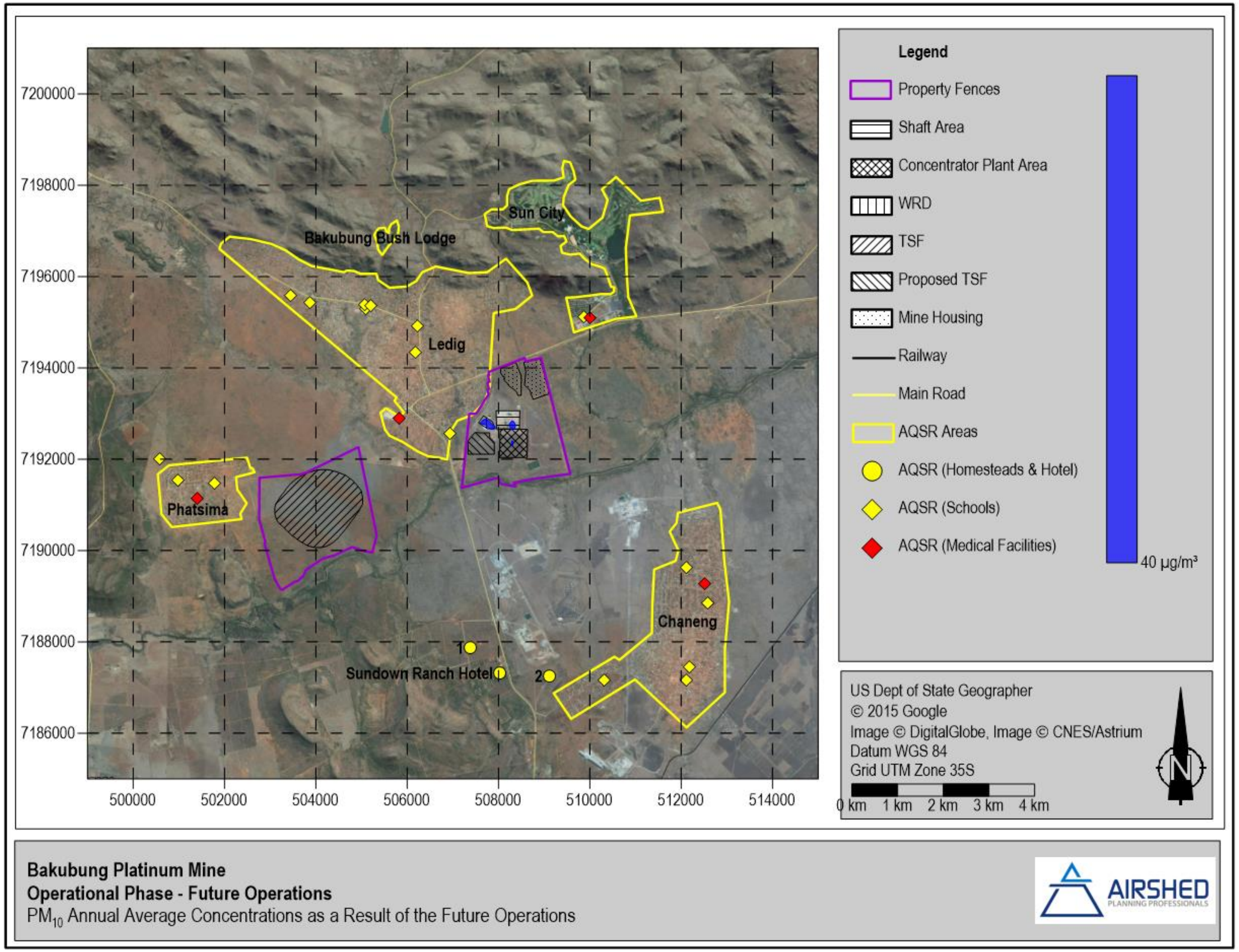


Figure 19: Future - simulated area of exceedance of the annual average PM_{10} NAAQS

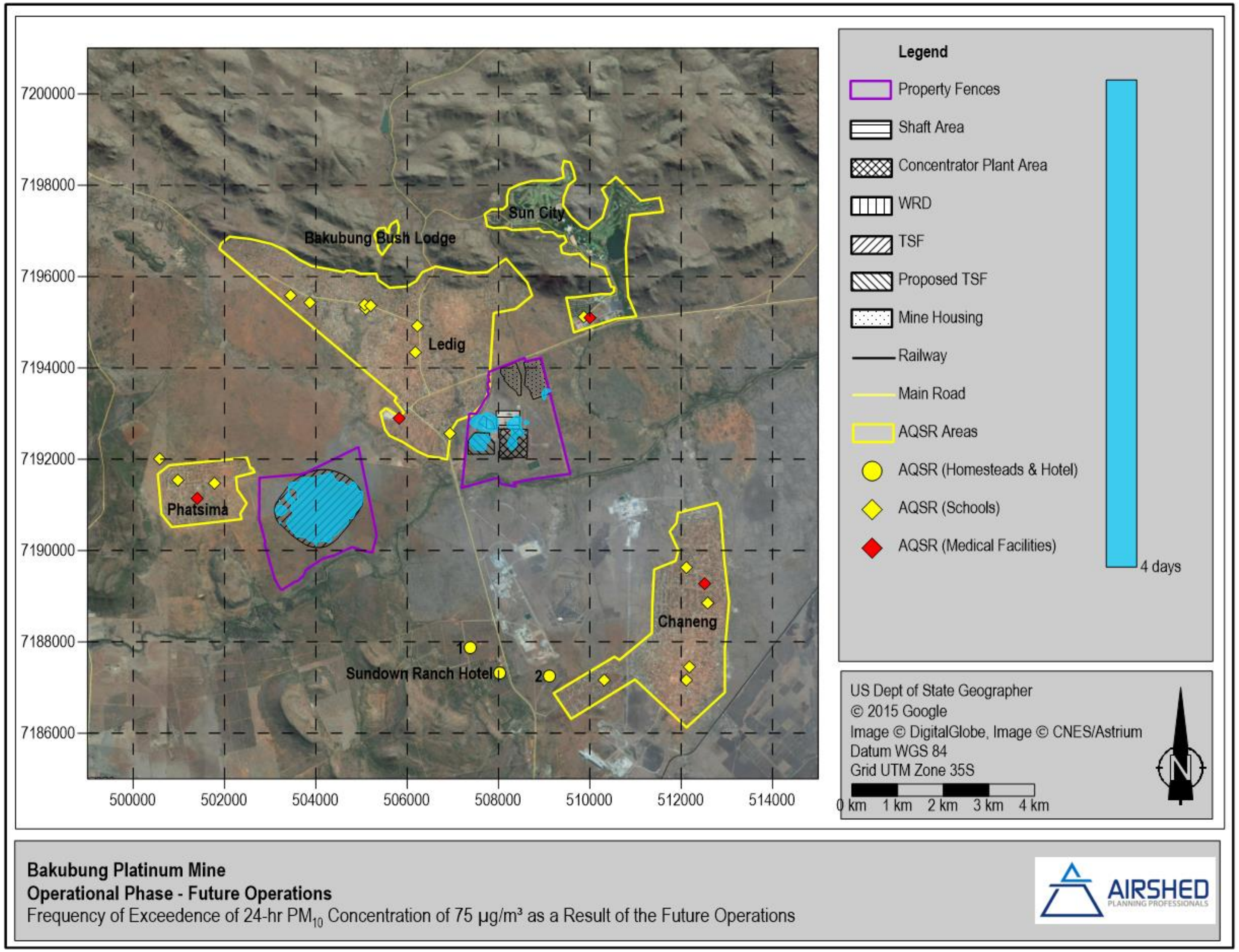


Figure 20: Future - simulated area of exceedance of the 24-hour PM_{10} NAAQS

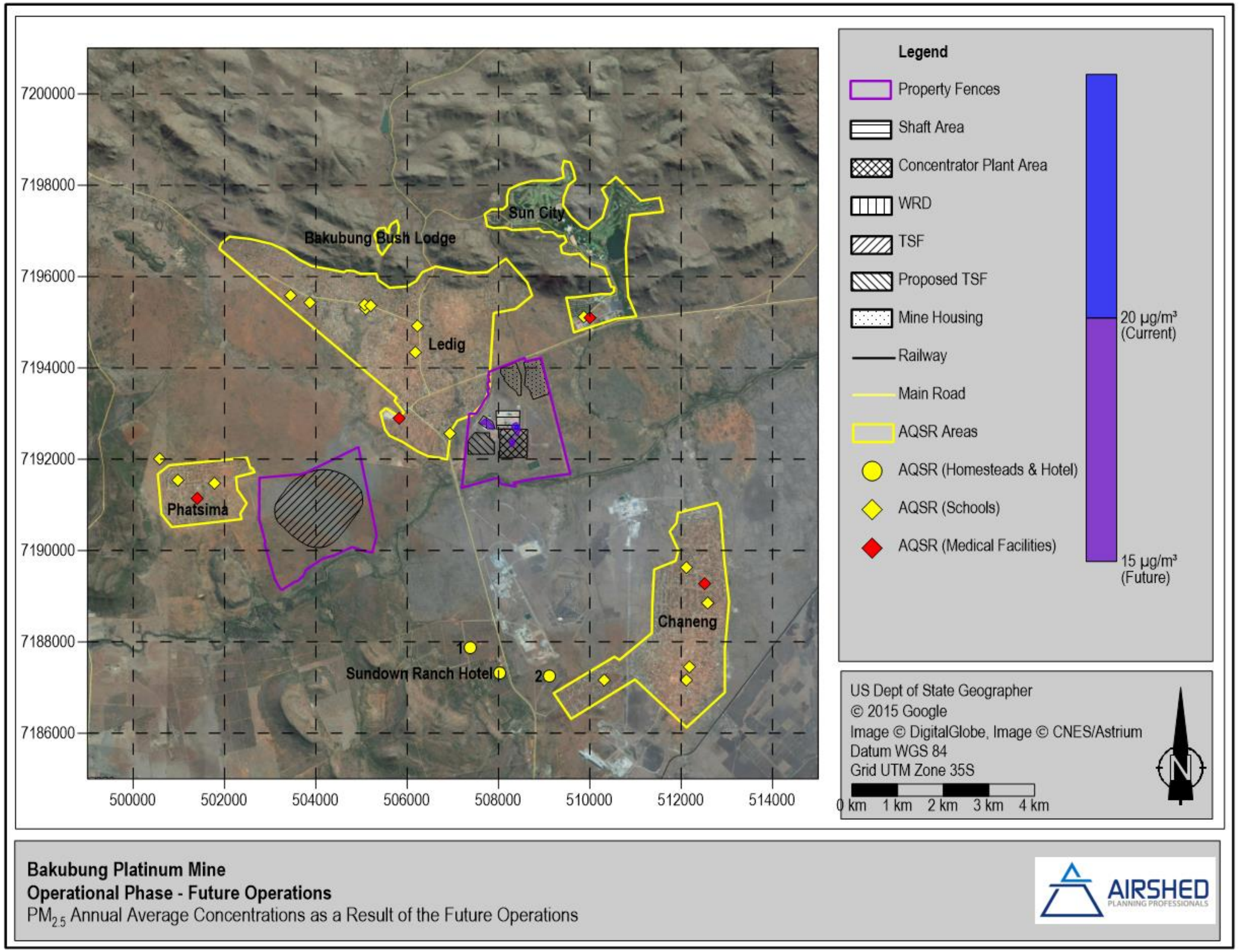


Figure 21: Future - simulated area of exceedance of the annual average $PM_{2.5}$ NAAQS

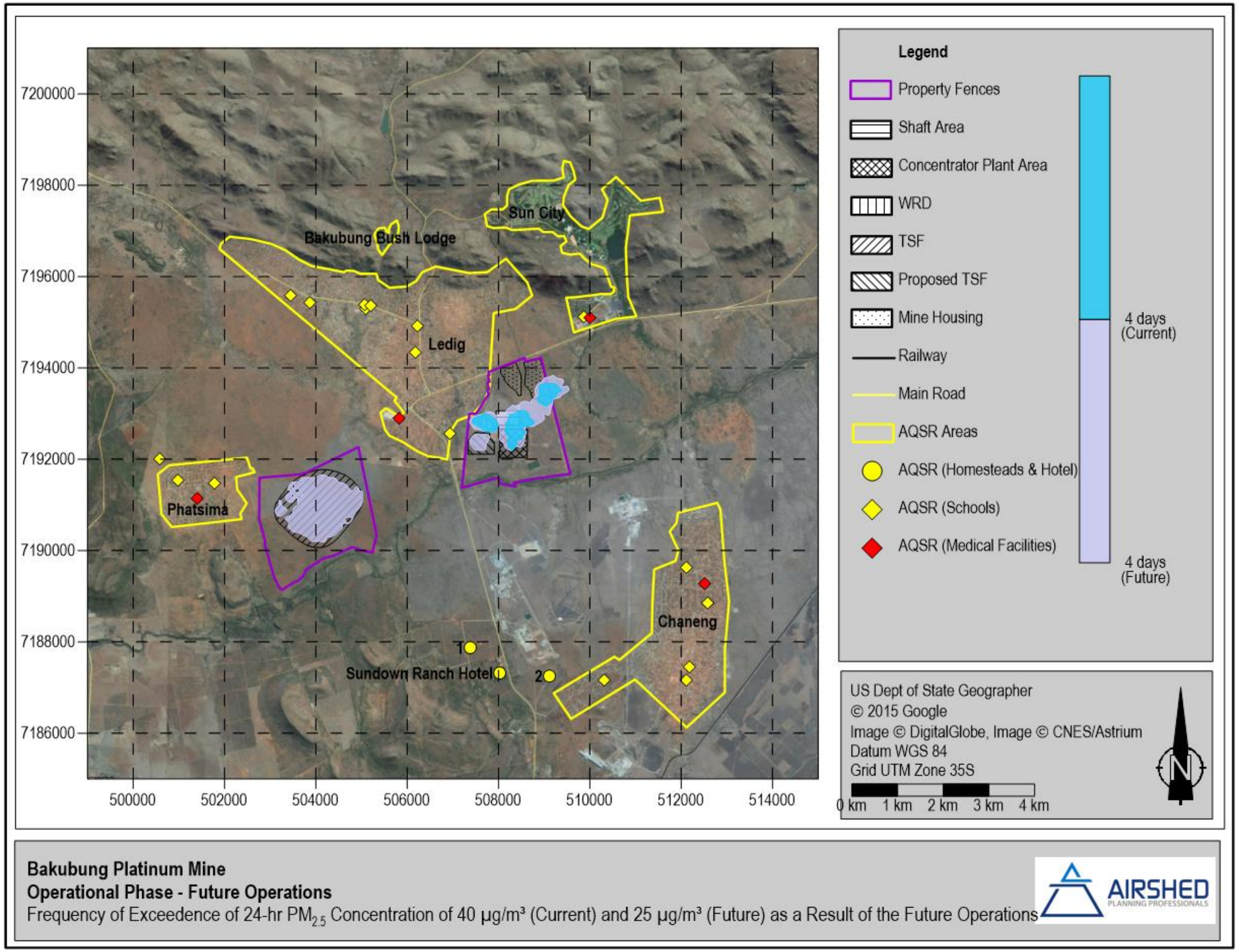


Figure 22: Future - simulated area of exceedance of the 24-hour PM_{10} NAAQS

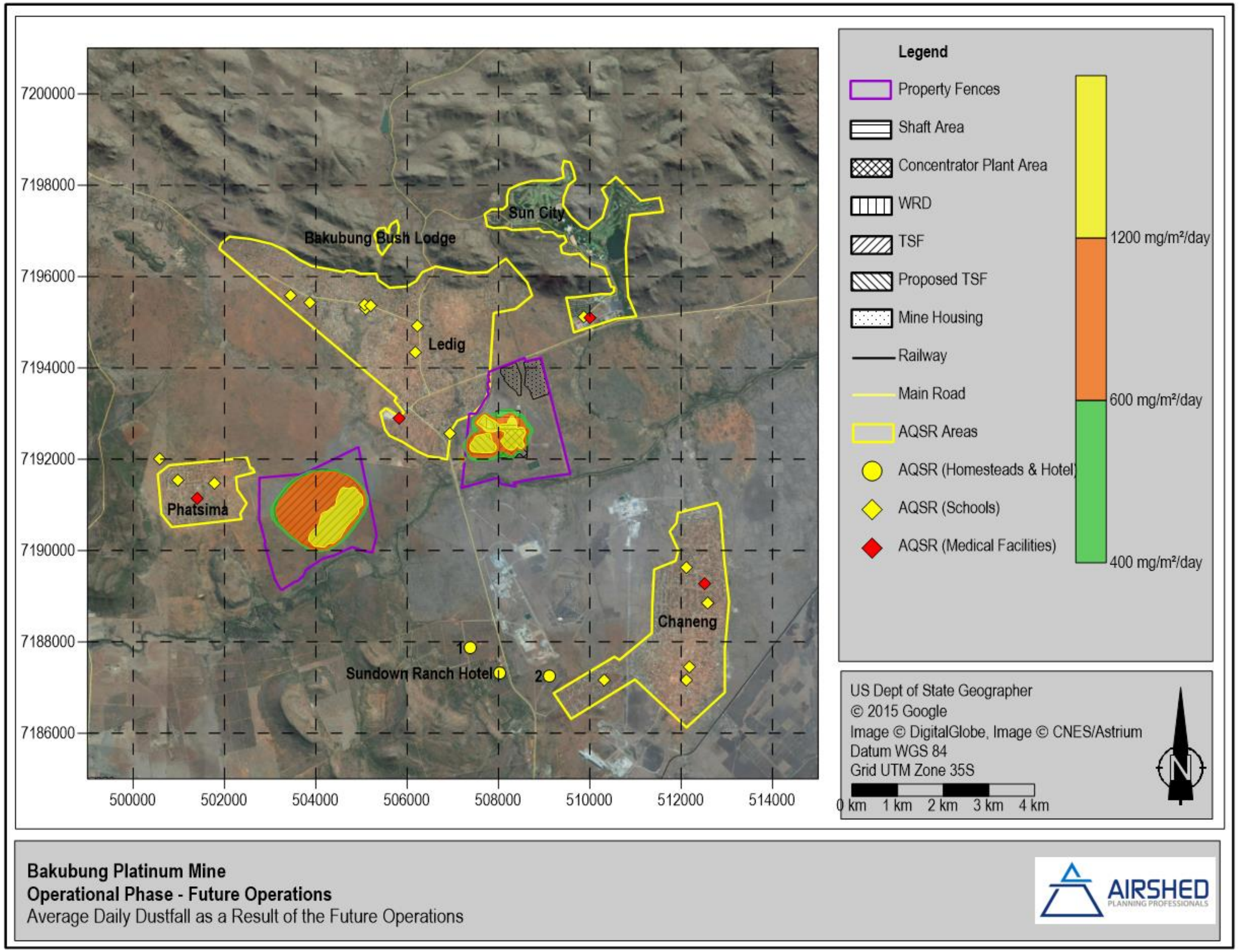


Figure 23: Future - average daily dustfall rates based on simulated highest monthly dust fallout

7.5 Impact Significance Rating - Operations

The main pollutants of concern were determined to be PM (including TSP, PM_{10} and $PM_{2.5}$). Non-compliance of PM_{10} and $PM_{2.5}$ concentrations could result in human health impacts. A quantitative assessment of the potential impacts from PM_{10}, $PM_{2.5}$ and dust fallout (TSP) during the operational phase is discussed below. The Knight Piésold rating methodology was used.

Two potential direct operational phase impacts on the air quality of the area were identified:

- B1: Potential impact on human health from increased pollutant concentrations due to proposed operations; and
- B2: Increased nuisance dustfall rates associated with the proposed operations.

Two potential cumulative operational phase impacts on the air quality of the area were identified:

- C1: Potential impact on human health from increased pollutant concentrations during the future operations; and
- C2: Increased nuisance dustfall rates associated with future operations.

7.5.1 Potential Impact B1: Potential Impact on Human Health from Increased Pollutant Concentrations Caused by Activities Associated with the Proposed Operations

It is unlikely that the long-term and short-term NAAQS will be exceeded at AQSRs (with and without mitigation). The proposed operations are proposed to last for 7 years. The rating is LOW without and with mitigation applied (Table 14).

7.5.2 Potential Impact B2: Increased Nuisance Dustfall Rates Associated with the Proposed Operations

It is unlikely that the NDCR limit for residential areas will be exceeded at AQSRs (with and without mitigation). The proposed operations are proposed to last for 7 years. The rating is LOW without and with mitigation applied (Table 15).

7.5.3 Potential Impact C1: Potential Impact on Human Health from Increased Pollutant Concentrations Caused by Activities Associated with the Future Operations

It is unlikely that the long-term NAAQS will be exceeded at AQSRs (with and without mitigation). The short-term is likely to be exceeded at the mine housing and thus the severity/magnitude of low was selected. The future operations are likely to last for more than 15 years. The rating is LOW without and with mitigation applied (Table 16).

7.5.4 Potential Impact C2: Increased Nuisance Dustfall Rates Associated with the Future Operations

It is unlikely that the NDCR limit for residential areas will be exceeded at AQSRs (with and without mitigation). The future operations are likely to last for more than 15 years. The rating is LOW without and with mitigation applied (Table 17).

Table 14: Health risk impact significance summary table for the proposed operations

Air Quality	Description	Rating
Project activity or issue	Proposed operations	N/A
Potential impact	Increased health risk at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in PM_{10} and $PM_{2.5}$ concentrations at AQSRs	-
Direct/Indirect/Cumulative	Direct	D
	Significance Before Mitigation	
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20%.	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Medium term - Impacts are predicted to be of medium duration (5 – 15 years).	3
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1
Probability (P)	Medium probability - 60% likelihood that the impact will occur.	3
Significance (SP)	**Low**	**18**
	Significance After Mitigation	
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Medium term - Impacts are predicted to be of medium duration (5 – 15 years).	3
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1

Air Quality	Description	Rating
Probability (P)	Low probability - 40% likelihood that the impact will occur.	2
Significance (SP)	Low	12
Potential mitigation measures (construction)	Vegetation and/or nets of side slopes.	N/A

Table 15: Nuisance impact significance summary table for the proposed operations

Air Quality	Description	Rating
Project activity or issue	Construction	N/A
Potential impact	Nuisance dustfall rates at AQSRs	N/A
Nature of the Impact		
Positive or negative	Negative due to increase in dustfall rates at AQSRs	-
Direct/Indirect/Cumulative	Direct	D
Significance Before Mitigation		
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Medium term - Impacts are predicted to be of medium duration (5 – 15 years).	3
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	Low	6
Significance After Mitigation		
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Reversible	1

Air Quality	Description	Rating
	Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	
Duration (D)	Medium term - Impacts are predicted to be of medium duration (5 – 15 years).	3
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**6**
Potential mitigation measures (construction)	Vegetation and/or nets of side slopes.	N/A

Table 16: Health risk impact significance summary table for the future operations

Air Quality	Description	Rating
Project activity or issue	Proposed operations	N/A
Potential impact	Increased health risk at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in PM_{10} and $PM_{2.5}$ concentrations at AQSRs	-
Direct/Indirect/Cumulative	Cumulative	C
	Significance Before Mitigation	
Severity / magnitude (M)	Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %	2
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Long term - impacts that will continue for the life of the Project but ceases when the Project stops operating.	4

Air Quality	Description	Rating
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2
Probability (P)	Medium probability - 60% likelihood that the impact will occur.	3
Significance (SP)	**Low**	**27**
Significance After Mitigation		
Severity / magnitude (M)	Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %	2
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Long term - impacts that will continue for the life of the Project but ceases when the Project stops operating.	4
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2
Probability (P)	Medium probability - 60% likelihood that the impact will occur.	3
Significance (SP)	**Low**	**27**
Potential mitigation measures (construction)	Vegetation and/or nets of side slopes of proposed TSF.	N/A

Table 17: Nuisance impact significance summary table for the future operations

Air Quality	Description	Rating
Project activity or issue	Construction	N/A
Potential impact	Nuisance dustfall rates at AQSRs	N/A
Nature of the Impact		
Positive or negative	Negative due to increase in dustfall rates at AQSRs	-
Direct/Indirect/Cumulative	Cumulative	C
Significance Before Mitigation		

Air Quality	Description	Rating
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Long term - impacts that will continue for the life of the Project but ceases when the Project stops operating.	4
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**6**
Significance After Mitigation		
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Long term - impacts that will continue for the life of the Project but ceases when the Project stops operating.	4
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**6**
Potential mitigation measures (construction)	Vegetation and/or nets of side slopes of proposed TSF.	N/A

8 Impact Assessment: Decommissioning and Closure Phases

8.1 Increase in Pollutant Concentrations and Dustfall Rates

It is assumed that all operations will have ceased by the decommissioning phase. It is expected that all surface infrastructure will be demolished and removed except for roads which will remain for public use. It is also expected that the TSF surfaces will be covered with topsoil and vegetated.

The potential for air quality impacts during the decommissioning phase will depend on the extent of demolition and rehabilitation efforts during decommissioning and on features which will remain.
The likely activities associated with the decommissioning phase of the operations are:

- infrastructure removal/demolition;
- topsoil recovered from stockpiles for rehabilitation and re-vegetation of surroundings;
- vehicle entrainment on unpaved road surfaces during rehabilitation. Once that is done, vehicle activity associated with BPM should cease; and
- exhaust emissions from vehicles utilised during the closure phase. Once that is done, vehicle activity associated with BPM should cease;

The closure phase includes the period of aftercare and maintenance after the decommissioning phase. During this phase rehabilitated areas are checked and maintained. The activities that may be included are irregular and minimal vehicle entrainment on roads and vehicle exhaust emissions when the property is checked on.

8.2 Assessment of Impact

Insufficient data was available for the decommissioning and closure phases thus dispersion modelling for the actual activities that will result in dust emissions could not be undertaken. It is not anticipated that the various activities would result in higher $PM_{2.5}$ and PM_{10}, GLCs and dustfall rates than the operational phase activities. The temporary nature of the decommissioning activities would likely reduce the significance of the potential impacts. The minimal activities during closure will likely result in insignificant potential impacts. A qualitative assessment of decommissioning and closure operations from the PM_{10} and TSP impacts perspective is discussed below.

Two potential direct decommissioning phase impacts on the air quality of the area were identified:

- D1: Potential impact on human health from pollutant concentrations associated with decommissioning activities;
- D2: Nuisance dustfall rates associated with decommissioning activities;

Two potential direct closure phase impacts on the air quality of the area were identified:

- E1: Potential impact on human health from pollutant concentrations associated with closure activities;
- E2: Nuisance dustfall rates associated with closure activities;

D1 and E1 would likely impact on human health whereas D2 and E2 would impact on amenities.

8.2.1 Potential Impact D1: Potential Impact on Human Health from Pollutant Concentrations Associated with Decommissioning Activities

The sources of emissions would include the demolition of infrastructure and removal of material; topsoil reclaiming and covering of exposed areas; re-vegetation; and the operation of mechanical equipment. It is unlikely that the long-term and short-term NAAQS will be exceeded at AQSRs with mitigation in place, but it is probable that the short-term NAAQS limits will likely be exceeded in the case of unmitigated operations. The decommissioning operations are likely to last for a few years but impacts at AQSRs are likely to be intermittent. The rating is LOW without and with mitigation applied (Table 18).

8.2.2 Potential Impact D2: Nuisance Dustfall Rates Associated with Decommissioning Activities

The sources of emissions would include the demolition of infrastructure and removal of material; topsoil reclaiming and covering of exposed areas; re-vegetation; and the operation of mechanical equipment. It is probable that the NDCR limit for residential areas will not be exceeded at AQSRs (with and without mitigation). The decommissioning operations are likely to last for a few years but impacts at AQSRs are likely to be intermittent. The rating is LOW without and with mitigation applied (Table 19).

8.2.3 Potential Impact E1: Impaired Human Health from Pollutant Concentrations Associated with Closure Activities

The sources of emissions would include the site inspections and where necessary the addition of topsoil and vegetation; and the operation of mechanical equipment. It is unlikely that the long-term and short-term NAAQS will be exceeded at AQSRs (with and without mitigation). The operations will likely occur for less more than 5 year but less than 15 years but impacts at AQSRs are likely to be intermittent. The rating is LOW without and with mitigation applied (Table 20).

8.2.4 Potential Impact E2: Nuisance Dustfall Rates Associated with Closure Activities

The sources of emissions would include the site inspections and where necessary the addition of topsoil and vegetation; and the operation of mechanical equipment. It is probable that the NDCR limit for residential areas will not be exceeded at AQSRs (with and without mitigation). The operations will likely occur for less more than 5 year but less than 15 years but impacts at AQSRs are likely to be intermittent. The rating is LOW without and with mitigation applied (Table 21).

Table 18: Health risk impact significance summary table for the decommissioning operations

Air Quality	Description	Rating
Project activity or issue	Decommissioning	N/A
Potential impact	Increased health risk at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in PM_{10} and $PM_{2.5}$ concentrations at AQSRs	-
Direct/Indirect/Cumulative	Direct	D
	Significance Before Mitigation	
Severity / magnitude (M)	Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %	2
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**6**
	Significance After Mitigation	
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20%.	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1

Air Quality	Description	Rating
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**4**
Potential mitigation measures	• Reduction of fugitive PM emissions through the watering of roads, stockpiles and inactive open areas and the use of screens. • Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	N/A

Table 19: Nuisance impact significance summary table for the construction operations

Air Quality	Description	Rating
Project activity or issue	Decommissioning	N/A
Potential impact	Nuisance dustfall rates at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in dustfall rates at AQSRs	-
Direct/Indirect/Cumulative	Direct	D
	Significance Before Mitigation	
Severity / magnitude (M)	Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %	2
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**6**
	Significance After Mitigation	

Air Quality	Description	Rating
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**4**
Potential mitigation measures	• Reduction of fugitive PM emissions through the watering of roads, stockpiles and inactive open areas and the use of screens. • Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	N/A

Table 20: Health risk impact significance summary table for the closure operations

Air Quality	Description	Rating
Project activity or issue	Closure	N/A
Potential impact	Increased health risk at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in PM_{10} and $PM_{2.5}$ concentrations at AQSRs	-
Direct/Indirect/Cumulative	Direct	D
	Significance Before Mitigation	
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Reversible	1

Air Quality	Description	Rating
	Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**4**
	Significance After Mitigation	
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**4**
Potential mitigation measures	Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	N/A

Table 21: Nuisance impact significance summary table for the closure operations

Air Quality	Description	Rating
Project activity or issue	Closure	N/A
Potential impact	Nuisance dustfall rates at AQSRs	N/A

Air Quality	Description	Rating
	Nature of the Impact	
Positive or negative	Negative due to increase in dustfall rates at AQSRs	-
Direct/Indirect/Cumulative	Direct	D
	Significance Before Mitigation	
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20%.	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	1
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**4**
	Significance After Mitigation	
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20%.	1
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Temporary - Impacts are predicted to intermittent/ occasional over a short period	1
Spatial extent (S)	Site only - Impacts that are limited to the site boundaries.	1
Probability (P)	Improbable - 20% likelihood that the impact will occur.	1
Significance (SP)	**Low**	**4**

Air Quality	Description	Rating
Potential mitigation measures	Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	N/A

9 Impact Assessment: Cumulative Including Other Operations in the Region

9.1 Elevated Pollutant Concentrations and Dustfall Rates

Land use in the region includes residences, farming, mining, industry and wilderness. The mining and processing operations (BPM as well as other companies), industrial activities, farming activities, domestic fires, vehicle exhaust emissions and dust entrained by vehicles on public roads without the addition of the proposed operations will likely result in elevated ambient air pollutant concentrations and dustfall rates compared to an area where there are no anthropogenic emission sources. The simulated impacts from the approved operations are discussed in Section 7.3 and are likely to be the greatest contributor to ambient air quality in close proximity to the proposed TSF project operational areas. It is difficult to predict the location and contribution of the sources from residences, farming and wilderness to existing air quality, but it is unlikely these sources will result in NAAQS being exceeded, at least in the long-term.

The potential cumulative scenario includes the following atmospheric emissions:

a. Particulate emissions from BPM future operations;
b. Miscellaneous fugitive dust sources including vehicle entrainment on roads and wind-blown dust from open areas;
c. Particulate emissions from vehicle exhaust emissions;
d. Particulate emissions from household fuel burning; and
e. Particulate emissions from biomass burning (e.g. wild fires).

Based on the simulated results there is not likely to be any exceedances of the long-term NAAQS at AQSRs near BPM.

10 Impact Assessment: No Go Option

10.1 Potential State of the Air Quality

Should the no go option be embarked on, only the approved activities will occur in the area without the addition of the proposed TSF operations. Thus, the potential for an increase in ambient air pollutant concentrations and dustfall rates is small. The current site operations are also likely to cease at some stage and the ambient air quality will improve. There is the possibility of a gradual reduction in ambient air quality in close proximity to the operations should there be any additional mining, industrial and farming operations, vehicle entrainment on roads, wind-blown dust from open areas, vehicle exhaust, household fuel burning and biomass burning.

11 Management of Atmospheric Emissions and Air Quality Impacts

11.1 Bojanala Platinum District Municipality Environmental Management Framework

The Bojanala Platinum District Municipality Environmental Management Framework (EMF) (Meyer, Cilliers, & Kriek, 2015) was compiled by the Centre for Environmental Management (CEM) of North-West University on for the North West Department of Rural, Environment and Agricultural Development (NWREAD). The EMF provides guidance to the Provincial, District and Local Departments on systems that can be implemented to protect the environment (and human health) and to provide information that can assist in the decision-making regarding authorisation of environmental applications and requirements of authorisations. The following topics in this document are of key importance in improving air quality within Ledig, Chaneng and Phatsima located in the vicinity of the BPM:

- “The living conditions of the majority of the population have improved in respect of access to services and rollout of formal housing, but concerns about the maintenance of service infrastructure and the lack of basic services in informal and rural settlements, remain.
- There has been a transformation in terms of the general approach to waste management, but technical limitations still limit the effectiveness of interventions and roll-out of waste removal services to rural settlements.”

11.2 North West Province Air Quality Management Plan

As stated in the North West EIP the 2015 North West AQMP is under review; this is believed to still be true as the document could not be located on the Government Printing Works website nor the National and Provincial Governments Ministries responsible for Air Quality Management any other publicly accessible website after an extensive search (including the use of the ISBN, obtained from the 2018 Environment Outlook Report). Government Printing Works are the custodian and publisher of Government Gazettes including National Gazettes, Provincial Gazettes, Liquor License Gazettes, Legal Gazettes, and Tender Bulletins. The Bojanala Platinum District Municipality EMF and North West 2018 Environment Outlook Report mention the 2015 North West AQMP (North West Provincial Government, 2015) while the Waterberg-Bojanala Priority Area AQMP mentions the 2009 North West AQMP (North West Provincial Government, 2009). Although the 2009 North West AQMP could be accessed online, the document is less detailed than the 2015 North West AQMP.

The 2015 North West AQMP was obtained from North-West University, the compilers of the Bojanala Platinum District Municipality EMF. The 2015 North West AQMP is a guide for Government on strategies to be implemented to improve air quality in the Province. According to the 2015 North West AQMP other objectives are:

- “Identify and reduce the negative impact on human health and the environment of poor air quality;
- Address the effects of emissions from the use of fossil fuels in residential applications;
- Address the effects of emissions from industrial sources;
- Address the effects of emissions from any point or non-point source of air pollution other than residential applications and industrial processes;
- Implement South Africa’s international obligations relating to air quality;
- Give effect to best practice in air quality management; and
- Provide a framework for the district municipalities to develop their own air quality management plans.”

The 2015 North West AQMP included estimated PM_{10} emissions from mine tailings facilities in the North West and the Bojanala Platinum District Municipality. The proposed BPM TSF will be 24 ha which is approximately 0.25% of the total area (9 730 ha) of tailings facilities in the Bojanala Platinum District Municipality at the time that the 2015 NW AQMP emissions inventory was compiled; the estimated PM_{10} emissions from the BPM TSF is 0.022% of the Bojanala Platinum District Municipality estimated PM_{10} emissions from tailings (17 046 960 kg/year). The BPM TSF with respect to the NW tailings facilities is 0.062% of the size and 0.06% of the emissions. In summary, the BPM new TSF is expected to add 24 ha to the tailings area in North West Province, specifically the Bojanala Platinum District Municipality and 3 775 kg/year. Since the 2015 North West AQMP emissions inventory was initiated in 2010 and completed in 2011 it is unlikely that both the approved and proposed BPM TSFs were included; both tailings will add 259 ha and 40 491 kg/year of PM_{10} emissions. The 2015 North West AQMP dispersion modelling results show that in the area of the BPM; the SO_2, NO_2 and PM_{10} are all incompliance with the NAAQS.

11.3 Bakubung Platinum Mine Dust Management Plan

Based on the findings of the impact assessment, the following mitigation, management and monitoring recommendations are made.

11.4 Air Quality Management Objectives

The main objective of the proposed air quality management measures for the project is to ensure that operations at the facility cumulatively result in ambient air concentrations that are within the relevant ambient air quality criteria off-site. In order to define site specific management objectives, the main sources of pollution needed to be identified.

11.4.1 Source Specific Management and Mitigation Measures

Windblown dust is the main source of pollution from the proposed project.

11.4.1.1 Windblown dust control options

Main techniques adopted to reduce windblown dust potential include source extent reduction, source improvement and surface treatment methods:

- Source extent reduction:
  - Disturbed area reduction – planned through deposition on one area at a time.
  - Disturbance frequency reduction – planned through continuous revegetation and rehabilitation.
  - Dust spillage prevention and/or removal.
- Source Improvement:
  - Disturbed area wind exposure reduction, e.g. vegetation on side slopes, wind fences/nets at source areas. Erosion losses from grassed slopes measured by (Blight, 1989) was found to be in the order of 80% less compared to uncontrolled slopes.

A combination of the above measures could be applied to the operations to ensure exposed areas are kept free of dry fine materials.

11.4.2 Source Monitoring

It should be noted that the data provider will be required to continue reporting annual emissions on the NAEIS system. Dustfall monitoring near sources can be an effective mechanism in determining the main emission sources and the continuation of the current network is suggested.

11.4.3 Ambient Air Quality Monitoring

Ambient air quality monitoring can serve to meet various objectives, such as:

- Compliance monitoring;
- Validate dispersion model results;
- Use as input for health risk assessment;
- Assist in source apportionment;
- Temporal trend analysis;
- Spatial trend analysis;
- Source quantification; and,
- Tracking progress made by control measures.

It is recommended that, as a minimum continuous dustfall sampling continue to be conducted as part of the project's management plan. The current sampling network locations should be sufficient.

11.4.3.1 Dustfall Sampling

The ASTM method covers the procedure of dustfall collection and its measurement and employs a simple device consisting of a cylindrical container (not less than 150 mm in diameter) exposed for one calendar month (30 ±2 days). Even though the method provides for a dry bucket, de-ionised (distilled) water can be added to ensure the dust remains trapped in the bucket. The bucket stand includes a wind shield at the level of the rim of the bucket to provide an aerodynamic shield. The bucket holder is connected to a 2 m galvanized steel pole, which is either planted and cemented or directly attached to a fence post (Figure 24). This allows for a variety of placement options for the fallout samplers. Two buckets are usually provided for each dust bucket stand. Thus, after the first month, the buckets get exchanged with the second set.

Collected sampled are sent to an accredited laboratory for gravimetric analysis. At the laboratory, each sample will be rinsed with clean water to remove residue from the sides, and the contents filtered through a coarse (>1 mm) filter to remove insects and other course organic detritus. The sample is then filtered through a pre-weighed paper filter to remove the insoluble fraction. This residue and filter are dried, and gravimetrically analysed to determine total dustfall.

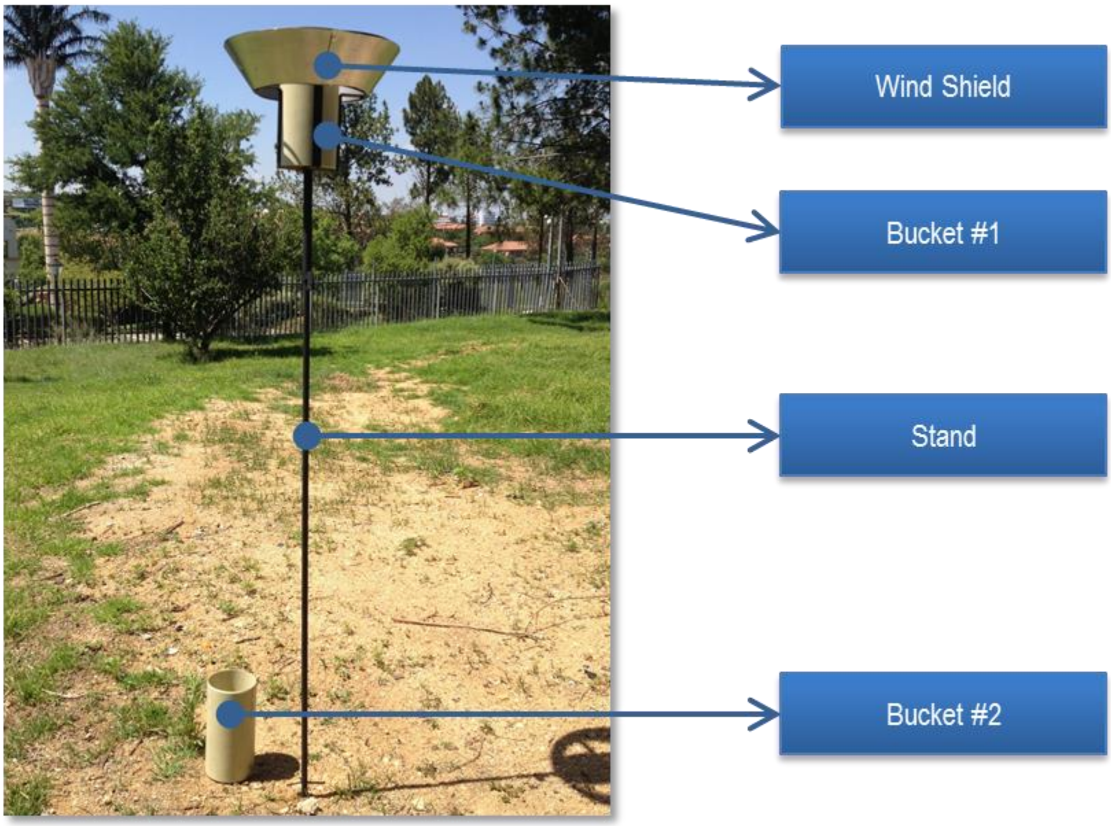


Figure 24: Dustfall collection unit example

11.5 Record-keeping, Environmental Reporting and Community Liaison

11.5.1 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), 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 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.

11.5.2 Liaison Strategy for Communication with I&APs

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

11.5.3 Financial Provision

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 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.

12 FINDINGS AND RECOMMENDATIONS

12.1 Main Findings

An air quality impact assessment was conducted for activities proposed as part of the TSF project. The main objective of this study was to establish baseline air quality in the study area and to quantify the extent to which ambient pollutant levels will change as a result of the proposed operations. The baseline and impact study then informed the air quality management and mitigation measures recommended as part of the Air Quality Management Plan (AQMP). This section summarises the main findings of the baseline and impact assessments.

The main findings of the baseline assessment are:

- The significant AQSRs are those of Ledig, Sun City, Chaneng, Phatsima, along with isolated homesteads and the Sundown Ranch Hotel.
- The main sources likely to contribute to baseline PM emissions include mining and processing operations, industrial operations, vehicle entrained dust from local roads, vehicle exhaust and windblown dust from exposed areas.
- Other sources of PM include farm activities, occasional biomass burning and household fuel burning in the residential areas of Ledig, Chaneng and Phatsima.
- The area is dominated by winds from the east. These westerly winds are associated with strong winds of above 6 m/s. According to the US EPA wind speeds exceeding 5 m/s are likely to result in windblown dust emissions.
- A fallout dust measurements dataset was provided for the area from September 2008 to December 2019. The National Dust Control Regulations (NDCR) limit for residential areas of 600 mg/m^2-day were exceeded at some of the residential sites. SA NDCR limit for non-residential areas of 1 200 mg/m^2-day were exceeded at some of the non-residential sites. However, there were not more than two exceedances or consecutive exceedances in a year at any of the sites.

The main findings of the impact assessment are as follows:

- Construction phase:
  - The significance of construction related inhalation health and nuisance impacts are likely to have a "low" rating without and with mitigation.
- Operational phase:
  - PM (TSP, PM_{10} and $PM_{2.5}$) emissions and impacts were quantified.
  - PM_{10} and $PM_{2.5}$ concentrations are within compliance off-site and at all the AQSRs over the short- and long-term for the proposed TSF operations. PM_{10} and $PM_{2.5}$ concentrations are within compliance off-site and at all the AQSRs over the short- and long-term for the approved and proposed and future operations; however they exceed the short-term NAAQS at a portion of the mine housing.
  - Dustfall rates are below the NDCR limits for residential areas at all AQSRs and 400 mg/m^2-day at all agricultural areas.

  - The significance of operations related inhalation health and nuisance impacts are likely to be "low" without and with mitigation.
- Decommissioning and closure phases:
  - The significance of decommissioning operations related inhalation health and nuisance impacts are likely "low".
  - The significance of closure operations related inhalation health and nuisance impacts are likely "low".

12.2 Air Quality Recommendations

To ensure the lowest possible impact on AQSRs and environment it is recommended that the air quality management plan as set out in this report should be adopted. This includes:

- The management of the proposed operations; resulting in the mitigation of associated air quality impacts;
- The continuation of ambient air quality monitoring; and
- Record keeping and community liaison procedures.

Based on these findings and provided the measures recommended are in place, it is the specialist opinion that the project may be authorised.

13 GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE STATEMENT

13.1 Introduction

13.1.1 The greenhouse effects

Greenhouse gases are "those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC, 2007). Human activities since the beginning of the Industrial Revolution (taken as the year 1750) have produced a 40% increase in the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 406 ppm in early 2017 (NOAA, 2017). This increase has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle (NOAA, 2017). Anthropogenic carbon dioxide (CO_2) emissions (i.e., emissions produced by human activities) come from combustion of fossil fuels, principally coal, oil, and natural gas, along with deforestation, soil erosion and animal agriculture (IPCC, 2007).

13.1.2 International agreements

In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change, (UNFCCC) as a framework for international cooperation to combat climate change by limiting average global temperature increases and the resulting climate change, and coping with impacts that were, by then, inevitable.

By 1995, countries launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol. The Kyoto Protocol legally binds developed country parties to emission reduction targets. The Protocol's first commitment period started in 2008 and ended in 2012. As agreed in Doha in 2012, the second commitment period began on 1 January 2013 and will end in 2020 (UNFCCC, 2017) but due to lack of ratification has not come into force.

The Paris Agreement (2016) builds upon the Convention and – for the first time – brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.

The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives.

The Paris Agreement requires all Parties to put forward their best efforts through “nationally determined contributions” (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts.

In 2018, Parties will take stock of the collective efforts in relation to progress towards the goal set in the Paris Agreement and to inform the preparation of NDCs. There will also be a global stocktake every 5 years to assess the collective progress towards achieving the purpose of the Agreement and to inform further individual actions by Parties. As of February 2020, 189 Parties of the 197 Parties to the UNFCCC Convention, including South Africa, had ratified the Paris agreement. South Africa submitted its intended NDC (INDC) to the UNFCCC on 1 November 2016.

13.2 The Project

Wesizwe owns and operates the BPM and as part of this operation proposes to construct and operate another TSF prior to the operation of the already approved TSF. The operations are in North West Province of South Africa, near Ledig. The approved operations are the underground mining and processing of platinum. It is likely that the current power requirements will be sufficient for the proposed TSF operations and no change will be made to the mobile equipment fleet due to the operations.

13.3 Methodology

13.3.1 Impact Assessment Methodology

As the emission of greenhouse gases has a global impact, it is not feasible to follow the normal impact assessment methodology viz. comparing the state of the physical environment after implementation of the project to the condition of the physical environment prior to its implementation. Instead, this report will assess the following

(i) The GHG emissions during the construction, operation and decommissioning of the project compared to the global and South African emission inventory and to international benchmarks for the project.
(ii) The impact of climate change over the lifetime of the project taking the robustness of the project into account.
(iii) The vulnerability of communities in the immediate vicinity of the project to climate change.

13.3.1.1 Carbon Footprint Methodology

The Carbon Footprint is an indication of the greenhouse gases estimated to be emitted directly and/or indirectly by an organisation, facility or product.

It can be estimated from

$$Carbon\ emissions = Activity\ information * emission\ factor * GWP$$

where

- *Activity information* relates to the activity that causes the emissions
- *emission factor* refers to the amount of GHG emitted per unit of activity
- *GWP* or global warming potential is the potential of an emitted gas to cause global warming relative to CO_2. This converts the emissions of all GHGs to the equivalent amount of CO_2 or CO_2-e.

For combustion processes, the emission factor is often calculated from a carbon mass balance, where the combustion of each unit mass of carbon in the fuel leads to an equivalent emission of 3.67 mass units of CO_2 (from 44/12, the ratio of molecular weight of CO_2 to that of carbon).

13.3.1.1.1 Scope of Carbon Footprint

This report considers Scope 1 emissions, which are the emissions directly attributable to the project, as well as Scope 2 emissions, which are the emissions associated with bought-in electricity over the lifetime of the project. Scope 3 emissions, which consider the “embedded” carbon in bought-in materials, are not considered here, in line with the guidelines provided by the International Finance Corporation (IFC, 2012)

13.4 Description of the Baseline

13.4.1 South African Climate Change Literature and Legislation

13.4.1.1 National Climate Change Response Policy 2011

South Africa ratified the UNFCCC in August 1997 and acceded to the Kyoto protocol in 2002, with effect from 2005. However, since South Africa is an Annex 1 country it implies no binding commitment to cap or reduce GHG emissions.

The National Climate Change Response White Paper stated that in responding to climate change, South Africa has two objectives: to manage the inevitable climate change impacts and to contribute to the global effort in stabilising GHG emissions at a level that avoids dangerous anthropogenic interference with the climate system. The White Paper proposes mitigation actions, especially a departure from coal-intensive electricity generation, be implemented in the short- and medium-term to match the GHG trajectory range. Peak GHG emissions are expected between 2020 and 2025 before a decade long plateau period and subsequent reductions in GHG emissions.

The White Paper also highlighted the co-benefit of reducing GHG emissions by improving air quality and reducing respiratory diseases by reducing ambient particulate matter, ozone and SO_2 concentrations to levels in compliance with NAAQS by 2020. In order to achieve these objectives, the DEA has appointed a service provider to establish a national GHG emissions inventory, which will report through SAAQIS.

13.4.1.2 Intended Nationally Determined Contribution

The South African Intended Nationally Determined Contribution (INDC) submission was completed in 2015. This was undertaken to comply with decision 1/CP.19 and 1/CP.20 of the Conference of the Parties to the UNFCC. This document describes South Africa's INDC on adaptation, mitigation and finance and investment necessities to undertake the resolutions.

As part of the adaption portion the following goals have been assembled:

1. Goal 1: Development and implementation of a National Adaption Plan. The implementation of this will also result in the implementation of the National Climate Change Response Plan (NCCRP) as per the 2011 policy.
2. Goal 2: In the development of national, sub-national and sector strategy framework, climate concerns must be taken into consideration.
3. Goal 3: An official institutional function for climate change response planning and implementation needs to be assembled.
4. Goal 4: The creation of an early warning, vulnerability and adaptation monitoring system
5. Goal 5: Develop policy regarding vulnerability assessment and adaptation needs.
6. Goal 6: Disclosure of undertakings and costs with regards to past adaptation strategies.

As part of the mitigation portion the following have been or can be implemented:

- The approval of 79 (5 243 MW) renewable energy Independent Power Producer (IPP) projects as part of a Renewable Energy Independent Power Producer Procurement Programme (REI4P). An additional 6 300 MW is being deliberated.
- A "Green Fund" has been created to back green economy initiatives. This fund will be increased in the future to sustain and improve successful initiatives.
- It is intended that by 2050 electricity will be decarbonised.
- Carbon Capture and Sequestration (or Carbon Capture and Storage) (CCS) which is discussed in more detail in the mitigation section.
- To support the use of electric and hybrid electric vehicles.
- Reduction of emissions can be achieved through the use of energy efficient lighting; variable speed drives and efficient motors; energy efficient appliances; solar water heaters; electric and hybrid electric vehicles; solar PV; wind power; CCS; and advanced bio-energy.

13.4.1.3 Greenhouse Gas Emissions

Regulations pertaining to GHG reporting using the NAEIS were published on 3 April 2017 (Republic of South Africa, 2017) (GN 257 in GG 40762; amended by GN R994, 11 September 2020). The South African mandatory reporting guidelines 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 South African Greenhouse Gas Emission Reporting System (SAGERS) web-based monitoring and reporting system will be used to collect GHG information in a standard format for comparison and analyses. The system forms part of the national atmospheric emission inventory component of South African Atmospheric Emission Licensing and Inventory Portal (SAAELIP). The site operations qualify to report their GHG emissions to SAGERS.

The DEFF is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the Intergovernmental Panel on Climate Change's (IPCC) default emission figures may be used to populate the SAAQIS GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors. Technical guidelines for GHG emission estimation have been issued.

Also, the Carbon Tax Act (Act 15 of 2019) (Republic of South Africa, 2019) includes details on the imposition of a tax on the CO_2-e of GHG emissions. Certain production processes indicated in Annexure A of the Declaration of Greenhouse Gases as Priority Pollutants (GN 710 in GG 40966, 21 July 2017) (Republic of South Africa, 2017) with GHG in excess of 0.1 megatonnes (Mt), measured as CO_2-e, are required to submit a pollution prevention plan to the Minister for approval.

13.4.2 South African Energy supply

Coal provides in the order of 70% of the primary energy supply to the SA economy, with in excess of 90% of the electricity being generated from coal combustion. South Africa is thus regarded as having a carbon-intensive energy economy.

13.4.2.1 Planning framework

The 1998 White Paper on the Energy Policy of the Republic of South Africa covered both supply and demand of energy for the next decade and made specific provision for independent suppliers of energy to enter the market. No additional capacity ensued during the decade 1998 to 2008, leading to the 'load shedding' of 2008 and the subsequent short-term interventions to ensure stability of supply. The 2011 Integrated Resource Plan (IRP) (Department of Energy, 2011) provided a planning basis for the period up to 2030 and made provision for the supply of energy (including renewable energy) by independent producers, as well as 9600 MW of nuclear energy over that period. An update of the IRP was published in October 2019 (Department of Energy, 2019); the drafts have attracted considerable criticism regarding the cost and greenhouse gas implications as part of the public participation process, including a report by the CSIR arguing for a much larger use of renewable sources (Wright, et al., 2017). The published 2019 IRP includes plans for electricity supply up to 2030 and beyond, including the decarbonisation of electricity supply after 2050. The plan includes the expansion of electricity generated through gas to power technologies such that they contribute 8.1% of the installed capacity by 2030 making use of imported gas imports until local natural gas reserves are explored (Department of Energy, 2019).

13.4.2.2 Additional energy supply

Seventy-nine renewable energy Independent Power Producer (IPP) projects have been approved and several others are being deliberated as part of a Renewable Energy Independent Power Producer Procurement Programme (REI4P).

13.4.3 GHG Inventories

13.4.3.1 National GHG Emissions Inventory

South Africa is perceived as a global climate change contributor and is undertaking steps to mitigate and adapt to the changing climate. DEA is categorised as the lead climate change institution and is required to coordinate and manage climate related information such as development of mitigation, monitoring, adaption and evaluation strategies (Department of Environmental Affairs, 2014). This includes the establishment and updating of the National GHG Inventory. The National Greenhouse Gas Improvement Programme (GHGIP) has been initiated; it includes sector specific targets to improve methodology and emission factors used for the different sectors as well as the availability of data.

The 2000 to 2010 National GHG Inventory was prepared using the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines (IPCC, 2006). According to the National GHG Inventory (Department of Environmental Affairs, 2014) the 2010 total GHG emissions were estimated at approximately 544.314 million metric tonnes CO_2-e (excluding Forestry and Other Land Use (FOLU)). This was a 21.1% increase from the 2000 total GHG emissions (excluding FOLU). FOLU is estimated to be a net carbon sink which reduces the 2010 GHG emissions to 518.239 million metric tonnes CO_2-e. The assessment (excluding FOLU) showed the main sectors contributing to GHG emissions in 2010 to be the energy industries (solid fuels); road transport; manufacturing industry and construction (solid fuels); and energy industries (liquid fuels). In 2010 the energy industry contributed 78.7% to the total GHG emissions (excluding FOLU), this increased by 3.6% from 2000.

The DEA is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the IPCC default emission figures may be used to populate the SAAQIS GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors.

13.4.3.2 GHG Emission Inventory for the sector

The proposed operations would most likely fall under the category of “industry” for the global GHG inventory and “manufacturing industries and construction” for the national GHG inventory. According to the “mitigation of climate change” document as part of the IPCC fifth Assessment Report (AR5) (IPCC, 2014) the 2010 global GHG emissions were 49 (±4.5) Gt CO_2-e, 21% (10 Gt CO_2-e) of which is as a result of industry. The South African category contributes approximately 41.117 million metric tonnes CO_2-e (excluding and including FOLU).

13.5 Effects of Climate Change on the Region

13.5.1.1 Climate Change Reference Atlas

In 2017 the SAWS published an updated Climate Change Reference Atlas (CCRA) based on Global Climate Change Models (GCMs) projections. It must be noted that as with all atmospheric models there is the possibility of inaccuracies in the results as a result of the model's physics and accuracy of input data; for this reason, an ensemble of models' projections is used to determine the potential change in near-surface temperatures and rainfall depicted in the CCRA. The projections are for to 30-year periods described as the near future (2036 to 2065) and the far future (2066 to 2095). Projected changes are defined relative to a historical 30-year period (1976 to 2005). The Rossby Centre regional model (RCA4) was used in the predictions for the CCRA which included the input of nine GCMs results. The RCA4 model was used to improve the spatial resolution to 0.44° x 0.44°- the finest resolution GCMs in the ensemble were run at resolutions of 1.4° x 1.4° and 1.8° x 1.2°.

Two trajectories are included based on the four Representative Concentration Pathways (RCPs) discussed in the IPCC's fifth assessment report (AR5) (IPCC, 2013). RCPs are defined by their influence to atmospheric radiative forcing in the year 2100. RCP4.5 represents an addition to the radiation budget of 4.5 W/m^2 as a result of an increase in GHGs. The two RCPs selected were RCP4.5 representing the medium-to-low pathway and RCP8.5 representing the high pathway. RCP4.5 is based on a CO_2 concentration of 560 ppm and RCP8.5 on 950 ppm by 2100. RCP4.5 is based on if current interventions to reduce GHG emissions being sustained (after 2100 the concentration is expected to stabilise or even decrease). RCP8.5 is based on if no interventions to reduce GHG emissions being implemented (after 2100 the concentration is expected to continue to increase).

13.5.1.1.1 RCP4.5 trajectory

Based on the median, for the region in which the BPM and AQSRs discussed are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 1°C and 2.5°C for the near future and between 2.5°C and 3°C for the far future. The seasonal average temperatures are expected to increase for all seasons. The total annual rainfall is expected to decrease by between 0 mm and 10 mm for the near future and the far future. For the near future the total seasonal rainfall is expected to increase in summer, remain the same or slightly increase for autumn. Winter total rainfall is expected to decrease and spring to stay the same or decrease slightly for near future. The total seasonal rainfall is expected to remain the same or slightly decrease for summer, winter and spring for the far future. Autumn total rainfall is expected to increase for the far future.

13.5.1.1.2 RCP8.5 trajectory

Based on the median, the region in which the BPM and AQSRs discussed are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 2.5°C and 3°C for the near future and between 4.5°C and 5°C for the far future. The seasonal average temperatures are expected to increase for all seasons. The total annual rainfall is expected to decrease by between 0 mm and 10 mm for the near future and far future. For the near future the total seasonal rainfall is expected to increase for summer and remain the same or slightly increase for autumn and spring. Winter total rainfall is expected to decrease for the near future. The total seasonal rainfall is expected to decrease for autumn and winter for the far future. Spring and summer total rainfall is expected to increase for the far future.

13.6 Impact Assessment: The Project's Carbon Footprint

13.6.1 The Project's GHG Emissions

For the construction and the future operations, scope 1 and scope 2 are applicable. The future scope 1 emissions based on the annual fuel use will likely not change from the approved scope 1 emissions. For the future scope 2 emissions based on the approximate electricity requirements there will be no change from the current scope 2 emissions. Ultimately there will be no project specific GHG emissions during the operational phase. For the decommissioning operations scope 1 and scope 2 are also applicable but available data is insufficient to determine construction operations GHG emissions.

13.6.1.1 Carbon Sequestration and Carbon Sink

Accounting for the uptake of carbon by plants, soils and water is referred to as *carbon sequestration* and these sources are commonly referred to as *carbon sinks*. Quantifying the rate of carbon sequestration is however not a trivial task requiring detailed information on the geographical location, climate (specifically temperature and humidity) and species dominance (Ravin & Raine, 2007).

Photosynthesis is the main sequestration process in forests and in soils. Carbon is absorbed as fixed carbon into the roots, trunk, branches and leaves and during the shedding of leaves, but is emitted – although at a reduced percentage – from foliage and when biomass decays. Several factors also determine the amount of carbon absorbed by trees such as species, size and age. Mature trees, for example, will absorb more carbon than saplings (Ravin & Raine, 2007).

Aspects required in order to calculate the carbon stack change in the pool (in tons of carbon per year) include the climate, the type of forest or vegetation removed and the type to be re-introduced, and management measures. Soil type also has different absorption and release ratios that need to be included. This level of information was not available for the quantification of carbon sequestration for the project.

There will be an initial carbon sink loss due to the vegetation removal for the expansion area. As operations progress, the previously cleared areas that form part of the project will be rehabilitated resulting in a carbon sink gain. Even assuming rehabilitation uses the same indigenous vegetation, the carbon balance will not be completely restored. There may also be potential soil degradation due to stockpiling. The main CO_2 contribution from the project will therefore be based on the clearing of vegetation.

13.6.1.2 Construction

Comparison of the results of this section with the figures obtained for the operational period will indicate that the GHG emissions during construction do not constitute a material fraction of the overall emissions; fairly rudimentary estimation methods were therefore considered sufficient for this sub-section.

Scope 1: This includes clearing of the area (assumed to be grassland. The IPCC methodology (IPCC, 2006) assumes a cropland carbon stock of 6.1 tonne C/ha. For the construction period, approximately 24.1 hectares (ha) will be denuded for the construction of the TSF. To account for additional service road surfaces and other possible laydown space, a total of 50.4 ha land clearance was assumed for the calculations. Assuming all carbon eventually reports to the atmosphere as CO_2, it is therefore calculated that a total of 307 tonnes of CO_2 would be released. The IPCC provides default emission factors for diesel in kg CO_2/unit energy content, while the density and calorific values are available from a number of standard engineering databases (Table 22). The United States Environmental Protection Agency (US EPA) provides default emission factors for distillate fuel oil no. 2 (diesel) powered off-road heavy vehicles in kg CO_2/gallon (US) (Table 23). The emissions may vary slightly depending on the calorific value of the diesel. Using the values in Table 22 and Table 23, the emission factor can be calculated per litre or gallon of fuel used, which allows calculation of the total emissions directly from proposed fuel use. The estimated amount of fuel (diesel) used per annum by mobile equipment is 1 605 240 litres (424 059 gallons (US)).

A summary of the greenhouse gas emissions is provided in Table 24. The total CO_2 (equivalent) emissions of approximately 4 369 tpa should be seen in the perspective of the annual South African emission rate of GHG, which is approximately 518.239 million metric tonnes CO_2-e. The calculated CO_2-e emissions from the construction operations therefore contribute less than 0.0008% to the total of South African GHG emissions, 0.01% of the total “manufacturing industries and construction” sector.

Table 22: Calculation of liquid fuel-related CO_2 emission factors for vehicles

Type of fuel	CO_2 emission factor kg/TJ	Density kg/m^3	Calorific value kJ/kg	Emission factor kg CO_2/litre fuel
Diesel	74100	840	43 400	2.701

Table 23: Vehicles - liquid fuel-related methane and nitrous oxide emission factors

Type of fuel	Density kg/m^3	Emission factor g CH_4/gallon	Emission factor g N_2O/gallon
Diesel	840	0.58	0.26

Table 24: Summary of estimated greenhouse gas emissions for the construction operations

Source Group	CO_2	CH_4 as CO_2-e	N_2O as CO_2-e	Total CO_2-e	CO_2-e
	tpa	tpa	tpa	tpa	%
Mobile Equipment Exhaust	4 330	6.04	32.9	***4 369***	93%

Source Group	CO_2	CH_4 as CO_2-e	N_2O as CO_2-e	Total CO_2-e	CO_2-e
	tpa	tpa	tpa	tpa	%
Clearing	307	-	-	***307***	7%
Total	**4 637**	**6.04**	**32.9**	**4 676**	**100%**

13.6.1.3 Operations

The main sources of GHG due to approved operations are the mobile and stationary equipment consuming diesel (scope 1) and the electricity usage (scope 2). The scope 1 sources of GHG as well as the emission quantities will change slightly for future operations; thus, the Project will not have a significant additional operational GHG emissions.

Scope 1: The IPCC provides default emission factors for diesel in kg CO_2/unit energy content, while the density and calorific values are available from a number of standard engineering databases (Table 22). The United States Environmental Protection Agency (US EPA) provides default emission factors for distillate fuel oil no. 2 (diesel) powered off-road heavy vehicles in kg CO_2/gallon (US) (Table 23). Using the values in Table 22 and Table 23, the emission factor can be calculated per litre or gallon of fuel used, which allows calculation of the total emissions directly from proposed fuel use. The estimated amount of fuel (diesel) used per annum by mobile equipment is 112 000 litres (29 587 gallons (US)).

Scope 2: These emissions are related to purchased energy, heat or steam and can be calculated from the average South African emission factor published annually by Eskom in its integrated report. The emission factors for the last four years are given in Table 25. This allows the scope 2 emissions to be calculated directly from electricity consumption from the Eskom or local authority account. The 2018/2019 value of 1.04 tonnes CO_2/MWh was used in the calculations. The average annual electricity usage for BPM based on 2019 data is 25 036 715.38 kWh.

Table 25: Eskom electricity emission factors

Year	Emission Factor (tonnes CO_2/MWh)	Source
2015/2016	1.00	Eskom 2016 Integrated Report
2016/2017	0.98	Eskom 2017 Integrated Report
2017/2018	0.97	Eskom 2018 Integrated Report
2018/2019	1.04	Eskom 2019 Integrated Report
Median	0.99	

A summary of the greenhouse gas emissions for scope1 and scope 2 is provided in Table 26. The total CO_2 (equivalent) emissions of approximately 26 343 tpa should be seen in the perspective of the annual South African emission rate of GHG, which is approximately 518.239 million metric tonnes CO_2-e. The calculated CO_2-e emissions from the approved operations therefore contribute approximately 0.0048% to the total of South African GHG emissions, 0.06% of the total "manufacturing industries and construction" sector.

Table 26: Summary of estimated greenhouse gas emissions for the approved operations

Source Group	CO_2	CH_4 as CO_2-e	N_2O as CO_2-e	Total CO_2-e	CO_2-e
	tpa	tpa	tpa	tpa	%
Mobile Equipment Exhaust	302	0.422	2.29	***305***	1%
Electricity Usage	26 038	-	-	***26 038***	99%
Total	**26 340**	**0.422**	**2.29**	**26 343**	**100%**

13.6.1.4 Decommissioning

There is insufficient data at this point to determine the decommissioning GHG emissions.

13.6.2 The Project's GHG Impact

13.6.2.1 Magnitude

The GHG emissions from the project will be relatively low and will not likely result in a noteworthy contribution to climate change on its own.

13.6.2.2 Impact on the sector

With the future operations there will be not likely be additions to the equipment fleet, thus no change in scope 1 emissions from the proposed BPM operations is expected. This would therefore not change the "manufacturing industry and construction" sector's total annual CO_2-e emissions.

13.6.2.3 Impact on the National Inventory

The clearing of vegetation (even though the TSF will likely be re-vegetated at some stage) will result in a carbon sink loss and an increase towards the national GHG inventory. With the construction operations there will also be additions to the equipment fleet and will likely result in an increase in scope 1 emissions from the BPM; therefore, changing the national inventory's total annual CO_2-e emissions by approximately 4 676 tpa during the construction phase.

13.6.2.4 Alignment with national policy

Most of the South African policy is still draft or in the planning phase; however, as from the next SAGERS reporting period BPM may have to start reporting on GHG emissions.

13.7 Impact Assessment: Potential Effect of Climate Change on the Project

The most significant of the discussed climate change impacts on the project would be because of temperature increase and possible reduction in rainfall.

13.7.1 Temperature

With the increase in temperature there is the likelihood of an increase in discomfort, possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). Both these have the potential to negatively affect staff performance and productivity. There is also the increased change in the overheating of equipment/machinery with effects on production. Finally, there is the possibility of increased evaporation and thus the need for increased use of water for mitigation and process operations.

13.7.2 Rainfall

The decrease in rainfall can result in reduced water supply.

13.8 Impact Assessment: Potential Effect of Climate Change on the Community

From the discussed climate change impacts, all aspects would likely have a significant effect on the surrounding communities.

13.8.1 Temperature

With the increase in temperature there is the likelihood of an increase in discomfort and possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). There is also the possibility of increased evaporation which in conjunction with the decrease in rainfall can result in water shortage. This does not only negatively affect the community's water supply but can reduce the crop yields and affect livestock (agriculture) resulting in a food security issue.

13.8.2 Rainfall

As discussed above the decrease in rainfall can result in the following effects:

- Reduced water supply
- A negative impact on food security

13.9 Adaptation and Management Measures

Climate change management includes both mitigation and adaptation. The main aim of mitigation is to stabilise or reduce GHG concentrations as a result of anthropogenic activities. This is achievable by lessening sources (emissions) and/or enhancing sinks through human intervention.

13.9.1.1 Bojanala Platinum District Municipality Climate Change Vulnerability Assessment and Response Plan

The Bojanala Platinum District Municipality Climate Change Vulnerability Assessment and Response Plan (Bojanala Platinum District Municipality, 2016); hereafter referred to as the BPDM CCVA&RP was completed in October 2016. The study determined that Human Health and Human Settlements were of high sensitivity and low adaptability. The BPDM CCVA&RP identified the following as the main risks to human health associated with climate change:

- "Projected increases in storm events may result in increased risk of drowning, injuries and population displacement impacts.
- A changing climate will also result in increased water borne and communicable diseases as increasing air and water temperatures may create favourable conditions for the incubation and transmission of waterborne diseases.
- Projected temperature increases will also impact negatively on the young and elderly. People working outdoors will be particularly vulnerable to increases in temperature."

The BPDM CCVA&RP proposed the following Projects were included in the Service Delivery and Budget Implementation Plan (SDBIP):

1. Human Health
    a. "Manage potential increased impacts on strategic infrastructure
        i. Conduct risk and vulnerability assessment of climate change on key transport infrastructure.
        ii. Develop a framework that will equip the transport sector with responding to climate change impacts of extreme weather such as floods, increased rainfall and storm surges.
        iii. Conduct a routine assessment of transport infrastructure in order to identify priority areas for interventions to reduce climate change risk.
        iv. Incorporate climate change resilience when planning, designing and implementing transport infrastructure. Engineering approaches and choice of materials should consider impacts.
        v. Include climate change resilience into tendering documents for transport infrastructure.
        vi. Implement effective disaster management systems that will deal with increased number of extreme events affecting transport infrastructure."
2. Human Settlements
    a. "Manage potential increased impacts on informal dwellings
        i. Conduct a climate change risk assessment on informal dwellings.
        ii. Develop mechanisms that will enable vulnerable communities in informal dwellings to respond to climate change risks.
        iii. Conduct regular assessments of informal dwellings in order to identify priority areas for interventions to reduce climate change risk.
        iv. Make use of early warning systems that will inform communities of possible extreme weather events.
        v. Develop community emergency plans that will assist with responding to climate change related impacts/risks.

vi. Implement informal settlement upgrades.

b. Manage potential increased isolation of rural communities
   i. Identify alternative access routes to rural communities.
   ii. Identify roads at risk of flooding and erosion and prioritise those for upgrading and maintenance.
   iii. Identify local responses that will reduce isolation of rural communities.
   iv. Build climate change resilient road infrastructure that serves as a link for rural areas.
   v. Implement flooding drainage systems that will reduce impacts on rural roads.
   vi. Develop economic nodes and improved service provision in rural areas to improve connectivity.

c. Manage potential increased migration to urban and peri-urban areas
   i. Assess drivers and dynamics of migration.
   ii. Identify alternative basic service provision options for rural areas, such as water tanks, new sanitation services, etc.
   iii. Develop and implement rural development programs to create economic opportunities.
   iv. Promote behavioral change within communities that will contribute towards the building of economic nodes within rural areas and consequently reduce the need for migration.

d. Manage potential decreased income from tourism
   i. Conduct climate change impact assessment on tourism.
   ii. Develop resilience programs for tourism assets.
   iii. Investigate available alternative tourism and recreational opportunities.
   iv. Develop and promote tourism opportunities that are climate change robust.
   v. Develop disaster risk management plans that consider climate change impacts on tourism assets.that will alert industries and businesses on extreme weather events in order to manage exposure of employees."

13.9.1.2 Project adaptation and mitigation measures

13.9.1.3 General

Additional support infrastructure can reduce the climate change impact on the staff and project, for example ensuring adequate water supply for staff and reducing on-site water usage as much as possible. Wesizwe could initiate a community development program if one is not already in place.

There are research studies and literature reviews that have been and are being undertaken regarding the effects of Climate Change on water-borne and communicable diseases in South Africa most of which relate to vector-borne diseases and to a lesser extent contaminated food (mostly animal) products. There is also research on the negative effects of climate change on persons with HIV/AIDS and Tuberculosis as well as other sensitive populations such as children and the elderly. Most of these issues will likely require significant resources to combat including funds and international collaborations for both research and implementation plans as well as on-going programs that will exceed the operational period of BPM. If Wesizwe initiates a community development program if one is not already in place, it can assist the surrounding communities both with knowledge and tools in an effort to reduce the impact of climate change in these communities.

13.9.1.3.1 Scope 1 (technology/sector-specific)

One way to keep GHG emissions to a minimum would be to ensure there is minimal fuel use, this can be achieved by ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program. A measure of reducing the project's impact is to limit the removal of vegetation and to ensure that that as much as possible revegetation occurs and possibly even the addition of vegetation to the surrounding project area.

13.9.1.3.2 Scope 2

Carbon Capture and Storage (CCS) is a method of mitigating the contribution of fossil fuel emissions based on capturing CO_2 from large point sources such as power stations and storing it. CCS involves carbon dioxide being concentrated through various options and then permanently stored. The best researched carbon dioxide storage option is geological storage which involves injecting CO_2 directly into underground geological formations. Oil fields, gas fields, saline formations, un-mineable coal seams, and saline-filled basalt formations have been suggested as storage sites. Various physical (e.g. highly impermeable rock) and geochemical trapping mechanisms would prevent the CO_2 from escaping to the surface. The CSIR undertook a study into the potential for CO_2 storage in South Africa (2004). The study concluded that the storage of CO_2 in depleted gas fields, coal mines or gold mines is very limited. Deep saline reservoirs offer the highest potential for the geological storage of CO_2 in South Africa, especially withing the Karoo Super Group sediments of the Vryheid Formation in the north and the Katberg Formation near Burgersdorp/Molteno. However, due to a lack of information about the porosity and permeability of these of reservoirs, significant work is required before CO_2 sequestration into geological formations will be possible (Engelbrecht, Golding, Hietkamp, & Scholes, 2004). The South African CCS Atlas (Cloete, 2010) identified at a theoretical level that South Africa had about 150 Gigatons (Gt) of storage capacity. Less than 2% of this is onshore.

A significant limitation of CCS is its energy penalty. The technology is expected to use between 10 – 40% of the energy produced by a power station to capture the CO_2 (IPCC, 2005). Wide scale adoption of CCS may erase efficiency gains of the last 50 years and increase resource consumption by one third. However, even taking the fuel penalty into account, overall levels of CO_2 abatement remain high, at approximately 80 - 90% compared to a plant without CCS.

Carbon offset options could include investment in REDD+ (Reducing Emissions from Deforestation and forest Degradation) initiatives (Thambiran & Naidoo, 2017). REDD+ initiatives in developing countries incentivise communities to undertake forestry and related activities that can contribute to reducing land-based GHG emissions associated with deforestation and degradation and through sequestration of CO_2 in forests and agroforestry (Thambiran & Naidoo, 2017). REDD+ programmes are also mechanisms for socio-economic development. However, the expansion of the forestry industry in South Africa, will require quantification of the impact of expanded activities on water resources (as highlighted in the Draft National Climate Change Adaptation Strategy [Government Gazette No.42466:644, May 2019]).

13.10 Impact Significance Rating

13.10.1 Potential for Impacts on Global Climate Change from Greenhouse Gases Associated with the Project Activities

The sources of emissions would include site establishment in proposed additional operating areas; vegetation clearing; stripping and stockpiling of topsoil and other earthworks; collection, storage and removal of construction related waste; the construction of all required infrastructure; and the operation of mechanical equipment. It is unlikely that the long-term and short-term NAAQS will be exceeded at AQSRs (with and without mitigation). The construction operations are likely to last for less than a year. The rating is LOW without and with mitigation applied (Table 27).

Table 27: Greenhouse gases impact significance summary table the construction phase

Climate Change	Description	Rating
Project activity or issue	Construction	N/A
Potential impact	Reduction in carbon sink through vegetation clearance and increased GHG emissions from equipment associated with construction activities	N/A
	Nature of the Impact	
Positive or negative	Negative due to reduction in carbon sink and increase in GHG emissions	-
Direct/Indirect/Cumulative	Direct	D
	Significance Before Mitigation	
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Recoverable Environmental - where the affected environment is altered but natural functions and ecological processes may continue or recover with human input.	3
Duration (D)	Short term - Impacts are predicted to be of short duration (0 – 5 years)	2
Spatial extent (S)	International - Impacts that affect internationally important resources such as areas protected by international conventions, international waters etc	5
Probability (P)	Medium probability - 60% likelihood that the impact will occur	3
Significance (SP)	**Low**	**27**
	Significance After Mitigation	
Severity / magnitude (M)	Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20	1
Reversibility (R)	Recoverable Environmental - where the affected environment is altered but natural functions and ecological processes may continue or recover with human input.	3
Duration (D)	Short term - Impacts are predicted to be of short duration (0 – 5 years)	2
Spatial extent (S)	International - Impacts that affect internationally important resources such as areas protected by international conventions, international waters etc	5
Probability (P)	Low probability - 40% likelihood that the impact will occur	2

Climate Change	Description	Rating
Significance (SP)	**Low**	**18**
Potential mitigation measures	• Minimising the area cleared and adequate revegetation or the addition of vegetation around the project. • Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	N/A

13.11 Conclusions and recommendation

- The CO_2-e (scope 1) emissions for construction is approximately 4 676 tpa therefore contributing less than 0.001% to the total of South Africa's GHG emissions and 0.01% of the total "manufacturing industry and construction" sector.
- The CO_2-e (scope 1) emissions for approved operations is approximately 305 tpa therefore contributing less than 0.0001% to the total of South Africa's GHG emissions and 0.0007% of the total "manufacturing industry and construction" sector.
- The GHG emissions from the project are low and will not likely result in a noteworthy contribution to climate change on their own.
- The project and the community are likely to be negatively impacted by climate change due to increased temperatures and possible water shortages (decreased rainfall and possible increased evaporation).
- The following is recommended to reduce the impacts of climate change on the project and the community:
    - Additional support infrastructure can reduce the climate change impact on the staff and project, for example ensuring adequate water supply for staff and reducing on-site water usage as much as possible.
    - Wesizwe could initiate a community development program if one is not already in place.
- The following is recommended to reduce the GHG emissions from project:
    - Ensuring the vehicles and equipment are maintained through an effective inspection and maintenance program.
    - Limiting the removal or vegetation and ensuring adequate re-vegetation or addition of vegetation surrounding the project. Vegetation acts as a carbon sink.

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15 APPENDIX A: AUTHORS' CURRICULUM VITAE AND SACNASP CERTIFICATE

CURRICULUM VITAE

Name	Natasha Anne Shackleton (née Gresse)
Date of Birth	12 September 1988
Nationality	South African
Identification Number	880912 0054 081
Passport Number	A05514095
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Senior Consultant
Profession	Meteorologist employed as an Air Quality and Noise Consultant
Years with Firm	9
E-mail Address	natasha@airshed.co.za
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MEMBERSHIP OF SOCIETIES

- Registered Professional Natural Scientist (Registration Number 116335) with South African Council for Natural Scientific Professions (SACNASP), 2018 to present.
- National Association for Clean Air (NACA), 2011 to present
- South African Society for Atmospheric Sciences (SASAS), 2016 to present.
- American Meteorological Society (AMS), 2017 and 2018.
- Golden Key International Honour Society, 2011 to present.

EXPERIENCE

Natasha has several years of experience in air quality and noise impact assessments and management. She is an employee of Airshed Planning Professionals (Pty) Ltd and is tasked with completing air, noise, greenhouse gas and climate change studies involving ambient measurements; meteorological data processing and preparation; the compilation of emission inventories; undertaking of air dispersion and noise propagation modelling; impact and compliance assessment using her substantial knowledge of South African and international legislation and requirements pertaining to air quality and noise; air quality, noise, greenhouse gas and climate change management plan preparation and report writing. Many of her projects within various countries in Africa required international financing, providing her with an inclusive knowledge base of IFC guidelines and requirements pertaining to air quality.

PROJECTS COMPETED IN VARIOUS SECTORS ARE LISTED BELOW:

Mining Sector

- Coal mining: Argent Colliery, Commissiekraal Coal Mine, Estima Coal Project (Mozambique), Grootegeluk Coal Mine, Matla Coal Mine, Rietvlei Coal Mine, Vierfontein Coal Mine.
- Metalliferous mines: AngloGold Ashanti, Atlantic Sands, Bakubung Platinum Mine, Bannerman Uranium Mine (Namibia), Consol Industrial Minerals, Gold Fields' South Deep Gold Mine, Kitumba Copper Project (Zambia), Lehating Manganese Mine, Lesego Platinum Mine, Lofdal Mining Project (Namibia), Marula Platinum Mine, Maseve Platinum Mine, Mkuju River Uranium Project (Tanzania), Namakwa Sands Quartz Rejects Disposal and Mine, Otjikoto Gold Project (Namibia), Otjikoto Gold Mine's Wolfshag Project (Namibia), Pan Palladium Project, Perkoa Zinc Project (Burkina Faso), Storm Mountain Diamonds (Lesotho), Tete Iron Ore Project / Tete Steel and Vanadium Project (Mozambique), Thabazimbi Iron Ore's Infinity Project, Toliara Sands Project (Madagascar), Tormin Mineral Sands Mine, Trekkopje Uranium Mine (Namibia), Tri-K Project (Guinea), Tschudi Copper Mine (Namibia), Wayland Iron Ore Project, Zulti South Project, Impala Platinum Rustenburg Mine and Smelter.
- Quarries: AfriSam Saldanha Cement Project Limestone Quarry, Bundu Mining, Tete Iron Ore Project / Tete Steel and Vanadium Project (Mozambique).

Industrial Sector

AfriSam Saldanha Project; CAH Chlorine Caustic Soda and HCl Plant, Consol Industrial Minerals, Corobrik Driefontein, Metal Concentrators SA Paarden Eiland, Namakwa Sands Dryer, Otavi Rebar Manufacturing, Phakisa Project, Pan Palladium Project, PPC Riebeeck Cement, Rare Earth Elements Saldanha Separation Plant, Saldanha Steel, Siyanda Project, Tete Iron Ore Project / Tete Steel and Vanadium Project (Mozambique), Tri-K Project (Guinea), Tormin Mineral Sands MSP, Tronox Namakwa Sands Smelter, Tronox Namakwa Sands UMM Plant, Tronox Namakwa Sands MSP, ZMY Steel Recycling Plant, Nyanza TiO_2 Pilot Plant, Musina-Makhado SEZ, West African Resources Sanbrado Project (Burkina Faso), Impala Platinum Rustenburg Mine and Smelter.

Power Generation, Oil and Gas

H2 Energy Power Station, Hwange Thermal Power Station Project (Zimbabwe), Ibhubesi Gas Project, Expansion of Staatsolie Power Company, Suriname Operations (Suriname), Tri-K Project (Guinea), Tete Iron Ore Project / Tete Steel and Vanadium Project (Mozambique).

Waste Disposal and Treatment Sector

Fishwater Flats Waste Water Treatment Works, Khutala Water Treatment Project, Moz Environmental Industrial Landfill (Mozambique), Wolverand Crematorium.

Petroleum Sector

Chevron Refinery, Exol Oil Refinery, Puma South Africa's Fuel Storage Facility, Oilkol Depot, Astron Energy Cape Town Refinery.

Transport and Logistics Sector

Saldanha Port Project.

Ambient Air Quality and Noise Sampling/Monitoring

Gravimetric particulate matter (PM) sampling, Dustfall sampling, Passive diffusive gaseous pollutant sampling, Continuous ambient air quality monitoring, Environmental noise sampling.

SOFTWARE PROFICIENCY

Software utilised in conducting air and noise studies:

- WRPLOT (wind & pollution rose generation);
- OpenAir (ambient and meteorological data processing)
- ScreenView (screening model);
- AERMOD suite (air dispersion model);
- ADMS (air dispersion model);
- CALPUFF suite (air dispersion model);
- GRAL system (air dispersion model);
- TANKS (emission estimation model);
- GasSim (emission estimation model);
- DataKustic CadnaA (noise propagation model);

- CONCAWE (noise propagation model); and
- SANS 10201 (calculating and predicting road traffic noise).

EDUCATION

- 2016 to present - MSc: Applied Science (Environmental Technology) student at the University of Pretoria (Faculty of Engineering, Built Environment and Information Technology), Pretoria. Currently undertaking studies. Supervisor: Dr G Kornelius.
- 2010 to 2011 - BSc Honours (Meteorology) student at the University of Pretoria (Faculty of Natural and Agricultural Sciences), Pretoria. Completed 30 November 2011. Degree issued/conferred 13 April 2012. Research project supervisor: Dr S Venkataraman.
- 2007 to 2010 - BSc student at the University of Pretoria (Faculty of Natural and Agricultural Sciences), Pretoria. Completed 30 June 2010. Degree issued/conferred 2 September 2010.

CONFERENCES ATTENDED, ARTICLES PUBLISHED AND COURSES COMPLETED

- Conference: Innovation Bridge and Science Forum South Africa (December 2019), attended.
- Conference: NACA (October 2018), attended and presented a paper (Correlating Dust Concentration Measurements aloft with Opencast Mining Surface Operations).
- Conference: NACA (October 2017), attended and presented a paper (Correlating Dust Concentration Measurements aloft with Opencast Mining Surface Operations).
- Published Article: Beukes, JP; Van Zyl, PG; Sofiev, M; Soares, J; Liebenberg-Enslin, H; Shackleton, N; Sundstrom, AM (2018). The use of satellite observations of fire radiative power to estimate the availabilities (activity patterns) of pyrometallurgical smelters. Journal of the Southern African Institute of Mining and Metallurgy, 118(6), 619-624., co-author.
- Undergraduate courses passed: computer literacy (word processing, spreadsheet processing, Microsoft power point, Microsoft publisher, use of Internet and Microsoft front page); MATLAB; ArcGIS 9.0.; ERDAS Image; Aan Arbor; IDRISI TAIGA; GRADS; TITAN; SUMO 3.00; and Danny Rosenfeld 2007-01.

COUNTRIES OF WORK EXPERIENCE

South Africa, Botswana, Burkina Faso, Guinea, Lesotho, Mozambique, Madagascar, Namibia, Suriname, Tanzania, Zambia and Zimbabwe.

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Limited working proficiency

REFERENCES

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Dr Gerrit Kornelius	Associate of Airshed Planning Professionals	+27 82 925 9569 gerrit@airshed.co.za
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Dr Hanlie Liebenberg-Enslin	Managing Director at Airshed Planning Professionals	+27 11 805 1940 hanlie@airshed.co.za

CERTIFICATION

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

22/04/2020

SACNASP
South African Council for Natural Scientific Professions

herewith certifies that

Natasha Anne Shackleton

Registration Number: 116335

is a registered scientist

in terms of section 20(3) of the Natural Scientific Professions Act, 2003
(Act 27 of 2003)
in the following fields(s) of practice (Schedule 1 of the Act)

Physical Science (Professional Natural Scientist)

Effective **6 June 2018** Expires **31 March 2021**

Chairperson

Chief Executive Officer

To verify this certificate scan this code

16 Appendix B: Competencies for Performing Air Dispersion Modelling

All modelling tasks were performed by competent personnel. Table 28 is a summary of competency requirements. Apart from the necessary technical skills required for the calculations, personnel competency also include the correct attitude, behaviour, motive and other personal characteristic that are essential to perform the assigned job on time and with the required diligence as deemed necessary for the successful completion of the project.

The project technical team included a principal scientist with relevant experience of more than 15 years and one senior scientist with 9 years relevant experience. The principal scientist managed and directed the project.

Verification of modelling results was conducted by the principal scientist. The latter function requires a thorough knowledge of the

- meteorological parameters that influence the atmospheric dispersion processes and
- atmospheric chemical transformations that some pollutants may undergo during the dispersion process.

In addition, the project team included another senior staff member as a reviewer.

Table 28: Competencies for Performing Air Dispersion Modelling

Competency	Task, Knowledge and Experience
Context	Communication with field workers, technicians, laboratories, engineers and scientists and project managers during the process is important to the success of the model
	Familiar with terminology, principles and interactions
	Record keeping is important to support the accountability of the model - Understanding of data collection methods and technologies
Knowledge	Meteorology: Obtain, review and interpret meteorological data Understanding of meteorological impacts on pollutants Ability to identify and describe soil, water, drainage and terrain conditions Understanding of their interaction Familiarity with surface roughness` Ability to identify good and bad data points/sets Understanding of how to deal with incomplete/missing meteorological data
	Atmospheric Dispersion models Select appropriate dispersion model Prepare and execute dispersion model Understanding of model input parameters Interpret results of model
	Chemical and physical interactions of atmospheric pollutants Familiarity with fate and transport of pollutants in air Interaction of primary pollutants with other substances (natural or industrial) to form secondary pollutants
	Information relevant to the model Identify potential pollution (emission) sources and rates

Competency	Task, Knowledge and Experience
	Gather physical information on sources such as location, stack height and diameter Gather operating information on sources such as mass flow rates, stack top temperature, velocity or volumetric flow rate Calculate emission rates based on collected information Identify land use (urban/rural) Identify land cover/terrain characteristics Identify the receptor grid/site
	Legislation, regulations and guidelines in regard to National Environment Management: Air Quality Act (Act No 39 of 2004), including Minimum Emissions Standards (Section 21 of Act) National Atmospheric Emissions Reporting Regulations regarding Air Dispersion Modelling National Ambient Air Quality Standards Atmospheric Impact Report (AIR)
Abilities	Ability to read and understand map information
	Ability to prepare reports and documents as necessary
	Ability to review reports to ensure accuracy, clarity and completeness
	Communication skills
	Team skills

17 APPENDIX C: DESCRIPTION OF WIND EROSION ESTIMATION TECHNIQUE

Emission quantification was done using the in-house modelled ADDAS (Burger *et al*., 1997; Burger, 2010, Liebenberg-Enslin, 2014). This model is based on the dust emission scheme of Marticorena and Bergametti (1995) referred to as MB95 (from this point forward) and Shao *et al*. (2011) (referred to as SH11). A study conducted by Liebenberg-Enslin (2014) set out to establish a best practice prescription for modelling aeolian dust emissions from mine tailings storage facilities. Site specific particle size distribution data, bulk density and moisture content were used in the dust flux schemes of MB95, and SH11 to test the effects on a local scale. This was done by coupling these schemes with the US EPA regulatory Gaussian plume AERMOD dispersion model for the simulation of ground level concentrations resulting from aeolian dust from mine tailings facilities. Simulated ambient near surface concentrations were validated with ambient monitoring data for the same period as used in the model. Coupling the dust flux schemes with a regulatory Gaussian plume model provided simulated ground level PM_{10} concentrations in good agreement with measured data.

The model inputs include material particle density, moisture content, particle size distribution and site-specific surface characteristics such as whether the source is active or undisturbed. All input parameters that were not measured as part of this work, have been drawn from or calculated using referenced methodologies (Liebenberg-Enslin, 2014).

For the purpose of this study, the MB95 dust flux model as schematically represented in Figure 25 is used.

Meteorological data from the WRF model, run for the years 2014, 2015 and 2016, were extracted for locations close to each of the TSF and used to determine the friction velocity and threshold friction velocity. Parameters of importance include wind speed, wind direction and temperature.

The relationship between particle sizes ranging between 1 µm and 500 µm and threshold friction velocities (0.24 m/s to 3.5 m/s), estimated based on the equations proposed by (Marticorena & Bergametti, 1995), is illustrated in Figure 26. The wind speed variation over the storage piles is based on the work of Cowherd et al. (1988). With the aid of physical modelling, the US EPA has shown that the frontal face of an elevated pile (i.e. windward side) is exposed to wind speeds of the same order as the approach wind speed at the top of the pile. The ratios of surface wind speed (us) to approach wind speed (ur), derived from wind tunnel studies for two representative pile shapes, are illustrated in Figure 26 (viz. a conical pile, and an oval pile with a flat top and 37° side slope). The contours of normalised surface wind speeds are indicated for the oval, flat top pile for various pile orientations to the prevailing direction of airflow (the higher the ratio, the greater the wind exposure potential). These flow patterns are only applicable with piles that have a height to base ratio of more than 0.25.

1 Input parameters

u^* (m s^{-1}): friction velocity

u^*_t (m s^{-1}): threshold friction velocity

η_c (%): clay content

θ (%): total soil moisture

w' (%): adsorbed soil moisture

z_0 (m): surface roughness length

z_{0s} (m): smooth roughness length

D_{ls} (m): mean distance between roughness elements

f : fraction of erodible area

psd (m): particle size distribution

p_b (kg m^{-3}): bulk soil density

pa (kg m^{-3}): air density

g (m s^{-2}): acceleration due to gravity

$p(di)$: dust mass fraction of j^{th} particle-size bin

2 Threshold friction velocity

2a ***Threshold friction velocity over smooth surface***

$$u_t^*(d) = \frac{0.129 \times K}{(1.928 \times Re^{0.092} - 1)^{0.5}} \qquad 03 < Re < 10$$

$Re > 10$

$$u_t^*(d) = 0.129 \times K[1 - 0.0858\, exp(-0.0617(Re - 10))]$$

$$where:\ K = \left(\frac{P_p g d}{P_a}\right)^{0.5} \times \left(1 + \frac{0.006}{P_p g d^{2.5}}\right)^{0.5}$$

$$Re = 1331\, d^{1.56} + 0.38 \qquad \text{(eq.4)}$$

2b ***Drag partition correction*** **(*R*)**

$$R(z_0, z_{0s}) = 1 - \frac{ln\left(\frac{z_0}{z_{0s}}\right)}{ln\left[0.35\left(\frac{D_{ls}/30}{z_{0s}}\right)^{0.8}\right]} \qquad \text{(eq.6)}$$

2c ***Moisture correction (H)***

$$\frac{u_{tw}^*}{u_{td}^*} = 1 \qquad w < w'$$

$$\frac{u_{tw}^*}{u_{td}^*} = [1 + 1.21(w - w')^{0.68}]^{0.5} \qquad w > w'$$

$$w' = 0.0014(\eta_c)^2 + 0.17(\eta_c) \qquad \text{(eq.11)}$$

$$u_t^*(d; \lambda; w) = \frac{u_{ts}^*(d)}{R(z_0, z_{0s})}(w)$$

3 Horizontal Saltation Flux (WH79)

$$Q(d) = C_0 \frac{P_a}{g} u_*^3 \left(1 - \frac{u_t^*}{u^*}\right)\left(1 + \frac{u_t^*}{u^*}\right)^2 \qquad C_o = 2.6$$

$$Q = \int_{d_0}^{d_n} Q(d)$$

(kg m^{-1} s^{-1})

4 Vertical Dust Flux (MB95)

$$F(d) = 10^{(0.134\, x\, \eta c - 6)} \times Q \times p(dj) \times \frac{1}{K_h}$$

(kg m^{-2} s^{-1})

4a **Crusting correction (*K*$_h$)**

$$F_{crusted} = \frac{F_{uncrusted}}{K_h}$$

$$K_h = -0.03\left(\frac{\tau}{10}\right)^6 + 0.42\left(\frac{\tau}{10}\right)^5 - 2.17\left(\frac{\tau}{10}\right)^4 + 4.88\left(\frac{\tau}{10}\right)^3 - 3.35\left(\frac{\tau}{10}\right)^2 + 0.85\left(\frac{\tau}{10}\right) + 1 \qquad \text{(eq.14)}$$

4b **Accounting for emissions per particle size group (*p(di)*)**

$$p_m(dj) = \frac{1}{d} \times \sum_{j=1}^{N} \frac{w_j}{\sqrt{2\pi}\sigma_j} exp\left[-\frac{(lnd - lnD)^2}{2\sigma_j^2}\right] \qquad (\text{m}^{-1})$$

(eq.15)

Figure 25: Schematic diagram of parameterisation options and input parameters for the Marticorena and Bergametti (1995) dust flux scheme (Liebenberg-Enslin, 2014)

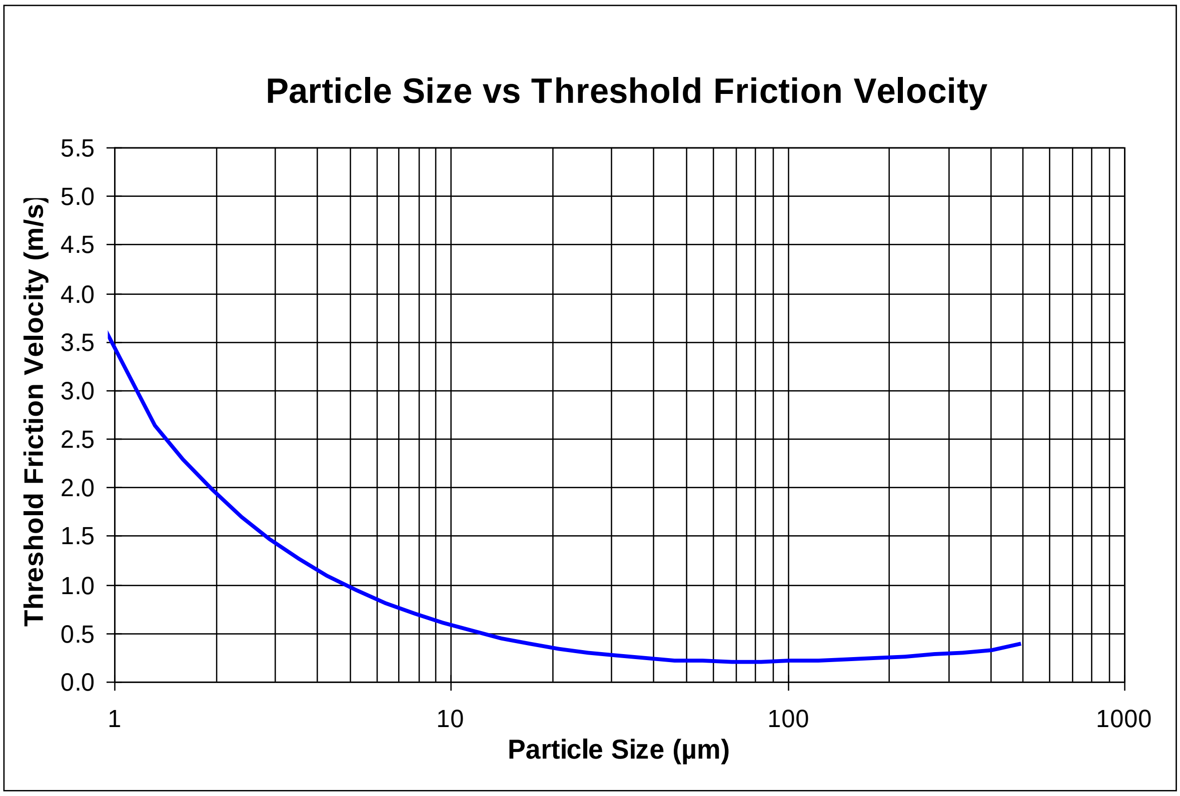

Figure 26: Relationship between particle sizes and threshold friction velocities using the calculation method proposed by Marticorena and Bergametti (1995)

18 APPENDIX D: IMPACT SIGNIFICANCE METHODOLOGY

Date:	09 March 2020	**File No.:**	301-00509/14
To:	All specialists involved in Bakubung TSF EIA		
Copy To:			
From:	Tania Oosthuizen, Knight Piésold		
Re:	**Knight Piésold Impact assessment methodology**		

1.0 PURPOSE

This memorandum serves to provide a standardised impact assessment methodology for all specialist to apply during the ESIA process.

The purpose of this methodological approach to impact assessments serves to identify economic, environmental and social impacts of a potential project and the implications thereof which need to be taken into account during the planning stages. By predicting possible impacts during project planning and design, it provides the project team with the opportunity to reduce adverse impacts and to provide alternatives to the decision makers of the project. By utilising this methodology, both environmental and economic targets can be reached, such as reducing cost and time of project implementation and design, avoided treatment/clean-up costs and impacts of laws and regulations, and finally, assisting with client approval of proposed projects.

2.0 INTRODUCTION

The adequate assessment and evaluation of the potential impacts and benefits that will be associated with a proposed project necessitates the development of a scientific method that will reduce the subjectivity involved in making such evaluations. Knight Piésold uses a simple, clearly defined method in order to accurately determine the significance of the predicted impact on, or benefit to, the surrounding natural and/or social environment.

Nonetheless, an impact assessment will always contain a degree of subjectivity, as it is based on the value judgment of various specialists and Environmental Assessment Practitioners. The evaluation of significance is thus contingent upon values, professional judgement, and dependent upon the environmental and community context. Ultimately, impact significance involves a process of determining the acceptability of a predicted impact to society.

The purpose of impact assessment is to identify and evaluate the likely significance of the potential impacts on identified receptors and resources according to defined assessment criteria, to develop and describe measures that will be taken to avoid, minimise, reduce or compensate for any potential adverse environmental effects, and to report the significance of the residual impacts that remain following mitigation.

3.0 COMPONENTS OF THE IMPACT RATING

3.1 DEFINING THE NATURE OF THE IMPACT

An impact is essentially any change to a resource or receptor brought about by the presence of the proposed project component or by the execution of a proposed project related activity. The terminology used to define the nature of an impact is detailed in Table 1 below.

Table 1: Impact Nature

Term	Definition
Positive (+)	An impact that is considered to represent an improvement on the baseline or introduces a positive change.
Negative (-)	An impact that is considered to represent an adverse change from the baseline or introduces a new undesirable factor.
Direct impact (D)	Impacts that result from a direct interaction between a planned project activity and the receiving environment/receptors (e.g. between occupation of a site and the pre-existing habitats or between an effluent discharge and receiving water quality).
Indirect impact (I)	Impacts that result from other activities that are encouraged to happen as a consequence of the Project (e.g. in-migration for employment placing a demand on resources).
Cumulative impact (C)	Impacts that act together with other impacts (including those from concurrent or planned future third party activities) to affect the same resources and/or receptors as the Project.

3.2 ASSESSING SIGNIFICANCE

The Knight Piésold impact significance rating system is based on the following equation:

Significance of Environmental / Social Impact = Consequence x Probability

The consequence of an impact can be derived from the following factors:

Severity / Magnitude – the degree of change brought about in the environment

Reversibility - the ability of the receptor to recover after an impact has occurred

Duration - how long the impact may be prevalent

Spatial Extent - the physical area which could be affected by an impact.

The **severity, reversibility, duration, and spatial extent** are ranked using the criteria indicated in Table 2 and then the overall consequence is determined by adding up the individual scores and multiplying it by the **overall probability** (the likelihood of such an impact occurring). Once a score has been determined, this is checked against the **significance** descriptions indicated in Table 3.

Table 2: Ranking Criteria

Severity / magnitude (M)	Reversibility (R)	Duration (D)	Spatial extent (S)	Probability (P)
5 – Very high – The impact causes the characteristics of the receiving environment/ social receptor to be altered by a factor of 80 – 100 %	**5 – Irreversible** – *Environmental* - where natural functions or ecological processes are altered to the extent that it will permanently cease. *Social* - Those affected will not be able to adapt to changes and continue to maintain-pre impact livelihoods.	**5 – Permanent** - Impacts that cause a permanent change in the affected receptor or resource (e.g. removal or destruction of ecological habitat) that endures substantially beyond the Project lifetime.	**5 – International** - Impacts that affect internationally important resources such as areas protected by international conventions, international waters etc.	**5 – Definite** - The impact will occur.
4 – High – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 60 – 80 %		**4 – Long term** - impacts that will continue for the life of the Project, but ceases when the Project stops operating.	**4 – National** - Impacts that affect nationally important environmental resources or affect an area that is nationally important/ or have macro-economic consequences.	**4 – High probability** – 80% likelihood that the impact will occur
3 – Moderate – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 40 – 60 %	**3 – Recoverable** *Environmental* - where the affected environment is altered but natural functions and ecological processes may continue or recover with human input. *Social* - Able to adapt with some difficulty and maintain pre-impact	**3 – Medium term** - Impacts are predicted to be of medium duration (5 – 15 years)	**3 – Regional** - Impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries, habitat type/ecosystem.	**3 – Medium probability** – 60% likelihood that the impact will occur u

Severity / magnitude (M)	Reversibility (R)	Duration (D)	Spatial extent (S)	Probability (P)
	livelihoods but only with a degree of support or intervention.			
2 – Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %		**2 – Short term** - Impacts are predicted to be of short duration (0 – 5 years)	**2 – Local** - Impacts that affect an area in a radius of 2 km around the site.	**2 – Low probability** - 40% likelihood that the impact will occur
1 – Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20 %	**1 – Reversible** Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	**1 – Temporary** - Impacts are predicted to intermittent/ occasional over a short period.	**1 – Site only** - Impacts that are limited to the site boundaries.	**1 – Improbable** - 20% likelihood that the impact will occur

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Table 3: Significance Definitions

Score According to Impact Assessment Matrix	Significance Definitions	Colour Scale Ratings	
		Negative Ratings	Positive Ratings
Between 0 and 29 significance points indicate **Low Significance**	An impact of low significance is one where an effect will be experienced, but the impact magnitude is sufficiently small and well within accepted standards, and/or the receptor is of low sensitivity/value.	Low	Low
Between 30 and 59 significance points indicate **Moderate Significance**	An impact of moderate significance is one within accepted limits and standards. The impact on the receptor will be noticeable and the normal functioning is altered, but the baseline condition prevail, albeit in a modified state. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is As Low As Reasonably Practicable (ALARP). This does not necessarily mean that "moderate" impacts have to be reduced to "low" impacts, but that moderate impacts are being managed effectively and efficiently to not exceed accepted standards.	Moderate	Moderate
60 to 100 significance points indicate **High Significance**	An impact of high significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An impact with high significance will completely modify the baseline conditions. A goal of the ESIA process is to get to a position where the Project does not have any high negative residual impacts, certainly not ones that would endure into the long term or extend over a large area. However, for some aspects there may be high residual impacts after all practicable mitigation options have been exhausted (i.e. ALARP has been applied). It is then the function of regulators and stakeholders to weigh such negative factors against the positive factors, such as employment, in coming to a decision on the Project.	High	High

3.3 MITIGATION AND RESIDUAL IMPACTS

It is expected that for the identified significant impacts, the project team will work with the client in identifying suitable and practical mitigation measures that are implementable. Mitigation that can be incorporated into the Project design in order to avoid or reduce the negative impacts or enhance the positive impacts will be developed. A description of these mitigation measures will also be included within the Environmental and Social Management Plan (ESMP).

Residual impacts are those impacts which remain once the mitigation measures have been designed and applied. Once the mitigation is applied, each impact is re-evaluated (assuming that the mitigation measure is effectively applied) and any remaining impact is rated once again using the process outlined above. The result is a significance rating for the residual impact.

4.0 APPLICATION

All specialists are required to conduct their respective impact assessment studies using this standardised procedure. This will ensure standardisation and ease of integration of the various components.

A Microsoft Excel sheet has been developed to facilitate capturing of impacts per environmental receptor. Impacts should be described per facility / activity and rated using the methodology above. The narrative for each impact should be described in the specialist study (Word document). This narrative should describe the reasons for the ratings provided and the overall significance rating. The assigned ratings should be captured in the attached Excel sheet. Where construction phase, operational and closure phase impacts are expected to differ, these impacts should be described separately.

Yours sincerely,
Knight Piésold (Pty) Ltd

19 APPENDIX E: ASSESSMENT OF IMPACTS - APPROVED OPERATIONS

Simulation results of windblown dust emissions from the approved operations are discussed in this section. The simulation results are for the approved operations only and do not include any other sources contributions in the area, as is common practice when assessing an individual facility.

19.1 Inhalable particulate matter (PM_{10})

Simulated annual average PM_{10} concentrations do not exceed the NAAQS of 40 µg/m^3 off-site or at and AQSRs or at the mine housing (Figure 27). The 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) are not exceeded off-site or at any AQSRs; however, the 24-hour NAAQS is exceeded at a portion of the mine housing (Figure 28). The NAAQS 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. Simulated results show that only the short-term NAAQS are exceeded at the mine housing but at no off-site AQSRs, thus the simulated operations are unlikely to be a significant risk to human health at the surrounding receptors.

19.2 Respirable particulate matter ($PM_{2.5}$)

Simulated annual average $PM_{2.5}$ concentrations do not exceed the NAAQS of 20 µg/m^3 off-site or at any of the AQSRs (Figure 29). The 24-hour NAAQS (4 days of exceedance of 40 µg/m^3) are exceeded only at a portion of the mine housing and not at any off-site AQSRs (Figure 30). Simulated results show that only the short-term NAAQS are exceeded at the mine housing but no off-site AQSRs, thus the simulated operations are unlikely to be a significant risk to human health at the surrounding receptors.

19.3 Fallout Dust

Based on the highest monthly simulated dustfall rates, the daily average dustfall rate does not exceed the NDCR residential limit of 600 mg/m²-day of site or at any AQSRs and are below 400 mg/m²-day at all agricultural areas (Figure 31). Dust fallout is associated with nuisance impacts and not human health impacts; however, it could also compromise photosynthetic rates depending on species sensitivity.

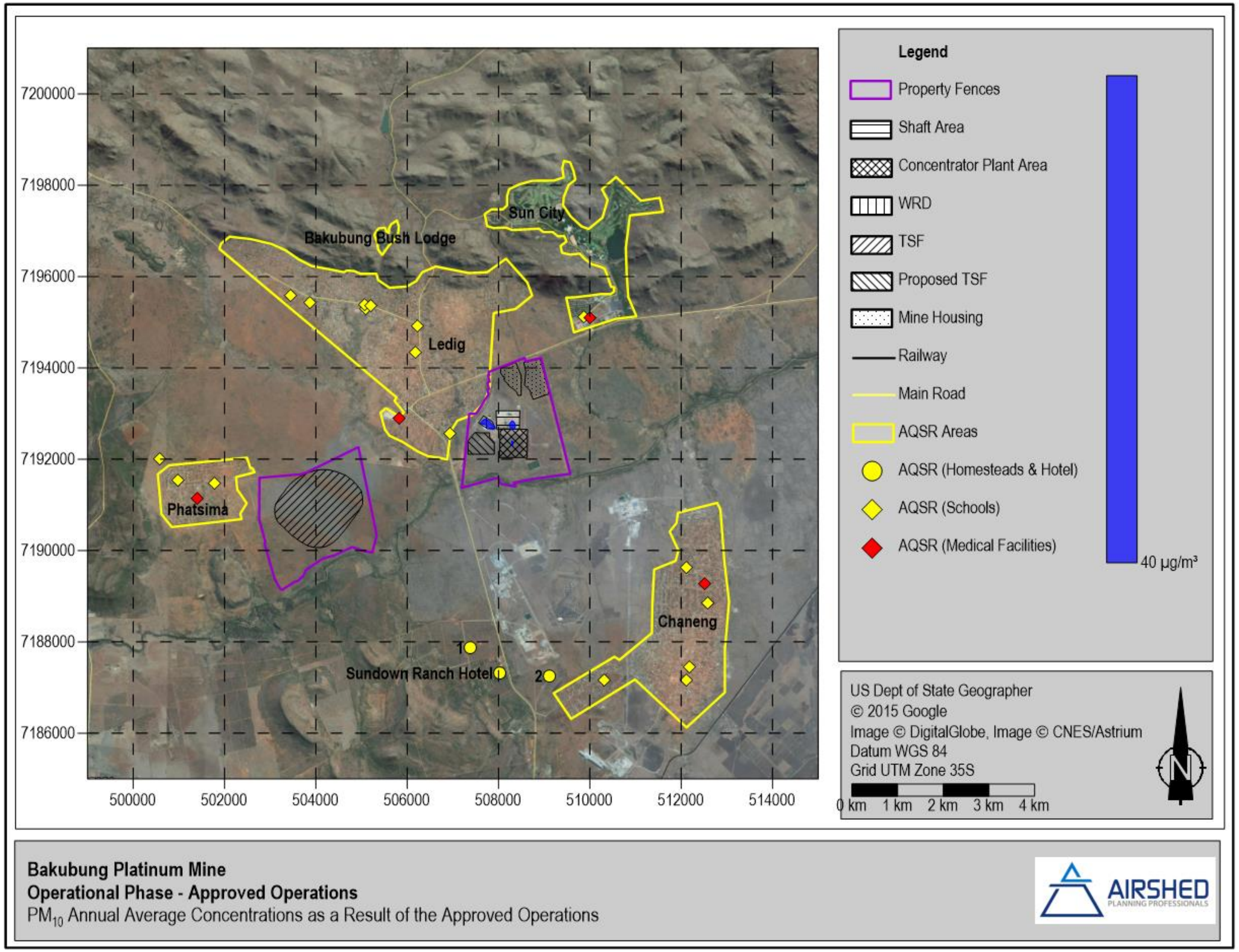

Figure 27: Approved – simulated area of exceedance of the annual average PM_{10} NAAQS

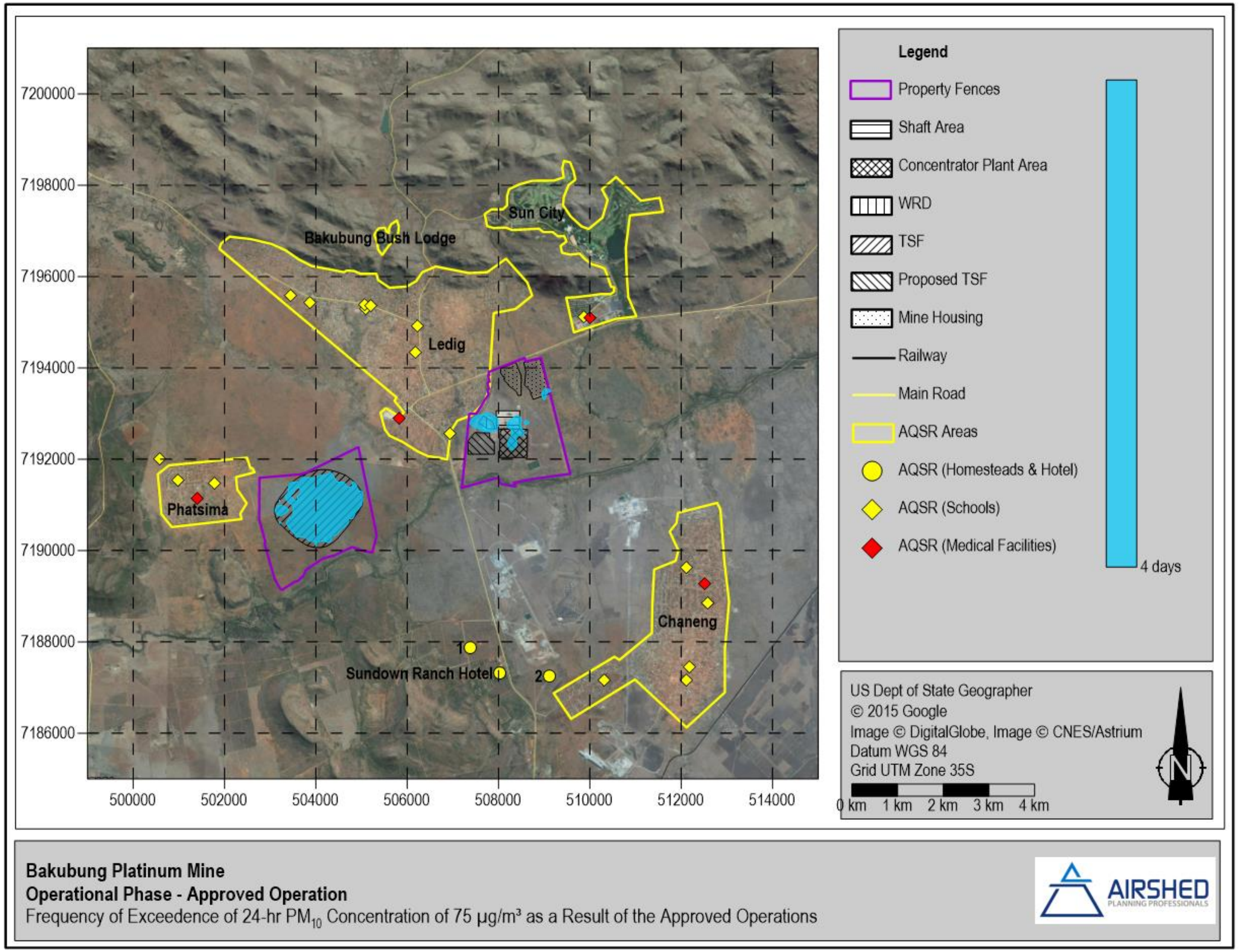

Figure 28: Approved – simulated area of exceedance of the 24-hour PM_{10} NAAQS

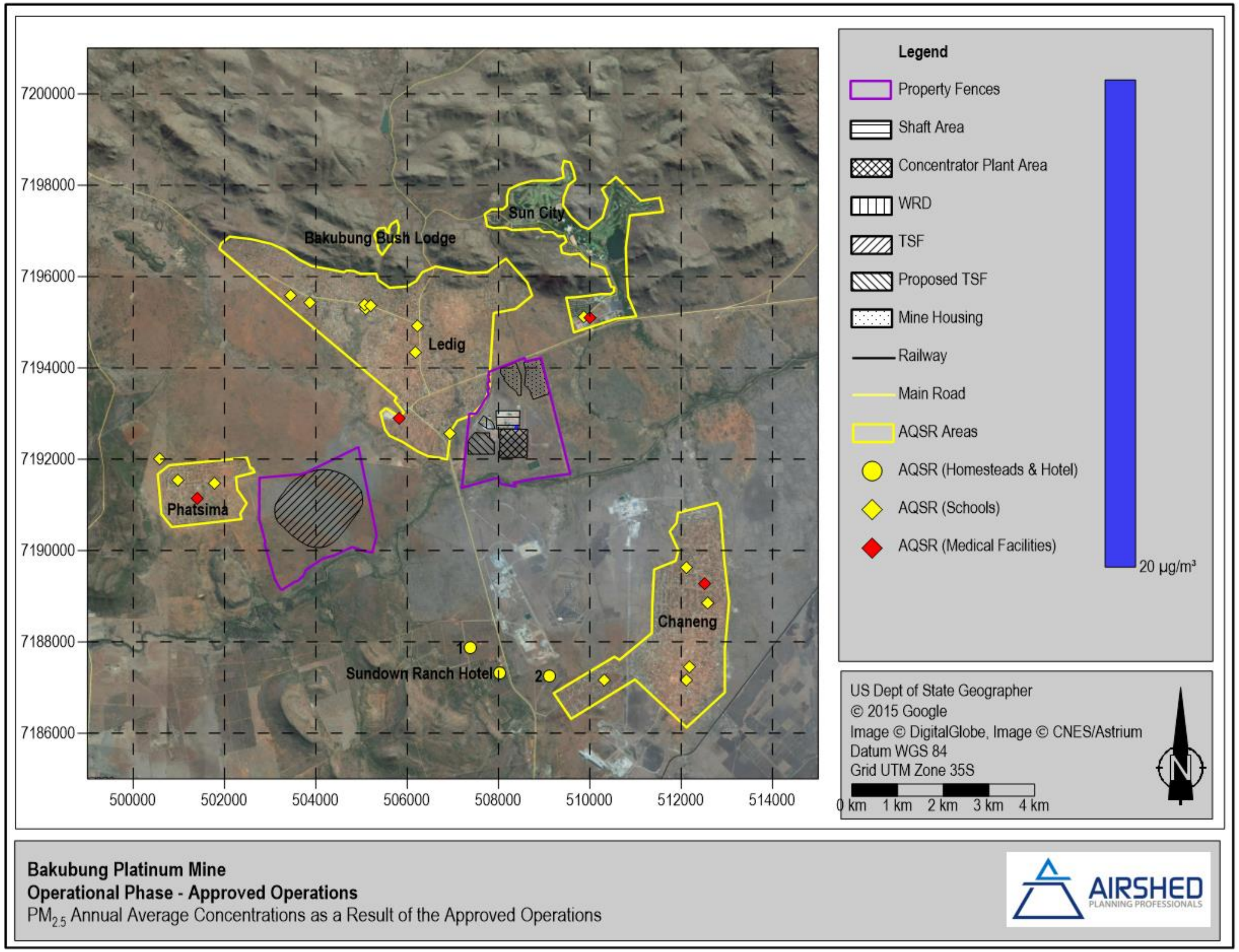

Figure 29: Approved – simulated area of exceedance of the annual average $PM_{2.5}$ NAAQS

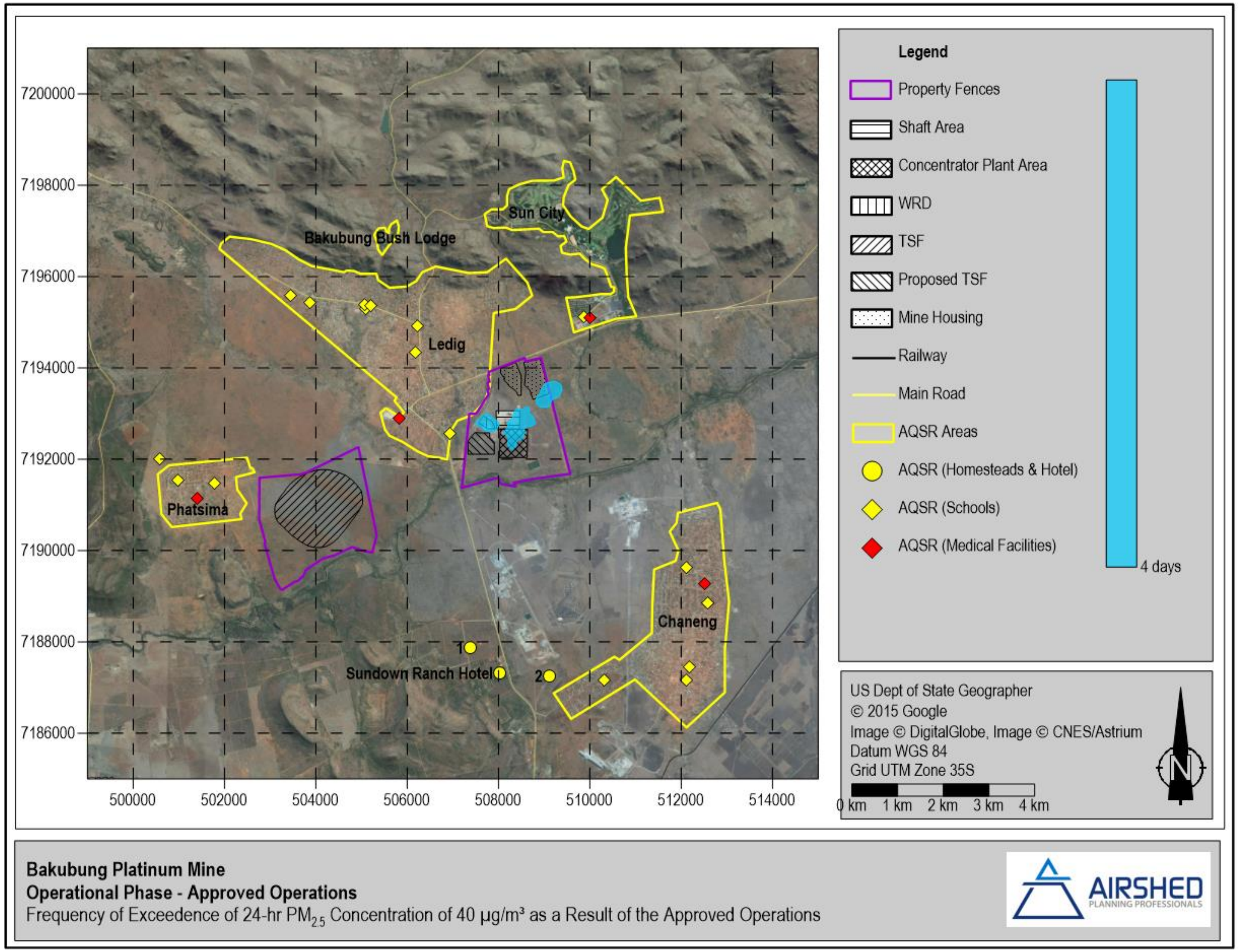

Figure 30: Approved – simulated area of exceedance of the 24-hour $PM_{2.5}$ NAAQS

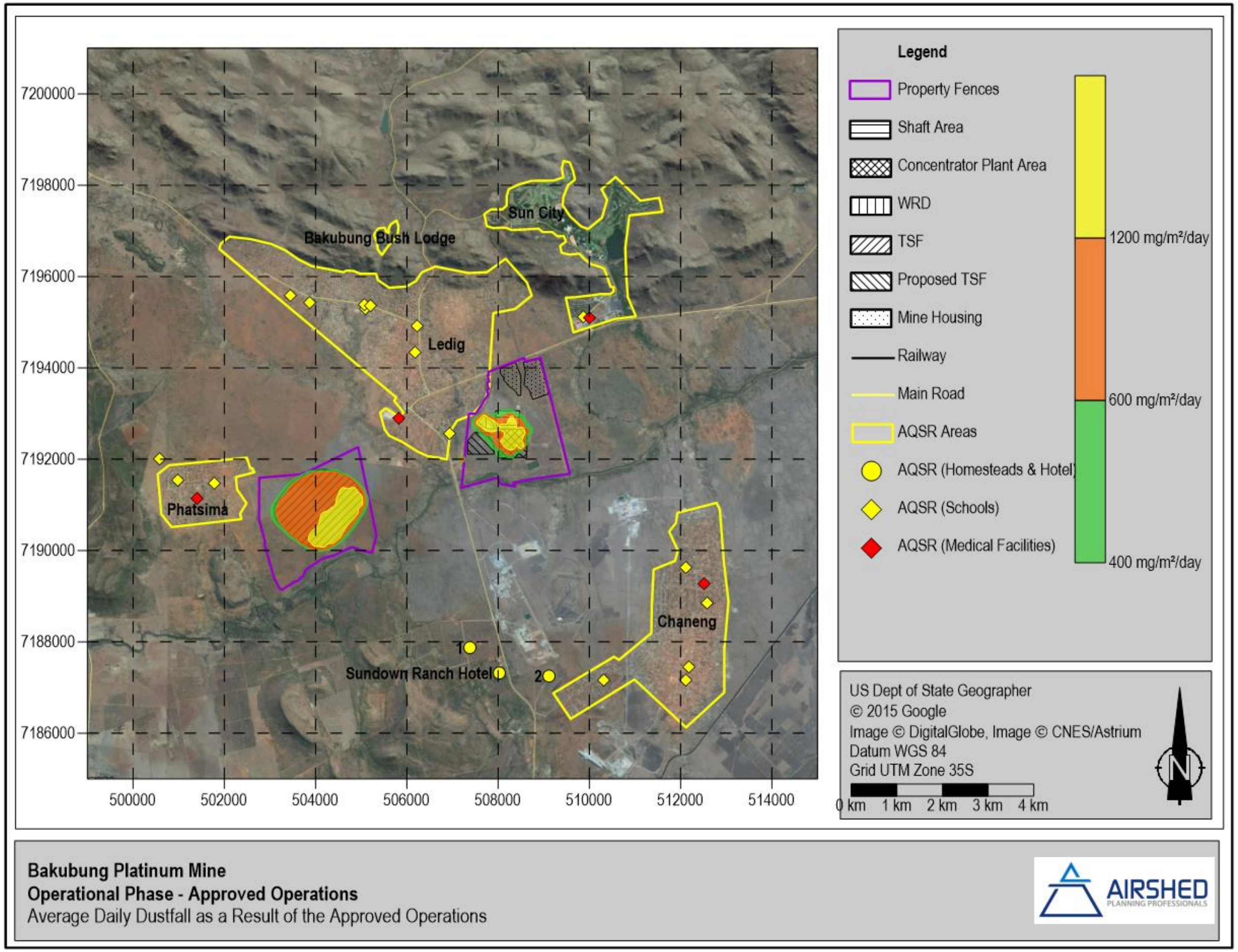

Figure 31: Approved - average daily dustfall rates based on simulated highest monthly dust fallout