APPENDIX 7

AIR QUALITY, GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE IMPACT ASSESSMENT

Air Quality Specialist Study Report for the Proposed Tawana Hotazel Mine in Northern Cape Province

Project done for **Prime Resources (Pty) Ltd**

Report Compiled by
N Shackleton

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Report Details

Report Title	Air Quality Specialist Study Report for the Proposed Tawana Hotazel Mine in Northern Cape Province
Applicant	Tawana Hotazel Mining (Pty) Ltd
Environmental Assessment Practitioners	Prime Resources (Pty) Ltd
Reference	20PRE01a
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Date	January 2022
Prepared by	Natasha Shackleton, Pr. Sci. Nat., BSc Hons (Meteorology) (University of Pretoria)
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 specialist for the "Air Quality Specialist Study Report for the Proposed Tawana Hotazel Mine in Northern Cape 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	January 2022	Original	For review by Applicant and Environmental Assessment Practitioners (EAP)
Final v1	January 2022	Section 1	Updated based on EAP comments, correction of the stage of the application including addition of the reference number.

Competency Profiles

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

Natasha Shackleton is a registered Professional Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) (registration no. 116335), a member of the National Association for Clean Air (NACA), and a member of the South African Society for Atmospheric Sciences (SASAS). Natasha 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 has worked on several air quality specialist studies since 2011. She has experience in the various components including monitoring and sampling data analysis, emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments as well as the development of air quality management plans. 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.

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

NEMA Regulations (2014, as amended) - 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) Appendix A: Authors' Curriculum Vitae (page 125)
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: Study Objective and Terms of Reference (page 4)
An indication of quality and age of base data used.	Section 2.4: Managing Uncertainties (page 10) Section 5.2: Atmospheric Dispersion Potential (page 28) Section 5.3: Existing Air Quality (page 34)
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 34) Cumulative impacts to be determined in next phase. Section 4: Legislation (page 21)
The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment.	A site visit was undertaken by specialists from 30 November 2020 to 4 December 2020. Description of the current land use in the region, simulations undertaken for the proposed operations and meteorological data included used in the study are considered representative of all seasons. Section 5.2: Atmospheric Dispersion Potential (page 28) Section 5.3: Existing Air Quality (page 34)
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 2: Methodology (page 6)
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 5: Air Quality Baseline (page 28)
An identification of any areas to be avoided, including buffers.	Section 5.1: Affected Environment Air Quality Sensitive Receptors (AQSRs) (page 28) Section 7.2: Assessment of Impact: (page 53)
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 Figure 2 Section 7.2: Assessment of Impact: (page 53)
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 2.4: Managing Uncertainties (page 10)
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 7.2: Assessment of Impact: (page 53) Section 7.3: Impact Significance Rating: Incremental (Project) Operations (page 82) Section 11: Air Quality Management Plan (page 94)
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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 102)
A description of any consultation process that was undertaken during the course of carrying out the study.	None
A summary and copies if any comments that were received during any consultation process.	Appendix D
Any other information requested by the competent authority.	Appendix D

List of Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
AEL	Atmospheric Emission Licence
AIR	Atmospheric Impact Report
APPA	Atmospheric Pollution Prevention Act
AQIA	Air quality impact assessment
AQSRs	Air quality sensitive receptors
ASTM	American Standard Test Method
ATSDR	US Agency for Toxic Substances and Disease Registry
CCWR	Computing Centre for Water Research, Natal University
CCIA	Climate change impact assessment
CCS	Carbon Capture and Sequestration (or Carbon Capture and Storage
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and Environment
DMRE	Department of Mineral Resources and Energy
DoE	Department of Energy
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
FOLU	Forestry and Other Land Use
g	Gram
g/s	Gram per second
GG	Government Gazette
GHG	Greenhouse Gases
GLC(s)	Ground level concentration(s)
GLCC	Global land cover characterisation
GN	Government Notice
Gt	Gigatonne
GV	Guideline Value
H_2O	Water vapour
ha	Hectare
HFCs	Hydrofluorocarbons
HMM	Hotazel Manganese Mine
HV	Heavy vehicles
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
INDC	Intended Nationally Determined Contribution

IRIS	Integrated Risk Information System
kg	Kilogram
ktpm	Kilotonnes per month
kVA	Kilo-volt-ampere
kW	Kilowatt
kWh	Kilowatt hour
LDV's	Light duty vehicles
m	Metre
m^2	Metre squared
m^3	Metre cubed
mamsl	Metres above mean sea level
MES	Minimum Emission Standards
mg	Milligrams
mm	Millimetres
m/s	Metres per second
MPRDA	Mineral and Petroleum Resources Development Act (No. 28 of 2002)
MR	Mining Right
MRA	Mining Right Application
MRL	Minimal risk levels for hazardous substances
Mt	Megatonnes
MWh	Megawatt hour
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)
NAEIS	National Atmospheric Emissions Inventory System
NDCs	Nationally Determined Contributions
NEMA	National Environmental Management Act (No. 107 of 1998)
NEM:AQA	National Environmental Management: Air Quality Act (No. 39 of 2004)
N_2O	Nitrous oxide
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
O_3	Ozone
PFCs	Perfluorocarbons
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
PM_{30}	Particulate matter with diameter of less than 30 µm
Prime Resources	Prime Resources (Pty) Ltd
RCP(s)	Representative Concentration Pathway(s)
RfCs	Inhalation reference concentrations
RoM	Run of Mine
SAAQIS	South African Air Quality Information System

SAGERS	South African Greenhouse Gas Emission Reporting System
SAWS	South African Weather Service
SF_6	Sulfur hexafluoride
SO_2	Sulfur dioxide
SRTM	Shuttle radar topography mission
t/a	Tonnes per annum
Tawana	Tawana Hotazel Mining (Pty) Ltd
THM	Tawana Hotazel Mine
TJ	Terajoules
TSP	Total suspended particulates
UNFCCC	United Nations Framework Convention on Climate Change
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VKT	Vehicle kilometres travelled
WHO	World Health Organisation
WRF	Weather Research and Forecasting
WULA	Water Use Licence Application
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.

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

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.
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.

Executive Summary

The Department of Mineral Resources and Energy (DMRE) has accepted an application for Environmental Authorisation (EA) (ref No. NC 30/5/1/2/3/2/1/10197MR) in support of a Mining Right (MR) made by Tawana Hotazel Mining (Pty) Ltd (THM) in terms of Section 22 of the Mineral and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA) (Republic of South Africa, 2004), as amended in 2008 (Republic of South Africa, 2009) for the proposed Tawana Hotazel Mine (hereafter referred to as "THM" or "the Project"). The types of minerals applied for are: all (Code UN); Iron and Iron bearing minerals including hematite, goethite, specularite and limonite (Code (Fe) Type (B)) and Manganese and manganese bearing minerals (Code (Mn) Type (B)).

The Project covers portions of two farms (Hotazel 280 and York 279) and is located approximately 1 km south-east of the town of Hotazel within the Joe Morolong Local Municipality (LM) in the John Taolo Gaetsewe District Municipality (DM) of the Northern Cape Province of South Africa.

The THM largely incorporates the historical Hotazel Manganese Mine (HMM), and the MR area includes the residual opencast void and surface dumps of low-grade material. The mothballed processing plant and rail loadout facility fall outside the MR area. HMM stopped production in 1989. The area was historically mined by both opencast and underground means and yielded high grade manganese ore. All current plans for the project specifically exclude underground mining. The overall area applied for is approximately 154 hectares (Ha) (inclusive of the MR application area and access roads). Surface infrastructure will include the opencast pit (incorporating the historical HMM void and further expansion of the opencast footprint), in-pit waste rock dumps (residue material), surface residue handling / storage, vehicle yard, workshop, access and haul roads, offices, stores, processing plant for the crushing and screening of mined ore, product stockpile area, run of mine pad, refuel station and water management

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Prime Resources (Pty) Ltd (Prime Resources) to undertake an Air Quality Impact Assessment (AQIA) and Climate Change Impact Assessment (CCIA) as part of the EA process to identify key aspects that may have significant air quality and climate change 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 Environmental Impact Assessment (EIA) Regulations (Republic of South Africa, 2014) (as amended by Government Notice [GN] 326 of 7 April 2017; GN 706 of 13 July 2018 and GN 320 of 20 March 2020).

Receiving Environment

Air quality sensitive receptors (AQSRs) generally include places of residence and areas where members of the public or sensitive environments may be adversely affected by air pollutants emitted by the proposed activities. All AQSRs within a 10 km radius were identified. Receptors located within 10 km of the Project are residences, schools and medical facilities within Hotazel as well as farmsteads/homesteads and Gloria Mine village.

There were no on-site or nearby South African Weather Service (SAWS) weather stations thus it was decided to use the WRF (Weather Research and Forecasting) modelled meteorological data for a point on-site. The WRF data indicates a wind field dominated by winds from the north-easterly sector. Night-time shows dominant north-easterly, east-north-easterly, south-south-easterly and southerly components to the wind field and during the day these winds decrease, and the northerly winds dominate. The average temperature in the study area over the three-year period was 21°C and the average humidity 31%. Long-term impacts are expected to be more notable to the south-west of the operations.

The topography of the study area is mostly flat. The land use in the vicinity of the operations comprises primarily mining, residential and farming. The vegetation is classified as part of the Savanna Biome and is mostly used for grazing.

The main sources likely to contribute to baseline PM emissions include mining and processing operations, farming activities, vehicle entrained dust from local roads, vehicle exhaust and windblown dust from exposed areas.

Fine particulate matter sampling was undertaken using passive particulate matter samplers from 7 September 2021 to 21 September 2021. The passive PM sampling comprised of two sampling campaigns at two locations in Hotazel town. Site 1 (Hotazel Guesthouse) extrapolated 24-hour concentration for the first 7-day sampling period indicated that the 24-hour average PM_{10} concentration could exceed the 24-hour NAAQ limit. If the relevant 24-hour NAAQ limits are exceeded more than 4 days in a calendar year, then that pollutant would not be in compliance with the NAAQS.

Dustfall sampling was undertaken at four locations around the proposed facility. The dustfall rates at the unit on the boundary of Hotazel is below the NDCR limit for residential areas for all four months. The sampled dustfall rates are compliant with the NDCR based as the four months results do not have more than two exceedances of the applicable limit in the sampling period or for consecutive months at all sites. As only four months of sampling was undertaken and there was high rainfall in the area during the first month the sampling period there is still the potential that the dustfall rates in the area may be non-compliant with the NDCR.

Impact Assessment

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 mitigation and "low" rating with additional mitigation measures applied.
- Operational phase:
    - PM_{10}, $PM_{2.5}$, TSP, SO2, NO_x, CO and DPM emissions and impacts were quantified.
    - PM_{10} concentrations as a result of unmitigated operations are not within compliance with the NAAQS at multiple AQSRs over the long-term (annual) and short-term (24-hour).
    - PM_{10} concentrations as a result of operations with design mitigation measures and recommended additional mitigation measures applied are not within compliance with the NAAQS at multiple AQSRs over the short-term (24-hour).
    - $PM_{2.5}$ concentrations as a result of unmitigated operations are not within compliance with the NAAQS at multiple AQSRs over the short-term (24-hour).
    - $PM_{2.5}$ concentrations as a result of operations with design mitigation measures and recommended additional mitigation measures applied are within compliance with the current

NAAQS. $PM_{2.5}$ concentrations as a result of operations with design mitigation measures and recommended additional mitigation measures applied are not within compliance with the future[2] NAAQS at multiple AQSRs over the short-term (24-hour).
    - PM_{10} concentrations as a result of design mitigated operations are not within compliance at Hotazel and some individual AQSRs over the short-term and long-term.
    - $PM_{2.5}$ concentrations as a result of design mitigated operations are in compliance with the NAAQS at all AQSRs over the long-term; however, not in compliance with the NAAQS at some AQSRs over the short-term.
    - Dustfall rates are above the NDCR limits for non-residential areas; however, the dustfall rates are below the NDCR limits for residential areas at all AQSRs and below 400 mg/m²-day at all agricultural areas.
    - Annual Mn concentrations as a result of unmitigated operations and design mitigated operations exceed the WHO GV at AQSRs.
    - Annual DPM does not exceed the US EPA IRIS RfC at any AQSRs.
    - NO_x concentrations are not in compliance with the NO_2 NAAQS at multiple AQSRs over the long-term (annual) and short-term (1-hour). The simulated annual NO_x concentrations exceed the critical level for all vegetation types. It was conservatively assumed that all NO_x is converted to NO_2.
    - SO_2 and CO concentrations are below the NAAQ limit values.
    - The significance of operations related inhalation health impacts is likely to be "moderate" without mitigation and "moderate" with the design mitigation measures applied. With the recommended design mitigation measures applied the significance reduces to "low". The significance of operations related to nuisance impacts are likely to be "low" without and with design mitigation, as well as with recommended additional mitigation measures applied. The significance of operations related vegetation health impacts as a result of NO_x concentration is likely to be "low" without mitigation measures applied but result in a moderate loss of resources. The significance of operations related vegetation health impacts as a result of dustfall rates is likely to be "low" without and with design mitigation, as well as with recommended additional mitigation measures applied with a minor loss of resources (lowest descriptor available for loss of resources).
- Decommissioning and closure phases:
    - The significance of decommissioning operations related inhalation health and nuisance impacts are likely to have a "low" rating without mitigation and with mitigation.
    - The significance of closure operations related inhalation health and nuisance impacts are likely "low".

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 use of chemical suppressants on the surface haul roads and access road should be considered

[2] Applicable from 1January 2030

- The dustfall sampling and ambient fine particulate monitoring
    - Should the dustfall sampling show higher rates than those estimated in this study it is suggested that THM investigate and consider adopting additional mitigation and management measures. Fallout dust tends to settle relatively close to sources of emissions and thus if the dustfall sampling show significantly higher rates there is likely to be significantly higher finer particulate matter concentrations as well
- Record keeping and community liaison procedures.

Based on these findings and provided the measures recommended are in place as well as regular (maximum of 5 years) review of the mitigation, management and monitoring procedures takes place, it is the specialist opinion that the project may be authorised but investigations into economically and environmentally viable mitigation measures to reduce fine particulate matter (especially PM_{10}) should be undertaken prior to initiation of operations and feedback provided to the authorities.

Note: The limited water resources limit the use of water sprays on other sources and increasing watering rates on unpaved roads. Sealing of roads have not been considered as a recommended mitigation measure as this could negatively affect the rehabilitation efforts to restore the site as much as possible to pre-development conditions, especially since in-pit roads are the most significant contributor to the simulated elevated PM_{10} concentrations in Hotazel town.

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Air Quality Specialist Study Report for the Proposed Tawana Hotazel Mine in Northern Cape Province

1 INTRODUCTION

1.1 Background

The Department of Mineral Resources and Energy (DMRE) has accepted an application for Environmental Authorisation (EA) (ref No. NC 30/5/1/2/3/2/1/10197MR) in support of a Mining Right (MR) made by Tawana Hotazel Mining (Pty) Ltd (THM) in terms of Section 22 of the Mineral and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA) (Republic of South Africa, 2004), as amended in 2008 (Republic of South Africa, 2009) for the proposed Tawana Hotazel Mine (hereafter referred to as "THM" or "the Project"). The types of minerals applied for are: all (Code UN); Iron and Iron bearing minerals including hematite, goethite, specularite and limonite (Code (Fe) Type (B)) and Manganese and manganese bearing minerals (Code (Mn) Type (B)). The Project covers portions of two farms (Hotazel 280 and York 279) and is located approximately 1 km south-east of the town of Hotazel within the Joe Morolong Local Municipality (LM) in the John Taolo Gaetsewe District Municipality (DM) of the Northern Cape Province of South Africa (Figure 1 and Figure 2).

The THM largely incorporates the historical Hotazel Manganese Mine (HMM), and the MR area includes the residual opencast void and surface dumps of low-grade material. The mothballed processing plant and rail loadout facility fall outside the MR area. HMM stopped production in 1989. The area was historically mined by both opencast and underground means and yielded high grade manganese ore. All current plans for the project specifically exclude underground mining. The overall area applied for is approximately 154 hectares (Ha) (inclusive of the MR application area and access roads). Surface infrastructure (Figure 3) will include the opencast pit (incorporating the historical HMM void and further expansion of the opencast footprint), in-pit waste rock dumps (residue material), surface residue handling / storage, vehicle yard, workshop, access and haul roads, offices, stores, processing plant for the crushing and screening of mined ore, product stockpile area, run of mine pad, refuel station and water management

As part of the EA process an air quality specialist study and climate change study is required, amongst other specialist studies. Specialist studies have been commissioned to assess the impacts of the Project on all aspects of biophysical and socio-economic receptors within the area. Mitigation, management, and monitoring designs will be informed by a team of specialists and engineers once all the studies required for the Project are completed. Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Prime Resources (Pty) Ltd (Prime Resources) to undertake an Air Quality Impact Assessment (AQIA) and Climate Change Impact Assessment (CCIA) as part of the EA process to identify key aspects that may have significant air quality and climate change 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 Environmental Impact Assessment (EIA) Regulations (Republic of South Africa, 2014) (as amended by Government Notice [GN] 326 of 7 April 2017; GN 706 of 13 July 2018 and GN 320 of 20 March 2020).

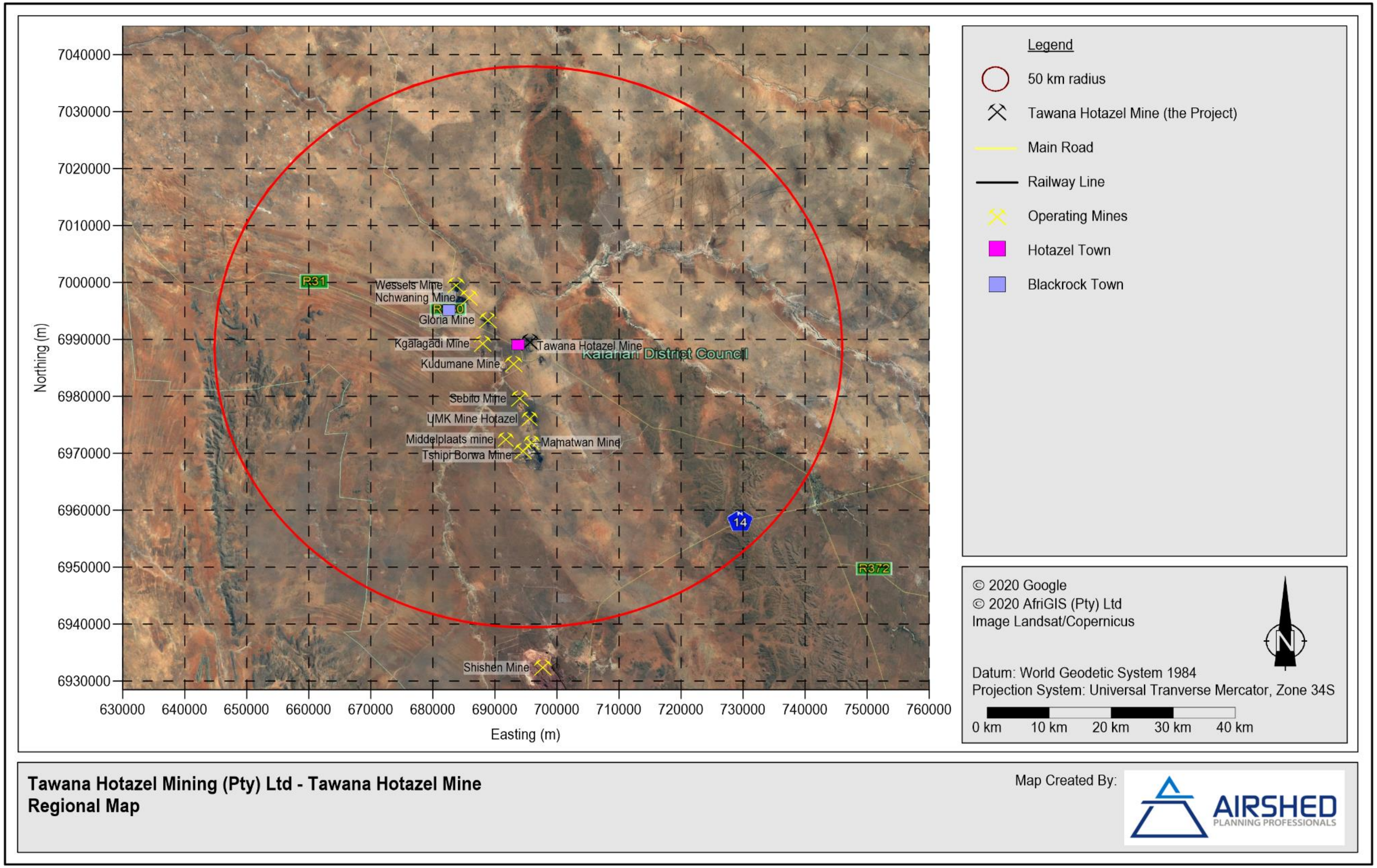


Figure 1: Regional map

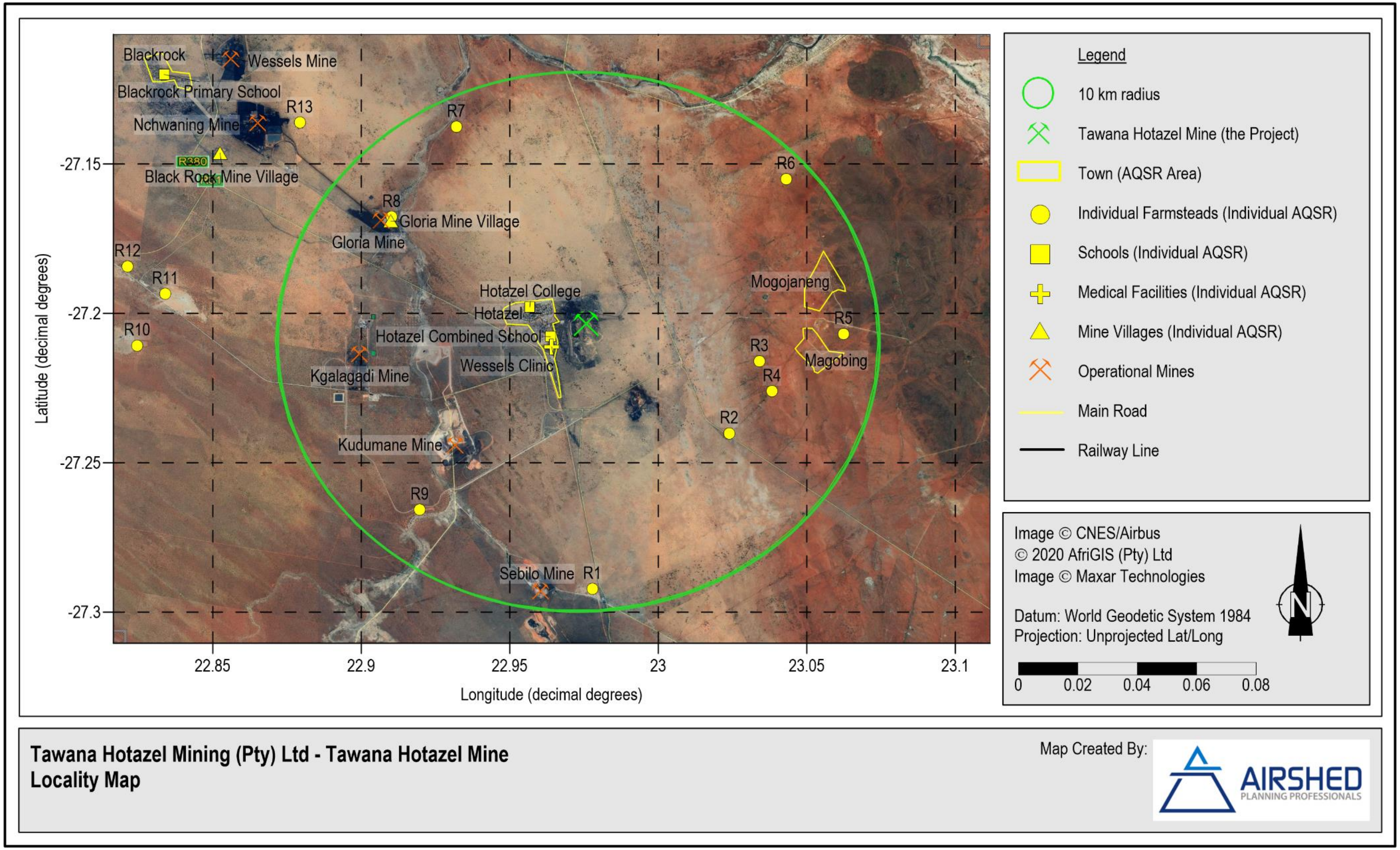


Figure 2: Locality map

Figure 3: Layout map

1.2 Study Objective and Terms of Reference

The main objective of the air quality specialist study is to assess the impacts of the proposed THM operations on all aspects of biophysical and socio-economic receptors within the area and recommend mitigation, management, and monitoring measures based on the results of the assessment. The specific terms of reference for the overall study were:

1. Identify and describe the existing air quality of the Project area, as well as the dispersion potential and geography of the area (i.e., the baseline).
2. Model the project related sources/emissions to determine the project contribution to air quality in the area, focusing mainly on particulate matter with reference to total particulate matter (TSP), particulate matter with an aerodynamic diameter less than 10 µm (PM_{10}), particulate matter with an aerodynamic diameter less than 2.5 µm ($PM_{2.5}$), sulfur dioxide (SO_2), oxides of nitrogen (NO_x) assessed as nitrogen dioxide (NO_2), carbon monoxide (CO) and manganese (Mn).
3. Assess the impact on human health and biota resulting from the proposed operations, including the construction, operational, decommissioning and post-closure phases of the project.
4. Identify and describe potential cumulative air quality impacts resulting from the proposed operations in relation to other existing developments in the surrounding area.
5. Recommend mitigation and management measures to minimise impacts and/or optimise benefits associated with the project.
6. Recommend a monitoring network to ensure the correct implementation and adequacy of recommended mitigation and management measures, if applicable.
7. Estimate the greenhouse gases (GHG) emissions during construction, operation and decommissioning phases of the project compared to the global and national emission inventories and compared to international benchmarks for the project.
8. Determine the robustness of the project with the impact of climate change over the lifetime of the project considered.
9. Ascertain the vulnerability to climate change of communities in the immediate vicinity of the project.

The first and last three activities form part of the climate change specialist study, and the first six activities form part of the air quality specialist study.

2 METHODOLOGY

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

- Identification of existing sources of emission and characterisation of ambient air quality and dustfall levels in the study area.
    - A quantitative assessment of long-term (one year) baseline air quality was not possible due to the limited sampling periods allowed for as part of the air quality study due to the EIA timeframes.
    - Brief fine particulate matter sampling was undertaken within Hotazel town using passive particulate samplers.
    - Short-term fallout dust sampling was undertaken.
    - The description of the baseline air quality in the area is both qualitative and quantitative.
- 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 and if available the solar radiation. The depth of the atmosphere in which the pollutants mix is similarly derived from other meteorological parameters by means of mathematical parameterizations.
    - The first step was therefore to source any on-site or near-site meteorological observations. As a minimum this data had to include hourly averaged wind speed, wind direction and ambient air temperature.
    - Since none of the closest measured stations would be suitable for the site, WRF (Weather Research and Forecasting) data was acquired for the study.
    - The wind roses, general climatic information such as diurnal temperature variations, atmospheric stability estimates have been based on the WRF data.
- Potential sensitive receptors within the study area were identified for inclusion in the dispersion model to determine the potential impact significance ratings for the various project phases.

The impact assessment included the tasks below:

- The dispersion modelling executed as per *The Regulations Regarding Air Dispersion Modelling* (Republic of South Africa, 2014). Three *Levels of Assessment* are defined in the Regulations. A Level 2 assessment approach was deemed adequate.
- Preparation of the model control options and input files for the AERMOD dispersion modelling suite. This includes the compilation of:
    - Terrain information (topography, land use, albedo, and surface roughness).
    - Sources layout and pollutant emissions, as well as the temporal and spatial parameters.
    - Grid and receptor definitions.

- Output requirements including periods, rankings and units of measurements extracted for each pollutant.

- Preparation of hourly average meteorological data for the wind field and atmospheric dispersion and pollutant deposition parameters.
- Preparation of an emissions inventory for the proposed operations, including fugitive sources[3] and applicable point sources. The mining rates, production rates, mobile and stationary equipment power ratings, as well as operational times, source extents and emission factors were used for the fugitive and point sources.
- Simulations were conducted using the AERMOD dispersion modelling suite, which allows for the calculations of the ambient inhalable concentrations ($PM_{2.5}$, PM_{10}, SO_2, NO_x, CO, and Mn) and deposition rates (based on particulate matter with an aerodynamic diameter less than 30 µm [PM_{30}] emission rates). The hourly, daily, and annual concentrations as well as highest monthly deposition rates were computed by the dispersion model.
- The number of exceedances of the hourly and daily National Ambient Air Quality (NAAQ) limits and the maximum average daily dustfall rates were determined using the computed concentrations and deposition rates.
- The legislative and regulatory context, including ambient air quality guidelines and dustfall classifications will be used to assess the impact and recommend additional mitigation measures and air quality management plan to reduce the impact of air pollution from the project in the study area as much as practically possible. The model results will be evaluated against the National Ambient Air Quality Standards (NAAQS), National Dust Control Regulations (NDCR), and international guidelines and limits.

2.1 Atmospheric Dispersion Modelling

2.1.1 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 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

[3] 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).

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 21112	Gaussian plume dispersion model.
AERMET	Breeze v7.9.0.3	(US) EPA 18081	Meteorological pre-processor for creating AERMOD compatible formats.

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.

2.1.1 Meteorological Requirements

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. WRF modelled meteorological data was used. The WRF 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 near Hotazel was extracted for the period from January 2017 to December 2019.

2.1.2 Topographical and Land Use Data

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 to determine the topography. The topography within the modelling domain is flat or gently sloping (less than 10%), and therefore does not meet the recommendation to include terrain in the dispersion model setup (US EPA, 2005).

2.1.3 Receptors

The dispersion of pollutants expected to arise from proposed operations was simulated for an area covering 15 km (east-west) by 15 km (north-south). The area was divided into a grid matrix with a resolution of 100 m. Individual receptors were included as discrete receptors. AERMOD calculates ground-level concentrations and deposition rates at each grid point and discrete receptor.

2.1.4 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.

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 hourly and daily averaging periods where the NAAQ limits were not exceeded contain the highest 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.

2.1.5 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 at a fine spatial resolution (1-hour) for the simulation period was required which was not available for this study.

2.2 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 Prime Resources impact rating methodology provided. The impact significance was rated for unmitigated project operations and assuming the effective implementation of design mitigation measures for the project operations as well as with recommended additional mitigation measures applied.

2.3 Mitigation and Management Recommendations

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

2.4 Managing Uncertainties

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

1. All project information will be provided by Prime Resources and Tawana; it is assumed that all this information will be the most recent data and correct.
2. Meteorology:
    a. There is no on-site or nearby South African Weather Service (SAWS) weather stations thus it was decided to use the WRF modelled meteorological data for a point near Hotazel.
    b. The closest SAWS stations are Kuruman and Kathu which are both approximately 50 kilometres (km) away from the proposed operations and based on the terrain and land use in the area these sites most likely will not be representative. Considering the land use surrounding the stations (especially close to the stations) it is not the same as the site and the effects of the difference in land use on the other meteorological parameters (not measured by these stations) but required for dispersion modelling would vary. The National Code of Practice for Air Dispersion Modelling described in the Regulations regarding air dispersion modelling discusses this and it is evident from surface roughness lengths, albedo values and Bowen ratios provided in the regulations and international modelling guidelines for different land uses vary in terms of these parameters which affect the wind profile, atmospheric mixing and other planetary boundary layer parameters.

c. The National Code of Practice for Air Dispersion Modelling described in the Regulations regarding air dispersion modelling 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 Level 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 WRF dataset period January 2017 to December 2019 is within the timeframe recommended by the National Code of Practice for Air Dispersion Modelling as the meteorological data is for three years (modelled data) and less than five years old during the assessment period (2021).

3. Ambient air quality sampling data from sampling campaigns undertaken by Airshed was available thus both a qualitative assessment of sources in the area and quantitative assessment of pre-development PM_{10} and $PM_{2.5}$ concentrations and dustfall rates are included.
4. Emissions:
    a. The impact assessment will be limited to the pollutants of concern (those included in Section 4). These pollutants are regulated under NAAQS or considered key pollutants released by the operations associated with the Project.
    b. The quantification of sources of emission will be restricted to the Project operations. Other existing sources of emission within the area including mining, processing, and farming activities, domestic fires, biomass burning, vehicle exhaust emissions and dust entrained by vehicles on public roads will not be included as part of the emissions inventory and simulations. Without detailed proposed (for when this project will be operational) operational data for other companies' mining and processing operations as well as estimated future vehicle data for public roads it is difficult to quantify these sources for the period of the proposed project operations. It is difficult to predict the contribution of the domestic and natural fires and farming sources to air quality during the period of the proposed project operations due to variability of these operations with regards to locality, spatial extent and duration.
5. Dispersion Simulations:
    a. It will be assumed that all NO_x emitted is converted to NO_2.
6. Assessment of impacts:
    a. The health risk assessment is limited to the screening of ambient air concentrations against NAAQS and applicable international legal guidelines and limits and does not include a detailed human health risk assessment. Human health risk can occur due to exposures through inhalation, ingestion, and dermal contact. The scope of the study will be confined to the quantification of impacts due to exposures via the inhalation pathway only.
    b. A human health risk and nuisance and environmental impact screening assessment for the Project operational phase will be based on dispersion simulation results.
    c. 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.

d. The EA process will be completed by Prime Resources. For this reason, the expected impact significance of the operations was determined based on the Prime Resources impact significance methodology.

7. Manganese:

   a. There are no NAAQS for Manganese (Mn) and there is substantial variability in the international limits proposed for Mn (with the most commonly referred to chronic inhalation criteria or guidelines ranging from 0.05 µg/m³ to 0.3 µg/m³). Reference is made to the inhalation guideline values (GVs) published by the World Health Organisation (WHO); the inhalation reference concentrations (RfCs) published by the US EPA Integrated Risk Information System (IRIS); and minimal risk levels for hazardous substances (MRLs) published by the US Agency for Toxic Substances and Disease Registry (ATSDR) in the legislation section.

   b. The predicted annual average pollutant concentrations are assessed against the World Health Organisation (WHO) Guideline Value (GV) even though the US EPA IRIS RfC appears to be a stricter value based on the fact that the US EPA IRIS defines chronic exposure as "repeated exposure by the oral, dermal, or inhalation route for more than approximately 10% of the life span in humans".

   c. Potential Mn ground-level concentrations as a result of the project operations have been included in this study by multiplying the simulated PM_{10} concentrations for sources related to the ore mining, handling and processing and product handling as well as erosion of the Run-of-Mine (RoM) and product stockpiles. by the Mn content of the ore. This methodology is used as no measured values for the Mn content for the individual sources included are available. There are two assumption that could be applied in the study.

      i. Classification of certain sources as non-Mn sources based on the reasoning that they will have a lower Mn content; or

      ii. All sources have the same Mn content associated with the inhalable particulate matter (PM_{10}) fraction which would not be the case. Considering the roads for example, the assumption of the same Mn content as the ore would fundamentally mean that the vehicles are travelling along the ore body.

   d. Both the application of the ore Mn content in PM to all sources as well as the exclusion of certain sources (due to low Mn content) would theoretically result in inaccurate representation of the potential Mn ground-level concentrations.

   e. Multiple studies have determined that Mn ground-level concentrations tend to be linked with particulate matter with an aerodynamic dimeter less than 5 µm (PM_5) and not PM_{10}, thus applying either of the methodology above could possibly result in an overestimation of Mn ground-level concentrations.

2. Greenhouse gas (GHG):

   a. GHG emissions estimation was included as part of the climate change study but GHG emission modelling was not included in the scope of work.

3 PROJECT DESCRIPTION

Fugitive particulate matter (PM) emissions will be released to the 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).

It should be noted that in the discussion, regulation and estimation of PM emissions and impacts a distinction is made between different particle size fractions, *viz*. TSP, PM_{10} and $PM_{2.5}$. Whereas PM_{10} and $PM_{2.5}$ fractions are taken into account to determine the potential for human health risks, TSP is included to assess nuisance dustfall rates. In addition to fugitive PM emissions, combustion related PM and gaseous emissions will also be released from mobile and stationary equipment exhausts. Key pollutants from combustion of fossil fuels include PM_{10} and $PM_{2.5}$, NO_x, SO_2, CO, formaldehyde and volatile organic compounds (VOCs). PM emitted from diesel combustion will mostly be in the form of black carbon, commonly referred to as diesel particulate matter (DPM). Fuel storage for equipment use and electricity supply would result in additional amounts of VOCs.

Timeframes and scheduling of phases

- 2 years have been allowed for pre-stripping and mining infrastructure construction.
- The Life of mine (LoM) indicated by the conversion of the resource to reserve is 30 years for the open pit operation.
- Backfilling/rehabilitation will commence immediately after the commencement of the mining operation and its advance will match the depletion rate of the open pit.
- A period of 3 years is expected for final rehabilitation after closure.

3.1 Construction Phase

During the construction phase several facilities need to be established. These include additional contractor's laydown areas, workshops (instrumentation, electrical and mechanical), stores for the storing and handling of fuel, lubricants, solvents, paints and construction materials, a wash bay, laboratory, construction waste collection and storage facilities, a store, a parking area for cars and equipment, site offices, portable ablution facilities, electricity supply (possibly generators), portable water supply (bowsers), change houses, soil stockpiles, water management infrastructure, security and access control, and the roads. These facilities will either be removed at the end of the construction phase or incorporated into the layout of the operation phase facilities. Access to site will be via the existing access roads. The following activities are likely:

- Site establishment of construction phase facilities
- Clearing of vegetation
- Stripping and stockpiling of soil resources and earthworks
- Drilling and blasting
- Handling and storage of construction materials
- Collection, storage, and removal of construction related waste
- Transportation of materials and waste on-site and along the access roads
- Construction of all infrastructure required for the operational phase.

The potential construction activities that will take place during the construction phase and the associated pollutants are included in Table 2.

Table 2: Potential construction activities resulting in emissions and the associated pollutants

Activity	Associated pollutants
Handling and storage area for construction materials (paints, solvents, oils, grease) and waste	PM[(a)] and VOCs
Clearing, grubbing and other earth moving activities	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2[(b)]; CH_4[(b)]; N_2O[(b)])
Stockpiling topsoil and sand	PM
Foundation excavations	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Establishment or expansion of access roads (scraping and grading)	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Digging of foundations and trenches	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Delivery of materials, storage and handling of material such as sand, rock, cement, chemical additives, etc.	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
General building/construction activities including, amongst others: mixing of concrete; operation of construction vehicles and machinery; refuelling of machinery; civil, mechanical and electrical works; painting; grinding; welding; etc	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Handling, storage and disposal of non-hazardous and hazardous waste	PM and gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O), potential for dioxin and furans from blasting cassettes incineration (burning grounds)

Notes: (a) Particulate matter (PM) comprises a mixture of organic and inorganic substances, ranging in size and shape and can be divided into coarse and fine particulate matter i.e., TSP, PM_{10} and $PM_{2.5}$

(b) carbon dioxide, methane and nitrous oxide are greenhouse gases (GHG)

3.2 Operational Phase

The main operations are opencast mining, material storage, crushing and screening of ore, grading of roads, bulldozing of stockpiles for stockpile management. Backfilling/rehabilitation will be undertaken simultaneously with the mining operations and its advance will match the depletion rate of the open pit. There will an all-weather access road with the main road users being Heavy Vehicles (HV) which will have a dedicated access road running from the product stockpile area to the east of the operations, Light Delivery Vehicles (LDV's) and personnel vehicles, and buses will have a desiccated access road to extending to the west of the operations from the Hotazel town. In addition, on-site access roads will be required for use by the secondary support fleets and haul trucks. More detail all the functions associated with the proposed project is provided below.

Mining

- Opencast mining methods will be used to a maximum depth of 95 m.
- The orezone of the various seams is found at depths from 25 to 91 m below the surface and the manganese seam thicknesses varies from 3 to 27 m.
- The proposed mining process is as follows: drilling → blasting → load and haul → dry crushing and screening plant → product stockpiling → road truck loading.
- The annual Run of Mine (RoM) ore production is estimated at 0.5 Mt.
- The mining of the opencast pit will require as many as two active work areas in certain schedule overlap years.

Blasting

- The blast designs will aim for productive blasting, whilst achieving the environmental controls that are needed for mining safely at the proposed THM.
- The blast designs (including timing and stemming requirements) will take the rock type descriptions, mining methods including planned bench height and hole diameter and the distribution of sensitive receptors surrounding the mine into account.
- The following limits will be applied:
  - Ground vibration: A maximum peak particle velocity (PPV) of 6 mm/s for the closest house.
  - Air blast: A peak air blast level of 120 dBL.
  - Maximum fly rock range: Three fly-rock limits will apply using a factor of safety of two for the safety of people, these being 100 m maximum for all blasts, a 300 m alert or exceedance range for which a special internal investigation is needed if fly rock occurs in this range at distances more than 100 m, and a 500 m clearance zone.
- Cartridge explosives and detonators will be sourced from a licensed explosive magazine provided for use by the blasting contractor, the location which will not be situated within the mining area and adjacent residential area. The blasting contractor office and ammonium nitrate silos and emulsion tank will be stored within a fenced compound to be developed in accordance with the legislated requirements.
- If ammonium nitrate prill is required in the future it will be delivered to site by truck.

Loading and hauling

- Due to the mixing requirements, where high-grade ore will be mixed with the lower grade material from the lower benches within the pit, the loading equipment will be mobile.
- The excavators will load the 40t haulage units with three to four passes and will be supported by a bulldozer to assist with oversize handling, ore crowding and road construction.
- RoM ore will be trucked out of the open pit and tipped onto the RoM ore stockpile.

Processing

- From the RoM stockpile, front end loaders (FELs) will feed the ore into the primary crusher (jaw crusher).

- The primary crusher will feed the screening plant. In the initial stages these will be mobile units.
- The different size fractions will be sampled and stockpiled into separate stockpiles according to grade and size at the dedicated stockpile area.
- From these stockpiles, the product will be loaded onto road trucks using a FEL according to the customer's requirements in terms of size and grade (some blending may be required).
- Water mist will be added to all processes to reduce dust generation.
- Fines will be stockpiled for sale as and when the demand arises.
- The mobile crushing and screening plant is currently planned to be located at the southern end of the new open pit.
- Road transport loading with suitable weighbridges will take place via a dedicated loading facility. Road trucks will then transport product to Lohatla for train loading, after passing over the weighbridge.

Mine entrance and access roads

- There are two main access roads to the mine, one intersects with Provincial Road D3463 from Kuruman to Severn and enters the mine at the northern easter corner, while the other road is from Hotazel town in the west and enters the mine from the north. The two roads intersect before entering the mining area.
- The main transport route to the north east will be for Heavy Vehicles (HVs), potentially 80 – 100 trucks per day, and the main entrance to the west (near Hotazel) will be for Light Delivery Vehicles (LDV's).
- In addition, on-site access roads will be required for use by the secondary support fleets and earthmoving haul trucks, with ramps that lead in and out of the pit and haul roads for the transportation of processed products and waste amongst others.
- In order to improve mobility around the mine and to potentially reduce road user costs, a ring road (haul road) around the mine pit has been proposed. This road will also intercept stormwater which will be channelled to the stormwater ponds.
- The minimum width of all the roads is 10m as they generally have to accommodate large trucks, with sufficient space for surface water flow.

Support Equipment

- Four excavators (5 m^3 capacity) and FELs (5 m^3 capacity) will be required for flexibility and management of the various stockpiles.
- Eight trucks (in the 40 t class with 320 kW engines) will be required in the initial production period with this increasing to sixteen once steady state RoM production has been achieved.
- Three primary blast hole drill rigs will be required
- One road grader will maintain the roads on the property.
- One water truck for dust suppression on main haul routes.
- Two track dozer will be used for typical dozer functions including maintenance of dumps, drill site preparation, road building, ditching, bench repair, shovel clean-up and stockpile dozing.
- A rubber-tired dozer for lighter dozer work such as shovel excavator clean-up and road sweeping.
- Diesel LDVs will be supplied for the Mine Superintendent, Engineering Superintendent, Mining Supervisor, Blaster, Geologist, Surveyors, and the plant production crew. A total of eight units are provided for initially.

- Maintenance support vehicles and equipment will include flat deck trucks and fuel, water, and lube trucks for servicing the excavators.
- Miscellaneous units such as personnel carriers, lighting towers etc. are also provided for the support of mine operations.

Electricity

- The mine reticulation will be provided from the existing 11 kV Eskom overhead power supply line from a substation in Hotazel, which terminates close to the north-western corner of the mine, next to the existing railway line.
- A new mini-substation will be connected to the incoming Eskom overhead powerline, from where the mine's offices and weighbridge will be connected by an underground power cable.
- A single Eskom 132 kV line will be brought into the main substation switching yard.
- The expected full load power requirement is calculated as 3 326 kVA. An application for 4.0 mVA has been submitted to cover the power requirements for the proposed THM.
- The remaining facilities and plant (i.e. processing plant) will not be connected to the grid as they will use their own power. The entire processing plant will be diesel operated.
- Until such time as power infrastructure is installed on site a mix of solar and diesel generators will be used as an alternate supply source.

Water

- All potable water will be supplied through the Vaal Gamagara water scheme via a bulk water meter, managed by Sedibeng Water.
- Sedibeng Water has therefore been engaged and has provisionally approved a connection point for water supply approximately 2km south west of the mine. A design is required to be submitted to Sedibeng Water for approval.
- Water will be required for processing, mining, change houses, offices, and workshops. Each supply area will be individually metered to enhance control and minimize wastage.
- Water supply for other purposes (i.e. dust suppression and industrial use on site) will be sourced from the either the stormwater ponds or the PCD.
- The estimated that the potable water consumption volumes per day is 4800 – 6480 litres per day plus 10% for wastage/losses.
- The remainder of the water to be used for general purposes (i.e. dust suppression and process water purposes) will be sourced from the PCD and the stormwater ponds.
- An application for a water connection has been submitted to Sedibeng Water.
- Precipitation has collected in the open void and underground workings since the mine stopped production in 1989. Thus this water will need to be fully removed before mining work can commence. A forced-evaporation system to eliminate water from the initial void may be implemented for water management purposes.
- A lined 5 m deep Pollution Control Dam (PCD) is planned with a minimum capacity of 20 000 $m^{3.}$
- The site has been split into three main catchment areas, excluding the mining pit, resulting in a total of three planned stormwater ponds to store as much of the surface water as practically possible. The surface water will mainly be intercepted by the roads and channelled to the respective stormwater ponds. The capacity of

the stormwater ponds is as follows: stormwater pond 1 (12 250 m^3), stormwater pond 2 (6500 m^3) and stormwater pond 3 (7313 m^3). The ponds have been sized for a 1 in 50 year return flood.

- Mine dewatering will be carried out using diesel powered submersible pumps installed in sumps at the bottom of the pit. Water will be pumped from the open pit and discharged into the freshwater tank for use in the plant with any excess water discharged to the PCD.

Waste

- The mining project will generate general (domestic) waste and mining waste.
- Sanitation from the mine will be piped to a septic tank which will be located on the eastern side of the offices. This septic tank will have a capacity of a minimum two (2) weeks before it is filled-up. Design drawings are to be submitted to the municipality for approval prior to start of construction. Similar to the water supply, sanitation infrastructure will only be connected to the office block.
- Non-hazardous domestic and industrial waste will be stored temporarily within a hard-standing area for covered bins / skips.
- All recyclable waste will be collected by a contractor where it will be recycled off-site. Only materials which cannot be reused, recycled or recovered will be disposed of at an appropriately licensed facility by a licensed contractor.
- An estimated stripping ratio is set at 2.98 t of waste per tonne of ore. Residue material (overburden and waste rock) arising from the development and ongoing operation of the opencast mine pit will be disposed back into the existing historical opencast void and the trailing mined out opencast void through backfilling. There will be 3 waste dumps with the following capacities and maximum heights:
    - Waste dump no.1 (3 859 493 m^3) – 15 m above current surface
    - Waste dump no.2 (3 487 682 m^3) - level with current surface
    - Waste dump no.3 (5 783 722 m^3) – 30 m above current surface
- There will also be a topsoil stockpile with a capacity of 210 000 m^3 and estimated height of 10 m and a sand stockpile with a capacity of 1 185 000 m^3 and estimated height of 20m.

Other infrastructure

- A new weighbridge facility, which will comprise of a weighbridge and an office, is planned to be constructed between the offices and the product stockpile area, close to the northern boundary of the of the mine. This facility will be manned as per the operational requirements of the mine. In order to cater for trucks that may be overload or underloaded, a turning loop will be constructed next to the weighbridge facility to allow for easy access back to the product stockpile area.
- The new offices and parking will be located along the northern boundary of the mine. The offices will be accessible via the new access road that ties-in with the main access road from the north, used by LDVs.
- A plant yard/ workshop will be located on the western side of the pit, between the mine pit and a haul road that links the processing plant and the product stockpile area. This facility will mainly be used for repairs, servicing and washing of vehicles/plant. The surface will be a concrete slab with a slope towards various sumps to contain oil and contaminated water.
- A Refuelling Station will be located on the western side of the pit. This facility is anticipated to have at least two 30 000 l refuelling tanks, and will have a concrete slab with sumps to contain oil and contaminated water.

Operating hours and staff

- The mine and plant will operate on a continuous basis, with 330 working days per annum.
- The mine will employ approximately 177 people (inclusive of outsourced service providers).

The proposed project operations that would result in emissions to the atmosphere and the associated potential pollutants from these operations are discussed in Table 3:

Table 3: Air emissions and pollutants associated with the Project operational phase

Activity	Description	Sources of emission	Main Pollutants
Mining operations	Opencast mining method. Drilling, and blasting, excavation, transfer of materials to trucks and transport of ore to the ore stockpiles and waste to dedicated stockpile areas and reclamation. Waste will be trucked to the mine voids for backfilling. Topsoil and sand will be stored at dedicated stockpiles and trucked to the mine voids for rehabilitation. Bulldozing will likely be required during the rehabilitation process.	Drilling	TSP; PM_{10} and $PM_{2.5}$
		Blasting	TSP, PM_{10}, $PM_{2.5}$, NO_x; SO_2; CO; CO_2; CH_4; N_2O
		Vehicle entrainment	TSP; PM_{10} and $PM_{2.5}$
		Vehicle exhaust	TSP, PM_{10}, $PM_{2.5}$, DPM, CO, NO_x, SO_2
		Materials handling	TSP; PM_{10} and $PM_{2.5}$
		Windblown dust	TSP; PM_{10} and $PM_{2.5}$
		Bulldozing	TSP; PM_{10} and $PM_{2.5}$
Crushing and screening	Ore is fed into the crushing and screening plant.	Screening	TSP, PM_{10} and $PM_{2.5}$
		Crushing	TSP, PM_{10} and $PM_{2.5}$
		Materials handling	TSP, PM_{10} and $PM_{2.5}$
Transportation, handling of product	Product will be transported using on-site haul roads to the product stockpiles where it will be stored, reclaimed and the transported off-site via trucks to a dedicated train loading facility and then transported via train using existing railway lines. Product will be reclaimed from the product stockpiles using front end loaders (FELs) and transferred into trucks.	Materials handling	TSP; PM_{10} and $PM_{2.5}$
		Windblown dust	TSP; PM_{10} and $PM_{2.5}$
		Vehicle entrainment	TSP, PM_{10} and $PM_{2.5}$
		Vehicle exhaust	TSP, PM_{10}, $PM_{2.5}$, DPM, CO, NO_x, SO_2, VOC
		Trains travelling on railway lines which occurs off-site and thus was excluded	TSP, PM_{10} and $PM_{2.5}$
Ore, waste, topsoil and sand handling and transportation	Ore, waste, topsoil, and sand and are stored on stockpiles on-site and transported using trucks along dedicated on-site haul roads.	Materials handling	TSP; PM_{10} and $PM_{2.5}$
		Windblown dust	TSP; PM_{10} and $PM_{2.5}$
		Vehicle entrainment	TSP, PM_{10} and $PM_{2.5}$
		Vehicle exhaust	TSP, PM_{10}, $PM_{2.5}$, DPM, CO, NO_x, SO_2, VOC

3.3 Decommissioning and Closure Phase

The removal of infrastructure as well as sloping and revegetation of the area are planned for the decommissioning phase. Fugitive PM emissions as well as combustion related PM and gaseous emissions will be released from mobile equipment, and traffic. This phase will include removal of plant and equipment, shaping of disturbed and formed areas of the landscape, land rehabilitation/revegetation and construction of structures to make the site safe. Closure monitoring usually occurs periodically over five (5) years to determine if the decommissioning and rehabilitation works have been successfully completed.

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. The National Environmental Management: Air Quality Act, 2004 (hereafter referred to as “NEM:AQA”) (Act No. 39 of 2004) was made law by the President on 19 February 2005 and was brought into effect by the Minister on 11 September 2005 (Republic of South Africa, 2005).

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 NEMA and NEM:AQA. A portion of the NEMA EIA Regulations, the National Atmospheric Emission Reporting Regulations, Regulations regarding Air Dispersion Modelling, NAAQS and NDCR are relevant to the Project and are discussed below.

4.1 NEMA EIA Regulations

In terms of the National Environmental Management Act, 1998 (NEMA) Environmental Impact Assessment (EIA) Regulations (Republic of South Africa, 2014) (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 requirement for this report is that it fulfils the 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, and 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 DFFE published amendments to Category 1 (Republic of South Africa, 2020). None of the 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 National Atmospheric Emission Reporting Regulations (NAERR)

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, Tawana and/or their data provider should register on the NAEIS. 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 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 published in 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 this study:

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

The Regulations will be applied in undertaking this study.

4.5 South African National Ambient Air Quality Standards

Criteria pollutants are considered those pollutants commonly found in the atmosphere, that have proven detrimental health effects when inhaled and are regulated by ambient air quality criteria. These generally include PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO and O_3. The state of the air document published by the DEA now DFFE says: "Air quality limits and thresholds are fundamental to effective air quality management. Ambient air quality limits serve to indicate what levels of exposure to pollution are generally safe for most people, including the very young and the elderly, over their lifetimes."[4]

[4] https://www.environment.gov.za/sites/default/files/docs/stateofair_executive_iaiquality_standardsonjectives.pdf

The final National Ambient Air Quality Standards (NAAQS) were published by the DEA now DFFE in 2009 (Republic of South Africa, 2009) and additional standards for $PM_{2.5}$ were published in 2012 (Republic of South Africa, 2012). The NAAQS for the pollutants assessed in this study are listed in Table 4.

Table 4: National Ambient Air Quality Standards for criteria pollutants associated with this study

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
$PM_{2.5}$	24-hour	40	-	4	1 Jan 2016 – 31 Dec 2029
	24-hour	25	-	4	1 Jan 2030
	1-year	20	-	0	1 Jan 2016 – 31 Dec 2029
	1-year	15	-	0	1 Jan 2030
PM_{10}	24-hour	75	-	4	Currently enforceable
	1-year	40	-	0	Currently enforceable
NO_2	1-hour	200	106	88	Currently enforceable
	1-year	40	21	0	Currently enforceable
SO_2	10-minute	500	191	526	Currently enforceable
	1-hour	350	134	88	Currently enforceable
	24-hour	125	48	4	Currently enforceable
	1-year	50	19	0	Currently enforceable
CO	1-hour	30 000	26 (ppm)	88	Currently enforceable
	8-hour	10 000	8.7 (ppm)	11	Currently enforceable

4.6 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. Acceptable dustfall rates per the regulations are summarised in Table 5.

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

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

4.7 Inhalation Health Criteria and Unit Risk Factors for Non-Criteria Pollutants

The potential for health impacts associated with non-criteria pollutants emitted from mobile and stationary diesel combustion sources are assessed according to guidelines published by the following institutions:

1. Inhalation reference concentrations (RfCs) and cancer unit risk factors (URFs) published by the US EPA Integrated Risk Information System (IRIS).
2. Reference Exposure Levels (RELs) and Cancer Potency Values (CPV) published by the California Environmental Protection Agency (CAL EPA).

Chronic inhalation criteria and guidelines for manganese, as published by various international organisations, are summarised in Table 6. Chronic inhalation criteria and URFs/CPVs for diesel particulate matter are summarised in Table 7. Increased lifetime cancer risk is conservatively calculated by applying the unit risk factors to predicted long term (annual average) pollutant concentrations.

Table 6: Chronic inhalation criteria and guidelines for manganese

Source	Concentration (µg/m^3)
WHO GV (WHO, 2001)	0.15
US EPA IRIS RfC (US EPA, 2012)[(a)]	0.05
US ATSDR MRL (ATSDR, 2012)[(b)]	0.3

Notes: (a) The US EPA Integrated Risk Information System (IRIS) defines chronic inhalation as "repeated exposure by the oral, dermal, or inhalation route for more than approximately 10% of the life span in humans".
(b) The Agency for Toxic Substances and Disease Registry (ATSDR) refers to the chronic exposure duration as 365 days and longer.

Table 7: Inhalation screening criteria and cancer potency values for diesel particulate matter

Pollutant	Chronic screening criteria (µg/m^3)	Cancer potency value (µg/m^3)$^{-1}$
Diesel exhaust as DPM	5 (US EPA IRIS)	0.0003 (CAL EPA)

The identification of an acceptable cancer risk level has been debated for many years and it possibly will continue as societal norms and values change. Some people would easily accept higher risks than others, even if it were not within their own control; others prefer to take very low risks. An acceptable risk is a question of societal acceptance and will therefore vary from society to society. Despite the difficulty to provide a definitive "acceptable risk level", the estimation of a risk associated with an activity provides the means for a comparison of the activity to other everyday hazards, and therefore allowing risk-management policy decisions. Technical risk assessments seldom set the regulatory agenda because of the different ways in which the non-technical public perceives risks. Consequently, science does not directly provide an answer to the question.

Whilst it is perhaps inappropriate to make a judgment about how much risk should be acceptable, through reviewing acceptable risk levels selected by other well-known organizations, the US EPA's application appears the most suitable, i.e. *"If the risk to the maximally exposed individual (MEI) is no more than 1 x 10^{-6}, then no further action is required. If not, the MEI risk must be reduced to no more than 1 x 10^{-4}, regardless of feasibility and cost, while protecting as many individuals as possible in the general population against risks exceeding 1 x 10^{-6}"*. Some authorities tend to avoid the specification of a single acceptable risk level. Instead, a “risk-ranking system” is preferred.

For example, the New York State Department of Health (NYSDOH) produced a qualitative ranking of cancer risk estimates, from very low to very high (Table 8). Therefore, if the qualitative descriptor was "low", then the excess lifetime cancer risk from that exposure is in the range of greater than one per million to less than one per ten thousand.

Table 8: Excess Lifetime Cancer Risk (as applied by NYSDOH)

Risk ratio	Qualitative descriptor
Equal to or less than one in a million	Very low
Greater than one in a million to less than one in ten thousand	Low
One in ten thousand to less than one in a thousand	Moderate
One in a thousand to less than one in ten	High
Equal to or greater than one in ten	Very high

4.8 Screening criteria for animals and vegetation

4.8.1 Assessment Criteria for Vegetation Impacts from Dustfall Rates

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).

4.8.2 Assessment Criteria for Vegetation Impacts from SO_2 and NO_2

The impact of emissions on surrounding vegetation was assessed by comparing the simulated annual SO_2 and NO_2 concentrations for each of the emission scenarios against the critical levels for vegetation as defined by the United Nations Economic Commission for Europe (UNECE) Convention on Long Range Trans-boundary Air Pollution Limits (CLRTAP, 2015) (Table 9).

Table 9: Critical levels for SO_2 and NO_2 by vegetation type (CLRTAP, 2015)

Pollutant	Vegetation Type	Critical Level (µg/m³)	Time Period[(a)]
SO_2	Cyanobacterial lichens	10	Annual average
	Forest ecosystems (including understorey vegetation)	20	Annual average and Half-year mean (winter)
	(Semi-)natural vegetation	20	Annual average and Half-year mean (winter)
	Agricultural crops	30	Annual average and Half-year mean (winter)

Pollutant	Vegetation Type	Critical Level (µg/m³)	Time Period[(a)]
NO_2	All	30	Annual average and Half-year mean (winter)
		75	Daily average

Notes: (a) For the purposes of mapping of critical levels and exceedances CLRTAP recommend using only the annual average, due to increased reliability of mapped and simulated data for the longer time period. It is also noted that long-term effects of NO_X are more significant than short-term effects (CLRTAP, 2015).

5 AIR QUALITY BASELINE

This chapter provides details of the receiving environment which is described in terms of:

- The identification of Air Quality Sensitive Receptors (AQSRs) from available maps;
- A study of the atmospheric dispersion potential of the area;
- The identification of existing sources of emissions in the study area; and

5.1 Affected Environment Air Quality Sensitive Receptors (AQSRs)

AQSRs primarily refer to places where people reside; however, it may also refer to other sensitive environments that may adversely be affected by air pollutants. Ambient air quality guidelines and standards, as discussed under Section 4, have been developed to protect human health. Ambient air quality, in contrast to occupation exposure, pertains to areas outside of an industrial site/mine boundary where the public has access to and according to the NEM:AQA excludes areas regulated under the Occupational Health and Safety Act (No 85 of 1993) (Republic of South Africa, 1993). Receptors near the Project include the residential areas of Hotazel, Blackrock, Mogojaneng, and Magobing which are made up of individual residences, schools, medical facilities as well as contractors and leisure accommodation. There are also isolated farmsteads, contractors and leisure accommodation and mining villages near the Project that would also be classified as sensitive receptors. Receptors located within 10 km of the Project are listed in Table 10 and shown in Figure 2. These were included in the dispersion model setup as discrete receptors.

Table 10: Identified individual air quality sensitive receptors

ID/Name	Type	Longitude	Latitude
R1	Farmstead	22.977907761	-27.292087813
R2	Farmstead	23.023908003	-27.240601303
R3	Farmstead	23.034036496	-27.216124110
R4	Farmstead	23.038256702	-27.226252604
R5	Farmstead	23.062311874	-27.206839657
R6	Farmstead	23.042898928	-27.154931127
R7	Farmstead	22.931907518	-27.137628284
R8	Farmstead	22.910384469	-27.168013765
R9	Farmstead	22.919668922	-27.265500517
Hotazel Combined School	School	22.963981082	-27.208105719
Hotazel College	School	22.956806732	-27.197977225
Wessels Clinic	Medical Facility	22.963981082	-27.211059863
Gloria Mine Village	Mine Village	22.909962449	-27.170123868

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 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.

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 6 and 8 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

The 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 north-easterly sector. The strongest winds (>6 m/s) occurred mostly from the northerly sectors. Calm conditions occurred 3.66% of the time, with the average wind speed over the period of 4.36 m/s. Wind speeds are stronger during the day but with a higher frequency of calm conditions (4.01% during the day) than during the night (3.31% during the night). Night-time shows dominant north-easterly, east-north-easterly, south-south-easterly and southerly components to the wind field and during the day these winds decrease, and the northerly winds dominate. Strong winds exceeding 6 m/s occurred most frequently during summer and spring, followed by winter. Calm conditions occurred most frequently during the autumn and winter months.

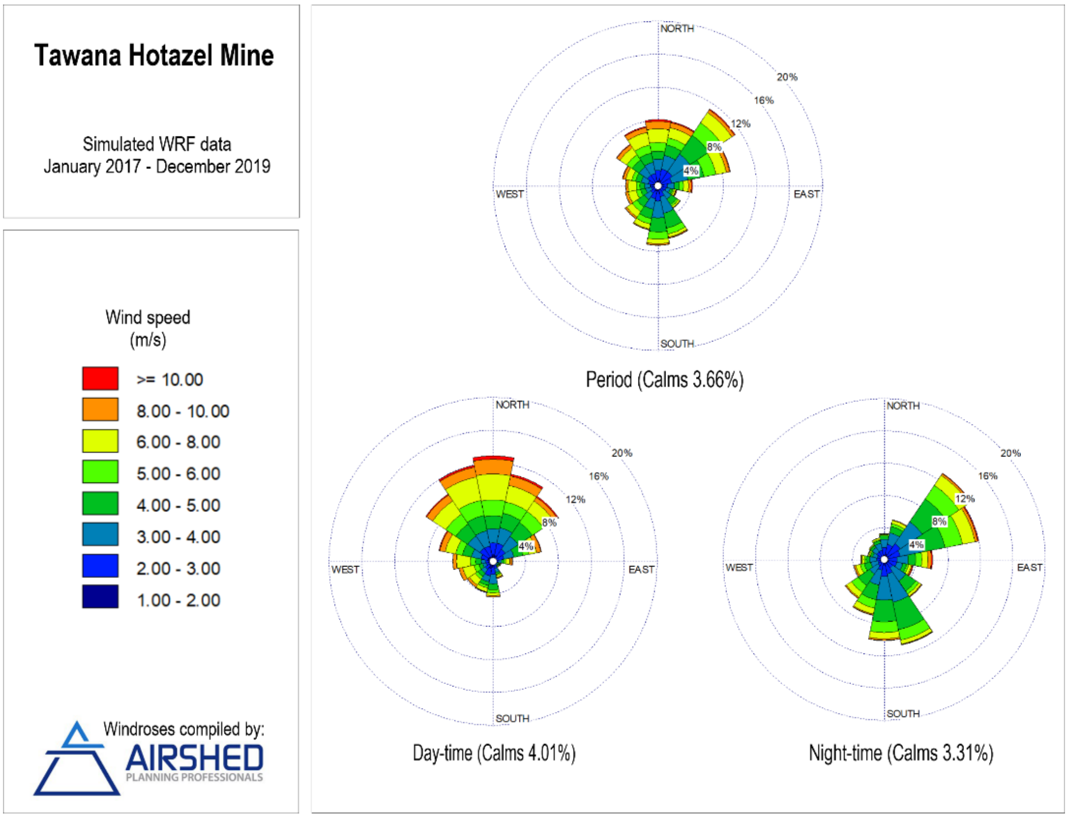


Figure 4: Period, day- and night-time wind roses (AERMET processed WRF data, January 2017 to December 2019)

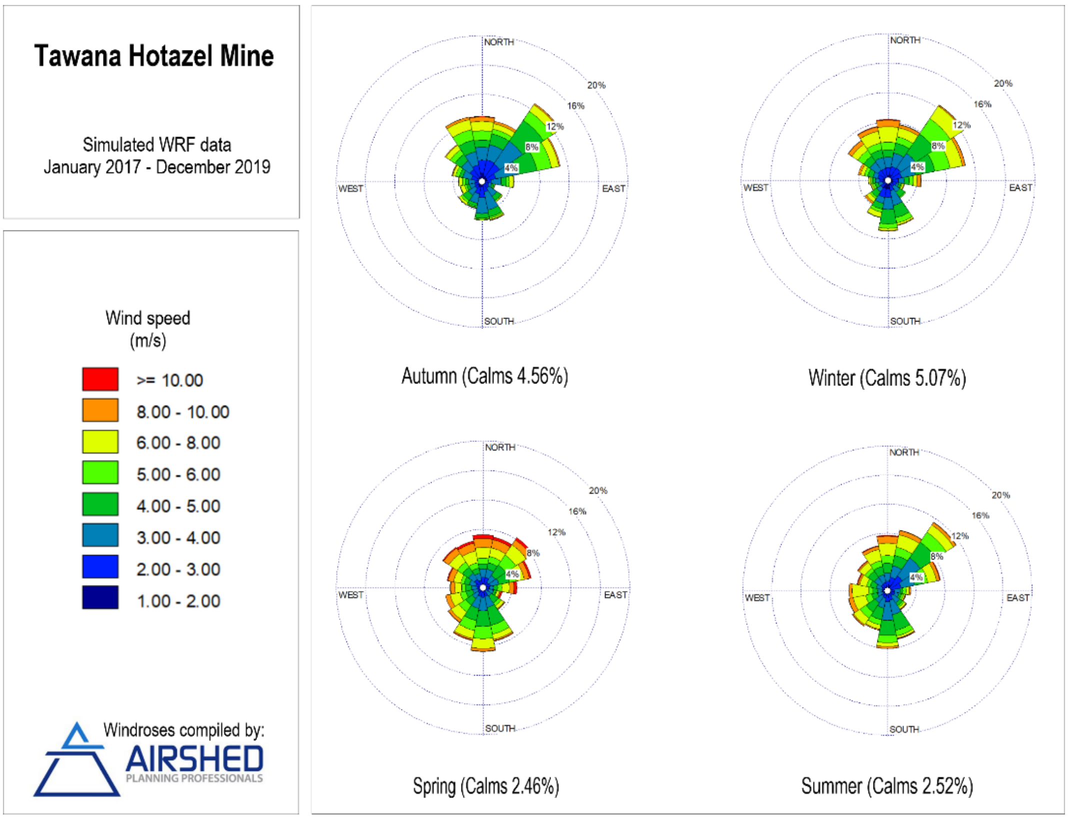


Figure 5: Seasonal wind roses (AERMET processed WRF data, January 2017 to December 2019)

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 11. Diurnal temperature variability is presented in Figure 6. Temperatures ranged between -5°C and 39°C. The highest temperatures occurred in December and January and the lowest in 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 11: Monthly temperature summary (AERMET processed WRF 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	12	9	5	0	-3	-5	-4	-4	-1	6	11
Monthly Average	28	27	25	22	17	13	12	14	19	22	25	27
Hourly Maximum	39	37	37	34	30	26	27	30	35	36	38	39

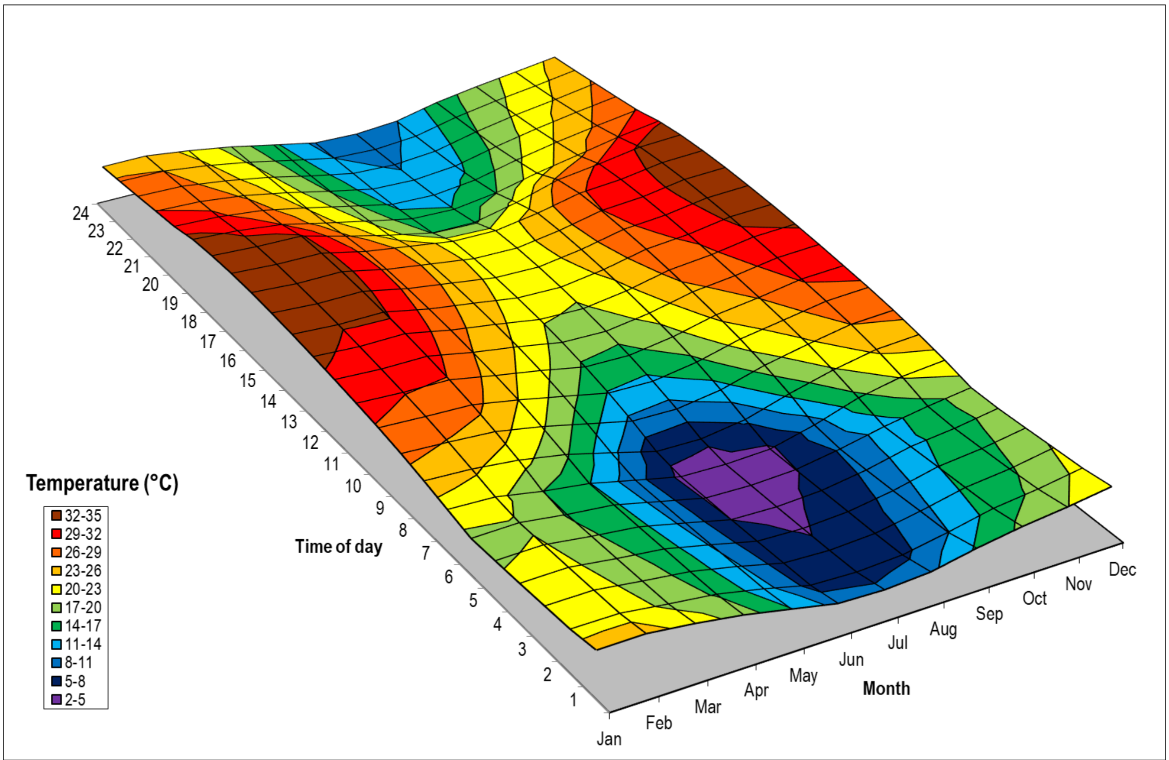


Figure 6: Diurnal temperature profile (AERMET processed WRF data, January 2017 to December 2019)

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.

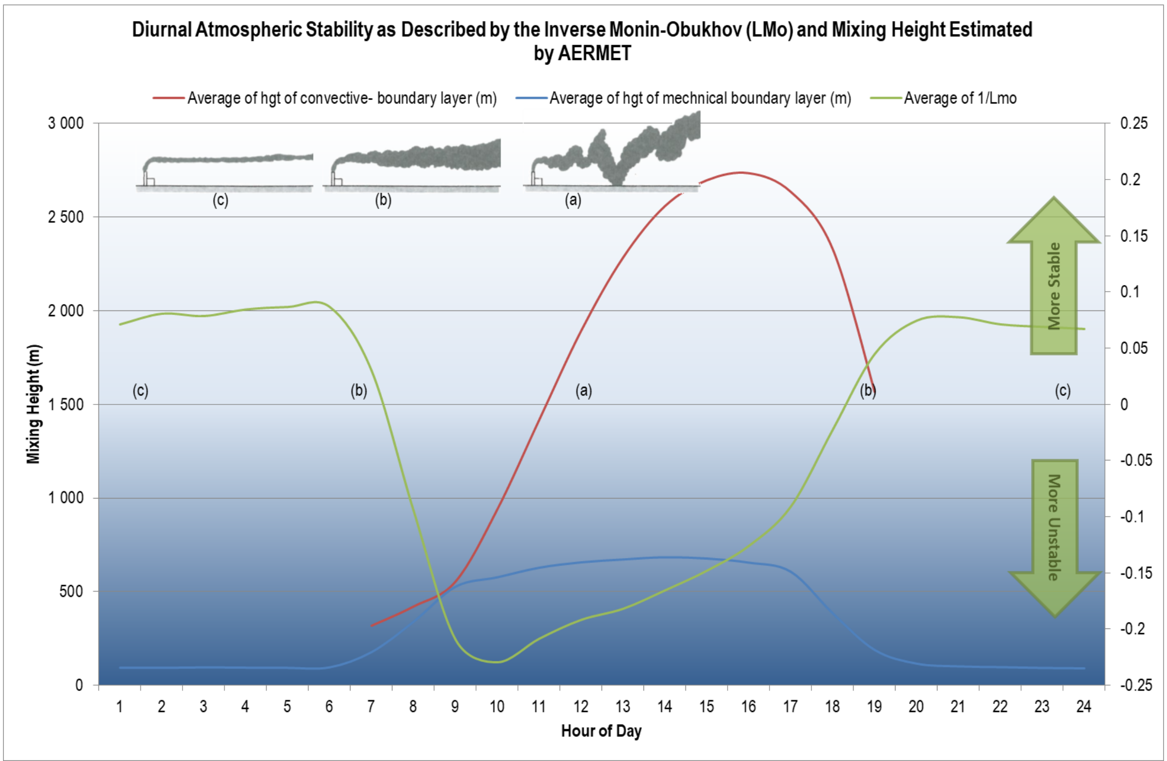
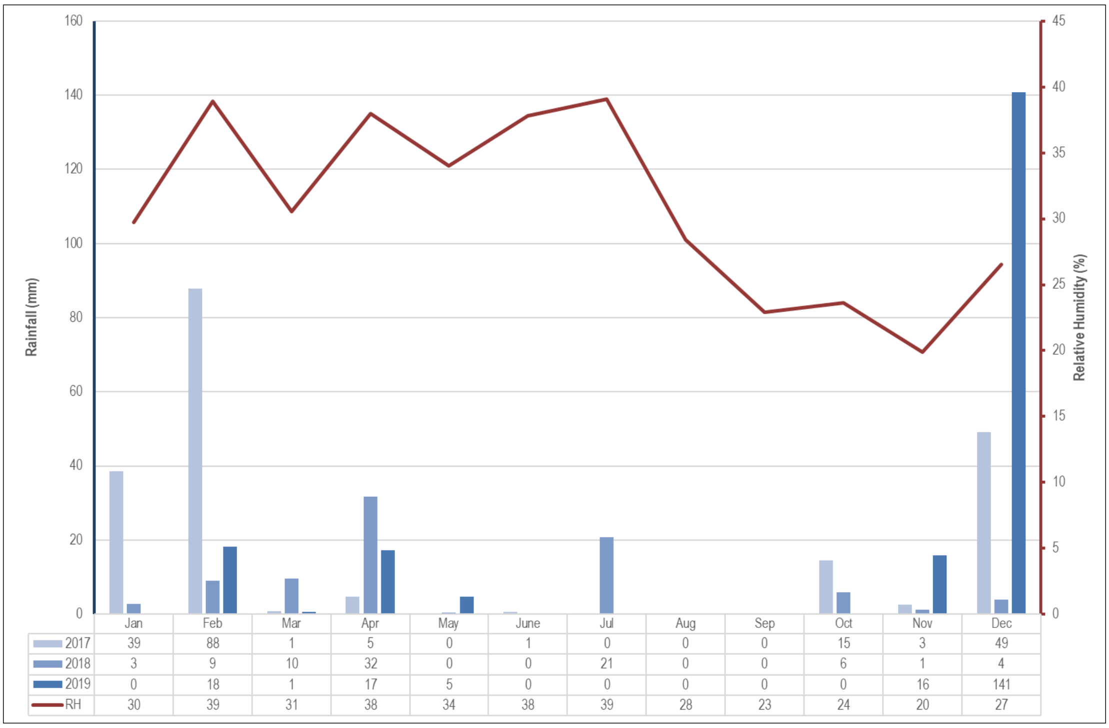


Figure 7: Diurnal atmospheric stability (AERMET processed WRF data, January 2017 to December 2019)

5.2.4 Precipitation

Rainfall is important to air pollution studies since it represents an effective removal mechanism of atmospheric pollutants. Rainfall primarily is a result of storms and individual rainfall events can be intense. This creates an uneven rainfall distribution over the study area. Dust can be generated by strong winds that accompany storms. This dust generally occurs in areas with dry soils and sparse vegetation. The average annual total rainfall in the vicinity of the mine right area based on long-term data (the surface water specialist study dataset from May 1937 to November 2020) is 267 mm.

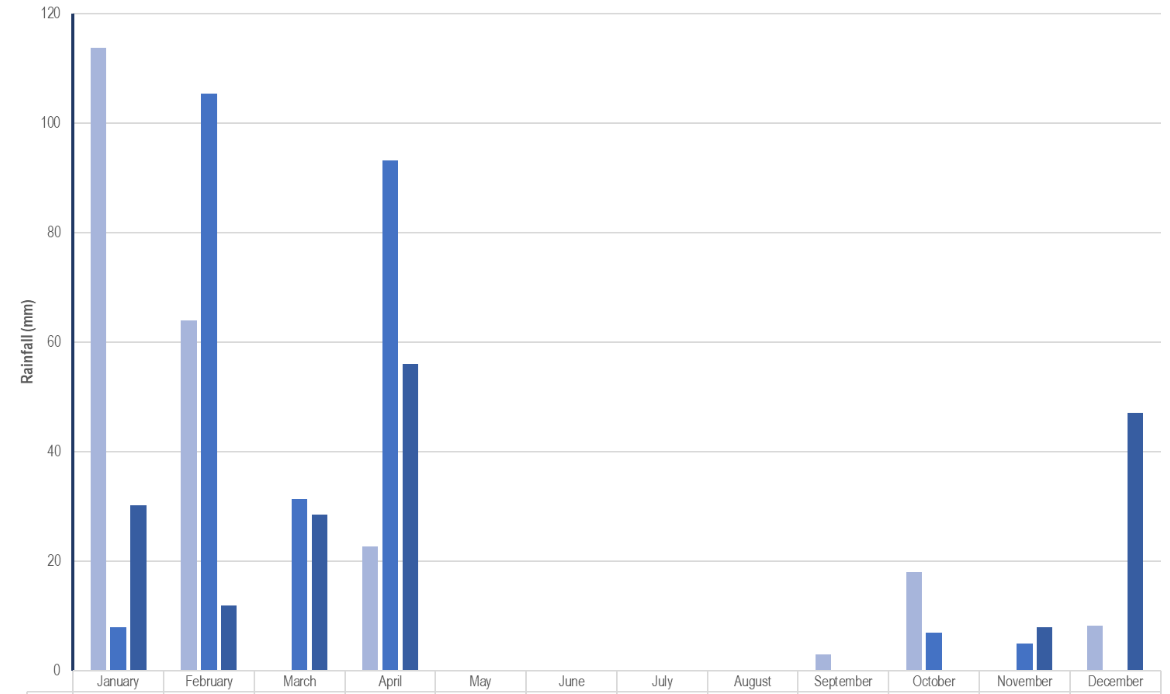
The monthly rainfall totals obtained from the hourly sequential WRF data for a location within the mining rights area is presented in Figure 8. Average total annual rainfall from January 2017 to December 2019 is 161 mm. The rainfall for 2017, 2018 and 2019 was 199 mm, 86 mm, and 198 mm, respectively. 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	39	88	1	5	0	1	0	0	0	15	3	49
2018	3	9	10	32	0	0	21	0	0	6	1	4
2019	0	18	1	17	5	0	0	0	0	0	16	141
RH	30	39	31	38	34	38	39	28	23	24	20	27

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

Daily rainfall totals were acquired by the surface water specialist contained data from the Mukulu and Tsineng gauges. Data from the Computing Centre for Water Research, Natal University (CCWR) database for gauge number 0392640 (Mukulu) was used as well as the South African Weather Service (SAWS) gauge number 0393126 1 (Tsineng - POL). The Mukulu gauge is located approximately 15 km west-north-west of the mining rights area and the Tsineng gauge approximately 13 km north west of the mining rights area. The Mukulu gauge contained missing data between 1965 and 1977. The full dataset assessed for the surface water specialist study ran from May 1937 to November 2020 but contains the missing data between 1965 and 1977. The monthly rainfall totals obtained from this data for the period from January 2017 to December 2019 (the same period as the modelled WRF dataset) is presented in Figure 9. Average total annual rainfall from January 2017 to December 2019 is 201 mm. The rainfall for 2017, 2018 and 2019 was 230 mm, 250 mm and 182 mm, respectively.



	January	February	March	April	May	June	July	August	September	October	November	December
2017	114	64	0	23	0	0	0	0	3	18	0	8
2018	8	105	31	93	0	0	0	0	0	7	5	0
2019	30	12	29	56	0	0	0	0	0	0	8	47

Figure 9: Monthly rainfall (Mukulu and Tsineng combined daily rainfall data, January 2017 to December 2019)

5.3 Existing Air Quality

The current air quality in the study area is mostly influenced by mining and processing 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 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 farming 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 Measured Fine Particulate Matter Concentrations and Dustfall Rates

A site visit was undertaken by specialists from 30 November 2020 to 4 December 2020 where dustfall units were installed to undertake three months of dustfall sampling. A site visit was undertaken by a specialist on 7 September 2021 where passive particulate samplers were deployed, and competent people trained to collect and deploy samplers for the two sampling periods. Figure 10 shows the sampling locations, receptors including the proposed solar facility (sensitive to fallout dust), and the THM proposed surface infrastructure area.

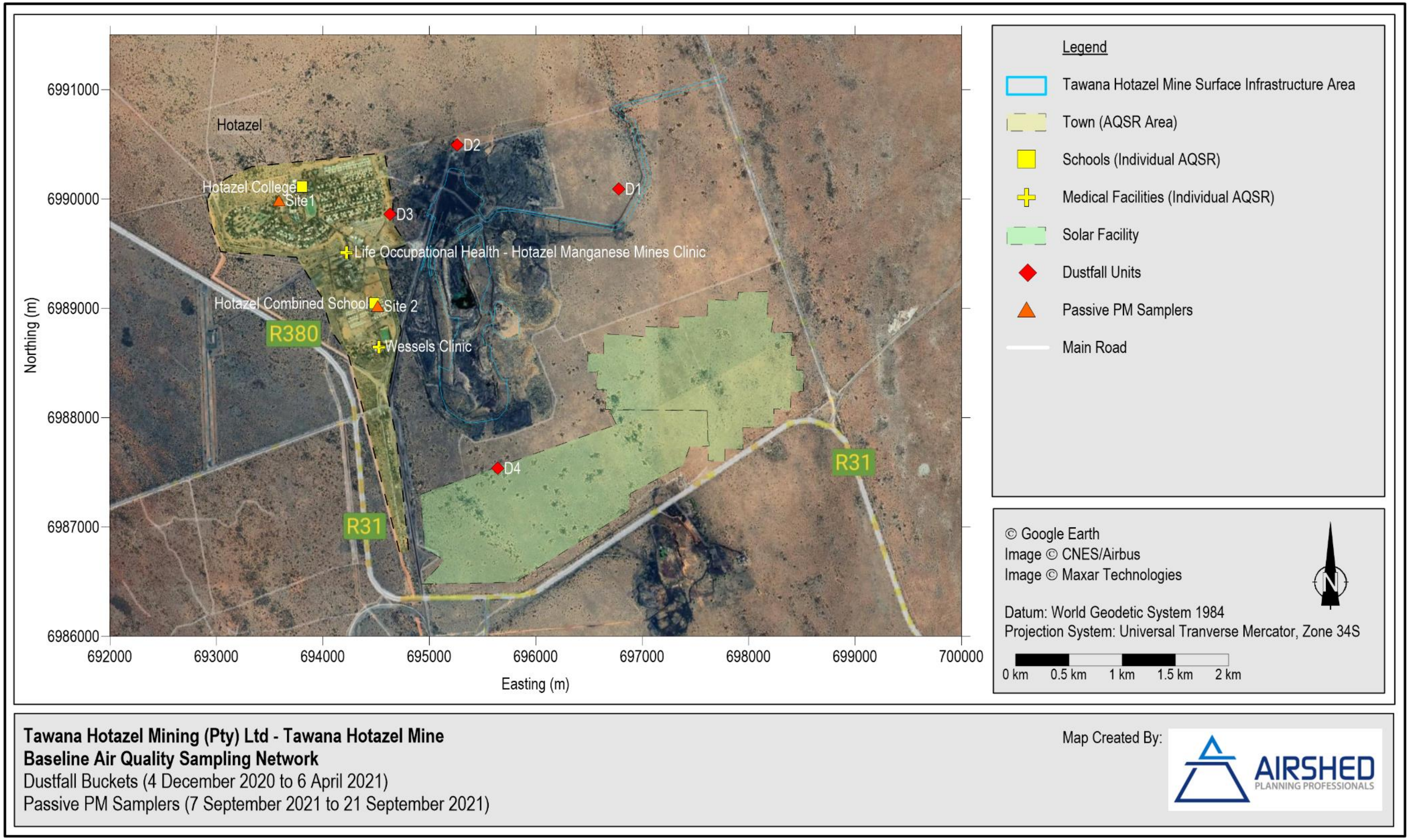


Figure 10: Pre-development sampling map

5.3.1.1 Fine Particulate Matter

Fine particulate matter sampling was undertaken using passive particulate matter samplers from 7 September 2021 to 21 September 2021. The passive PM sampling comprised of two sampling campaigns at two locations in Hotazel town (Figure 10). Table 12 shows the determined 7-day PM_{10} and $PM_{2.5}$ concentrations using Scanning Electron Microscope (SEM) to examine the passive samplers substrate and the extrapolated annual and 24-hour average concentrations screened against NAAQS and NAAQ limits. All samples extrapolated concentrations indicated that the annual average PM_{10} and $PM_{2.5}$ concentration are not likely to exceed the annual (1-year) NAAQS. Concentration values in bold (Table 12) indicate that the extrapolated concentration exceeds the NAAQ limit for that pollutant. Site 1 extrapolated 24-hour concentration for the first 7-day sampling period indicated that the 24-hour average PM_{10} concentration could exceed the 24-hour NAAQ limit. If the relevant 24-hour NAAQ limits are exceeded more than 4 days in a calendar year, then that pollutant would not be in compliance with the NAAQS.

To compare the average sampled concentrations to long term (annual average) and short-term (24-hour average) evaluation criteria (Section 4), equivalent annual average concentrations were extrapolated. For extrapolating time averaging periods from 7 days to 1 year and 24-hours, Beychock (2005) recommends the following equation:

$$\frac{C_x}{C_p} = \left(\frac{t_p}{t_x}\right)^{0.53}$$

where:

C_x *and* C_p are concentrations over any two averaging periods between 24 hours and 1 year;

t_x *and* t_p are corresponding averaging times in days.

Table 12: PM_{10} and $PM_{2.5}$ results for each of the samples analysed

Sample ID/Site	**1/Site 1**	**2/Site 2**	**3/Site 1**	**4/Site 2**
PM_{10} concentration (µg/m³)	29.26	8.16	6.97	7.04
$PM_{2.5}$ concentration (µg/m³)	4.54	6.59	3.84	4.32
Sampling period	07/09/2021 09:15 – 14/09/2021 12:09	07/09/2021 09:28 – 14/09/2021 11:53	14/09/2021 11:55 – 21/09/2021 13:00	14/09/2021 12:12 – 21/09/2021 13:13
Calculated Annual PM_{10} concentration (µg/m³)	3.60	1.00	0.857	0.866
Calculated 24-hr PM_{10} concentration (µg/m³)	**82.1**	22.9	19.5	19.7
Calculated Annual $PM_{2.5}$ concentration (µg/m³)	0.558	0.811	0.472	0.531
Calculated 24-hr $PM_{2.5}$ concentration (µg/m³)	12.7	18.5	10.8	12.1

5.3.1.2 Dustfall Rates

Dustfall units were installed to undertake three months of dustfall sampling; however, the samples for the first month contained a large amount of rainwater and during courier to the laboratory the samples leaked water which could have resulted in some of the dust being leaking out of the buckets with the rainwater and thus it was decided that an additional month of sampling would be undertaken (March/April 2021). The fourth month samples appeared to have a large quantity of organic material (insects) and the laboratory undertook weighing and ashing of the samples to determine the percentage that organic matter contributes to the sample weight.

The dust fallout sampling was undertaken in accordance with ASTM D1739 (2017) as the draft NDCR recommends the most recent version of ASTM D1739. The sampling network includes four locations: three classified as non-residential sites and one as a residential site according to the NDCR; Figure 10 shows the locations of the units. Site D4 is located at the proposed Solar Facility, were the dustfall rates as a result of the THM proposed operations were expected to be the highest[5]. Dustfall rates at the sampling sites from 4 December 2020 to 6 April 2021 are summarised in Table 13 and Figure 11. There was one exceedance of the NDCR limit for non-residential areas at D1 (north of mine access road) in Month 2 (value in bold); determination of the organic matter content of this filter may be requested in the future. The dustfall rates at the unit on the boundary of Hotazel is below the NDCR limit for residential areas for all four months. The sampled dustfall rates are compliant with the NDCR based as the four months results do not have more than two exceedances of the applicable limit in the sampling period or for consecutive months at all sites. As only four months of sampling was undertaken and there was high rainfall in the area during the first month the sampling period there is still the potential that the dustfall rates in the area may be non-compliant with the NDCR.

Table 13: Dustfall rates summary

Dustfall rate ***(NDCR Limit for Residential Areas = 600 mg/m²-day; NDCR Limit for Non-Residential Areas = 1 200 mg/m²-day)***							
Map ID	**Location**	**Applicable NDCR limit**	**Month 1(a)**	**Month 2(b)**	**Month 3(c)**	**Month 4(d)(e)**	**Month 4(d)(f)**
D1	North of mine access road (likely HMM)	Non-Residential	137	**3 376**	266	23.0	110
D2	North of HMM	Non-Residential	77	911	655	53.7	218
D3	East of Hotazel near Dwarsstraat	Residential	79	375	190	23.5	103
D4	South of HMM	Non-Residential	165	320	673	12.9	61.5

Notes:

(a) Sampling period from 4 December 2020 to 5 January 2021 = 32 days exposure

(b) Sampling period from 5 January 2021 to 5 February 2021 = 31 days exposure

(c) Sampling period from 5 February 2021 to 5 March 2021 = 28 days exposure

(d) Sampling period from 5 March 2021 to 6 April 2021 = 32 days exposure

(e) Dustfall rate excluding organic matter contribution

(f) Dustfall rate including organic matter contribution

[5] The simulated results discussed in Section 7.2.3 did have the highest dustfall rates for the proposed solar facility area at this location (D4).

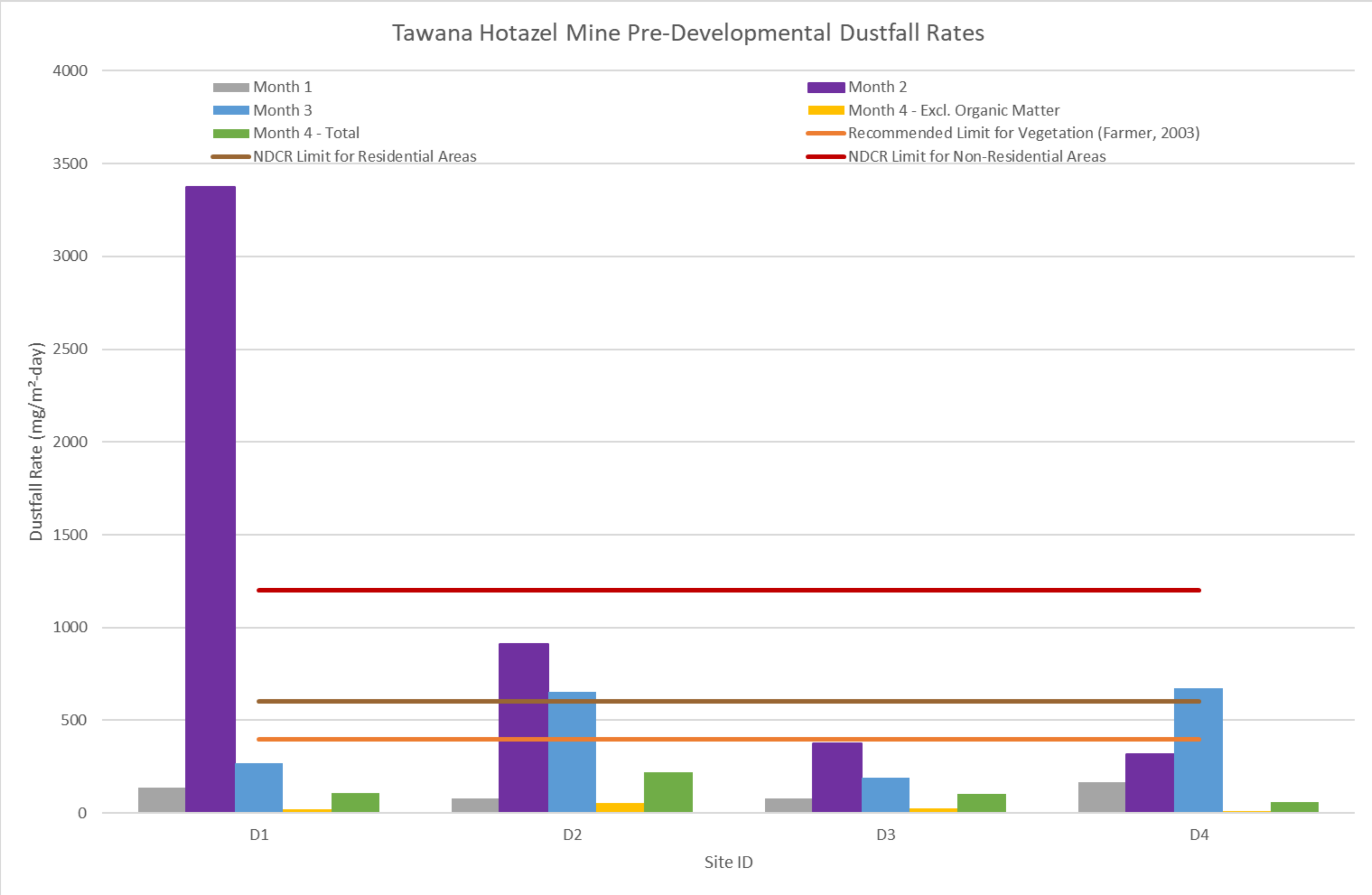


Figure 11: Sampled dustfall rates from 4 December 2020 to 6 April 2021

6 Impact Assessment: Site Preparation and Construction Phase

6.1 Emissions Inventory: Site Preparation and Construction Phase

The sources of atmospheric emissions during the site preparation and construction phase associated with the proposed project include:

- Particulate emissions from
    - stripping of topsoil
    - excavation of sand
    - materials handling
    - bulldozing
    - erosion of stockpiles due to the wind lifting and dispersing loose material during high wind incidents (>5m/s)
    - entrainment of loose material at unpaved areas because of the movement of mobile equipment in these areas
    - grading of unpaved roads
- Particulate and gaseous emissions from
    - mobile equipment exhaust
    - diesel generators exhaust
    - barge diesel generators used for the void/pit dewatering
    - evaporators used for the void/pit dewatering

A summary of emission sources, estimation techniques, and source input parameters is included in Table 14. A summary of estimated emissions in tonnes per annum (t/a) associated with the proposed pre-development and construction phase operations is provided in Table 15.

Table 14: Emission estimation techniques and parameters for the site preparation and construction phase activities

Source group	Emission estimation technique	Input parameters and activities
Topsoil stripping	ADE NPI single valued emission factors for scrapers (removing of topsoil) (ADE, 2012). EF_{PM30} = 0.029 kg/tonne EF_{PM10} = 0.0073 kg/tonne $EF_{PM2.5}$ = 0.0073 kg/tonne (*assumed* to be 100% of PM_{10})	Stripping activities include the stripping of the topsoil within the surface infrastructure area. Amount of topsoil stripped based on the topsoil stockpile volume of 210 000 m³, a topsoil density of 1.6 tonnes per cubic metre (t/m³) and 2 years of stripping resulting in approximately 19.2 tonnes per hour (t/h) of topsoil. **Hours of operation:** 365 days per year, 24 hours per day. **Design mitigation:** None.
Sand excavation	ADE NPI single valued emission factors for excavation of overburden (ADE, 2012). EF_{PM30} = 0.025 kg/tonne EF_{PM1} = 0.012 kg/tonne $EF_{PM2.5}$ = 0.00179 kg/tonne (*assumed* that the $PM_{2.5}/PM_{30}$ ratio for materials handling)	Amount of sand removed based on the sand stockpile volume of 1 185 000 m³, a sand density of 1.6 t/m³ and 2 years of sand removal resulting in approximately108 t/h of sand. **Hours of operation:** 365 days per year, 24 hours per day. **Design mitigation:** None.
General construction	US EPA AP 42 emission factor equation for general construction (US EPA, 1995). $$EF = k \cdot 2.69$$ EF is the emission factor in t/ha-month k is the particle size multiplier k_{PM30} = 1 k_{PM10} = 0.35 $k_{PM2.5}$ = 0.18	A total surface infrastructure/disturbed area of approximately 145 ha. 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:** 365 days per year, 24 hours per day. **Design mitigation:** None.
Mobile equipment exhaust	ADE NPI single valued emission factors for mobile equipment exhaust (kg/kW-h) (ADE, 2008). Scraper Wheeled dozer Wheeled tractor Crane Motor grader Loader (average of wheeled loader and track type loader) Off-highway truck	**Mobile equipment types:** Assumed 1 scraper operating at 114 kW Assumed 2 excavators operating at 304 kW 3 wheeled bulldozers operating at 114 kW Assumed 1 wheeled tractor operating at 60.8 kW Assumed 2 cranes operating at 76 kW 1 motor grader operating at 76 kW 3 FELs operating at 57kW 8 heavy duty trucks operating at 320 kW

Source group	Emission estimation technique	Input parameters and activities
	Miscellaneous mobile equipment SO_2 emission factors adjusted for 50 ppm sulfur content in fuel.	1 water bowser operating at 320 kW Assumed 6 light delivery vehicles operating at 125 kW **Hours of operation:** 365 days per year, 24 hours per day. **Design mitigation:** None.
Diesel generators exhaust	US EPA AP 42 emission factor (lb/hp-h converted to kg/kW-h) for diesel industrial engines (US EPA, 1996). SO_2 emission factors adjusted for 50 ppm sulfur content in fuel.	Total power input of 2 781 kW **Hours of operation:** 365 days per year, 24 hours per day. **Design mitigation:** None.

Table 15: Summary of estimated emissions for the site preparation and construction phase

Source group	**Estimated emissions with no mitigation measures applied (t/a)**							**Estimated emissions with recommended additional mitigation measures applied (t/a)[3]**		
	PM_{30}	**PM_{10}**	**$PM_{2.5}$**	**DPM**	**SO_2**	**NO_x**	**CO**	**PM_{30}**	**PM_{10}**	**$PM_{2.5}$**
Preparation of site[1]	28.6	12.6	2.92	-	-	-	-	14.3	6.30	1.46
General construction	12.1	8.94	4.47	-	-	-	-	6.03	4.47	2.23
Equipment exhausts[2]	53.8	53.8	49.5	49.5	51.6	763	225	53.8	53.8	49.5
Total	**94.5**	**75.4**	**56.9**	**49.5**	**51.6**	**763**	**225**	**74.2**	**64.6**	**53.2**

Notes:
(1) Stripping of topsoil and excavation of sand
(2) Mobile and stationary equipment
(3) Recommended additional mitigation measures include water bowsers on unpaved roads, water sprays at stockpiles and handling points, and limiting construction (including mobile equipment) activities to take place during day-light hours

6.2 Assessment of Impact: Site Preparation and Construction Phase

It is likely that simulated results for the estimated emissions for the construction phase would be unrepresentative of the actual activities without knowing the construction schedule. It is not anticipated that the various construction activities will result in higher PM_{10}, $PM_{2.5}$, SO_2, NO_x and CO ground level concentrations (GLCs) and dustfall rates than the operational phase activities.

6.3 Impact Significance Rating: Site Preparation and Construction Operations

Non-compliance of PM_{10}, $PM_{2.5}$, SO_2, NO_x or CO concentrations with the relevant NAAQS could result in human health impacts. Non-compliance of dustfall rates with NDCR and odorous pollutants (secondary pollutants associated with the pit dewatering evaporators) being above 50% recognition threshold concentrations would result in nuisance impacts. Non-compliance of SO_2 and NO_x concentrations as well as dustfall rates with the selected international and literature-based limits could result in vegetation health impacts. The potential significance of the site preparation and construction operations related to the project based on a qualitative assessment of PM_{10}, $PM_{2.5}$, SO_2, NO_x and CO concentrations and dustfall rates (PM_{30}) are discussed below. The activities that will occur simultaneously will likely be HMM void (pit) dewatering, clearing of vegetation (bulldozing/excavation and removal using cranes), topsoil stripping and sand removal, and stockpiling of these soil resources, handling and storage of construction materials, collection, storage, and removal of construction related waste, transportation of materials and waste on-site and along the access roads, construction of all (structural, mechanical and electrical) infrastructure required for the operational phase, diesel generators and construction equipment operations. The Prime Resources impact rating methodology was used. Three potential direct site preparation and construction phase impacts on the air quality of the area were identified:

- A1: Impaired human health from increased pollutant concentrations associated with the construction phase activities (Table 16).
- A2: Increased nuisance dustfall rates associated with the construction phase activities (Table 17)
- A3: Potential impact on vegetation health from increased dustfall rates and pollutant concentrations due to the construction phase activities (Table 18).

A1 is the direct impact on human health, A2 is the direct impact on amenities whereas A3 would be the direct impact on vegetation health and indirect impact on animal and human health, and amenities.

Table 16: Increase in human health risk impact significance summary table for the pre-development and construction phase operations only

Air Quality: Human Health Impact	Occurrence		Severity		Significance		Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude					
Significance of potential impact without mitigation measures applied									
Pre-development and construction phase	Medium probability	Short-term (0-5 years)	Local	Moderate	**21**	**Low**	–'ve	Moderate loss (50%-74%)	n/a
	3	2	2	3				3	
Significance of potential impact with design mitigation measures applied									
n/a									
Significance of potential impact with recommended additional mitigation measures applied									
Pre-development and construction phase	Low probability	Short-term (0-5 years)	Site only	Moderate	**12**	**Low**	–'ve	Minor loss (24%-49%)	43%
	2	2	1	3				2	
Recommended additional mitigation measures: Water bowsers on unpaved roads, water sprays at stockpiles and handling points, and limiting construction (including mobile equipment) activities to take place during day-light hours									

Table 17: Increase in nuisance impact significance summary table for the pre-development and construction phase operations only

Air Quality: Nuisance Impact	Occurrence		Severity		Significance		Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude					
Significance of potential impact without mitigation measures applied									
Pre-development and construction phase	Low probability	Short-term (0-5 years)	Local	Low	**12**	**Low**	–'ve	Limited loss (0%-24%)	n/a
	2	2	2	2				1	
Significance of potential impact with design mitigation measures applied									
n/a									

Air Quality: Nuisance Impact	Occurrence		Severity		Significance		Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude					
Significance of potential impact with recommended additional mitigation measures applied									
Pre-development and construction phase	Low probability	Short-term (0-5 years)	Site only	Minor	**8**	**Low**	–'ve	Limited loss (0%-24%)	33%
	2	2	1	1				1	
Recommended additional mitigation measures: Water bowsers on unpaved roads, water sprays at stockpiles and handling points, and limiting construction (including mobile equipment) activities to take place during day-light hours									

Table 18: Increase in vegetation health risk impact significance summary table for the pre-development and construction phase operations only

Air Quality: Vegetation Health Impact	Occurrence		Severity		Significance		Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude					
Significance of potential impact without mitigation measures applied									
Pre-development and construction phase	Low probability	Short-term (0-5 years)	Local	Moderate	**14**	**Low**	–'ve	Moderate loss (50%-74%)	n/a
	2	2	2	3				3	
Significance of potential impact with design mitigation measures applied									
n/a									
Significance of potential impact with recommended additional mitigation measures applied									
Pre-development and construction phase	Improbable	Short-term (0-5 years)	None	Minor	**3**	**Low**	–'ve	Limited loss (0%-24%)	79%
	1	2	0	1				1	
Recommended additional mitigation measures: Water bowsers on unpaved roads, water sprays at stockpiles and handling points, and limiting construction, especially mobile equipment activities to take place during day-light hours									

7 Impact Assessment: Operational Phase

7.1 Emissions Inventory: Incremental (Project) Operations

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

- Particulate emissions from
  - drilling
  - blasting
  - excavation
  - materials handling
  - crushing and screening
  - bulldozing as part of stockpile management
  - erosion of RoM, product, topsoil and sand stockpiles and portions of the waste stockpiles due to the wind lifting and dispersing loose material during high wind incidents (>5m/s)
  - entrainment of loose material along the unpaved in-pit, haul roads and access roads because of vehicles travelling along these roads
  - grading of unpaved haul roads and access roads
- Particulate and gaseous emissions from
  - vehicles exhaust
  - diesel generator(s) exhaust.

A summary of emission sources quantified, estimation techniques applied, and source input parameters is included in Table 19. A summary of estimated emissions in t/a associated with the operational phase is provided in Table 20.

Figure 12 is a chart showing the source group contributions as a percentage of the total emissions associated with the unmitigated operations. The source group that was determined will contribute the most to the annual PM_{30}/TSP, PM_{10}, and $PM_{2.5}$ emissions for unmitigated operations is vehicles travelling along unpaved roads. The second greatest contributor to unmitigated annual PM_{30}/TSP, and PM_{10} emissions is crushing and screening. The second greatest contributor to unmitigated annual $PM_{2.5}$ emissions is vehicles exhausts.

Figure 13 is a chart showing the source group contributions as a percentage of the total emissions associated with the proposed operations with design mitigation measures applied. The source group that was determined will contribute the most to the annual PM_{30}/TSP, and PM_{10} emissions for mitigated operations is vehicles travelling along unpaved roads. The second greatest contributor to mitigated annual PM_{30}/TSP emissions is crushing and screening. The second greatest contributor to mitigated annual PM_{10} emissions is vehicles exhausts. The source group that was determined will contribute the most to the annual $PM_{2.5}$ emissions for mitigated operations is vehicles vehicle exhausts, followed by vehicles travelling along unpaved roads.

Table 19: Emission estimation techniques and parameters for the operational phase activities

Source group	Emission estimation technique	Input parameters and activities
Drilling	ADE NPI single valued emission factors for drilling (ADE, 2012). EF_{PM30} = 0.59 kg/hole EF_{PM10} = 0.31 kg/hole $EF_{PM2.5}$ = 0.155 kg/hole (*assumed* to be 50% of PM_{10})	730 holes per month, with a maximum hole depth of 95 m. **Hours of operation** 365 days per year, 24 hours per day. **Design mitigation:** None.
Blasting	US EPA AP 42 emission factor equation for blasting (US EPA, 1998). $$EF = k \cdot (A)^{1.5}$$ EF is the emission factor in kg/blast k is the particle size multiplier (k_{PM30} = 0.00022) A is the average area in m² PM_{10}/PM_{30} ratio is 0.52 $PM_{2.5}/PM_{30}$ ratio is 0.03	8 030 m² blasted per month. **Hours of operation** 2 days per week, 24 hours per day. **Design mitigation:** None.
Excavation	ADE NPI single valued emission factors for excavation of overburden (ADE, 2012). EF_{PM30} = 0.025 kg/tonne EF_{PM10} = 0.012 kg/tonne $EF_{PM2.5}$ = 0.00179 kg/tonne (*assumed* that the $PM_{2.5}/PM_{30}$ ratio for materials handling)	Ore mined = 57.1 t/h. Waste mined =170 t/h. **Hours of operation:** 365 days per year, 24 hours per day. **Design mitigation:** None.
Materials handling	US EPA AP 42 emission factor equation for miscellaneous transfer (US EPA, 2006a) $$EF = k \cdot 0.0016 \cdot \left(\frac{U}{2.3}\right)^{1.3} \cdot \left(\frac{M}{2}\right)^{-1.4}$$ EF is the emission factor in kg/tonne material handled k is the particle size multiplier (k_{PM30} – 0.74, 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 %	Ore mined = 57.1 t/h. Waste mined =170 t/h. Topsoil returned to pit for continuous rehabilitation = 1.16 t/h. Sand returned to pit for continuous rehabilitation = 6.56 t/h. Waste returned to pit for continuous rehabilitation = 155 t/h. Product handled = 55.4 t/h. Moisture content of 4% was assumed for ore, waste, and product. Moisture content of 2.3% was assumed for topsoil and sand. An average wind speed of 4.36 m/s was determined from the WRF data set. **Hours of operation:** 365 days per year, 24 hours per day. **Design mitigation:** None.

Source group	Emission estimation technique	Input parameters and activities
Crushing and screening	ADE NPI single valued emission factors for low moisture ore (ADE, 2012). EF_{PM30} = 0.2 kg/tonne (primary crushing), 0.08 kg/tonne (screening) EF_{PM10} = 0.02 kg/tonne (primary crushing), 0.06 kg/tonne (screening) $EF_{PM2.5}$ = 0.01 kg/tonne (primary crushing), 0.03 kg/tonne (screening) (*assumed* to be 50% of PM_{10})	Primary (Jaw) crusher and screen with a feed rate of 55.4 t/h. **Hours of operation:** 365 days per year, 24 hours per day. **Design mitigation:** Water sprays**.**
Bulldozing	ADE NPI single valued emission factor for bulldozing (ADE, 2012). EF_{PM30} = 17 kg/h-vehicle EF_{PM10} = 4.1 kg/h-vehicle $PM_{2.5}/PM_{30}$ ratio = 0.105 (US EPA AP 42 emission estimation technique manual for western surface coal mining (US EPA, 1998)).	Bulldozing activities include the bulldozing of waste rock at the waste stockpiles. **Hours of operation:** 365 days per year, 24 hours per day. **Design mitigation:** None.
Wind erosion	ADE NPI single valued emission factors for overburden wind erosion (ADE, 2012). EF_{PM30} = 0.4 kg/ha-h EF_{PM10} = 0.2 kg/ha-h $EF_{PM2.5}$ = 0.1 kg/ha-h (*assumed* to be 50% of PM_{10})	**Hours of emission:** For wind erosion to occur, the wind speed needs to exceed a certain threshold, called the threshold velocity. Emissions are only calculated for wind speeds exceeding the threshold of ≥5 m/s for the topsoil, ore, and product stockpiles as well as a small area of the waste stockpiles. **Design mitigation:** None.
Vehicle entrained dust from unpaved roads	US EPA AP 42 emission factor equation for unpaved roads (US EPA, 2006b). $$EF = k \cdot \left(\frac{s}{12}\right)^{a} \cdot \left(\frac{W}{3}\right)^{b} \cdot 281.9$$ EF is the emission factor in g/VKT k is the particle size multiplier (k_{PM30} = 4.9, k_{PM10} = 1.5, $k_{PM2.5}$ = 0.15) a is a constant (k_{PM30} = 0.7, k_{PM10} = 0.9, $k_{PM2.5}$ = 0.9) b is a constant (k_{PM30} = 0.45, k_{PM10} = 0.45, $k_{PM2.5}$ = 0.45) s is the road surface material silt content in % W is the vehicles average weight in tonnes	Transport activities that could be included were the transport of ore, waste, topsoil and sand within the pit, transportation of waste rock to the waste stockpiles, transportation of waste rock, topsoil and sand from stockpiles to the pit, transportation of the ore to the RoM pad and then the processing plant and product stockpiles area as well as product off-site. VKT were calculated from road lengths (limited to simulation area), truck capacities and the number of trips required to transport materials. A road surface silt content of 8.8% from similar operations in the area. **Hours of operation:** 365 days per year, 24 hours per day. **Design mitigation:** Level-1 watering (2 litres/m_2/h), with a dust control efficiency of 50% (ADE, 2012).

Source group	Emission estimation technique	Input parameters and activities
Vehicle exhaust	ADE NPI single valued emission factors for mobile equipment exhaust (kg/kW-h) (ADE, 2008). Wheeled dozer Motor grader Loader (average of wheeled loader and track type loader) Off-highway truck Miscellaneous equipment SO_2 emission factors adjusted for 50 ppm sulfur content in fuel.	Operational phase diesel powered trucks - 343 kW. Note that sulfur content of diesel fuel was assumed to be 50 ppm. **Hours of operation:** 365 days per year, 24 hours per day. **Design mitigation:** None
Grading of unpaved roads	ADE NPI emission factor equation for grading (ADE, 2012). $$EF = 0.0034 \cdot (S)^{2.5}$$ EF is the emission factor in kg/VKT S is the speed as km/h PM_{10}/PM_{30} ratio = 0.60 (US EPA AP 42 emission estimation technique manual for western surface coal mining (US EPA, 1998)). $PM_{2.5}/PM_{30}$ ratio = 0.031 (US EPA AP 42 emission estimation technique manual for western surface coal mining (US EPA, 1998)).	Grading activities include the grading of the haul roads and the access road. **Hours of operation:** 3 days per week, 12 hours per day. **Design mitigation:** None.
Diesel generator(s) exhaust	US EPA AP 42 emission factor for diesel industrial engines (lb/hp-h converted to kg/kW-h) (US EPA, 1996). EF_{CO} = 6.68x10^{-03} lb/hp-h EF_{NOx} = 0.031 lb/hp-h EF_{PM10} = 2.20x10^{-03} lb/hp-h EF_{SO2} = 2.05x10^{-03} lb/hp-h (30 ppm sulfur content) EF conversion (lb/hp-h converted to kg/kW-h) value = 0.608. SO_2 emission factors adjusted for 50 ppm sulfur content in fuel.	Total power input of 120 kW **Hours of operation:** 365 days per year, 24 hours per day. **Design mitigation:** None.

Table 20: Summary of estimated emissions for the operational phase activities

Source group	Estimated emissions with no mitigation measures applied (t/a)							Estimated emissions with design mitigation measures applied (t/a)(1)			Estimated emissions with recommended additional mitigation measures applied (t/a)(2)		
	PM_{30}	PM_{10}	PM_{30}	PM_{30}	PM_{30}	NO_x	CO	PM_{30}	PM_{10}	$PM_{2.5}$	PM_{30}	PM_{10}	$PM_{2.5}$
Drilling	2.58	2.66	1.39	-	-	-	-	2.58	2.66	1.39	2.58	2.66	1.39
Blasting	0.323	0.318	0.166	-	-	-	-	0.323	0.318	0.166	0.323	0.318	0.166
Excavation	24.9	22.7	3.55	-	-	-	-	24.9	22.7	3.55	24.9	22.7	3.55
Materials handling	7.29	4.24	0.654	-	-	-	-	7.29	4.24	0.654	7.29	4.24	0.654
Bulldozing	0.447	0.108	0.054	-	-	-	-	0.447	0.108	0.054	0.447	0.108	0.054
Crushing and screening	136	38.8	19.4	-	-	-	-	67.9	19.4	9.70	67.9	19.4	9.70
Wind erosion	15.6	7.80	3.90	-	-	-	-	15.6	7.80	3.90	15.6	7.80	3.90
Unpaved roads	1 630	570	58.0	-	-	-	-	815	285	29.0	296	110	11.3
Grading	4.4	1.96	0.979	-	-	-	-	4.4	1.96	0.979	4.4	1.96	0.979
Vehicle exhausts	33.9	33.9	31.2	31.2	1.66	510	210	33.9	33.9	31.2	33.9	33.9	31.2
Diesel generator(s) exhausts	1.41	1.41	1.41	1.41	2.18	19.8	4.27	1.41	1.41	1.41	1.41	1.41	1.41
Total	***1 857***	***684***	***121***	***32.6***	***3.85***	***530***	***215***	***974***	***379***	***82***	***455***	***205***	***64.2***

Notes:
(1) Design mitigation measures include level-1 watering (2 litres/m²/h) on unpaved roads and water sprays at the crusher and screen.
(2) Recommended additional mitigation measures include level-2 watering (> 2 litres/m²/h) on in-pit and waste stockpiles unpaved roads and water sprays with chemicals on haul roads and access roads. The design mitigation measures include water sprays at the crusher and screen.

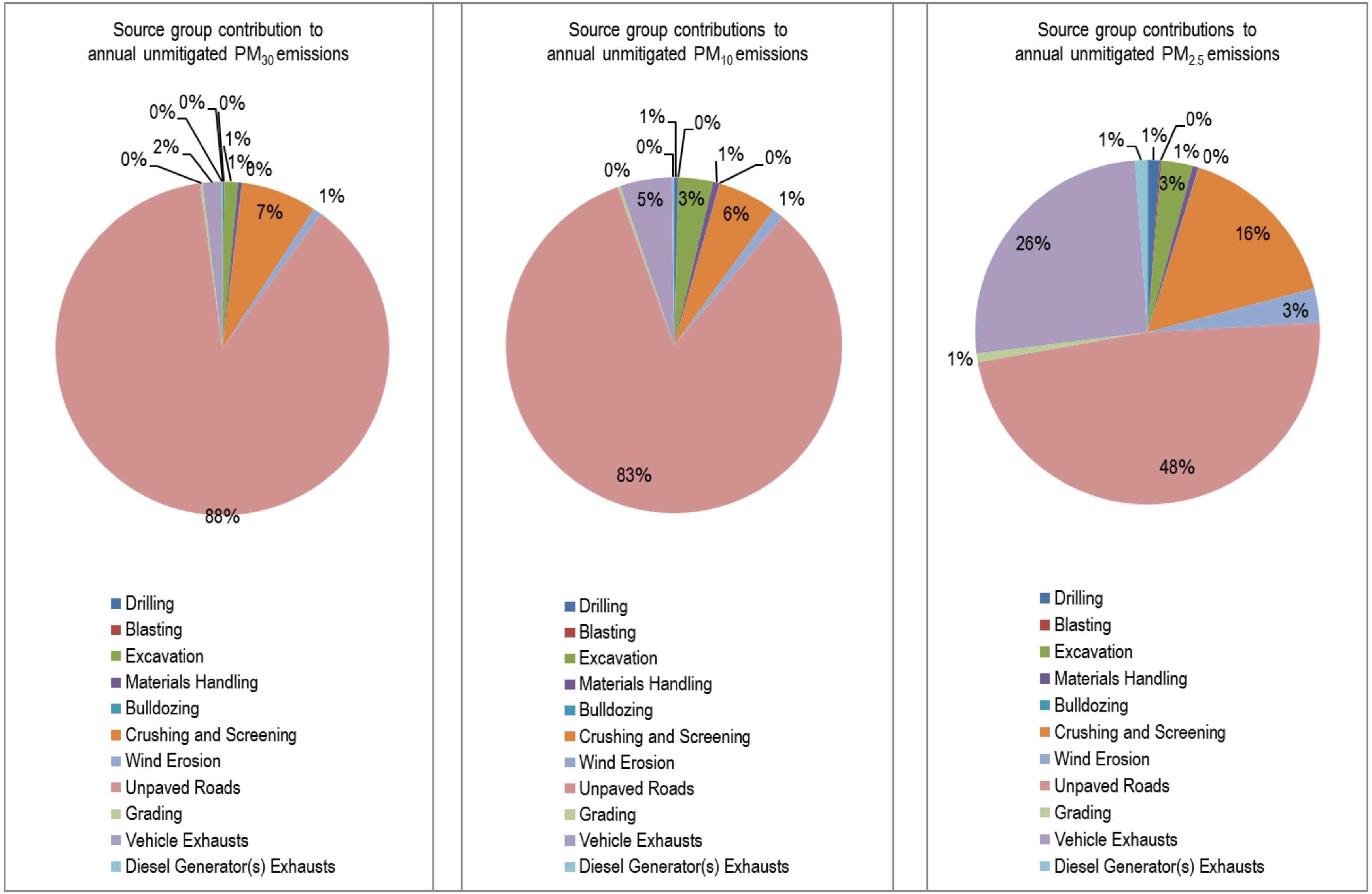


Figure 12: Source group contributions to the operational phase unmitigated emissions

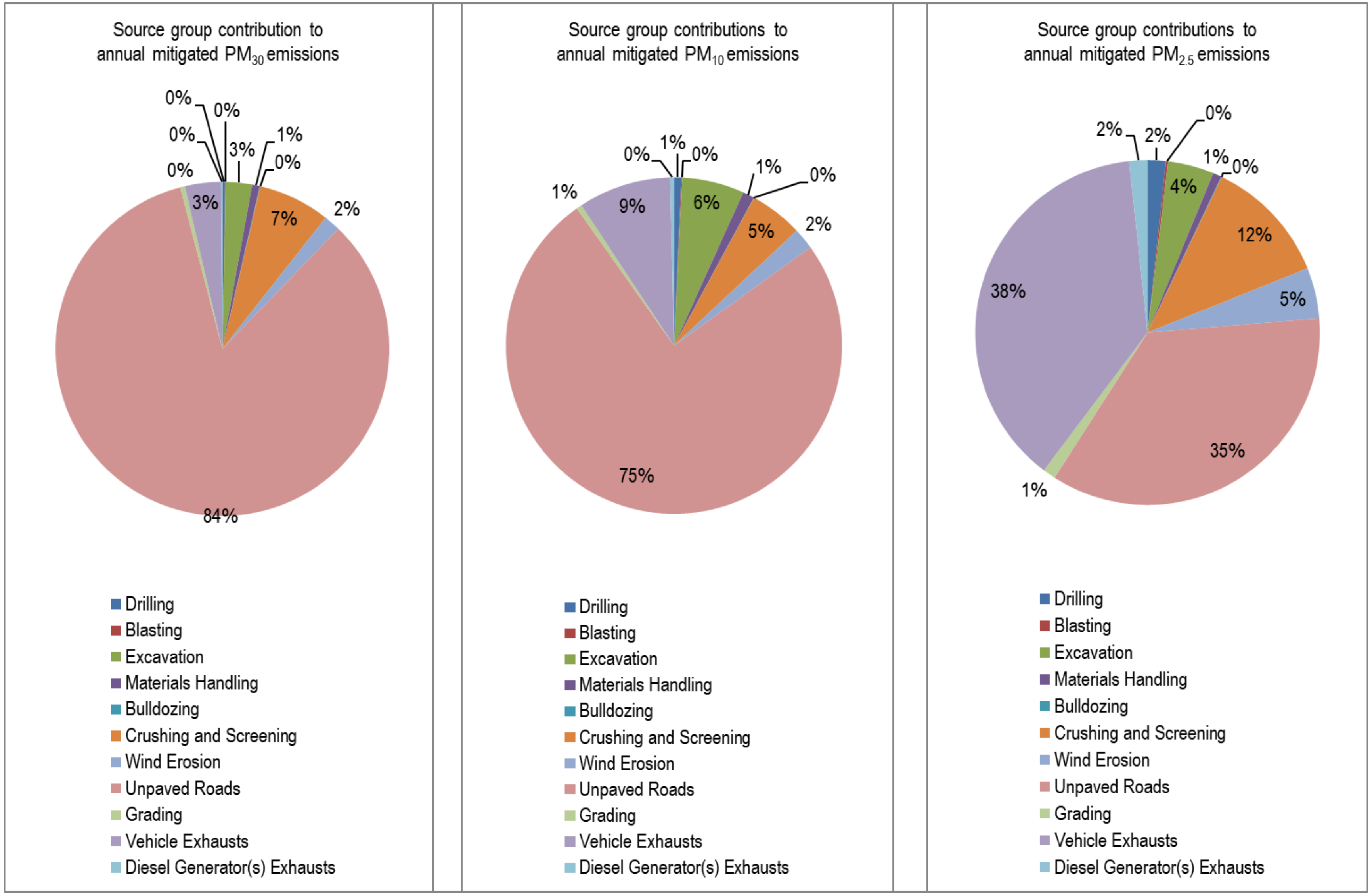


Figure 13: Source group contributions to the operational phase design mitigated emissions

7.2 Assessment of Impact: Incremental (Project) Operations

Simulation results of the future (proposed) operations are discussed in this section. The simulation results are for the future THM operations only and does not include the contributions of any other sources' in the area. The main pollutants of concern with regards to human health impacts are PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO, Mn and DPM. Given the size of the fallout dust particles, dustfall rates could reduce the efficiency of panels at the solar facility as well as being a nuisance to residents as well as contractors and leisure accommodation owners.

7.2.1 Inhalable particulate matter (PM_{10})

Without mitigation applied, simulated annual average PM_{10} concentrations exceed the NAAQS of 40 µg/m^3 at multiple AQSRs (residences in Hotazel as well as Hotazel Combined School and Wessels Clinic) (Figure 14). Without mitigation applied, the 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) is exceeded at multiple AQSRs (most residences in Hotazel as well as Hotazel College, Hotazel Combined School, Life Occupational Health - Hotazel Manganese Mines Clinic and Wessels Clinic) (Figure 15).

With design mitigation measures applied, simulated annual average PM_{10} concentrations exceed the NAAQS of 40 µg/m^3 but not at any AQSRs (Figure 16). With design mitigation measures applied, the 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) is exceeded at multiple AQSRs (residences in Hotazel as well as Hotazel Combined School, Life Occupational Health - Hotazel Manganese Mines Clinic and Wessels Clinic) (Figure 17).

With design mitigation measures applied to the crusher and screen and recommended additional mitigation measures applied to the unpaved roads, simulated annual average PM_{10} concentrations exceed the NAAQS of 40 µg/m^3 but not at any AQSRs (Figure 18). With design mitigation measures applied to the crusher and screen and recommended additional mitigation measures applied to the unpaved roads, the 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) is exceeded at multiple residences in Hotazel town (AQSRs) (Figure 19).

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

Without mitigation applied, simulated annual average $PM_{2.5}$ concentrations exceed the current and future[6] NAAQS of 20 µg/m^3 and 15 µg/m^3 but not at any AQSRs (Figure 20). Without mitigation applied, the current 24-hour NAAQS (4 days of exceedance of 40 µg/m^3) is exceeded at multiple AQSRs (residences in Hotazel as well as Hotazel Combined School and Wessels Clinic) (Figure 21). Without mitigation applied, the 24-hour future[7] NAAQS (4 days of exceedance of 25 µg/m^3) is exceeded at multiple AQSRs (residences in Hotazel as well as Hotazel Combined School and Wessels Clinic) (Figure 21).

With design mitigation measures applied, simulated annual average $PM_{2.5}$ concentrations exceed the current and future[8] NAAQS of 20 µg/m^3 and 15 µg/m^3 but not at any AQSRs (Figure 22). With design mitigation measures applied, the current 24-hour NAAQS (4 days of exceedance of 40 µg/m^3) is exceeded but not at any AQSRs (Figure

[6] Applicable from 1January 2030
[7] Applicable from 1January 2030
[8] Applicable from 1January 2030

23). With design mitigation measures applied, the 24-hour future[9] NAAQS (4 days of exceedance of 25 µg/m³) is at multiple AQSRs (residences in Hotazel as well as Hotazel Combined School and Wessels Clinic) (Figure 23).

With design mitigation measures applied to the crusher and screen and recommended additional mitigation measures applied to the unpaved roads, simulated annual average $PM_{2.5}$ concentrations exceed the current and future[10] NAAQS of 20 µg/m³ and 15 µg/m³ but not at any AQSRs (Figure 24). With design mitigation measures applied to the crusher and screen and recommended additional mitigation measures applied to the unpaved roads, the current 24-hour NAAQS (4 days of exceedance of 40 µg/m³) is exceeded but not at any AQSRs (Figure 25). With design mitigation measures applied to the crusher and screen and recommended additional mitigation measures applied to the unpaved roads, the 24-hour future[11] NAAQS (4 days of exceedance of 25 µg/m³) is exceeded at multiple residences in Hotazel town (Figure 25).

7.2.3 Fallout dust

Based on the highest monthly simulated TSP deposition rates for unmitigated operations, the daily average dustfall rates exceed the NDCR limit for non-residential areas (1 200 mg/m²-day); but are below the NDCR limit for residential areas (600 mg/m²-day) at AQSRs and the selected limit for agricultural areas (400 mg/m²-day) at all agricultural operations (Figure 26). The highest dustfall rate at the solar facility to the south-east is 94.6 mg/m²-day and the lowest is 6 mg/m²-day (Figure 26).

Based on the highest monthly simulated TSP deposition rates for mitigated operations, the daily average dustfall rates exceeds the NDCR limit for non-residential areas (1 200 mg/m²-day) on-site only; but are below the NDCR limit for residential areas (600 mg/m²-day) at AQSRs and the selected limit for agricultural areas (400 mg/m²-day) at all agricultural operations (Figure 27). The highest dustfall rate at the solar facility to the south-east is 49.9 mg/m²-day and the lowest is 3 mg/m²-day (Figure 27).

Based on the highest monthly simulated TSP deposition rates for additionally mitigated operations, the daily average dustfall rates exceeds the NDCR limit for non-residential areas (1 200 mg/m²-day) on-site only; but are below the NDCR limit for residential areas (600 mg/m²-day) at AQSRs and the selected limit for agricultural areas (400 mg/m²-day) at all agricultural operations (Figure 28). The highest dustfall rate at the solar facility to the south-east is 26.7 mg/m²-day and the lowest is 1 mg/m²-day (Figure 28).

[9] Applicable from 1January 2030
[10] Applicable from 1January 2030
[11] Applicable from 1January 2030

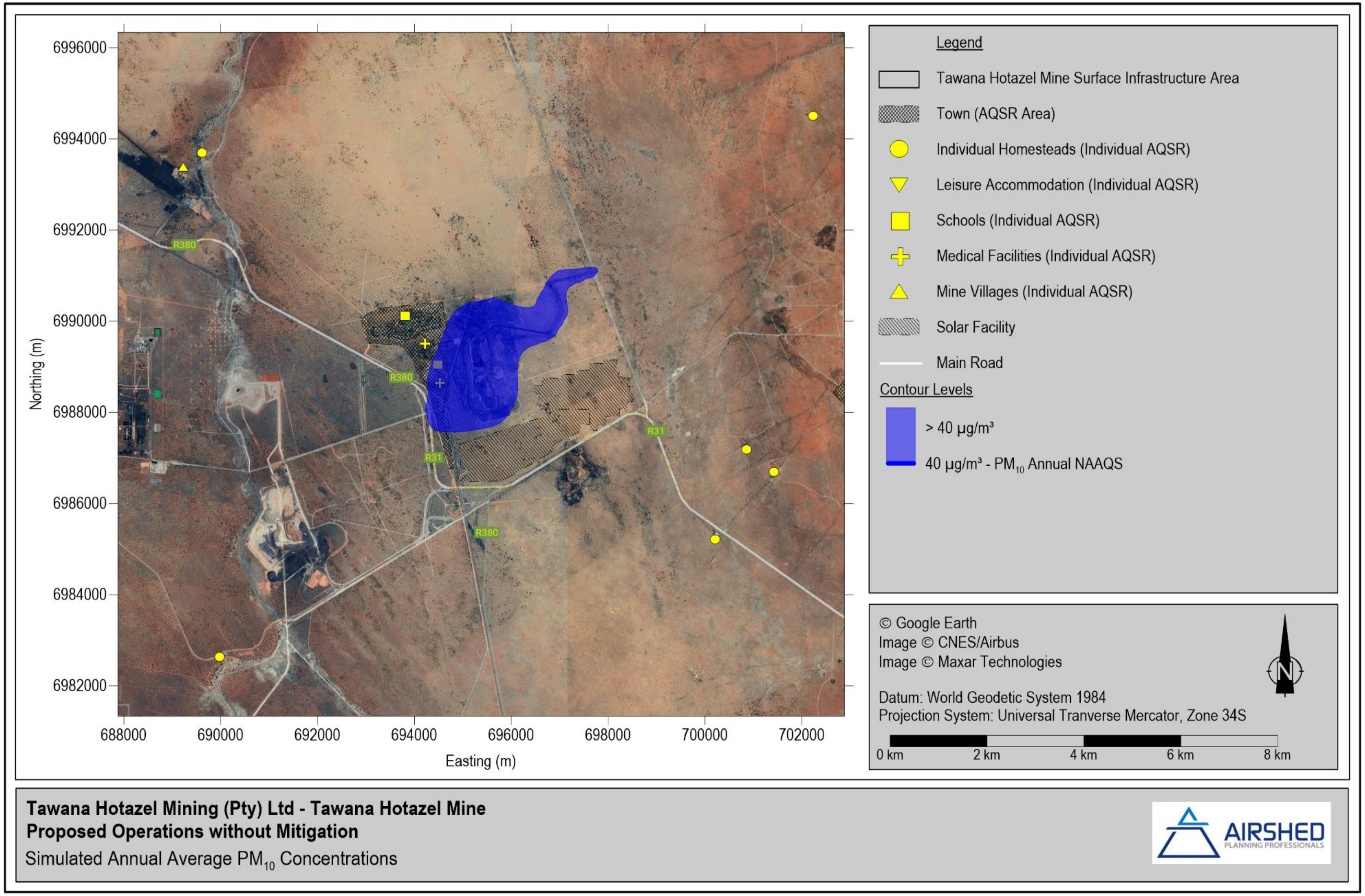


Figure 14: Simulated area of exceedance of the annual average PM_{10} NAAQS as a result of unmitigated THM operations

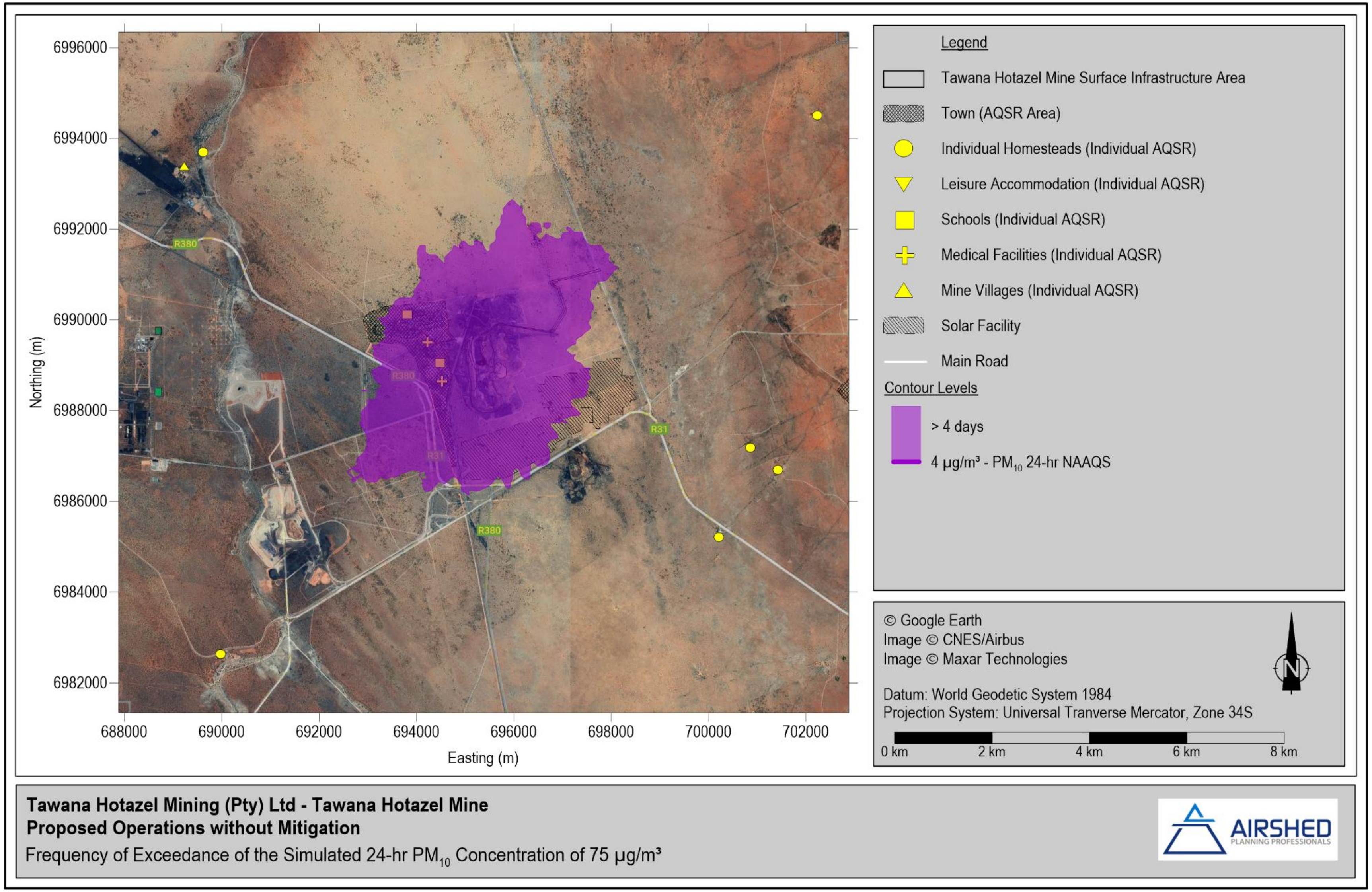


Figure 15: Simulated area of exceedance of the 24-hour PM_{10} NAAQS as a result of unmitigated THM operations

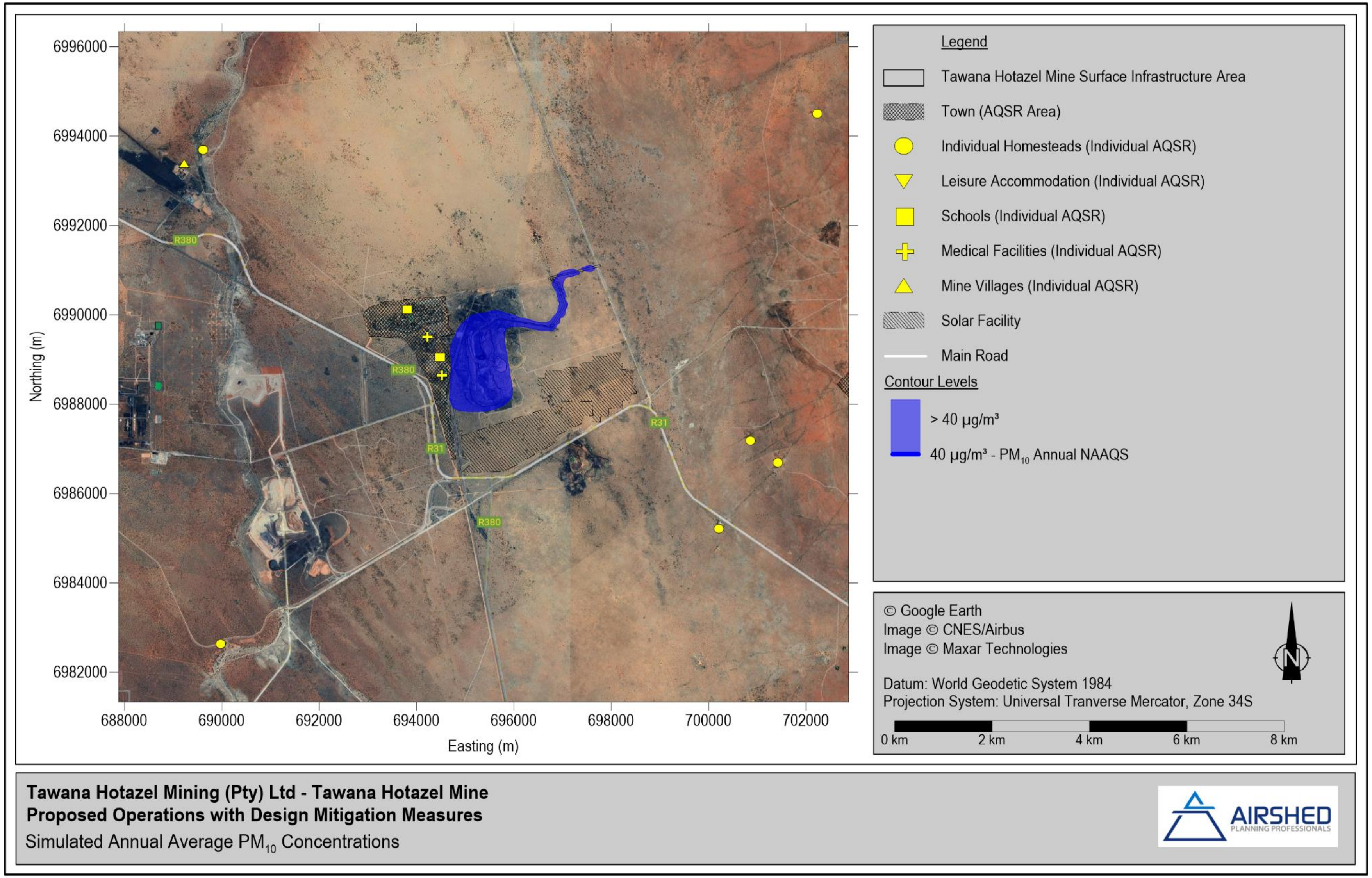


Figure 16: Simulated area of exceedance of the annual average PM_{10} NAAQS as a result of mitigated THM operations

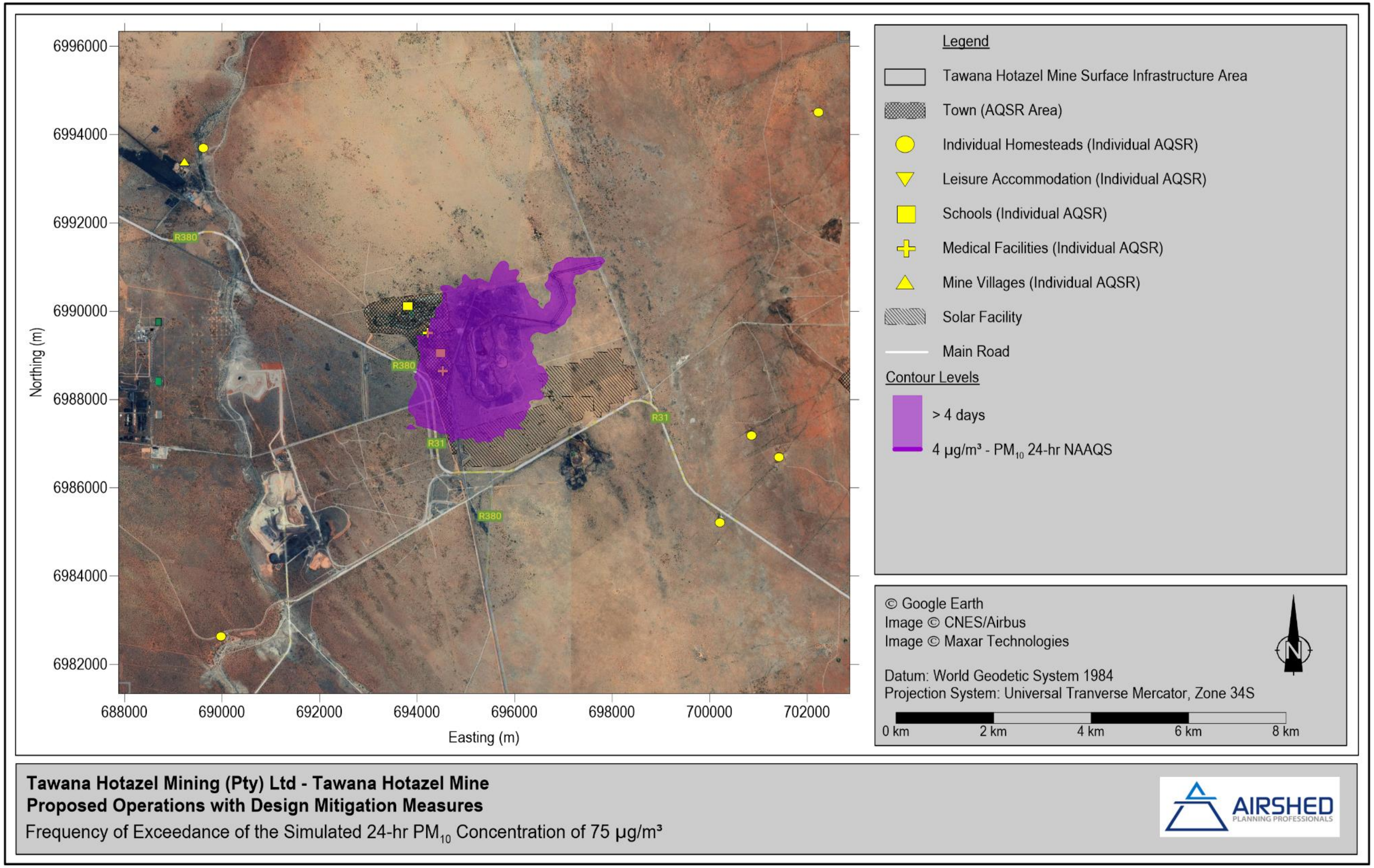


Figure 17: Simulated area of exceedance of the 24-hour PM_{10} NAAQS as a result of mitigated THM operations

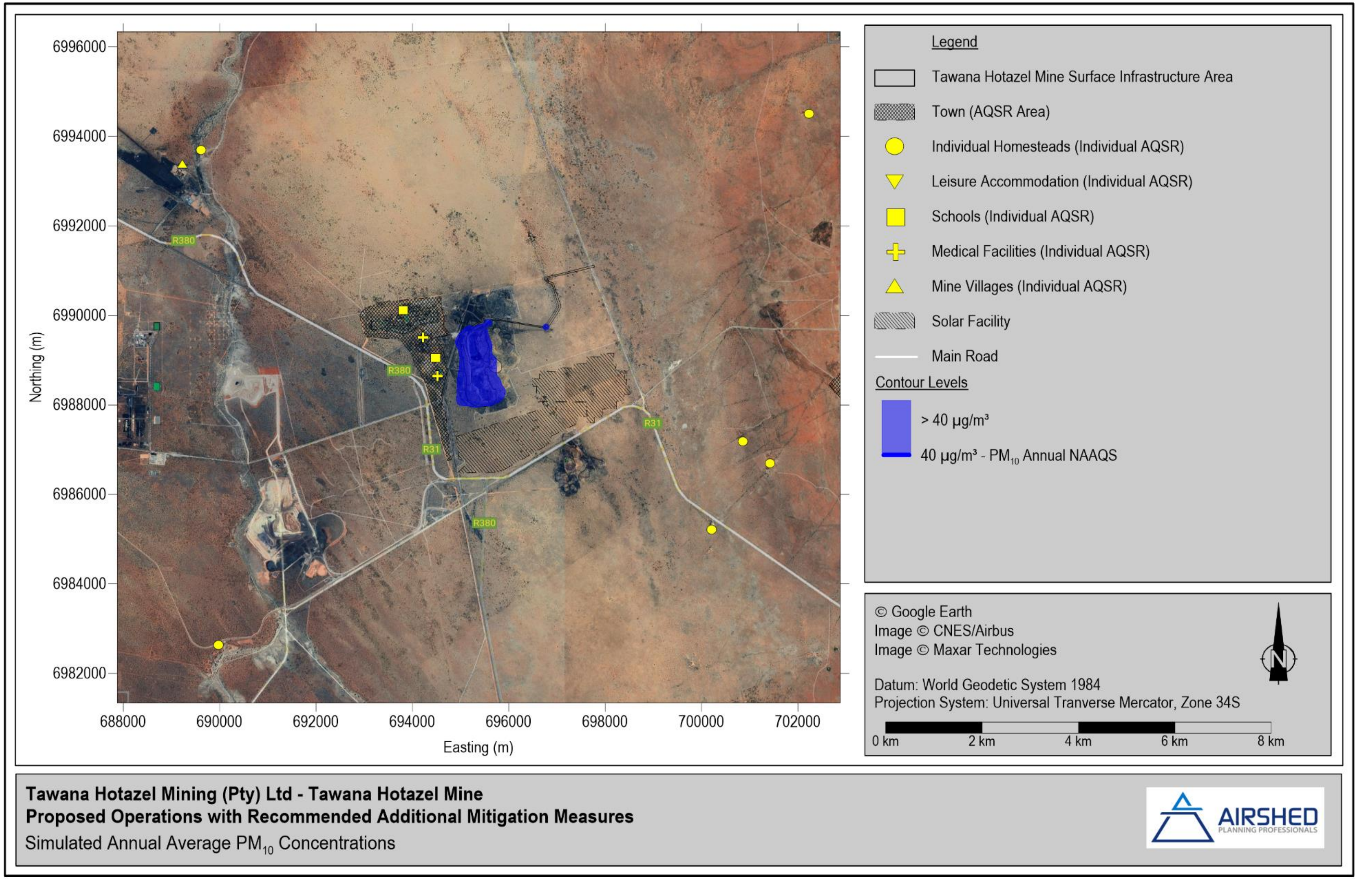


Figure 18: Simulated area of exceedance of the annual average PM_{10} NAAQS as a result of additionally mitigated THM operations

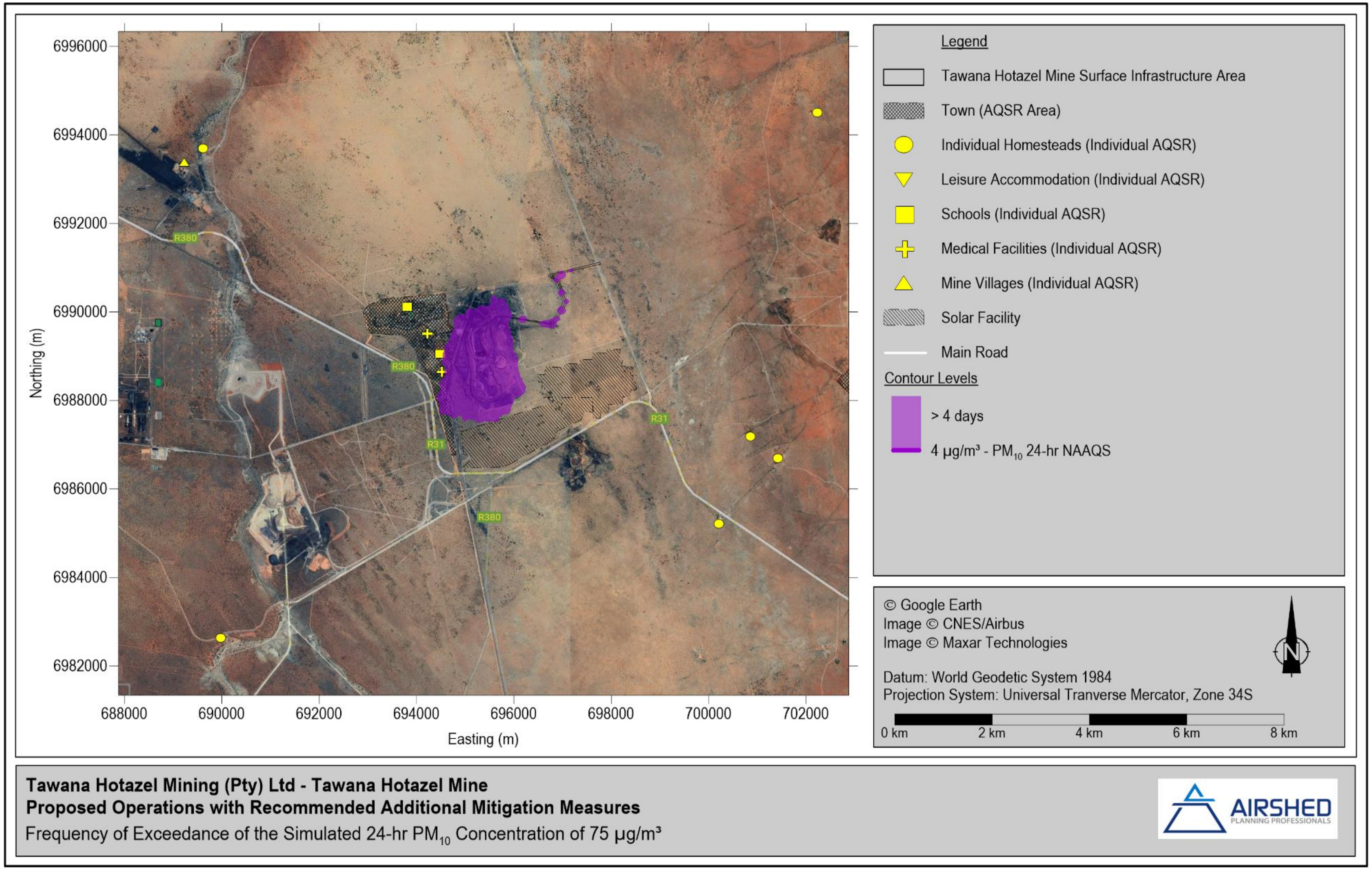


Figure 19: Simulated area of exceedance of the 24-hour PM_{10} NAAQS as a result of additionally mitigated THM operations

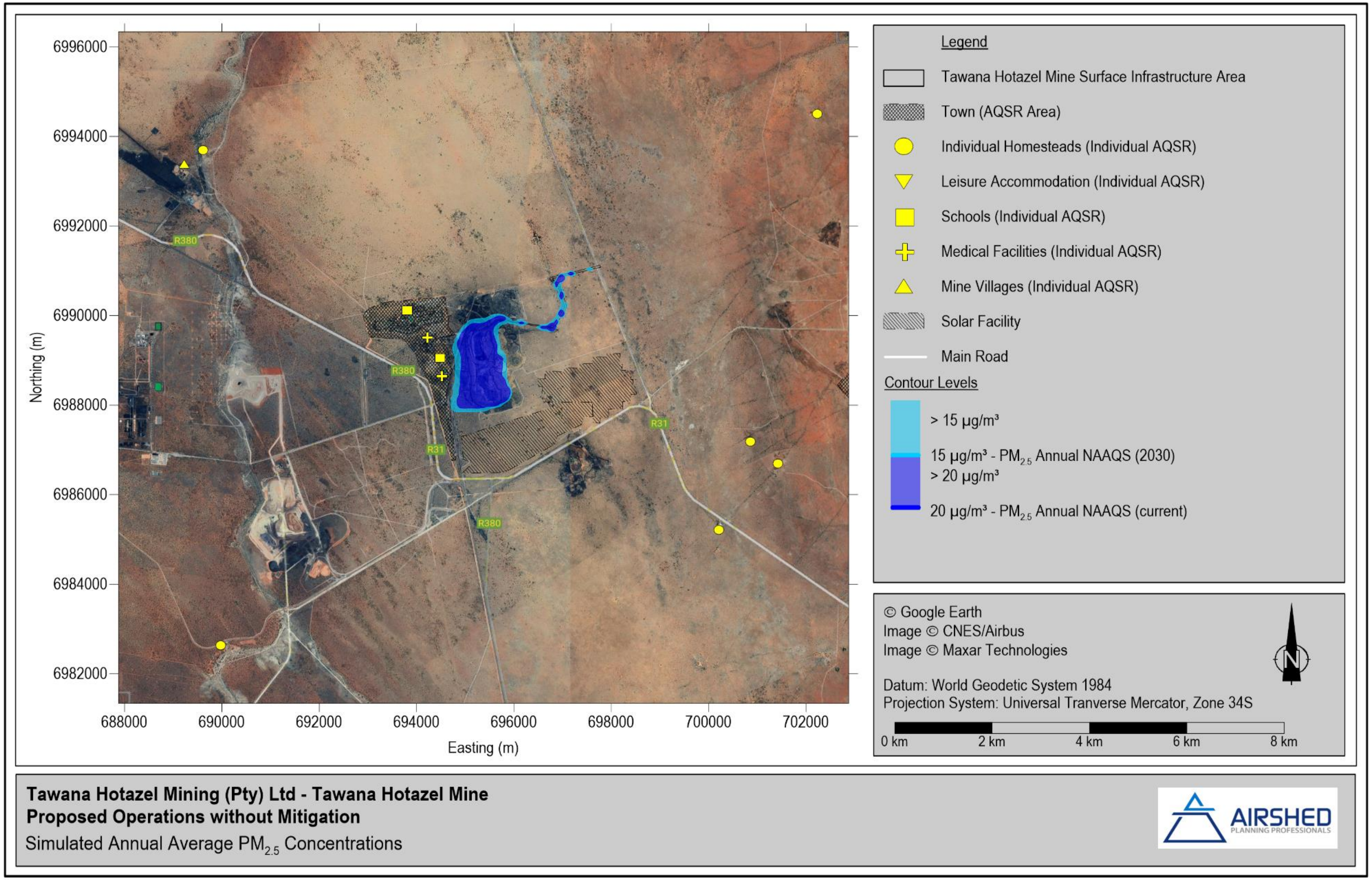


Figure 20: Simulated area of exceedance of the annual average $PM_{2.5}$ NAAQS as a result of unmitigated THM operations

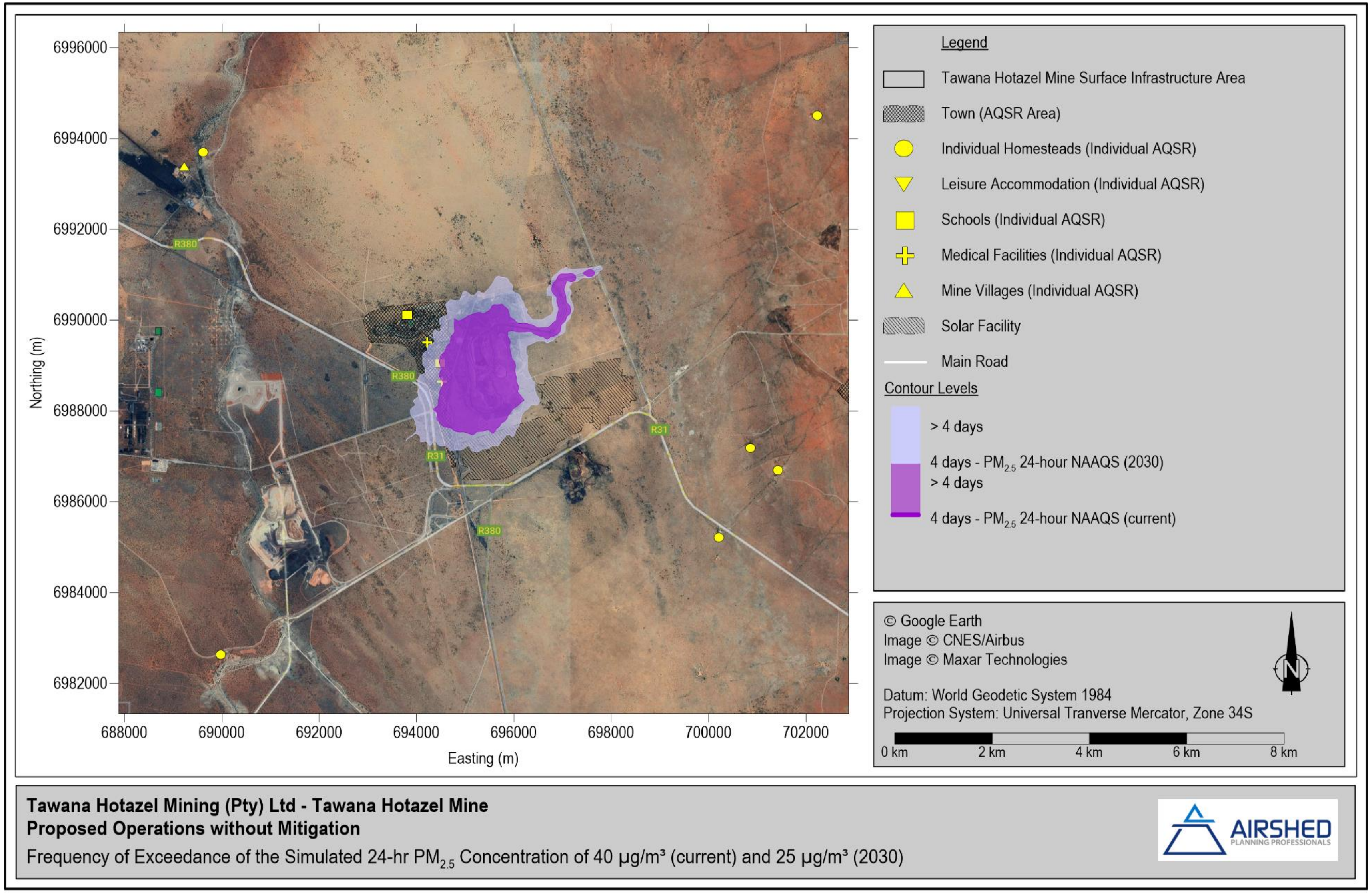


Figure 21: Simulated area of exceedance of the 24-hour $PM_{2.5}$ NAAQS as a result of unmitigated THM operations

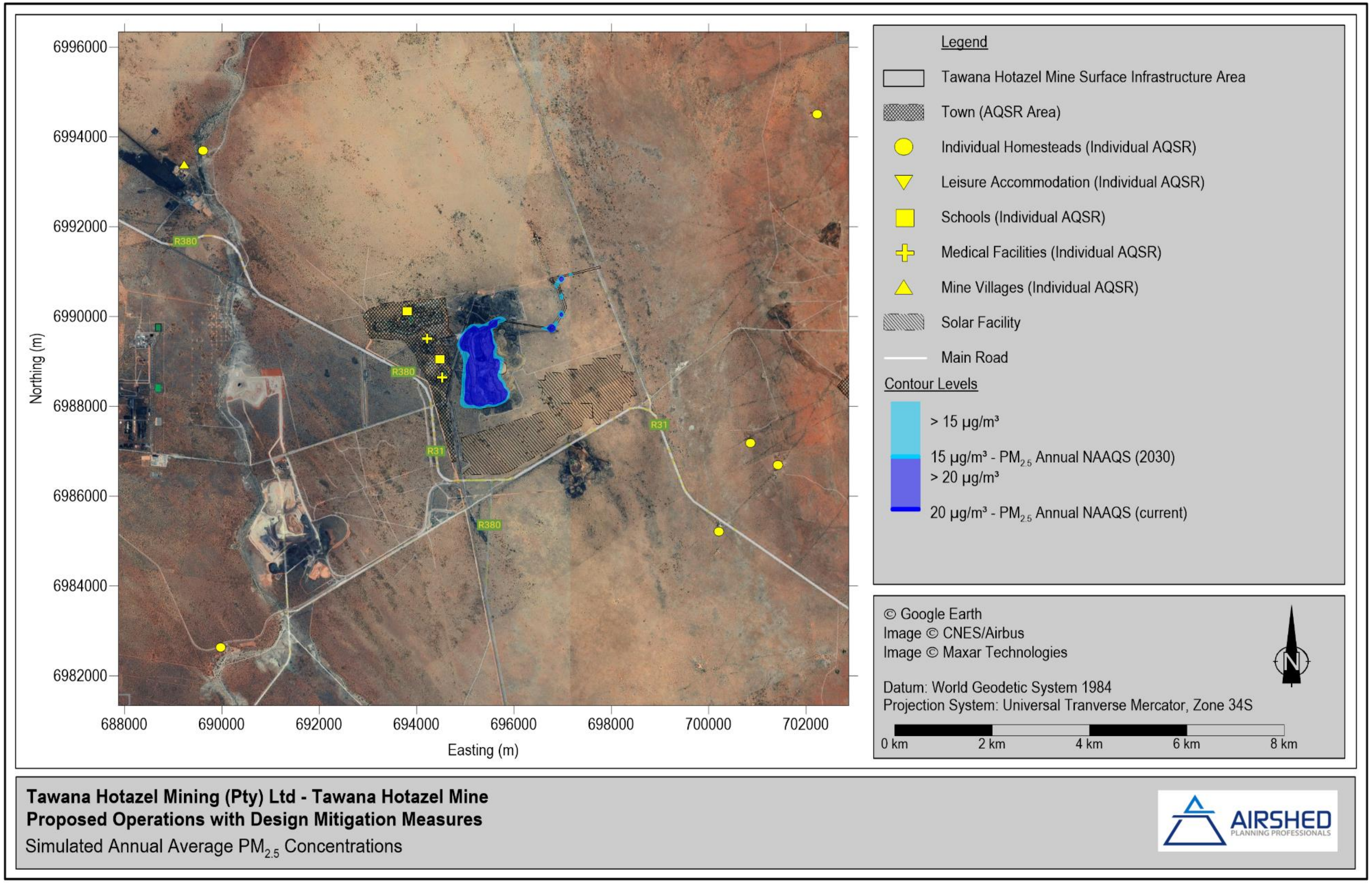


Figure 22: Simulated area of exceedance of the annual average $PM_{2.5}$ NAAQS as a result of mitigated THM operations

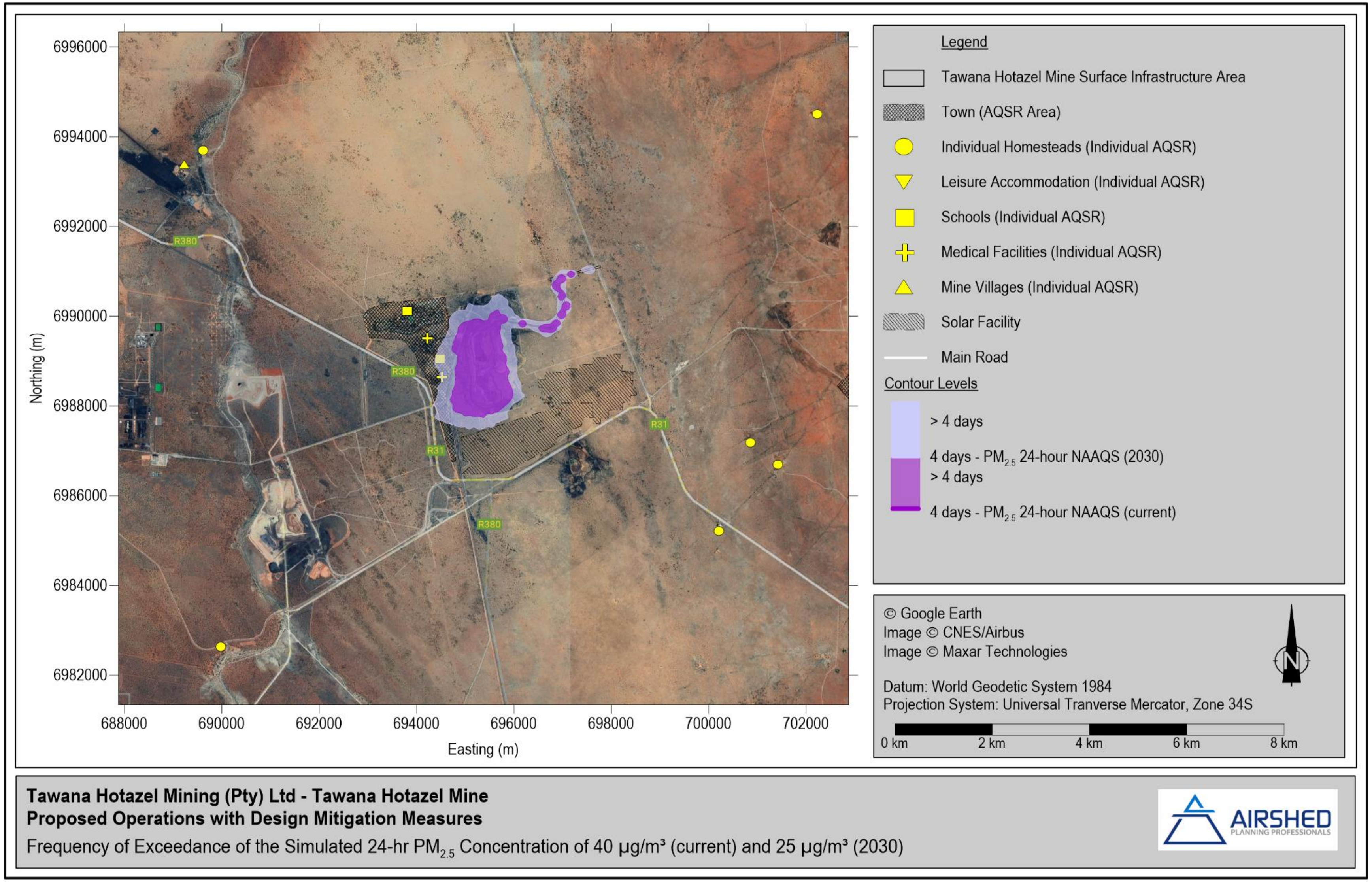


Figure 23: Simulated area of exceedance of the 24-hour $PM_{2.5}$ NAAQS as a result of mitigated THM operations

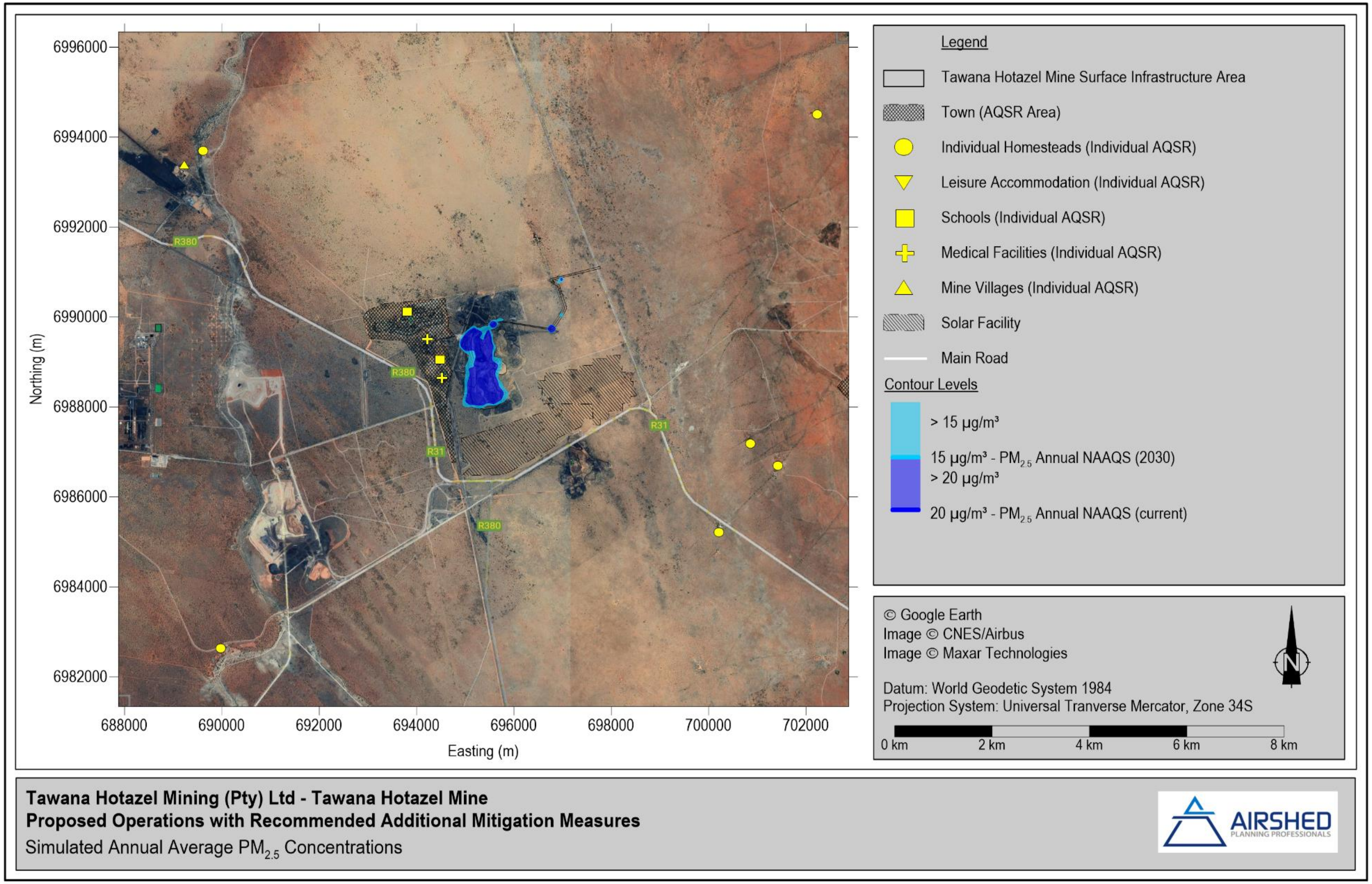


Figure 24: Simulated area of exceedance of the annual average $PM_{2.5}$ NAAQS as a result of additionally mitigated THM operations

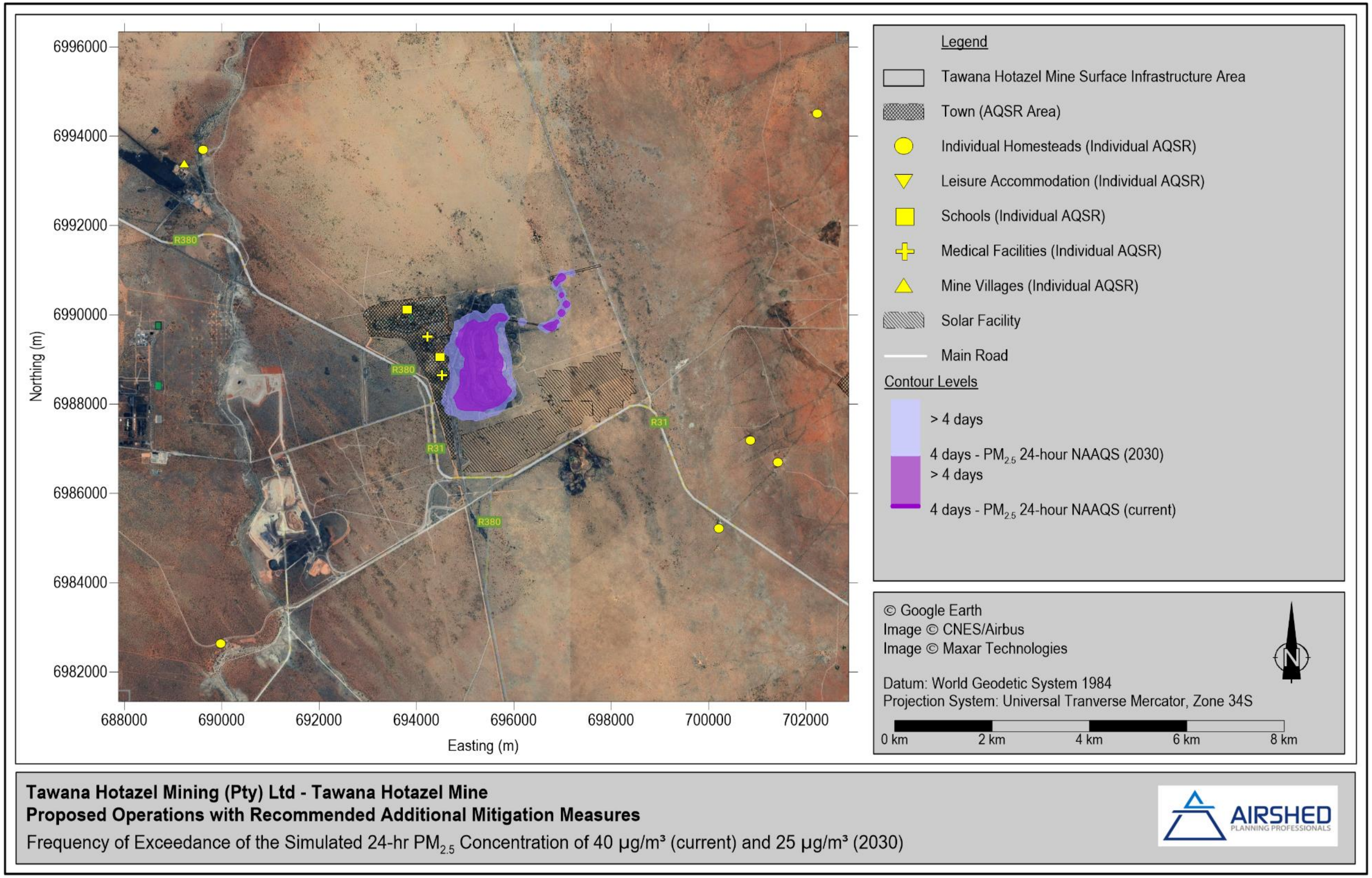


Figure 25: Simulated area of exceedance of the 24-hour $PM_{2.5}$ NAAQS as a result of additionally mitigated THM operations

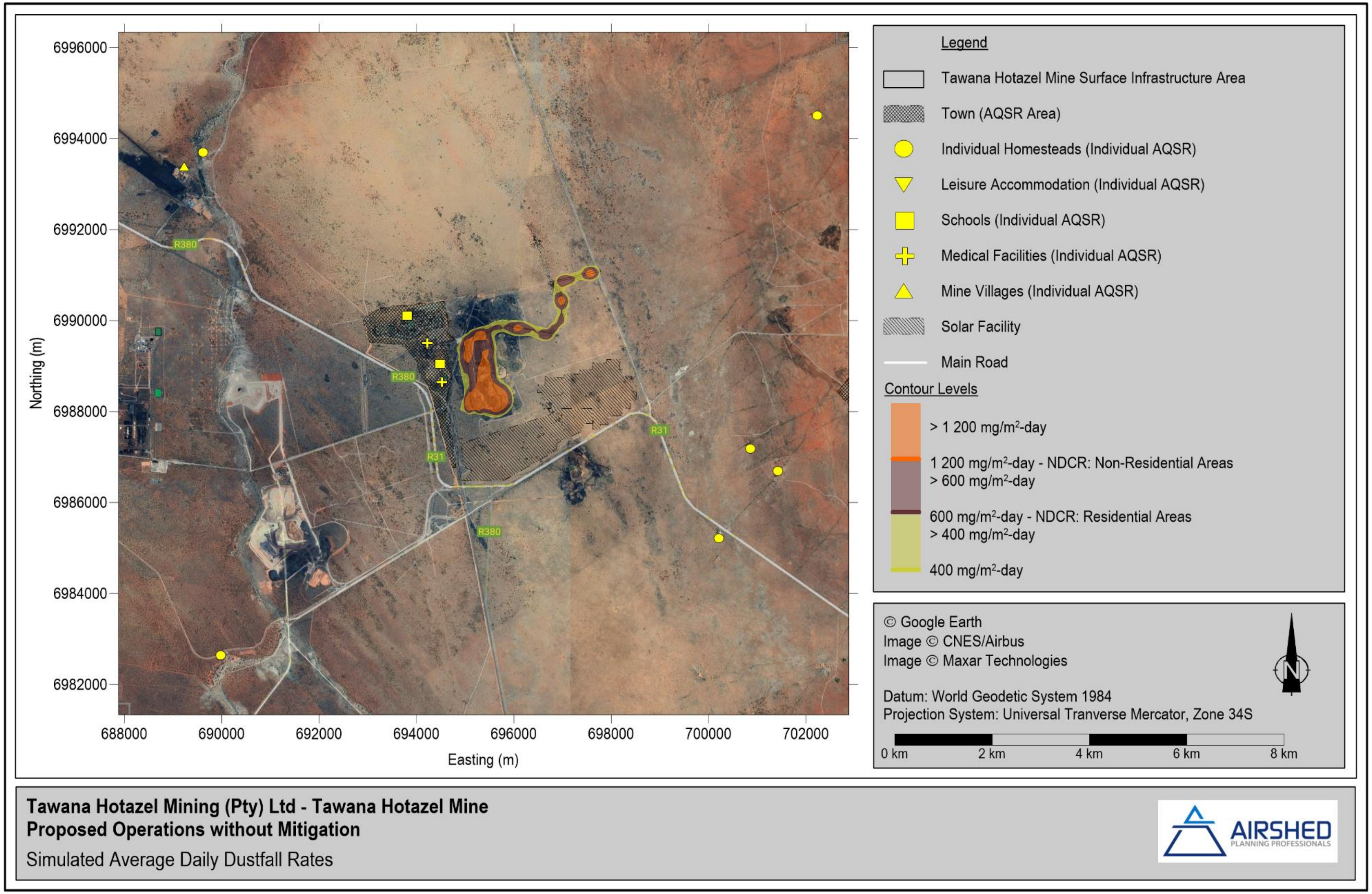


Figure 26: Average daily dustfall rates based on simulated highest monthly dust fallout as a result of unmitigated THM operations

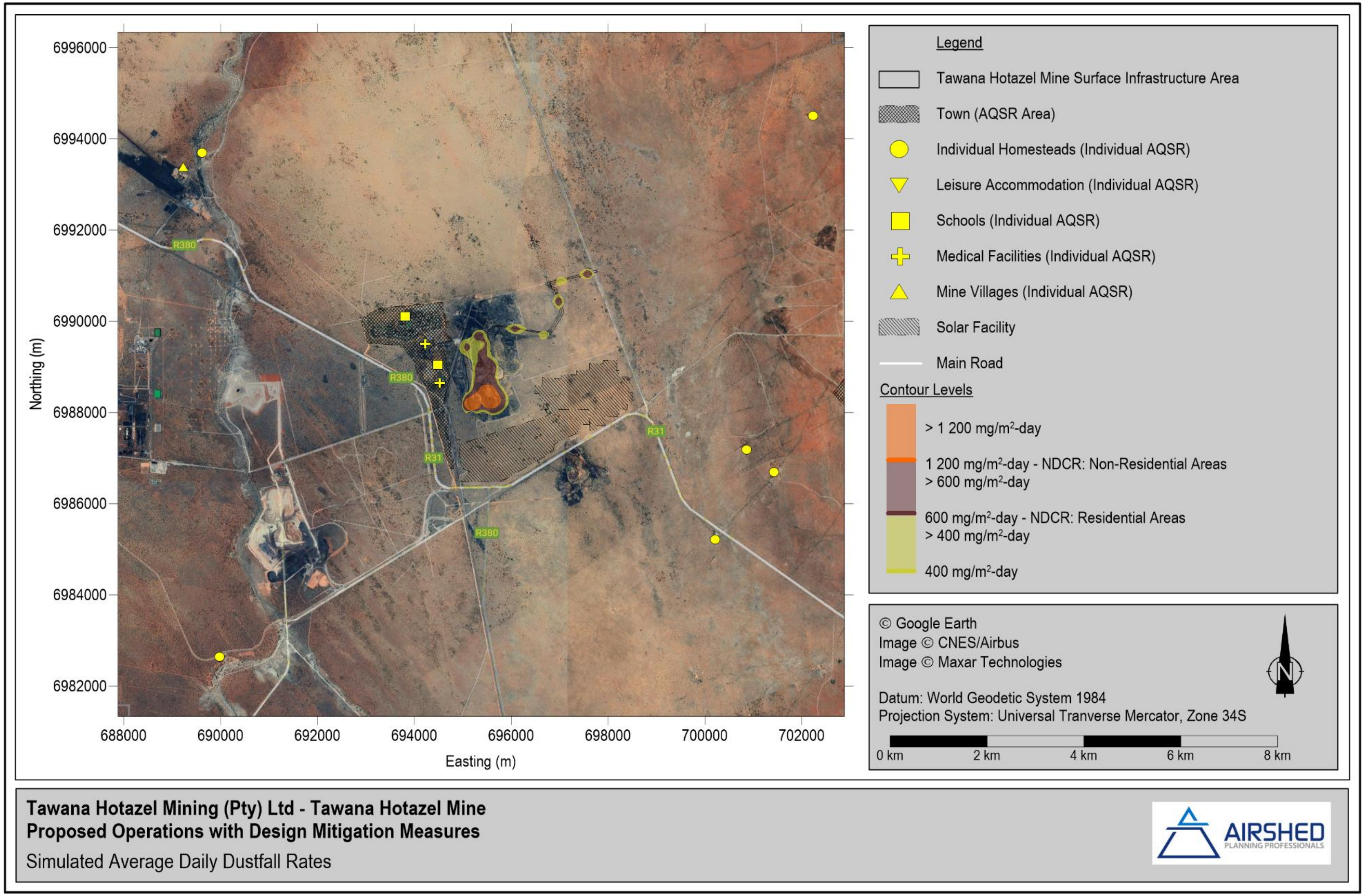


Figure 27: Average daily dustfall rates based on simulated highest monthly dust fallout as a result of mitigated THM operations

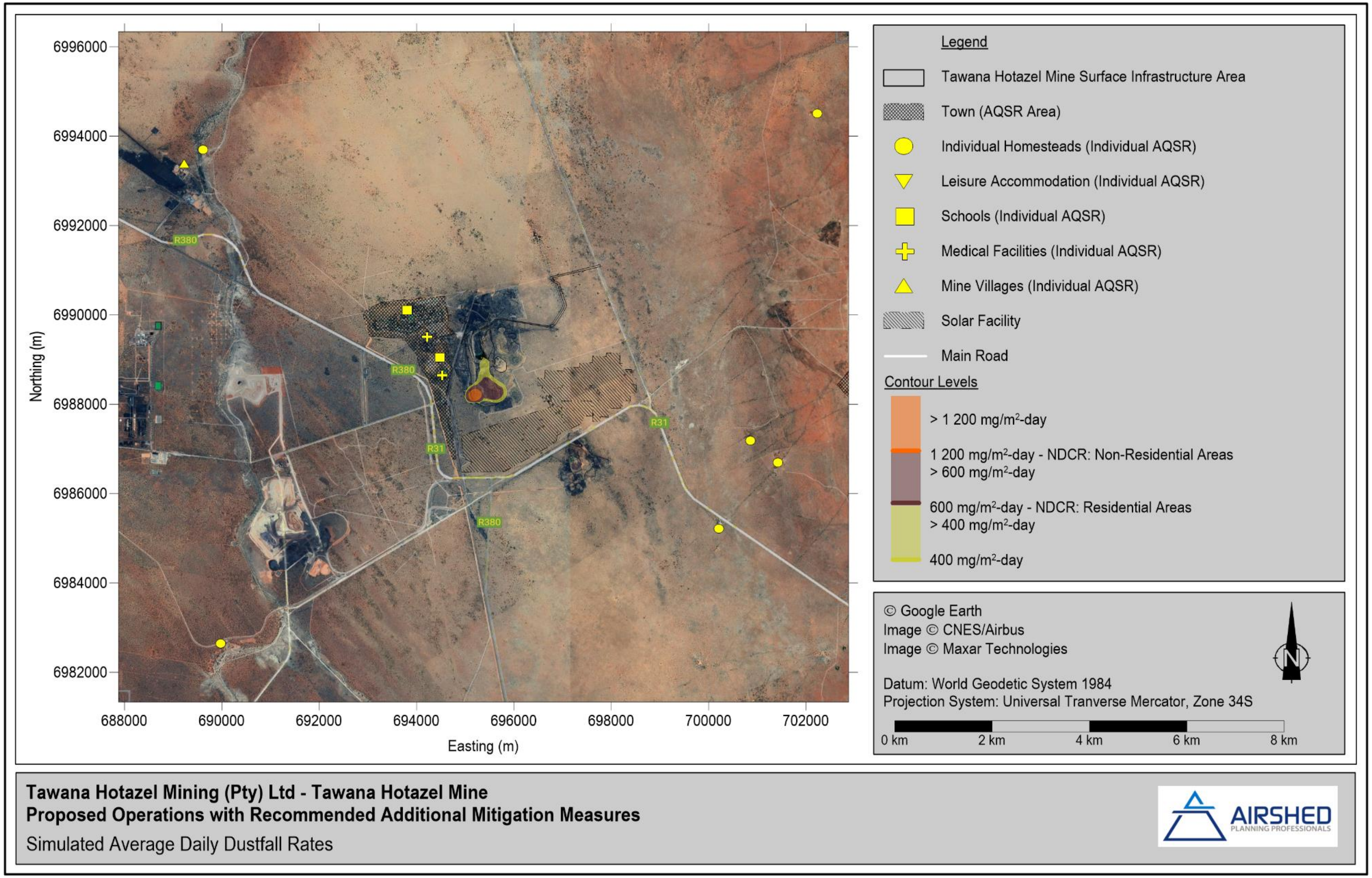


Figure 28: Average daily dustfall rates based on simulated highest monthly dust fallout as a result of additionally mitigated THM operations

7.2.4 Manganese (Mn)

The potential Mn GLCs is based on applying 32% Mn content to simulated PM_{10} concentrations as a result of activities associated with RoM and product material. It must be noted that there are no measured values for the Mn content for the individual sources included thus the assumption that was applied in this study was that the PM_{10} concentrations associated with all the proposed activities except for the transport of ore, waste, topsoil, sand and product along the unpaved roads, vehicles exhaust, grading of unpaved roads, bulldozing of waste stockpiles and generator(s) exhaust is multiplied by 0.32 based on the Mn content of much of the ore bearing rock in the region. The calculated annual average Mn concentrations (based on simulated PM_{10}) exceed the WHO Chronic Inhalation Guideline Value of 0.15 µg/m^3 at all AQSR in Hotazel town (Figure 29 and Figure 30).

7.2.5 Diesel Particulate Matter (DPM)

Simulated annual average DPM concentrations exceeded the US EPA IRIS RfC of 5 µg/m^3 but not at any of the AQSRs (Figure 31). The CAL EPA cancer URF of 3x10^{-4} (µg/m^3)$^{-1}$ was applied to simulated annual average concentrations to provide a conservative estimate of increased lifetime cancer risk (ILCR) since it assumes an individual will be exposed to this concentration constantly over a period of 70 years. Increased lifetime cancer risk at AQSRs range between very low (less than 1:1 000 000) and low (between 1:1 000 000 and 1:10 000); the AQSRs where the ILCR was estimated to be low are all residences in Hotazel town as well as Hotazel College, Hotazel Combined School, Life Occupational Health - Hotazel Manganese Mines Clinic and Wessels Clinic. The sources of DPM are the vehicles and generator(s) exhausts.

7.2.6 Sulfur dioxide (SO_2)

Simulated annual average SO_2 concentrations do not exceed the NAAQS of 50 µg/m^3 (Figure 32). The 24-hour NAAQS (4 days of exceedance of 125 µg/m^3) (Figure 33) and 1-hour NAAQS (88 hours of exceedance of 350 µg/m^3) (Figure 34) are also not exceeded; in fact, the concentrations are below the NAAQ limits.

7.2.7 Nitrogen dioxide (NO_2)

Simulated annual average NO_x concentrations exceed the NAAQS of 40 µg/m^3 at multiple AQSRs (residences in Hotazel as well as Hotazel Combined School and Wessels Clinic) (Figure 35). The 1-hour NAAQS (88 hours of exceedance of 200 µg/m^3) is exceeded at multiple AQSRs (most residences in Hotazel as well as Hotazel College, Hotazel Combined School, Life Occupational Health - Hotazel Manganese Mines Clinic and Wessels Clinic) (Figure 36). The simulated annual NO_x concentrations (Figure 37) exceed the critical level for all vegetation types. It was conservatively assumed that all NO_x is converted to NO_2.

7.2.8 Carbon monoxide (CO)

The 8-hour NAAQS (11 of exceedance of 8-hour rolling average concentrations of 10 000 µg/m^3) (Figure 38) and 1-hour NAAQS (88 hours of exceedance of 30 000 µg/m^3) (Figure 39) are not exceeded; in fact, the concentrations are below the NAAQ limits.

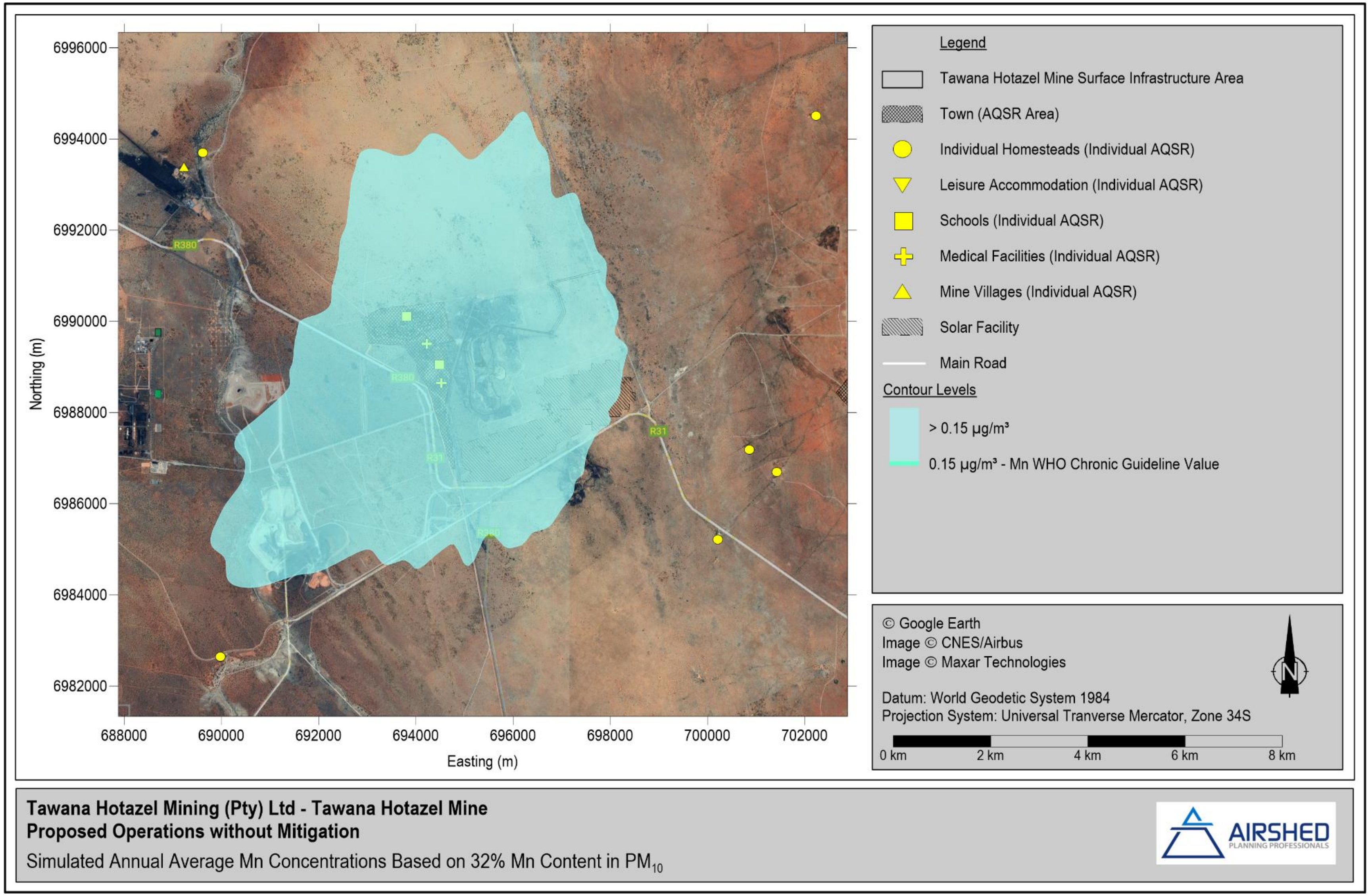


Figure 29: Simulated area of exceedance of the WHO chronic GV for Mn as a result of unmitigated THM operations

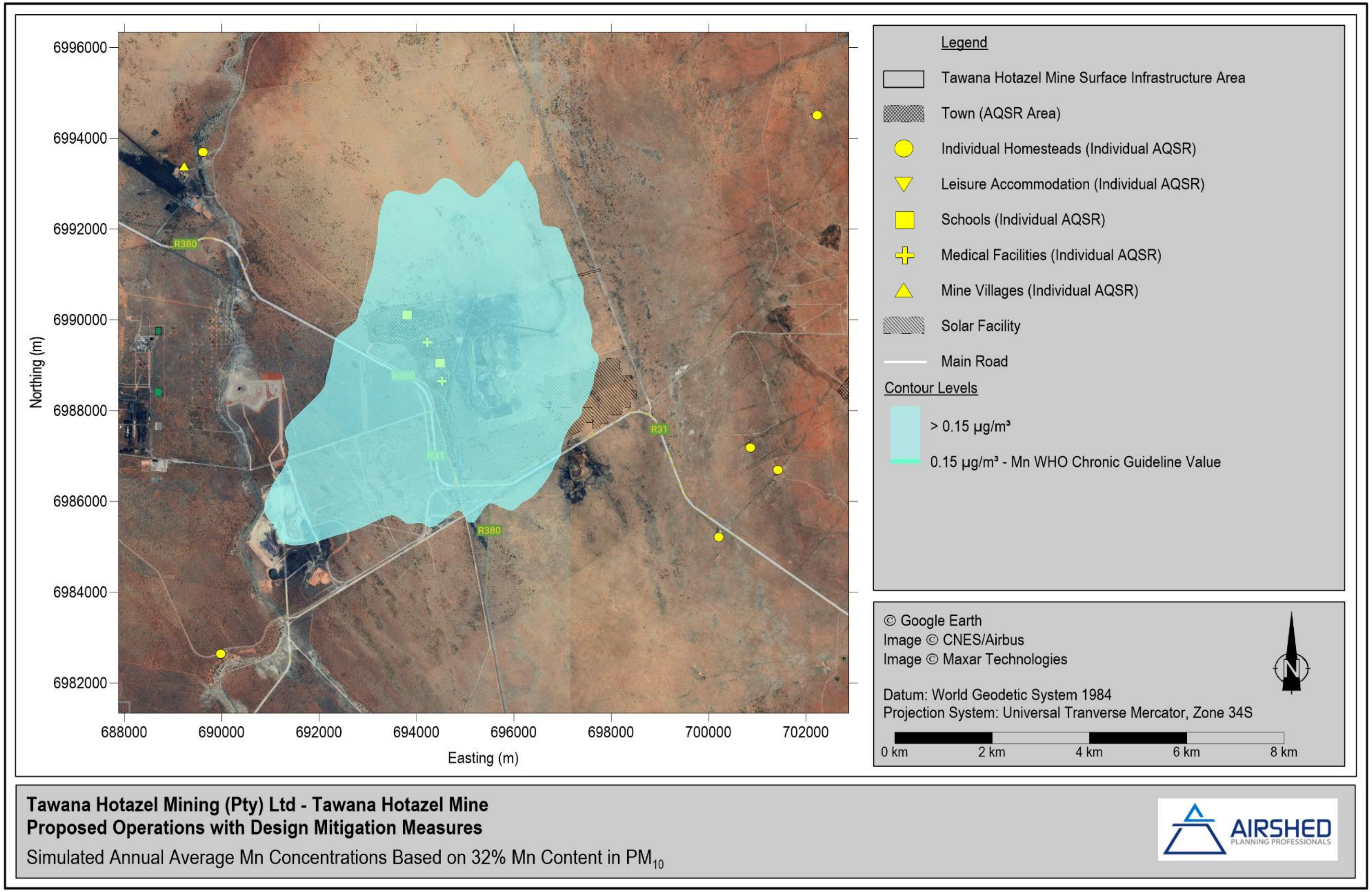


Figure 30: Simulated area of exceedance of the WHO chronic GV for Mn as a result of mitigated THM operations

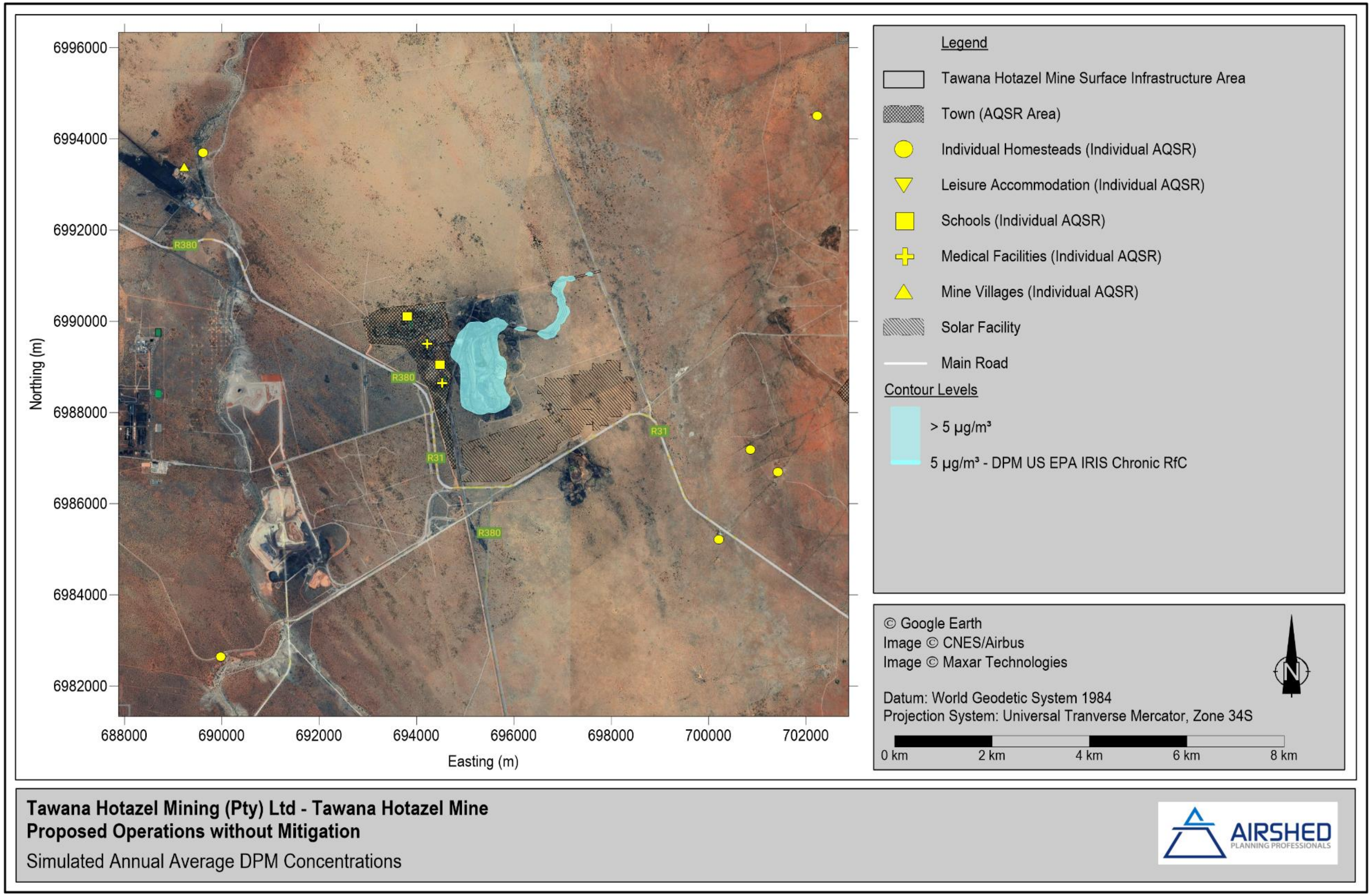


Figure 31: Simulated area of exceedance of the US EPA IRIS chronic RfC for DPM as a result of THM operations

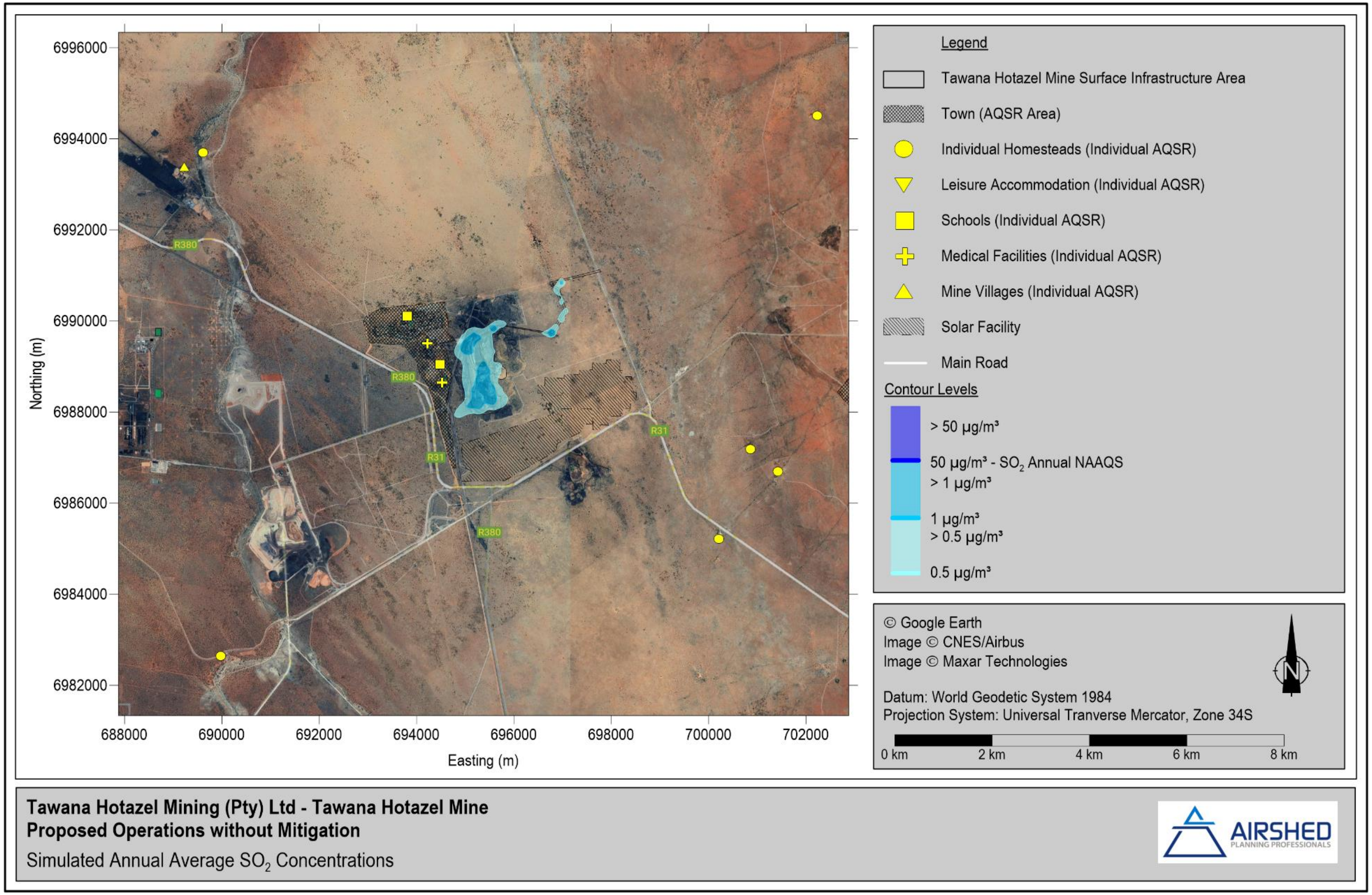


Figure 32: Simulated annual SO_2 concentrations as a result of THM operations

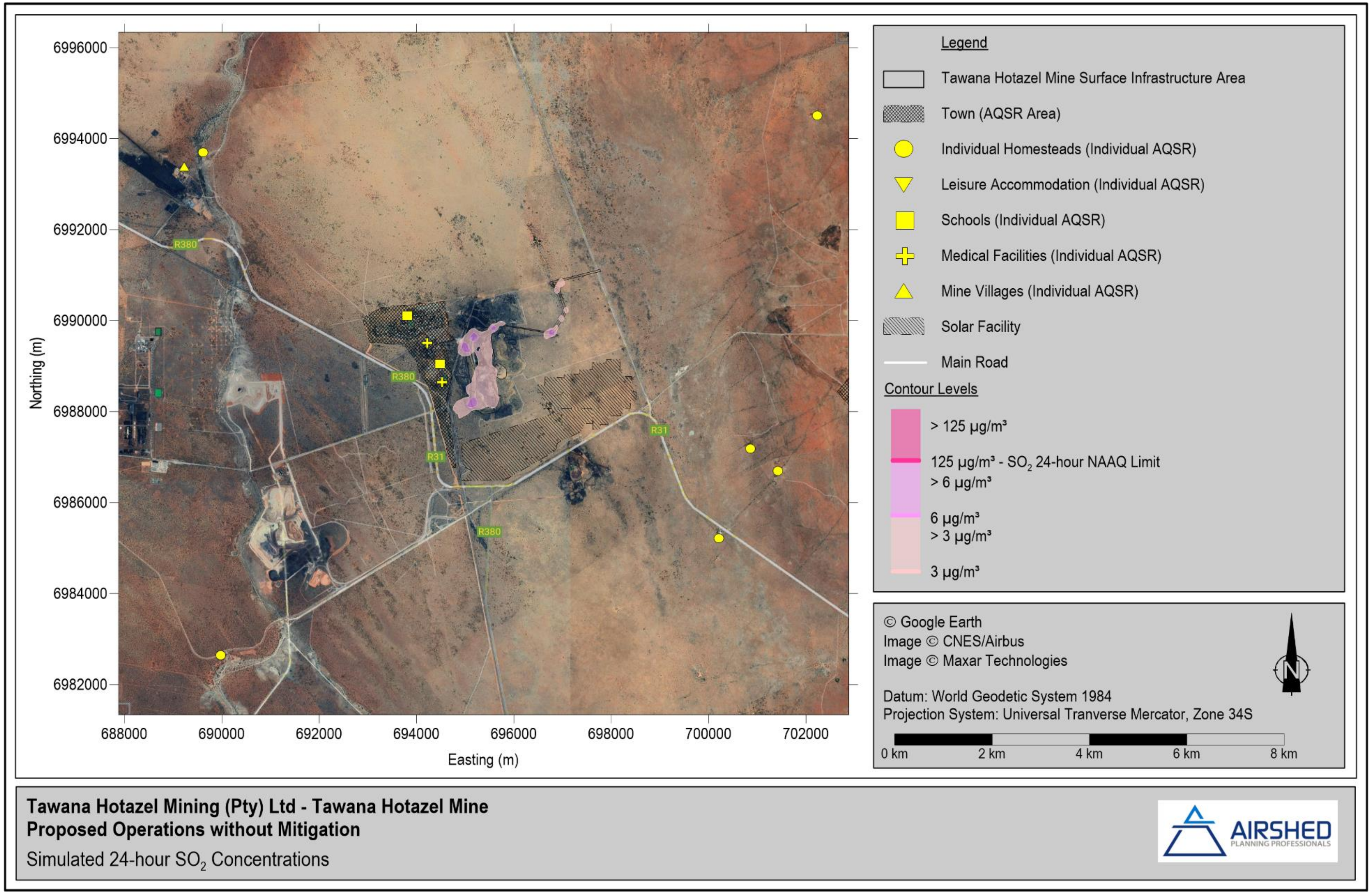


Figure 33: Simulated 24-hour SO_2 concentrations as a result of THM operations

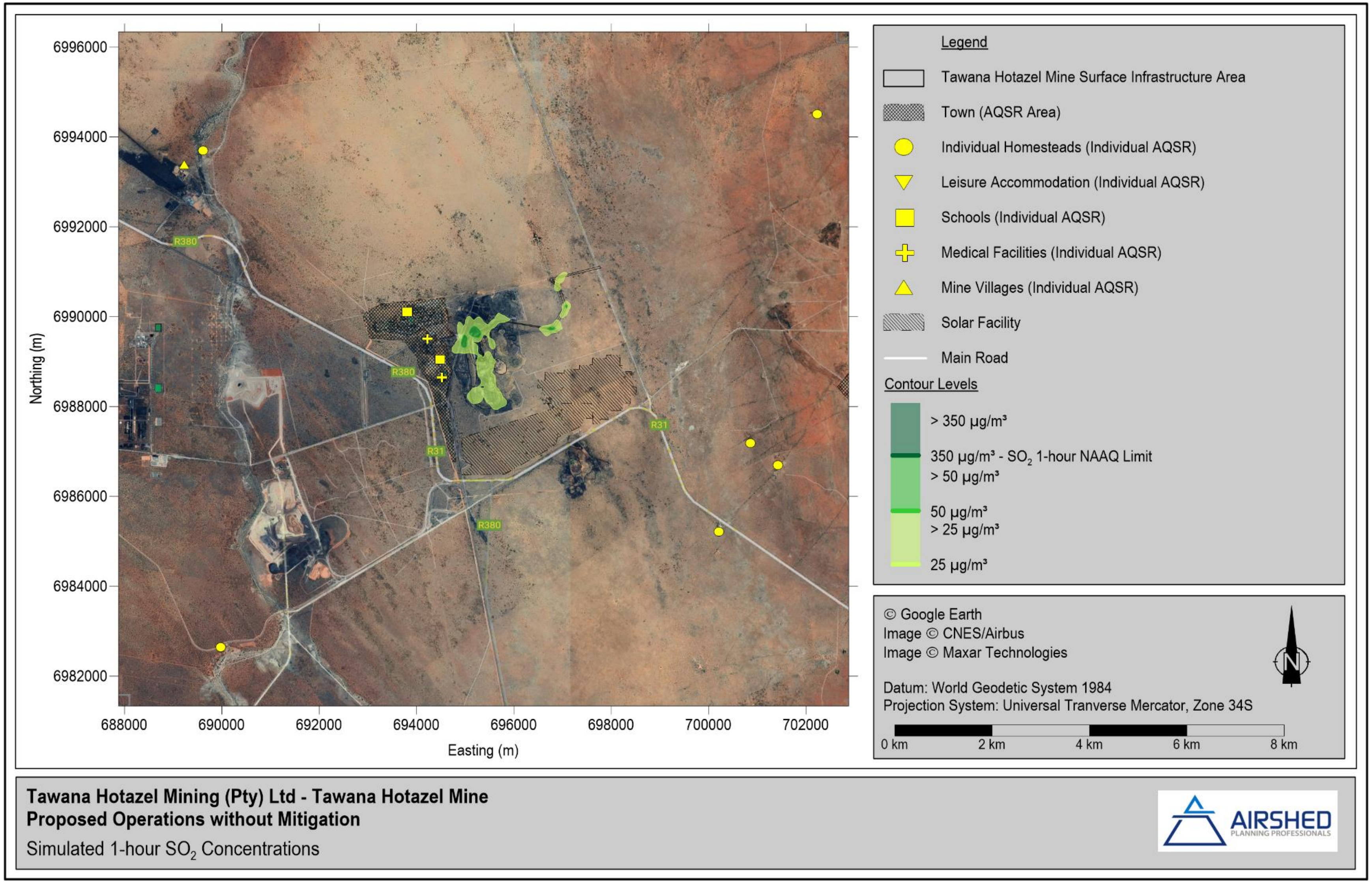


Figure 34: Simulated 1-hour SO_2 concentrations as a result of THM operations

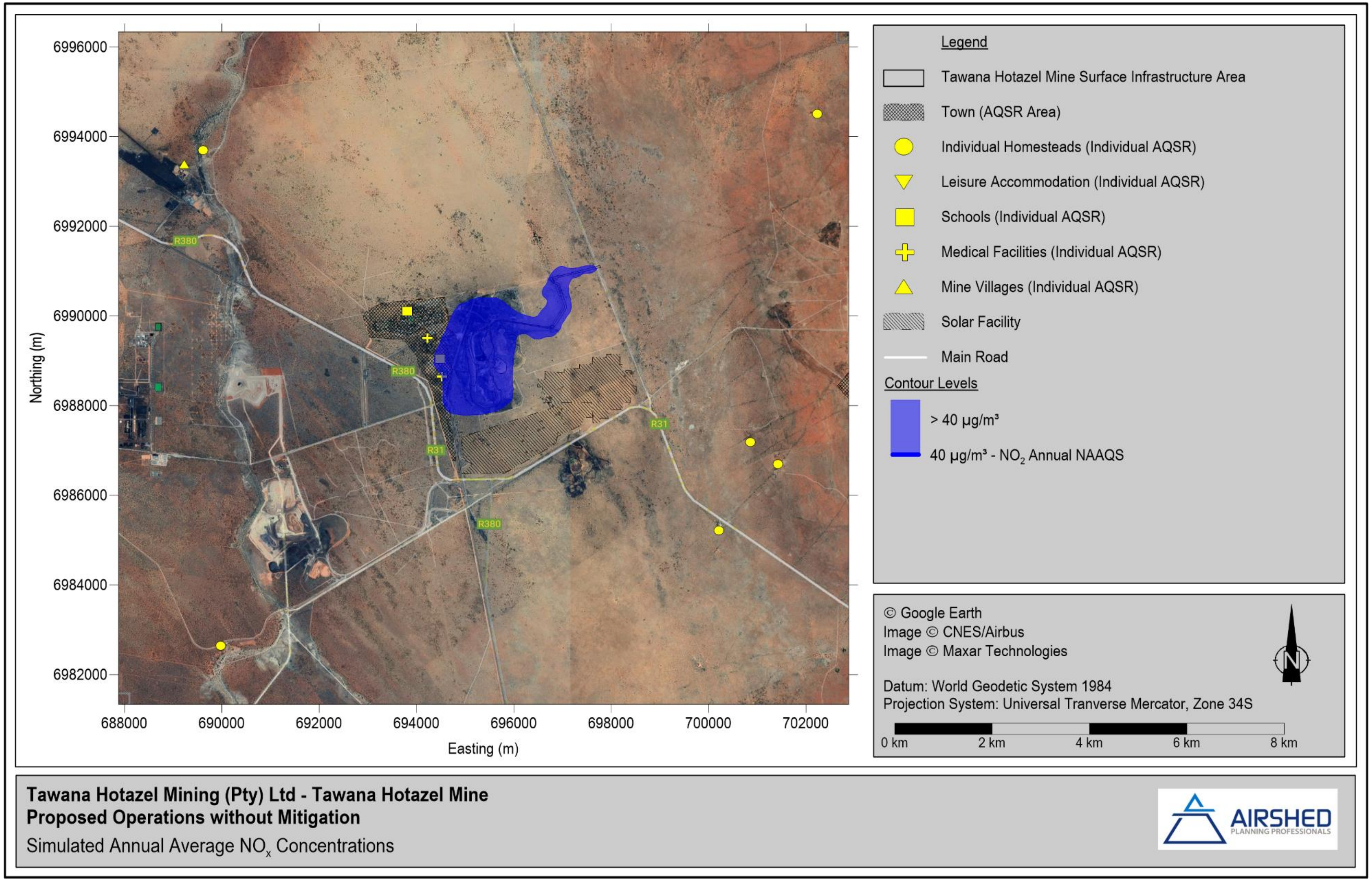


Figure 35: Simulated area of exceedance of the annual average NO_2 NAAQS as a result of THM operations (assuming all NO_x is converted to NO_2)

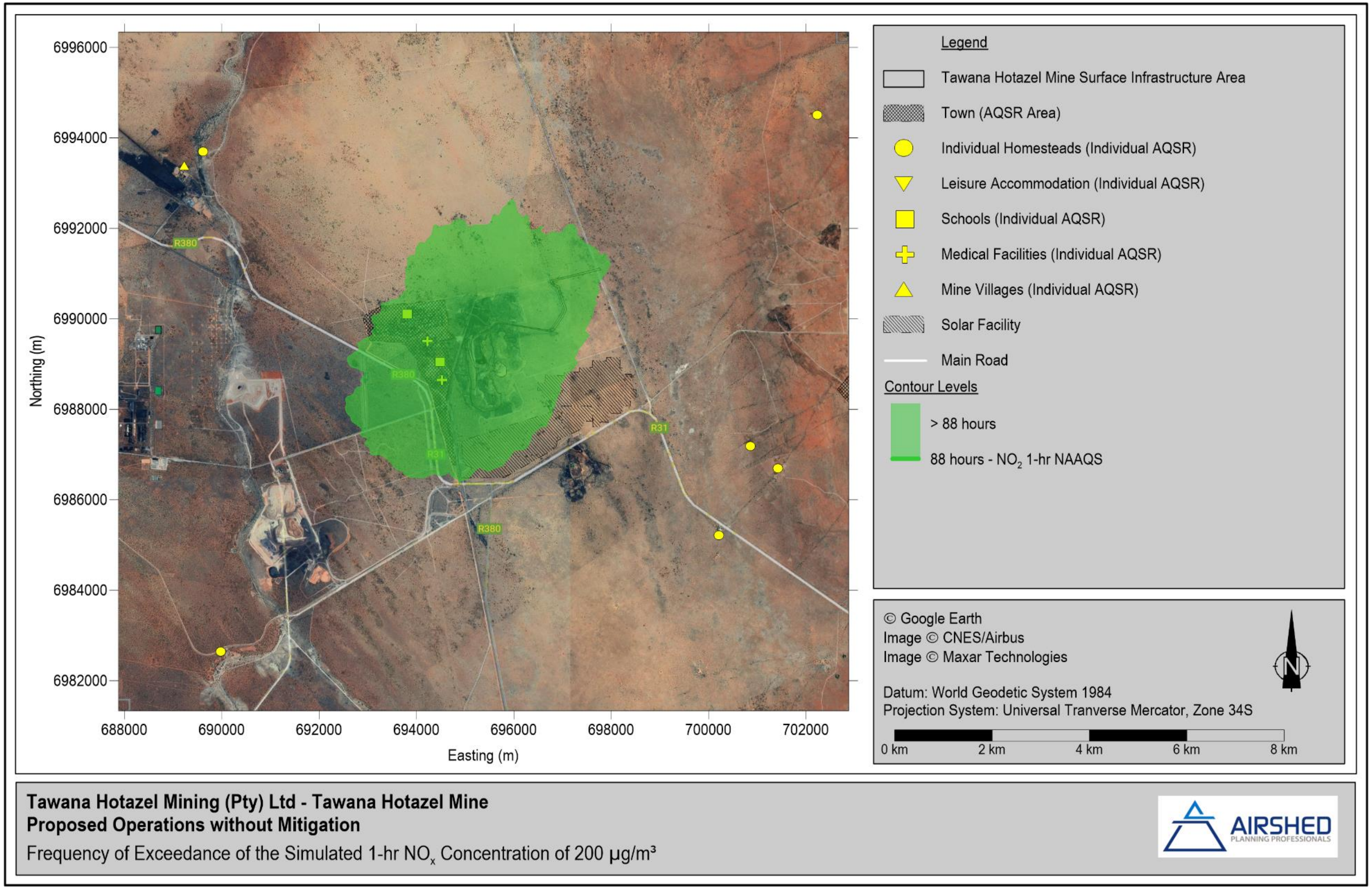


Figure 36: Simulated area of exceedance of the 1-hour NO_2 NAAQS as a result of THM operations (assuming all NO_x is converted to NO_2)

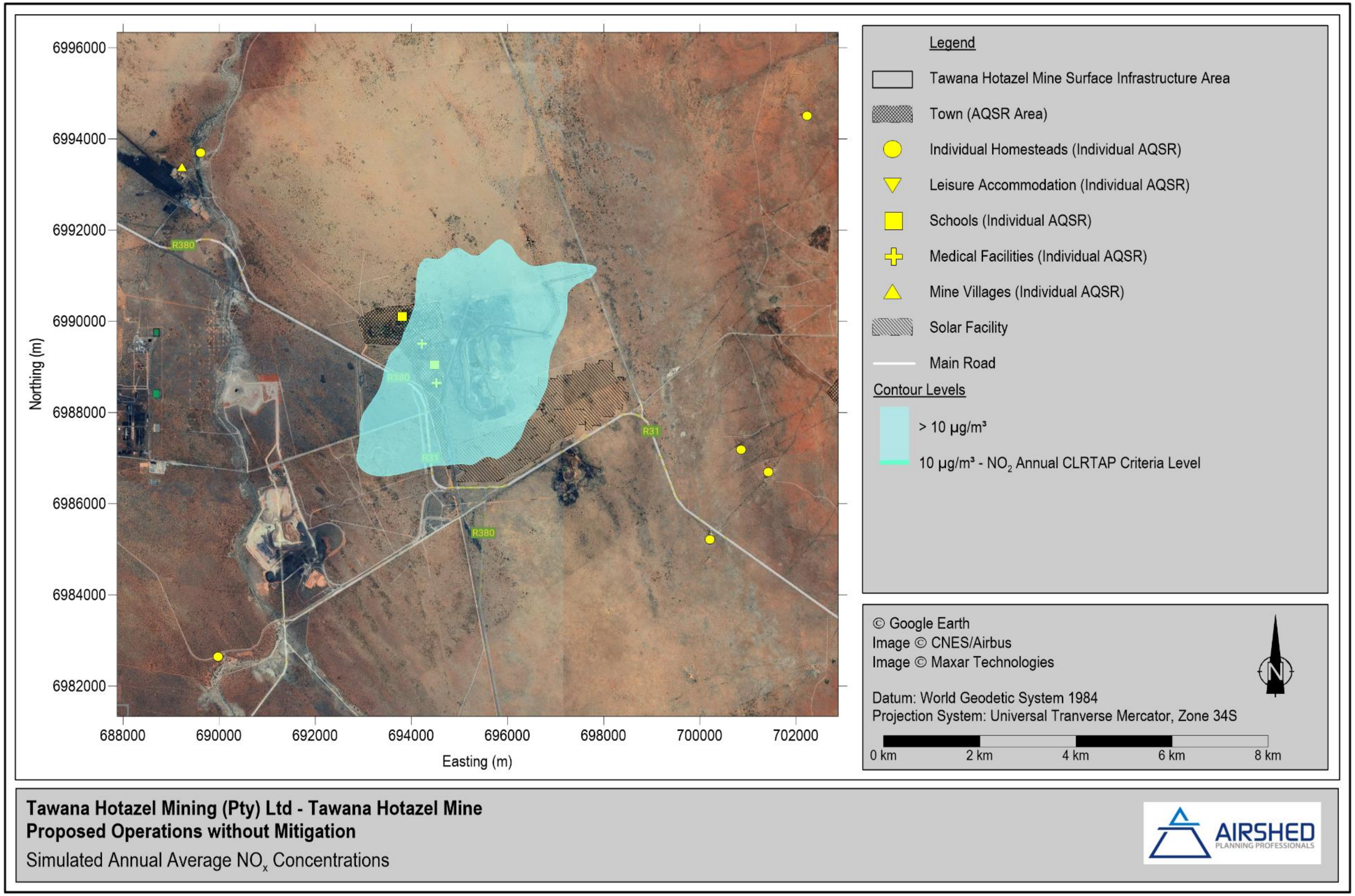


Figure 37: Simulated area of exceedance of the annual average NO_2 CLRTAP criteria as a result of THM operations (assuming all NO_x is converted to NO_2)

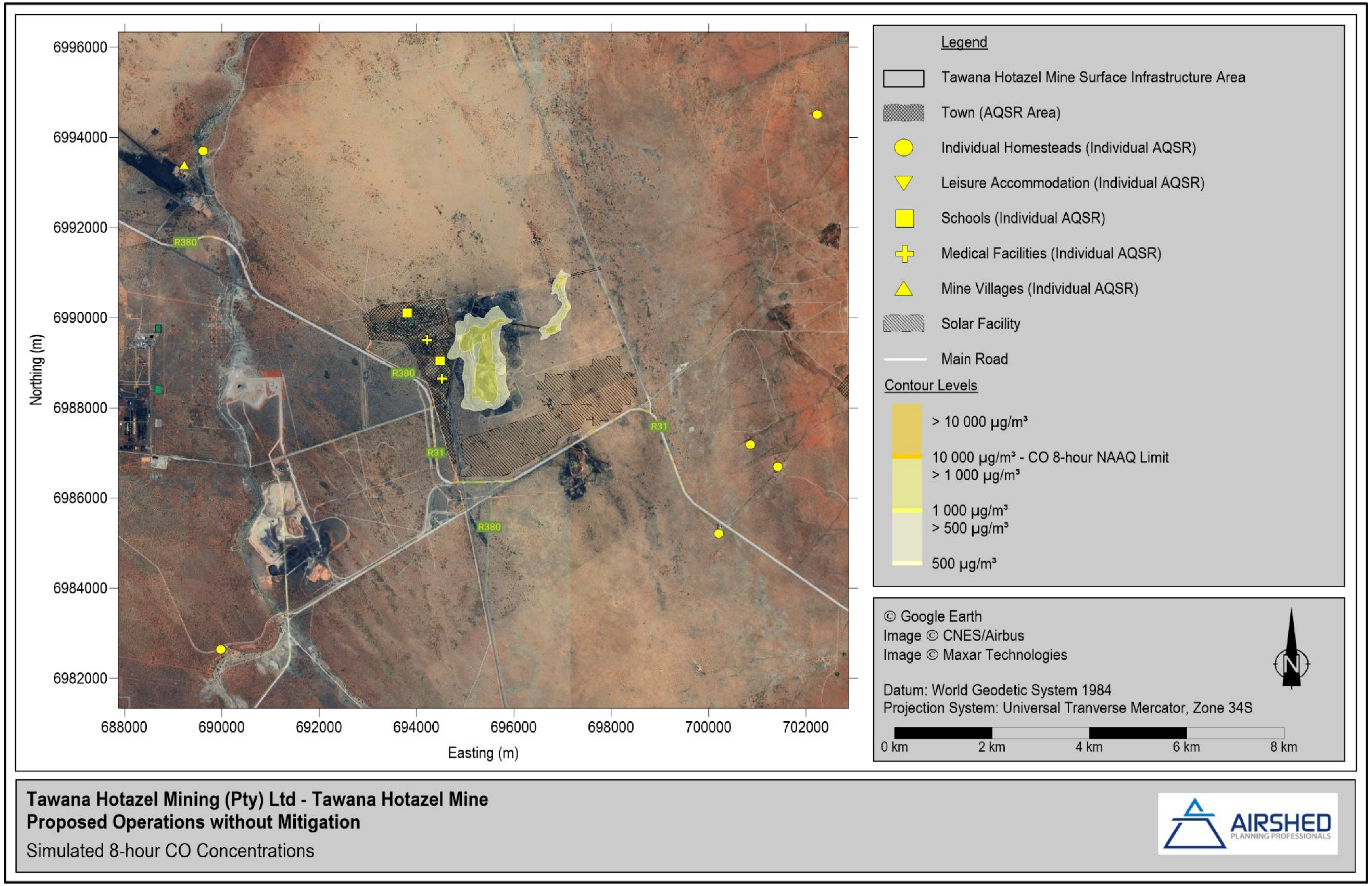


Figure 38: Simulated 8-hour average CO concentrations as a result of THM operations

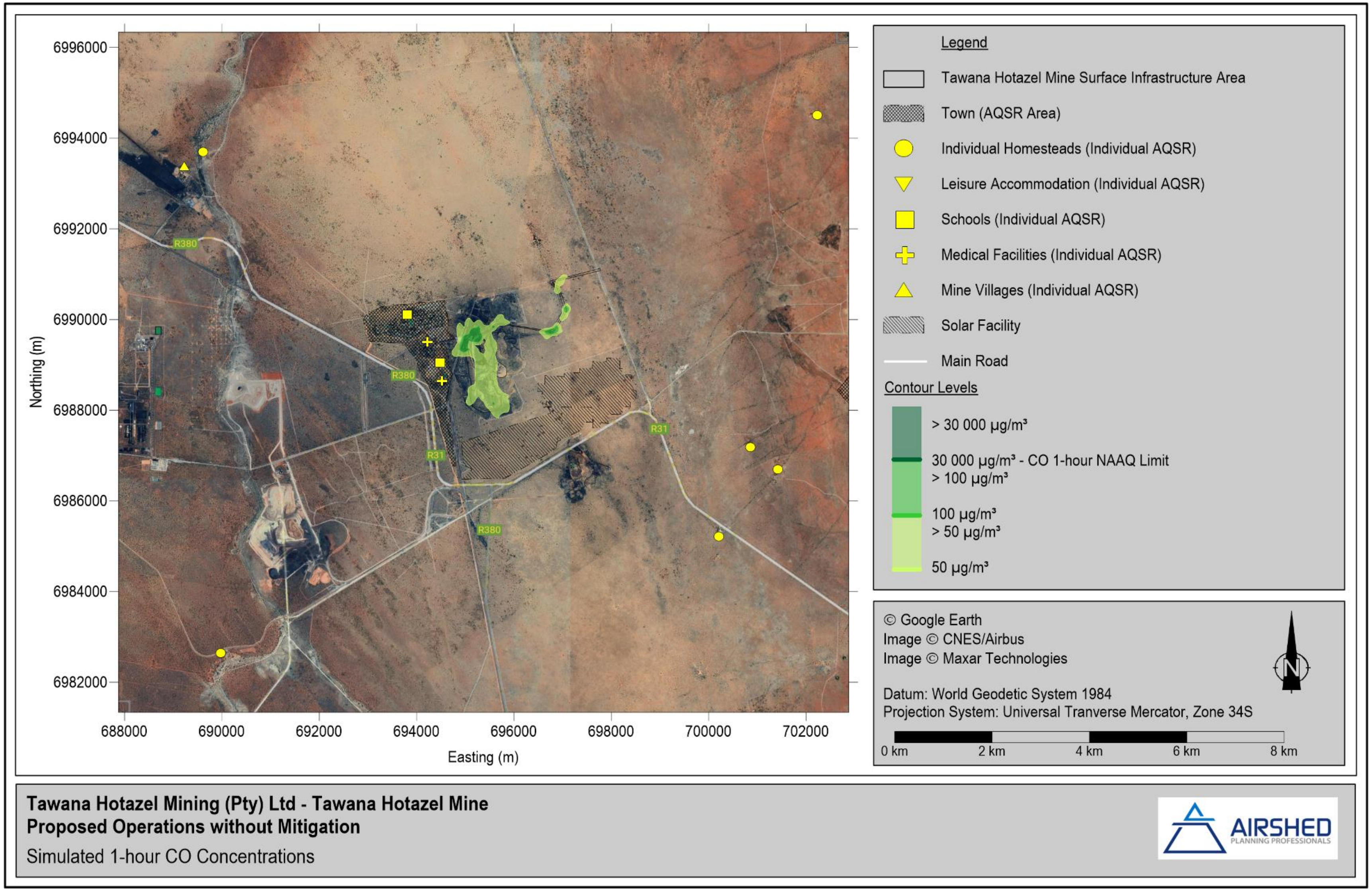


Figure 39: Simulated 1-hour CO concentrations as a result of THM operations

7.3 Impact Significance Rating: Incremental (Project) Operations

The main pollutants of concern were determined to be PM (including TSP, PM_{10} and $PM_{2.5}$) and NO_x. Non-compliance of NAAQS could result in human health impacts. A quantitative assessment of the potential impacts from PM_{10}, $PM_{2.5}$, NO_x, and dust fallout (TSP) during the operational phase is discussed below. The Prime Resources rating methodology was used. The NAAQS are intended to indicate safe daily exposure levels for most of the population, including the very young and the elderly, throughout an individual's lifetime. Simulated results show that the NAAQS are exceeded at multiple AQSRs, thus the simulated operations are likely to be a significant risk to human health at the existing surrounding receptors. Dust fallout is associated with nuisance impacts and not human health impacts; however, it could also compromise photosynthetic rates depending on species sensitivity. The simulated NO_x concentrations exceed the critical level for all vegetation types at vegetated areas, thus the simulated operations could be a risk to flora health and indirectly fauna health and aesthetic preferences for the surrounding (undeveloped) environment (nuisance impact). It was conservatively assumed that all NO_x is converted to NO_2. Three potential direct operational phase impacts on the air quality of the area were identified:

- B1: Impaired human health from increased pollutant concentrations associated with the project operations only (Table 21).
- B2: Increased nuisance dustfall rates associated with the project operations only (Table 22).
- B3: Impaired vegetation health from dustfall rates associated with the project operations only (Table 23).

Table 21: Increase in human health risk impact significance summary table for the proposed THM operational activities only

Air Quality: Human Health Impact	Occurrence		Severity		Significance		Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude					
Significance of potential impact without mitigation measures applied									
Operational phase	Highly probable	Long-term	Local	High	**40**	**Moderate**	–'ve	Moderate loss (50%-74%)	n/a
	4	4	2	4				3	
Significance of potential impact with design mitigation measures applied									
Operational phase	Medium probability	Long-term	Local	High	**30**	**Moderate**	–'ve	Moderate loss (50%-74%)	25%
	3	4	2	4				3	
Design mitigation measures: Level-1 watering (2 litres/m2/h) on unpaved roads and water sprays at crusher and screen.									
Significance of potential impact with additional mitigation measures applied									
Operational phase	Medium probability	Long-term	Local	Moderate	**27**	**Low**	–'ve	Minor loss (24%-49%)	33%
	3	4	2	3				2	
Additional mitigation measures: Additional mitigation measures include level-2 watering (> 2 litres/m²/h) on in-pit and waste stockpiles unpaved roads and water sprays with chemicals on haul roads and access roads. The design mitigation measures include water sprays at the crusher and screen.									

Table 22: Increase in nuisance impact significance summary table for the proposed THM operational activities only

Air Quality: Nuisance Impact	Occurrence		Severity		Significance	Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude				
Significance of potential impact without mitigation measures applied								

Air Quality: Nuisance Impact	Occurrence		Severity		Significance		Status	Loss of resources	Degree of mitigation (%)
	Probability	**Duration**	**Extent/Scale**	**Magnitude**					
Operational phase	Medium probability	Long-term	Local	Low	**24**	**Low**	–'ve	Limited loss (0%-24%)	n/a
	3	4	2	2				1	
Significance of potential impact with design mitigation measures applied									
Operational phase	Low probability	Long-term	Local	Low	**16**	**Low**	–'ve	Limited loss (0%-24%)	33%
	2	4	2	2				1	
Design mitigation measures: Level-1 watering (2 litres/m2/h) on unpaved roads and water sprays at crusher and screen.									
Significance of potential impact with additional mitigation measures applied									
Operational phase	Improbable	Long-term	Site only	Minor	**6**	**Low**	–'ve	Limited loss (0%-24%)	75%
	1	4	1	1				1	
Additional mitigation measures: Additional mitigation measures include level-2 watering (> 2 litres/m^2/h) on in-pit and waste stockpiles unpaved roads and water sprays with chemicals on haul roads and access roads. The design mitigation measures include water sprays at the crusher and screen.									

Table 23: Increase in vegetation health risk impact significance summary table for the proposed THM operational activities only

Air Quality: Vegetation Health Impact	Occurrence		Severity		Significance		Status	Loss of resources	Degree of mitigation (%)
	Probability	**Duration**	**Extent/Scale**	**Magnitude**					
Significance of potential impact without mitigation measures applied									
Operational phase (NO_x)	Low probability	Long-term	Local	Moderate	**18**	**Low**	–'ve	Moderate loss (50-74%)	n/a
	2	4	2	3				3	

Air Quality: Vegetation Health Impact	Occurrence		Severity		Significance		Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude					
Significance of potential impact with design/additional mitigation measures applied									
Operational phase (NO_x)	n/a								
Significance of potential impact for all mitigation scenarios (including unmitigated operations)									
Operational phase (dustfall)	Improbable	Long-term	None	Minor	**5**	**Low**	–'ve	Limited loss (0%-24%)	n/a
	1	4	0	1				1	

Design mitigation measures:

Level-1 watering (2 litres/m2/h) on unpaved roads and water sprays at crusher and screen.

Additional mitigation measures:

Additional mitigation measures include level-2 watering (> 2 litres/m^2/h) on in-pit and waste stockpiles unpaved roads and water sprays with chemicals on haul roads and access roads. The design mitigation measures include water sprays at the crusher and screen.

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 stockpile surfaces will be covered with topsoil and vegetated. The potential for air quality impacts during the closure 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 THM should cease.
- exhaust emissions from vehicles utilised during the closure phase. Once that is done, vehicle activity associated with THM 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: Decommissioning and Closure Phases

Insufficient data was available for the decommissioning and closure phases to allow for dispersion modelling of the actual activities that will result in dust emissions to be undertaken. It is anticipated that the various activities would not 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 $PM_{2.5}$, PM_{10} and TSP impacts perspective is discussed below.

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

- C1: Potential impact on human health from pollutant concentrations associated with decommissioning activities (Table 24).
- C2: Nuisance dustfall rates associated with decommissioning activities (Table 25)

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

- D1: Potential impact on human health from pollutant concentrations associated with closure activities (Table 26).
- D2: Nuisance dustfall rates associated with closure activities (Table 27).

C1 and D1 would likely impact on human health whereas C2 and D2 would impact on amenities.

Table 24: Health risk impact significance summary table for the decommissioning activities only

Air Quality: Human Health Impact	Occurrence		Severity		Significance		Status	Loss or Resources
	Probability	Duration	Extent/Scale	Magnitude				
Significance of potential impact without mitigation measures applied								
Decommissioning phase	Low probability	Short-term (0-5 years)	Local	Moderate	**14**	**LOW**	–'ve	Minor loss (24%-49%)
	2	2	2	3				2
Mitigation measures: None								

Table 25: Nuisance impact significance summary table for the decommissioning activities only

Air Quality: Nuisance Impact	Occurrence		Severity		Significance		Status	Loss or Resources
	Probability	Duration	Extent/Scale	Magnitude				
Significance of potential impact without mitigation measures applied								
Decommissioning phase	Low probability	Short-term (0-5 years)	Local	Low	**12**	**LOW**	–'ve	Limited loss (0%-24%)
	2	2	2	2				1
Mitigation measures: None								

Table 26: Health risk impact significance summary table for the closure activities only

Air Quality: Human Health Impact	Occurrence		Severity		Significance	Status	Loss or Resources
	Probability	Duration	Extent/Scale	Magnitude			
Significance of potential impact without mitigation measures applied							

Air Quality: Human Health Impact	Occurrence		Severity		Significance		Status	Loss or Resources
	Probability	Duration	Extent/Scale	Magnitude				
Closure phase	Low probability	Short-term (0-5 years)	Site only	Low	**10**	**LOW**	–'ve	Limited loss (0%-24%)
	2	2	1	2				1
Mitigation measures: None								

Table 27: Nuisance impact significance summary table for the closure activities only

Air Quality: Nuisance Impact	Occurrence		Severity		Significance		Status	Loss or Resources
	Probability	Duration	Extent/Scale	Magnitude				
Significance of potential impact without mitigation measures applied								
Closure phase	Low probability	Short-term (0-5 years)	Local	Minor	**8**	**LOW**	–'ve	Limited loss (0%-24%)
	2	2	1	1				1
Mitigation measures: None								

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 and wilderness. The mining and processing operations (other companies), farming activities, domestic fires, vehicle exhaust emissions and dust entrained by vehicles on public roads, and wind-blown dust from undeveloped areas without the addition of the proposed operations will likely result in elevated ambient air pollutant concentrations at AQSRs and elevated dustfall rates compared to other areas where there are no anthropogenic emission sources due to the high erodibility of the area/region due to the limited vegetation and disintegration of surface material, dryness of the region and frequent elevated wind speeds. It is difficult to predict the location and contribution of the sources from residences, farming and wilderness to existing air quality using dispersion modelling. The potential cumulative scenario includes the following atmospheric emissions:

a. Particulate and gaseous emissions from THM operations.
b. Particulate and gaseous emissions from other mining, processing and industry related power generation operations.
c. Particulate emissions form miscellaneous fugitive dust sources including vehicle entrainment on local roads and wind-blown dust from open areas.
d. Particulate and gaseous emissions from vehicles exhausts.
e. Particulate and gaseous emissions from household fuel burning.
f. Particulate and gaseous emissions from biomass burning (e.g., wildfires).

Based on the sampled PM concentrations, as well as the THM operations simulated results there is likely to be long-term and short-term exceedances of the NAAQS at AQSRs in Hotazel town as a result of all activities in the region. Based on the sampled dustfall rates, as well as the simulated results there could to be exceedances of the NDCR limit for non-residential areas one or more months in a year at AQSRs in Hotazel town but is likely to be compliant with the NDCR as a result of all activities in the region. Based on the highest sampled dustfall rate, as well as the simulated results for unmitigated THM operations, the dustfall rates at the solar facility could range between 164 mg/m²-day and 766 mg/m²-day as a result of all activities in the region.

9.2 Impact Significance Rating – Cumulative Activities

Three quantifiable cumulative air quality impacts for the area are:

- E1: Potential impact on human health from elevated pollutant concentrations due to existing activities in the region and proposed THM operations (Table 28).
- E2: Potential impact of nuisance dustfall rates associated with the existing activities in the region and proposed THM operations (Table 29).
- E3: Potential impact on vegetation health from dustfall rates due to the existing activities in the region and proposed THM operation (Table 30).

Table 28: Increase in human health risk impact significance summary table for the cumulative sources

Air Quality: Human Health Impact	Occurrence		Severity		Significance		Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude					
Significance of potential impact without mitigation measures applied									
Cumulative activities in the region	Highly probable	Long-term	Local	High	**40**	**Moderate**	–'ve	Moderate loss (50%-74%)	n/a
	4	4	2	4				3	
Significance of potential impact with design mitigation measures applied									
Cumulative activities in the region	Medium probability	Long-term	Local	High	**30**	**Moderate**	–'ve	Moderate loss (50%-74%)	25%
	3	4	2	4				3	
Design mitigation measures: Level-1 watering (2 litres/m2/h) on unpaved roads and water sprays at crusher and screen.									
Significance of potential impact with additional mitigation measures applied									
Cumulative activities in the region	Medium probability	Long-term	Local	Moderate	**27**	**Low**	–'ve	Minor loss (24%-49%)	33%
	3	4	2	3				2	
Additional mitigation measures: Additional mitigation measures include level-2 watering (> 2 litres/m^2/h) on in-pit and waste stockpiles unpaved roads and water sprays with chemicals on haul roads and access roads. The design mitigation measures include water sprays at the crusher and screen.									

Table 29: Increase in nuisance impact significance summary table for the cumulative sources

Air Quality: Nuisance Impact	Occurrence		Severity		Significance	Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude				
Significance of potential impact without mitigation measures applied								

Air Quality: Nuisance Impact	Occurrence		Severity		Significance		Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude					
Cumulative activities in the region	Medium probability	Long-term	Local	Low	**24**	**Low**	–'ve	Limited loss (0%-24%)	n/a
	3	4	2	2				1	
Significance of potential impact with design mitigation measures applied									
Cumulative activities in the region	Medium probability	Long-term	Local	Low	**24**	**Low**	–'ve	Limited loss (0%-24%)	0%
	3	4	2	2				1	
Design mitigation measures: Level-1 watering (2 litres/m2/h) on unpaved roads and water sprays at crusher and screen.									
Significance of potential impact with additional mitigation measures applied									
Cumulative activities in the region	Low probability	Long-term	Local	Minor	**14**	**Low**	–'ve	Limited loss (0%-24%)	42%
	2	4	2	1				1	
Additional mitigation measures: Additional mitigation measures include level-2 watering (> 2 litres/m²/h) on in-pit and waste stockpiles unpaved roads and water sprays with chemicals on haul roads and access roads. The design mitigation measures include water sprays at the crusher and screen.									

Table 30: Increase in vegetation health risk impact significance summary table for the cumulative sources

Air Quality: Vegetation Health Impact	Occurrence		Severity		Significance		Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude					
Significance of potential impact for all mitigation scenarios (including unmitigated operations)									
Cumulative activities in the region	Medium probability	Long-term	Regional	Moderate	**40**	**Moderate**	–'ve	Limited loss (0%-24%)	n/a
	3	4	3	3				1	

Air Quality: Vegetation Health Impact	Occurrence		Severity		Significance	Status	Loss of resources	Degree of mitigation (%)
	Probability	Duration	Extent/Scale	Magnitude				
<u>Design mitigation measures:</u> Level-1 watering (2 litres/m2/h) on unpaved roads and water sprays at crusher and screen. <u>Additional mitigation measures:</u> Additional mitigation measures include level-2 watering (> 2 litres/m^2/h) on in-pit and waste stockpiles unpaved roads and water sprays with chemicals on haul roads and access roads. The design mitigation measures include water sprays at the crusher and screen.								

10 IMPACT ASSESSMENT: NO GO OPTION

10.1 Potential State of the Air Quality

Should the no go option be embarked on, none of the proposed activities will occur in the area. Thus, the potential for an increase in ambient air pollutant concentrations and dustfall rates is small. 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. Based on sampled fine PM concentrations and simulated results, the proposed THM operations could result in a doubling of annual average PM_{10} concentrations in Hotazel town.

11 AIR QUALITY MANAGEMENT PLAN

The mitigation, management and monitoring recommendations included in this section are based in the results of the impact assessment.

11.1 Air Quality Management Objectives

The main objective of the recommended additional mitigation measures and management measures for the project is to ensure that operations at the facility do not significantly reduces the air quality within the region. To define project specific management objectives, the main sources of pollution needed to be identified. Based on the emissions estimation and dispersion modelling results the two main sources groups associated with the proposed operations were determined to be crushing and screening operations and vehicles travelling on unpaved roads as well as vehicles exhausts.

11.1.1 Source Specific Management and Mitigation Measures

For the proposed project, the use of chemical suppressants on the surface haul roads and access road should be considered. The following section refers to more detail on the additional mitigation and management measures.

The limited water resources limit the use of water sprays on other sources and increasing watering rates on unpaved roads. Sealing of roads have not been considered as a recommended mitigation measure as this could negatively affect the rehabilitation efforts to restore the site as much as possible to pre-development conditions, especially since in-pit roads are the most significant contributor to the simulated elevated PM_{10} concentrations in Hotazel town.

11.1.1.1 Dust Control Options for Unpaved Roads

There are three types of measures that can be taken to reduce emissions from unpaved roads: (a) measures aimed at reducing the extent of unpaved roads, e.g. paving, (b) traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds, and (c) measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilization (Cowherd, Muleski, & Kinsey, 1988); (APCD, 1995).
The main dust generating factors on unpaved road surfaces include:

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

When quantifying emissions from unpaved road surfaces, most of these factors are accounted for. Vehicle speed is one of the significant factors influencing the amount of fugitive dust generated from unpaved roads surfaces. The control efficiency obtained by speed reduction can be calculated by varying the vehicle speed input parameter in the predictive emission factor equation given for unpaved roads. An evaluation of control efficiencies resulting from reductions in traffic volumes can be calculated due to the linear relationship between traffic volume, given in terms of vehicle kilometres travelled, and fugitive dust emitted. Similar effects will be achieved by reducing the truck volumes on the roads. Thus, by increasing the payload of the truck, fewer trips will be required to transport the same amount of material.

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

11.1.2 Source Monitoring

It should be noted that Tawana will be required to report annual emissions on the NAEIS system. Effective inspection and maintenance programs will ensure new vehicles remain in good condition and reduce emissions from vehicles. It is recommended that mobile equipment emission testing for PM, SO_2 and NO_x be conducted regularly as part of the inspection and maintenance program.

11.1.3 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 there be a dustfall rates sampling network as well as a PM_{10} monitor and weather station. The proposed locations for the sampling and monitoring equipment are included in Table 31 and shown in Figure

40. The description of these locations in relation to the proposed operations and the main parameters that should be measured are included in Table 31. Dustfall sampling near sources can be an effective mechanism in determining the main emission sources. It is recommended that as a minimum continuous dustfall sampling be conducted as part of the project's management plan, where the dust bucket network comprises of eight single units. The method to be used for measuring dustfall and the guideline for locating sampling points shall be American Standard Test Method (ASTM) D1739 (2017), or equivalent method approved by any internationally recognized body is suggested. The dustfall sampling and reporting must be conducted according to the NDCR. It is suggested that the PM_{10} monitor be located at the closest potentially impacted sensitive receptor (house in Hotazel) or the passive PM sampling Site 2 or Hotazel Combined School or Wessels Clinic in Hotazel town. The residence is the most likely place of constant human occupation where PM_{10} concentrations may exceed the standards as the predicted area of exceedance extends to this receptor. It is also suggested that a weather station be erected at the offices to record hourly meteorological data for the site. The inclusion of meteorological data (wind speed, wind direction, and rainfall) in the dustfall reports is a requirement of the NDCR. The measurement of meteorological parameters also allows for a more comprehensive analysis of the PM_{10} monitoring data. This location is suggested as the mine infrastructure is not likely to interfere with the wind flow thus making it less likely to produce incorrect readings for the wind field and the site is secure. It is recommended that dustfall sampling be initiated prior to construction, continue throughout the construction phase, operational phase and decommissioning phase.

Table 31: Sampling and monitoring equipment locations and parameters to be measured

No.	Description	Parameter to be Measured	Reasoning
D1	Off-site, non-residential area, along heavy vehicles access road	Dustfall	To determine dustfall rates as a result of operations
D2	Off-site, north of THM proposed operations, pre-development dustfall sampling unit D2	Dustfall	To determine dustfall rates as a result of operations
D3	Off-site, residential area, pre-development dustfall sampling unit D3	Dustfall	To determine dustfall rates as a result of operations
D4/PM10b	Off-site in residential area, Passive PM sampling Site 2 – Resident is known by the EAP	Dustfall (and possibly PM_{10})	To determine dustfall rates and possibly PM_{10} concentrations as a result of operations
D5/PM10d	Off-site, residential area, Wessels Clinic	Dustfall (and possibly PM_{10})	To determine dustfall rates and possibly PM_{10} concentrations as a result of operations
D6	Off-site, location of highest calculated dustfall rates at the proposed solar facility, pre-development dustfall sampling unit D4	Dustfall	To determine dustfall rates as a result of operations.
D7	Off-site, at the proposed solar facility	Dustfall	To determine dustfall rates and PM_{10} concentrations as a result of operations.
D8	Off-site, east of THM proposed operations	Dustfall	To determine dustfall rates as a result of operations
PM10a	Residence impacted the most- Preferred location	PM_{10}	To determine PM_{10} concentrations as a result of operations
PM10c	Off-site, residential area, Hotazel Combined School – Backup option	Possibly PM_{10}	To possibly determine PM_{10} concentrations as a result of operations
WS	On-site, proposed offices	Meteorological data (including but not limited to wind speed, wind direction, temperature, and rainfall)	To measure meteorological parameters for dustfall reporting and more comprehensive analysis of dustfall and PM_{10} data

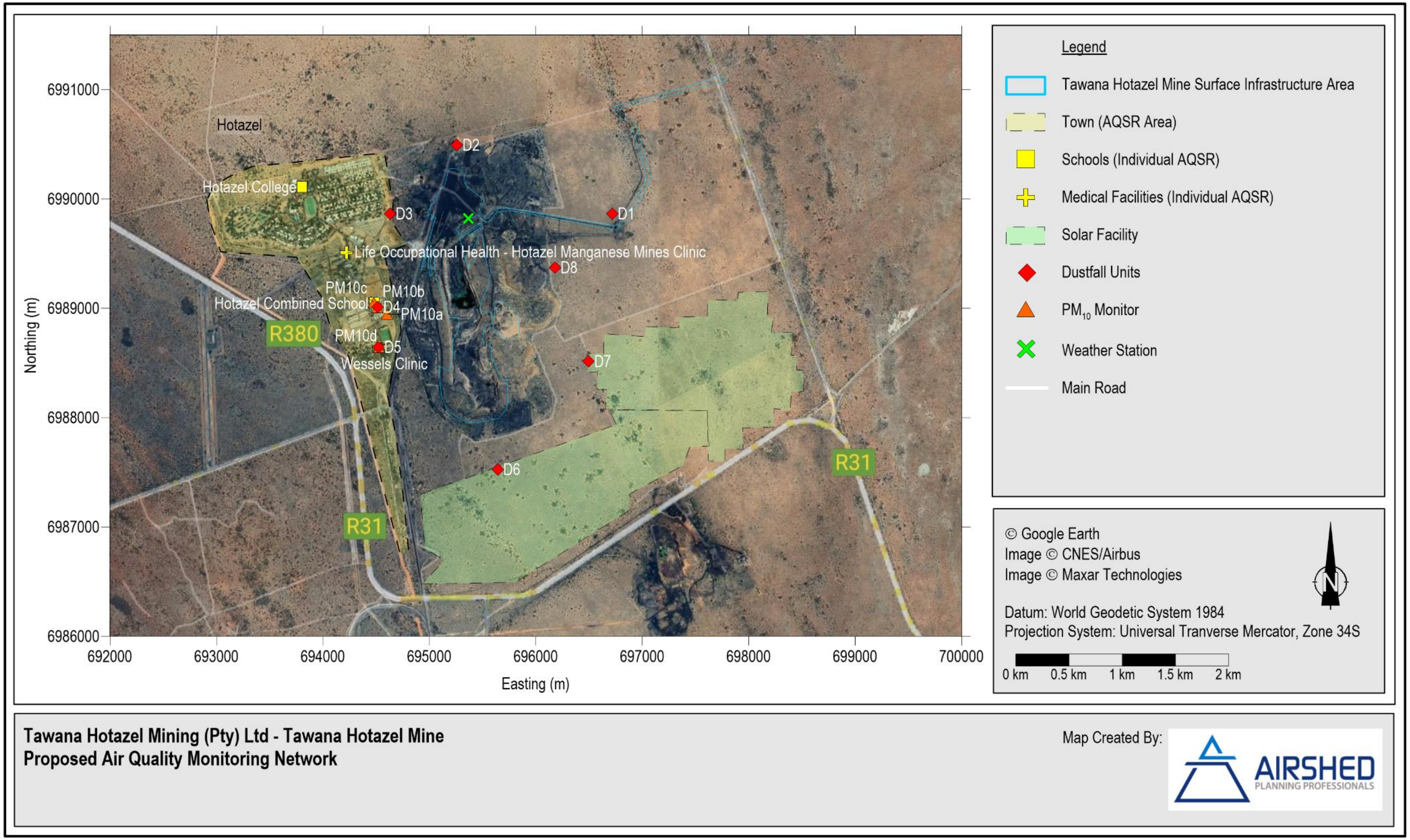


Figure 40: Proposed air quality monitoring network

11.1.3.1 Recommended Dustfall Sampling Methodology

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 planted and cemented (Figure 41). 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.

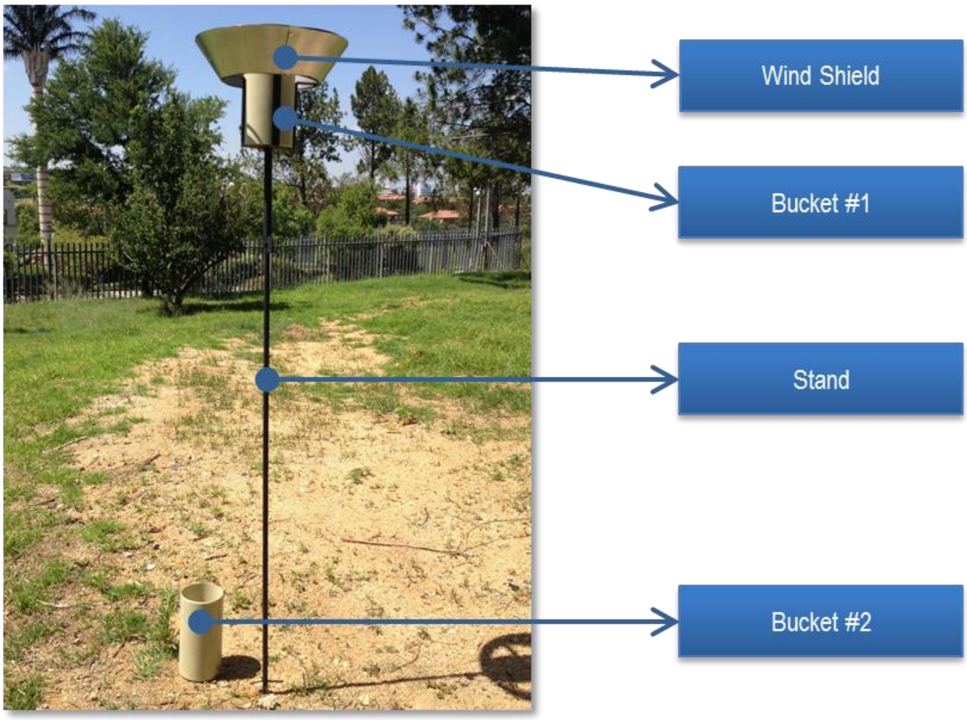


Figure 41: Dustfall collection unit example

11.1.3.2 PM_{10} and Meteorological Data Monitoring

It is recommended that continuous PM_{10} monitoring be undertaken at one location off-site (preferably PM10a). The three possible instrumentations include:

1. Indicative instruments;
2. Near-reference instruments; and

3. Refence instruments.

If the monitoring equipment has gravimetric sampling abilities as well, then it is recommended that a gravimetric sample be taken quarterly. Prior to and after sampling, a gravimetric analysis (weighing) must be undertaken on the PM_{10} "filter" to determine the pre-weight and post-weight. The preferred exposure (sampling) period for the "filter" would be 24-hours. The PM_{10} concentration for the "filter" can be determined based on the difference in filter weight, the exposure period and the equipment flow rate (thus with every gravimetric sample the date, start time, end time, flow rate and calibration flow must be logged as well as any notes on potential sources at the time of sampling). The gravimetric analysis (post-weigh) should be followed by an ICP MS analysis to determine the manganese content. The manganese concentration for the sampling period can be determined based on the PM_{10} concentration and manganese content. An accredited laboratory should be used for the analysis.

It is recommended that continuous meteorological data monitoring be undertaken at the offices; should the PM_{10} equipment selected have an associated weather station then the metrological data monitoring can be conducted at the PM_{10} monitoring location. The station must be in an area where no infrastructure or vegetation would interfere with the anemometer (wind sensor) readings. As a minimum the station should measure wind speed, wind direction, temperature and rainfall.

11.2 Record-keeping, Environmental Reporting and Community Liaison

11.2.1 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.

Should any environmental emergency incidents occur, the incident will need to be documented in detail. The summary of each emergency incident must include:

1. Nature and cause of incident
2. Actions taken immediately following the incident to minimise impact
3. Actions taken after to reduce the likelihood of reoccurrence.

11.2.2 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.

11.2.3 Budgeting

The budget should provide a clear indication of the capital and annual maintenance costs associated with 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 THM. 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 receptors near the Project include the residential areas of Hotazel, Blackrock, Mogojaneng, and Magobing which are made up of individual residences, schools, medical facilities as well as contractors and leisure accommodation. There are also isolated homesteads, contractors and leisure accommodation and mining villages near THM that would also be classified as sensitive receptors.
- The main sources likely to contribute to baseline PM emissions include mining and processing 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 individual residences.
- The area is dominated by winds from the north-east. The northerly winds are associated with wind speeds of above 6 m/s. According to the US EPA wind speeds exceeding 5 m/s are likely to result in windblown dust emissions.

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 mitigation and "low" rating with additional mitigation measures applied.
- Operational phase:
  - PM_{10}, $PM_{2.5}$, TSP, SO2, NO_x, CO and DPM emissions and impacts were quantified.
  - PM_{10} concentrations as a result of unmitigated operations are not within compliance with the NAAQS at multiple AQSRs over the long-term (annual) and short-term (24-hour).
  - PM_{10} concentrations as a result of operations with design mitigation measures and recommended additional mitigation measures applied are not within compliance with the NAAQS at multiple AQSRs over the short-term (24-hour).
  - $PM_{2.5}$ concentrations as a result of unmitigated operations are not within compliance with the NAAQS at multiple AQSRs over the short-term (24-hour).
  - $PM_{2.5}$ concentrations as a result of operations with design mitigation measures and recommended additional mitigation measures applied are within compliance with the current NAAQS. $PM_{2.5}$ concentrations as a result of operations with design mitigation measures and

recommended additional mitigation measures applied are not within compliance with the future[12] NAAQS at multiple AQSRs over the short-term (24-hour).

  - PM_{10} concentrations as a result of design mitigated operations are not within compliance at Hotazel and some individual AQSRs over the short-term and long-term.
  - $PM_{2.5}$ concentrations as a result of design mitigated operations are in compliance with the NAAQS at all AQSRs over the long-term; however, not in compliance with the NAAQS at some AQSRs over the short-term.
  - Dustfall rates are above the NDCR limits for non-residential areas; however, the dustfall rates are below the NDCR limits for residential areas at all AQSRs and below 400 mg/m²-day at all agricultural areas.
  - Annual Mn concentrations as a result of unmitigated operations and design mitigated operations exceed the WHO GV at AQSRs.
  - Annual DPM does not exceed the US EPA IRIS RfC at any AQSRs.
  - NO_x concentrations are not in compliance with the NO_2 NAAQS at multiple AQSRs over the long-term (annual) and short-term (1-hour). The simulated annual NO_x concentrations exceed the critical level for all vegetation types. It was conservatively assumed that all NO_x is converted to NO_2.
  - SO_2 and CO concentrations are below the NAAQ limit values.
  - The significance of operations related inhalation health impacts is likely to be "moderate" without mitigation and "moderate" with the design mitigation measures applied. With the recommended design mitigation measures applied the significance reduces to "low". The significance of operations related to nuisance impacts are likely to be "low" without and with design mitigation, as well as with recommended additional mitigation measures applied. The significance of operations related vegetation health impacts as a result of NO_x concentration is likely to be "low" without mitigation measures applied but result in a moderate loss of resources. The significance of operations related vegetation health impacts as a result of dustfall rates is likely to be "low" without and with design mitigation, as well as with recommended additional mitigation measures applied with a minor loss of resources (lowest descriptor available for loss of resources).
- Decommissioning and closure phases:
  - The significance of decommissioning operations related inhalation health and nuisance impacts are likely to have a "low" rating without mitigation and with mitigation.
  - 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 use of chemical suppressants on the surface haul roads and access road should be considered

[12] Applicable from 1January 2030

- The dustfall sampling and ambient fine particulate monitoring
    - Should the dustfall sampling show higher rates than those estimated in this study it is suggested that THM investigate and consider adopting additional mitigation and management measures. Fallout dust tends to settle relatively close to sources of emissions and thus if the dustfall sampling show significantly higher rates there is likely to be significantly higher finer particulate matter concentrations as well
- Record keeping and community liaison procedures.

Based on these findings and provided the measures recommended are in place as well as regular (maximum of 5 years) review of the mitigation, management and monitoring procedures takes place, it is the specialist opinion that the project may be authorised but investigations into economically and environmentally viable mitigation measures to reduce fine particulate matter (especially PM_{10}) should be undertaken prior to initiation of operations and feedback provided to the authorities.

Note: The limited water resources limit the use of water sprays on other sources and increasing watering rates on unpaved roads. Sealing of roads have not been considered as a recommended mitigation measure as this could negatively affect the rehabilitation efforts to restore the site as much as possible to pre-development conditions, especially since in-pit roads are the most significant contributor to the simulated elevated PM_{10} concentrations in Hotazel town.

13 Greenhouse Gases and Impacts of Climate Change

13.1 The Greenhouse Effect

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).

13.2 IFC Literature on GHG

The International Finance Corporation (IFC) lists methods that countries and projects can reduce GHG impacts. These include carbon financing; improvement of energy efficiency; GHG sinks and reservoir protection and improvements; that environmentally friendly agriculture and forestry be encouraged; the increased use of renewable energy methods; implementation of carbon capture and sequestration methods; and, improved waste management (recovery and use of methane emissions) as well as reducing GHG emissions from vehicle use and industrial, construction and energy production processes (IFC, 2007). Carbon financing may have much potential in developing countries as well as sustainable agriculture and forestry practices (IFC, 2012). Carbon financing supported by government may be a way of reducing the country’s GHG impacts. Where projects receive carbon credits and financing for reducing GHG emissions and installing more environmentally friendly alternatives. Different industries would contribute various amounts of GHG emissions. The IFC performance standards suggests that for industrial processes the CO_2-equivalent (CO_2-e) emissions per year do not exceed 100 000 tonnes; this including direct (scope 1) and indirect (scope 2) sources (IFC, 2012).

13.3 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 was adopted by 196 Parties at Conference of the Parties (COP) 21 in Paris, on 12 December 2015 and commenced 4 November 2016. 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 is founded on the idea of countries improving on their climate change strategies in 5-year cycles. 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.

The Paris Agreement proposes that Parties submit long-term low greenhouse gas emission development strategies (LT-LEDS) by 2020 but this was not mandatory.

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. Ethiopia submitted their first NDC to the UNFCCC secretariat and ratified the Paris agreement on 9 March 2017. Existing Parties were expected to submit their updated NDC in 2020; and new Parties their original NDCs. Parties are to submit updated NDCs every 5 years. As of May 2021, there are 192 parties that have submitted their NDCs and 8 parties that have submitted their second NDC. There are only 191 Parties to the Paris Agreement; Eritrea has not become a Party to the Paris Agreement but has submitted its first NDC.

Countries as part of the Paris agreement established an enhanced transparency framework (ETF). ETF is to start in 2024 and all countries will need to openly report on all activities untaken and progress in climate change mitigation, adaptation measures as well as any support provided or received. ETF also sets out a procedure for reviewing submitted reports. The information provided as part of the ETF will be used as an input for the Global stocktake which will assess the collective progress towards the long-term climate goals.

13.4 Global GHG Emission Inventory

The proposed operations would most likely fall under the category of “industry” for the global 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, of which 21% (10 Gt CO_2-e) was a result of industry. The World Resources Institute Climate Watch[13] global GHG emissions from the “industrial processes” sector were 2.7711 Gt CO_2-e in 2016 (6% of total anthropogenic GHG emissions).

13.5 South Africa’s Status in terms of Climate Change and Quantification of Greenhouse Gases

13.5.1 Paris Agreement - Nationally Determined Contribution

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 South African Intended Nationally Determined Contribution (INDC) was completed in 2015 and submitted to the UNFCCC[14] on 1 November 2016. 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 at National level:

- 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 Climate 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).
- To support the use of electric and hybrid electric vehicles.

[13] http://cait.wri.org/ and https://www.climatewatchdata.org/ghg-emissions?breakBy=sector&sectors=energy%2Ctotal-excluding-lucf%2Ctotal-including-lucf
[14] https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx

- 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 photovoltaic; wind power; CCS; and advanced bioenergy.

A draft update of the first NDC was published for public comment[15] on the 30th of March 2021 and the final updated of the first NDC was published and submitted to the UNFCCC[16] on the 27th of September 2021 in preparation for the 26th Conference of the Parties (to held in Glasgow, Scotland in November 2021). The final update of the first NDC South Africa has not submitted its second NDC to UNFCCC. The draft document describes South Africa's NDC on adaptation, mitigation and finance and investment necessities to undertake the resolutions with updated revisions to the adaptation goals and mitigation targets.

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

1. Goal 1: Enhance climate change adaptation governance and legal framework.
2. Goal 2: Develop an understanding of the impacts on South Africa of 1.5 and 2°C global warming and the underlying global emission pathways through geo-spatial mapping of the physical climate hazards, and adaptation needs in the context of strengthening the key sectors of the economy. This will provide the scientific basis for strengthening the national and provincial governments' readiness to respond to climate risk.
3. Goal 3: Implementation of National Climate Change Adaptation Strategy (NCCAS) adaptation interventions for the period 2021 to 2030, where priority sectors have been identified as biodiversity and ecosystems; water; health; energy; settlements (coastal, urban, rural); disaster risk reduction, transport infrastructure, mining, fisheries, forestry and agriculture.
4. Goal 4: Mobilise funding for adaptation implementation through multilateral funding mechanisms.
5. Goal 5: Quantification and acknowledgement of the national adaptation and resilience efforts.

As part of the mitigation portion the following have been, or can be, implemented at National level:

- The approval of 79 (5 243 MW) renewable energy Independent Power Producer projects as part of a Renewable Energy Independent Power Producer Procurement Programme. An additional 6 300 MW is being deliberated.
- A "Green Climate 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.
- CCS
- 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 photovoltaic (PV); wind power; CCS; and advanced bioenergy.
- Updated targets based on revised 100-year global warming potential (GWP) factors (published in the Annex to decision 18/CMA.1 of the Intergovernmental Panel on Climate Change's (IPCC) 5th assessment

[15] https://www.environment.gov.za/mediarelease/creecy_indc2021draftlaunch_climatechangecop26
[16] https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx

report) and based on exclusion of land sector emissions arising from natural disturbance. The updated NDC mitigation targets, consistent with South Africa's fair share, are presented in Table 32.

Table 32: South Africa's NDC mitigation targets

Year	Target	Corresponding period
2025	South Africa's annual GHG emissions will be in a range between 398 - 510 Mt CO_2-e.	2021-2025
2030	South Africa's annual GHG emissions will be in a range between 398 - 440 Mt CO_2-e.	2026-2030

13.5.2 National Climate Change Response Policy 2011

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 DFFE has appointed a service provider to establish a national GHG emissions inventory, which will report through SAAQIS.

13.5.3 Greenhouse Gas Emissions Reporting

Regulations pertaining to GHG reporting using the NAEIS were published in 2017 (Republic of South Africa, 2017) (as 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 DFFE 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 (No 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 (Republic of South Africa, 2017) with GHG more than 0.1 mega tonnes (Mt) or million metric tonnes, measured as CO_2-e, are required to submit a pollution prevention plan to the Minister for approval.

13.5.4 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. DFFE 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 (DEA, 2019). 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 2017 National GHG Inventory was prepared using the 2006 IPCC Guidelines (IPCC, 2006) based on updated sector information and emission estimation techniques. According to the 4th Biennial Update Report to the UNFCCC (DFFE, 2021), the total GHG emissions in 2017 were estimated at approximately 512.66 million metric tonnes CO_2-e (excluding Forestry and Other Land Use [FOLU]). This was a 14.2% increase from the 2000 total GHG emissions (excluding FOLU) and 2.8% decrease from the 2015 total GHG emissions (excluding FOLU). FOLU is estimated to be a net carbon sink which reduces the 2017 GHG emissions to 482.02 million metric tonnes CO_2-e. The estimated GHG emissions (excluding FOLU) for 2017 showed the Industrial Processes and Product Use (IPPU) sector contributed 10.3% to the total GHG emissions (excluding FOLU). The estimated CO_2-e emissions (excluding FOLU) for 2017 for the IPPU sector is 32.02 million metric tonnes.

The DFFE 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 GHG emission factor database. The country specific emission factors, when developed, will replace some of the default IPCC emission factors.

13.6 Greenhouse Gases Emissions Assessment Methodology

GHG emissions for the project were calculated and compared to the global and national emission inventory and compared to international benchmarks for the project.

13.6.1 Carbon Footprint Calculation

The Carbon Footprint is an indication of the GHGs 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).

The previous National inventory for 2015 GWPs (obtained from the IPCC Second Assessment Report [AR2]) were applied in this study. These GWPs are compliant with UNFCCC Reporting Requirements. The GWPs used were 21 for CH_4 and 310 for N_2O.

13.6.2 Scope of Carbon Footprint

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.

This study considered 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. Scope 3 emissions which consider the “embedded” carbon in bought-in materials and transport as well as the use of exported materials, were not estimated. Only scope 1 emissions need to be quantified to be in line with the DFFE guidelines; the addition of scope 2 would put it in line with the guidelines provided by the International Finance Corporation (IFC, 2012).

13.6.3 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.

13.7 Impact Assessment: The Project's Carbon Footprint

13.7.1 The Project's GHG Emissions

13.7.1.1 Clearing and Rehabilitation - 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.

13.7.1.2 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

The clearing of the area which falls within the Savanna Biome (Mucina & Rutherford, 2006) and assumed to be alike to low shrublands in the National Greenhouse Gas Emission Inventory. The National Greenhouse Gas Emission Inventory (DEA, 2019) assumes a low shrubland carbon stock of 0.7 tonne C/ha.

The operation of diesel-powered mobile equipment. The IPCC provides default methane and nitrous oxide emission factors for diesel off-road mobile source and machinery with the unit kg/TJ (IPCC code 1.A.3.e.ii - Off-road), while the density and calorific values are available from the National Greenhouse Gas Emission Inventory (Table 33). The United States provides default emission factors for diesel powered heavy vehicles in gCO_2/MJ (Table 33) (IPCC code 1 A 3 b iii - Heavy-duty trucks and buses). The emissions may vary slightly depending on the calorific value of the diesel. For construction, no details were provided on the estimated amount of fuel (diesel) used per annum by the mobile equipment however, it was assumed based on the types of equipment used for similar construction operations as listed in Table 34, the input energy will be 163 TJ for all the diesel-powered mobile equipment.

Diesel-powered generators are expected to be the main supply of electricity for a large portion of the construction operations and thus GHG emissions from stationary combustion of diesel would also occur during construction operations. The IPCC provides default carbon dioxide, methane and nitrous oxide emission factors for stationary combustion (IPCC code 1.A.4.a - Commercial/Institutional) with the unit kg/TJ (Table 35). Using these emission factors and the calculate potential input energy of 89 TJ required to provide the electricity required for the site.

A summary of the construction greenhouse gas emissions is provided in Table 36. The total CO_2-e emissions of approximately 19 964 t/a should be seen in the perspective of the annual South African GHG emission. The calculated CO_2-e emissions from the construction operations are approximately 0.004% of the 2017 total South African GHG emissions excluding FOLU and including FOLU. The calculated CO_2-e emissions from the construction operations are approximately 0.062% of the 2017 South African IPPU sector GHG emissions.

Table 33: Liquid fuel-related carbon dioxide, methane and nitrous oxide emission factors for vehicles

Type of fuel	CO_2 emission factor (g/MJ)	CH_4 emission factor (kg/TJ)	N_2O emission factor (kg/TJ)	Energy conversion factor (TJ/kWh)
Diesel	72.098	4.15	28.6	$3.6x10^{-06}$

Table 34: Details of the assumed mobile equipment used during construction

Type of equipment	kW	no. of equip	hours
Scraper	114	1	8760
Excavator	304	2	8760
Bulldozer	114	3	8760
Tractor	60.8	1	8760
Crane	76	2	8760
Grader	76	1	8760
Front end loader	57	3	8760
Off-highway truck	320	8	8760
Water bowser	350	1	8760
Light delivery vehicles	125	6	8760

Table 35: Liquid fuel-related carbon dioxide, methane and nitrous oxide emission factors for stationary equipment

Type of fuel	CO_2 emission factor (kg/TJ)	CH_4 emission factor (kg/TJ)	N_2O emission factor (kg/TJ)	Energy conversion factor (TJ/kWh)
Diesel	74100	10	0.6	$3.6x10^{-06}$

Table 36: 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	% contribution to total CO_2-e
	t/a	t/a	t/a	t/a	
Mobile equipment	11786	14.2	1449	13250	66.4%
Power generation	6605	18.7	16.6	6640	33.3%
Vegetation clearing	73.5	-	-	73.5	0.368%
Total	**18465**	**33**	**1466**	**19964**	**100%**

13.7.1.3 Operations

The main sources of GHG due to the proposed operations are the mobile and stationary equipment consuming diesel (scope 1) and the electricity usage (scope 2).

Scope 1

The IPCC default emission factors for diesel off-road mobile source and machinery (IPCC code 1.A.3.e.ii - Off-road) were used to determine the methane and nitrous oxide emissions; and the United States default emission factor for diesel powered heavy vehicles for carbon dioxide (IPCC code 1 A 3 b iii - Heavy-duty trucks and buses) (Table 33). For construction, no details were provided on the estimated amount of fuel (diesel) used per annum by the mobile equipment however, it was assumed based on the types of equipment used for similar construction operations as listed in Table 34, the input energy will be 313 TJ for all the diesel-powered mobile equipment.

Diesel-powered generator(s) will be used to generate electricity for the processing plant. Thus, GHG emissions from stationary combustion of diesel would also occur during the operational phase. The IPCC provides default carbon dioxide, methane and nitrous oxide emission factors for stationary combustion (IPCC code 1.A.4.a - Commercial/Institutional) (Table 35). Using these emission factors and the calculate potential input energy of 3.78 TJ required to provide the electricity required for the processing plant.

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 37. This allows the scope 2 emissions to be calculated directly from electricity consumption from the Eskom or local authority account. The median value of 1.02 tonnes CO_2/MWh was used in the calculations. The estimated annual electricity requirement for the proposed project operations (excluding the processing plant operations) was 23 309 MWh.

Table 37: Eskom electricity emission factors

Year	Emission factor (tonnes CO_2-e/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	1.06	Eskom 2019 Integrated Report
2019/2020	1.04	Eskom 2020 Integrated Report
2020/2021	1.08	Eskom 2020 Integrated Report

Year	Emission factor (tonnes CO_2-e/MWh)	Source
Median	***1.02***	

A summary of the greenhouse gas emissions for scope1 and scope 2 is provided in Table 38. The Scope 1 and combines Scope 1 and Scope 2 CO_2-e emissions of approximately 25 686 t/a and 49 461 t/a, respectively. The proposed project operations CO_2-e emissions should be seen in the perspective of the annual South African GHG emission. The calculated Scope 1 CO_2-e emissions from the proposed operations are approximately 0.005% of the 2017 total South African GHG emissions excluding FOLU and including FOLU. The calculated Scope 1 CO_2-e emissions from the proposed project operations are approximately 0.08% of the 2017 South African IPPU sector GHG emissions. The calculated combined Scope 1 and Scope 2 CO_2-e emission from the proposed operations are approximately 0.01% of the 2017 total South African GHG emissions excluding FOLU and including FOLU.

Table 38: Summary of estimated annual greenhouse gas emissions for the proposed operations

Source Group	CO_2	CH_4 as CO_2-e	N_2O as CO_2-e	Total CO_2-e	% of total CO_2-e emissions
	t/a	t/a	t/a	t/a	
Mobile equipment	22598	27.3	2779	25404	51.4%
Power generation	280	0.79	0.70	282	0.57%
Electricity usage	23775	-	-	23775	48.1%
Total	***46653***	***28.1***	***2780***	***49461***	***100%***

13.7.1.4 Decommissioning

There is insufficient data at this point to determine the decommissioning GHG emissions. This is likely to be equivalent or less than the construction phase, with the reestablishment of a carbon sink in the revegetation of the site.

13.7.2 The Project's GHG Emissions Impact

13.7.2.1 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.

13.7.2.2 Impact on the National Inventory

The construction operations will likely result in an increase in scope 1 emissions for the IPPU sector; therefore, changing the national inventory's total annual CO_2-e emissions by approximately 19 964 t/a during the construction phase. With the proposed operations will likely result in an increase in scope 1 emissions to the IPPU sector; therefore, changing the national inventory's total annual CO_2-e emissions by approximately 25 686 t/a during the operational phase.

13.7.2.3 Alignment with national policy

Most of the South African policy is still in the planning phase; however, the project will likely not have to report on GHG emissions in the SAGERS reporting format once operational, but it may be in the future as DFFE develops more country specific emission factors. Should the mine report the annual CO_2-e to DFFE voluntarily it could assist with improving the accuracy of future National GHG inventories and developing country specific emission factors. The CO2-e emissions will be below the SAGERS and Carbon Tax reporting as well as the pollution prevention plan requirement threshold of 100 000 t/a.

13.8 Effects of Climate Change on the Region

13.8.1 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 on 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).

13.8.1.1 RCP4.5 trajectory

Based on the median, for the region in which the Project operations and AQSRs are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 1.5°C and 2.0°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 5 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 spring. Autumn and winter total rainfall is expected to remain the same or slightly decrease. The total seasonal rainfall is expected to remain the same or slightly increase for summer for the far future. Autumn, winter, and spring total rainfall is expected to remain the same or slightly decrease for the far future.

13.8.1.2 RCP8.5 trajectory

Based on the median, the region in which the Project and AQSRs 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°C and 4.5°C for the far future. The seasonal average temperatures are expected to increase for all seasons. The total annual rainfall is expected to increase by between 0 mm and 5 mm for the near future and decrease by between 5 mm and 10 mm for the far future. For the near future the total seasonal rainfall is expected to increase for summer and remain the same or slightly increase for spring. Winter total rainfall is expected to decrease and remain the same or slightly decrease for autumn for the near future. The total seasonal rainfall is expected to decrease for autumn and spring for the far future. Summer total rainfall is expected to increase for the far future. Winter total rainfall is expected to remain the same or slightly decrease for the far future.

13.9 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 increase in rainfall based on near future predictions.

13.9.1 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.

13.9.2 Rainfall

The impact of intense rainfall events, on the project cannot be ruled out, where the frequency of these event could increase from the long-term baseline. These events could affect access to the site and result in physical damage to infrastructure due to flooding.

13.10 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.

13.10.1 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.

13.10.2 Rainfall

The impact of intense rainfall events, on the communities cannot be ruled out, where the frequency of these event could increase from the long-term baseline. These events could result in physical damage to public and private infrastructure due to flooding.

The decrease in rainfall can result in the following effects:

- Reduced water supply
- A negative impact on food security.

13.11 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.

13.11.1 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. Tawana could initiate a community development program. It is recommended that Tawana investigate the option of using solar power (preferably from on-site PV panels) rather than electricity from the National Grid for the operations to minimise scope 2 emissions.

13.11.2 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.

13.11.3 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]).

13.12 Conclusions and recommendation

- The Scope 1 CO_2-e emissions for construction and operations will be approximately 19 964 t/a and 25 686 t/a, respectively.
- The combined Scope 1 and Scope 2 CO_2-e emissions for operations will be approximately 49 461 t/a.
- 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 community are likely to be negatively impacted by climate change if extreme rainfall events increase due to flooding.
- 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.
    - Tawana could initiate a community development program.
    - Investigating solar power for the operations to minimise scope 2 emissions.
- 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.

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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	10
E-mail Address	natasha@airshed.co.za
Contact Numbers	+27 11 8051940 (Office Switchboard) +27 10 500 1147 (Office Direct)

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), 2020 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. These studies usually involve dustfall sampling data analysis, pollutant concentration measurements or sampling data analysis, meteorological data processing and preparation, noise sampling and data analysis; 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, greenhouse gases emissions and noise; air quality, noise, greenhouse gas and climate change management plan preparation and report writing. Natasha has also assisted with South African Emissions Reporting (National Atmospheric Emission Inventory System [NAEIS] and South African Greenhouse Gas Emissions Reporting System [SAGERS]) for various mines and industries. She has worked on many projects within various countries in Africa which required international financing, providing her with an inclusive knowledge base of IFC guidelines and requirements pertaining to air quality and greenhouse gases emissions.

PROJECTS COMPETED IN VARIOUS SECTORS ARE LISTED BELOW:

Mining Sector

Air Quality Studies

- Coal mining: Argent Colliery; Commissiekraal Coal Mine; Estima Coal Project (Mozambique); Grootegeluk Coal Mine; Matla Coal Mine; Rietvlei Coal Mine; Vierfontein Coal Mine; Goedehoop Coal Mine.
- Metalliferous mines: AngloGold Ashanti Vaal River and West Wits Operations; Harmony Vaal River Operations as part of the Radionuclides Health and Environmental Risks Assessment; Atlantic Sands; Bakubung Platinum Mine; Bakubung Platinum Mine's new Tailings Storage Facility (TSF) Project; Bannerman Uranium Mine (Namibia); 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; West African Resources Sanbrado Project (Burkina Faso); Impala Platinum Rustenburg Mine and Smelter; Mn48 Manganese Mine.
- Quarries: AfriSam Saldanha Cement Project Limestone Quarry; Consol Industrial Minerals; Bundu Mining (air quality and noise), Tete Iron Ore Project / Tete Steel and Vanadium Project (Mozambique).

Noise Studies

- Metalliferous mines: Bakubung Platinum Mine's new TSF Project; West African Resources Sanbrado Project (Burkina Faso).
- Quarries: Bundu Mining.

Climate Change Studies

- Metalliferous mines: Bakubung Platinum Mine's new TSF Project; Tormin Mineral Sands Mine; West African Resources Sanbrado Project (Burkina Faso); Mn48 Manganese Mine.

Industrial Sector

Air Quality Studies

AfriSam Saldanha Project; CAH Chlorine Caustic Soda and HCl Plant; Consol Industrial Minerals Processing Plant; Corobrik Driefontein new Brick Kiln Project; Metal Concentrators SA Paarden Eiland; Tronox Namakwa Sands Un-Attritioned Magnetic Material (UMM) Plant Environmental Authorisation (EA) application process as well as the Atmospheric Impact Report (AIR) as part of the Atmospheric Emission Licence (AEL) application process and the LNG Project; Otavi Rebar Manufacturing; Phakisa Project; Pan Palladium Project; PPC Riebeeck Cement; Rare Earth Elements (REE) Saldanha Separation Plant; Saldanha Steel; Siyanda Project; Tete Iron Ore Project / Tete Steel and Vanadium Project (Mozambique); Tri-K Project (Guinea); Tormin Mineral Sands Mineral Separation Plant (MSP); Tronox Namakwa Sands Smelter; Tronox Namakwa Sands MSP including LNG Project; ZMY Steel Recycling Plant; Nyanza TiO_2 Pilot Plant; Musina-Makhado Special Economic Zone (SEZ); West African Resources Sanbrado Project Gold Processing (Burkina Faso), Mortar SA Operations in Darling; Impala Platinum Rustenburg Mine and Smelter including the proposed Second Flash Dryer Project; Mine Waste Solutions (Chemwes) operations including the proposed Kareerand TSF expansion; Sublime Technologies Silicon Carbide Plant; Vanchem Vanadium Products.

Noise Studies

West African Resources Sanbrado Project Gold Processing (Burkina Faso).

Climate Change Studies

Tormin Mineral Sands MSP; West African Resources Sanbrado Project Gold Processing (Burkina Faso); Mine Waste Solutions (Chemwes) operations including the proposed Kareerand TSF expansion.

Power Generation

Air Quality Studies

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); Medupi Power Station; Matimba Power Station; Acacia Peaking Power Station; Port Rex Peaking Power Station; Musina-Makhado SEZ.

Waste Disposal and Treatment Sector

Air Quality Studies

Fishwater Flats Waste Water Treatment Works; Khutala Water Treatment Project; Moz Environmental Industrial Landfill (Mozambique); Koedoeskloof Waste Disposal Site; Interwaste FG Landfill Midrand; Wolverand Crematorium; Green Oil and Lubricants Plant.

Petroleum Sector

Air Quality Studies

Chevron Refinery, Exol Oil Refinery, Puma South Africa's Fuel Storage Facility, Oilkol Depot, Astron Energy Cape Town Refinery; Saldanha Bay Industrial Development Zone Fuel Storage Facilities; Green Oil and Lubricants Plant.

Transport and Logistics Sector

Air Quality Studies

Saldanha Port Project.

Ambient Air Quality and Noise Sampling/Monitoring

Types of Sampling and Monitoring

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

Locations of Sampling and Monitoring Projects

South Africa including Limpopo, North West, Mpumalanga, Gauteng and Northern Cape; Burkina Faso; Guinea; Zimbabwe.

SOFTWARE PROFICIENCY

Software utilised in conducting air and noise studies:

- WRPLOT View (wind and pollution rose generation);
- OpenAir (ambient and meteorological data processing);
- Golden Software Surfer (mapping);

- TANKS 4.0.9d (emission estimation model);
- GasSim (emission estimation model);
- SCREEN3 using ScreenView (screening model);
- AERMOD suite (air dispersion model);
- ADMS (air dispersion model);
- CALPUFF suite (air dispersion model);
- CALINE4, CAL3QHC, and CAL3QHCR (traffic air dispersion models);
- GRAL system (air dispersion model);
- DataKustic CadnaA (noise propagation model);
- CONCAWE (noise propagation model); and
- SANS 10201 (calculating and predicting road traffic noise).

EDUCATION

- 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: NACA (November 2020), attended.
- 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; FORTRAN, 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 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.

09/04/2021

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 2022**

Chairperson

Chief Executive Officer

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APPENDIX B: ADDITIONAL DETAILS ON DUST CONTROL FOR UNPAVED ROADS

There are three types of measures that can be taken to reduce emissions from unpaved roads: (a) measures aimed at reducing the extent of unpaved roads, e.g. paving, (b) traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds, and (c) measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilization (Cowherd, Muleski, & Kinsey, 1988); (APCD, 1995). The main dust generating factors on unpaved road surfaces include:

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

When quantifying emissions from unpaved road surfaces, most of these factors are accounted for. Vehicle speed is one of the significant factors influencing the amount of fugitive dust generated from unpaved roads surfaces. The control efficiency obtained by speed reduction can be calculated by varying the vehicle speed input parameter in the predictive emission factor equation given for unpaved roads. An evaluation of control efficiencies resulting from reductions in traffic volumes can be calculated due to the linear relationship between traffic volume, given in terms of vehicle kilometres travelled, and fugitive dust emitted. Similar effects will be achieved by reducing the truck volumes on the roads. Thus, by increasing the payload of the truck, fewer trips will be required to transport the same amount of material.

Thompson and Visser (2000) developed a model to determine the cost and management implications of dust suppression on mine haul roads using water or other chemical palliatives. The study was undertaken at 10 mine sites in southern Africa. The model was first developed looking at the re-application frequency of water required for maintaining a specific degree of dust palliation. From this the cost effectiveness of water spray suppression could be determined and compared to other strategies. Factors accounted for in the model included climate, traffic, vehicle speed and the road aggregate material. A number of chemical palliative products, including hygroscopic salts, lignosulponates, petroleum resins, polymer emulsions and tar and bitumen products were assessed to benchmark their performance and identify appropriate management strategies. Cost elements taken into consideration included amongst others capital equipment, operation and maintenance costs, material costs and activity related costs. The main findings were that water-based spraying is the cheapest dust suppression option over the short term. Over the longer term however, the polymer-emulsion option is marginally cheaper with added benefits such as improved road surfaces during wet weather, reduced erosion and dry skid resistance (Thompson & Visser, 2000).

APPENDIX C: DUSTFALL RATES AT SOLAR FACILITY

The simulated maximum dustfall rate at the solar facility for all mitigation scenarios are provided in Table C-1. The monthly trend for the dustfall rate at the solar facility is provided in Figure C-1.The dustfall rates are at a minimum in February and increase to a maximum in May and then decrease, increasing in September (5th highest dustfall rate), decreasing again with another spike in December (7th highest dustfall rate).

Table C - 1: Simulated maximum dustfall rate at the solar facility

Rank	Month	All Sources - Unmitigated	All Sources - Design Mitigation	All Sources - Design & Additional Mitigation
1st highest	May	94.6	49.9	26.7
2nd highest	Jun	84.5	44.3	24.3
3rd highest	Jul	68.6	35.9	19.8
4th highest	Apr	66.4	35.1	19.4
5th highest	Sep	62.8	32.6	18.2
6th highest	Aug	58.8	30.1	17.3
7th highest	Dec	52.0	27.6	15.0
8th highest	Oct	46.5	23.8	14.1
9th highest	Nov	45.1	23.7	13.5
10th highest	Mar	42.0	21.9	12.5
11th highest	Jan	40.4	21.1	11.7
12th highest	Feb	38.0	20.0	11.0

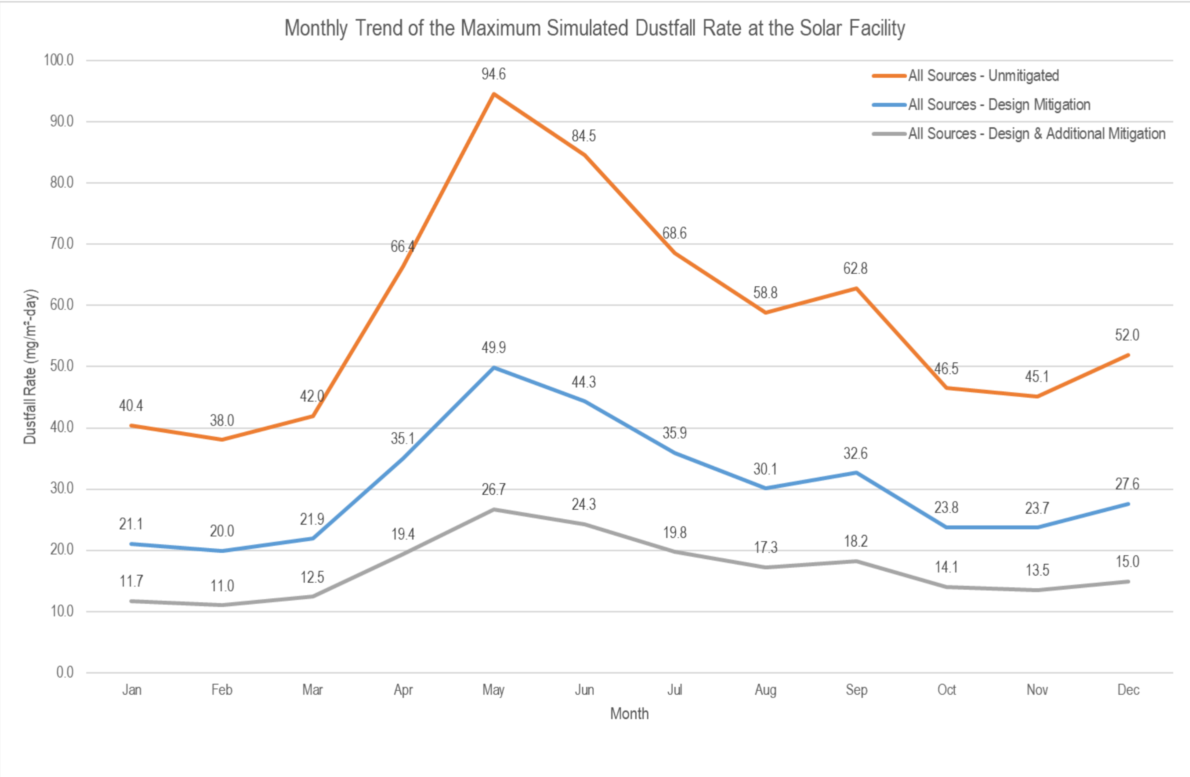


Figure C - 1: Monthly trend of the maximum simulated dustfall rate at the solar facility

Appendix D: Comments Received from I&APs During Initial Public Participation Process

Table D - 1: I&APs comments and specialist responses

Comment	Response
Hotazel Solar PV facilities to the south/south-east of the site - Activities at these areas could pose the following risks to the Hotazel Solar PV facilities	
Loss of/reduced power output by the PV panels as a result of dust and possible shading	Larger particulate matter particles contributing to dustfall have are deposited close to the source due to the higher mass limiting the time these particles remain suspended in the air (i.e., the deposition velocity for these particles is high). Dustfall rates/dust deposition at the solar facility would largely be from sources in the immediate vicinity of the faculty such as windblown dust from open areas at and around the site. There is currently no legislation regarding maximum allowable dustfall rates from other industrial operations for solar facilities. There is limited literature on the impact of dustfall rates on the reduction in efficiency/power output reduction. It is known that settled dust on PV panels does reduce the efficiency due to soiling and the movement of large dust particles over panels could damage the panels also leading to a reduction in efficiencies. There are currently no research findings determining exact percentage reduction per mg deposited on the panels and the dust deposition rates although with the increase in use of PV panels for power generation on a commercial scale other facilities engineers have obliged to undertake research, but they are not obligated to conduct such investigations and thus these studies may not be undertaken. The potential of damage to panels also cannot be determined as the amount of windblown dust from the landscape in the immediate vicinity of the solar facility is extremely variable as the erosion potential (and dust quantity) is dependent on the wind speed, the amount of fine loose surface material that can be lifted by the wind, surface crusting, vegetation cover and features that could act as wind-breaks. Support vehicles associated with the solar facility travelling on-site and near site as well as the use of public roads especially those that are unpaved as well as the R31 would also have a significant impact on the solar facility. Dustfall sampling was undertaken as part of this project at the proposed location of the solar facility (D4) and the highest sampled pre-development dustfall rate at this site was 673 mg/m²-day. With the highest simulated dustfall rate of almost 95 mg/m²-day for unmitigated operations (49.9 mg/m²-day for

Comment	Response
	mitigated operations) added to the highest sampled dustfall rate, the dustfall rate at the solar facility could be 768 mg/m²-day. Over time, the dustfall rates at the Solar Facility would continue to increase with increased use of public roads and the initiation/ramp-up of on-site (solar facility) support operations as the Solar Facility operations commence/expand. Section 5.3.1.2 discusses the sampled dustfall rates in the area (four sites) with one site located at the proposed solar facility location. Section 7.2.3 discusses the simulated potential dustfall rates from the proposed THM operations. Section 9 discusses the potential cumulative dustfall rates/impacts from other sources in the area and the proposed THM operations.
The air quality impact must please address the impact of dust on the Hotazel solar facilities, particularly detailing the anticipated average volumes of dust that would reach the facilities during each season with and without the application of mitigation measures by the mine. It is important that the specialist confirms any monthly or seasonal variation in anticipated dust volumes (noting that the specialist would need to consider inter alia, seasonal variation in wind, humidity, rain and mining operations). Please also include the following specification in the Operational Environmental Management Programme: • Dust/air quality monitoring (specifically for dust) must be done at various points along the shared cadastral boundaries (the siting of the points to be recommended by the relevant specialist) and the results of the monitoring are to be regularly provided to a representative of ABO Wind Hotazel PV (Pty) Ltd and/or Hotazel Solar Facility 2 (Pty) Ltd, or whichever entity is operating the Hotazel solar facilities (as per whatever is relevant at the time).	Although there will be monthly and seasonal variability the highest (worst-case) predicted dustfall rates from a three-year simulation period from the THM operations have been discussed in the main report and the monthly trend for the location of the maximum (May) dustfall rate at the solar facility are discussed in Appendix C. If the solar facility has a ratio for efficiency reduction to dustfall rate that can be applied; then it is recommended that the simulated worst case dustfall rate for the THM (94.6 mg/m²-day, unmitigated operations) is applied to the entire area that the PV panels cover for all months of the year. The operators of the Solar Facility/Technical staff should remain cognisant that the effects (and uncertainty in the extent) of climate change makes a high level of detail regarding the future monthly and seasonal variations in the meteorological conditions (including solar radiation and sunshine hours) for the area difficult to predict; as well as the future impacts and efficiency reductions from the nearby sources (especially windblown dust from open areas, vehicles travelling on public roads near the solar facility and internal service roads). As stated above, the sources that would have the greatest impact on the facility will be on-site or just beyond the facility boundary. The simulated dustfall rate for the second highest month at the solar facility location is 84.5 mg/m²-day (unmitigated operations) and 44.3 mg/m²-day when design mitigated measures are applied to the operations. The recommendation of this study is that there be a dustfall rates sampling network. The proposed locations for the sampling and monitoring equipment are included in Table 31 and shown in Figure 40. It has been recommended that two units be located on the boarder of the solar facility. The method to be used for measuring

Comment	Response
	dustfall must be compliant with the American Standard Test Method (ASTM) D1739 (2017), or equivalent method approved by any internationally recognized body. The dustfall sampling and reporting must be conducted according to the NDCR. It has also been recommended that progress reports should be reported to all interested and affected parties, including authorities and persons affected by pollution and stakeholder forum/feedback meetings be scheduled and held at least on a bi-annual basis and that a complaints register must be kept at all times. Regular (maximum of 5 years) review of the mitigation, management and monitoring procedures should take place. Section 11 discusses the recommended mitigation, monitoring and management procedures.
The specifications in the Construction Environmental Management Programme must also include mitigation measures for dust, as well as the requirement that the contractor communicate (ahead of time) with ABO Wind Hotazel PV (Pty) Ltd and/or Hotazel Solar Facility 2 (Pty) Ltd / the Hotazel solar facilities operator (whichever is applicable at the time) when activities that would produce a lot of dust (e.g., excavations, blasting, etc.) are programmed to occur. These specifications must also require that stockpiles must be located as far from the property boundary of the Hotazel solar facilities as possible (the north-east corner of the site appears to have the fewest surrounding receptors, so that would be an adequate location).	Mitigation measures have been recommended for construction phase operations which include water bowsers on unpaved roads, water sprays at stockpiles and handling points, and limiting construction (including mobile equipment) activities to take place during day-light hours. It is recommended that dustfall sampling be initiated prior to construction, continue throughout the construction phase, operational phase and decommissioning phase. Section 11 discusses the recommended mitigation, monitoring and management procedures.
Wessels Mine	
Dust generation from the following activities: 1. blasting 2. hauling roads 3. crushing and screening 4. Fines and stockpile area	The emissions from these sources were quantified as well as other sources. The dispersion model setup included all sources with and without design mitigation applied. Both source group and all operations were outputs of the model to determine the sources that required additional mitigation. The unpaved haul roads, especially in-pit and the waste stockpile roads had an overwhelming contribution to exceedances of the NAAQS, excluding the other sources the exceedance areas for the roads were similar to those for all sources. Section 7.2.3 discusses the simulated potential dustfall rates from the proposed THM operations. Section 9 discusses the potential cumulative dustfall rates/impacts from other sources in the area and the proposed THM operations.

Comment	Response
What other controls are being considered other than suppression on hauling roads? Positioning location of product stockpiles and fines vs community houses direction? Dust exposure surveys within households to understand level of exposure and establishment of dust monitoring station to monitor PM_{10} due to sensitive receptors?	Water sprays at the crusher and screen as been considered by Tawana as likely mitigation measure that will be applied. Indoor air quality sampling/monitoring has not been undertaken but two short fine particulate matter sampling campaigns were undertaken at two areas in Hotazel town using passive particulate matter samplers which is a very cost-effective method of sampling multiple size fractions of fine particulate matter as well as for source apportionment. Four months of dustfall sampling was also undertaken at four sites with two sites being in Hotazel town. Section 5 discusses the sampled pre-development conditions in the area. Section 6 discussed the potential impacts associated with the construction phase. Section 7 discusses the simulated pollutant concentrations and dustfall rates as well as the significance of the impact from the proposed THM operations. Section 8 discusses the impacts associated with the decommissioning and closure phases. Section 9 discusses the potential cumulative dustfall rates/impacts from other sources in the area and the proposed THM operations. Section 10 discusses the no-go option. Section 11 discusses the recommended mitigation, monitoring and management procedures.
Northern Cape Provincial Government - Air Quality & Climate Change Unit	
A full air quality impact assessment specialist study must be undertaken (is required), the said area is already plagued by high levels of dust and particulates, and also based on the close proximity to receptor communities. The study should highlight assessment of potential health impact.	A full air quality impact assessment/specialist study was undertaken but not a detailed Health Impact Assessment (HIA). The air quality model results were only be compared to legislated standards for ambient pollutant concentrations and only as screening of the potential health impacts from inhalation of pollutants was undertaken, not a full health risk including the potential for fatalities, cancers or illnesses. It is suggested that HIA should be undertaken by a registered Health Risk Assessment (HRA) professional, if required. This report describes the air quality specialist study methodology, current sir quality in the region, potential impacts from the construction phase, simulated potential impacts from the operational phase, potential impacts

Comment	Response
	from the decommissioning and closure phases, potential cumulative impacts, no-go option and recommended mitigation, monitoring and management procedures.
Air quality must be assessed not only for Tawana's individual contribution, but in terms of its additive contribution to baseline ambient air quality i.e., cumulative effects must be considered.	Section 5 discusses the sampled pre-development conditions in the area. Section 6 discussed the potential impacts associated with the construction phase. Section 7 discusses the simulated pollutant concentrations and dustfall rates as well as the significance of the impact from the proposed THM operations. Section 8 discusses the impacts associated with the decommissioning and closure phases. Section 9 discusses the potential cumulative dustfall rates/impacts from other sources in the area and the proposed THM operations. Section 10 discusses the no-go option. A thorough quantitative assessment would require either a year or more of monitoring data which was not available; or the operational data from all mines, farmers and residences. For dispersion modelling the input from the other mines, farmers and the Provincial, District and Local government “census” data including fuel use per household, number of households, population per km², and traffic counts for all roads within the local municipality would be required.
A comprehensive dust management plan (as per the NDCR 2013) must be developed and submitted to the department for approval, the plan should include all the phases of development from road construction to total ROM.	Section 11 discusses the recommended mitigation, monitoring and management procedures; however, the applicant will need to compile the final dust management plan based on these recommendations and what is feasible for the facility.
A dustfall monitoring programme must be clearly outlined as per section 4 & 5 of the NDCR 2013; and a reporting regime established.	Section 11 discusses the recommended mitigation, monitoring and management procedures; however, the applicant will need to compile the final dustfall monitoring programme based on these recommendations and what is feasible for the facility.
NAEIS registration and reporting must be established and undertaken.	Section 4.3 discusses the NAEIS reporting requirements and Section 11.1.2 notes that Tawana will be required to report annual emissions on the NAEIS system. The assigned accounting officer (ACO) for the facility will need to register on the NAEIS system and request the addition of the facility to the system and linking of the facility to their profile by submitting the required facility information and ACO details to NAEIS admin. The applicant will need to undertake the registration application with DFFE after acquiring EA and the reporting will

Comment	Response
	need to be undertaken after the commencement of the operations. NAEIS reporting submissions will need to be completed annually for the previous calendar year operations by 31 March.

Declaration of Independence by Specialist

I, Natasha Anne Shackleton________________, in my capacity as a specialist consultant, hereby declare that I –

- act as an independent specialist;
  Where **"independent"** in relation **a specialist** means the following, as defined in GN982 of 2014 (*as amended*):
  (a) that such EAP, **specialist** or person has no business, financial, personal or other interest in the activity or application in respect of which that EAP, specialist or person is appointed in terms of these Regulations; or
  (b) that there are no circumstances that may compromise the objectivity of that EAP, specialist or person in performing such work;
  excluding -
  (i) normal remuneration for a specialist permanently employed by the EAP; or
  (ii) fair remuneration for work performed in connection with that activity, application or environmental audit;
- will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- declare that there are no circumstances that may compromise my objectivity in performing such work;
- do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- have expertise in conducting the specialist report relevant to this application, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998), regulations and any guidelines that have relevance to the proposed activity;
- based on information provided to me by the project proponent and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional ability; and
- undertake to have my work peer reviewed on a regular basis by a competent specialist in the field of study for which I am registered.

Signature of the Specialist

Airshed Planning Professionals (Pty) Ltd

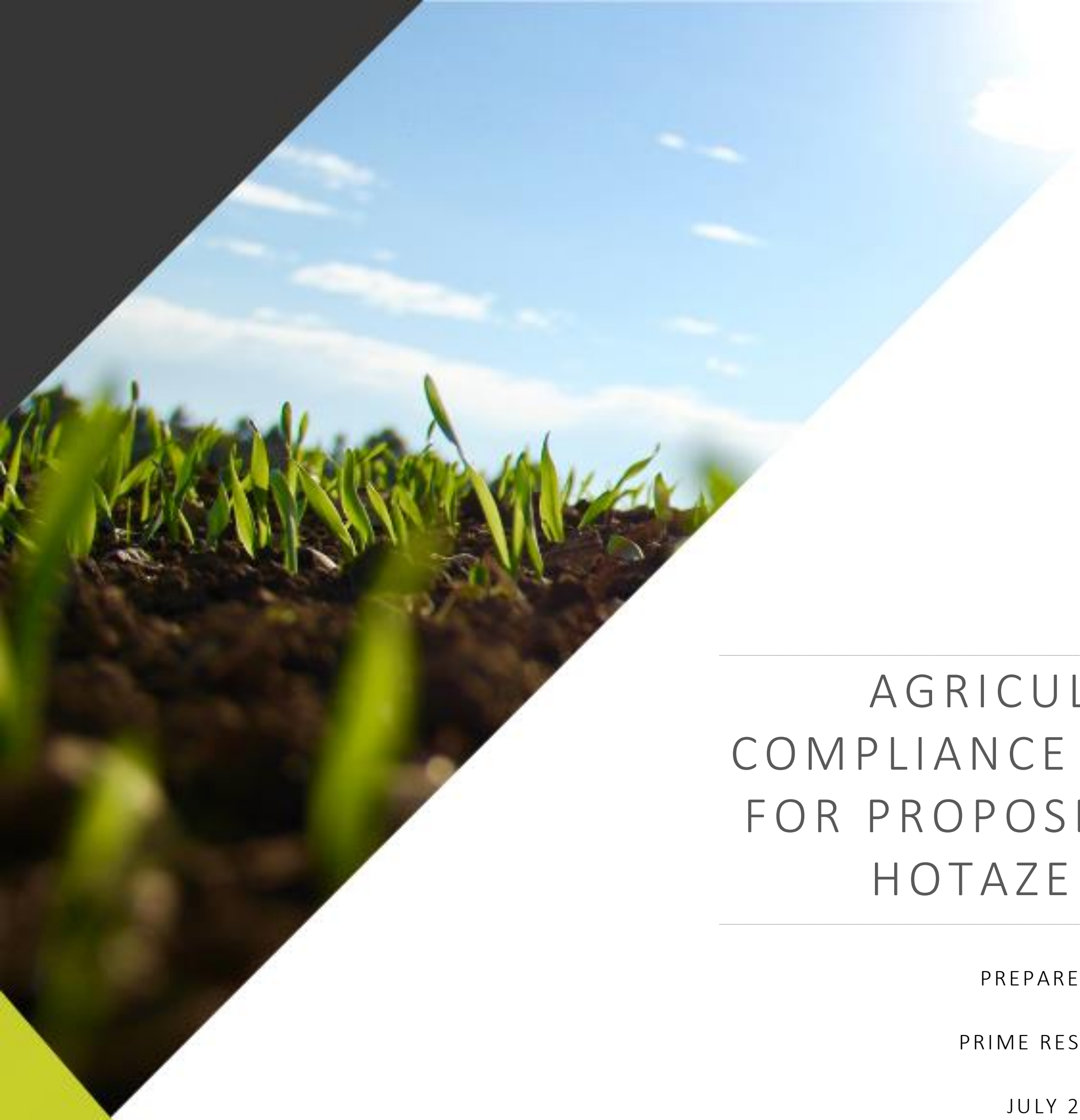
Name of Company:

27/08/2021

Date

APPENDIX 8

AGRICULTURAL COMPLIANCE STATEMENT



AGRICULTURAL COMPLIANCE STATEMENT FOR PROPOSED TAWANA HOTAZEL MINE

PREPARED FOR

PRIME RESOURCES

JULY 2021

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Digital Soils Africa

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Directors:
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SPECIALIST CV

DR DARREN BOUWER

EDUCATION

PhD Soil Science	University of the Free State	2018
M.Sc. Soil Science	University of the Free State	2013
B.Sc. Soil Science (Hon)	University of the Free State	2009
B.Sc. Soil Science	University of the Free State	2008
Matric certificate	Queens College	2005

PROFESSIONAL AFFILIATIONS

- SACNASP- Pri Nat Sci 400081/16
- Member of the Soil Science Society of South Africa
- Member of the Soil Classification Work Group
- Member of South African Soil Surveyors Organisation

WORK EXPERIENCE

- **Digital Soils Africa** / Soil Scientist - May 2012 – Present
- **Ghent University** / Researcher- January 2016 - December 2016
- **University of the Free State**/ Assistant Researcher- January 2011- December 2015

PUBLICATIONS

Total consultancy reports: 95 **Total Publications: 5**

Most relevant:

Bouwer, D., Le Roux, P. A., van Tol, J. J., & van Huyssteen, C. W. (2015). Using ancient and recent soil properties to design a conceptual hydrological response model. Geoderma, 241, 1–11.

Van Zijl, G. M., Bouwer, D., van Tol, J. J., & le Roux, P.A.L. (2014). Functional digital soil mapping: A case study from Namarroi, Mozambique. Geoderma, 219-220, 155–161.

SPECIALIST DECLARATION

I, Darren Bouwer, declare that –

- I act as the independent specialist in this application;
- I regard the information contained in this report to be true and correct;
- I do not have a conflict of interest in this project;
- I will conduct the work relating to the project in an objective manner.

Dr Darren Bouwer
PhD Soil Science
Pri Nat Sci 400081/16

BACKGROUND TO THE STUDY

Digital Soils Africa (Pty) LTD (DSA) were tasked by Prime Resources to undertake an Agricultural Compliance Statement for the Environmental Authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) ("NEMA"), Environmental Impact Assessment ("EIA") Regulations, 2014. As per GN960 of 2019, read with Section 24(5)(a) of the NEMA, an Environmental Screening Report (ESR) was generated for the application using the National Web-based Screening Tool. The ESR classifies the area as being of medium sensitivity for the *Agricultural* theme. The Compliance Statement is reported according to the protocol for the specialist assessment and minimum report content requirements for the environmental impacts on agricultural resources (GN320 of 2020).

Tawana Hotazel Mining (Pty) Ltd has applied for a Mining Right (MR) to the Department of Mineral Resources and Energy (DMRE) for the proposed Tawana Hotazel Mine (THM). The MR application area is 145.1026 Ha. The types of minerals applied for are: all (Code UN); Iron and Iron bearing minerals including hematite, goethite, specularite and limonite (Code (Fe) Type (B)) and Manganese and manganese bearing minerals (Code (Mn) Type (B)).

The THM covers portions of two farms within the Joe Morolong Local Municipality (JMLM) in the Northern Cape Province; Hotazel 280 and York 279 and is located approximately 1 km south-east of the town of Hotazel. The THM largely incorporates the historical Hotazel Manganese Mine (HMM), including the residual opencast void, surface dumps of low-grade material and the mothballed processing plant and rail loadout facility. HMM stopped production in 1989. The area was historically mined by both opencast and underground means and yielded high grade manganese ore. All current plans for the project specifically exclude underground mining.

The overall area applied for is approximately 154 Ha (inclusive of the MR application area and access road). Surface infrastructure will include the opencast pit (incorporating the historical HMM void and further expansion of the opencast footprint), in-pit waste dumps (residue material), vehicle yard, workshop, access and haul roads, offices, stores, processing plant for the crushing and screening of mined ore, product stockpile area, run of mine pad, refuel bay and water management infrastructure.

There will be two main access points into the mine and all-weather access roads (12 m wide) will need to be constructed. The main transport route to the east will be for Heavy Vehicles (HV), potentially 80 – 100 trucks per day, and the main entrance to the west (near Hotazel) will be for Light Delivery Vehicles (LDV's). In addition, on-site access roads (12 m wide) will be required for use by the secondary support fleets and earthmoving haul trucks.

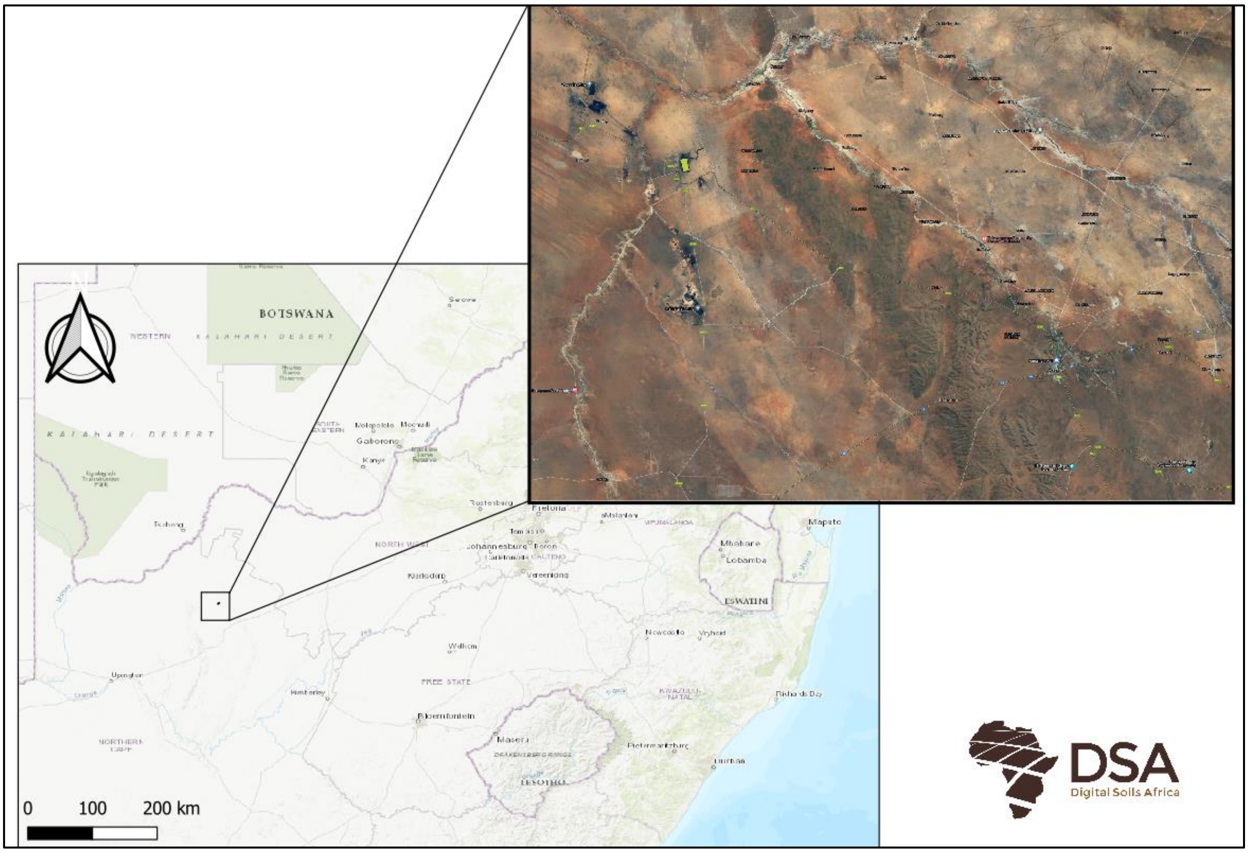

FIGURE 1: LOCATION OF THE STUDY AREA IN THE NORTHERN PROVINCE.

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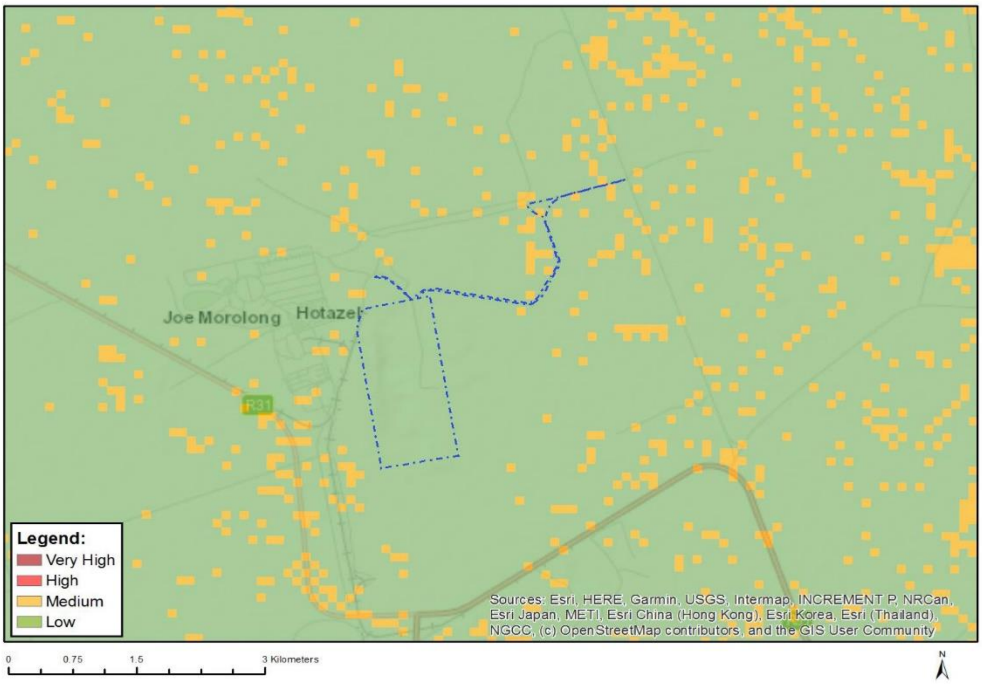
ENVIRONMENTAL SCREENING TOOL

From the ESR, the area is dominated by low Agricultural sensitivity around the mine, while the access road also classified as medium Agricultural sensitivity.

The new Land capability (DAFF, 2017) has fifteen classes, as opposed to the eight classes described by Schoeman et al. (2002). Classes 1 to 7 are of low land capability and only suitable for wilderness or grazing. Classes 8 to 15 are considered to have arable land capability with the potential for high yields increasing with the land capability class number. The feature which increases the low Agricultural sensitivity to medium sensitivity are Land capability values of between 6 and 8, which are considered moderately arable soils.

MAP OF RELATIVE AGRICULTURE THEME SENSITIVITY



Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
		X	

Sensitivity Features:

Sensitivity	Feature(s)
Low	Land capability;01. Very low/02. Very low/03. Low-Very low/04. Low-Very low/05. Low
Medium	Land capability;06. Low-Moderate/07. Low-Moderate/08. Moderate

FIGURE 2: RESULTS FROM THE ESR.

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METHODOLOGICAL APPROACH

DESKTOP SURVEY

All information used to compile the Compliance Statement is found in Table 1 below.

TABLE 1: LIST OF DATA USED TO COMPILE COMPLIANCE STATEMENT

Land type	Land Type Survey Staff, 1972 – 2002
Climate	Schulze (2007)
South African Nation Land Cover 2018	Department of Environmental Sciences (2018)
Long Term Grazing Capacity Map for South Africa	Department of Agriculture, Forestry and Fisheries (2016)

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RESULTS

DESKTOP

LAND TYPE INFORMATION

There is only one land type occurring in the study area, namely Ah9 (Figure 3) (Appendix 1). Ah9 is dominated by freely drained and structureless soils (93%). Most of the soils are deeper than 1200 mm (96%) and have less than 6% clay. The criteria for an area to qualify for inclusion in the landtypes are given in Table 2.

TABLE 2: BRIEF DESCRIPTION OF BROAD LANDTYPES FOUND IN THE STUDY AREA.

Landtype	Description
Ah	Freely drained, red and yellow, eutrophic, apedal soils comprise >40% of the land type (red and yellow soils each comprise >10%)

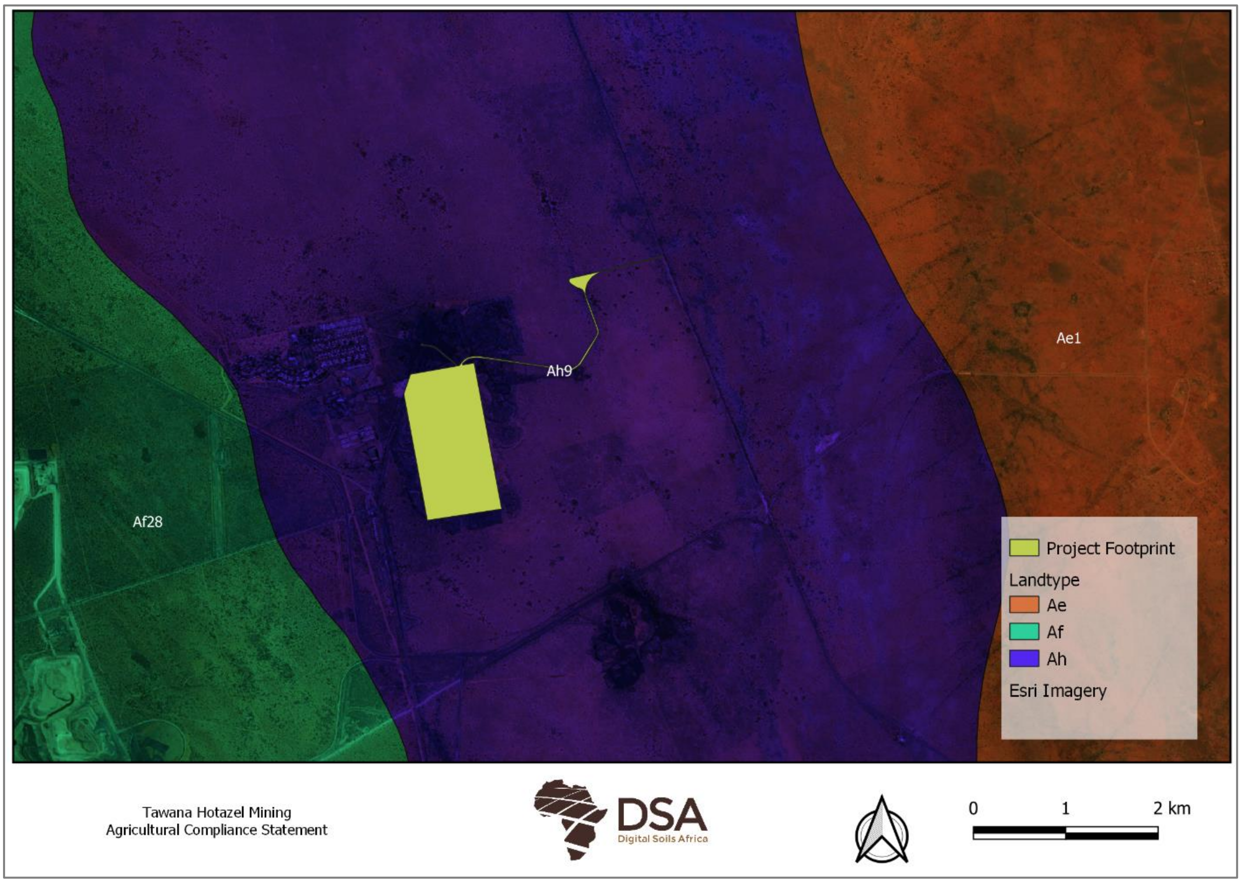

FIGURE 3: LAND TYPES OCCURRING IN THE STUDY AREA (LAND TYPE SURVEY STAFF, 1972 – 2002).

CLIMATE

The mean annual rainfall distribution is between 200 and 400 mm and the site falls within the arid climate.

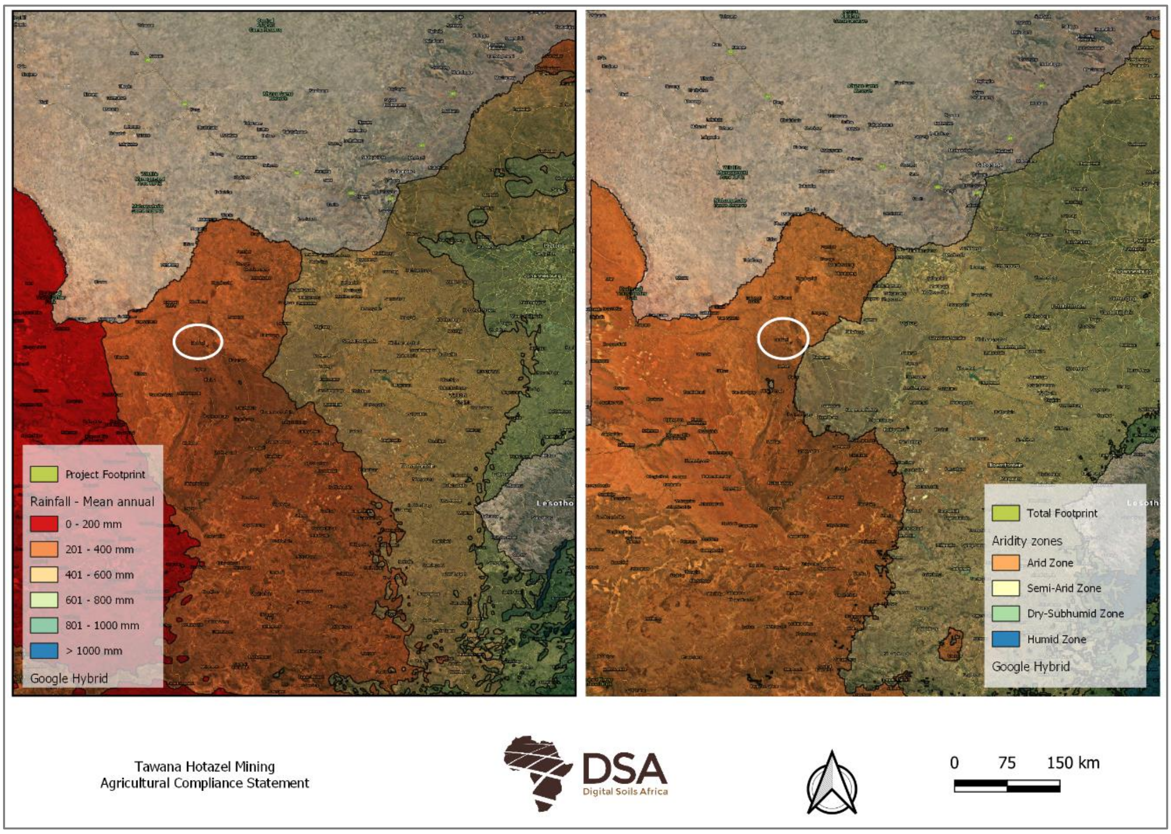

FIGURE 4: RAINFALL DISTRIBUTION AND ARIDITY ZONES OF THE SITE AND SURROUNDING AREA (SCHULZE, 2007).

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LAND USE

The current land use is dominated by historic open cast mining and mining infrastructure (Figure 5). The access road does intersect natural grasses.

TABLE 3: SELECTED NATIONAL LAND-COVER LEGEND AND CLASS DEFINITIONS USED IN THE SOUTH AFRICAN LAND-COVER 2018

No.	Class Name	Class Definition
3	Dense Forest & Woodland	Natural tall woody vegetation communities, with canopy cover ranging between 35 - 75%, and canopy heights exceeding 2.5 metres. Typically represented by dense bush, dense woodland and thicket communities.
4	Contiguous & Dense Planted Forest	Dense to contiguous cover, planted tree forests, consisting primarily of exotic timber species, with canopy cover exceeding 35%, and canopy heights exceeding 2.5 metres. Typically represented by mature commercial plantation tree stands. This class also includes smaller woodlots and windbreaks, where they have been identified by the same spectral-based image modelling procedures used to detect the plantation forests.
8	Low Shrubland (Fynbos)	Natural, low woody shrubland communities, where the total plant canopy cover is typically both dominant over any adjacent bare ground exposure, and the canopy height ranges between 0.2 – 2 metres. Note: this definition differs slightly from the equivalent gazetted class definition (i.e. total plant canopy cover ranges between 10 - 100%) in order to provide a more comparable content to the 1990 and 2013-14 SANLC datasets. If a tree or tall bush woody cover is evident it is typically < 0.1 % of total canopy cover. Typically representative of low, indigenous karoo-type vegetation communities, which have been identified using image-based spectral models, but which fall spatially *outside* the SANBI defined boundaries for Fynbos, Succulent and Nama-Karoo vegetation communities. This is the same approach as used in the 1990 and 2013-14 SANLC datasets and has been replicated for consistency and comparability.
13	Natural Grassland	Natural and/or semi-natural indigenous grasslands, typically devoid of any significant tree or bush cover, and where the grassland component is typically dominant over any adjacent bare ground exposure. Note this this definition differs slightly from the equivalent gazetted class definition (i.e. total plant canopy cover ranges between 4 - 100%) in order to provide a more comparable content to the 1990 and 2013-14 SANLC datasets. Typically representative of low, grass-dominated vegetation communities in the Grassland and Savanna Biomes.
21	Artificial Flooded Mine Pits	Man-generated artificial inland waterbodies, specifically associated with flooded mine pits, tailings ponds, or other surface-based mining activities. The spatial extent of classified water is the cumulative extent of all image-detectable water surfaces from all available images used in the production of the NLC dataset; which is comparable to the annual maximum extent. Note that the occurrence of rooted or floating emergent aquatic vegetation that covers the water surface may influence the area of image-detected open water.
47	Residential Formal (Tree)	Built-up areas primarily containing formally planned and constructed residential structures and associated utilities. The dominant vegetation (in gardens etc) is tree-based.

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49	Residential Formal (low veg / grass)	Built-up areas primarily containing formally planned and constructed residential structures and associated utilities. The dominant vegetation (in gardens etc) is grass and/or low shrub based.
50	Residential Formal (Bare)	Built-up areas primarily containing formally planned and constructed residential structures and associated utilities. The surface is predominantly non-vegetated. This class therefore has the closest spatial representation to all formal residential structures and associated hard-surface footprints.
55	Village Scattered	Built-up areas primarily associated with scattered rural settlements and associated utilities. It may include some adjacent areas of subsistence farming, especially if the village structures and fields are inter-mixed. This class is also associated with both structures on individual (commercial or smallholding) farming units, depending on clustering and size. *Scattered villages* are defined as those represented by contiguous / adjacent village-classified cells which collectively *do not form the majority cover* in a surrounding 1 ha window. Note that the class extent includes both bare / non-vegetated and low vegetation covered areas within the village boundary. Woody cover is excluded from this class and represented separately (i.e. classes 2 – 4).
59	Smallholdings (low veg / grass)	Agricultural holdings typically located in peri-urban environments, where the dominant vegetation is low shrub or grass based. Any large cultivated lands within smallholdings are typically classified as one of the cultivated classes. Any building structures within the smallholdings are typically classified as village.
66	Industrial	Built-up areas primarily containing formally planned and constructed industrial structures and associated utilities. Includes both light and heavy industry, power generation, airports, rail terminals and ports. In the agricultural sector this class also represents (chicken and pig) animal batteries, greenhouses and tunnels and intensive feedlots
67	Roads & Rail (Major Linear)	Built-up features represented by primary road and rail networks that are image-detectable (i.e. networks are non-contiguous), as well as smaller airfields and airstrips. Note that road and rail networks have not been mapped as contiguous networks, but are only represented in the NLC dataset where the linear feature is image detectable, which is dependent on object size, shape, orientation, material and surrounding landscape characteristics. This class is therefore not a definitive representation of road and rail networks. It has been included as a requirement to match, as far as possible, the gazetted land-cover standard.
68	Mines: Surface Infrastructure	Built-up structures associated with the administration and/or industrial processing and extraction of mined resources. This class may be associated with either surface or sub-surface mining activities.
69	Mines: Extraction Sites: Open Cast & Quarries *combined*	Non-vegetated, active and/or non-active extraction pits associated with surface-based mining activities, including open-cast mines, quarries, and road-side borrow pits etc. Note that in some cases (especially coal mining) there may be some overlap/mis-representation between mine-extraction *pits* and mine-*tailings*, due to the challenge of separating these accurately.

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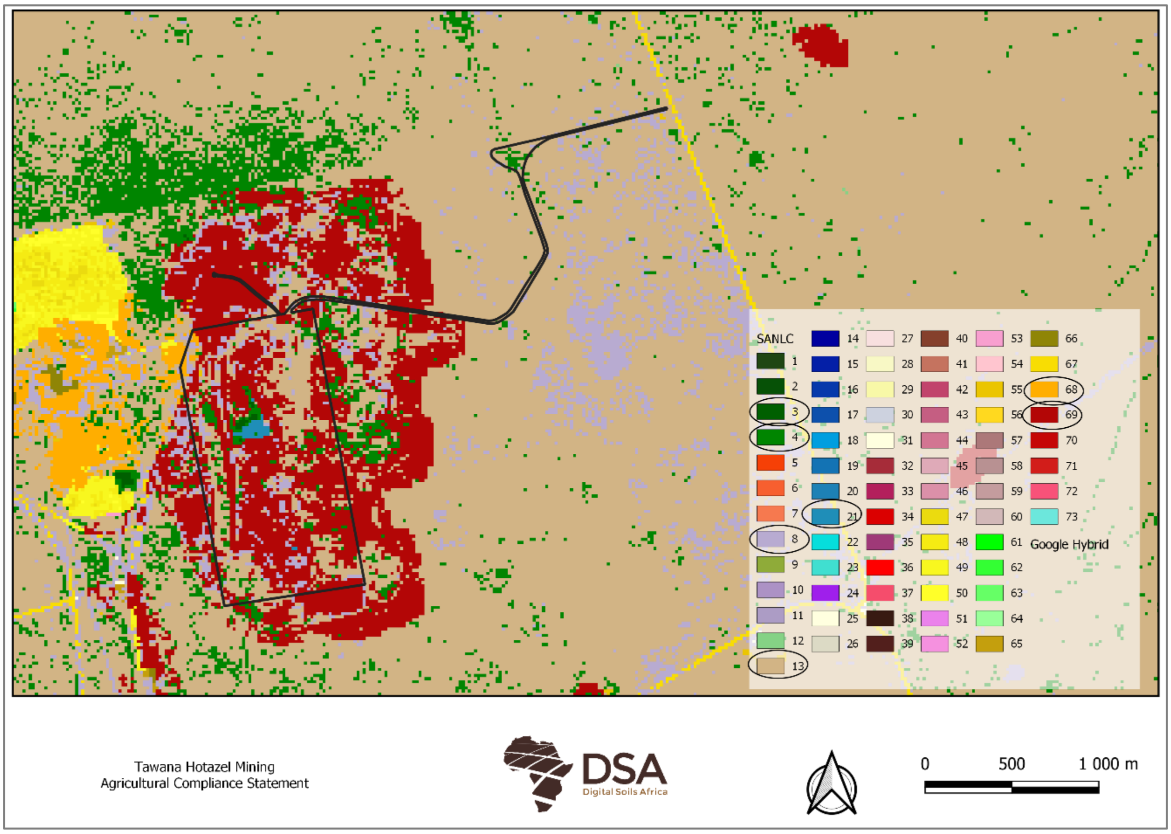

FIGURE 5: SOUTH AFRICAN NATIONAL LAND-COVER 2018 (SANLC, 2018). *LANDUSES IN THE PROJECT AREA HIGHLIGHTED IN THE LEGEND.

GRAZING CAPACITY

A homogeneous unit of vegetation expressed as the area of land required (in hectares) to maintain a single animal unit (LSU) over an extended number of years without deterioration to vegetation or soil. Where an LSU = An animal with a mass of 450 kg and which gains 0,5 kg per day on forage with a digestible energy of 55%. (Trollope et. Al., 1990).

The unit used in the grazing capacity is hectares per large stock unit (ha/LSU), therefore the site falls in a low grazing capacity of 13 ha/LSU (Figure 6). Most of the site is sparsely vegetated mine site; therefore, the grazing potential would be very limited as most the area is bare mine discard with small areas of tree cover. The access road does cover grassland (Figure 5), and therefore more likely having a grazing capacity of 13 ha/LSU.

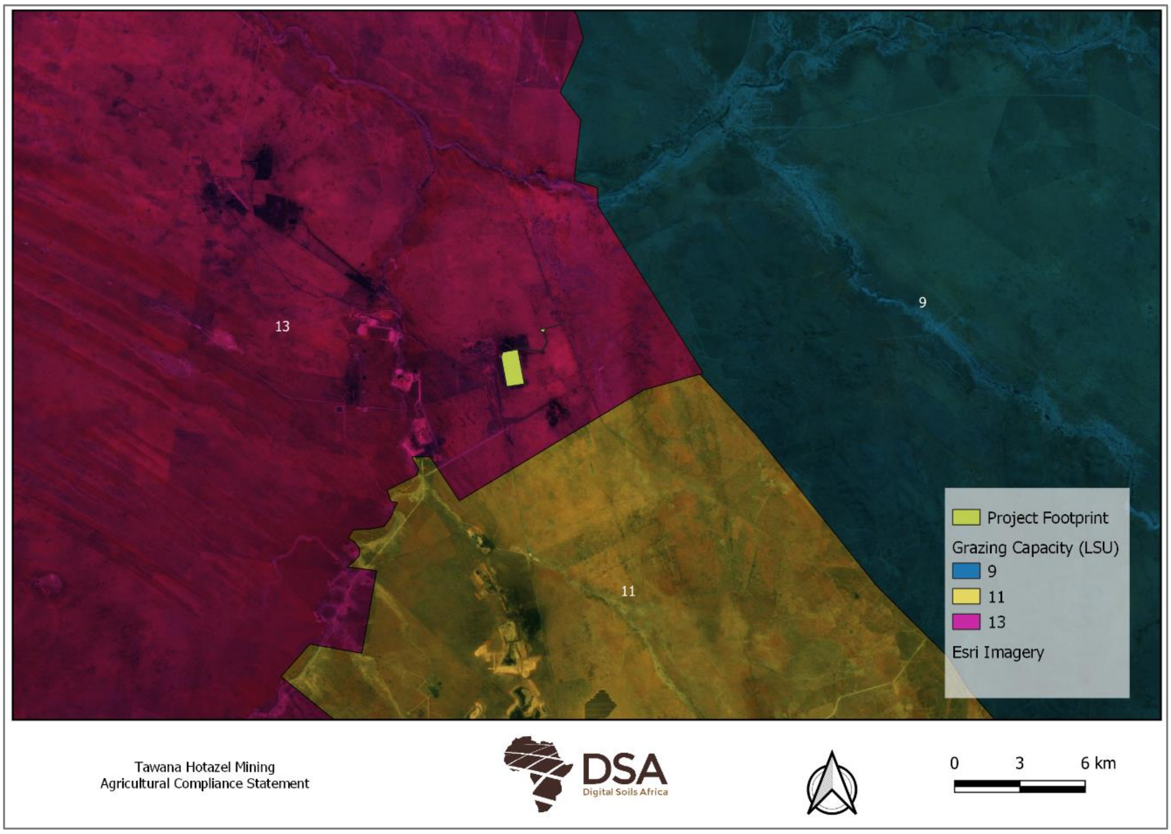

FIGURE 6: GRAZING CAPACITY OF THE SITE AND SURROUNDING AREA (DEPARTMENT OF AGRICULTURE, FORESTRY AND FISHERIES, 2016).

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SOIL AND VEGETATION PHOTOGRAPHS

Photographs taken of the site confirm the sparse vegetation on the mining area and conditions not conducive for animal rearing (Figure 7).

FIGURE 7: PHOTOGRAPHS OF THE SITE. (PHOTOS TAKEN BY PRIME RESOURCES ON 04/07/2018)

COMPLIANCE STATEMENT

The desktop study confirmed that the proposed development site is of a low Agricultural sensitivity with small areas of medium Agricultural sensitivity, as classified by the ESR.

The landtypes of the area predict deep red sandy soils. These soils will have a low water holding capacity which will limit crop production in the arid climate. Therefore, the soil capability is considered low, and therefore a low Land Capability of less than 5. Most of the site footprint is dominated by historic mining activities and therefore minimal soil is present.

The grazing potential of 13 ha/LSU is low. Given that the grazing capacity effected by the footprint is mainly the access roads, small portion of grazing will be lost.

When considering the climate (low rainfall, high temperatures, and evaporation) in combination with the sandy deep soils (low water holding capacity) the area is poorly suited to arable agriculture. As the proposed development site is situated within a historically mined area, grazing is also not considered a compatible land use as animals are likely to be injured.

It is the specialist’s opinion that the proposed development site is therefore of a low agricultural sensitivity and that the development at the proposed site will not significantly impact agricultural activities. In terms of agricultural sensitivity, the proposed development should thus be allowed to proceed at the identified site subject to recommendations provided.

Recommendations

1. Restrict the proposed development to the smallest footprint possible and do not disturb/alter areas outside the development.
2. Ensure that access roads are kept clear and that construction and operational activities do not interfere with agricultural activities.
3. Fencing is maintained to avoid animals onto the site.

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REFERENCE

Department of Agriculture, Forestry and Fisheries, 2016. 2016 Grazing Capacity map of South Africa. Pretoria

Department of Environmental Sciences, 2018. South African National Land-Cover 2018; Department of Environmental Affairs, Pretoria, South Africa.

Land Type Survey Staff. 1972 – 2002. Land types of South Africa:Digital map (1:250 000 scale) and soil inventory datases. ARC-Institute for Soil, Climate and Water, Pretoria.

Schulze, R.E. 2007. South African Atlas of Climatology and Agrohydrology. Water Research Commission, Pretoria, RSA, WRC Report 1489/1/06.

W.S.W. Trollope, Lynne A. Trollope & O.J.H. Bosch (1990) Veld and pasture management terminology in southern Africa, Journal of the Grassland Society of Southern Africa, 7:1, 52-61

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APPENDIX 1: LANDTYPE

LAND TYPE / *LANDTIPE* .... : **Ah9**
CLIMATE ZONE / *KLIMAATSONE* .... : 5S
Area / *Oppervlakte* .... : 89190 ha
Estimated area unavailable for agriculture
Beraamde oppervlakte onbeskikbaar vir landbou : 1080 ha

Terrain unit / *Terreineenheid*	**4**	**5**
% of land type / *% van landtipe*	95	5
Area / *Oppervlakte (ha)*	84730	4460
Slope / *Helling (%)*	0 - 1	1 - 3
Slope length / *Hellingslengte (m)*	1000 - 10000	200 - 1200
Slope shape / *Hellingsvorm*	Z	Z
MB0, MB1 (ha)	83883	1784
MB2 - MB4 (ha)	847	2676

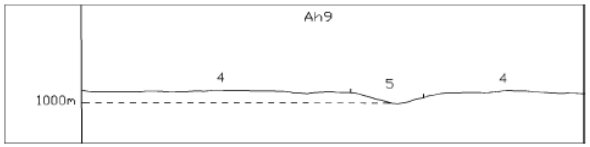
Occurrence (maps) and areas / *Voorkoms (kaarte) en oppervlakte :*
2722 Kuruman (89190 ha)

Inventory by / *Inventaris deur :*
J F Eloff en A T P Bennie

Modal Profiles / *Modale profiele :*
None / Geen

Soil series or land classes / ***Grondseries of landklasse***	**Depth** / ***Diepte*** (mm)	**MB**	ha	%	ha	%	**Total** / ***Totaal*** ha	%	**Clay content %** / ***Klei-inhoud %*** A	E	B21	Hor	**Texture** / ***Tekstuur*** Class / *Klas*	**Depth limiting material** / ***Diepte-beperkende materiaal***
Sunbury Cv30	>1200	0	35587	42			35587	39.9	2-4		3-6	B	fiSa	
Mangano Hu33	>1200	0	15251	18			15251	17.1	3-6		6-10	B	fiSa	
Annandale Cv33	>1200	0	15251	18			15251	17.1	3-6		6-10	B	fiSa	
Roodepoort Hu30, Gaudam Hu31	>1200	0	10168	12			10168	11.4	2-4		3-6	B	fi/meSa	
Sandspruit Cv31	>1200	0	6778	8			6778	7.6	2-4		3-6	B	meSa	
Mispah Ms10, Kalkbank Ms22	100-250	3	847	1	2230	50	3077	3.5	6-10			A	fiSa	R,ka
Maputa Fw10, Motopi Fw20, Fernwood Fw11, Langebaan Fw21	>1200	0	847	1	1338	30	2185	2.5	3-6		4-8	B	fiSa	
Shorrocks Hu36	>1200	0			446	10	446	0.5	7-10		15-18	B	fiSaLm	
Pans/Panne		4			446	10	446	0.5						

Terrain type / *Terreintipe* : A1
Terrain form sketch / *Terreinvormskets*



For an explanation of this table consult LAND TYPE INVENTORY (table of contents)
Ter verduideliking van hierdie tabel kyk LANDTIPE - INVENTARIS (inhoudsopgawe)

Geology: Aeolian sand of Recent age with a few outcrops of Tertiary Kalahari beds (surface limestone, silcrete and sandstone) in the riverbeds.

Geologie: Eoliese sand van Resente ouderdom met enkele dagsome van Tersiere Kalaharilae (oppervlakkalksteen, silkreet en sandsteen) in die rivierlope.