AIRSHED
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Air Quality Specialist Report for Mn48 in Northern Cape Province

Project done for **SLR Consulting (South Africa) (Pty) Ltd**

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Revision Record

Revision Number	Date	Section Revised	Reason for Revision
Draft	30 July 2020		Original for client (SLR) comment
Final v1	31 August 2020	Section 2.4: Managing Uncertainties Updated to include all study uncertainties. Section 4: Legislation and Section 7.2: Assessment of Impact – Proposed Mn48 Operations Inclusion of details relating to Manganese assessment. Section 7.3: Impact Significance Rating – Proposed Mn48 Operations Significance rating tables updated to use the previous SLR methodology to allow for comparison with the ratings provided in the 2012 report (Liebenberg-Enslin & Gresse, 2013).	Incorporation of SLR comments
Final v2	23 October 2020	Section 4: Legislation Inclusion of details relating to the NEMA EIA Regulations. Section 11: Air Quality Management Plan Update with proposed locations for equipment for the sampling/monitoring network.	Incorporation of additional comments from SLR

Competency Profiles

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

Natasha Shackleton started her professional career in Air Quality in April 2011 when she joined Airshed Planning Professionals (Pty) Ltd after completing her Undergraduate Degree at the University of Pretoria in Science. In 2011 she completed her Honours Degree at the University of Pretoria in Meteorology. Natasha is also a member of the South African Society for Atmospheric Sciences (SASAS) and is a registered Professional Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) (registration no. 116335). She is currently undertaking her MSc: Applied Science (Environmental Technology) through the University of Pretoria. Natasha has worked on several air quality specialist studies between 2011 and 2020. She has experience in the various components including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality. Whilst most of his working experience has been in South Africa, a number of investigations were made in countries elsewhere, including Burkina Faso, Guinea, Ghana, Madagascar, Mozambique, Namibia, Suriname, Tanzania, Zimbabwe and Zambia.

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

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

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

NEMA Regulations (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 Section 15: Appendix A: Authors' Curriculum Vitae (page 99)
A declaration that the person is independent in a form as may be specified by the competent authority.	Report Details (page i)
An indication of the scope of, and the purpose for which, the report was prepared.	Section 1.1: Background (page 1) Section 1.2: Terms of Reference (page 5)
An indication of quality and age of base data used.	Section 5.1: Affected Environment (page 22) Section 5.2: Atmospheric Dispersion Potential (page 22) Section 5.3: Existing Air Quality (page 28)
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 28) Section 9: Impact Assessment: Cumulative (page 66) Section 4: Legislation (page 17)
The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment.	No site visit was undertaken by the specialist. 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 22) Section 5.3: Existing Air Quality (page 28)
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 2: Methodology (page 7)
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 5: Air Quality Baseline (page 22)
An identification of any areas to be avoided, including buffers.	Not applicable
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Figure 1 and Section 5.1: Affected Environment (page 22)
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 2.4: Managing Uncertainties (page 11)
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 6: Impact Assessment: Construction Phase (page 29) Section 7: Impact Assessment: Operational Phase (page 34) Section 8: Impact Assessment: Decommissioning and Closure Phases (page 59) Section 9: Impact Assessment: Cumulative (page 66) Section 10: Impact Assessment: No Go Option (page 70)
Any mitigation measures for inclusion in the EMPr.	Section 11: Air Quality Management (page 71)

NEMA Regulations (2014, as amended) - Appendix 6	Relevant section in report
Any conditions for inclusion in the environmental authorisation	Section 11: Air Quality Management (page 71)
Any monitoring requirements for inclusion in the EMPr or environmental authorisation.	Section 11: Air Quality Management (page 71)
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Section 12: Findings and Recommendations (page 79)
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan.	Section 12: Findings and Recommendations (page 79)
A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable.
A summary and copies if any comments that were received during any consultation process.	None received.
Any other information requested by the competent authority.	None

Executive Summary

Khwara Manganese (Pty) Ltd "Khwara" and Lehating Mining (Pty) Ltd "Lehating" entered into an amalgamation agreement on 2 December 2016. The agreement combines the two adjacent, contiguous mineral resources and surface rights comprising the Khwara Lehating Manganese Mine into a single, high-grade manganese mining company known as Mn48 (Pty) Ltd ("Mn48").

The Mn48 project comprises a high-grade 48% (in-situ) manganese deposit situated in the Northern Cape Kalahari Manganese Field in South Africa. The deposit spans a mining right area located north of the town of Black Rock within the Kuruman Magisterial District and in the John Taolo Gaetsewe District Municipality in the Kalahari District of the Northern Cape Province of South Africa.

Both Khwara and Lehating have conducted an Environmental Impact Assessment (EIA) process for the development of each mine. Both mines received Environmental Authorisation in terms of both the National Environmental Management Act (No. 107 of 1998) (NEMA) and Mineral and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA).

The combined resource yields a 19-year total Life of Mine (LOM). The Mn48 operation is proposed to be an 80 kilotonnes per month (ktpm) underground operation with associated surface infrastructure and process plant facilities. The 47.33% Mn lumpy and fine product is transported from the mine for local consumption or exported via the port of Saldanha Bay to international markets.

Specialist studies have been commissioned to assess the impacts of the Mn48 project on all aspects of biophysical and socio-economic receptors within the area. Mitigation, management, and rehabilitation designs are informed by a team of specialists and engineers.

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by SLR Consulting (South Africa) (Pty) Ltd (SLR) to undertake an Air Quality Impact Assessment (AQIA) and Climate Change Impact Assessment (CCIA) as part of the Environmental Authorisation (EA) process to identify key aspects that may have significant air quality impacts during the various project phases. As such the report conforms to the amended regulated format requirements for specialist reports as per Appendix 6 of the Environmental Impact Assessment (EIA) Regulations (Government Notice [GN] R982 as amended by GN 326 of 7 April 2017; GN 706 of 13 July 2018 and GN 320 of 20 March 2020). This report covers the impact assessment for the Mn48 project (the project).

The scope of work had to include the following:

- Identify and describe the existing air quality of the project area, as well as climatic patterns and features (i.e. the baseline);
- Assess (model) the impact on air quality (specifically particulate matter [PM] with reference to Total Particulate Matter [TSP], PM_{10} [Particulate matter with an aerodynamic dimeter less than 10 µm] and $PM_{2.5}$ [particulate matter with an aerodynamic dimeter less than 2.5 µm]), human health and biota

resulting from the proposed project (including impacts associated with the construction, operations, decommissioning and post-closure phases of the project);

- Identify and describe potential cumulative air quality impacts resulting from the proposed project in relation to proposed and existing developments in the surrounding area;
- Recommend mitigation measures to minimise impacts and/or optimise benefits associated with the project;
- Recommend a monitoring campaign to ensure the correct implementation and adequacy of recommenced mitigation measures, if applicable;
- Estimate the greenhouse gas (GHG) emissions during construction, operation and decommissioning of the project compared to the global and national emission inventories; and compared to international benchmarks for the project;
- Determine the robustness of the project with the impact of climate change over the lifetime of the project considered; and;
- Ascertain the vulnerability to climate change of communities in the immediate vicinity of the project.

The main findings of the baseline assessment are:

- The significant Air Quality Sensitive Receptors (AQSRs) is Black Rock, along with isolated farmsteads and the mine villages.
- 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. These winds are associated with wind speeds of above 6 m/s.

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 “very low” rating without mitigation and “insignificant” rating with mitigation.
- Operational phase:
  - PM ($PM_{2.5}$, PM_{10} and TSP) emissions and impacts were quantified.
  - $PM_{2.5}$ and PM_{10} concentrations as a result of unmitigated operations are not within compliance off-site and at two AQSRs over the short-term.
  - $PM_{2.5}$ and PM_{10} concentrations as a result of design mitigated operations are in compliance with the NAAQS at all AQSRs over the short- and long-term; however, the NAAQS are exceeded beyond the surface boundary (off-site).
  - Annual Mn concentrations as a result of unmitigated operations and design mitigated operations exceed the WHO GV off-site and at AQSRs.
  - Dustfall rates are above the NDCR limits for non-residential areas on-site and beyond the boundary (off-site); 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.

  - The significance of operations related inhalation health impacts is likely to be “medium” without mitigation and with the design mitigation measures applied. The significance of operations related to nuisance impacts are likely to be “medium” without and with design mitigation.
- Decommissioning and closure phases:
  - The significance of decommissioning operations related inhalation health and nuisance impacts are likely to have a “very low” rating without mitigation and “insignificant” rating with mitigation.
  - The significance of closure operations related inhalation health and nuisance impacts are likely “insignificant”.

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

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

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

- The CO_2-e (scope 1) emissions for construction is approximately 8 081 t/a therefore contributing less than 0.0016% to the total of South Africa’s GHG emissions and 0.0003% of the global “industrial processes” sector.
- The CO_2-e (scope 1) emissions for proposed operations is approximately 14 734 t/a therefore contributing less than 0.0027% to the total of South Africa’s GHG emissions and 0.0005% of the global “industrial processes” sector.
- The GHG emissions from the project are low and will not likely result in a noteworthy contribution to climate change on their own.
- The project is likely to be negatively impacted by climate change in the near future due to increased temperatures and possibly extreme rainfall events increasing the likelihood of flooding.
- The community are likely to be negatively impacted by climate change in the near future due to increased temperatures and possibility of extreme rainfall events increasing the likelihood of flooding. The community are likely to be negatively impacted by climate change in the far future due to increased temperatures and possible water shortages (decreased rainfall and possible increased evaporation).
- The following is recommended to reduce the impacts of climate change on the project and the community:
  - Additional support infrastructure can reduce the climate change impact on the staff and project, for example ensuring adequate water supply for staff and reducing on-site water usage as much as possible.
  - Mn48 could initiate a community development program.
  - Investigating solar power for the operations and the community 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 of vegetation during the construction and operational phases and ensuring adequate re-vegetation during closure phases of the project.

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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
ATSDR	US Agency for Toxic Substances and Disease Registry
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
DEFF	Department of Environment, Forestry and Fisheries
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
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IRIS	Integrated Risk Information System
kg	Kilogram
Khwara	Khwara Mining (Pty) Ltd
ktpm	Kilotonnes per month
kVA	Kilo-volt-ampere
kW	Kilowatt
kWh	Kilowatt hour
Lehating	Lehating Mining (Pty) Ltd

LOM	Life of mine
m	Metre
m^2	Metre squared
m^3	Metre cubed
mamsl	Metres above mean sea level
MES	Minimum Emission Standards
mm	Millimetres
m/s	Metres per second
Mn48	Mn48 (Pty) Ltd
MPRDA	Mineral and Petroleum Resources Development Act (No. 28 of 2002)
MRL	Minimal risk levels for hazardous substances
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
RCP(s)	Representative Concentration Pathway(s)
RfCs	nhalation reference concentrations
SAAQIS	South African Air Quality Information System
SAGERS	South African Greenhouse Gas Emission Reporting System
SAWS	South African Weather Service
SF_6	Sulfur hexafluoride
SLR	SLR Consulting (Africa) (Pty) Ltd
SO_2	Sulfur dioxide
SRTM	Shuttle radar topography mission
t/a	Tonnes per annum
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

µ	micro
°C	Degrees Celsius

Glossary

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

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

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

Air Quality Specialist Report for Mn48 in Northern Cape Province

1 INTRODUCTION

1.1 Background

Khwara Manganese (Pty) Ltd "Khwara" and Lehating Mining (Pty) Ltd "Lehating" entered into an amalgamation agreement on 2 December 2016. The agreement combines the two adjacent, contiguous mineral resources and surface rights comprising the Khwara Lehating Manganese Mine into a single, high-grade manganese mining company known as Mn48 (Pty) Ltd ("Mn48"). In support of this, the approved layout of surface infrastructure located on Portion 1 of the Farm Lehating 741 has been optimised based on the outcomes of the Bankable Feasibility Study (BFS) (Worley, 2019). In summary, the changes of the approved operations and surface infrastructure include the following:

- Relocation of the primary crushing facilities from underground to surface;
- Extension of the footprint and capacity of the approved PCD;
- Addition of a second PCD, and relocation of the already approved PCD (note that the previously proposed emergency control dam will no longer be required);
- General re-configuration of approved surface infrastructure;
- Revision of the stormwater management plan to accommodate the changes to the surface infrastructure layout; and
- Establishment of proposed new support infrastructure such as helicopter pad and weighbridge.

In addition to the above, the approved EMPr for Mn48 specified the need for a TSF. This will no longer be required. The project has made a fundamental change to the mineral processing methodology whereby a dry screening process will be used, instead of a wet screening process which would produce tailings.

The Mn48 project comprises a high-grade 48% (in-situ) manganese deposit situated in the Northern Cape Kalahari Manganese Field in South Africa. The deposit spans a mining right area located north of the town of Black Rock within the Kuruman Magisterial District and in the John Taolo Gaetsewe District Municipality in the Kalahari District of the Northern Cape Province of South Africa (Figure 1 and Figure 2).

Both Khwara and Lehating have conducted an Environmental Impact Assessment (EIA) process for the development of each mine. Both mines received Environmental Authorisation in terms of both the National Environmental Management Act (No. 107 of 1998) (NEMA) and Mineral and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA). The Mn48 operations will have a different underground mining plan and surface infrastructure layout than that assessed as part of the Khwara and Lehating operations.

The combined resource yields a 19-year total life of mine (LOM). The Mn48 operation is proposed to be an 80 kilotonnes per month (ktpm) underground operation with associated surface infrastructure and process plant facilities. The 47.33% Mn lumpy and fine product is transported from the mine for local consumption or exported via the port of Saldanha Bay to international markets. The locality of Mn48, in relation to surrounding residential areas is shown in Figure 2.

Specialist studies have been commissioned to assess the impacts of the Mn48 project on all aspects of biophysical and socio-economic receptors within the area. Mitigation, management, and rehabilitation designs are informed by a team of specialists and engineers.

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by SLR Consulting (South Africa) (Pty) Ltd (SLR) to undertake an Air Quality Impact Assessment (AQIA) and Climate Change Impact Assessment (CCIA) as part of the Environmental Authorisation (EA) process to identify key aspects that may have significant air quality impacts during the various project phases. As such the report conforms to the amended regulated format requirements for specialist reports as per Appendix 6 of the Environmental Impact Assessment (EIA) Regulations (Government Notice [GN] R982 as amended by GN 326 of 7 April 2017; GN 706 of 13 July 2018 and GN 320 of 20 March 2020). This report covers the impact assessment for the Mn48 project (the project).

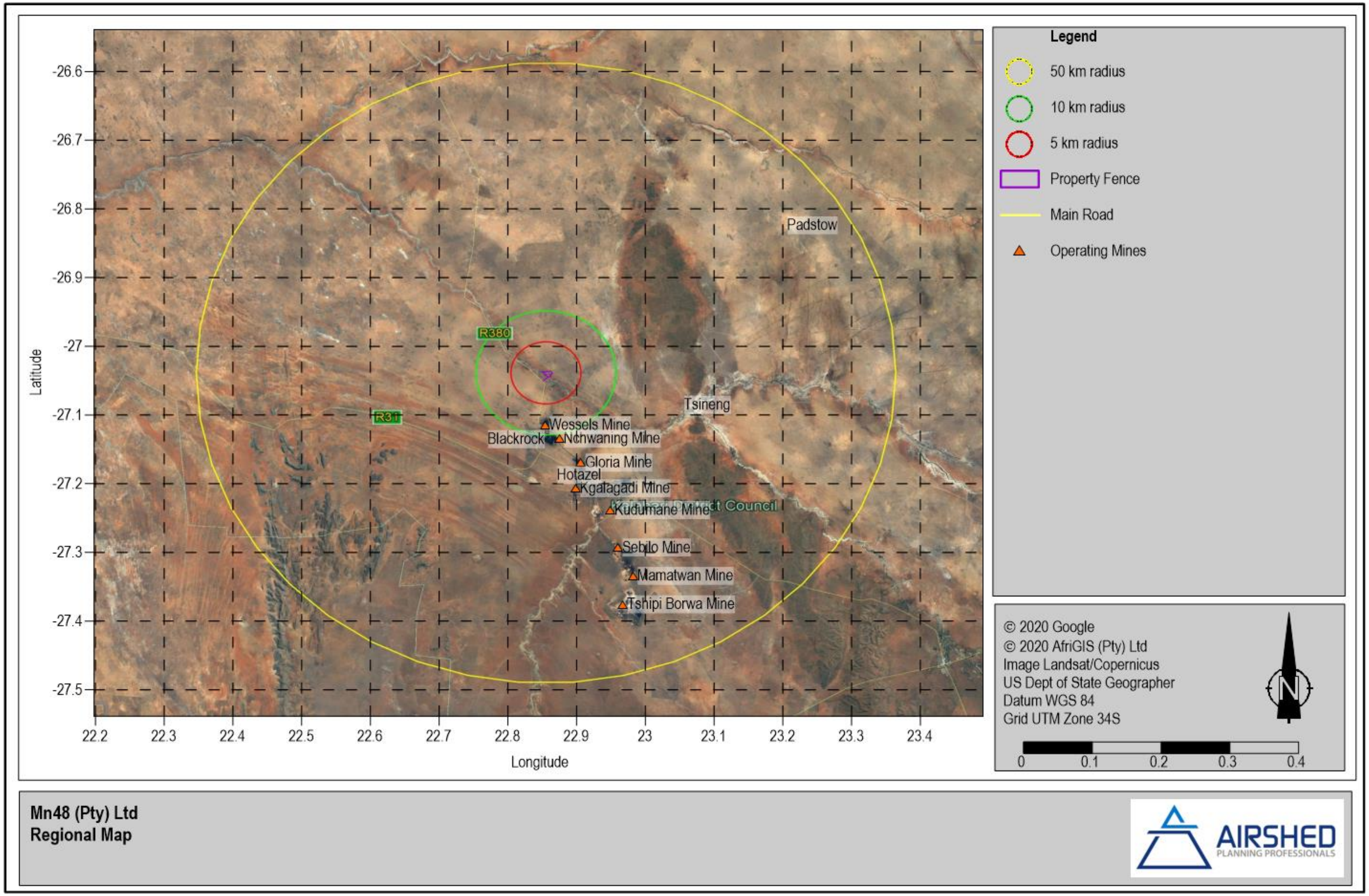

Figure 1: Regional locality map

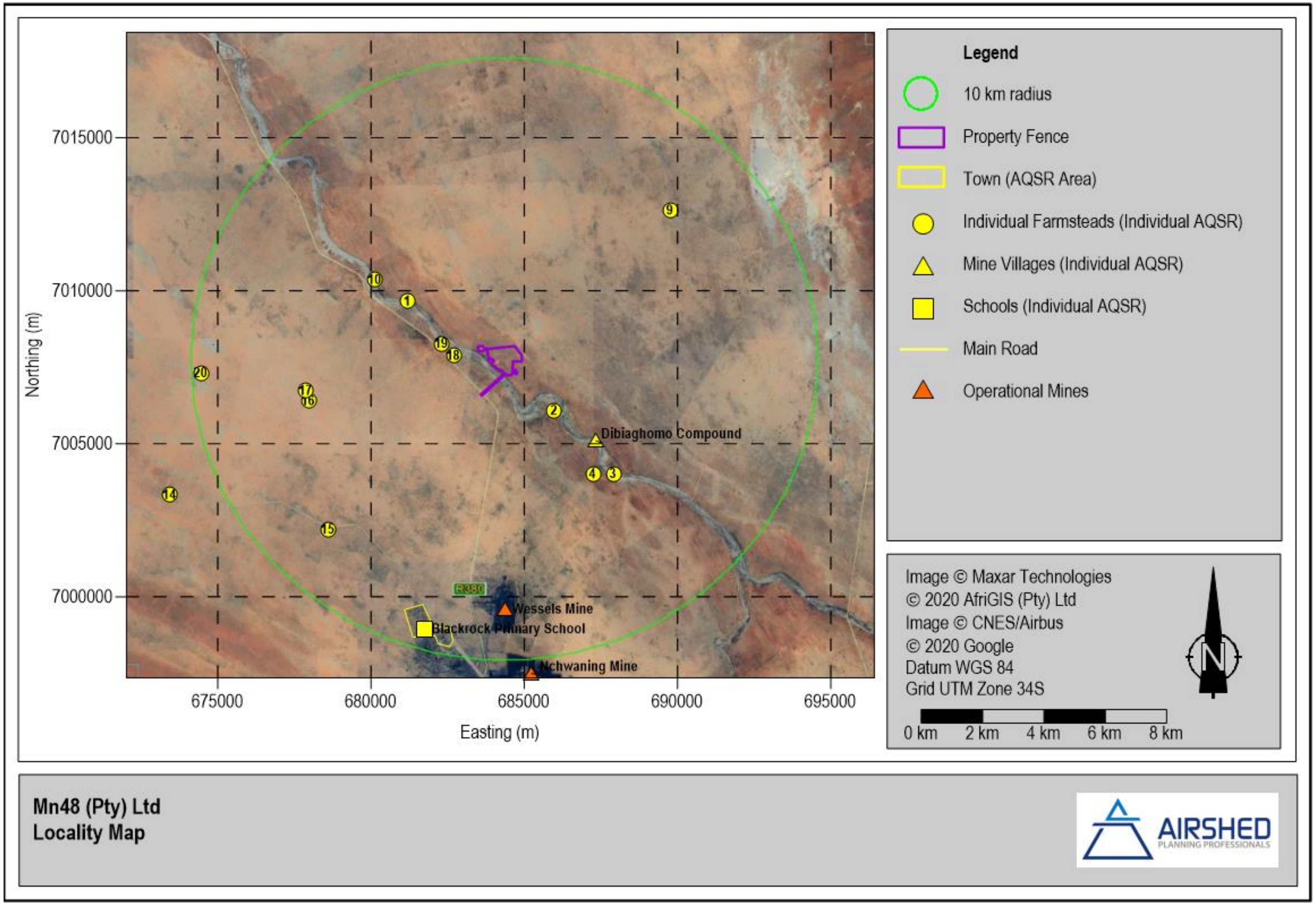

Figure 2: Location of Mn48, sensitive receptors and operational mines

1.2 Terms of Reference

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

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

1.3 Report Structure

Section	Description	Page
1 - Introduction	An introduction to the study including a description of the project and the scope of work.	1
2 - Methodology	A detailed description of the study methodology is given in this section along with all limitations and assumptions relevant to it.	7
3 - Project Description	The project operations are described.	14
4 - Legislation	A summary of applicable environmental legislation is presented	17
5 - Air Quality Baseline	A description of the receiving environment is given. It addresses AQSRs, dispersion potential as well as baseline air quality.	22
6 - Impact Assessment: Construction Phase	Impact discussion and significance rating based on specialist knowledge and the new SLR methodology.	29
7 - Impact Assessment: Operational Phase	Emissions and modelling results and significance ranting of air quality impacts based on the old SLR methodology.	34
8 - Impact Assessment: Decommissioning and Closure Phases	Impact discussion and significance rating based on specialist knowledge and the new SLR methodology.	56

Section	Description	Page
9 - Impact Assessment: Cumulative	Impact discussion based on specialist knowledge and simulation results.	66
10 - Impact Assessment: No Go Option	Discussion of the No-Go option.	70
11 - Air Quality Management	Detailed discussion on recommended mitigation, management, and monitoring.	71
12 - Findings and Recommendations	The main findings of the study and recommendations of mitigation, management and monitoring.	79
13 - Greenhouse Gas Emission and Climate Change Impact Statement	A discussion of GHG legislation, literature, potential operations' emissions and likely impacts.	81
14 - References	A list of works cited.	96
15 - Appendix A: Authors' Curriculum Vitae	Curriculum Vitae and Professional Registration (SACNSP) certificate of the report author.	99
16 - Appendix B: Competencies for Performing Air Dispersion Modelling	Discussion on the Project team members experience in performing atmospheric dispersion modelling and related tasks.	105
17 - Impact Significance Methodologies	Description of the SLR impact significance methodology.	107
18 - Appendix D: Proposed Mn48 Operations Impact Significance Rating Based on the Current SLR Methodology for Assessing the Significance of Impacts	Operational phase significance ranting based on the new SLR methodology.	112

2 METHODOLOGY

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

- Identification of existing sources of emission and characterization of ambient air quality and dustfall levels in the study area;
    - A quantitative assessment of baseline air quality was not possible due to the availability of ambient data within the area; thus, the baseline air quality is qualitative.
- It is important to have a good understanding of the meteorological parameters governing the rate and extent of dilution and transportation of air pollutants that are generated by the proposed project. The primary meteorological parameters to obtain from measurement include wind speed, wind direction and ambient temperature. Other meteorological parameters that influence the air concentration levels include rainfall (washout) and a measure of atmospheric stability. The latter quantities are normally not measured and are derived from other parameters such as the vertical height temperature difference or the standard deviation of wind direction. The depth of the atmosphere in which the pollutants are able to mix is similarly derived from other meteorological parameters by means of mathematical parameterizations.
    - The first step was therefore to source any on-site 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 used to construct wind roses, general climatic information such as diurnal temperature variations, atmospheric stability estimates and used for dispersion modelling.
- Potential air pollution sensitive receptors within the study area were identified and georeferenced for detailed analysis of the impact assessment calculations.

The impact assessment followed with the tasks below:

- The dispersion modelling was executed as per *The Regulations Regarding Air Dispersion Modelling* (GN 533 in Gazette No 37804, 11 July 2014). Three *Levels of Assessment* are defined in the Regulations. Level 2 was deemed adequate. These are described under Section 4.3.
- Preparation of the model control options and input files for the AERMOD dispersion modelling suite. This included the compilation of:
    - terrain information (topography, land use, albedo and surface roughness);
    - source layout; and
    - grid and receptor definitions.
- Preparation of hourly average meteorological data for the wind field and atmospheric dispersion model.
- Preparation of an emissions inventory (particulates) for the approved and proposed operations, including fugitive sources[2]. Ideally, the emission rates should be based on actual measurements, but since this is not possible for the project, emission factors are used.

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[2] 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).

- For the study, simulations were conducted using the AERMOD dispersion modelling suite, which allowed the calculations of the ambient inhalable concentrations ($PM_{2.5}$ and PM_{10}) and dust fallout. The daily and annual concentrations and total daily dust deposition were calculated. Dispersion modelling was completed for all operations associated with the proposed Mn48 project.
- The legislative and regulatory context, including emission limits and guidelines, ambient air quality guidelines and dustfall classifications were used to assess the impact and recommend additional emission controls, mitigation measures and air quality management plans to maintain the impact of air pollution to acceptable limits in the study area. The model results were analysed against the National Ambient Air Quality Standards (NAAQS) and National Dust Control Regulations (NDCR).

2.1 Data Analysis for 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 soundings. Output includes surface meteorological observations and parameters and vertical profiles of several atmospheric parameters. AERMAP is a terrain pre-processor designed to simplify and standardise the input of terrain data for AERMOD. Input data includes receptor terrain elevation data which may be in the form of digital terrain data. The output includes, for each receptor, location and height scale, which are elevations used for the computation of air flow around hills. A disadvantage of the model is that spatially varying wind fields, due to topography or other factors cannot be included. Input data types required for the AERMOD model includes source data, meteorological data (pre-processed by the AERMET model), terrain data (pre-processed by the AERMAP model) and information on the nature of the receptor grid.

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

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

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

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

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

2.1.1 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 on-site 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 and Global Land Cover Characterisation (GLCC) data for Africa.

2.1.3 Receptor Grid

The dispersion of pollutants expected to arise from proposed operations was simulated for an area covering 16 km (east-west) by 16 km (north-south). The area was divided into a grid matrix with a resolution of 50 m. AERMOD calculates ground-level concentrations and dustfall rates at each grid point. The grid details used in dispersion modelling are given in Table 2.

Table 2: Simulation domain

Simulation domain	
South-western corner of simulation domain	676 000 m (Easting); 7 000 000.00 m (Northing)
Domain size	16 x 16 km
Projection	Grid: UTM Zone 34S, Datum: WGS-84
Resolution	50 m

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. The post-processing of air concentrations at discrete receptors as well as the regular grid points includes the calculation of various percentiles, specifically the 99^{th} percentile, which corresponds to the requirements of the NAAQS.

Ground level concentration (GLC) isopleth plots presented in this report depict interpolated values from the concentrations simulated by AERMOD for each of the receptor grid points specified. Plots reflecting daily averaging periods contain only the 99.73^{rd} percentile of simulated ground level concentrations, for those averaging periods, over the entire period for which simulations were undertaken. It is therefore possible that even though a high daily average concentration is simulated at certain locations, this may only be true for one day during the period. Typically, NAAQS apply to areas where the Occupational Health and Safety regulations do not apply, thus outside the mine property or lease area. Ambient air quality guidelines and standards are therefore not occupational health indicators but applicable to areas where the public has access i.e. off-site.

2.1.5 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 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 SLR 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.

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

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

1. All project information required to calculate emissions for proposed operations was provided by SLR; it is assumed that all this information is the most recent data and correct.
1. The EA process will be completed by SLR. For this reason, the impact significance of the project was determined based on the SLR impact significance methodology. The significance rating tables in Section 7.2.4 are based on the previous SLR methodology to allow for comparison with the ratings provided in the 2012 report (Liebenberg-Enslin & Gresse, 2013).
2. Particulate matter, with reference to TSP, PM_{10} and $PM_{2.5}$ is the main pollutant of concern from the proposed project.
3. 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 were 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 for comparison purposes using the same methodology as the previous study (Liebenberg-Enslin & Gresse, 2013). It must be noted that at the time of the previous study there were and there still are no measured values for the Mn content for the individual sources included (being a proposed operation) thus there are two assumption that can 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 (which is what was used in the previous study); or

    ii. All sources have a 48% 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 48% Mn content would fundamentally mean that the vehicles are travelling along the ore body.

d. Both the application of a 48% 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.

4. No ambient air quality data is available thus a qualitative assessment of sources in the area is included.

5. The impact of the construction and decommissioning phase impacts are expected to be similar or somewhat less significant than operational phase impacts. Mitigation and management measures recommended for the construction phase are also applicable to the decommissioning phase. No impacts are expected post-closure provided the rehabilitation of final landforms is successful.

6. Meteorology:

    a. There were 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 on-site. The data for the period January 2017 to December 2019 was used in the dispersion modelling. The closest SAWS stations are Kuruman and Kathu which are both 72 kilometres (km) away from this site and although based on the terrain in the area it may be considered potentially representative (that is without taking into account the land use surrounding the station and that surrounding the site). But when taking into account 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 (GN 533; 11 July 2014) 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.

   b. 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 dataset period 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 (2020).

7. Emissions:
   a. The impact assessment was limited to airborne particulates (including TSP, PM_{10} and $PM_{2.5}$). These pollutants are regulated under NAAQS and considered key pollutants released by the operations associated with the proposed project.
   b. The quantification of sources of emission was restricted to the proposed project operations. Other existing sources of emission within the area including other companies' mining and processing operations, farming activities, domestic fires, vehicle exhaust emissions and dust entrained by vehicles on public roads were not included as part of the project's 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 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.
8. Greenhouse gas (GHG):
   a. Scope 1 and Scope 2, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions were calculated for the construction phase and operational phase;
   b. Scope 1 and Scope 2 emissions were converted to CO_2 equivalent (CO_2-e) emissions for the construction phase and operational phase; and
   c. Modelling was not included in the scope of work.

3 PROJECT DESCRIPTION

The proposed project will make use of some of the facilities included in the previous assessment (Liebenberg-Enslin & Gresse, 2013) as well as the proposed production rate and infrastructure layout. Air emissions during the proposed activities will result from a variety of air emission sources, from which airborne particulates are the most significant emissions. Airborne particulate may contain sizes up to about 100 micron in diameter. Particles of sizes larger than about 75 micron tend to deposit out of the plume relatively nearby their source of emission. Particles less than about 20 micron, on the other hand, can be carried for considerable distances before depositing out. Dust emissions are produced from the mechanical movement of large volumes of material, as well as by the movement of mobile equipment and trucks, both within the proposed stockpile and dump areas and along the unsealed roadways on the property. Dust particles, especially the very fine particles, will potentially be harmful to human health, may create amenity issues and might result in soiling of buildings, structures and other objects at nearby residences. Particle fallout in significant quantities can also negatively impact vegetation due to the reduction in photosynthesis.

3.1.1 Construction Phase

During the construction phase several facilities need to be established. These include 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 (generators), portable water supply (bowsers), change houses, soil stockpiles, water management infrastructure, security and access control, and the main access and haul 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 project access road.

The following activities are proposed:

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

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 $PM_{2.5}$. PM_{10} is defined as particulate matter with an aerodynamic diameter of less than 10 µm and is also referred to as thoracic particulates. Inhalable particulate matter, $PM_{2.5}$, is defined as particulate matter with an aerodynamic diameter of less than 2.5 µm. Whereas PM_{10} and $PM_{2.5}$ fractions are taken into account to determine the potential for human health risks, total suspended particulate matter (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 construction equipment, diesel generators and construction related traffic. Key pollutants from combustion of fossil fuels include PM_{10} and $PM_{2.5}$, carbon monoxide (CO), formaldehyde, nitrogen oxides (NO_x), sulfur dioxide (SO_2) 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). Diesel fuel and heavy fuel oil (HFO) storage for electricity supply would result in additional amounts of VOCs. It is anticipated the construction phase activities would be undertaken for a period of 44 months, 12-hours per day, Monday to Saturday.

3.1.2 Operational Phase

Underground mining will take place at the proposed project. Waste will be hoisted from underground during the development phase only and thus the waste associated facilities will not be operational during the ramped-up operations. There will however be erosion of the existing waste dump. Ore from the shaft will be transported on site via conveyor to the crushing and screening facilities and product stockpiles and then reclaimed by twin side-tipping 34 tonne payloaders via a dedicated haul road to the off-site storage facility. The on-site facilities will process approximately 80 kilo tonnes of ore per month (ktpm) and produces 64 ktpm lumpy (-75 + 6 mm) and 16 ktpm (-6 mm) fine product. On-site operations will be powered by grid power with two emergency generators. The life of mine (LoM) is 19 years. Potential pollutants from the operations are discussed in Table 3.

The mining operations will take place 20 hours per day, 5 days per week. The processing plant will be operational 20 hours per day, 5 days per week. The transport activity on the access road will take place for 16 hours per day, 7 days per week.

3.1.3 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. The duration of this phase is likely to be 24 months and 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 will occur periodically over the following five (5) years to determine if the decommissioning and rehabilitation works have been successfully completed.

Table 3: Air emissions and pollutants associated with the Mn48 Project operational phase

Activity	Description	Sources of emission	Main Pollutants
Mining operations and waste rock storage	Underground mining will be pillar and board method. Drilling and blasting with excavation, transfer to 30 tonne dump trucks and transport of ore to underground silos and reclamation from silos onto skips and hoisting to the surface.	Ventilation shaft	TSP, PM_{10}, $PM_{2.5}$, DPM, CO, NO_x, SO_2, VOC
Transportation, handling of ore and product	Ore will be transported on-site via conveyors while product will be transported off-site via side-tippers along dedicated access road. Topsoil and waste removed during development is stored on stockpiles on-site. Crushed ore and fine and lumpy product are stored on stockpiles on-site. Product will be reclaimed from the product stockpiles using front end loaders (FELs) and transfer into side tippers and transported ff-site.	Vehicle entrainment	TSP, PM_{10} and $PM_{2.5}$
		Vehicle exhaust	TSP, PM_{10}, $PM_{2.5}$, DPM, CO, NO_x, SO_2, VOC
		Materials handling	TSP, PM_{10} and $PM_{2.5}$
		Windblown dust	TSP, PM_{10} and $PM_{2.5}$
Crushing, screening and stacking of ore	Ore is conveyed to a primary crusher and then onto a stockpile. The crushed ore is then conveyed to the secondary crusher and screening plant.	Screening	TSP, PM_{10} and $PM_{2.5}$
		Crushing	TSP, PM_{10} and $PM_{2.5}$
		Stacking	TSP, PM_{10} and $PM_{2.5}$
		Materials handling	TSP, PM_{10} and $PM_{2.5}$

4 LEGISLATION

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

Emission standards are generally provided for point sources, specify the amount of the pollutant acceptable in an emission stream and are often based on proven efficiencies of air pollution control equipment. Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality standards and guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging or exposure periods.

This section summarises legislation from 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 (GN R982 as amended by GN 326 of 7 April 2017; GN 706 of 13 July 2018 and GN 320 of 20 March 2020) a specialist report must contain certain information (see table on page iv for full list of information required). A site environmental sensitivity screening must also be conducted for the specialist assessment using the Department screening tool to determine among other information the development incentives, restrictions, exclusions or prohibitions that apply to the proposed development site as well as the most environmental sensitive features on the site based on the site sensitivity screening results for the application classification that was selected. Based on the site sensitivity screening the only requirement for this report is that it fulfils the Appendix 6 Specialist Report requirements.

4.2 Emissions Standards

The NEM:AQA (Act No. 39 of 2004 as amended) mandates the Minister of Environment to publish a list of activities which result in atmospheric emissions and consequently cause significant detrimental effects on the environment, human health and social welfare, economic conditions, ecological conditions or cultural heritage. The updated Listed Activities and Minimum National Emission Standards (MES) were published in 2013 (GN 893, in Government Gazette No. 37054) as amended by GN 551, 12 June 2015; GN 1207, 18 October 2018; GN 687, 22 May 2019 and GN 421, 27 March 2020). None of the approved or proposed operations on-site would not fall under any listed activities nor require an Atmospheric Emissions Licences (AEL) thus national MES, AELs and Atmospheric Impact Reports (AIRs) are not discussed in this section.

4.3 Atmospheric Emissions Reporting Regulations

The National Atmospheric Emission Reporting Regulations (GN R283 in Government Gazette No. 38633) came into effect on 2 April 2015. The purpose of the regulations is to regulate 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). 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.

Emission sources and data providers are classified according to groups. The Mn48 operations would be classified under Group C ("Mines"). Emission reports from this group must be made in the format required for NAEIS.

As per the regulations, Mn48 and/or their data provider should be registered on the NAEIS system as they are currently operating. Data providers must inform the relevant authority of changes if there are any:

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

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

4.4 Atmospheric Dispersion Modelling Regulations

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Regulations regarding Air Dispersion Modelling were promulgated in GN 533, in Government Gazette No. 37804; 11 July 2014, 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.

4.5 South African National Ambient Air Quality Standards

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

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

Table 4: National Ambient Air Quality Standards

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

Pollutant	Averaging Period	Concentration ($\mu g/m^3$)	Permitted Frequency of Exceedance	Compliance Date
PM_{10}	24-hour	75	4	Currently enforceable
	1 year	40	-	Currently enforceable

4.6 National Dust Control Regulations

The NDCR were published on 1 November 2013 (GN R827 in Government Gazette No. 36974). 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/m^2- day in residential and light commercial areas; or 1 200 mg/m^2-day in areas other than residential and light commercial areas.

In addition to the dustfall limits, the NDCR prescribe monitoring procedures and reporting requirements. This will be based on the measuring reference method ASTM 01739 averaged over 30 days.

Table 5: Acceptable dustfall rates

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

Notes: The method to be used for measuring dustfall rate and the guideline for locating sampling points shall be ASTM D1739: 1970, or equivalent method approved by any internationally recognized body

4.7 International Health Criteria

Chronic inhalation criteria and guidelines for manganese, as published by various international organisations, are summarised in Table 6.

Table 6: Chronic inhalation criteria and guidelines for manganese

Source	Concentration ($\mu g/m^3$)
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.

4.8 Screening criteria for animals and vegetation

Limited information is available on the impact of dust on vegetation and grazing quality. While there is little direct evidence of the impact of dustfall on vegetation in the South African context, a review of European studies has shown the potential for reduced growth and photosynthetic activity in sunflower and cotton plants exposed to dust fall rates greater than 400 mg/m²- day (Farmer, 1993). In addition, there is anecdotal evidence to indicate that over extended periods, high dustfall levels in grazing lands can soil vegetation and this can impact the teeth of livestock (Farmer, 1993).

5 AIR QUALITY BASELINE

5.1 Affected Environment

AQSRs generally include places of residence and areas where members of the public may be affected by air pollution generated by the Mn48 activities. AQSRs within a 10 km radius (Figure 2) of the operations include Black Rock to the south. Aside from the residential area of Black Rock, individual farmsteads, and mine villages near the Mn48 surface operations were identified as AQSRs and agricultural areas were identified as environmentally sensitive areas. Table 7 is a summary of the nearby farmsteads, mine villages and schools that may be influenced by air pollution emissions from the proposed Project. These receptors are also depicted in Figure 2.

The topography of the site is fairly flat and ranges from 1 000 mamsl at the riverbed near the project site to 1 015 mamsl near the R380. The land use in the area comprises primarily mining, residential and farming (Figure 1).

Table 7: Identified individual air quality sensitive receptors

ID/Name	Type	Longitude	Latitude
1	Farmstead	22.82647223	-27.02345565
2	Farmstead	22.87522334	-27.05505744
3	Farmstead	22.89494951	-27.0733785
4	Farmstead	22.88828209	-27.07357326
9	Farmstead	22.91233829	-26.99540758
10	Farmstead	22.81563889	-27.01725000
14	Farmstead	22.74916852	-27.08159027
15	Farmstead	22.80142334	-27.09107938
16	Farmstead	22.79436618	-27.05323434
17	Farmstead	22.79348248	-27.05030758
18	Farmstead	22.84183092	-27.03928546
19	Farmstead	22.83786902	-27.03576099
20	Farmstead	22.75886588	-27.04542822
Dibiaghomo Compound	Mine Village	22.88905738	-27.06375032
Black Rock Primary School	School	22.83265062	-27.12186256

5.2 Atmospheric Dispersion Potential

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

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

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

5.2.1 Local Wind Field

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

The wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the yellow area, for example, representing winds between 5 and 6 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

The period wind field and diurnal variability in the wind field are shown in Figure 3, while the seasonal variations are shown in Figure 4. The wind field is dominated by winds from the northerly sectors. The strongest winds (>6 m/s) occurred mostly from the north. Calm conditions occurred 2.47% of the time, with the average wind speed over the period of 3.88 m/s. Wind from the north-north-west and north having greater speeds were greater during the day with a higher frequency of calm conditions (2.85% during the day) than during the night (2.09% during the night). Day-time shows dominant north-north-westerly and northerly components to the wind field and during the night winds these winds decrease and the north-north-easterly and north-easterly winds dominate. Strong winds in excess of 6 m/s occurred most frequently during spring followed by summer. Calm conditions occurred most frequently during the autumn and winter months.

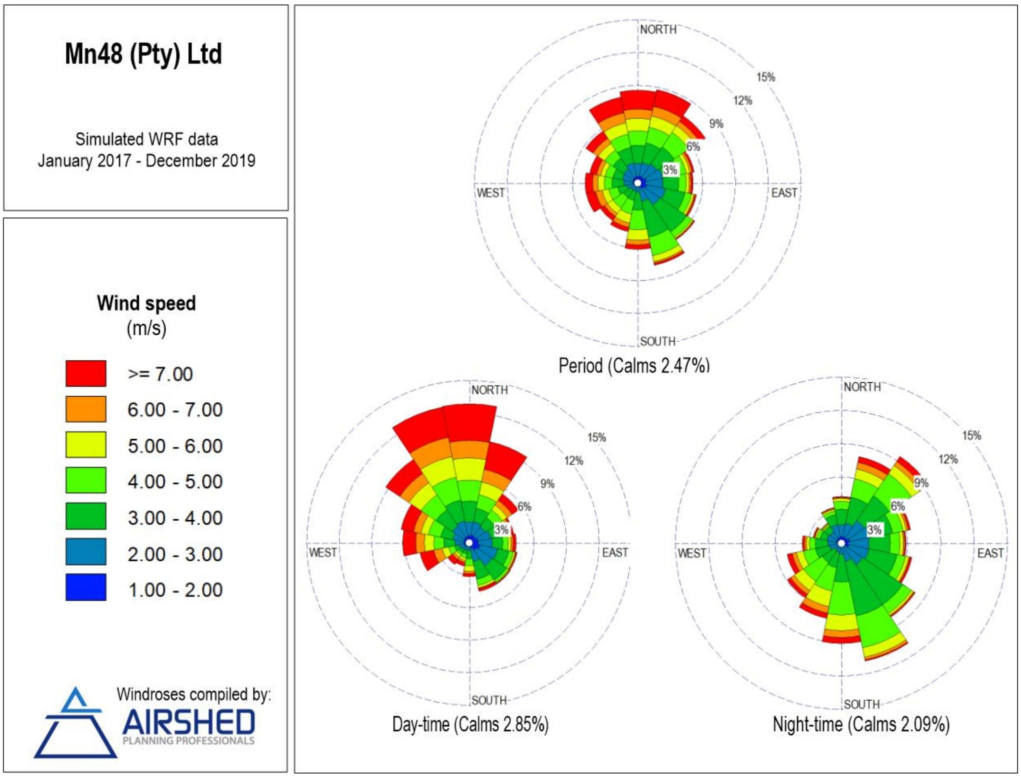

Figure 3: Period, day- and night-time wind roses (AERMET processed WRF data, January 2017 to December 2019)

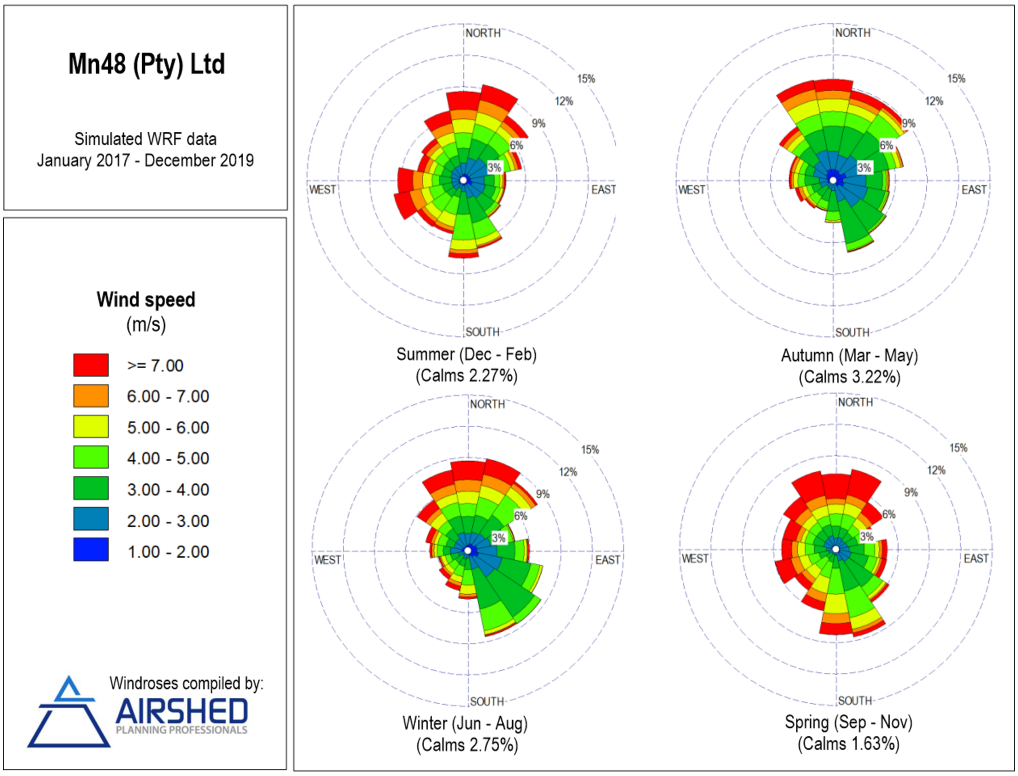

Figure 4: Seasonal wind roses (AERMET processed WRF data, January 2017 to December 2019)

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 8. Diurnal temperature variability is presented in Figure 5. 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 8: 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**
Monthly Average	28	27	25	21	17	12	12	14	18	22	25	27
Hourly Maximum	39	38	37	34	30	27	27	31	36	36	39	39
Hourly Minimum	12	12	10	6	1	-3	-5	-4	-4	0	6	11

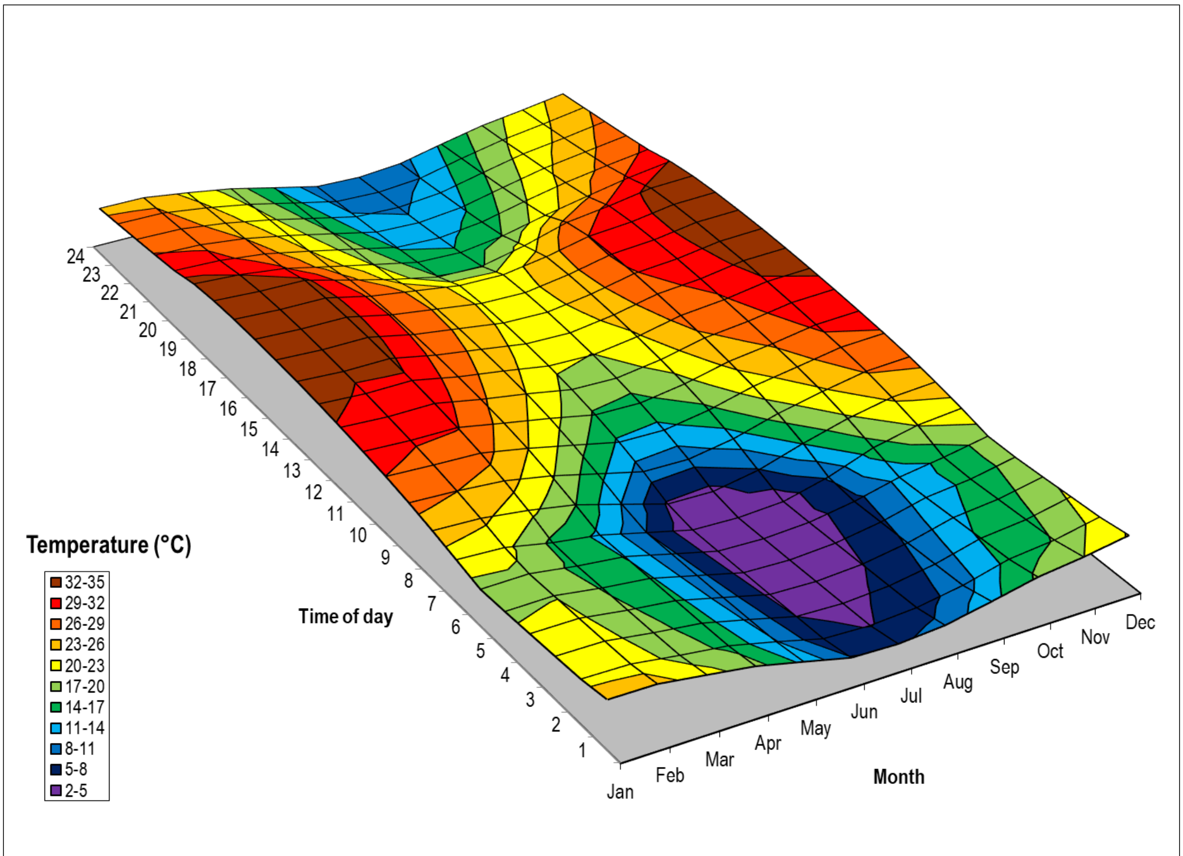

Figure 5: Diurnal temperature profile (AERMET processed WRF data, January 2017 to December 2019)

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 6. 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 6(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 6(b)). Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called *fanning* (Figure 6(a)) (Tiwary & Colls, 2010). For ground level releases such as fugitive dust the highest ground level concentrations will occur during stable night-time conditions.

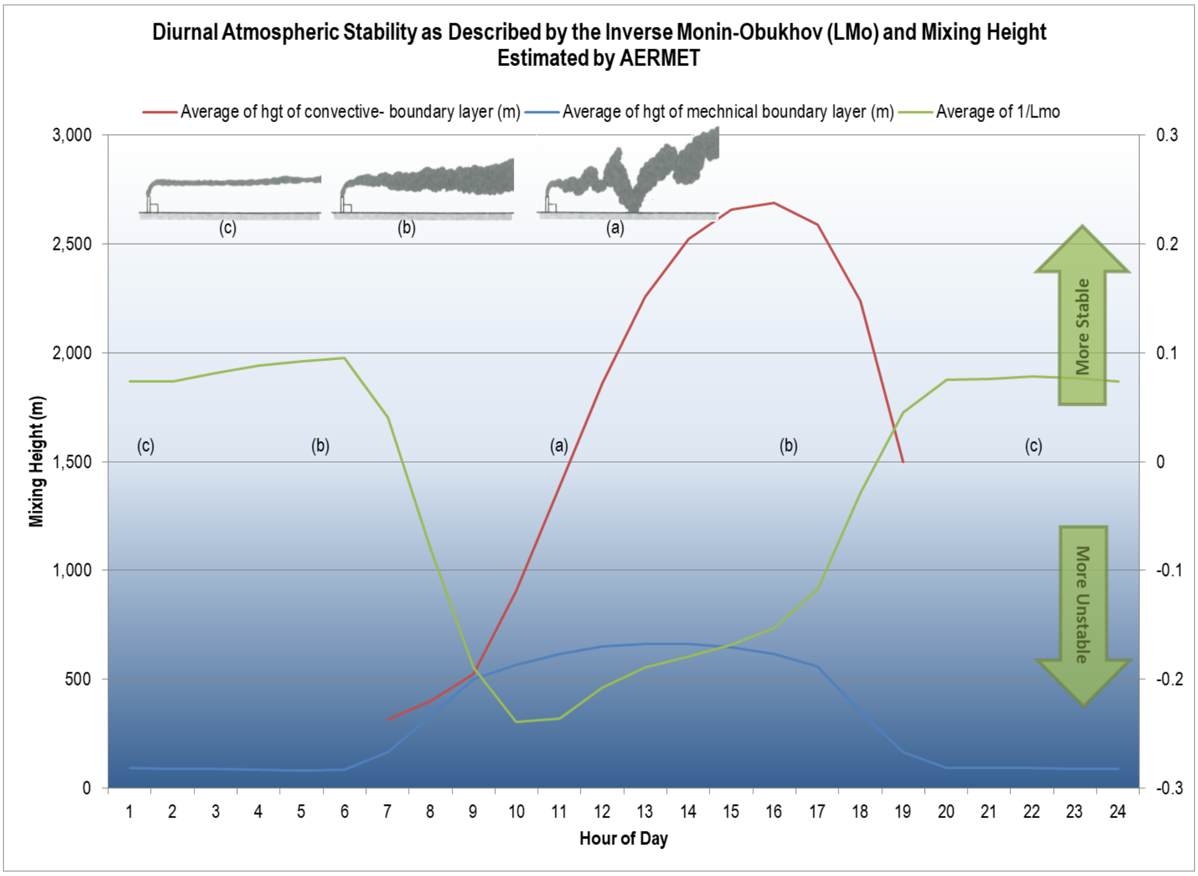

Figure 6: Diurnal atmospheric stability (AERMET processed WRF data, January 2017 to December 2019)

5.2.4 Precipitation

Rainfall is important to air pollution studies since it represents an effective removal mechanism of atmospheric pollutants. Monthly rainfall obtained from the WRF data is presented in Figure 7. Total average annual rainfall from January 2017 to December 2019 is 375 mm. The rainfall for 2017, 2018 and 2019 was 540 mm, 285 mm, and 300 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.

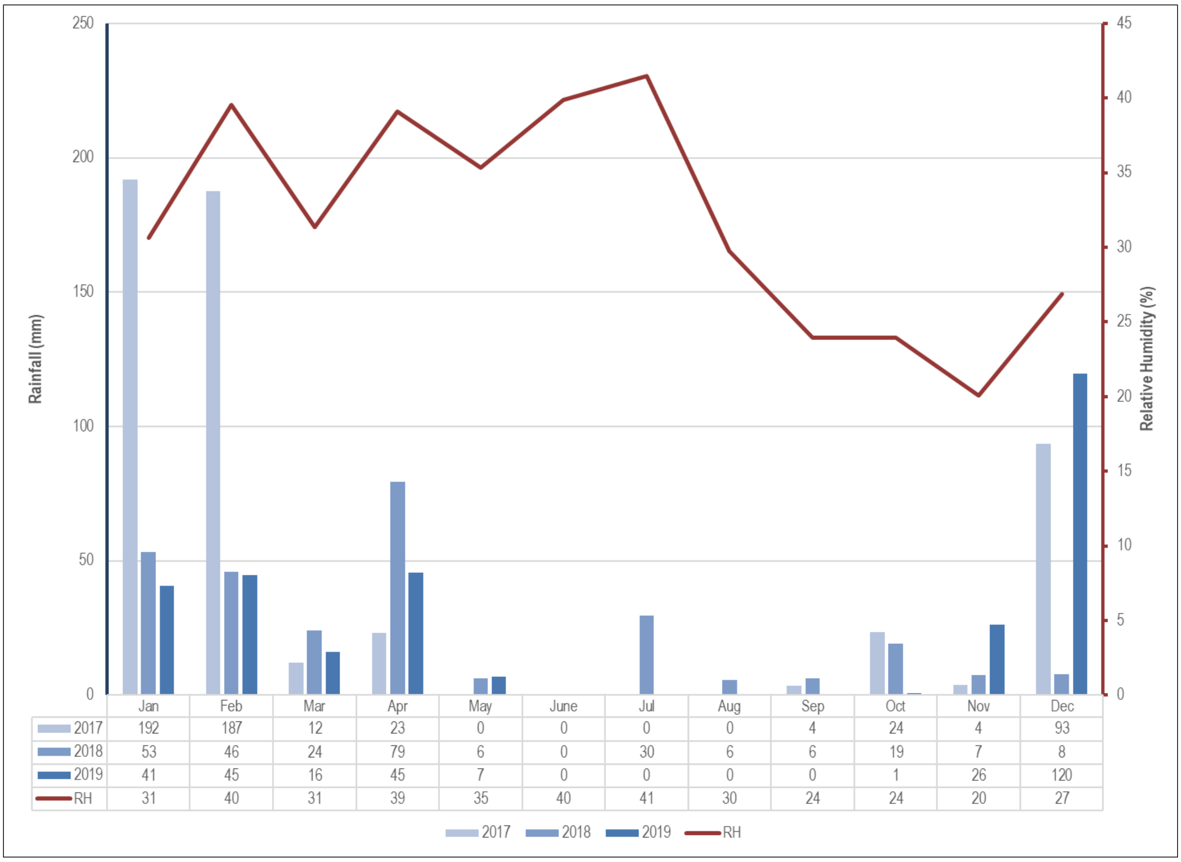

Figure 7: Monthly rainfall and relative humidity (AERMET processed WRF data, January 2017 to December 2019)

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.

6 IMPACT ASSESSMENT: CONSTRUCTION PHASE

6.1 Emissions Inventory for Construction Phase

During the construction phase several facilities need to be added. The following activities will take place:

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

A summary of sources quantified, emissions estimation techniques applied, and source input parameters are summarised in Table 9 and the summary of estimated particulate emissions is provided in Table 10.

Table 9: Emission estimation techniques and parameters for construction

Source Group	Emission Estimation Technique	Input Parameters/Notes
General construction	US EPA emission factor (US EPA, 1995) $EF = k \cdot 2.69$ Where EF is the emission factor in t/ha-month k is the particle size multiplier (k_{TSP} – 1, k_{PM10} – 0.35, $k_{PM2.5}$ – 0.18)	A total surface infrastructure/disturbed area of ~80 ha was estimated from the site layout map. It was assumed that 25% of this area would be under construction at any given point in time. It is assumed that roads will likely be unpaved for most of the construction period. **Hours of operation:** 6 days per week (Monday to Saturday), 12-hours per day (06H00 – 18H00) **Design mitigation:** None **Additional mitigation:** Dust management and water sprays (assumed 50% control efficiency)
Construction equipment	NPI single valued emission factors (ADE, 2008) for: Excavator Bulldozer Tractor Crane Front End Loader Gen Set	**Operating power:** Excavator – 304 kW Bulldozer – 114 kW Tractor – 60.8 kW Crane – 76 kW Front End Loader – 57 kW Gen Set – 60 kW **Hours of operation:** 6 days per week (Monday to Saturday), 12-hours per day (06H00 – 18H00) **Design Mitigation:** None

Table 10: Summary of estimated particulate emissions in tonnes per annum for construction

Source Group	Estimated UNMITIGATED Particulate Emissions (t/a)			Estimated MITIGATED Particulate Emissions (t/a)		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP

General Construction	0.922	1.84	5.27	0.461	0.922	2.63
Mobile Construction Equipment	1.85	1.85	1.85	-	-	-

6.2 Assessment of Impact – Construction

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

6.3 Impact Significance Rating - Construction

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

The sources of emissions would include site establishment in proposed additional operating areas; vegetation clearing; stripping and stockpiling of topsoil and other earthworks; collection, storage and removal of construction related waste; the construction of all required infrastructure; and the operation of mechanical equipment. It is unlikely that the long-term and short-term NAAQS will be exceeded at AQSRs (with and without mitigation). The construction operations are likely to last for less than 5 years. The significance rating is “very low” without mitigation applied and “insignificant” with mitigation measures applied (Table 11).

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

The sources of emissions would include site establishment in proposed additional operating areas; vegetation clearing; stripping and stockpiling of topsoil and other earthworks; collection, storage and removal of construction related waste; the construction of all required infrastructure; and the operation of mechanical equipment. It is unlikely that the NDCR limit for residential areas will be exceeded at AQSRs (with and without mitigation). The construction operations are likely to last for less than 5 years. The significance rating is “very low” without mitigation applied and “insignificant” with mitigation measures applied (Table 12).

Table 11: Health risk impact significance summary table for the construction operations

Air Quality	Description	Rating
Project activity or issue	Construction	Not applicable (N/A)
Potential impact	Increased health risk at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in $PM_{2.5}$ and PM_{10} concentrations at AQSRs	-
	Significance Before Mitigation	
Intensity	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.	L
Duration	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.	L
Extent	A part of the site/property.	VL
Consequence	Very Low.	
Probability	Conceivable.	L
Significance	**It will not have an influence on the decision. Does not require any mitigation.**	**Very Low**
	Significance After Mitigation	
Intensity	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.	VL
Duration	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.	L
Extent	A part of the site/property.	VL
Consequence	Low.	
Probability	Conceivable.	L
Significance	**Inconsequential, not requiring any consideration.**	**Insignificant**
Potential mitigation measures (construction)	• Reduction of fugitive PM emissions through the watering of roads, stockpiles and inactive open areas and the use of screens.	N/A

Air Quality	Description	Rating
	• Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	

Table 12: Nuisance impact significance summary table for the construction operations

Air Quality	Description	Rating
Project activity or issue	Construction	N/A
Potential impact	Nuisance dustfall rates at AQSRs	N/A
Nature of the Impact		
Positive or negative	Negative due to increase in dustfall rates at AQSRs	-
Significance Before Mitigation		
Intensity	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.	L
Duration	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.	L
Extent	A part of the site/property.	VL
Consequence	Very Low.	
Probability	Conceivable.	L
Significance	**It will not have an influence on the decision. Does not require any mitigation.**	**Very Low**
Significance After Mitigation		
Intensity	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.	VL
Duration	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.	L
Extent	A part of the site/property.	VL
Consequence	Low.	

Air Quality	Description	Rating
Probability	Conceivable.	L
Significance	**Inconsequential, not requiring any consideration.**	**Insignificant**
Potential mitigation measures (construction)	• Reduction of fugitive PM emissions through the watering of roads, stockpiles and inactive open areas and the use of screens. • Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	N/A

7 IMPACT ASSESSMENT: OPERATIONAL PHASE

The following scenarios were included in the dispersion modelling:

1. The proposed operations without mitigation; and
2. The proposed operations with design mitigation.

7.1 Emissions Inventory

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

- Particulate emissions from underground operations, emitted through the ventilation shaft;
- Particulate emissions from materials handling at the shaft, at conveyor transfer points and stockpiles;
- Particulate emissions from crushers and screens;
- Particulate emissions from wind erosion at stockpiles;
- Particulate emissions from vehicle entrainment along the unpaved access and on-site roads; and
- Particulate emissions from vehicles' exhaust.

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

A summary of emission sources quantified, estimation techniques applied, and source input parameters is included in Table 13. A summary of estimated particulate emissions in tonnes per annum (t/a) associated with the proposed operations is provided in Table 14. The charts showing the unmitigated and design mitigated source group percentage contributions to the total annual particulate emissions are shown in Figure 8 and Figure 9, respectively.

The source group that was determined will contribute the most to the annual $PM_{2.5}$ emissions for unmitigated operations is crushing and screening, followed by underground operations (ventilation shaft). For the unmitigated annual PM_{10} emissions, vehicles travelling along unpaved roads was estimated to become the main contributor, followed by underground operations (ventilation shaft). The source group that was determined will contribute the most to the annual TSP emissions for unmitigated operations is crushing and screening, followed by vehicles travelling along unpaved roads.

For the operations with design mitigation measures implemented the main contributor to total annual $PM_{2.5}$ emissions was estimated to be underground operations (ventilation shaft) followed by crushing and screening. The source group that was determined will contribute the most to the annual PM_{10} emissions for design mitigated operations is underground operations (ventilation shaft) followed by crushing and screening. The source group that was determined will contribute the most to the annual TSP emissions for design mitigated operations is crushing and screening, followed by vehicles travelling along unpaved roads.

Table 13: Emission estimation techniques and parameters

Source Group	Emission Estimation Technique	Input Parameters and Activities
Underground operations (ventilation shaft)	South African Occupational Exposure Limits (OEL) for $PM_{2.5}$ and PM_{10}	3 mg/m³ for $PM_{2.5}$ and 10 mg/m³ for PM_{10} It was assumed that TSP is the same as PM_{10}. The maximum volumetric flow rate of 300 m³/s was provided; exit tip diameter of 5.4 m was provided; exit velocity 13.1 m/s was calculated; exit temperature of 32°C was provided; and release height of 8 m assumed. Hours of operation: 365 days per year, 24 hours per day.
Materials handling	US EPA miscellaneous transfer and conveying emission factor equation (US EPA, 2006) $EF = k \cdot 0.0016 \cdot \left(\frac{U}{2.3}\right)^{1.3} \cdot \left(\frac{M}{2}\right)^{-1.4}$ (1) EF is the emission factor in kg/tonne material handled k is the particle size multiplier (k_{PM10} – 0.35, $k_{PM2.5}$ – 0.053) U is the average wind speed in m/s M is the material moisture content in %	Handling of materials at the shaft, conveyor transfer points, crushed ore stockpile, lumpy and fine product stockpiles. Run of mine ore: 182 tonnes per hour (t/h); moisture content of 4% and average wind speed of 3.88 m/s. Lumpy product: 145 t/h; moisture content of 4.39% and average wind speed of 3.88 m/s. Fine product: 36 t/h; moisture content of 4.37% and average wind speed of 3.88 m/s. Hours of operation: 264 days per year, 20 hours per day (03h00-23h00). Design mitigation: 70% control efficiency (CE) at conveyors for enclosure and 50% CE at stockpiles for water sprays.
Crushing and screening	NPI single valued emission factors for low moisture ore (ADE, 2012) TSP – 0.2 kg/tonne (primary crushing), 0.6 kg/tonne (secondary crushing), 1.4 kg/tonne (tertiary crushing), 0.08 kg/tonne (screening) PM_{10} – 0.02 kg/tonne (primary crushing), 0.04 kg/tonne (secondary crushing), 0.08 kg/tonne (tertiary crushing), 0.06 kg/tonne (screening) $PM_{2.5}$ – *assumed* to be 50% of PM_{10} resulting in 0.01 kg/tonne (primary crushing), 0.02 kg/tonne (secondary crushing), 0.04 kg/tonne (tertiary crushing), 0.03 kg/tonne (screening)	Primary crushing rate ~ 182 t/h Screening rate ~ 182 t/h Secondary crushing rate ~ 83 t/h Hours of operation: 264 days per year, 20 hours per day (03h00-23h00). Design mitigation: water sprays with a resultant CE of 50% (ADE, 2012).
Wind erosion	NPI single valued emission factors (ADE, 2012) TSP – 0.4 kg/ha-h PM_{10} – 0.2 kg/ha-h $PM_{2.5}$ – 0.1 kg/ha-h (assumed)	Waste stockpile, topsoil stockpile, crushed ore stockpile and product stockpiles. Hours of emission: When wind speed ≥ 5 m/s. Design mitigation: water sprays resulting in a CE of 40% (ADE, 2012).

Source Group	Emission Estimation Technique	Input Parameters and Activities
Vehicle entrainment along unpaved roads	US EPA emission factor equation (US EPA, 2006a) $EF = k \cdot \left(\frac{s}{12}\right)^a \cdot \left(\frac{W}{3}\right)^b \cdot 281.9$ (2) Where EF is the emission factor in g/VKT k is the particle size multiplier (k_{TSP} – 4.9, k_{PM10} – 1.5, $k_{PM2.5}$ – 0.15) a is a constant (k_{TSP} – 0.7, k_{PM10} – 0.9, $k_{PM2.5}$ – 0.9) b is a constant (k_{TSP} – 0.45, k_{PM10} – 0.45, $k_{PM2.5}$ – 0.45) s is the road surface material silt content in % W is the average weight vehicles in tonnes	Transport activities included the transport of product along the unpaved roads. Total VKT were calculated from the road length, vehicle payload and production rate. Vehicle weights assumed: empty 21.22 t; full 56 t; payload 34.78 t; average weight 49.22 t. The unpaved road surface material silt content is 8.8% based on the previous study (Liebenberg-Enslin & Gresse, 2013). Hours of operation: 365 days per year,16 hours per day (06h00-23h00). Design mitigation: level 2 watering with a CE of 75% (ADE, 2012).

Table 14: Summary of estimated particulate emissions in tonnes per annum

Source Group	Estimated UNMITIGATED Particulate Emissions (t/a)			Estimated MITIGATED Particulate Emissions (t/a)		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Underground operations (ventilation shaft)	28.4	94.6	94.6	28.4	94.6	94.6
Materials handling	0.290	1.91	4.05	0.109	0.719	1.52
Crushing and screening	47.2	94.3	532	23.6	47.2	266
Wind erosion	1.88	3.76	7.51	1.13	2.25	4.51
Vehicles travelling along unpaved roads	12.4	124	432	3.11	31.1	108
Total	90.1	319	1 070	56.3	176	474

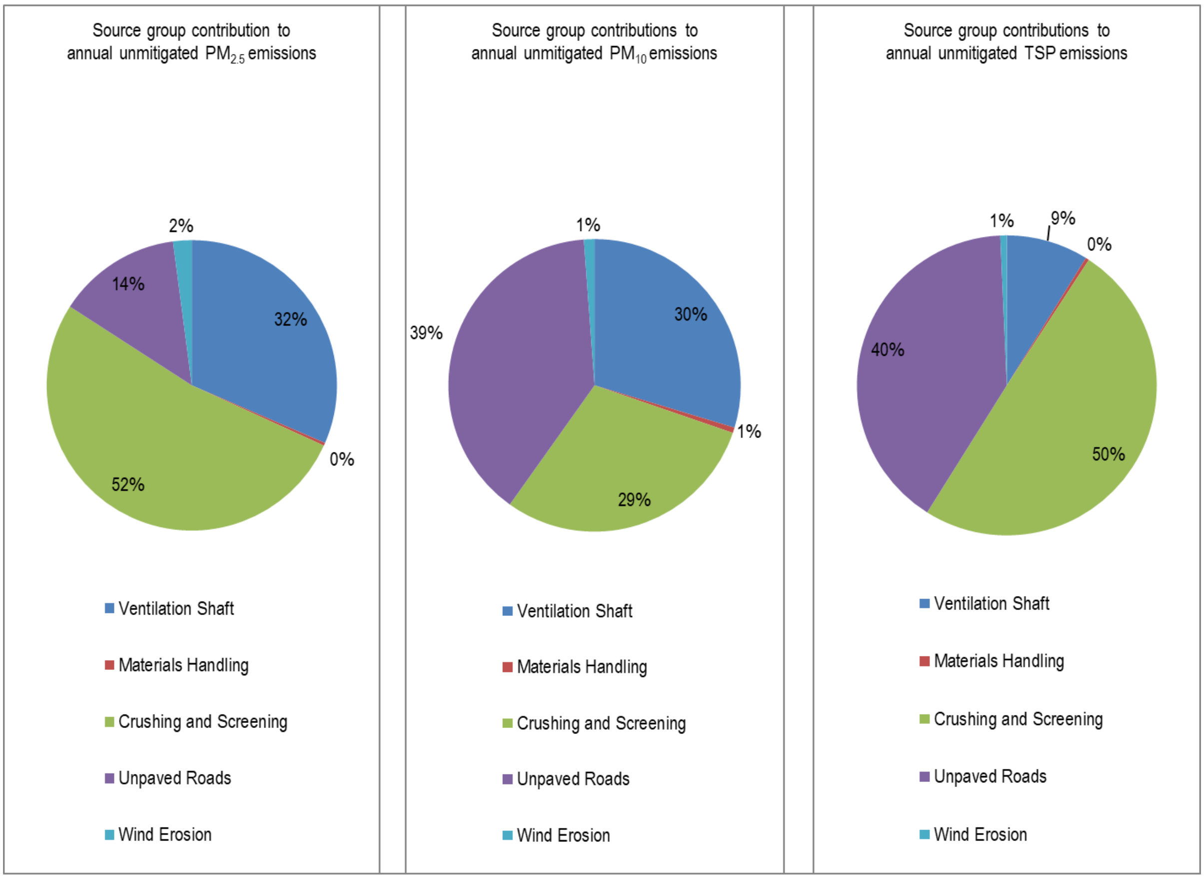

Figure 8: Source group contributions to annual unmitigated particulate emissions

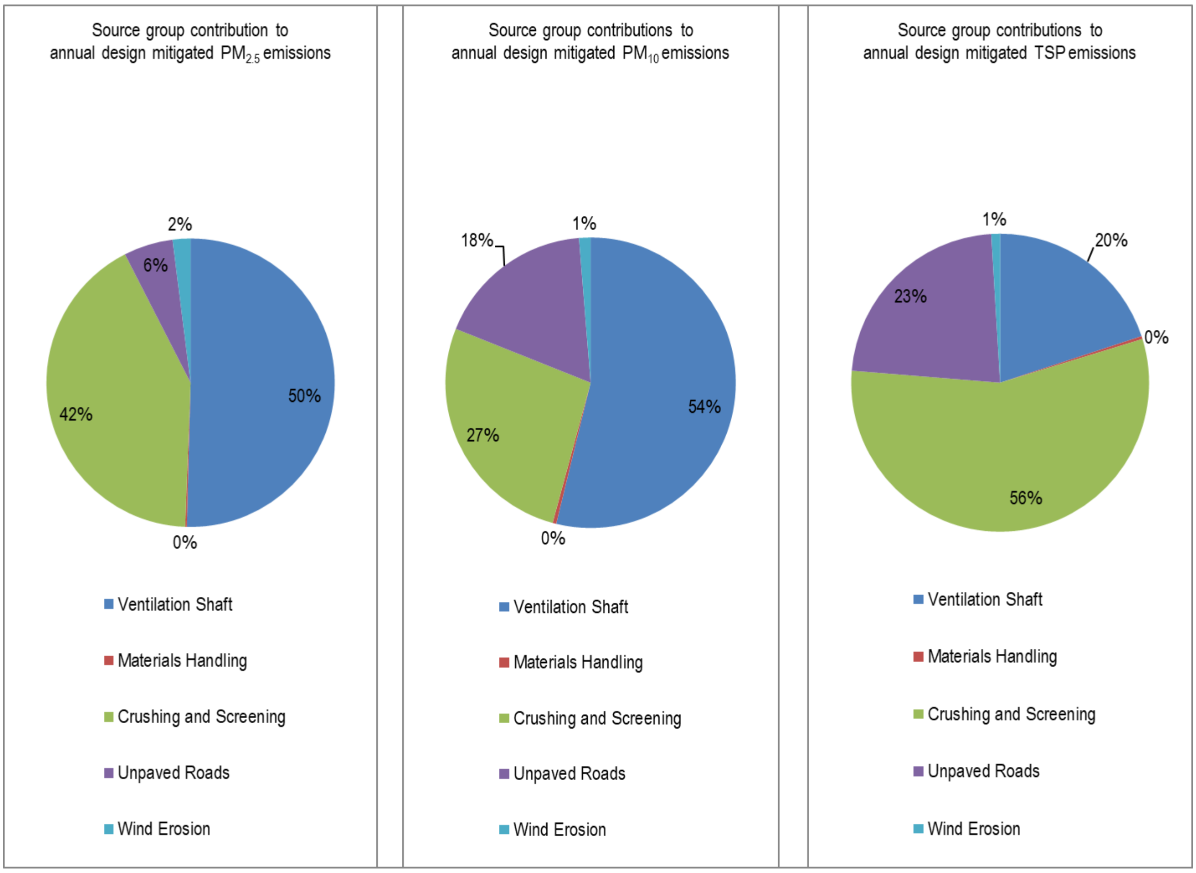

Figure 9: Source group contributions to annual design mitigated particulate emissions

7.2 Assessment of Impact – Proposed Mn48 Operations

Simulation results of particulate emissions for the proposed operations are discussed in this section.

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

Without any mitigation measures applied the simulated annual average $PM_{2.5}$ concentrations exceed the current NAAQS of 20 µg/m^3 and the future NAAQS of 15 µg/m^3 off-site but not at any AQSRs (Figure 10). The current 24-hour NAAQS (4 days of exceedance of 40 µg/m^3) are exceeded off-site but not at any AQSRs (Figure 11) without mitigation measures applied. The future 24-hour NAAQS (4 days of exceedance of 25 µg/m^3) are exceeded off-site and at two AQSRs (Figure 11) without mitigation measures applied to operations, these two AQSRs being the farmsteads west of the proposed operations, along the R380. Since the simulated results without any mitigation measures applied show that the future short-term NAAQS are exceeded, there is a potential risk to human health at these receptors as a result of the proposed operations.

With the design mitigation measures applied the simulated annual average $PM_{2.5}$ concentrations exceed the current NAAQS of 20 µg/m^3 and the future NAAQS of 15 µg/m^3 off-site but not at any AQSRs (Figure 12). The current 24-hour NAAQS (4 days of exceedance of 40 µg/m^3) are exceeded off-site but not at any AQSRs (Figure 13) with the design mitigation measures applied. The future 24-hour NAAQS (4 days of exceedance of 25 µg/m^3)

are exceeded off-site but not at any AQSRs (Figure 13) with the design mitigation measures applied to operations. Since the simulated results with the design mitigation measures applied show that the NAAQS are exceeded at any AQSRs, there is no significant risk to human health at any receptors as a result of the proposed operations.

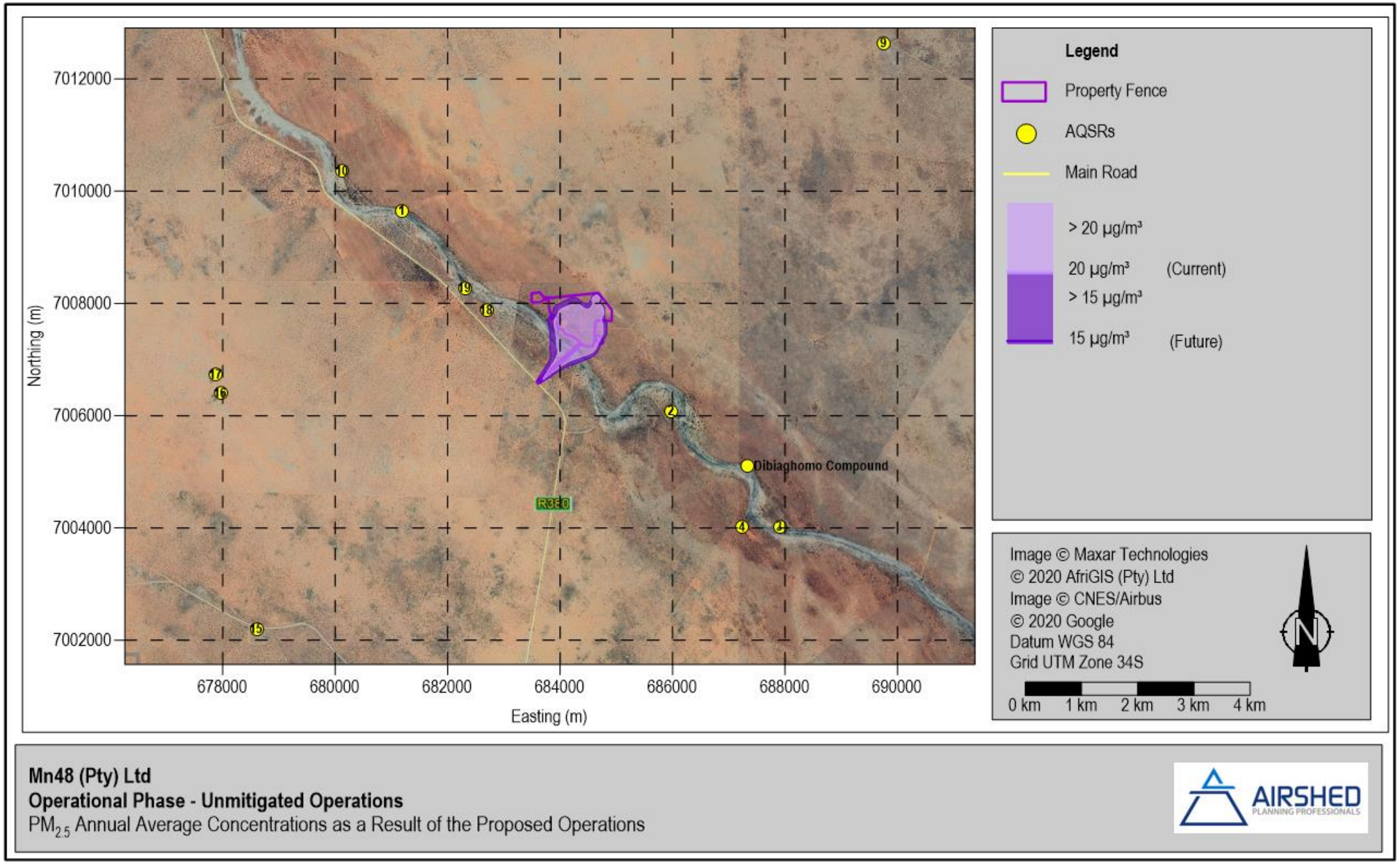

Figure 10: Simulated annual average $PM_{2.5}$ concentrations as a result of unmitigated operations

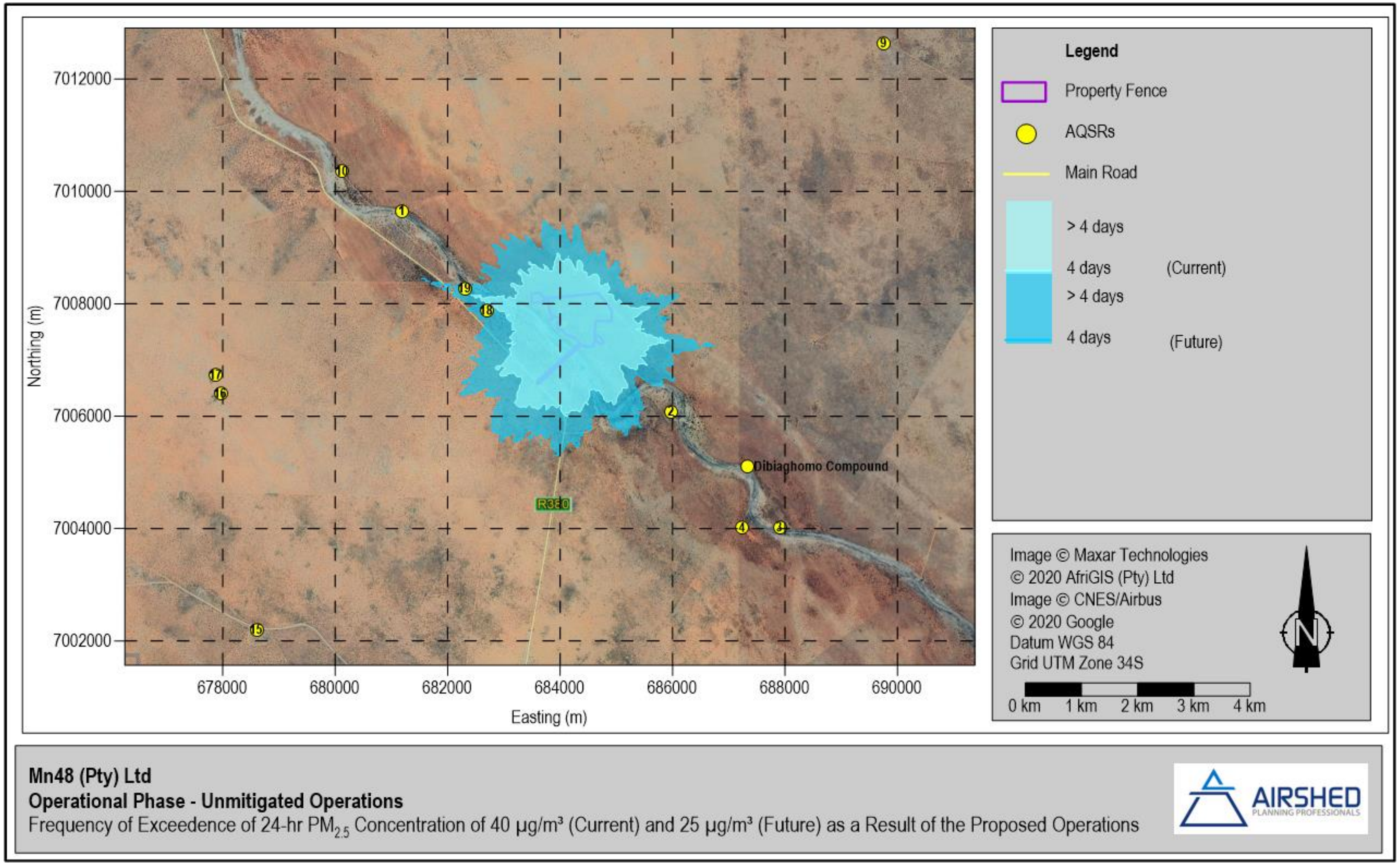

Figure 11: Simulated area of exceedance of the 24-hour $PM_{2.5}$ NAAQS as a result of unmitigated operations

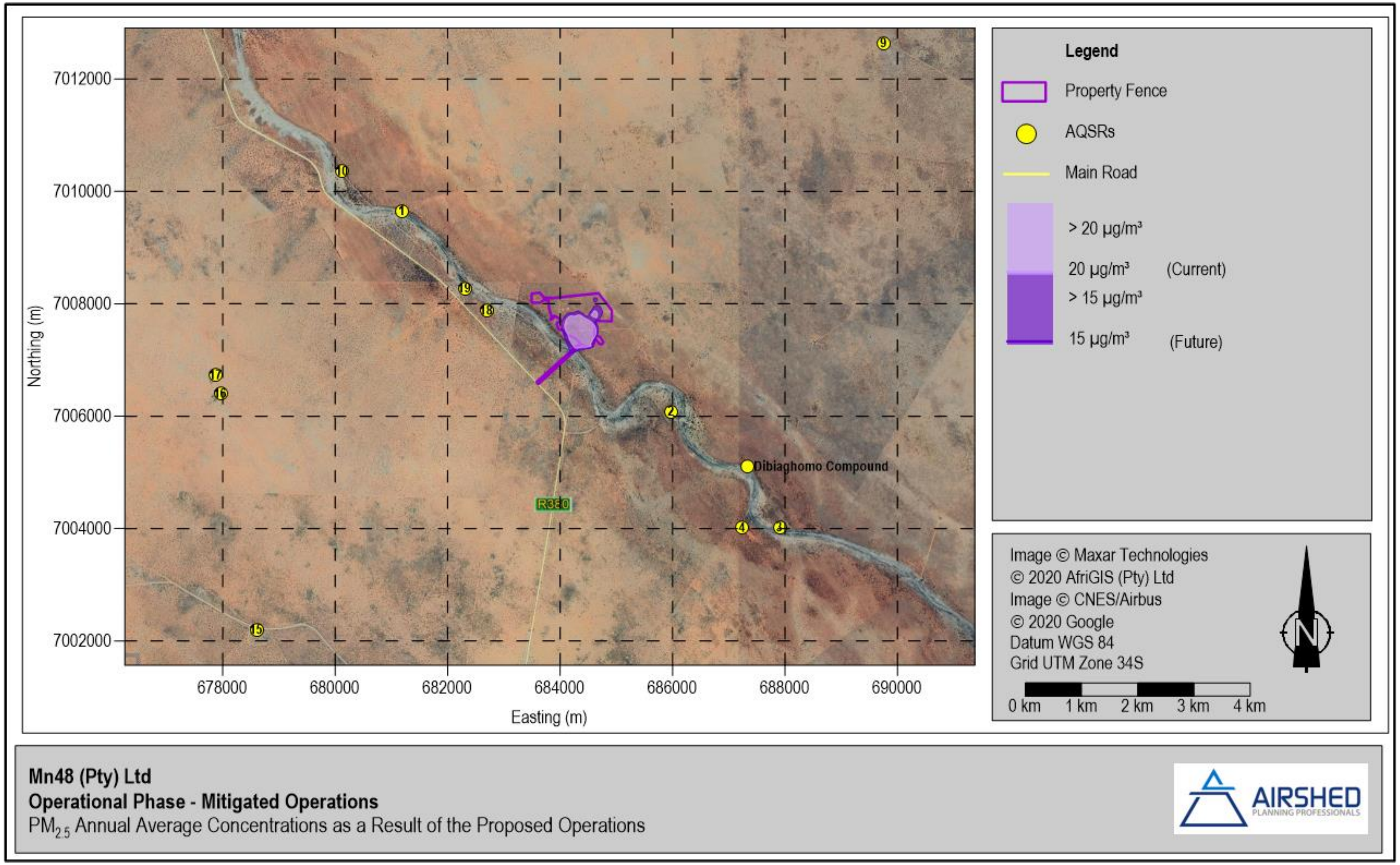

Figure 12: Simulated annual average $PM_{2.5}$ concentrations as a result of operations with design mitigation measures applied

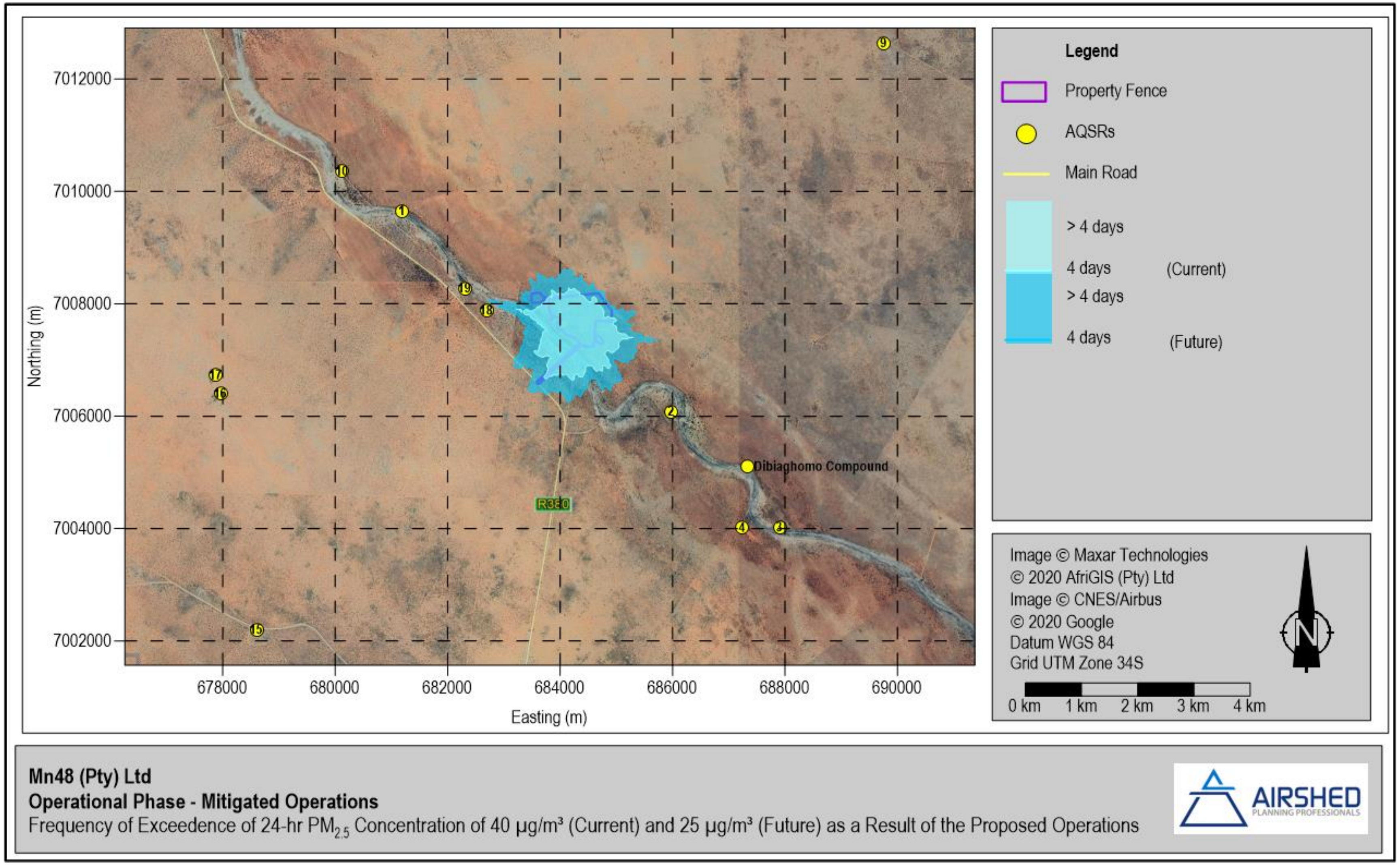

Figure 13: Simulated area of exceedance of the 24-hour $PM_{2.5}$ NAAQS as a result of operations with design mitigation measures applied

7.2.2 Inhalable particulate matter (PM_{10})

Simulated annual average PM_{10} concentrations as a result of unmitigated operations exceed the NAAQS of 40 µg/m^3 off-site but not at any AQSRs (Figure 14). The 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) are exceeded off-site and at two AQSRs (Figure 15) without mitigation measures applied to the operations, these two AQSRs being the farmsteads west of the proposed operations, along the R380. Since the simulated results without any mitigation measures applied show that the short-term NAAQS are exceeded, there is a potential risk to human health at these receptors as a result of the proposed operations.

Simulated annual average PM_{10} concentrations as a result of the design mitigated operations exceed the NAAQS of 40 µg/m^3 off-site but not at any AQSRs (Figure 16). The 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) are exceeded off-site but not at any AQSRs (Figure 17) with design mitigation measures applied to the operations. Since the simulated results with design mitigation measures applied show that the NAAQS are not exceeded at AQSRs, there is no significant risk to human health at these receptors as a result of the proposed operations.

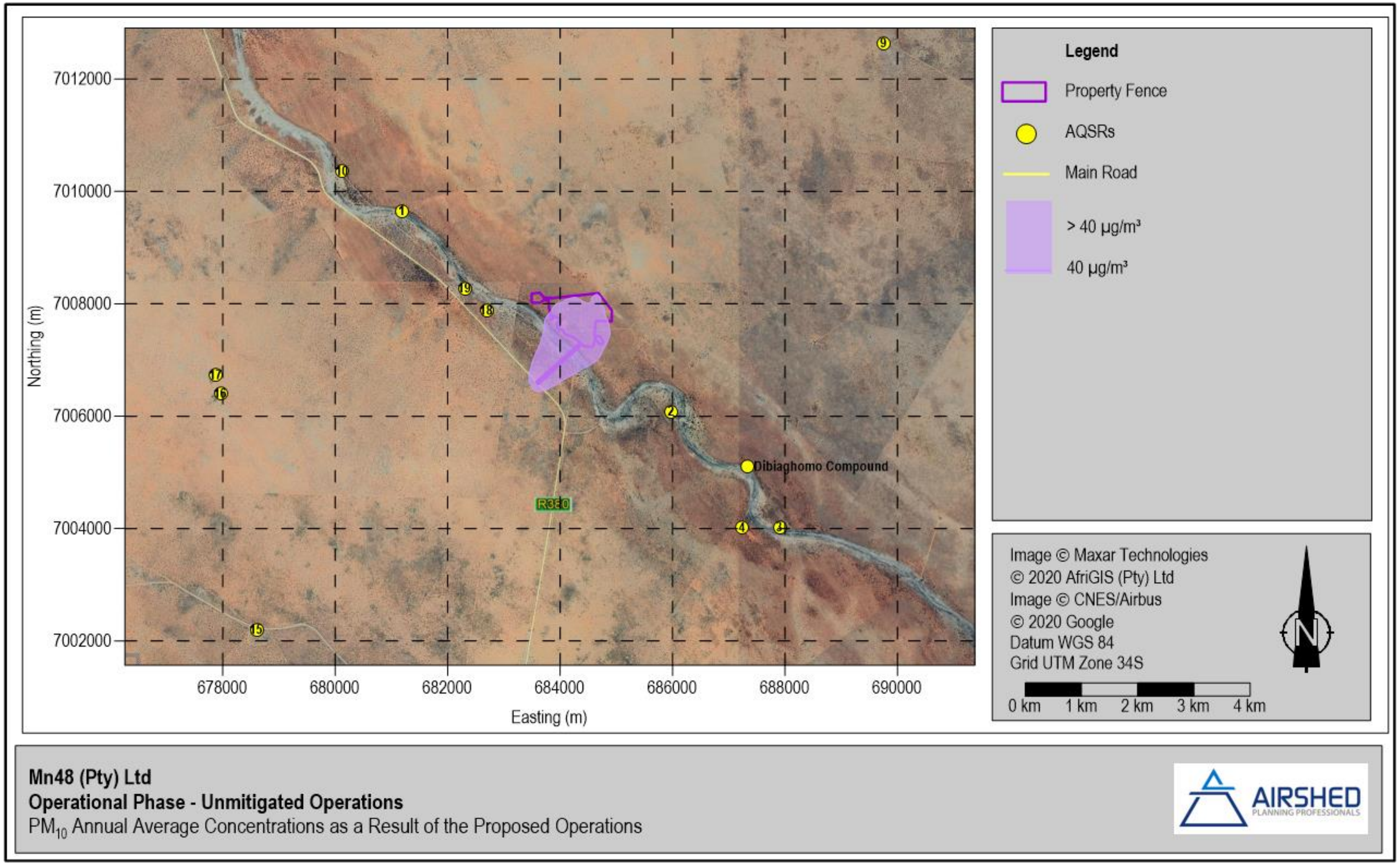

Figure 14: Simulated annual average PM_{10} concentrations as a result of unmitigated operations

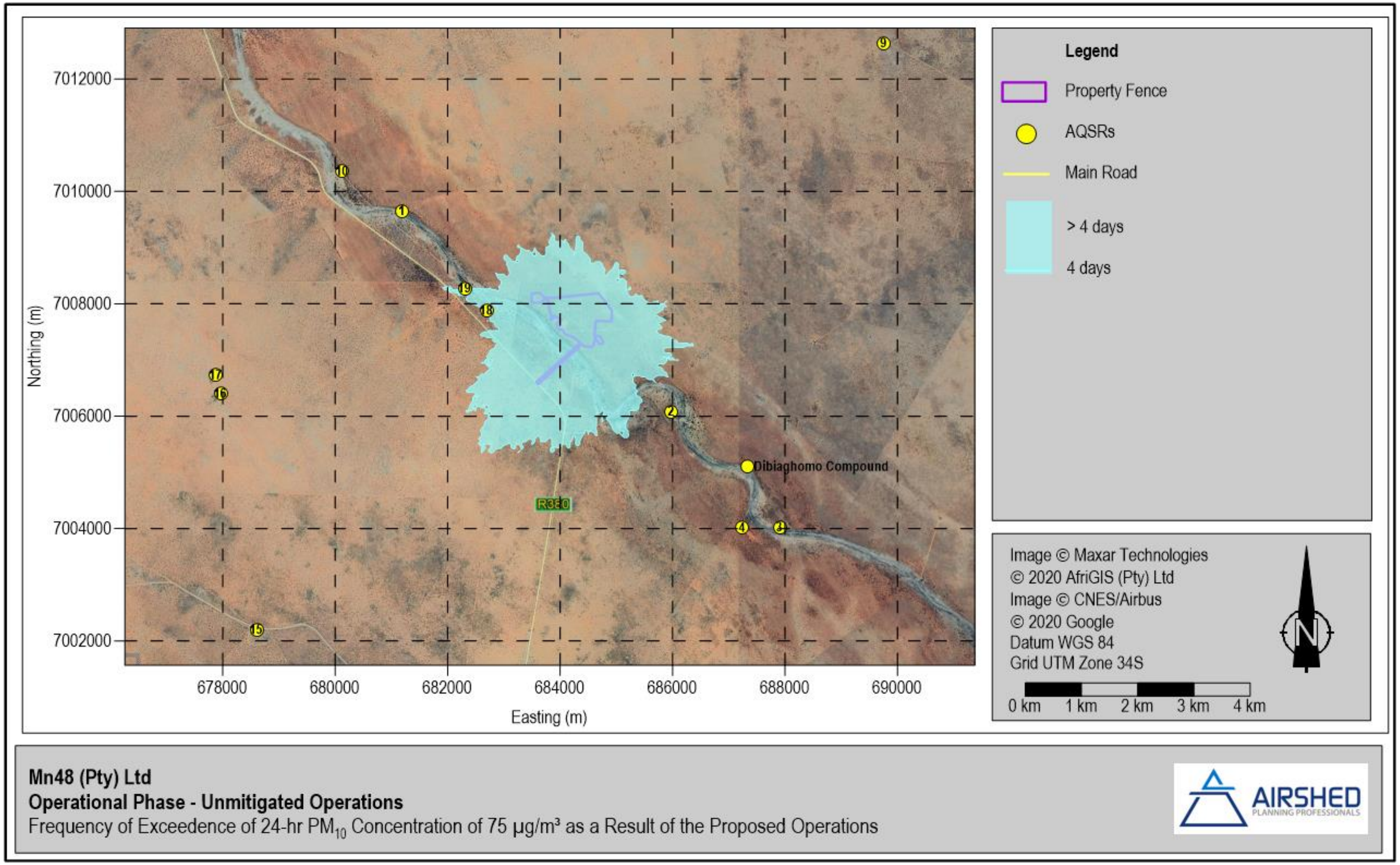

Figure 15: Simulated area of exceedance of the 24-hour PM_{10} NAAQS as a result of unmitigated operations

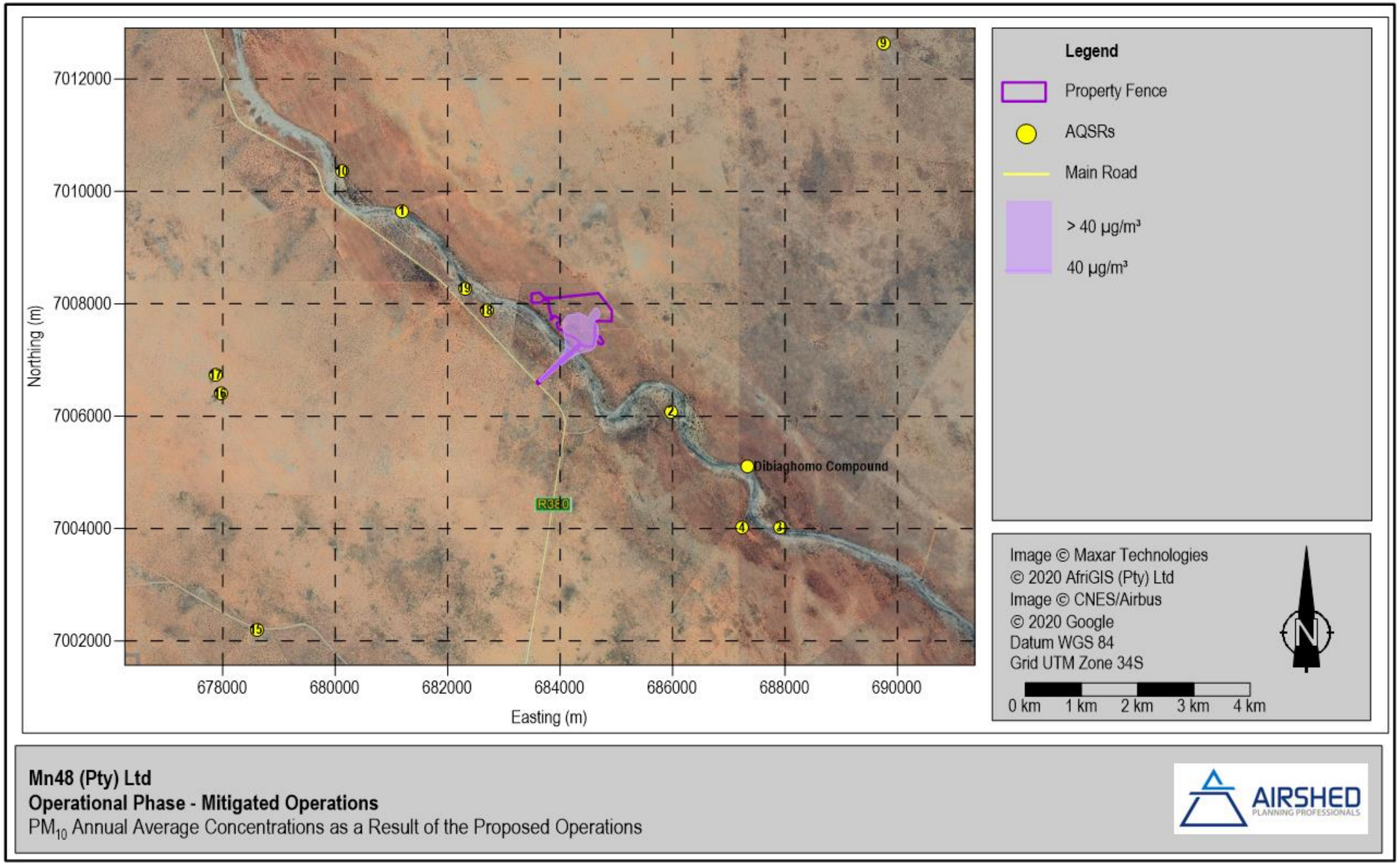

Figure 16: Simulated annual average PM_{10} concentrations as a result of operations with design mitigation measures applied

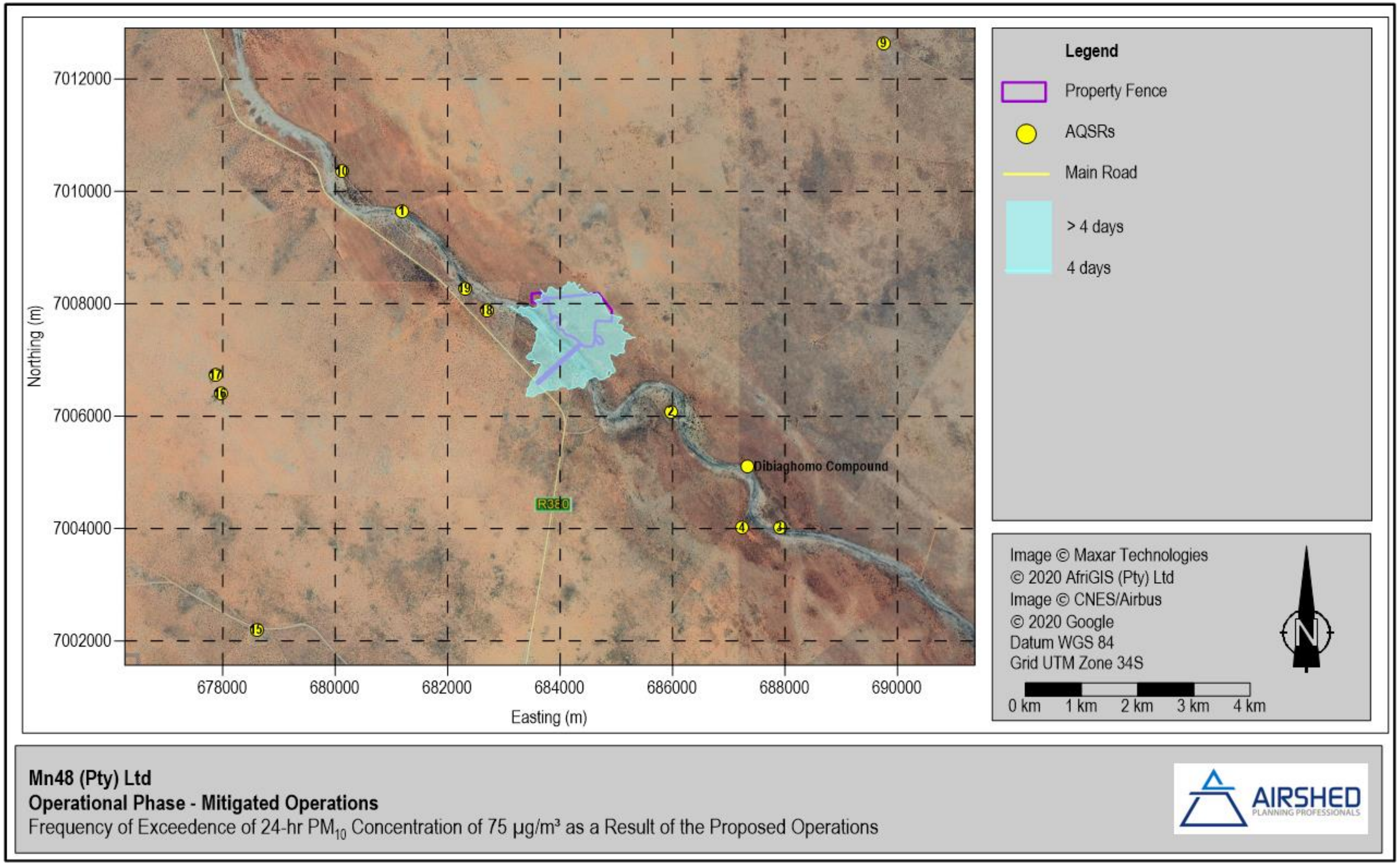

Figure 17: Simulated area of exceedance of the 24-hour PM_{10} NAAQS as a result of operations with design mitigation measures applied

7.2.3 Fallout Dust

The simulated daily average dustfall rates without mitigation applied to the operations exceed the NDCR limit for non-residential areas (1 200 mg/m²-day) but does not exceed the NDCR limit for residential areas (600 mg/m²-day) at any AQSRs and are below 400 mg/m²-day at all agricultural areas (Figure 18).

The simulated daily average dustfall rates with design mitigation measures applied to the proposed operations exceed the NDCR limit for non-residential areas (1 200 mg/m²-day) but does not exceed the NDCR limit for residential areas (600 mg/m²-day) at any AQSRs and are below 400 mg/m²-day at all agricultural areas (Figure 19).

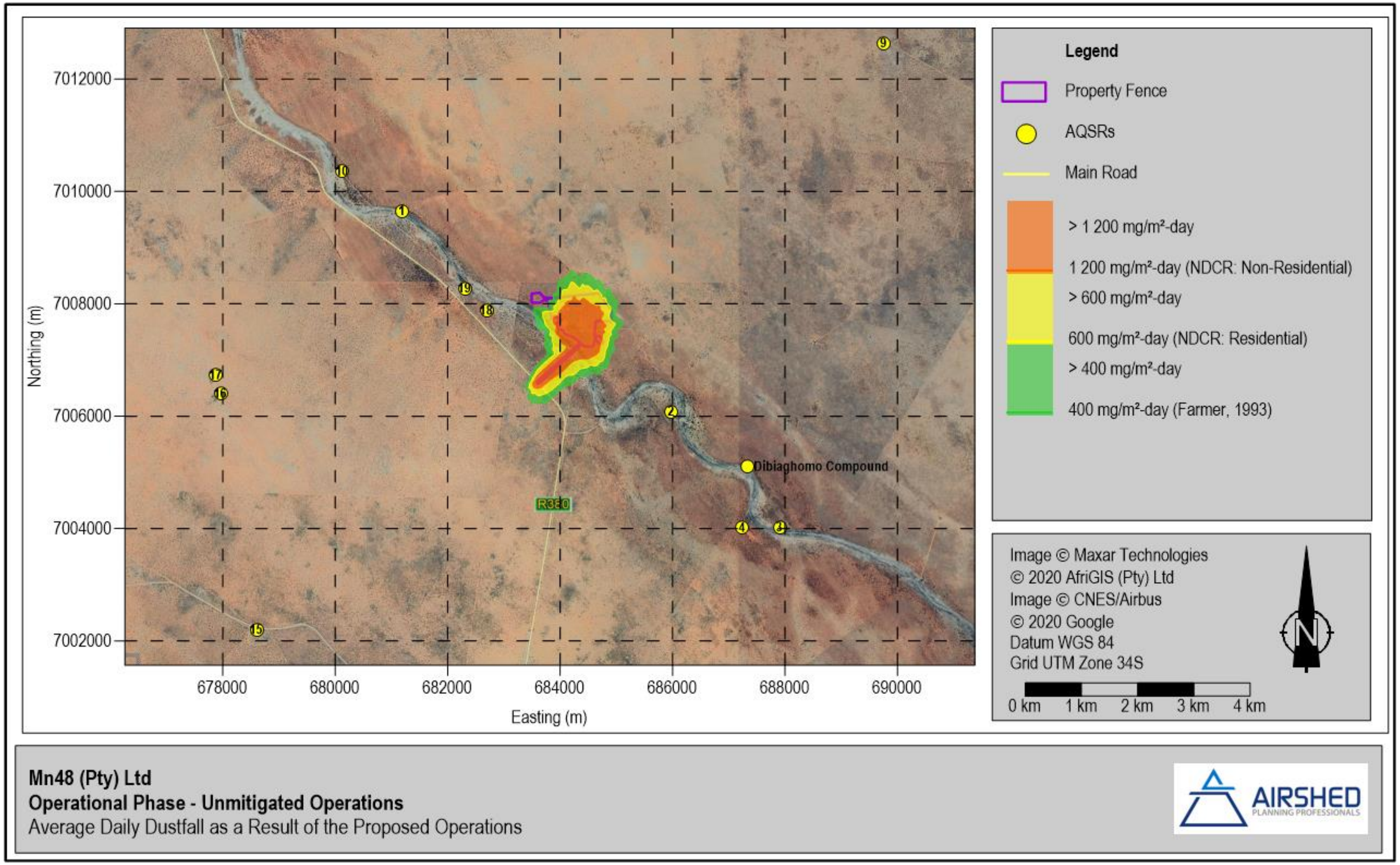

Figure 18: Simulated average daily dustfall rates as a result of unmitigated operations

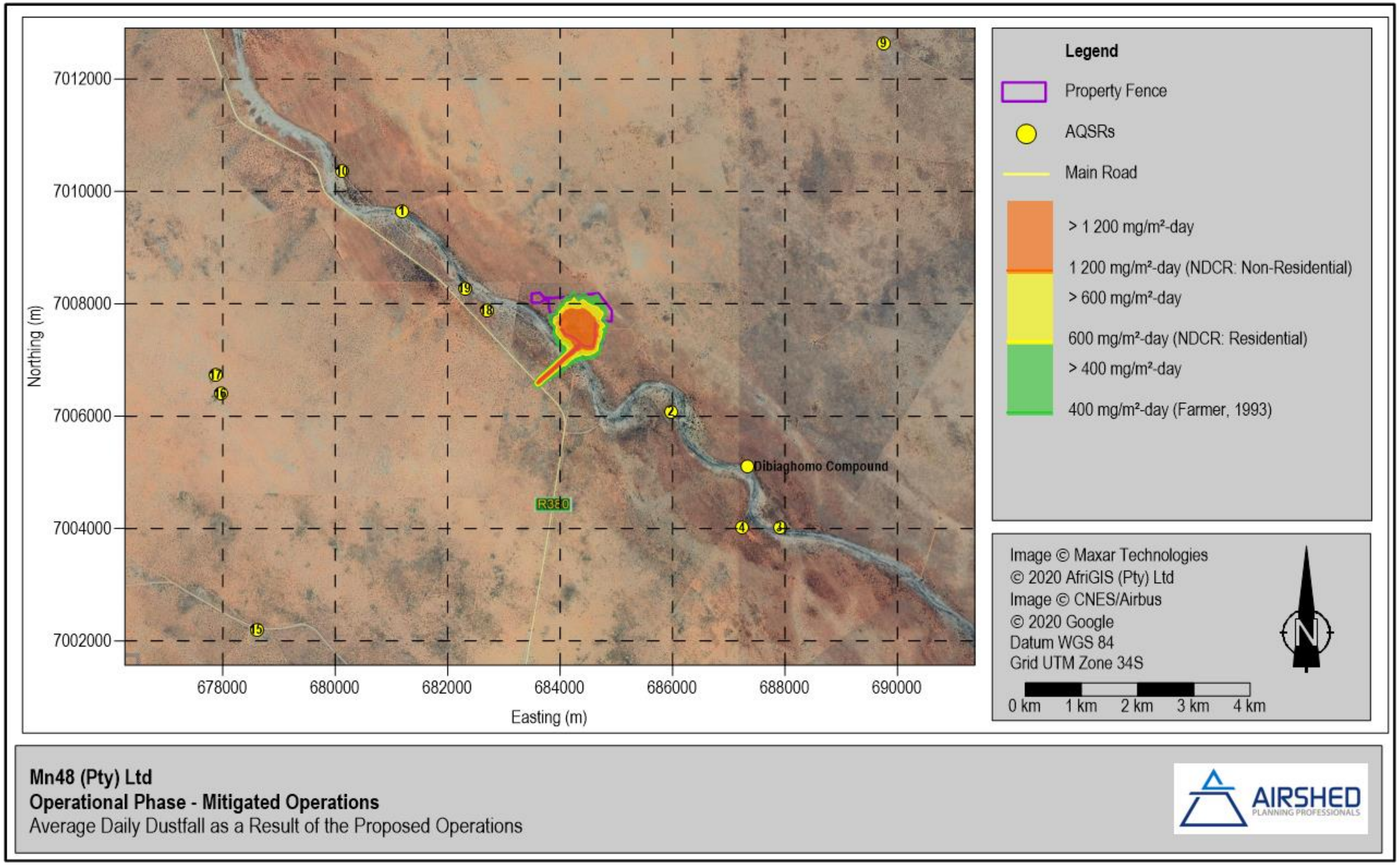

Figure 19: Simulated average daily dustfall rates as a result of operations with design mitigation measures applied

7.2.4 Manganese (Mn)

Potential Mn ground-level concentrations as a result of the project operations have been included in this study for comparison purposes using the same methodology as the previous study (Liebenberg-Enslin & Gresse, 2013), except with a higher Mn content. It must be noted that at the time of the previous study there were and there still are no measured values for the Mn content for the individual sources included (being a proposed operation) 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 product along the unpaved road is multiplied by 0.48 based on the Mn content of the ore bearing rock.

Without any mitigation measures applied the simulated annual average Mn concentrations exceed the WHO GV of 0.15 µg/m^3 off-site and at numerous AQSRs (Figure 20). Since the simulated results without any mitigation measures applied show that the WHO GV is exceeded at numerous receptors, there is a potential risk to human health at these receptors as a result of the proposed operations.

With the design mitigation measures applied the simulated annual average Mn concentrations exceed the WHO GV of 0.15 µg/m^3 off-site and at AQSRs (Figure 21). Since the simulated results without design mitigation measures applied show that the WHO GV is exceeded at receptors, there is a potential risk to human health at these receptors as a result of the proposed operations.

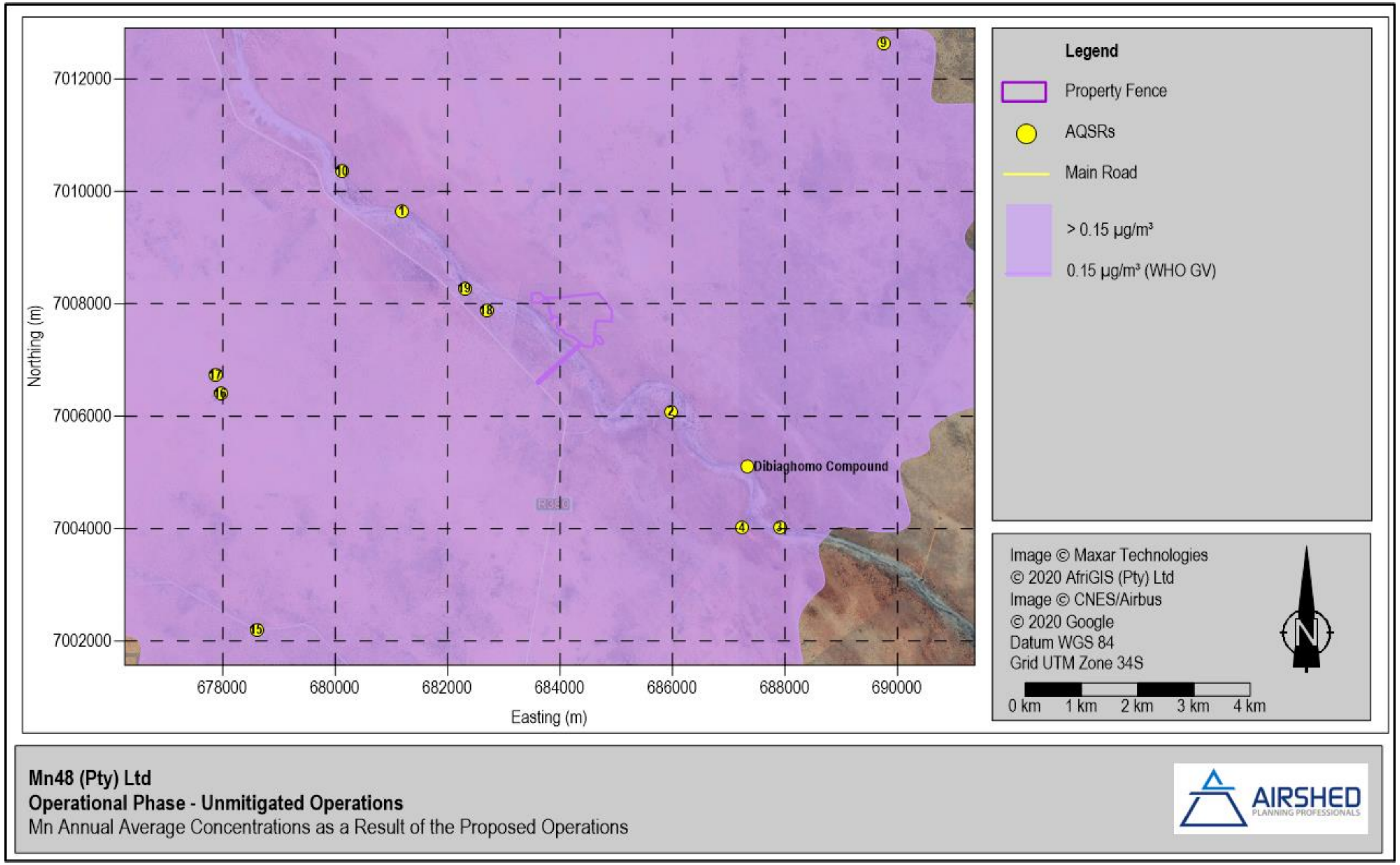

Figure 20: Simulated annual average Mn concentrations as a result of unmitigated operations

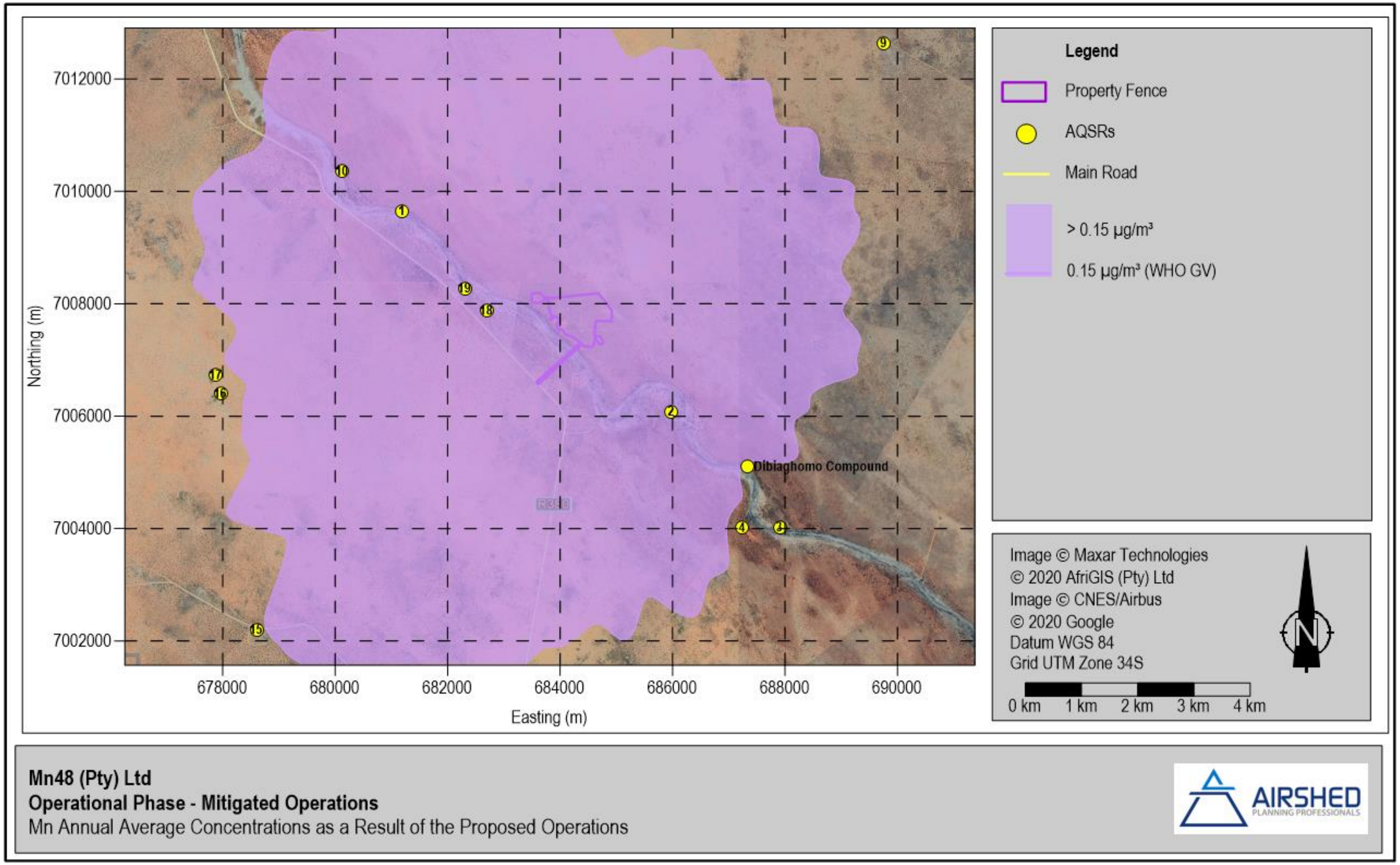

Figure 21: Simulated annual average Mn concentrations as a result of operations with design mitigation measures applied

7.3 Impact Significance Rating – Proposed Mn48 Operations

The main pollutants of concern were determined to be PM (including $PM_{2.5}$, PM_{10} and TSP). Non-compliance of $PM_{2.5}$ and PM_{10} concentrations could result in human health impacts. The potential significance of the impacts based the quantitative assessment of $PM_{2.5}$, PM_{10} and dustfall rates (TSP) during the operational phase is discussed below. The differences between the previous study (Liebenberg-Enslin & Gresse, 2013) include a change in the surface infrastructure layout and mitigation measures applied i.e. the previous studies mitigated scenario is the most comparable to the design mitigated scenario included in this study. To enable a comparison to be made between the previous study (Liebenberg-Enslin & Gresse, 2013) and this study the previous SLR rating methodology (section 17.1) was used in this section.

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

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

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

$PM_{2.5}$ and PM_{10} concentrations as a result of unmitigated operations are not within compliance off-site and at two AQSRs over the short-term. It is unlikely that the long-term and short-term NAAQS will be exceeded at AQSRs as a result of the project with design mitigation; however, the NAAQS are still expected to be exceeded in areas in which they are applicable (off-site). The annual Mn concentrations could exceed the WHO GV (with and without mitigation). The proposed operations are proposed to last for 19 years. The significance rating is “medium” without mitigation measures applied and with design mitigation measures applied (Table 15).

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

It is unlikely that the NDCR limit for residential areas will be exceeded at AQSRs (with and without mitigation) as a result of the project. The proposed operations are proposed to last for 19 years. The significance rating is “medium” without and with design mitigation measures applied (Table 16).

Table 15: Health risk impact significance summary table for the proposed operations

Air Quality	Description	Rating
Project activity or issue	Proposed operations	N/A
Potential impact	Increased health risk at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in $PM_{2.5}$, PM_{10} and Mn concentrations at AQSRs	-
	Significance Before Mitigation	
Severity/Nature	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action. Irreplaceable loss of resources.	H
Duration	Reversible over time. Life of the project. Medium term.	M
Extent	Fairly widespread – Beyond the site boundary. Local.	M
Consequence	Medium.	
Probability	Definite.	H
Significance	**It should have an influence on the decision unless it is mitigated.**	**Medium**
	Significance After Design Mitigation	
Intensity	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.	M
Duration	Reversible over time. Life of the project. Medium term.	M
Extent	Fairly widespread – Beyond the site boundary. Local.	M
Consequence	Medium.	
Probability	Possible/ frequent.	M
Significance	**It should have an influence on the decision unless it is mitigated.**	**Medium**
Design mitigation measures	Materials Handling - 70% CE at conveyors for enclosure and 50% CE at stockpiles for water sprays. Crushing and screening - water sprays with a resultant CE of 50%. Vehicles travelling on unpaved roads – 75% CE for level 2 watering.	N/A

Air Quality	Description	Rating
	Wind erosion - water sprays with a resultant CE of 40%.	
Potential additional mitigation measures	Crushing and screening – enclosure and water sprays with a resultant CE of 85%. Vehicles travelling on unpaved roads – up to 90% CE for spraying of roads containing with water and additives such as salts, vegetable oils, molasses, synthetic polymers, mulches, asphalt emulsion or lignin products.	N/A

Notes: Although the significance rating does not change for the "increased health risk at AQSRs" between unmitigated and design mitigated the extent of impacted area does reduce with design mitigation applied.

Table 16: Nuisance impact significance summary table for the proposed operations

Air Quality	Description	Rating
Project activity or issue	Proposed operations	N/A
Potential impact	Nuisance dustfall rates at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in dustfall rates at AQSRs	-
	Significance Before Mitigation	
Intensity	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. Limited loss of resources.	L
Duration	Reversible over time. Life of the project. Medium term.	M
Extent	Fairly widespread – Beyond the site boundary. Local.	M
Consequence	Low.	
Probability	Possible/ frequent.	M
Significance	**It should have an influence on the decision unless it is mitigated.**	**Medium**
	Significance After Mitigation	
Intensity	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. Limited loss of resources.	L
Duration	Reversible over time. Life of the project. Medium term.	M

Air Quality	Description	Rating
Extent	Fairly widespread – Beyond the site boundary. Local.	M
Consequence	Low.	
Probability	Possible/ frequent.	M
Significance	**It should have an influence on the decision unless it is mitigated.**	**Medium**
Design mitigation measures	Materials Handling - 70% CE at conveyors for enclosure and 50% CE at stockpiles for water sprays. Crushing and screening - water sprays with a resultant CE of 50%. Vehicles travelling on unpaved roads – 75% CE for level 2 watering. Wind erosion - water sprays with a resultant CE of 40%.	N/A
Potential additional mitigation measures	Crushing and screening – enclosure and water sprays with a resultant CE of 85%. Vehicles travelling on unpaved roads – up to 90% CE for spraying of roads containing with water and additives such as salts, vegetable oils, molasses, synthetic polymers, mulches, asphalt emulsion or lignin products.	N/A

Notes: Although the significance rating does not change for the “nuisance dustfall rates at AQSRs” between unmitigated and design mitigated the extent of impacted area does reduce with design mitigation applied.

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

- infrastructure removal/demolition;
- topsoil recovered from stockpiles for rehabilitation and re-vegetation of surroundings;
- vehicle entrainment on unpaved road surfaces during rehabilitation. Once that is done, vehicle activity associated with Mn48 should cease; and
- exhaust emissions from vehicles utilised during the closure phase. Once that is done, vehicle activity associated with Mn48 should cease;

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

8.2 Assessment of Impact

Insufficient data was available for the decommissioning and closure phases 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;
- C2: Nuisance dustfall rates associated with decommissioning activities;

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;
- D2: Nuisance dustfall rates associated with closure activities;

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

8.2.1 Potential Impact C1: Potential Impact on Human Health from Pollutant Concentrations Associated with Decommissioning Activities

The sources of emissions would include the demolition of infrastructure and removal of material; topsoil reclaiming and covering of exposed areas; re-vegetation; and the operation of mechanical equipment. It is unlikely that the long-term and short-term NAAQS will be exceeded at AQSRs. The decommissioning operations are likely to last for a few years but impacts at AQSRs are likely to be intermittent. The significance rating is "very low" without mitigation applied and "insignificant" with mitigation measures applied (Table 17).

8.2.2 Potential Impact C2: Nuisance Dustfall Rates Associated with Decommissioning Activities

The sources of emissions would include the demolition of infrastructure and removal of material; topsoil reclaiming and covering of exposed areas; re-vegetation; and the operation of mechanical equipment. It is probable that the NDCR limit for residential areas will not be exceeded at AQSRs (with and without mitigation). The decommissioning operations are likely to last for a few years but impacts at AQSRs are likely to be intermittent. The significance rating is "very low" without mitigation applied and "insignificant" with mitigation measures applied (Table 18).

8.2.3 Potential Impact D1: Impaired Human Health from Pollutant Concentrations Associated with Closure Activities

The sources of emissions would include the site inspections and where necessary the addition of topsoil and vegetation; and the operation of mechanical equipment. It is unlikely that the long-term and short-term NAAQS will be exceeded at AQSRs (with and without mitigation). The operations will likely occur for less more than 5 year but less than 10 years but impacts at AQSRs are likely to be intermittent. The significance rating is "insignificant" without and with design mitigation measures applied (Table 19).

8.2.4 Potential Impact D2: Nuisance Dustfall Rates Associated with Closure Activities

The sources of emissions would include the site inspections and where necessary the addition of topsoil and vegetation; and the operation of mechanical equipment. It is probable that the NDCR limit for residential areas will not be exceeded at AQSRs (with and without mitigation). The operations will likely occur for less more than 5 year but less than 10 years but impacts at AQSRs are likely to be intermittent. The significance rating is "insignificant" without and with design mitigation measures applied (Table 20).

Table 17: Health risk impact significance summary table for the decommissioning operations

Air Quality	Description	Rating
Project activity or issue	Decommissioning	N/A
Potential impact	Increased health risk at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in $PM_{2.5}$ and PM_{10} concentrations at AQSRs	-
	Significance Before Mitigation	
Intensity	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.	L
Duration	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.	L
Extent	A part of the site/property.	VL
Consequence	Very Low.	
Probability	Conceivable.	L
Significance	**It will not have an influence on the decision. Does not require any mitigation.**	**Very Low**
	Significance After Mitigation	
Intensity	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.	VL
Duration	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.	L
Extent	A part of the site/property.	VL
Consequence	Low.	
Probability	Conceivable.	L
Significance	**Inconsequential, not requiring any consideration.**	**Insignificant**
Potential mitigation measures	• Reduction of fugitive PM emissions through the watering of roads, stockpiles and inactive open areas and the use of screens.	N/A

Air Quality	Description	Rating
	• Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	

Table 18: Nuisance impact significance summary table for the decommissioning operations

Air Quality	Description	Rating
Project activity or issue	Decommissioning	N/A
Potential impact	Nuisance dustfall rates at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in dustfall rates at AQSRs	-
	Significance Before Mitigation	
Intensity	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.	L
Duration	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.	L
Extent	A part of the site/property.	VL
Consequence	Very Low.	
Probability	Conceivable.	L
Significance	**It will not have an influence on the decision. Does not require any mitigation.**	**Very Low**
	Significance After Mitigation	
Intensity	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.	VL
Duration	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.	L
Extent	A part of the site/property.	VL
Consequence	Low.	

Air Quality	Description	Rating
Probability	Conceivable.	L
Significance	**Inconsequential, not requiring any consideration.**	**Insignificant**
Potential mitigation measures	• Reduction of fugitive PM emissions through the watering of roads, stockpiles and inactive open areas and the use of screens. • Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	N/A

Table 19: Health risk impact significance summary table for the closure operations

Air Quality	Description	Rating
Project activity or issue	Closure	N/A
Potential impact	Increased health risk at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in $PM_{2.5}$ and PM_{10} concentrations at AQSRs	-
	Significance Before Mitigation	
Intensity	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.	VL
Duration	Medium-term, 5 to 10 years.	M
Extent	A part of the site/property.	VL
Consequence	Very Low.	
Probability	Unlikely/ improbable.	VL
Significance	**Inconsequential, not requiring any consideration.**	**Insignificant**
	Significance After Mitigation	
Intensity	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.	VL

Air Quality	Description	Rating
Duration	Medium-term, 5 to 10 years.	M
Extent	A part of the site/property.	VL
Consequence	Very Low.	
Probability	Unlikely/ improbable.	VL
Significance	**Inconsequential, not requiring any consideration.**	**Insignificant**
Potential mitigation measures	Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	N/A

Table 20: Nuisance impact significance summary table for the closure operations

Air Quality	Description	Rating
Project activity or issue	Closure	N/A
Potential impact	Nuisance dustfall rates at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in dustfall rates at AQSRs	-
	Significance Before Mitigation	
Intensity	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.	VL
Duration	Medium-term, 5 to 10 years.	M
Extent	A part of the site/property.	VL
Consequence	Very Low.	
Probability	Unlikely/ improbable.	VL
Significance	**Inconsequential, not requiring any consideration.**	**Insignificant**
	Significance After Mitigation	
Intensity	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never	VL

Air Quality	Description	Rating
	exceeded. No interventions or clean-up actions required. No complaints anticipated.	
Duration	Medium-term, 5 to 10 years.	M
Extent	A part of the site/property.	VL
Consequence	Very Low.	
Probability	Unlikely/ improbable.	VL
Significance	**Inconsequential, not requiring any consideration.**	**Insignificant**
Potential mitigation measures	Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	N/A

9 IMPACT ASSESSMENT: CUMULATIVE INCLUDING OTHER OPERATIONS IN THE REGION

9.1 Elevated Pollutant Concentrations and Dustfall Rates

Land use in the region includes residences, farming, mining and wilderness. The mining and processing operations (other companies), farming activities, domestic fires, vehicle exhaust emissions and dust entrained by vehicles on public roads without the addition of the proposed operations will likely result in elevated ambient air pollutant concentrations and dustfall rates compared to an area where there are no anthropogenic emission sources. It is difficult to predict the location and contribution of the sources from residences, farming and wilderness to existing air quality. The potential cumulative scenario includes the following atmospheric emissions:

a. Particulate emissions from Mn48 operations;
b. Miscellaneous fugitive dust sources including vehicle entrainment on roads and wind-blown dust from open areas;
c. Particulate emissions from vehicle exhaust emissions;
d. Particulate emissions from household fuel burning; and
e. Particulate emissions from biomass burning (e.g. wild fires).

Based on the simulated results there is not likely to be any exceedances of the long-term NAAQS at AQSRs near Mn48 as a result of the proposed Mn48 operations.

9.2 Impact Significance Rating – Cumulative Activities

Two potential cumulative air quality impacts for the area were identified:

- E1: Potential impact on human health from elevated pollutant concentrations due to existing activities and proposed Mn48 operations; and
- E2: Increased nuisance dustfall rates associated with the existing activities and proposed Mn48 operations.

9.2.1 Potential Impact E1: Potential Impact on Human Health from Elevated Pollutant Concentrations Associated with the Cumulative Activities

The short-term is likely to be exceeded at the two farmsteads west of the proposed Mn48 surface operations. Assuming that the pollutant concentrations from the existing activities will remain the same throughout the entire 19 years of the proposed Mn48 operational phase, the significance rating is “high” without mitigation measures applied and becomes “medium” with design mitigation measures applied (Table 21).

9.2.2 Potential Impact E2: Increased Nuisance Dustfall Rates Associated with the Cumulative Activities

It is unlikely that the NDCR limit for residential areas will be exceeded at AQSRs (with and without mitigation). Assuming that the dustfall rates from the existing activities will remain the same throughout the entire 19 years of the proposed Mn48 operational phase, the significance rating is “low” without and with design mitigation measures applied (Table 22).

Table 21: Health risk impact significance summary table for the cumulative activities

Air Quality	Description	Rating
Project activity or issue	Cumulative activities	N/A
Potential impact	Health risk at AQSRs	N/A
Nature of the Impact		
Positive or negative	Negative due to potentially elevated $PM_{2.5}$ and PM_{10} concentrations at AQSRs	-
Significance Before Mitigation		
Intensity	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the impact takes place.	H
Duration	Long term, between 10 and 20 years (likely to cease at the end of the operational life of the activity).	H
Extent	Beyond the site boundary, affecting immediate neighbours.	M
Consequence	High.	
Probability	Probable.	H
Significance	**It must have an influence on the decision. Substantial mitigation will be required.**	**High**
Significance After Design Mitigation		
Intensity	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.	M
Duration	Long term, between 10 and 20 years (likely to cease at the end of the operational life of the activity).	H
Extent	Beyond the site boundary, affecting immediate neighbours.	M
Consequence	Medium.	

Air Quality	Description	Rating
Probability	Probable.	H
Significance	**It should have an influence on the decision. Mitigation will be required.**	**Medium**
Design mitigation measures	Materials Handling - 70% CE at conveyors for enclosure and 50% CE at stockpiles for water sprays. Crushing and screening - water sprays with a resultant CE of 50%. Vehicles travelling on unpaved roads – 75% CE for level 2 watering. Wind erosion - water sprays with a resultant CE of 40%.	N/A
Potential additional mitigation measures	Crushing and screening – enclosure and water sprays with a resultant CE of 85%. Vehicles travelling on unpaved roads – up to 90% CE for spraying of roads containing with water and additives such as salts, vegetable oils, molasses, synthetic polymers, mulches, asphalt emulsion or lignin products.	N/A

Table 22: Nuisance impact significance summary table for the cumulative activities

Air Quality	Description	Rating
Project activity or issue	Cumulative activities	N/A
Potential impact	Nuisance dustfall rates at AQSRs	N/A
Nature of the Impact		
Positive or negative	Negative due to elevated dustfall rates at AQSRs	-
Significance Before Mitigation		
Intensity	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.	M
Duration	Long term, between 10 and 20 years (likely to cease at the end of the operational life of the activity).	H
Extent	Beyond the site boundary, affecting immediate neighbours.	M
Consequence	Medium.	

Air Quality	Description	Rating
Probability	Possible/ frequent.	M
Significance	**Unlikely that it will have a real influence on the decision. Limited mitigation is likely to be required.**	**Low**
	Significance After Mitigation	
Intensity	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.	M
Duration	Long term, between 10 and 20 years (likely to cease at the end of the operational life of the activity).	H
Extent	Beyond the site boundary, affecting immediate neighbours.	M
Consequence	Medium.	
Probability	Possible/ frequent.	M
Significance	**Unlikely that it will have a real influence on the decision. Limited mitigation is likely to be required.**	**Low**
Design mitigation measures	Materials Handling - 70% CE at conveyors for enclosure and 50% CE at stockpiles for water sprays. Crushing and screening - water sprays with a resultant CE of 50%. Vehicles travelling on unpaved roads – 75% CE for level 2 watering. Wind erosion - water sprays with a resultant CE of 40%.	N/A
Potential additional mitigation measures	Crushing and screening – enclosure and water sprays with a resultant CE of 85%. Vehicles travelling on unpaved roads – up to 90% CE for spraying of roads containing with water and additives such as salts, vegetable oils, molasses, synthetic polymers, mulches, asphalt emulsion or lignin products.	N/A

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. The current site operations (exploration) are also likely to cease at some stage and the ambient air quality will improve. There is the possibility of a gradual reduction in ambient air quality in close proximity to the operations should there be any additional mining, industrial and farming operations, vehicle entrainment on roads, wind-blown dust from open areas, vehicle exhaust, household fuel burning and biomass burning.

11 AIR QUALITY MANAGEMENT PLAN

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

11.1 Air Quality Management Objectives

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

11.1.1 Source Specific Management and Mitigation Measures

For the Mn48 Project, the use of chemical suppressants on the surface haul roads and access road as well as enclosure of the crushers and screens should be considered. The following section refers to more detail on the additional mitigation and management measures.

11.1.1.1 Dust control for Crushing and Screening

Enclosure of crushing operations is very effective in reducing dust. The ADE NPI (2012) indicates that a telescopic chute with water sprays would ensure 75% control efficiency and enclosure of storage piles where tipping occur would reduce the emissions by 99%. According to the ADE NPI (2012), having hoods with scrubbers up to 75% control efficiency can be reached. If in addition, the crushers and screens were to be enclosed; up to 100% control efficiency can be achieved. Hooding with fabric filters can result in control efficiencies of 83%. It is important that this control equipment be maintained and inspected on a regular basis to ensure that the expected control efficiencies are met.

11.1.1.2 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 Mn48 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 Mn48 (Pty) Ltd will be required to report annual emissions on the NAEIS system.

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 23 and shown in Figure 22. The description of these locations in relation to the proposed operations and the main parameters that should be measured are included in Table 23. 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 (18) which is southwest of the shaft. This is the most likely place of constant human occupation where PM_{10} concentrations may exceed the standards as the predicted area of exceedance (daily NAAQS) extends to this receptor. It is also suggested that a weather station be erected north of the access shaft 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 which 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.

Table 23: Sampling and monitoring equipment locations and parameters to be measured

No.	Longitude	Latitude	Description	Parameter to be Measured	Reasoning
D1	22.86303148	-27.03431886	Off-site, north of waste stockpile	Dustfall	To determine dustfall rates as a result of operations.
D2	22.85598295	-27.03747346	On-site, north of shaft	Dustfall and Meteorological data (including but not limited to wind speed, wind direction, temperature, and rainfall)	To determine dustfall rates as a result of operations. To measure meteorological parameters for dustfall reporting and more comprehensive analysis of dustfall and PM_{10} data.
D3	22.86315978	-27.04208853	Off-site, east of crushing and screening plant, as well as lumpy and fines stockpiles	Dustfall	To determine dustfall rates as a result of operations.
D4	22.85539145	-27.0414847	On-site, at Eskom sub-station, west of crushing and screening plant	Dustfall	To determine dustfall rates as a result of operations.
D5	22.85833226	-27.04438959	Off-site/at boundary near access road, south of all surface operations	Dustfall	To determine dustfall rates as a result of operations.
D6	22.85184754	-27.04989153	Off-site/at boundary near access road and R380	Dustfall	To determine dustfall rates as a result of operations.
D7	22.8418097	-27.03919043	AQSR 18 (Farmstead)	Dustfall and PM_{10}	To determine dustfall rates and PM_{10} concentrations as a result of operations.
D8	22.87520925	-27.05499840	AQSR 2 (Farmstead)	Dustfall	To determine dustfall rates as a result of operations.

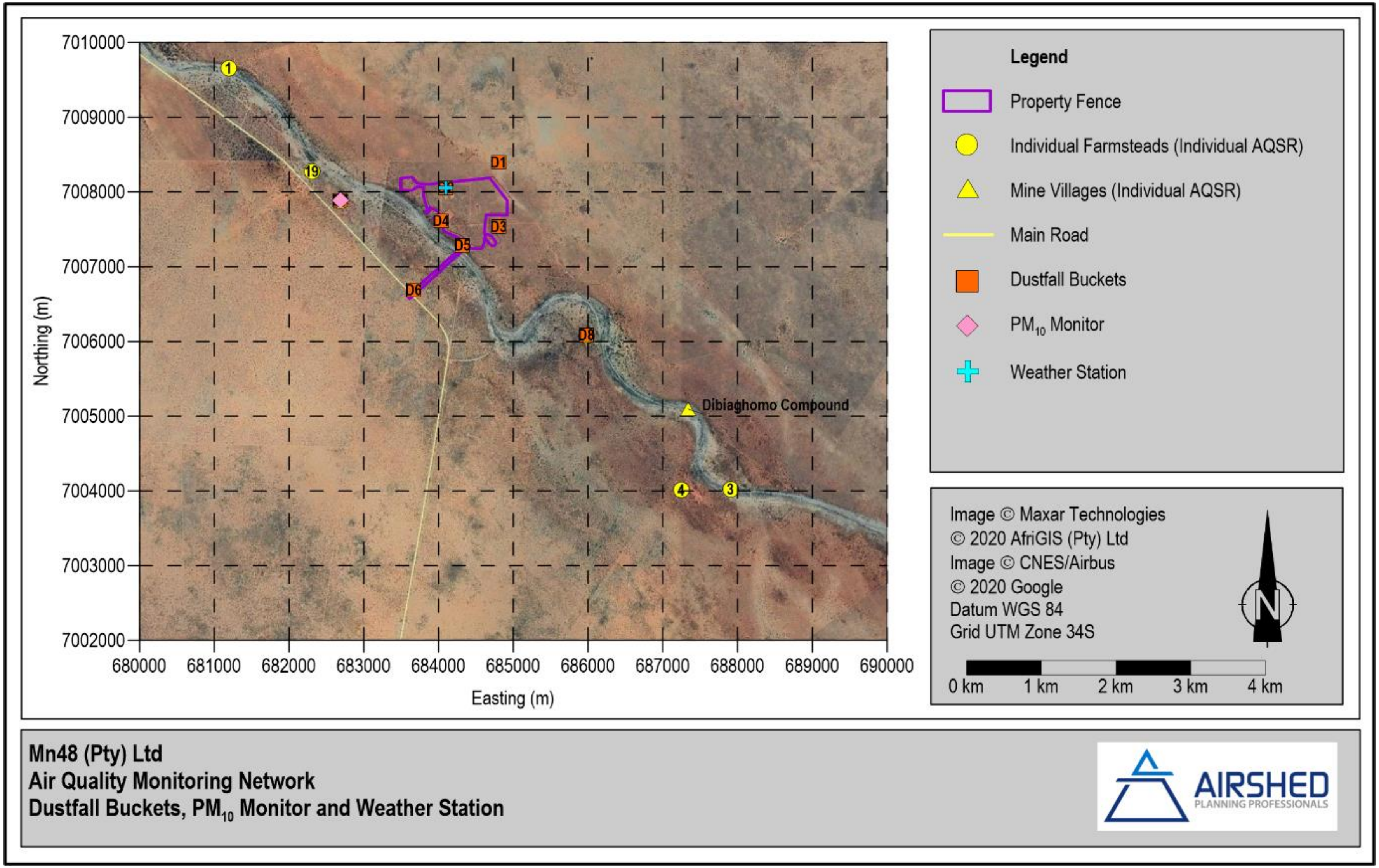

Figure 22: Proposed air quality monitoring network

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 either planted and cemented or directly attached to a fence post (Figure 23). 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.

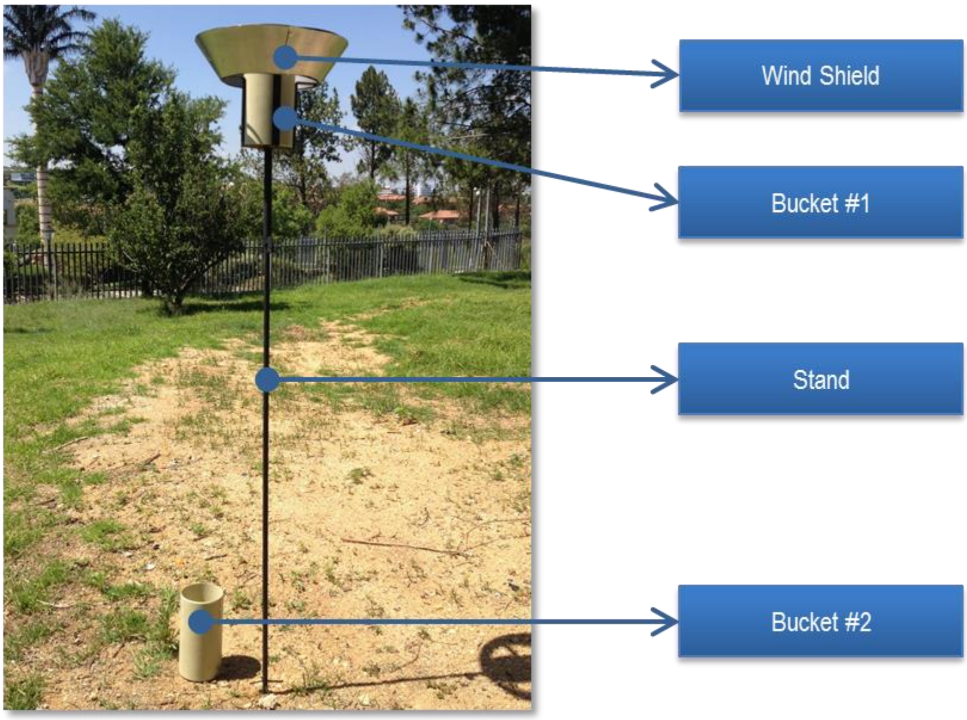

Figure 23: Dustfall collection unit example

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 at an AQSR 18). 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 north of the shaft; 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.

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 control measures and dust monitoring plans. It may be necessary to make assumptions about the duration of aftercare prior to obtaining closure. This assumption must be made explicit so that the financial plan can be assessed within this framework. Costs related to inspections, audits, environmental reporting and I&AP liaison should also be indicated where applicable. Provision should also be made for capital and running costs associated with dust control contingency measures and for security measures. The financial plan should be audited by an independent consultant, with reviews conducted on an annual basis.

12 FINDINGS AND RECOMMENDATIONS

12.1 Main Findings

An air quality impact assessment was conducted for activities proposed as part of the Mn48 project. The main objective of this study was to establish baseline air quality in the study area and to quantify the extent to which ambient pollutant levels will change as a result of the proposed operations. The baseline and impact study then informed the air quality management and mitigation measures recommended as part of the Air Quality Management Plan (AQMP). This section summarises the main findings of the baseline and impact assessments.

The main findings of the baseline assessment are:

- The significant AQSRs is Black Rock, along with isolated farmsteads and the mine villages.
- 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. These 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 “very low” rating without mitigation and “insignificant” rating with mitigation.
- Operational phase:
  - PM ($PM_{2.5}$, PM_{10} and TSP) emissions and impacts were quantified.
  - $PM_{2.5}$ and PM_{10} concentrations as a result of unmitigated operations are not within compliance off-site and at two AQSRs over the short-term.
  - $PM_{2.5}$ and PM_{10} concentrations as a result of design mitigated operations are in compliance with the NAAQS at all AQSRs over the short- and long-term; however, the NAAQS are exceeded beyond the surface boundary (off-site).
  - Annual Mn concentrations as a result of unmitigated operations and design mitigated operations exceed the WHO GV off-site and at AQSRs.
  - Dustfall rates are above the NDCR limits for non-residential areas on-site and beyond the boundary (off-site); 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.
  - The significance of operations related inhalation health impacts is likely to be “medium” without mitigation and with the design mitigation measures applied. The significance of operations related to nuisance impacts are likely to be “medium” without and with design mitigation.
- Decommissioning and closure phases:

- The significance of decommissioning operations related inhalation health and nuisance impacts are likely to have a "very low" rating without mitigation and "insignificant" rating with mitigation.
- The significance of closure operations related inhalation health and nuisance impacts are likely "insignificant".

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 ambient air quality monitoring; and
- Record keeping and community liaison procedures.

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

13 Greenhouse Gas Emission and Climate Change Impact Statement

13.1 Introduction

13.1.1 The greenhouse effects

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

13.1.2 International agreements

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

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

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

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

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

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

13.2 South Africa’s Status in terms of Climate Change and Greenhouse Gases Emissions

13.2.1 South African National Climate Change Response Policy 2011

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

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

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

13.2.2 Intended Nationally Determined Contribution

The South African Intended Nationally Determined Contribution (INDC) submission was completed in 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 Adaptation Strategy. 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.
- 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.

13.2.3 Greenhouse Gas Emissions

Regulations pertaining to GHG reporting using the NAEIS were published on 3 April 2017 (GN 257 in Government Gazette 40762). 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 DEFF is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the Intergovernmental Panel on Climate Change's (IPCC) default emission figures may be used to populate the SAAQIS GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors. Technical guidelines for GHG emission estimation have been issued.

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

13.2.4 South African Energy Supply

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

13.2.4.1 Planning Framework

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

13.2.4.2 Additional Energy Supply

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

13.3 GHG Inventories

13.3.1 National GHG Emissions Inventory

South Africa is perceived as a global climate change contributor and is undertaking steps to mitigate and adapt to the changing climate. DEFF 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, nd). 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 2015 National GHG Inventory was prepared using the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines (IPCC, 2006). According to the National GHG Inventory (DEA, nd) the 2015 total GHG emissions were estimated at approximately 540.854 million metric tonnes CO_2-e (excluding Forestry and Other Land Use (FOLU)). This was a 23.1% increase from the 2000 total GHG emissions (excluding FOLU). FOLU is estimated to be a net carbon sink which reduces the 2015 GHG emissions to 512.383 million metric tonnes CO_2-e. The assessment (excluding FOLU) showed the main sectors contributing to GHG emissions in 2015 to be the energy industries (solid fuels); road transport; manufacturing industry and construction (solid fuels); and energy industries (liquid fuels). In 2015 the Industrial Processes and Product Use (IPPU) sector contributed 7.8% to the total GHG emissions (excluding FOLU), this increased by 0.3% from 2000.

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

13.3.2 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[3] global GHG emissions from the "industrial processes" sector were 2.7711 Gt CO_2-e in 2016 (6% of total anthropogenic GHG emissions).

13.4 The Project

Khwara Manganese (Pty) Ltd "Khwara" and Lehating Mining (Pty) Ltd "Lehating" entered into an amalgamation agreement on 2 December 2016. The agreement combines the two adjacent, contiguous mineral resources and

[3] http://cait.wri.org/ and https://www.climatewatchdata.org/ghg-emissions?breakBy=sector&sectors=energy%2Ctotal-excluding-lucf%2Ctotal-including-lucf

surface rights comprising the Khwara Lehating Manganese Mine into a single, high-grade manganese mining company known as Mn48 (Pty) Ltd ("Mn48"). The operations will be in the Northern Cape Province of South Africa, near Black Rock. The proposed operations are the underground mining and processing of manganese. With a life of mine of 19 years, the proposed Mn48 project will likely cease operation before 2050.

13.5 Methodology

13.5.1 Impact Assessment Methodology

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

(i) The GHG emissions during the construction, operation and decommissioning of the project compared to the global and South African emission inventory and to international benchmarks for the project.

(ii) The impact of climate change over the lifetime of the project taking the robustness of the project into account.

(iii) The vulnerability of communities in the immediate vicinity of the project to climate change.

13.5.1.1 Carbon Footprint Methodology

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

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

where

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

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

13.5.1.1.1 Scope of Carbon Footprint

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

13.6 Effects of Climate Change on the Region

13.6.1 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).

13.6.1.1 RCP4.5 trajectory

Based on the median, for the region in which the Mn48 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.

13.6.1.2 RCP8.5 trajectory

Based on the median, the region in which the Mn48 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.

13.7 Impact Assessment: The Project's Carbon Footprint

13.7.1 The Project's GHG Emissions

13.7.1.1 Carbon Sequestration and Carbon Sink

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

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

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

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

13.7.1.2 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: This includes clearing of the area which falls within the Savanna Biome (Mucina & Rutherford, 2006) and assumed to be similar to low shrublands in the National Greenhouse Gas Emission Inventory. The National Greenhouse Gas Emission Inventory (DEA, nd) assumes a low shrubland carbon stock of 0.7 tonne C/ha. For the construction period, approximately 80 ha will be denuded for the construction of all surface facilities. Assuming all carbon eventually reports to the atmosphere as CO_2, it is therefore calculated that a total of 56 tonnes of CO_2 would be released.

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 24). The United States provides default emission factor for diesel powered heavy vehicles in gCO_2/MJ (Table 24) (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 and listed in Table 25 and the total of 1 431 612 kWh for all the diesel powered mobile equipment.

The emergency generators are expected to be the main supply of electricity for as 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 26), while the density and calorific values are available from the National Greenhouse Gas Emission Inventory (Table 24). Two 1 250 kVA diesel generator are planned to be used on-site but the generators manufacturer is unknown. An Atlas Copco 1 250 kVA large diesel generator is estimated to use 181 litres of diesel per hour and it was assumed that the generators that will operate on-site will use the same amount of fuel.

A summary of the construction greenhouse gas emissions is provided in Table 27. The total CO_2 (equivalent) emissions of approximately 8 081 t/a should be seen in the perspective of the annual South African emission rate of GHG, which is approximately 512.383 million metric tonnes CO_2-e (including FOLU). The calculated CO_2-e emissions from the construction operations therefore contribute less than 0.0015% to the total of South African GHG emissions, 0.003% of the global “industrial processes” sector.

Table 24: Calculation of 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)	Net calorific value (MJ/kg)	Density (kg/l)
Diesel	72.098	4.15	28.6	3.6×10^{-06}	38.1	0.845

Table 25: Details of the assumed mobile equipment used during construction

Equipment type	kW rating	kWh[(a)]
Excavator	304	711 360

Equipment type	kW rating	kWh(a)
Bulldozer	49.4	115 596
Tractor	114	266 760
Crane	106.4	248 976
Frontend Loader	60.8	142 272
Total	**611.8**	**1 431 612**

Notes: (a) Based on 2 340 operational hours per year.

Table 26: Calculation of liquid fuel-related emission factors for stationary equipment

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

Table 27: 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	% of total CO_2-e emissions
	t/a	t/a	t/a	t/a	
Mobile Equipment	372	0.535	43.9	*416*	5%
Diesel Generators (2 x 1 250 kVA)	7 565	25.5	18.3	*7 609*	94%
Clearing	56.0	-	-	*56.0*	1%
Total	**7 993**	**26.1**	**62.2**	***8 081***	**100%**

13.7.1.3 Operations

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

Scope 1: 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 24). The United States provides default emission factor for diesel powered heavy vehicles in gCO_2/MJ (Table 24) (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. Using the values in Table 24, the emission factor can be calculated per litre of fuel used, which allows calculation of the total emissions directly from proposed fuel use. The estimated amount of fuel (diesel) used per week by mobile equipment is 109 028 litres.

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 28. This allows the scope 2 emissions to be calculated directly from electricity consumption from the Eskom or local authority account. The median value of 0.99 tonnes CO_2/MWh was used in the calculations. The average annual electricity usage for Mn48 is 52.5 GWh per year.

Table 28: Eskom electricity emission factors

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

A summary of the greenhouse gas emissions for scope1 and scope 2 is provided in Table 29. The total CO_2 (equivalent) emissions of approximately 66 709 t/a should be seen in the perspective of the annual South African emission rate of GHG, which is approximately 512.383 million metric tonnes CO_2-e (including FOLU). The calculated CO_2-e emissions from the proposed operations therefore contribute approximately 0.013% to the total of South African GHG emissions, 0.0024% of the total “industrial processes” sector.

Table 29: 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	13 160	18.9	1 556	*14 734*	22%
Electricity Usage	51 975	-	-	*51 975*	78%
Total	**65 135**	**18.9**	**1 556**	***66 709***	**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 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 sector

With the proposed operations there will be additions to the equipment fleet, likely to result in in scope 1 emissions. This would therefore change the "industrial processes" sector's total annual CO_2-e emissions, increasing it by approximately 14 734 t/a. The project contribution towards the 2016 global "industrial processes" sector CO_2-e emissions is 0.0024%.

13.7.2.3 Impact on the National Inventory

The clearing of vegetation (even though the area will likely be re-vegetated at some stage) will result in a carbon sink loss and an increase towards the national GHG inventory. With the construction operations there will also be additions to the equipment fleet and will likely result in an increase in scope 1 emissions from the Mn48; therefore, changing the national inventory's total annual CO_2-e emissions by approximately 8 081 t/a during the construction phase. With the proposed operations there will also be additions to the equipment fleet and will likely result in an increase in scope 1 emissions from the Mn48 project; therefore, changing the national inventory's total annual CO_2-e emissions by approximately 14 734 t/a during the operational phase.

13.7.2.4 Alignment with national policy

Most of the South African policy is still draft or in the planning phase; however, Mn48 will likely not have to report on GHG emissions in the SAGERS reporting format once operational as the CO2-e emissions will be below the threshold of 100 000 t/a.

13.8 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.

13.8.1 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.

13.8.2 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.

13.9 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.

13.9.1 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.

13.9.2 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.

13.10 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.

13.10.1 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. Mn48 could initiate a community development program. It is recommended that Mn48 (Pty) Ltd investigate the option of using solar power for the operations and the community to minimise scope 2 emissions.

13.10.2 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.

13.10.3 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]).

13.11 Conclusions and recommendation

- The CO_2-e (scope 1) emissions for construction is approximately 8 081 t/a therefore contributing less than 0.0016% to the total of South Africa's GHG emissions and 0.0003% of the global "industrial processes" sector.
- The CO_2-e (scope 1) emissions for proposed operations is approximately 14 734 t/a therefore contributing less than 0.0027% to the total of South Africa's GHG emissions and 0.0005% of the global "industrial processes" sector.
- The GHG emissions from the project are low and will not likely result in a noteworthy contribution to climate change on their own.
- The project and the community are likely to be negatively impacted by climate change due to increased temperatures and possible water shortages (decreased rainfall and possible increased evaporation).
- The 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.
    - Mn48 could initiate a community development program.
    - Investigating solar power for the operations and the community 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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15 APPENDIX A: AUTHORS' CURRICULUM VITAE AND SACNASP CERTIFICATE

CURRICULUM VITAE

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

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

EXPERIENCE

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

PROJECTS COMPETED IN VARIOUS SECTORS ARE LISTED BELOW:

Mining Sector

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

Industrial Sector

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

Power Generation, Oil and Gas

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

Waste Disposal and Treatment Sector

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

Petroleum Sector

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

Transport and Logistics Sector

Saldanha Port Project.

Ambient Air Quality and Noise Sampling/Monitoring

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

SOFTWARE PROFICIENCY

Software utilised in conducting air and noise studies:

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

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

EDUCATION

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

CONFERENCES ATTENDED, ARTICLES PUBLISHED AND COURSES COMPLETED

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

COUNTRIES OF WORK EXPERIENCE

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

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Limited working proficiency

REFERENCES

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Dr Hanlie Liebenberg-Enslin	Managing Director at Airshed Planning Professionals	+27 11 805 1940 hanlie@airshed.co.za

CERTIFICATION

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

22/04/2020

SACNASP

South African Council for Natural Scientific Professions

herewith certifies that

Natasha Anne Shackleton

Registration Number: 116335

is a registered scientist

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

Physical Science (Professional Natural Scientist)

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

Chairperson

Chief Executive Officer

To verify this certificate scan this code

16 APPENDIX B: COMPETENCIES FOR PERFORMING AIR DISPERSION MODELLING

All modelling tasks were performed by competent personnel. Table 30 is a summary of competency requirements. Apart from the necessary technical skills required for the calculations, personnel competency also include the correct attitude, behaviour, motive and other personal characteristic that are essential to perform the assigned job on time and with the required diligence as deemed necessary for the successful completion of the project.

The project technical team included a senior scientist with relevant experience of 9 years who undertook the study and one senior scientist with 8 years relevant experience who reviewed the report and verified the modelling results. The latter function requires a thorough knowledge of the

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

Table 30: Competencies for Performing Air Dispersion Modelling

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

Competency	Task, Knowledge and Experience
	Identify land cover/terrain characteristics Identify the receptor grid/site
	Legislation, regulations and guidelines in regard to National Environment Management: Air Quality Act (Act No 39 of 2004), including Minimum Emissions Standards (Section 21 of Act) National Atmospheric Emissions Reporting Regulations Regarding Air Dispersion Modelling National Ambient Air Quality Standards National Dust Control Regulations Air Quality Specialist Report Atmospheric Impact Report (AIR)
Abilities	Ability to read and understand map information
	Ability to prepare reports and documents as necessary
	Ability to review reports to ensure accuracy, clarity and completeness
	Communication skills
	Team skills

17 IMPACT SIGNIFICANCE METHODOLOGIES

17.1 Previous SLR Methodology for Assessing the Significance of Impacts Utilised in the 2012 Study

PART A: DEFINITION AND CRITERIA		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of severity, spatial extent and duration**
Criteria for ranking of the SEVERITY/NATURE of environmental impacts	**H**	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action. Irreplaceable loss of resources.
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints. Noticeable loss of resources.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. Limited loss of resources.
	L+	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
Criteria for ranking the DURATION of impacts	**L**	Quickly reversible. Less than the project life. Short term
	M	Reversible over time. Life of the project. Medium term
	H	Permanent. Beyond closure. Long term.
Criteria for ranking the SPATIAL SCALE of impacts	**L**	Localised - Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local
	H	Widespread – Far beyond site boundary. Regional/ national

PART B: DETERMINING CONSEQUENCE					
				SEVERITY = L	
DURATION	Long term	**H**	**Medium**	**Medium**	**Medium**
	Medium term	**M**	**Low**	**Low**	**Medium**
	Short term	**L**	**Low**	**Low**	**Medium**
				SEVERITY = M	
DURATION	Long term	**H**	**Medium**	**High**	**High**
	Medium term	**M**	**Medium**	**Medium**	**High**
	Short term	**L**	**Low**	**Medium**	**Medium**
				SEVERITY = H	
DURATION	Long term	**H**	**High**	**High**	**High**
	Medium term	**M**	**Medium**	**Medium**	**High**
	Short term	**L**	**Medium**	**Medium**	**High**
			L	**M**	**H**
			Localised Within site boundary Site	Fairly widespread Beyond site boundary Local	Widespread Far beyond site boundary Regional/ national
				SPATIAL SCALE	

PART C: DETERMINING SIGNIFICANCE					
PROBABILITY	Definite/ Continuous	**H**	**Medium**	**Medium**	**High**

(of exposure to impacts)	Possible/ frequent	M	Medium	Medium	High
	Unlikely/ seldom	L	Low	Low	Medium
			L	M	H
			CONSEQUENCE		

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
High	It would influence the decision regardless of any possible mitigation.
Medium	It should have an influence on the decision unless it is mitigated.
Low	It will not have an influence on the decision.

17.2 Current SLR Methodology for Assessing the Significance of Impacts

PART A: DEFINITIONS AND CRITERIA*		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of intensity, spatial extent and duration**
Criteria for ranking of the INTENSITY of environmental impacts	**VH**	Severe change, disturbance or degradation. Associated with severe consequences. May result in severe illness, injury or death. Targets, limits and thresholds of concern continually exceeded. Substantial intervention will be required. Vigorous/widespread community mobilization against project can be expected. May result in legal action if impact occurs.
	H	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the impact takes place.
	M	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.
	L	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.
	VL	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.
	VL+	Negligible change or improvement. Almost no benefits. Change not measurable/will remain in the current range.
	L+	Minor change or improvement. Minor benefits. Change not measurable/will remain in the current range. Few people will experience benefits.

	M+	Moderate change or improvement. Real but not substantial benefits. Will be within or marginally better than the current conditions. Small number of people will experience benefits.
	H+	Prominent change or improvement. Real and substantial benefits. Will be better than current conditions. Many people will experience benefits. General community support.
	VH+	Substantial, large-scale change or improvement. Considerable and widespread benefit. Will be much better than the current conditions. Favourable publicity and/or widespread support expected.
Criteria for ranking the DURATION of impacts	**VL**	Very short, always less than a year. Quickly reversible
	L	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.
	M	Medium-term, 5 to 10 years.
	H	Long term, between 10 and 20 years. (Likely to cease at the end of the operational life of the activity)
	VH	Very long, permanent, +20 years (Irreversible. Beyond closure)
Criteria for ranking the EXTENT of impacts	**VL**	A part of the site/property.
	L	Whole site.
	M	Beyond the site boundary, affecting immediate neighbours
	H	Local area, extending far beyond site boundary.
	VH	Regional/National

PART B: DETERMINING CONSEQUENCE							
			EXTENT				
			A part of the site/property	Whole site	Beyond the site, affecting neighbours	Local area, extending far beyond site.	Regional/ National
			VL	**L**	**M**	**H**	**VH**
INTENSITY = VL							
DURATION	Very long	**VH**	**Low**	**Low**	**Medium**	**Medium**	**High**
	Long term	**H**	**Low**	**Low**	**Low**	**Medium**	**Medium**
	Medium term	**M**	**Very Low**	**Low**	**Low**	**Low**	**Medium**
	Short term	**L**	**Very low**	**Very Low**	**Low**	**Low**	**Low**
	Very short	**VL**	**Very low**	**Very Low**	**Very Low**	**Low**	**Low**
INTENSITY = L							
DURATION	Very long	**VH**	**Medium**	**Medium**	**Medium**	**High**	**High**
	Long term	**H**	**Low**	**Medium**	**Medium**	**Medium**	**High**
	Medium term	**M**	**Low**	**Low**	**Medium**	**Medium**	**Medium**

	Short term	L	Low	Low	Low	Medium	Medium
	Very short	VL	Very low	Low	Low	Low	Medium
INTENSITY = M							
DURATION	Very long	VH	Medium	High	High	High	Very High
	Long term	H	Medium	Medium	Medium	High	High
	Medium term	M	Medium	Medium	Medium	High	High
	Short term	L	Low	Medium	Medium	Medium	High
	Very short	VL	Low	Low	Low	Medium	Medium
INTENSITY = H							
DURATION	Very long	VH	High	High	High	Very High	Very High
	Long term	H	Medium	High	High	High	Very High
	Medium term	M	Medium	Medium	High	High	High
	Short term	L	Medium	Medium	Medium	High	High
	Very short	VL	Low	Medium	Medium	Medium	High
INTENSITY = VH							
DURATION	Very long	VH	High	High	Very High	Very High	Very High
	Long term	H	High	High	High	Very High	Very High
	Medium term	M	Medium	High	High	High	Very High
	Short term	L	Medium	Medium	High	High	High
	Very short	VL	Low	Medium	Medium	High	High

PART C: DETERMINING SIGNIFICANCE							
PROBABILITY (of exposure to impacts)	Definite/ Continuous	VH	Very Low	Low	Medium	High	Very High
	Probable	H	Very Low	Low	Medium	High	Very High
	Possible/ frequent	M	Very Low	Very Low	Low	Medium	High
	Conceivable	L	Insignificant	Very Low	Low	Medium	High
	Unlikely/ improbable	VL	Insignificant	Insignificant	Very Low	Low	Medium
			VL	L	M	H	VH
			CONSEQUENCE				

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**

Very High	Potential fatal flaw unless mitigated to lower significance.
High	It must have an influence on the decision. Substantial mitigation will be required.
Medium	It should have an influence on the decision. Mitigation will be required.
Low	Unlikely that it will have a real influence on the decision. Limited mitigation is likely to be required.
Very Low	It will not have an influence on the decision. Does not require any mitigation
Insignificant	Inconsequential, not requiring any consideration.

18 APPENDIX D: PROPOSED MN48 OPERATIONS IMPACT SIGNIFICANCE RATING BASED ON THE CURRENT SLR METHODOLOGY FOR ASSESSING THE SIGNIFICANCE OF IMPACTS

The main pollutants of concern were determined to be PM (including $PM_{2.5}$, PM_{10} and TSP). Non-compliance of $PM_{2.5}$ and PM_{10} concentrations could result in human health impacts. The potential significance of the impacts based the quantitative assessment of $PM_{2.5}$, PM_{10} and dustfall rates (TSP) during the operational phase is discussed below. The current SLR rating methodology (Section 17.2) was used.

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

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

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

It is unlikely that the long-term and short-term NAAQS will be exceeded at AQSRs as a result of the project (with and without mitigation); however, the NAAQS are still expected to be exceeded in areas in which they are applicable (off-site). The annual Mn concentrations could exceed the WHO GV (with and without mitigation). The proposed operations are proposed to last for 19 years. The significance rating is “high” without mitigation measures applied and becomes “low” with design mitigation measures applied (Table 31).

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

It is unlikely that the NDCR limit for residential areas will be exceeded at AQSRs (with and without mitigation) as a result of the project. The proposed operations are proposed to last for 19 years. The significance rating is “low” without and with design mitigation measures applied (Table 32).

Table 31: Health risk impact significance summary table for the proposed operations

Air Quality	Description	Rating
Project activity or issue	Proposed operations	N/A
Potential impact	Increased health risk at AQSRs	N/A
Nature of the Impact		
Positive or negative	Negative due to increase in $PM_{2.5}$, PM_{10} and Mn concentrations at AQSRs	-
Significance Before Mitigation		
Intensity	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the impact takes place.	H
Duration	Long term, between 10 and 20 years (likely to cease at the end of the operational life of the activity).	H
Extent	Beyond the site boundary, affecting immediate neighbours.	M
Consequence	High.	
Probability	Probable.	H
Significance	**It must have an influence on the decision. Substantial mitigation will be required.**	**High**
Significance After Design Mitigation		
Intensity	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.	M
Duration	Long term, between 10 and 20 years (likely to cease at the end of the operational life of the activity).	H
Extent	Beyond the site boundary, affecting immediate neighbours.	M
Consequence	Medium.	

Air Quality	Description	Rating
Probability	Possible/ frequent.	M
Significance	**Unlikely that it will have a real influence on the decision. Limited mitigation is likely to be required.**	**Low**
Design mitigation measures	Materials Handling - 70% CE at conveyors for enclosure and 50% CE at stockpiles for water sprays. Crushing and screening - water sprays with a resultant CE of 50%. Vehicles travelling on unpaved roads – 75% CE for level 2 watering. Wind erosion - water sprays with a resultant CE of 40%.	N/A
Potential additional mitigation measures	Crushing and screening – enclosure and water sprays with a resultant CE of 85%. Vehicles travelling on unpaved roads – up to 90% CE for spraying of roads containing with water and additives such as salts, vegetable oils, molasses, synthetic polymers, mulches, asphalt emulsion or lignin products.	N/A

Table 32: Nuisance impact significance summary table for the proposed operations

Air Quality	Description	Rating
Project activity or issue	Proposed operations	N/A
Potential impact	Nuisance dustfall rates at AQSRs	N/A
	Nature of the Impact	
Positive or negative	Negative due to increase in dustfall rates at AQSRs	-
	Significance Before Mitigation	
Intensity	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.	L
Duration	Long term, between 10 and 20 years (likely to cease at the end of the operational life of the activity).	H
Extent	Beyond the site boundary, affecting immediate neighbours.	M

Air Quality	Description	Rating
Consequence	Medium.	
Probability	Possible/ frequent.	M
Significance	**Unlikely that it will have a real influence on the decision. Limited mitigation is likely to be required.**	**Low**
	Significance After Mitigation	
Intensity	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.	L
Duration	Long term, between 10 and 20 years (likely to cease at the end of the operational life of the activity).	H
Extent	Beyond the site boundary, affecting immediate neighbours.	M
Consequence	Medium.	
Probability	Possible/ frequent.	M
Significance	**Unlikely that it will have a real influence on the decision. Limited mitigation is likely to be required.**	**Low**
Design mitigation measures	Materials Handling - 70% CE at conveyors for enclosure and 50% CE at stockpiles for water sprays. Crushing and screening - water sprays with a resultant CE of 50%. Vehicles travelling on unpaved roads – 75% CE for level 2 watering. Wind erosion - water sprays with a resultant CE of 40%.	N/A
Potential additional mitigation measures	Crushing and screening – enclosure and water sprays with a resultant CE of 85%. Vehicles travelling on unpaved roads – up to 90% CE for spraying of roads containing with water and additives such as salts, vegetable oils, molasses, synthetic polymers, mulches, asphalt emulsion or lignin products.	N/A

Notes:Although the significance rating does not change for the “nuisance dustfall rates at AQSRs” between unmitigated and design mitigated the extent of impacted area does reduce with design mitigation applied.