INFOTOX (Pty) Ltd

2001/000870/07

Retrieval and scientific interpretation of ecotoxicological information

PostNet Suite 112 Private Bag X25723 Monumentpark 0105 SOUTH AFRICA

Tel: 27(12) 346 4668 Fax: 086 513 5478 Cell: 082 416 5864

e-mail: Info@infotox.co.za www.infotox.co.za

Project conducted on behalf of Greenmined Environmental (Pty) Ltd

Mining Rights Application for Makganyane Iron Ore, Postmasburg, Northern Cape Province

Rapid Appraisal Health Impact Assessment (RAHIA)

Report No 030-2025 Rev 1.0

WCA van Niekerk PhD QEP(USA) Pr Sci Nat (Environmental Science)
MH Fourie PhD MSc Pr Sci Nat (Toxicological Science)

8 August 2025

Copyright Warning

WCA van Niekerk PhD QEP (USA) Pr Sci Nat (Environmental Science)
Managing Director

8 August 2025

Expertise and Declaration of Independence

This report was prepared by INFOTOX (Pty) Ltd ("INFOTOX"). Established in 1991, INFOTOX is a professional scientific company, highly focused in the discipline of ecotoxicological risk assessment. Both occupational and environmental human health risks, as well as risks to ecological receptors, are addressed.

Dr Willie van Niekerk, Managing Director of INFOTOX, has BSc, Hons BSc and MSc degrees from the University of Potchefstroom and a PhD from the University of South Africa. He is a Qualified Environmental Professional ("QEP"), certified by the Institute of Professional Environmental Practice ("IPEP") in the USA (No 07960160), and a registered Professional Natural Scientist (Pr Sci Nat, Environmental Science, No 400284/04). Dr Van Niekerk has specialised in chemical toxicology and human health risk assessments, but he has experience in many other areas in the disciplines of analytical and environmental sciences.

Dr Marlene Fourie has BSc and Hons BSc degrees from the University of Stellenbosch and MSc and PhD degrees from the University of Pretoria. Her field of specialisation is reproductive biology/toxicology. Dr Fourie also has an MSc-degree in epidemiology from the University of Pretoria. Following positions as Medical Natural Scientist at the Andrology Unit, Department of Urology, University of Pretoria and the Pretoria Academic Hospital from 1987 to 2001, she joined INFOTOX as a Medical Biological Scientist. Dr Fourie has conducted many health risk assessments and projects relating to the health status of communities. She is registered as a Professional Natural Scientist (Pr Sci Nat, Toxicological Science, No 400190/14).

This specialist report was compiled for Greenmined Environmental (Pty) Ltd. We do hereby declare that we are financially and otherwise independent of Greenmined Environmental (Pty) Ltd.

Signed on behalf of INFOTOX (Pty) Ltd, duly authorised in the capacity of Managing Director:

Willem Christiaan Abraham van Niekerk

8 August 2025

Executive Summary

Background to the study

The Applicant, Assmang (Pty) Ltd ("Assmang"), applied for a mining right ("MR") near Postmasburg in the Tsantsabane Local Municipality ("LM") in the ZF Mgcawu District Municipality ("DM") of the Northern Cape. The Environmental Impact Assessment ("EIA") process for the proposed Makganyane Mining Project is undertaken by Greenmined Environmental (Pty) Ltd ("Greenmined"). The Final EIA Scoping Report identified the requirement for a Health Impact Assessment, for which purpose INFOTOX (Pty) Ltd ("INFOTOX") was appointed to undertake a Rapid Appraisal Health Impact Assessment ("RAHIA") to assess the impact of the proposed project on human health in receptor communities.

Specialist reports and other documents compiled for the purposes of the EIA, and from which information is used in the RAHIA, are the following:

- Socio-Economic Impact Assessment for the Proposed Makganyane Mining Right (Eco-Thunder Consulting (Pty) Ltd, "Eco-Thunder" 2025).
- Waste Classification and Assessment of Expected Waste Rock for the Makganyane Iron Ore Mine, Northern Cape Province (Digby Wells Environmental 2025).
- Stormwater Management Plan ("SWMP") by The Biodiversity Company (Nakhooda 2025a).
- Hydrological Assessment Report prepared by The Biodiversity Company (Nakhooda 2025b).
- Groundwater Assessment Report (Groundwater Complete 2025).
- Air Quality Impact Assessment Report ("AIR") for the Proposed Makganyane Mine (Yellow Tree Environmental 2025).

Air quality-related human health risk assessment

The AIR identified airborne particulate matter ("PM"), including PM2.5[1] and PM10[2] as the main concern from sources such as:

- Blasting during open pit development, truck-based material handling, and wind erosion over the exposed pit areas.
- Vehicle entrainment on the trucking routes: heavy-duty trucks travelling on-site, including the transport of ore, waste rock, and crushed material, have the potential to generate fugitive dust through re-entrainment of particles on unpaved roads.
- Crushing and materials handling at the screening and crushing facility.
- Wind erosion from and material loading/drop operations at ore stockpiles.
- Materials handling at the waste dump.

PM2.5, rather than PM10, is the exposure indicator of choice for the assessment of the burden of disease or health risks associated with PM exposure. The sensitive receptors in the vicinity of the mine are scattered farms, of which the three most proximate to the mine were assessed as representative of the highest likely PM2.5 exposure ranges. Modelled PM2.5 air concentrations obtained from the AIR were used for human health risk assessment ("HHRA") calculations. Potential increases in the risk of hospital admissions or mortality due to specific causes, associated with modelled increases in air concentrations of PM2.5, were calculate using appropriate concentration-response functions derived from international health risk authorities (US Environmental Protection Agency ("USEPA") and the World Health Organization ("WHO")).

---

[1] Particulate matter with aerodynamic diameter equal to and smaller than 2.5 micron.

[2] Particulate matter with aerodynamic diameter equal to and smaller than 10 micron.

The PM2.5-related health outcomes assessed in the HHRA are:

- Cardiovascular (including stroke) hospital admissions
- Acute bronchitis symptoms, ages 8-12
- Chronic bronchitis incidence in age group 27+
- All-cause (natural) mortality
- Lung cancer incidence (diagnosis, not mortality) (annually) (ages 30+)

The following air-quality mitigation measures were proposed and modelled in the AIR:

- Spraying water on all haul roads twice per day.
- Application of a chemical dust suppressant on Route 3 (the haul road to the main gate).
- Windbreaks or three-sided enclosures around the ore stockpile, waste rock dump and open pits to reduce wind-blown dust.
- Application of a chemical dust suppressant in addition to water spraying on Route 2.

Three receptors (farmsteads) were identified as representative of the most exposed public receptors. The results of the risk calculations at each representative receptor are presented as the incremental percentage increase in the risk of a specific health effect, associated with an incremental increase in PM2.5 concentrations modelled at each receptor. The percentage increase is relative to the current health risk, that is, the background risk, prior to the mining development and operations. The significance of the calculated risks are also indicated in Table 1.

As can be expected, the increased risk of a health effect is always lower if additional mitigation measures are applied (Scenario 2), compared to baseline mitigated conditions (Scenario 1). Provided that enhanced (Scenario 2) dust suppression measures are implemented, the mitigated risks are at most rated as low, and not of serious concern, and this only at the representative receptor within 1 km to the north of the mine's fence line. Risks of PM2.5 health effects associated with the proposed mining activities are calculated as insignificant at receptors to the south and south-east of the mine, even if only the baseline dust suppression measures proposed by the client are implemented (Scenario 1).

Table 1: Calculated % increase in risk and significance assessment.

Receptor	Within 1 km to the north of the mine's fence line		Within 1 km to the south-east of the mine's fence line		Within 2 km to the south of the mine's fence line	
Health effect	**Scenario**		**Scenario**		**Scenario**	
	1	**2**	**1**	**2**	**1**	**2**
All-cause (natural) mortality	3.4	1.5	0.5	0.2	0.7	0.2
Cardiovascular (including stroke) hospital admissions	4.4	1.1	0.6	0.2	0.7	0.2
Acute bronchitis symptoms, ages 8-12	11.5	5.3	1.9	0.5	2.4	0.8
Chronic bronchitis incidence, ages 27+	6.0	2.7	1.0	0.3	1.2	0.4
Lung cancer incidence, ages 30+	15.6	7.3	0.2	0.8	3.3	1.1

Scenario 1: Baseline dust mitigation measures: spraying water on all haul roads 2x daily plus chemical dust suppressant on the haul road to the main gate (Route 3).
Scenario 2: Enhanced dust mitigation measures: windbreaks around dust sources and chemical dust suppressant in addition to water spraying on Route 2.

Key to significance rating:	Insignificant (0 – 5%)	Low of marginal concern (5 – 10%)	Low (10 – 20%)

Risks of water contamination and subsequent human health effects

It is concluded that the public utilisation of surface- and groundwater sources under the conditions of the proposed mining activities are not associated with risks to human (or animal) health, because water quality is not likely to be affected by the proposed mining operations, considering the following:

- Low leachable concentrations of hazardous elements from the waste rock.
- Assumed management of the proposed waste rock dump ("WRD") by the combination of standard engineered barriers and recommended monitoring of:
  - Groundwater quality down-gradient of the waste rock dump.
  - Water quality in the Soutloop River, if possible.
- Assuming efficient implementation of the SWMP.
- The impact on groundwater quality being assessed as "low" with and without mitigation.

However, the potential health risks associated with water sources utilisation is to be reassessed if:

- The SWMP design should change, or following major changes to the current mine operations plans.
- Recommended monitoring of ground- and surface water quality should indicate a deterioration of water quality.

Health impact assessment

The impact assessment was done considering the vulnerability of the receptor communities in the assessment rating. Vulnerability to PM2.5 health effects were assessed as follows:

- In general, regardless of the vulnerabilities of specific age groups, communities are slightly more vulnerable to the cardiovascular and moderately more vulnerable to the respiratory effects of PM2.5.
- The younger-than-15-years age group is moderately more vulnerability to the respiratory effects of PM2.5. Cardiovascular vulnerability is comparable to the South African group in general.
- The age group of 65 years and older are moderately more vulnerable to the respiratory and slightly more vulnerable to cardiovascular effects of PM2.5.
- In conclusion, receptors of all ages are moderately more vulnerable to the respiratory effects of PM2.5.

The baseline mitigation (Scenario 1) and enhanced mitigation (Scenario 2) health impact ratings associated with air quality impacts, and pre- and post-mitigation water quality impacts in the operational phase are summarised in Table 2.

Table 2: Summary of health impact significance ratings for the operational phase.

Operational phase impact via an impact on air quality		
Health effect	**Baseline mitigation (Scenario 1)**	**Enhanced mitigation (Scenario 2)**
All-cause (natural) mortality	Low	Low
Cardiovascular effects	Low	Low
Respiratory effects	Low-Medium	Low
Operational phase impact via an impact on water quality		
Low risk of an impact on surface- and groundwater quality, no specific health effect indicated.	Low-Medium	Low

Specific impacts of the construction- and closure phases on air quality where not considered in the AIR, likely because the operational phase was considered of primary importance to air quality impacts. Therefore, health impact ratings due to air quality impacts are not proposed for these phases.

Chemical and microbiological details of the potential contamination during the construction phase are not available; but a comprehensive groundwater monitoring plan/protocol is recommended for the construction, operational and post closure phases of mining. Therefore, continued sewage and storm water management and water quality monitoring during the construction phase, and appropriate actions if water quality should deteriorate, would conceivably limit health impacts to "low".

Furthermore, the water quality impact during the operational phase is rated as "low-medium" at most by the relevant water quality impact specialists. It is unlikely that the water quality impact would be more severe during the closure phase, because the properties of the waste rock stored in the dumps is unlikely to change, and because the mine would create a continuous sink to contain the movement of a potential contamination plume.

Cumulative impacts on health

The cumulative health impact associated with impacts on air quality is assessed as the accumulated impact of the proposed project and the current (existing) baseline health status. The baseline status is impacted by relevant background factors, such as:

- General ambient air pollution sources, e.g., veld fires, vehicle exhaust emissions, burning of wood and coal for household energy needs.
- Lifestyle factors such as smoking and lack of exercise.
- Other pre-existing health conditions, such as asthma or tuberculosis ("TB").

The cumulative impact on health is insignificantly different from the current impact on health, because the health risks associated with the modelled incremental increases in ambient PM2.5 concentrations are mostly negligible, with at most low risks of marginal concern after the implementation of enhanced dust suppression measures. Therefore, the health status of receptor communities will not be significantly changed after the implementation of the envisioned project, provided that such measures are implemented.

A cumulative impact via potential water quality impacts is not foreseen, due to the absence of other mining activities sufficiently close to the proposed mining site. Existing mining operations are too distant to exert a cumulative effect on ground- or surface water quality.

Post-mitigation outcome statement

Screening tool sensitivity	Verified sensitivity	Post-mitigation outcome statement	Relevant section motivating verification
Health Impact Assessment			
N/A	N/A	Low negative to negligible impacts are associated with the proposed development	N/A

Reasoned opinion regarding the acceptability of the proposed activity (and the issuing of an EA)

Based on the RAHIA presented in this report:

- An environmental authorisation ("EA") may be issued for the proposed redevelopment of the Makganyane Mine, and proposed prospecting and operations may commence, provided that:
- Enhanced dust mitigation measures recommended in the AIR and in this RAHIA report are implemented as strictly as possible, where feasible, in order to reduce dust emissions at the proposed mine.
- Storm water management is implemented according to the SWMP.
- Ground- and surface water monitoring continue as recommended in the waste rock assessment report, the surface water hydrology impact assessment report, and the groundwater assessment report.

- The HHRA should be repeated if a deterioration in surface- or groundwater quality should be observed after the initiation of mining activities.

Fatal flaws
No fatal flaws are identified.

Statement of confidence
The HHRA results and conclusions in this report are presented with a high degree of confidence, considering:

- The firm epidemiological foundation of the established associations of ambient PM2.5 exposure with the health effects assessed in this report.
- The rigorous basis of the development of the PM2.5 concentration coefficients used in risk calculations.
- The use of standard calculation methods proposed by the WHO and the USEPA.
- The standard air dispersion models used in the AIR.
- The standard procedures used by the surface- and groundwater assessment specialists.

Abbreviations and Acronyms

AF	Attributable (risk) fraction(s)
AIR	Atmospheric Impact Report
DM	District Municipality
DMRE	Department of Mineral Resources and Energy
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
EMPR	Environmental Management Plan Report
HHRA	Human health risk assessment
HIA	Health Impact Assessment
LM	Local Municipality
LoM	Life of mine
MPRDA	Mineral and Petroleum Resources Development Act
MR	Mining Right
NAAQS	National Ambient Air Quality Standards
NEMA	National Environmental Management Act
NEMAQA	National Environmental Management: Air Quality Act
NEMWA	National Environmental Management: Waste Act
OMI	Greenmined Environmental
PCD	Pollution Control Dam
PM	Airborne particulate matter
PM10	Particulate matter with aerodynamic diameter equal to and smaller than 10 micron.
PM2.5	Particulate matter with aerodynamic diameter equal to and smaller than 2.5 micron.
RAHIA	Rapid Appraisal HIA
RoM	Run of mine
SAMRAD	South African Mineral Resources Administration System
TGME	Transvaal Gold Mining Estates Limited
TSF	Tailings storage facility
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
WM	With mitigation
WOM	Without mitigation
WRD	Waste rock dump
WUL	Water Use Licence

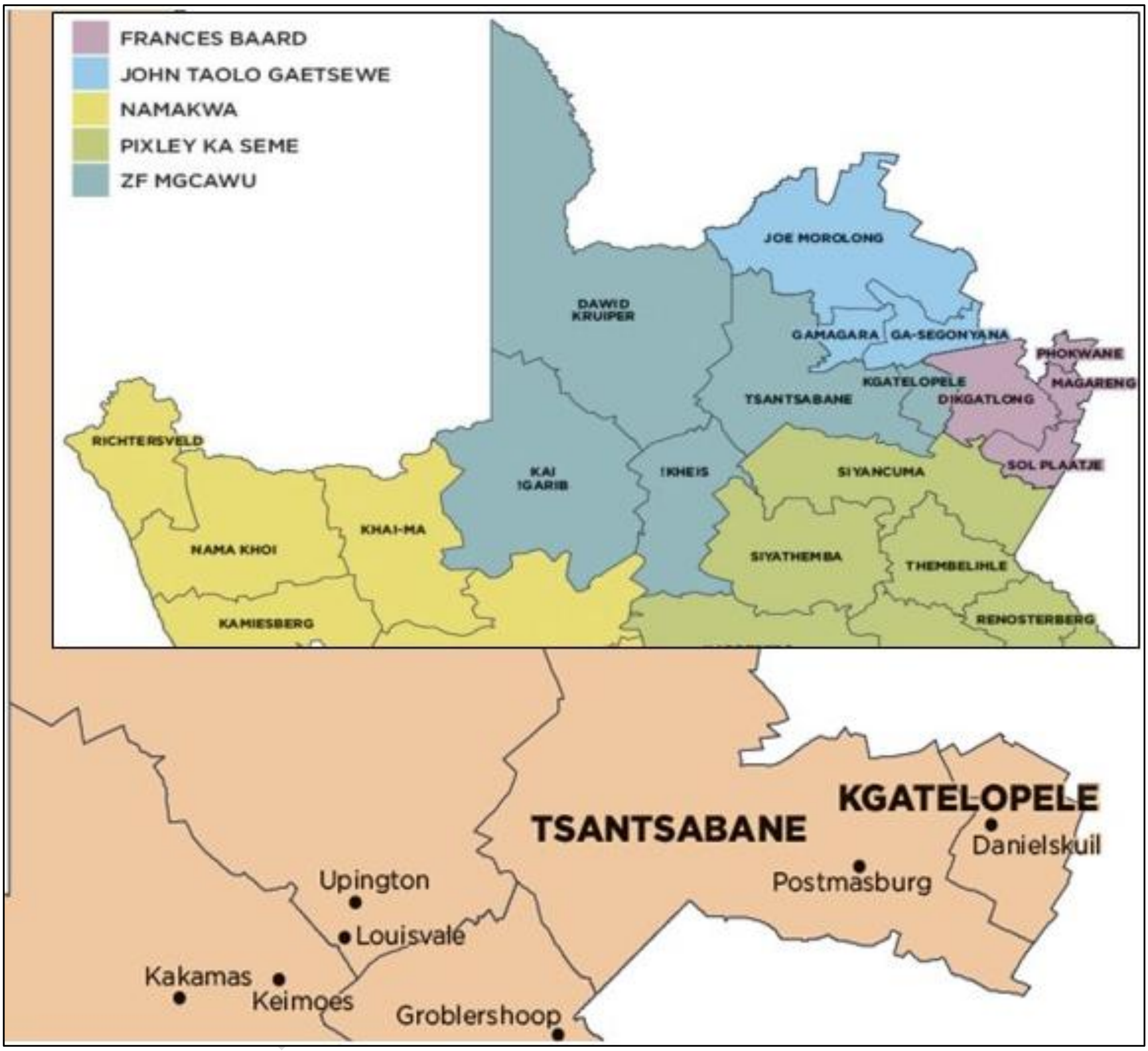
Table of Contents

List of Tables

List of Figures

1 Introduction and legal framework

The Applicant, Assmang (Pty) Ltd ("Assmang"), applied for a mining right ("MR") near Postmasburg in the Tsantsabane Local Municipality ("LM") in the ZF Mgcawu District Municipality ("DM") of the Northern Cape (Figure 1.1).



Source: Eco-Thunder (2025).

Figure 1.1: ZF Mgcawu DM with the Tsantsabane LM in the Northern Cape Province.

Assmang also applied for environmental authorisation ("EA") and waste licence ("WL") to mine hematite, magnetite, goethite, limonite, siderite, pyrolusite, psilomelane, rhodochrosite, manganite, braunite, hausmannite, manganese ore, iron ore, and diamonds (general).

The proposed project triggers environmental authorisation ("EA") requirements with listed activities in terms of the National Environmental Management Act ("NEMA"), 1998 (Act 107 of 1998) and the Environmental Impact Assessment ("EIA") Regulations 2014 (as amended), as well as the National Environmental Management: Waste Act ("NEMWA"), 2008 (Act 59 of 2008) and the National

Environmental Management: Air Quality Act ("NEMAQA") (Act 39 of 2004). The EIA process for the proposed project is undertaken by Greenmined Environmental (Pty) Ltd ("Greenmined") in accordance with the NEMA EIA Regulations. The EIA should assess project specific environmental impacts and alternatives, consider public input, and propose mitigation measures, to ultimately culminate in an environmental management programme that informs the competent authority (Department of Mineral Resources and Energy, "DMRE") when considering the environmental authorisation. Greenmined prepared a Final Scoping Report as part of the requirements regarding the EIA process to be accepted by the DMRE (Greenmined 2025).

National Ambient Air Quality Standards ("NAAQS") have been set under NEMAQA to give effect to section 24(b) of the Constitution in order to enhance the quality of ambient air for the sake of securing an environment that is not harmful to the health and wellbeing of people. The primary aim of NAAQS is to provide a uniform basis for the protection of public health and ecosystems from the adverse effects of air pollution, and to eliminate or reduce to a minimum, exposure to those pollutants that are known or likely to be hazardous (Department of Environmental Affairs 2004). However, it is mainly an air quality management tool and adherence to NAAQS does not guarantee the absence of an impact on health. Therefore, the Final Scoping Report identified the requirement for a Health Impact Assessment ("HIA"), for which purpose INFOTOX (Pty) Ltd ("INFOTOX") was appointed. The HIA is not concerned with emissions or releases of which the potential impact is limited to the mining property (within the fence line), but only with the environmental emissions which have a potential impact on health of receptor communities in the vicinity of the mine.

The NEMA EIA Regulations (Republic of South Africa 2014) as amended, specify requirements for specialist reports in Appendix 6 of GNR 982, Government Gazette 38282. A list of required information is presented in Table 1.1, with references to the HIA report sections satisfying these requirements.

Table 1.1: Compliance of this HIA report with Appendix 6 of the NEMA EIA Regulations.

Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6	Section of Report
(a) details of the specialist who prepared the report; and the expertise of that specialist to compile a specialist report including a *curriculum vitae*;	See the section *Expertise and Declaration of Independence* in the preface of this report, and the Specialist CVs are attached as Annexure 3.
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	See the section *Expertise and Declaration of Independence* in the preface of this report.
(c) an indication of the scope of, and the purpose for which, the report was prepared;	Sections 1 and 2
(cA) an indication of the quality and age of base data used for the specialist report;	Sections 5.1, 6, 7, 8 and 9.2
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 9.2 (vulnerability assessment) for existing impacts. Section 9.4.4 for cumulative impacts. Levels of acceptable change are not stipulated in legislation or guidelines. The acceptability of the assessed levels of change is discussed in Sections 5.9 and 9.4.
(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	N/A No site investigation required or conducted for the HHRA or the RAHIA. The HHRA and RAHIA is based on information provided by Greenmined Environmental, the AIR, the SIA, the SWMP, the surface water hydrological and the groundwater impact reports, and a desktop study of the baseline health of the potential receptor community (Section 9.2).

Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6	Section of Report
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Sections 5, 7, 9 and Annexures 1 and 2
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	The sensitivity of the site with regard to the health impact on receptor populations is assessed in the baseline health vulnerability section (Section 9.1).
(g) an identification of any areas to be avoided, including buffers;	None applicable
(h) 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 3.1.3
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Sections 7 and 8
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment or activities;	Sections 5, 6 and 9
(k) any mitigation measures for inclusion in the EMPR;	Section 9.5.2
(l) any conditions for inclusion in the environmental authorisation;	Section 9.5.3
(m) any monitoring requirements for inclusion in the EMPR or environmental authorisation;	Section 9.5.4
(n) a reasoned opinion— i. whether the proposed activity, activities or portions thereof should be authorised; iA. Regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr or Environmental Authorization, and where applicable, the closure plan;	Section 9.5.1
(o) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Not applicable
(p) any other information requested by the competent authority	Not applicable
(2) Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Not applicable

2 Scope of the report

The Health Impact Assessment ("HIA") presented in this report is scoped according to the Good Practice guidance of the International Finance Corporation ("IFC"), a member of the World Bank Group. INFOTOX is guided, amongst other IFC guidelines, by the IFC Environmental, Health and Safety ("EHS") Guidelines for Mining (IFC 2007).

The IFC differentiates between two types of health impact assessments ("HIAs"), namely, a Rapid Appraisal HIA ("RAHIA") and a comprehensive HIA. A comprehensive HIA is recommended when the project is likely to attract or involve a significant influx of people, for example a large construction work force. It was concluded in the Socio-Economic Impact Assessment ("SIA") that the development of the proposed mining right could result in a slight shift in local employment dynamics, as individuals associated with informal labour or neighbouring operations may seek opportunities during the construction or operational phases. However, this shift is expected to be minimal, due to the presence of multiple formal mining operations in the area (Eco-Thunder 2025). Other factors in favour of a comprehensive HIA include resettlement or relocation of local inhabitants or communities, significant construction activity, or the assessment of a large project in a rural setting. Since none of these factors are envisioned for the Makganyane Project, the RAHIA is a fitting format for the HIA.

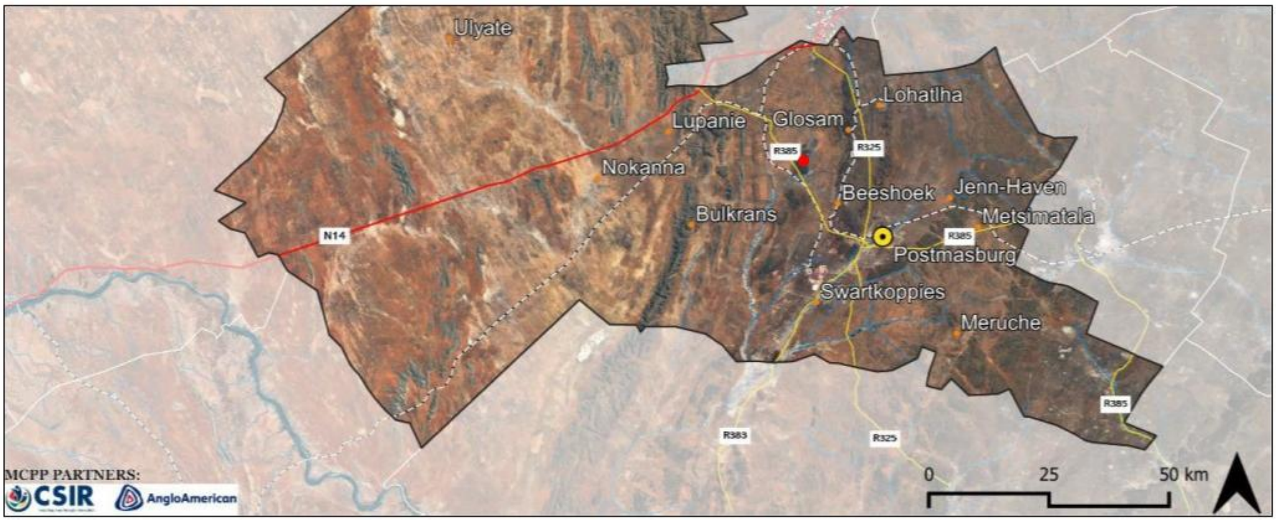
Specialist reports compiled for the purposes of the EIA, from which information is used in the RAHIA, are the following:

- Socio-Economic Impact Assessment for the Proposed Makganyane Mining Right (Eco-Thunder Consulting (Pty) Ltd, “Eco-Thunder” 2025).
- Waste Classification and Assessment of Expected Waste Rock for the Makganyane Iron Ore Mine, Northern Cape Province (Digby Wells Environmental 2025).
- Stormwater Management Plan (“SWMP”) by The Biodiversity Company (Nakhooda 2025a).
- Hydrological Assessment Report prepared by The Biodiversity Company (Nakhooda 2025b).
- Groundwater Assessment Report (Groundwater Complete 2025).
- Air Quality Impact Assessment Report (“AIR”) for the Proposed Makganyane Mine (Yellow Tree Environmental 2025).

3 Study area

3.1 Geography, layout and sensitive receptors

The proposed Makganyane Mining Right area is situated approximately 24 km north-west of the town of Postmasburg, which is the nearest formal settlement. The area is located within Municipal Ward 6 of the Tsantsabane LM (Figure 3.1.1).



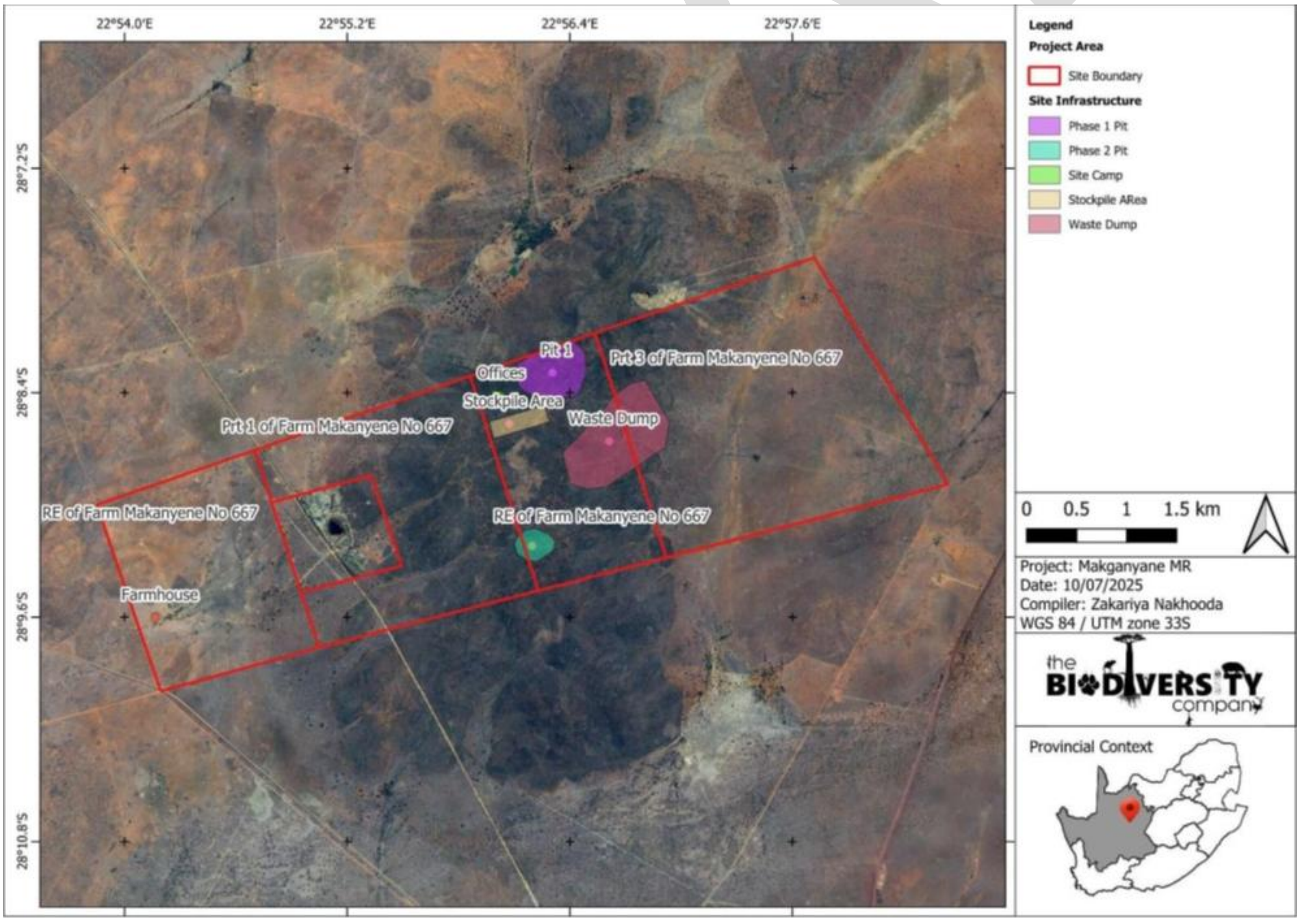
Source: Eco-Thunder (2025). Note: the approximate location of the Makganyane mining right area is indicated as a red dot to the east of the R385.

Figure 3.1.1: Tsantsabane LM Ward 6 geographical layout around the Makganyane mining right application area.

The mining right application is for 1 549.61 ha that extends over Portion 2 (portion of Portion 1), Remainder Portion, Remainder Portion of Portion 1 and Portion 3 of the farm Makganyane No 667 (Figure 3.1.2). The land in question comprises a 5-ha area currently classified as natural grasslands with sparse vegetation. The site is currently used for livestock and game farming; the primary land use across much of the project area is low-intensity grazing. Grazing is practiced informally on portions of the site by local land users. The broader study area includes a few farmsteads scattered within a radius of approximately 6 km from the proposed Makganyane Mining Right (Figure 3.1.3).

The AIR (Yellow Tree Environmental 2025) approached sensitive receptors as sites where the occupants are more susceptible to the adverse effects of exposure to air pollutants, e.g., hospitals, schools, daycare facilities, and elderly housing. Since the surrounding land use is limited to agricultural and mining activities, and since there are no known sensitive land uses within the vicinity of the site, the modellers did not include specific sensitive receptor sites in the AIR.

However, it is also true that children, that is, infants and young children (the under-5 age group), older children included in the under-15 age group and older persons (65+) should be regarded as sensitive to the respiratory and cardiovascular effects of air pollutants, such as airborne particulate matter ("PM"). Age-related vulnerability to health effects of air pollutants are discussed in Section 9.2.3. It cannot be excluded that such person are living at farmsteads noted in the vicinity of the project site according to Figure 3.1.3 from the SEIA (Eco-Thunder 2025). Therefore, the farmsteads are viewed as potential sensitive receptors for the purposes of the RAHIA.



Source: Nakhooda (2025a)

Figure 3.1.2: Proposed site layout in the Makganyane mining right area.

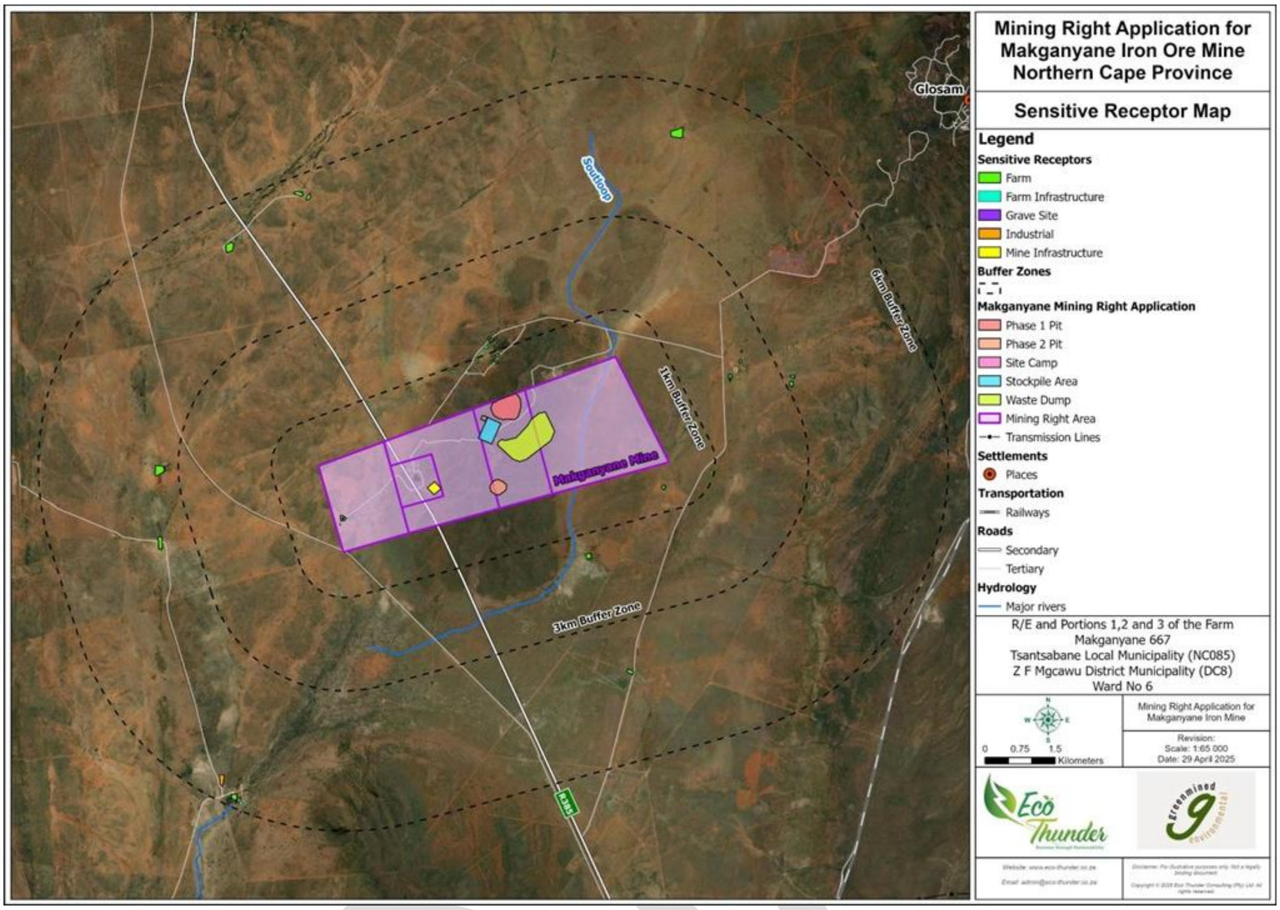


Figure 3.1.3: Public receptors (farms) within the broader study area.

3.2 Demography

The ZF Mgcawu DM contributes 21.4% of the Northern Cape population. Tsantsabane LM had a population 43 758 people in 2021, and is expected to reach 55 345 people by 2031 (Eco-Thunder 2025). Glosam SP is the only nearby community (see Figure 3.1.3), with a population of only 131 people in 2021.

Population numbers in the sensitive age groups in the Tsantsabane LM serves as an indication of the size of the sensitive population. Statistics South Africa ("Stats SA" 2023) compiled a Census 2022 Municipal Fact Sheet with age group percentages presented in Table 3.2.1. Age group percentages were not differentiated to the under-5 age group in the Fact Sheet, but were available on the Stats SA online portal with the "Key statistics for Tsantsabane" (Stats SA online), and, similarly, the key statistics for the ZF Mgcawu DM and the Northern Cape (Stats SA online). The Tsantsabane LM population is assumed to represent the receptor area of the proposed mining right application and Table 3.2.1 shows that the population percentage in the childhood age group is slightly lower than the Northern Cape and ZF Mgcawu DM percentages, but the elderly age group (65+) percentages are comparable. The sensitive groups represent approximately 30% of the all-ages group in the Tsantsabane LM.

Table 3.2.1: Northern Cape, ZF Mgcawu DM and Tsantsabane LM age-group percentages from the 2022 Census.

Province, DM and LM	<5 years (%)	<15 years (%)	65+ years (%)
Northern Cape	9.53	27.8	6.6
ZF Mgcawu DM	9.06	26.8	5.9
Tsantsabane LM	7.02	21.5	6.3
References: Key statistics (https://census.statssa.gov.za/#/province/5/2) and Stats SA (2023)			

4 Planned operations

4.1 Three key phases

The project activities can be divided into three key phases (Eco-Thunder 2025):

- Site establishment/construction phase, involving the demarcation of the site boundaries and buffer zones (if required) and site establishment including the clearing of vegetation, stripping and stockpiling of topsoil, and establishment of site infrastructure.

- The operational phase entailing opencast mining:
  - Pre-stripping of the top layer material, of which the topsoil will be stored separately for rehabilitation.
  - Waste rock stripped to access the ore body followed by open cast mining of Pit 1 and Pit 2 (refer to Figure 3.1.3).
  - Mining by drilling and blasting with associated truck and shovel operations.
  - Run of mine ("ROM") ore from the open pit/s reports to a crusher situated on site and in the stockpile area.
  - Crushed ore are stockpiled on-site from where ore will be transported via road (R385) to the Beeshoek Mine processing facility (off-site, Figure 3.1.1) using side tipper trucks. No processing will take place at the Makganyane mine.

- Decommissioning phase, with sloping and rehabilitation, the replacement of topsoil and the removal of infrastructure no longer needed by the landowners.

4.2 Water management

The Soutloop River, running along the eastern portion of the Makganyane mining right area (Figure 3.1.3) is apparently used for livestock and informal agricultural crop irrigation, while other landholders may also rely on non-perennial rivers channelling seasonal runoff, which traverses the area (Eco-Thunder 2025).

The Biodiversity Company (Nakhooda 2025a) prepared a Stormwater Management Plan ("SWMP") for the proposed Makganyane iron ore mine. The purpose of the SWMP is to prevent contamination of surface water resources by separating clean and dirty water systems, adhering to National Water Act regulations. The hydrology is characterised by the quaternary catchment area in which the proposed mine is situated, with low rainfall (323 mm/year) and high evaporation (2 450 mm/year) (Nakhooda 2025a).

The majority of the site boundary was considered “clean” and omitted from the SWMP, with the exception of areas that require diversions, since:

- Operations were restricted to a few site-specific areas.
- The clean areas in the site boundary are protected by the natural run-off flow direction, which would be away from the proposed operations.

The SWMP identified areas that would need stormwater infrastructure:

- Dirty stormwater channels around the waste dump, product stockpiles and office areas (site camp).
- 2 Evaporation dams, one each at the waste dump and the stockpile area, acting as containment facilities for dirty water emanating from these areas. It is assumed (in the SWMP) that the runoff from these dams will be reused, specifically for dust suppression.
- Sumps at the lowest point within the respective pits were proposed for Pits 1 and 2, which would collect runoff from within the pits as well as any decant as a result of the mining operations.
- It is assumed (in the SWMP) that the sumps within the pits will be kept as low as possible to cater for any runoff generated during rainfall events and that contained water will be utilised across the mining operations and specifically for dust suppression.
- Dirty stormwater channels around the office area and from the vehicle wash bay will divert runoff towards a sump with oil separator. Excess water from the sump can be considered clean after passing through the oil separator and can be allowed to flow away from the site into the nearby drainage line.
- Ablutions from the office area will drain into a septic tank (closed system to be serviced when needed.)

Nakhooda (2025a) recommended that the SWMP should be revisited subsequent to design changes or any major changes to the current mine operations plans.

5 Air contaminants HHRA

5.1 Air contaminants and sources

The AIR by Yellow Tree Environmental (2025) characterized the proposed mining and materials handling activities in the project area according to the potential to adversely affect ambient air quality.

The main concern was fugitive emissions of particulate matter (PM10[1] and PM2.5[2]) from sources such as:

- Blasting during open pit development, truck-based material handling, and wind erosion over the exposed pit areas.
- Vehicle entrainment on the trucking routes: heavy-duty trucks travelling on-site, including the transport of ore, waste rock, and crushed material, have the potential to generate fugitive dust through re-entrainment of particles on unpaved roads.
- Crushing and materials handling at the screening and crushing facility.
- Wind erosion from and material loading/drop operations at ore stockpiles.
- Materials handling at the waste dump.

[1] Particulate matter with aerodynamic diameter equal to and smaller than 10 micron.
[2] Particulate matter with aerodynamic diameter equal to and smaller than 2.5 micron.

5.2 AIR scenarios

Air quality impacts with dust mitigation measures were modelled to determine resulting changes in PM2.5 concentrations in air. Dust mitigation control efficiencies for area sources were obtained from the "WRAP Fugitive Dust Handbook" (WRAP 2006), which is a recognised reference for estimating emissions reductions, cited by Yellow Tree Environmental (2025). Table 5.2.1 summarises the selected dust control measures and associated PM10 control efficiencies. Due to limited information on PM2.5 efficiencies, the PM10 efficiencies were applied to PM2.5 emissions, viewed as a conservative measure by Yellow Tree Environmental (2025).

Table 5.2.1: Emissions control measures and efficiencies, applied to PM2.5.

Control Measure	PM_{10} Emissions Control Efficiency (%)
Watering of stockpiles and covering during wind events	90
Three-sided enclosures built around stockpiles with 50% porosity	75
Application of chemical suppressants to exposed surfaces	84
Gravel cover over exposed areas	84
Watering twice per day	55
Watering more than twice a day	70
Chemical suppressants	80

Two AIR scenarios were modelled, for the comparison of the expected air quality impacts under baseline mitigated and enhanced mitigated conditions.

Scenario 1: Baseline emissions with proposed dust mitigation measures:
Represents the baseline case with only the dust control measures proposed by the client:
- Spraying water on all haul roads twice per day.
- Application of a chemical dust suppressant on Route 3 (the haul road to the main gate).
- Emissions estimated for all major dust-generating activities, including open pit operations, haul roads, screening, crushing, and wind erosion from stockpiles and waste dumps.
- This scenario provides a worst-case estimate of potential air quality impacts based on the dust mitigation measures currently planned for the site.

Scenario 2 – Enhanced dust mitigation measures:
The implementation of additional dust control measures beyond those included in Scenario 1:
- Windbreaks or three-sided enclosures around the ore stockpile, waste rock dump and open pits to reduce wind-blown dust, with associated control efficiencies from Table 5.2.1.
- Application of a chemical dust suppressant in addition to water spraying on Route 2, targeted because of the high level of PM emissions predicted for this route in Scenario 1.

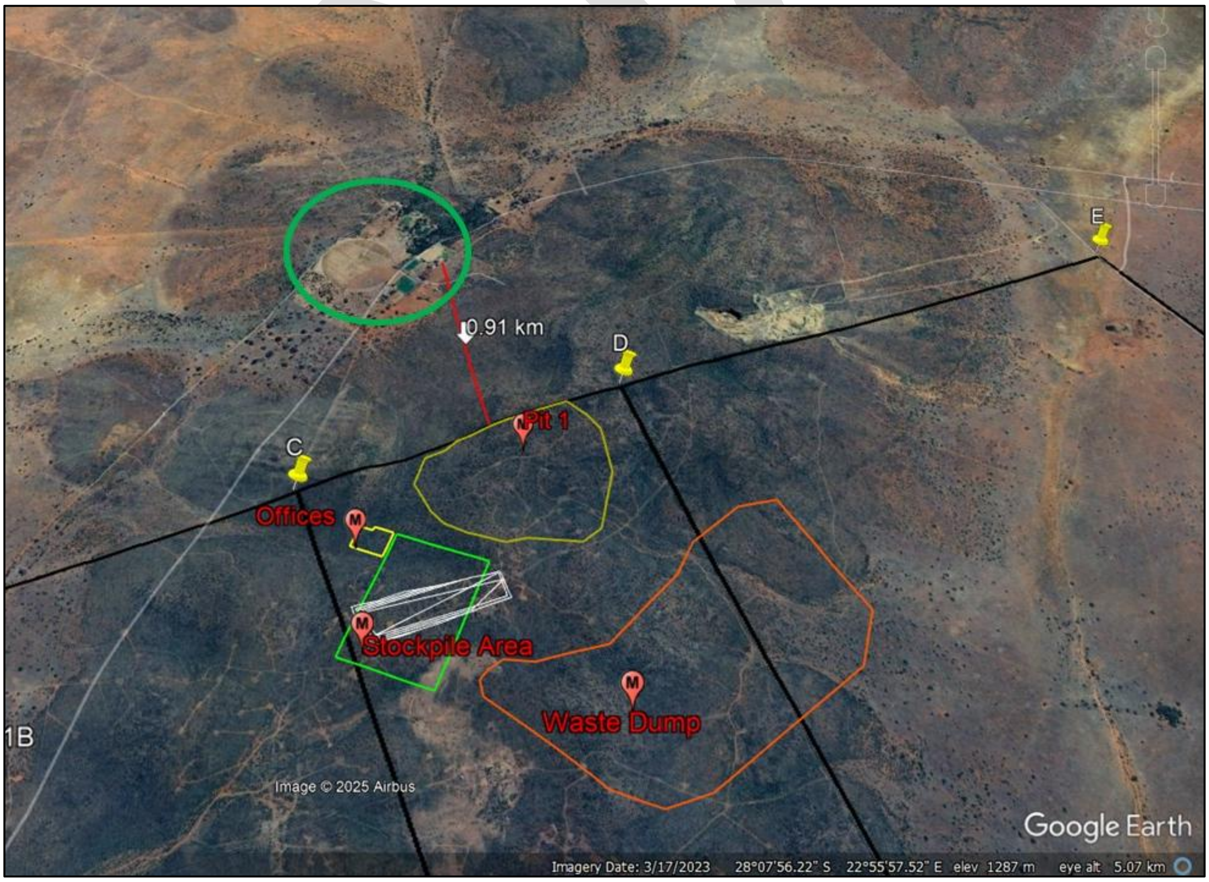
5.3 Receptors

A uniform cartesian grid with 50-metre spacing up to 10 km from the site and 100-metre spacing beyond 10 km was modelled (see Section 5.7 for maps with PM2.5 air dispersion isopleths). Yellow Tree Environmental (2025) viewed the maximum concentrations at the plant boundary as a surrogate for the surrounding land users and members of the public, for the purposes of comparisons with the NAAQS. However, for the purposes of the RAHIA, this approach overestimates public exposure, because the nearest public receptors are not situated at the boundary (Figure 3.1.3).

Yellow Tree Environmental (2025) notes that sensitive receptors are usually sites where the occupants are more susceptible to the adverse effects of exposure to air pollutants, e.g., hospitals, schools, daycare facilities, and elderly housing. Since the surrounding land use is limited to agricultural and mining activities, and since there are no known sensitive land uses within the vicinity of the site, the modellers did not provide PM2.5 concentrations at specific sensitive receptor sites. However, it was explained in Section 3.1 that farmsteads noted in the vicinity of the project site (Figure 3.1.3) are viewed as potential sensitive receptors for the purposes of the RAHIA.

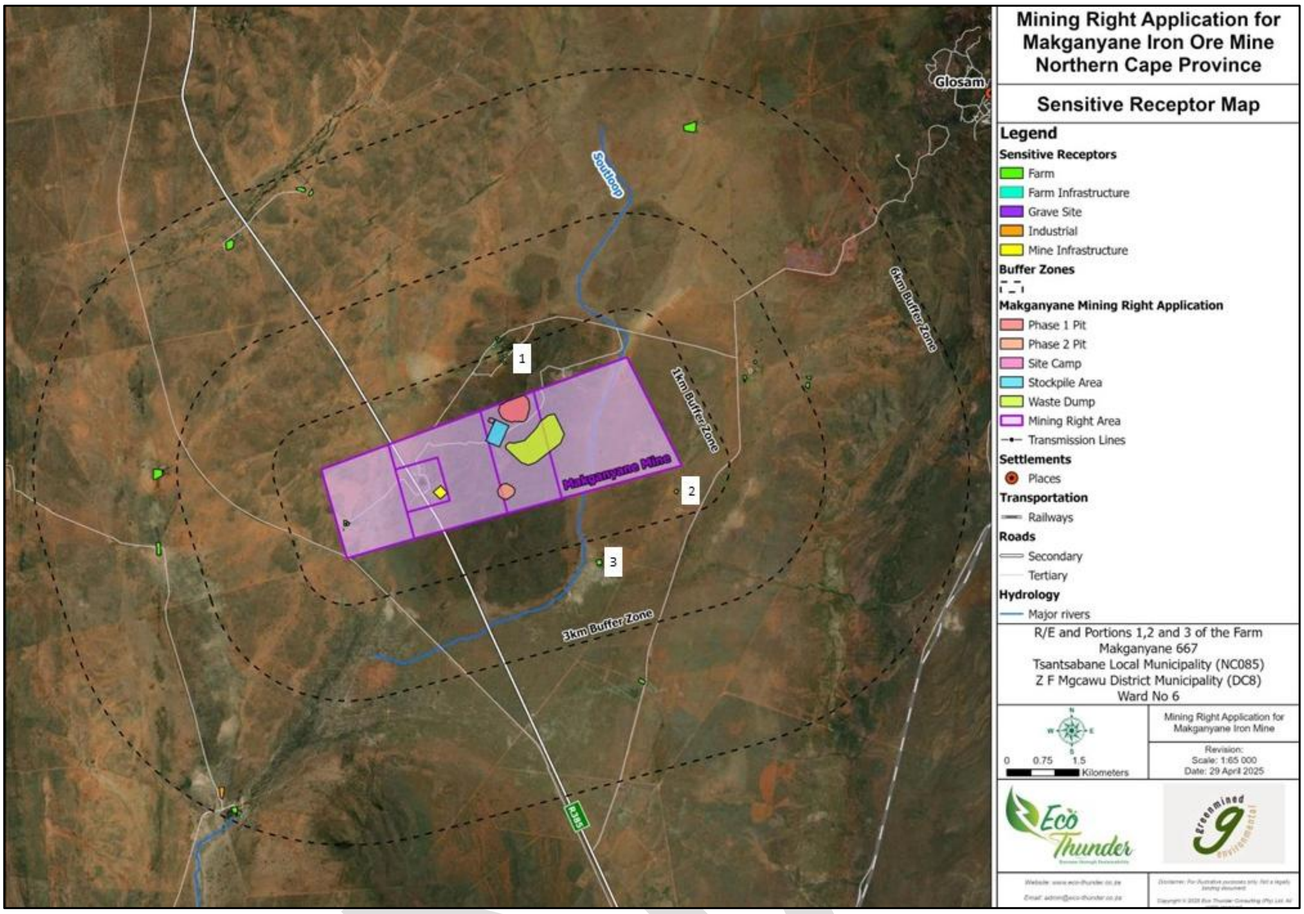
The most proximate identified farm (with residential buildings) is noted 910 meters to the north of Pit 1 on Google Earth images (Figure 5.3.1) and is a reasonable representation of a potential public receptor in close proximity to the north of the project site. A second tentatively identified public receptor was the "farmhouse" noted on the western portion of the project site in Figure 3.1.3. However, it was established by personal email communication with Greenmined in July 2025 that the farmhouse is currently unoccupied, and there are no plans for it to be inhabited during the mining phases. The farmhouse is thus not included as a public receptor, but two other proximate farms, noted to the south/south-east of the plant, are included.

Thus, in total, 3 proximate receptors are identified and their localities shown in Figure 5.3.2. The remaining farmsteads depicted in Figure 3.1.3 are all situated at greater distances from the project site, and are also not as significantly impacted by dust emitted from the proposed mining activity (see Section 5.7 for PM2.5 air dispersion isopleths). Accordingly, exposure at the nearest 3 farms represents a conservative estimate of exposure at farms within the broader study area, and it is not necessary to quantify PM2.5 exposure at the other more remote farmsteads.



Source: KML file, Greenmined per email, June 2025.
Note to figure: the farm is encircled by a green line.

Figure 5.3.1: Representative public receptor (farm) in proximity to the north of project site.



Note to figure: the numbers 1, 2 and 3 indicate representative public receptors in close proximity (within 2 km) of the fence line. The numbers were added by the authors and do not appear in the SEI report (Eco-Thunder 2025).

Figure 5.3.2: Public receptors (farms in green) within the broader study area.

5.4 Background to air contaminant HHRA

It is important to note that it is common to observe increases in mortality or hospitalisation rates even when the prevalent air concentrations do not exceed the environmental air quality guidelines or standards. For example, health effects from exposure to PM2.5 concentrations below particulate matter air quality guidelines are well documented (WHO 2005 and 2021). Simplistic comparisons between exposure concentrations and ambient air quality guidelines are inadequate to quantify health outcomes, mainly because ambient air quality guidelines are used for management of air quality and are not intended for risk quantification. Furthermore, researchers have not been able to establish a safe threshold below which there are no health risks (WHO 2005 and 2021). Assessment of air quality impacts on health may not be restricted to areas where guideline concentrations are exceeded, but should include those with modelled air concentrations within the NAAQS.

PM in air may be divided into the following main fractions of significance to health:

- Fine PM (PM2.5), particulate matter with a nominal mean aerodynamic diameter less than or equal to 2.5 µm.
- Thoracic coarse or coarse PM (PM10 to 2.5), particulate matter with a nominal mean aerodynamic diameter greater than 2.5 µm and less than or equal to 10 µm.
- Ultrafine particles ("UFPs"), generally considered as particulates with a diameter less than or equal to 0.1 µm (100 nm), based on physical size, thermal diffusivity or electrical mobility.

Combustion particles, organic compounds and fine metal particles are found in the PM2.5 fraction, but pollen and mould spores are mostly found in the coarse PM fraction (USEPA 2019).

PM2.5, rather than PM10, is the exposure indicator of choice for the assessment of the burden of disease or health risks associated with PM exposure (USEPA 2009). COMEAP (2007) had concluded that PM2.5 was the most satisfactory index of particulate air pollution for quantitative assessments. WHO reports (2013a and b) provided evidence for the causality of health effects associated with exposure to PM and also concluded that quantification of risks based on PM2.5 was more reliable than quantification based on PM10. The 2021 update of the WHO global Air Quality Guidelines assessed the certainty of evidence for a number of health effects of PM2.5 as high, while evidence for the same effects with PM10 was rated as moderate to low, with many effects failing to reach statistical significance. Therefore, PM risk analysis in this study is focused on PM2.5.

Mortality or hospitalisation rates for respiratory or cardiovascular causes are the measures of associated illness that are mostly applied in epidemiological studies of community health risks associated with exposure to the criteria pollutant PM2.5, as explained in the following sections.

5.5 Causality

Epidemiological and experimental human exposure studies are used to investigate the relationship between health effects and exposure to the criteria pollutants of interest. Epidemiological studies typically focus on incidence rates for various health endpoints such as cases of respiratory and cardiovascular disease, hospital admission and premature mortality. The purpose is to show a cause-effect relationship where cause relates to exposure and effect is the disease or death as a result of the cause (the exposure). Causation is an essential concept in epidemiology; yet there is no single, clearly expressed definition for causation. A statistically significant association between cause and an effect does not infer a causal relationship, although a strong association is often an indication of causality. Adequate evidence is necessary to establish a causal relationship between exposure and a consequence.

Criteria used to determine causality include the strength of association, temporality, consistency, theoretical plausibility, coherence, specificity in the causes, dose response relationships, experimental evidence and analogy. Causality determinations are therefore based on the evaluation and synthesis of evidence from across scientific disciplines. If evidence is sufficient to conclude that a causal relationship is likely to exist with relevant pollutant exposures, but important uncertainties remain, the relationship is referred to as "*likely to be causal*". That means that chance and bias can be ruled out with reasonable confidence, but potential issues may remain (USEPA 2019).

Discussions of the positions of the USEPA and the WHO on accepted causality of exposure to PM2.5 and of health effects for which causality are accepted, are presented in Annexure 1.

5.6 Exposure-response assessment

Predicted (modelled) or measured (monitored) impacts of mining and industrial emissions on air concentrations are used as a basis to assess impacts on health. For the purposes of the HHRA, this is achieved by calculating the potential increase in risk of hospital admissions or mortality due to specific causes, associated with modelled air concentrations of PM2.5. These calculations are based on results of epidemiological studies reported in the international scientific literature in which statistical methods were used to compare changes in hospitalisation or mortality rates with changes in air quality. Current statistical methods use the concept of relative risk ("RR") to derive the potential percentage increase in or contribution to effects. Methods of risk quantification are discussed in detail in Annexure 2.

Regarding exposure to PM2.5, the health effects of interest quantified in the HHRA are:

- Short-term (24-hour) PM2.5 concentrations:
  - Cardiovascular (including stroke) hospital admissions.
- Long-term (annual average) PM2.5 concentrations:
  - Acute bronchitis symptoms, ages 8-12.
  - Chronic bronchitis incidence in age group 27^{+}.
  - All-cause (natural) mortality.
  - Lung cancer incidence (annually) (ages 30+).

5.7 Receptor exposure assessment

Modelled concentration isopleth maps of PM2.5 dispersion in the study area around the proposed Makganyane Mining Right are included in the AIR (Yellow Tree Environmental 2025). Isopleths were mapped for Scenarios 1 and 2 (see descriptions in Section 5.2) and for daily and annual average ambient air concentrations of PM2.5 (Figures 5.7.1 to 5.7.4).

According to the AIR, as per the regulatory Code of Practice, all short-term averages (24 hours or less) were presented as 99th percentile concentrations. Daily average PM2.5 concentrations were calculated using meteorological data from three full calendar years (2022, 2023, and 2024); therefore, atmospheric impact modelling yielded daily average concentrations over a three-year period (1 096 days). The 99th percentiles of the daily average PM2.5 values "*are thus the 11th highest value recorded (1 096 x 0.01 = 10.96)*", that is, the lowest of the upper 1 per cent of modelled values.

Air concentrations at the representative proximate public receptors (farmsteads) marked 1, 2 and 3 in Figure 5.3.2 were estimated from the concentration isopleths in Figures 5.7.1 to 5.7.4. Receptors 1, 2 and 3 are located within 2 km of the fence line and are marked with numbered red dots on the concentration isopleths. The numbers were added by the authors and do not appear in the SEI report (Eco-Thunder 2025) or in the AIR (Yellow Tree Environmental 2025).

Estimated concentrations are presented in Table 5.7.1, and are equal to the modelled incremental increases in daily and annual PM2.5 concentrations due to proposed activities at the Makganyane Mining Right Area. The incremental increases are used for the calculation of human health risks, presented in Section 5.8, according to the methods and equations presented in Annexure 2.

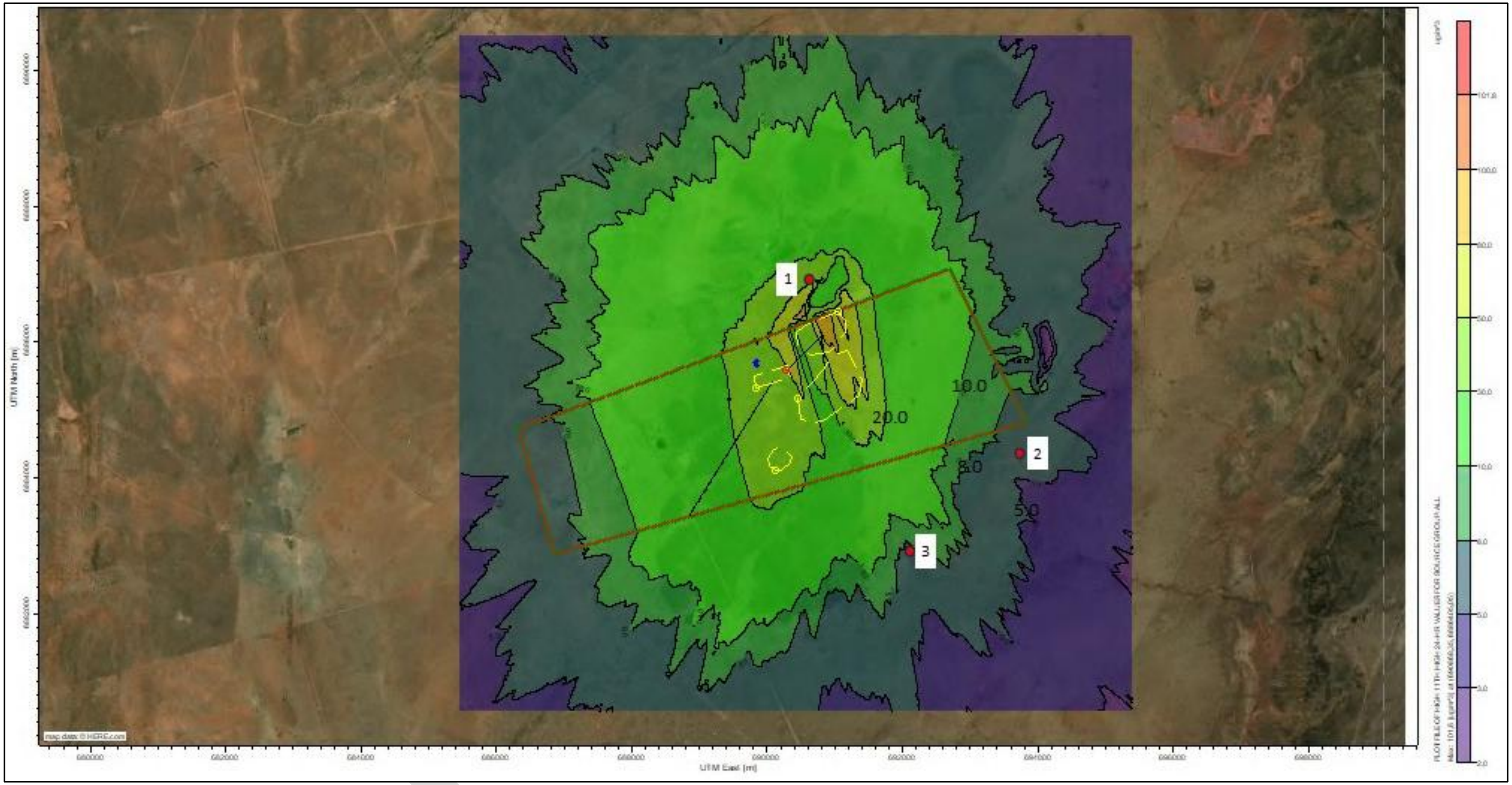


Figure 5.7.1: Scenario 1 isopleths of daily PM2.5 concentrations.

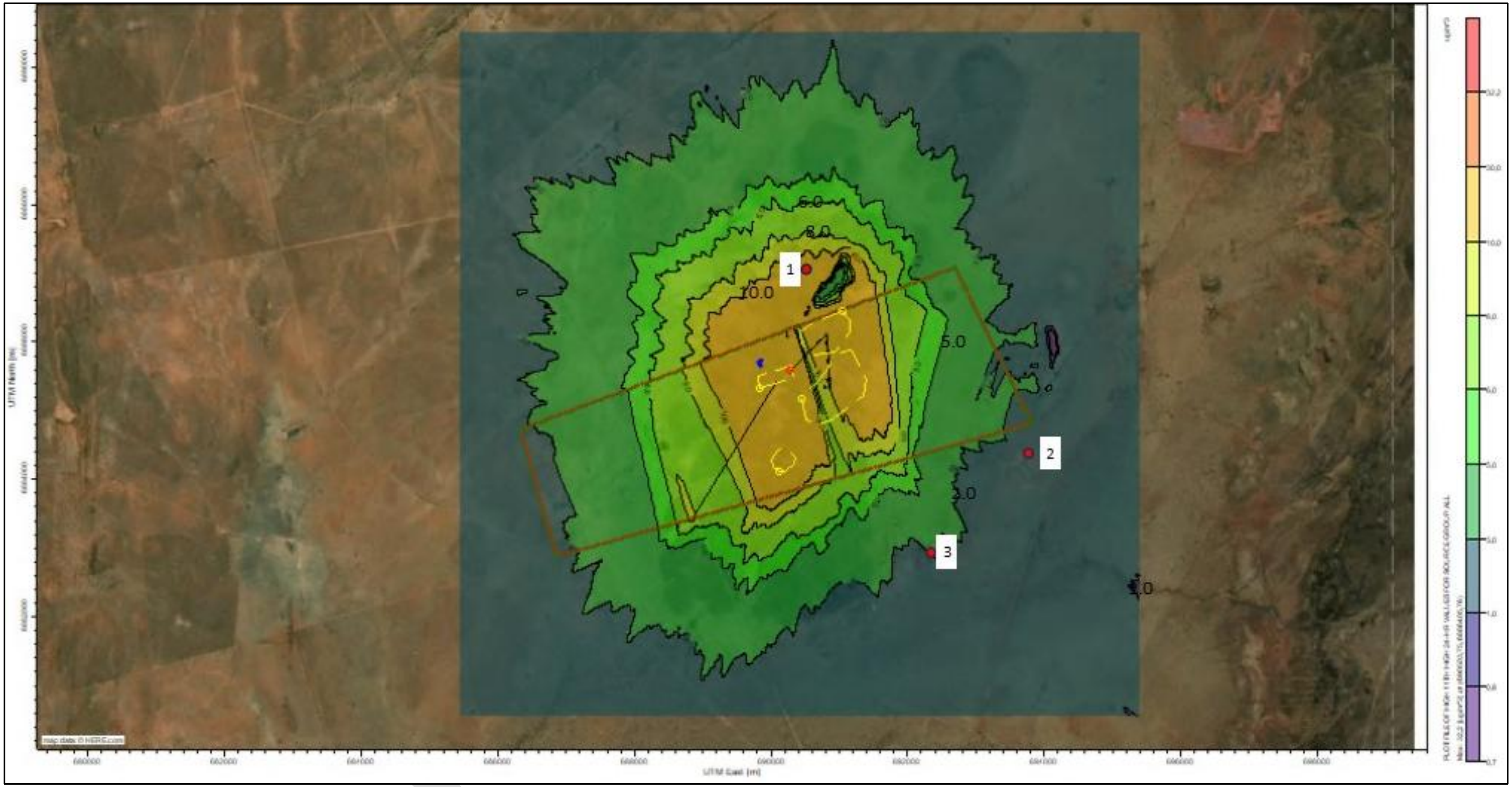


Figure 5.7.2: Scenario 2 isopleths of daily PM2.5 concentrations.

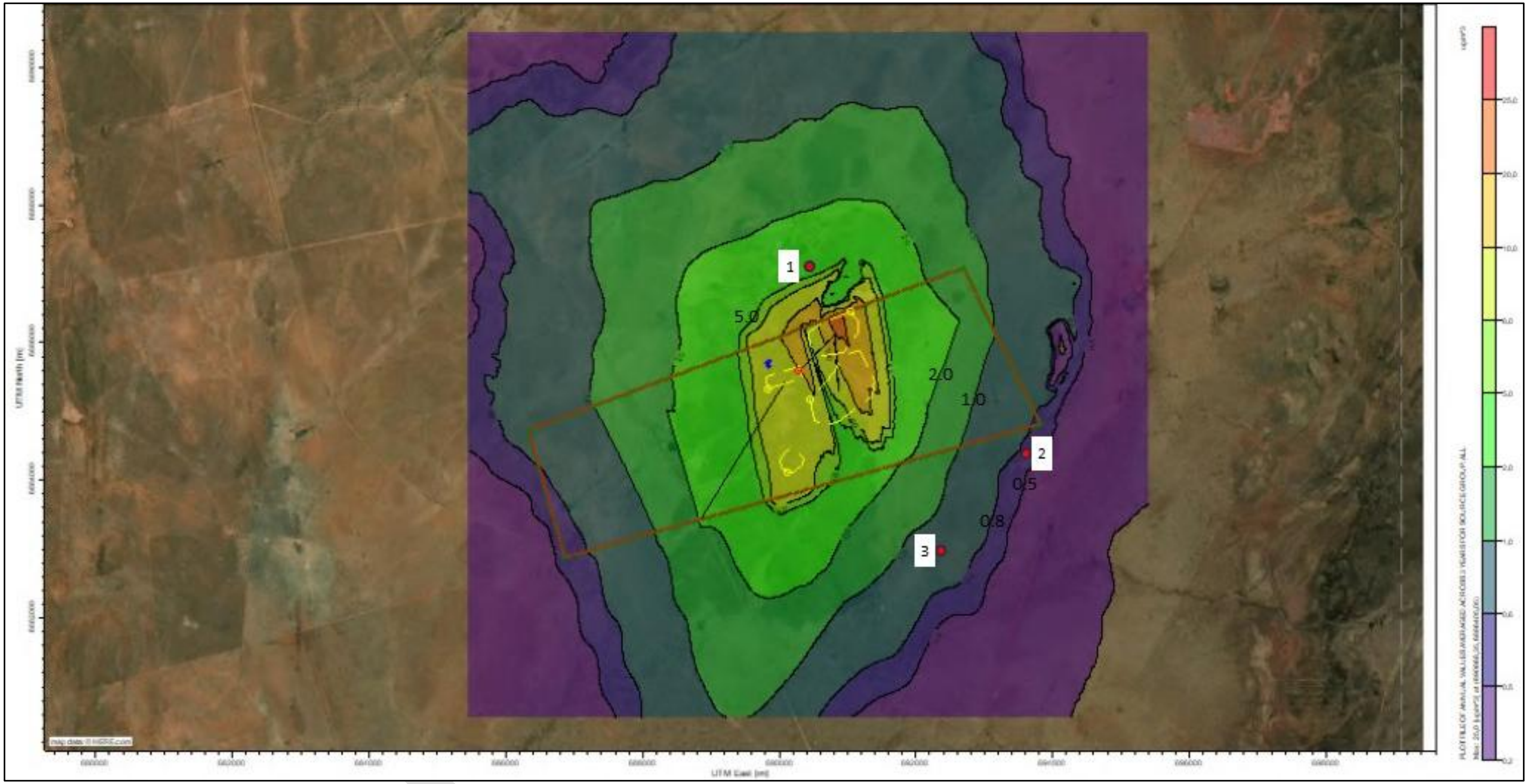


Figure 5.7.3: Scenario 1 isopleths of annual average PM2.5 concentrations.

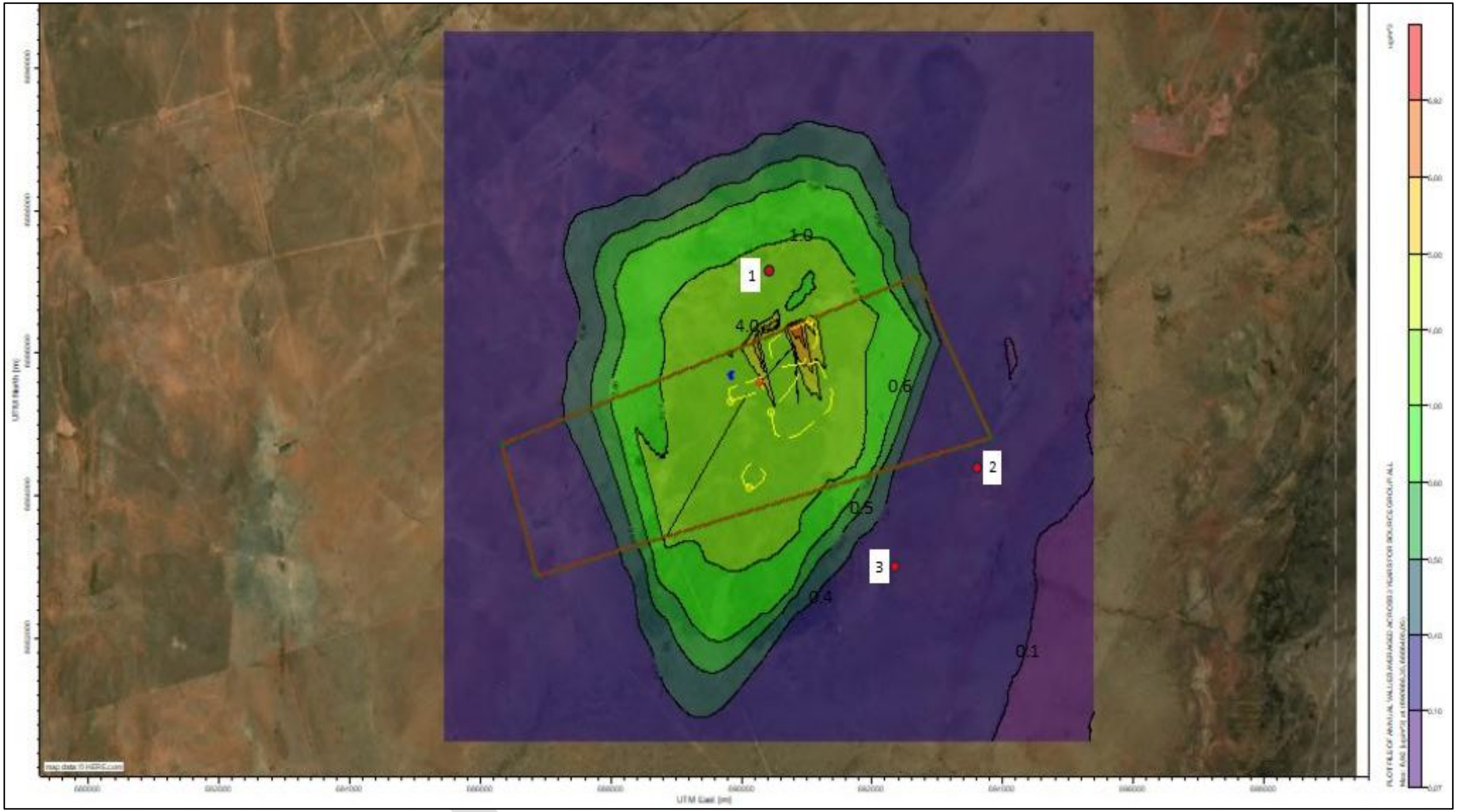


Figure 5.7.4: Scenario 2 isopleths of annual average PM2.5 concentrations.

Table 5.7.1: Modelled incremental increases in PM2.5 concentrations, estimated at the identified proximate receptors.

Receptor number	Incremental increase in PM2.5 concentrations (µg/m^3 air)			
	Daily (99th percentile)		Annual average	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	50.0	12.0	4.5	2.0
2	7.0	1.8	0.7	0.2
3	8.0	2.0	0.9	0.3

Scenario 1: Baseline emissions with proposed dust mitigation measures: spraying water on all haul roads 2x daily plus chemical dust suppressant on the haul road to the main gate.
Scenario 2: Enhanced dust mitigation measures: Scenario 1 plus additional measures.

5.8 Risk results

Calculations are performed using the exposure concentration incremental increases presented in Table 5.7.1, and the risk calculation methods described in Annexure 2. The results of the risk calculations are presented as attributable risk fractions ("AFs") in Tables 5.8.1 to 5.8.3. The AFs are the fractional increase in the disease burden that may reasonably be attributed to airborne PM2.5 generated from the proposed operations. The AF is described in more detail in Annexure 2. Results are also presented as the percentage increase in the health effect attributable to PM2.5 from the proposed operations (Tables 5.8.1 to 5.8.3). The percentage increase is the AF x 100.

Risks are interpreted and discussed in Sections 5.9 and 5.10.

Table 5.8.1: Proximate receptor 1: attributable fractions (AFs) and percentage increase in the risk of a health effect associated with modelled PM2.5 exposure.

Scenario / Health effect	Attributable fractions (AFs)		% Increase in risk	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
All-cause (natural) mortality	0.03	0.02	3.4	1.5
Cardiovascular (including stroke) hospital admissions	0.04	0.01	4.4	1.1
Acute bronchitis symptoms, ages 8-12	0.12	0.05	11.5	5.3
Chronic bronchitis incidence, ages 27+	0.06	0.03	6.0	2.7
Lung cancer incidence, ages 30+	0.16	0.07	15.6	7.3

Scenario 1: Baseline emissions with proposed dust mitigation measures: spraying water on all haul roads 2x daily plus chemical dust suppressant on the haul road to the main gate.
Scenario 2: Enhanced dust mitigation measures: Scenario 1 plus additional measures – windbreaks around dust sources and chemical dust suppressant in addition to water spraying on Route 2.

Table 5.8.2: Proximate receptor 2: attributable fractions (AFs) and percentage increase in the risk of a health effect associated with modelled PM2.5 exposure.

Scenario/ Receptor	Attributable fractions (AFs)		% Increase in risk	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
All-cause (natural) mortality	0.01	<0.01	0.5	0.2
Cardiovascular (including stroke) hospital admissions	0.01	<0.01	0.6	0.2
Acute bronchitis symptoms, ages 8-12	0.02	0.01	1.9	0.5
Chronic bronchitis incidence, ages 27+	0.01	<0.01	1.0	0.3
Lung cancer incidence, ages 30+	0.03	0.01	0.2	0.8

Scenario 1: Baseline emissions with proposed dust mitigation measures: spraying water on all haul roads 2x daily plus chemical dust suppressant on the haul road to the main gate.
Scenario 2: Enhanced dust mitigation measures: Scenario 1 plus additional measures – windbreaks around dust sources and chemical dust suppressant in addition to water spraying on Route 2.

Table 5.8.3: Proximate receptor 3: attributable fractions (AFs) and percentage increase in the risk of a health effect associated with modelled PM2.5 exposure.

Scenario/ Receptor	Attributable fractions (AFs)		% Increase in risk	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
All-cause (natural) mortality	0.01	<0.01	0.7	0.2
Cardiovascular (including stroke) hospital admissions	0.01	<0.01	0.7	0.2
Acute bronchitis symptoms, ages 8-12	0.02	0.01	2.4	0.8
Chronic bronchitis incidence, ages 27+	0.01	<0.01	1.2	0.4
Lung cancer incidence, ages 30+	0.03	0.01	3.3	1.1

Scenario 1: Baseline emissions with proposed dust mitigation measures: spraying water on all haul roads 2x daily plus chemical dust suppressant on the haul road to the main gate.
Scenario 2: Enhanced dust mitigation measures: Scenario 1 plus additional measures – windbreaks around dust sources and chemical dust suppressant in addition to water spraying on Route 2.

5.9 Approach for interpretation of risk results

The AFs and percentage increases presented in Section 5.8 are the calculated increases in the risk of a health effect (mortality, respiratory or cardiovascular), presenting as an increased occurrence of a specific health outcome, attributable to the PM2.5 fraction of fugitive dust escaping from the proposed mining activities. The health outcomes are the effects presented in Tables 5.8.1 to 5.8.3. The AFs and percentages express the fractional increase in the current disease burden. This fractional increase can be attributed to modelled increases in PM2.5 concentrations at the various receptors, in case the proposed mining activities should take place. The fractional increase is relative to the current risk of experiencing a health effect, or the current risk of mortality.

The health risk assessment methodology for PM2.5 is based on the calculation of risks to communities by using concentration-response functions ("CRFs"), which include the responses (health effects) in more sensitive people, such as children and the elderly, by default.

The concentrations modelled at the identified receptors for the purposes of the assessment of fugitive dust emissions are applicable to consecutive 24-hour exposures (daily exposures) or to continual exposure during a typical year of mining operations and weather conditions (the annual average concentrations).

The risks of a health effect causally associated with short-term (24-hour) exposure concentrations, namely cardiovascular hospital admissions presented in Tables 5.8.1 to 5.8.3, are calculated based on the modelled incremental increases in daily (24-hour) PM2.5 concentrations (refer to Section 5.6 for lists of effects based on daily and annual PM2.5 exposure, respectively). The daily (24-hour) exposure concentrations used for these calculations are the 99th percentiles of the modelled daily concentrations (Table 5.7.1). The 99th percentiles are modelled according to the requirements of the NAAQS, and not primarily for health risk calculation purposes.

The 99th percentile is the cut-off concentration below which 99 per cent of the modelled daily concentrations lie in a frequency distribution plot. Logically, less than 1 per cent of the modelled daily concentrations lie above this value, as explained by Yellow Tree Environmental (2025) (also refer to Section 5.7.1):

"*In the three-year period"* (that was modelled)*, there were 1 096 days. The 99th percentile values for the daily average values for PM10 and PM2.5 are thus the 11th highest value recorded* (meaning, modelled) *(1 096 x 0.01 = 10.96)*.

Therefore, it is true that the modelled daily values reported in Table 5.7.1 are relevant to only the upper range of exposure, which might be not much more than 11 of the total 1 096 days during the modelling period. Furthermore, on the other 99 per cent of days, the 24-hour concentrations will vary, and may on many days be much lower than the 99th percentile concentration.

Thus, it is important to recognise the inherently conservative nature of calculating the risk of cardiovascular hospital admissions based on the 99th percentile concentrations of daily PM2.5 concentrations. On the other 99 per cent of days, the health risk attributable to the fugitive PM2.5 will be less, and can be much lower on many days, depending on the shape of the air concentration frequency distribution plot.

The health risks associated with $PM_{2.5}$ concentrations at the identified sensitive receptors are calculated as AFs presented in Tables 5.8.1 to 5.8.3 and are interpreted as follows:

- AFs in the order of < 0.01 to 0.05 indicate an increased risk of a health effect in the range of less than 0.1 to 5 per cent, under the modelled air quality conditions at the various receptors. The implication of such low AFs is that, for all practical intents and purposes, the associated health risks will be insignificantly different from current or background risks.
- Slightly higher AFs in the range of more than 0.05 to 0.1 (more than 5, up to 10 per cent increase in risk) are viewed as indicating low risks of marginal concern.
- Higher AFs in the range of 0.1 to 0.2 (a 10 to 20 per cent increase in risk) are viewed as indicating low risks and the higher AFs up to less than 0.4 (40 per cent) as indicating a moderate risk of some, but not serious concern.
- AFs of 0.4 (40 per cent) and higher are viewed as of concern.

The interpretation of the risks based on the 99th percentile of daily concentrations is a highly conservative approach, because of the noted possibility that the modelled value may be applicable to as few as one day of a modelled year. This should be considered in the assessment of cardiovascular hospitalisation risks, which are based on the modelled daily maximum PM2.5 concentrations.

5.10 HHRA discussion

In general, as can be expected, the increased risks of a health effect is always lower under Scenario 2 conditions, which entail mitigation measures additional to those considered in Scenario 1.

At proximate receptor 1, situated approximately 900 meters to the north of Pit 1 (Figure 5.3.1), the proposed mining activities are associated with the following risks to health (Table 5.8.1):

- Insignificant risks of all-cause (natural) mortality and of cardiovascular hospital admissions:
  - In Scenario 1 (only dust suppression measures proposed by the client).
  - In Scenario 2 (measures proposed by the client and additional measures described in Section 5.2).
- Low risks of marginal concern (Scenario 1) and insignificant risks (Scenario 2) of chronic bronchitis.
- Regarding risks of acute bronchitis in children and of lung cancer in adults (aged 30+):
  - Low risks in Scenario 1 and 2, but
  - Risks in Scenario 2 are only of marginal concern.

At proximate receptors 2 and 3, situated to the south of the proposed site (Tables 5.8.2 and 5.8.3) risks of all health effects are insignificantly different from background (current) health risks, also in Scenario 1, with only the dust suppression measures proposed by the client (described in Section 5.2).

Provided that additional (Scenario 2) dust suppression measures are implemented, the mitigated risks are at most rated as low, and not of serious concern, and this only at receptor 1. Risks of PM2.5 health effects associated with the proposed mining activities are calculated as insignificant at receptors 2 and 3, assuming that the dust suppression measures proposed by the client are implemented. As expected, risks are even lower if additional dust suppression (Scenario 2) is undertaken.

Identification of receptor 1, the most proximate receptor to the north of Pit 1, as having moderately higher risks that the other two receptors to the south of the proposed fence line, is congruent with the modelled air quality maps showing higher concentrations to the north of the proposed fenceline, as in Figures 5.7.1 to 5.7.4.

The baseline risk of lung cancer in South Africa, in those older than 30, is 3.22/10 000 for females and 8.06/10 000 for males (NICD 2019). These risks are in the order of 0.03 to 0.08 per cent. Therefore, an additional risk of approximately 15 per cent (proximate receptor 1, Table 5.8.1) would only increase the actual risk to not more than 0.04 to 0.09 per cent, for females and males, respectively. Therefore, the projected risk of lung cancer after mitigation is not much different than the background risk prior to the inception of the proposed mining activities.

6 Surface- and groundwater contaminants HHRA

6.1 Water specialists' assessments

6.1.1 Surface hydrology

Surface run-off of potential contaminants from the mining operations into local surface water features such as non-perennial rivers and the Soutloop River (Figure 2.1) is of interest to the human and animal health risk assessments, since the socio-economic impact report identified these as potential sources of water for livestock and informal agricultural crop irrigation (Eco-Thunder 2025).

6.1.2 Waste rock seepage

The report on the assessment of the characteristics of waste rock generated by mining operations (Digby Wells Environmental 2025) indicated that:

- Waste rock is predominantly composed of quartz and hematite with minor contributions from other minerals.
- Sulphur concentrations were below acid-generating thresholds and it was confirmed that waste rock is non-acid forming, with a negligible risk of acid drainage.
- Leachable concentrations of hazardous elements were generally below relevant guidelines for domestic, irrigation, livestock, and aquatic use.
- Waste rock were classified as non-hazardous for landfill disposal.
- Modelling and risk assessment confirm a low risk of a significant impact on surface- and groundwater due to low rainfall and low leachable concentrations of hazardous elements.

6.1.3 Groundwater impacts

Aquifer characteristics

Groundwater Complete (2025) conducted a groundwater assessment and identified two aquifers relevant to the project area. The two aquifers are poorly connected with each other.

The first aquifer is located in the flat areas to the east and west of the Makganyane boundary (see Figure 3.1.3). It is a relatively shallow, semi-confined fractured aquifer. Due to the shallow water level and high permeability of the host rock, the boreholes drilled into this aquifer have high yields of good quality water. Farmers in the region use this aquifer widely for domestic purposes and livestock water supply with limited irrigation of gardens and fodder.

The second aquifer in the hills where proposed mining is to take place is a deeper aquifer than the first, but also fractured, displaying semi-confined or confined characteristics. The potential for extensive use of this aquifer for future domestic or stock watering is probably small, based on the Groundwater Complete (2025) assessment concluding that the second aquifer provides "*little to middling*" volumes of water. Therefore, extensive future use of this aquifer is not likely.

Noting that the two aquifers are poorly connected, it is reasonable to conclude that potential contamination of the second aquifer (more closely associated with the proposed mining area), although rated as of low likelihood, should not affect the first aquifer by default.

Baseline groundwater quality

Groundwater samples were collected from 20 boreholes located on and around the Makganyane property, from 10 pump-testing boreholes and from 10 user boreholes, currently in use for domestic or livestock watering purposes and located closer to mining operations, identified in the hydrocensus. Two samples were taken from the old Kimberlite shaft at different depths (Groundwater Complete 2025).

Samples were subjected to basic groundwater quality tests, with the following results and interpretations (Groundwater Complete 2025):

- Groundwater Total Dissolved Solids ("TDS") concentrations measured in the groundwater user boreholes:
    - Vary between 330 and 590 mg/litre; considered a normal range for an arid region.
    - The South African National Standard for drinking water (SANS 241:2015) prescribes a limit of 1 200 mg/litre.
- Nitrate concentrations:
    - The highest concentrations in the borehole census were around 7 mg/litre.
    - No mining occurs within the immediate vicinity of any of the hydrocensus boreholes; therefore, nitrates are mainly ascribed to areas where animals congregate in significant numbers (feedlot, kraal, etc.).
    - The SANS 241:2015 acute health-based nitrate drinking water limit is 12 mg/litre.
- Magnesium concentrations:
    - Relatively low and vary between ± 27 and 64 mg/litre.
    - The SANS 241:2015 limit is 70 mg/litre.
- Chloride concentrations:
    - Between approximately 8 to 68 mg/litre.
    - The SANS 241:2015 limit is 300 mg/litre.

The above results represents the baseline measures for later comparison with groundwater quality monitoring campaigns during the run of the mine. The following additional conclusions are stated in the Groundwater Complete (2025) report:

- Groundwater within the Makganyane area is dominated by calcium and magnesium cations, while bicarbonate alkalinity dominates the anion content.
- Groundwater parameter values measured in the old Kimberlite pit were largely similar to the other Makganyane boreholes.

6.2 Human health risks

Groundwater flow models indicate that the mostly dry riverbeds of the Soutloop River do not to receive any significant groundwater baseflow and are therefore not regarded as potential receptors of groundwater contamination that may originate from the mining rights area. Human health risks due to Soutloop River water use, on the few occasions when waterflow should actually occur, are thus unlikely to be different from the current (background) health risks, and a subsequent health impact is also unlikely.

Regarding the baseline groundwater quality, none of the water quality parameters or analysed inorganic constituent concentrations exceeded SANS 241:2015 limits (see Section 6.1). Therefore, at baseline, groundwater is considered to be of good quality and also suitable for human consumption (Groundwater Complete 2025).

Impacts on groundwater quality due to the proposed mining activities are important with regard to potential impacts on health in case the water quality should deteriorate. The Groundwater Complete (2025) report identified and assessed the main activities affecting groundwater quality, and it was concluded that risks of a negative impact on groundwater quality is low, regarding:

- Stockpiling and the waste rock dump ("WRD"):
  - Analyses of the material to be discarded in the WRD showed that acid drainage potential is minimal and as a result there are no chemicals of concern leaching from the waste material i.e., seepage quality is within relevant water quality guidelines (Digby Wells Environmental 2025).
  - The risk of a negative impact on groundwater quality is assessed as "Low", with and without mitigation (a sealing layer underneath the stockpiles and WRD).
- Excavation of the pits will not contribute to groundwater contamination.
- Waste water will be generated from the site office building ablution facilities with a sealed septic system to be serviced and extracted by professionals:
  - The system will only pose a risk to groundwater quality if a spill/leakage should take place.
  - The risk of a negative impact on groundwater quality is assessed as "Low", with and without mitigation (routine maintenance of the sewage system).

Based on the above assessment of "Low" risks of an impact on groundwater quality, it is concluded that the public utilisation of groundwater sources under the conditions of the proposed mining activities are not associated with risks to human (or animal) health, because water quality is not likely to be affected by the proposed mining operations.

Cumulative impacts on groundwater quality are unlikely, since active operations at other mine(s) in the broader study area occur at remote sites not near enough for any cumulative impacts to apply (Groundwater Complete 2025). Therefore, cumulative impacts on health, via potential impacts on groundwater quality are thus also unlikely.

However, the potential health risks associated with water sources utilisation is to be reassessed if:

- The SWMP design should change, or following major changes to the current mine operations plans (SWMP recommendations by Nakhooda (2025a)).
- Recommended monitoring of ground- and surface water quality down-gradient of the waste rock dump, or in the Soutloop River (Digby Wells Environmental 2025) should indicate a deterioration of water quality.

7 Uncertainties, assumptions and knowledge gaps

The HHRA in this report is based on modelled ambient air concentrations of PM2.5 provided by Yellow Tree Environmental (2025) in the AIR, on the geochemical assessment of expected waste rock (Digby Wells Environmental 2025), the proposed SWMP (Nakhooda 2025a) and the hydrogeological assessment report (Groundwater Complete 2025). Uncertainties associated with the modelled PM2.5 concentrations are discussed in that report and are not elaborated on in this RAHIA report. It is accepted that the other reports were conducted by professional specialists and particular uncertainties of knowledge gaps were not identified in these reports.

The PM2.5 HHRA followed standard international practices, based on methodologies applied in epidemiological studies. The results of the HHRA are presented with a high degree of confidence in the risk factors used to quantify potential health risks associated with each of the criteria pollutants assessed in this report. The PM2.5 concentration coefficients used for risk calculations are as proposed and supported by international regulatory and scientific agencies, namely the USEPA and the WHO. The coefficients were derived from large international epidemiological studies reviewed by these bodies, or by prominent epidemiologists appointed by these agencies.

Uncertainty in the results of the air quality HHRA is vested in the use of some risk factors based on studies in developed countries, since rigorously reviewed and internationally accepted risk factors applicable to a developing country such as South Africa are not available. However, the estimates presented in this report are the most accurate that are currently achievable.

The ideal source of concentration coefficients for PM2.5 risk quantification would be South African epidemiological studies, since socio-economic factors unique to South Africa might influence the estimated outcomes. However, a sufficient database of such epidemiological studies is not currently available in South Africa. This can be identified as a gap in our current epidemiological knowledge, which can only be bridged by assuming that risk factors from developed countries, and from other developing countries, such as countries in Asia, are applicable to the South African population. Nonetheless, it is not expected that the potential influence of these factors would significantly affect the outcome of the assessments, and the interpretations presented in this report are valid in the context of the acknowledged limitations.

Cardiovascular health risks potentially associated with PM2.5 exposure are based on highly conservative (maximum) daily (24-hour) exposure assumptions and are viewed as upper limits of potential risk, since these risks are based on the most conservative exposure estimates. The other health effect risks are based on the annual average PM2.5 concentration, which is viewed as a highly defensible statistical estimate of the general long-term air concentrations. Furthermore, the WHO and the USEPA concluded that the strength of association between long- and short-term exposure and the associated health effects is high (WHO 2021) and that exposure is causally, or at least likely to be causally, related to the health outcome under scrutiny (USEPA 2019). See Annexure 1 for a complete discussion of the assessments and for references to relevant documents.

Considering the information presented in this section, it is concluded that it is unlikely that the true risks contributed by PM2.5 emissions to air from the proposed mining operations will be higher than the estimates presented in this report.

8 Statement of confidence

The HHRA results and conclusions in this report are presented with a high degree of confidence, considering:

- The firm epidemiological foundation of the established associations of ambient PM2.5 exposure with the health effects assessed in this report.
- The rigorous basis of the development of the PM2.5 concentration coefficients used in risk calculations.
- The use of standard calculation methods proposed by the WHO and the USEPA.
- The standard air dispersion models used in the AIR.
- The PM2.5 concentrations used for calculations were modelled for the specific sensitive receptors and were not derived from isopleths of large areas covering many sensitive receptors.

9 Health impact rating

9.1 Rating approach

The impact rating (Section 9.4) considers, amongst other factors, the vulnerability of the exposed community receptors to the health effects of PM2.5, for which the cardiovascular system and the respiratory tract has been identified as the main targets of exposure to PM2.5. Therefore, the vulnerability of these organ systems in receptors in the vicinity of the proposed mine is assessed in Section 9.2. The vulnerability indicators used in the assessment are higher/lower rates of pre-existing cardiovascular or respiratory mortality in the ZF Mgcawu DM or in the Northern Cape, compared to national or provincial mortality rates.

9.2 Baseline health vulnerability of receptors

9.2.1 Assessment approach

The cardiovascular and respiratory systems are the main targets of PM2.5, specified in Section 2.2. Sensitivity of the receptor population is assessed from available health statistics, such as causes of mortality and hospital admission numbers. Hospital admission statistics are not generally accessible in the public domain, unless admissions numbers are the subject of health survey research, which is usually focussed on specific hospitals or causes for admission. Cause-of-death statistics reported annually by Stats SA are readily available for assessment and serve as the proxy for assessment of the health vulnerabilities of the receptor population, presented in Sections 9.2.2 to 9.2.4.

Stats SA's most recent cause-of-death data are from 2021, released in 2025. The published data (Stats SA 2025, Appendix P.4) extend to the level of the DM (ZF Mgcawu), but not the LM (Tsantsabane). Causes of death are broadly categorised as either natural or non-natural causes. Examples of non-natural causes of death are transport accidents, intentional self-harm and assault. Natural causes are non-violent, non-intentional, non-accidental causes, such as heart attacks and pneumonia. These are not the result of accidental or intentional harm.

The baseline health status of the receptor population, and their vulnerability to the health effects of air pollution, are assessed from the statistics on natural causes, with a focus on mortality caused by poor health of the respiratory and cardiovascular system, and other health indicators of vulnerability of these systems to the impacts of air pollution. The health effects of PM2.5 exposure are discussed in Section 5.4 to 5.6.

Diseases indicating vulnerability of the respiratory tract include viral infections, tuberculosis ("TB"), and a compromised immune system, such as in persons infected with the human immunodeficiency virus ("HIV"), increasing vulnerability to respiratory diseases. Regarding the cardiovascular system, the causes of death from Stats SA (2025) included by INFOTOX in the cardiovascular (with stroke) mortality group are:

- Ischaemic heart diseases (codes I20 to I25)
- Cerebrovascular diseases (codes I60 to I69)
- Other forms of heart disease (codes I30 to I52)

For the purpose of this report, cerebrovascular diseases are equated to stroke. The codes in brackets are the Stats SA (2025) grouping according to the 10th Revision of the ICD-10 codes, the disease classification codes of the International Statistical Classification of Diseases and Related Health Problems, maintained by the World Health Organization (WHO online).

Cause-of-death data specific to the ZF Mgcawu DM are only available for the all-ages group. Data for the Tsantsabane LM are not provided with the Stats SA (2025) release, but may be requested from Stats SA. Such request was made, but data had not been received at the time of writing of this report.

It is unlikely that there will be an influx of people seeking employment or working at the proposed mine and also unlikely that the disposable incomes in receptor communities will be significantly increased due the construction of infrastructure or during the operation of the facility. A shift from a rural to an urban lifestyle is not relevant. Socio-economic changes due to infrastructure development and operations at the proposed mine are not foreseen in the defined receptor area, and communicable and non-communicable diseases due to socio-economic changes are thus not assessed.

The Corona Virus Disease of 2019 ("COVID-19") was the single major natural cause of death in South Africa in 2021, at 15.1 per cent of deaths in the all-ages group, which is more than twice the percentage of the natural cause ranked second, namely, diabetes mellitus at 6.0 per cent of all mortalities. COVID-19 is a viral disease, but it was not considered as an indication of vulnerability to air pollution health effects as in the case of HIV and other viral infections, because it was a temporal event which cannot be used as a basis for predicting the vulnerability of receptor populations over the intermediate and longer term.

9.2.2 The all-ages population

The current health status of the ZF Mgcawu DM serves as the proxy for the baseline health status of the receptor communities near Postmasburg, because differentiated LM and small-area (e.g., municipal wards) health data were not available at the time of writing of this report.

The ten leading underlying natural causes of death are summarised in Stats SA (2025) and presented for South Africa, the Northern Cape and the ZF Mgcawu DM in Table 9.2.2.1. The purpose of the summary is to compare the cause-of-death ranking in the DM with the national and provincial rankings as indicators of the potential health vulnerabilities of Tsantsabane receptor communities to air pollution from the proposed mining project. DM percentages of deaths notably higher than the provincial percentages, indicating increased vulnerability in the DM community compared to the provincial community in general, are shaded in red and those notably lower are shaded in green.

Table 9.2.2.1: National, provincial and DM leading underlying natural causes of death in 2021, all ages, indicating vulnerability to air pollutants.

Cause of death with ICD10 codes	South Africa		Northern Cape		ZF Mgcawu DM	
	Rank	%	Rank	%	Rank	%
Hypertensive diseases (I10-I15)	3	4.9	2	7.0	2	8.9
Cerebrovascular diseases (I60-I69)	4	4.5	5	4.1	7	3.3
Human immunodeficiency virus [HIV] disease (B20-B24)	5	3.9	3	6.4	4	4.3
Influenza and pneumonia (J09-J18)	6	3.5	7	3.1	8	2.8
Tuberculosis (A15-A19)	7	2.9	6	3.4	3	4.6
Ischaemic heart diseases (I20-I25)	8	2.4	10	2.3	Not ranked	<2.2
Other forms of heart disease (I30-I52)	9	2.2	Not ranked	<2.3	Not ranked	<2.2
Other viral diseases (B25-B34)	10	2.2	9	2.5	9	2.4
Chronic lower respiratory diseases (J40-J47)	Not ranked	<2.2	8	3.0	6	3.8

%: Percentage of deaths due to cause.
Rank: Rank of cause of death, from 1 to 10 based on the number of deaths.
Not ranked: Not among the top 10 causes of death. The percentages of unranked causes were assumed to be lower than the cause ranked 10th.
Source: Stats SA 2025.

The burden of death summary (Table 9.2.2.1) informs the following conclusions concerning the all-ages baseline health of the ZF Mgcawu DM communities and their potential vulnerability to cardiovascular and respiratory effects of PM2.5 air pollution that might originate from the Makganyane mining project:

- Cardiovascular vulnerability:
  - The Northern Cape population appears more vulnerable to hypertensive diseases than the South African population in general, and this trend is emphasised in the DM. Moderately lower vulnerability is seen to cerebrovascular diseases, while the mortality due to ischaemic- and other forms of heart disease are comparable with the provincial and national rates.
  - Considering these observations holistically, it is concluded that the all-ages cardiovascular vulnerability of receptor communities is slightly increased in comparison to that of the South African population in general.

- Respiratory tract vulnerability:
  - The ZF Mgcawu DM population is significantly more vulnerable to tuberculosis than the Northern Cape and the South African population in general.
  - The Northern Cape population is likely more vulnerable to chronic lower respiratory diseases than the South African population in general, and this trend is emphasised in the DM.
  - The DM population is slightly less vulnerable to influenza and pneumonia.
  - Mortality rates due to HIV infection is moderately less in the DM compared to the province in general, but comparable to the South African population in general.
  - Overall, there are indications of increased respiratory tract vulnerability to the effects of PM2.5 air pollution in the ZF Mgcawu DM all-ages group, which may be extrapolated to the Makganyane receptor group in the Tsantsabane LM.

9.2.3 Age-related vulnerability to health effects of air pollutants

Younger children and older adults are more vulnerable to the effects of air pollution in general. The Expert Consensus Task Force of the China CDC (ECTF 2022), for example, identifies children, the elderly, and patients with cardiovascular or respiratory diseases as subpopulations with increased vulnerability to the health risks of PM2.5 pollution. This agrees with other and earlier opinions and findings. Millar et al. (2022), citing Lake et al. (2019) and Chen et al. (2015) emphasised the particular vulnerability of children and adolescents, even at low levels of exposure to air pollution.

Children and adolescents are particularly vulnerable to the effects of air pollution in general, for several reasons (Millar et al. 2022, WHO 2018 and American Lung Association 2022):

- Children are more active and breathe more rapidly than adults, absorbing more pollutants.
- Children inhale more polluted outdoor air than adults typically do, because they are outside for longer periods and are usually more active when outdoors, e.g., walking to school, participating in sport, or playing outdoors.
- The lungs and brain, along with other organs, and their metabolic functions are still in the process of development and maturation.

Children are more vulnerable to specifically the respiratory effects of air pollution, due to the following reasons (WHO 2018 and American Lung Association 2022):

- Their lungs and airways are smaller, which increases vulnerability to respiratory effects.
- Their immune systems are still developing, and with this their ability to fight off infections, also of the respiratory tract.
- Children have more respiratory infections than adults, which also seems to increase their susceptibility to air pollution.

Thus, the baseline health assessment should pay particular attention to the young, the elderly and those at risk of cardiovascular or respiratory diseases.

The relevant age groups for which mortality data are readily available from Stats SA are the group of children younger than 15 years of age and adults aged 65 years and older. Specific attention is given to the health status of these groups.

9.2.4 Baseline health of the population younger than 15 years of age

The demographic data presented in Section 2 indicate that the population younger than 15 years of age presents a likely proportion of approximately 21.5 per cent (Table 2.2.2) in the receptor area. Thus, it is important to assess the specific health vulnerabilities of this age group. As stated previously, cause-of-death data specific to the ZF Mgcawu DM were available only for the all-ages group at the time of writing of this report; therefore, provincial data serve as a surrogate indicating the vulnerability of the under-15 age group.

Cause-of-death data reported in Stats SA (2025) for the under 15 population are divided into the infant (younger than 1 year of age) and the 1-to-14 years age group. It is usually the case that most of the infant age group causes of death are those specific to the perinatal period, causes affected by maternal factors and complications of pregnancy, labour and delivery, which are not directly related to environmental pollution or socio-economic factors on the community level, but to factors specific to the foetus, infant, mother or events at the time of delivery (see Table 9.2.4.1). These factors do not play an important role in the 1-to-14 years age group; therefore, more attention is given to this group, and the vulnerabilities are viewed as indicators of vulnerabilities to all children younger than 15 years of age.

Provincial cause-of-death data for the under 15 population are presented as divided into the infant (younger than 1 year of age) (Table 9.2.4.1) and the 1-to-14 years age group (Table 9.2.4.2). Percentages of deaths due to causes indicating increased vulnerability to air pollutant health effects are shaded in red if provincial percentages are notably higher than the national numbers and shaded in green if the provincial percentages are notably lower. Higher and lower numbers are not shaded if the cause of death is not influenced by, or not indicating vulnerability to, the health effects of air pollution.

Table 9.2.4.1: Leading underlying infant (<1 years) mortality causes in 2021.

Cause of death with ICD10 codes	South Africa		Northern Cape	
	Rank	%	Rank	%
Respiratory and cardiovascular disorders specific to the perinatal period (P20-P29)	1	13.8	1	13.0
Intestinal infectious diseases (A00-A09)	2	6.4	5	3.9
Infections specific to the perinatal period (P35-P39)	3	5.5	7	3.6
Influenza and pneumonia (J09-J18)	4	5.5	3	4.6
Disorders related to length of gestation and foetal growth (P05-P08)	5	5.2	2	9.8
Other disorders originating in the perinatal period (P90-P96)	6	4.0	8	3.1
Foetus and newborn affected by maternal factors and by complications of pregnancy, labour and delivery (P00-P04)	7	3.5	4	4.3
Digestive system disorders of foetus and newborn (P75-P78)	8	2.7	Not ranked	<1.9
Congenital malformations of the circulatory system (Q20-Q28)	9	2.7	9	2.1
Other bacterial diseases (A30-A49)	10	1.9	Not ranked	<1.9
Haemorrhagic and haematological disorders of foetus and newborn (P50-P61)	Not ranked	<1.9	10	1.9
Other acute lower respiratory infections (J20-J22)	Not ranked	<1.9	6	3.6

%: Percentage of deaths due to cause.
Rank: Rank of cause of death, from 1 to 10 based on the number of deaths.
Not ranked: Not among the top 10 causes of death.
Source: Stats SA 2025.

According to current scientific knowledge, most of the causes of death among infants in the Northern Cape (10 of the 12 causes listed in Table 9.2.4.1) are not influenced by exposure of the mother or infant to PM2.5 air pollution.

These 10 causes are due to factors specific to the foetus, infant, or mother, or due to events at the time of delivery (the perinatal period), or are caused by known infectious agents:

- Respiratory and cardiovascular disorders specific to the perinatal period.
- Intestinal infectious diseases.
- Infections specific to the perinatal period.
- Disorders related to length of gestation and foetal growth.
- Other disorders originating in the perinatal period.

- Foetus and newborn affected by maternal factors and by complications of pregnancy, labour and delivery.
- Digestive system disorders of foetus and newborn.
- Congenital malformations of the circulatory system.
- Other bacterial diseases.
- Haemorrhagic and haematological disorders of foetus and newborn.

These findings are as expected for the infant age group. The remaining two causes, influenza and pneumonia, are indicators of vulnerability of the respiratory system to air pollutants. The percentage of mortalities due to influenza and pneumonia in the Northern Cape are moderately lower than in the general South African infant population (Table 9.2.4.1). On the other hand, mortality due to “other acute lower respiratory infections” represents a significantly higher percentage of the total mortality. Overall, infants in the receptor population may be more vulnerable to the respiratory effects of air pollution, but the overall vulnerability effect cannot be rated as more than moderate.

Considering that the majority of the highest ranked causes of death in the infant age group are not directly related to vulnerability to ambient air quality, the vulnerability of the 1-to-14 years age group, as derived from the evaluation of the causes of death, is an important assessment focus for the under-15 age group.

The mortality percentages due to specific causes in the Northern Cape are compared with percentages in the general South African population, to derive an indication of the potential health vulnerabilities of the Tsantsabane receptor communities. Malnutrition mortality is assessed in the under-15 age group, because malnutrition affects the immune system detrimentally, increasing vulnerability to infectious respiratory diseases and thus the respiratory health effects of air pollution. Percentages of deaths notably higher than the national percentages, potentially indicating increased vulnerability in the receptor population, are shaded in red and those notably lower are shaded in green (Table 9.2.4.2).

Table 9.2.4.2: Leading underlying causes of death in 2021 for the 1-to-14-years population.

Cause of death with ICD10 codes	South Africa		Northern Cape	
	Rank	%	Rank	%
Influenza and pneumonia (L09-J18)	2	5.3	7	2.3
Tuberculosis (A15-A19)	4	2.1	1	5.1
HIV (B20-B24)	6	2.1	2	4.5
Malnutrition (E40-E46)	7	2.0	5	2.5
Other viral diseases (B25-B34)	Not ranked	<1.4	8	2.3

%: Percentage of deaths due to cause.
Rank: Rank of cause of death, from 1 to 10 based on the number of deaths.
Not ranked: Not among the top 10 causes of death.
Source: Stats SA 2025.

The following conclusions regarding baseline health and potential vulnerability to the cardiovascular and respiratory effects of air pollutants follow from the burden of death summary of the 1-to-15-year age group (Table 9.2.4.2):

- Cardiovascular vulnerability:
    - Causes of death indicating cardiovascular vulnerability are not ranked among the 10 leading underlying causes in the Northern Cape. Therefore, there is no reason to

suspect that children in the receptor population are unusually vulnerable to the potential cardiovascular effects of air pollution.

- Respiratory tract vulnerability:
  - Significantly lower vulnerability to influenza and pneumonia is observed in the Northern Cape communities.
  - Mortality due to "other viral diseases" are moderately increased, but rates due to tuberculosis and HIV are significantly higher in the Northern Cape.
  - Malnutrition as an indication of susceptibility to respiratory infections was slightly higher in the province in comparison to South Africa in general.
  - Overall, respiratory health is potentially under pressure in the Northern Cape, and extrapolating this to the Tsantsabane receptor communities indicates a moderately increased vulnerability to the respiratory effects of air pollution.

In conclusion, consistent trends of increased vulnerability to the respiratory health effects of air pollution in the under-15 age group in the Tsantsabane receptor community is indicated.

An increased disposable income in receptor communities, or an influx of people seeking employment or working at the facility, or a shift from a rural to an urban lifestyle in the receptor community is not expected, as mentioned in Section 1. Therefore, non-communicable and communicable disease burdens related to socio-economic changes are not expected to change as a result of the construction or operation of the proposed facility.

9.2.5 Baseline health of the population aged 65 years and older

The demographic data presented in Section 3.2 indicate that the population aged 65 years and older presents a very low proportion of approximately 6 to 7 per cent of the total population. Nonetheless, considering the specific sensitivity of this age group to air quality impacts, their health vulnerabilities are assessed. Mortality data were obtained from the most recent Stats SA (2025) release of cause-of-death data and are presented as described previously. As noted in other age groups, causes of death in the 65+ group are not available on the sub-provincial level (DM, LM or ward-specific). Therefore, only national and provincial data are presented in Table 9.2.5.1. Causes of death influenced by exposure to ambient air PM2.5, or indicating vulnerability to the health effects of PM2.5 exposure, are presented and discussed.

Table 9.2.5.1: Leading underlying causes of death in 2021 in the population older than 65 years of age.

Cause of death with ICD10 codes	South Africa		Northern Cape	
	Rank	%	Rank	%
Cerebrovascular diseases (I60-I69)	4	6.9	4	6.3
Hypertensive diseases (I10-I15)	3	8.2	2	12.6
Other forms of heart disease (I30-I52)	7	3.1	8	2.1
Ischaemic heart disease (I20-I25)	6	3.4	6	3.3
Chronic lower respiratory diseases (J40-J47)	8	2.6	5	4.1
Influenza and pneumonia (L09-J18)	5	3.5	7	3.0
Tuberculosis (A15-A19)	Not ranked			
HIV (B20-B24)	Not ranked			

%: Percentage of deaths due to cause.
Rank: Rank of cause of death, from 1 to 10 based on the number of deaths.
Source: Stats SA 2025.

The Northern Cape health indicators for those aged 65+ were assumed to represent the likely baseline health of the 65+ age group in Tsantsabane LM receptors.

The differences in the health indicators were interpreted as indicating increased or decreased vulnerabilities to the cardiovascular and respiratory effects of air pollutants that might originate from the proposed mining project:

- Cardiovascular vulnerability in the Northern Cape:
    - Vulnerability to hypertensive diseases is significantly increased, moderately decreased in the case of "other forms of heart disease", and slightly decreased for cerebrovascular diseases.
    - Combining these observations, it is concluded that the all-ages vulnerability of receptor communities, projected from that of the Northern Cape province, is slightly increased compared to South Africa in general. There is reason to suspect increased vulnerability of the receptor population to the potential cardiovascular effects of air pollution.

- Respiratory tract vulnerability:
    - Significantly higher vulnerability to chronic lower respiratory diseases and slightly lower vulnerability to influenza and pneumonia is possible in the receptor community.
    - Increased respiratory tract vulnerability to the effects of air pollutants is thus likely in the elderly (65+) receptor group.

A generally increased disposable income due to increased levels of employment is unlikely in this age group, in which the majority is likely to be retired. As mentioned in Section 1, an influx of people seeking employment or working at the facility, or a shift from a rural to an urban lifestyle in the receptor community is not expected. Therefore, a shift in non-communicable and communicable disease burdens related to socio-economic changes is not expected and not assessed.

9.2.6 Baseline health status summary

Diseases transmitted by vectors dependent on water or natural vegetation for breeding, such as malaria transmitted by the *Anopheles* mosquito, are not considered, because the proposed mining project is not situated in a known malaria region.

Sexually transmitted diseases and other diseases ameliorated or evoked by lifestyle changes due to socio-economic impacts are not assessed, because it is unlikely that there will be an influx of people seeking employment or working at the mine and it is also unlikely that the disposable incomes in receptor communities will be increased due the construction at or operation of the mine. A shift from a rural to an urban lifestyle is not relevant. Socio-economic changes due to the construction and operation of the mine are thus unlikely in the defined receptor area, and communicable and non-communicable diseases due to socio-economic changes are not assessed.

Causes of death in the Northern Cape province and in the ZF Mgcawu DM (if available) were assessed as indicators of the potential vulnerability of the receptor population to the health effects of a potential impact on air quality. Construction and operation activities at the proposed mine may increase ambient air PM2.5 concentrations at the identified receptors in the Tsantsabane LM. Diseases indicating vulnerability to the health effects of air pollutants, and that are represented amongst the most important natural causes of death, are diseases affecting the respiratory tract, including tuberculosis, diseases of the cardiovascular system and diseases associated with a compromised immune system. A compromised immune system, such as in persons infected with HIV, increases the vulnerability to respiratory diseases.

Younger children and older adults are more vulnerable to the effects of air pollution by default. The relevant age groups for which mortality data are readily available in the public domain are the group of children younger than 15 years of age and adults aged 65 years and older. Specific attention is given to the vulnerabilities in these groups. Cause of death data specific to the ZF Mgcawu DM are only available for the all-ages group. Age-group data for the Northern Cape serve as a proxy for the under-15 and 65+ age group in the DM.

Provincial cause of death data for the under 15 population are divided into the infant (younger than 1 year of age) and the 1-to-14 years age group. Most of the infant age group causes of death are those specific to the perinatal period, affected by maternal factors and complications of pregnancy and delivery, or congenital malformations. Amongst the leading causes of death in this group, only 2 causes indicate vulnerability to a health influence of ambient air PM2.5 pollution, namely “influenza and pneumonia” and “other acute lower respiratory infections”. These findings are as expected for the infant age group.

Considering that the majority of the highest ranked causes of death in the infant age group are not directly related to vulnerabilities to ambient air quality, detailed attention was given to the causes of death in the 1-to-14 years age group, where factors specific to the foetus, infant, mother or events at the time of delivery do not play an important role. This allows focus on the causes of death that might be influenced by exposure to PM2.5 due to the proposed Makganyane project.

Based on the data and conclusions presented in Sections 9.2.2, 9.2.4 and 9.2.5, there are grounds to assume increased vulnerability to health effects related to exposure to the air pollutants of interest in the receptor group, regardless of age. There is a degree of uncertainty related to this comparative assessment, since mortality data specific to the Tsantsabane LM were not available, but it is likely that a moderately increased vulnerability exists in the receptor population.
The conclusions of the PM2.5 vulnerability assessment are:

- Regarding the all-ages population, communities are slightly more vulnerable to the cardiovascular and moderately more vulnerable to the respiratory effects of PM2.5.
- The younger-than-15-years age group is moderately more vulnerability to the respiratory effects of PM2.5. Cardiovascular vulnerability is comparable to the South African group in general.
- The age group of 65 years and older are moderately more vulnerable to the respiratory and slightly more vulnerable to cardiovascular effects of PM2.5.

9.3 Impact rating methodology

9.3.1 Assessment criteria

<u>Significance</u>

The concept of significance is at the core of impact identification, evaluation and decision-making. The concept remains largely undefined, and there is no international consensus on a single definition.

The following common elements are recognised from the various interpretations:

- Significance is a value judgment.
- The degree of significance depends on the nature of the impact.

- The importance is rated in terms of both biophysical and socio-economic values.
- Determining significance involves the amount of change to the environment perceived to be acceptable to affected communities.

Significance can be differentiated into impact magnitude and impact significance:

- Impact magnitude is the measurable change (i.e. intensity, duration and likelihood).
- Impact significance is the value placed on the change by different affected parties (i.e. level of acceptability).

Impact

The positive or negative effects on human well-being and/or the environment.

Consequence

The intermediate or final outcome of an event or situation OR it is the result, on the environment, of an event.

Likelihood

A qualitative term covering both probability and frequency.

Frequency

The number of occurrences of a defined event in a given time or rate.

Probability

The likelihood of a specific outcome measured by the ratio of a specific outcome to the total number of possible outcomes.

Environment

Surroundings in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans and their interrelation.

9.3.2 Method of application of the criteria

Significance calculation:

Environmental Significance = Overall Consequence x Overall Likelihood

Determination of Overall Consequence

Consequence analysis is a mixture of quantitative and qualitative information, and the outcome can be positive or negative. Several factors can be used to determine consequence.

For the purpose of determining the environmental significance in terms of consequence, the following factors were chosen:

- Severity/intensity,
- Duration and
- Extent/spatial Scale

Each factor is assigned a rating of 1 to 5, as described in the tables below.

Determination of severity/intensity

Severity relates to the nature of the event, aspect or impact to the environment and describes how severe the aspects impact on the biophysical and socio-economic environment (Table 9.3.2.1).

Table 9.3.2.1: Criteria for rating of severity of a health effect.

Type of criteria	Rating				
	1	2	3	4	5
Quantitative	0-20%	21-40%	41-60%	61-80%	81-100%
Qualitative	Insignificant/Non-harmful	Small/Potentially harmful	Significant/Harmful	Great/Very harmful	Disastrous/Extremely harmful
Social/Community response	Acceptable/I&AP satisfied	Slightly tolerable/Possible objections	Intolerable/ Sporadic complaints	Unacceptable/ Widespread complaints	Totally unacceptable/ Possible legal action
Irreversibility	Very low cost to mitigate/ High potential to mitigate impacts to level of insignificance/ Easily reversible	Low cost to mitigate	Substantial cost to mitigate/ Potential to mitigate impacts/ Potential to reverse impact	High cost to mitigate	Prohibitive cost to mitigate/ Little or no mechanism to mitigate impact Irreversible
Biophysical (Health status)	Insignificant change / deterioration or disturbance	Moderate change / deterioration or disturbance	Significant change / deterioration or disturbance	Very significant change / deterioration or disturbance	Disastrous change / deterioration or disturbance

Determination of duration

Duration refers to the amount of time that the environment will be affected by the event, risk or impact, if no intervention (e.g., remedial action) should take place (Table 9.3.2.2).

Table 9.3.2.2: Criteria for rating of duration of a health effect.

Rating	Description
1	Up to 1 month
2	1 to 3 months (quarter)
3	3 months to 1 year
4	1 to 10 years
5	beyond 10 years

Determination of extent/spatial scale

Extent or spatial scale is the area affected by the event, aspect or impact (Table 9.3.2.3).

Table 9.3.2.3: Criteria for the rating of extent/spatial scale.

Rating	Description
1	Immediate, fully contained area
2	Surrounding area
3	Within business unit area of responsibility
4	Within the farm/neighbouring farm area
5	Regional, national, international

Determination of overall consequence

Overall consequence is determined by adding the factors determined above and summarized below (Table 9.3.2.4), and then dividing the sum (subtotal) by 3.

Table 9.3.2.4: Example of calculating overall consequence.

Consequence	Rating
Severity	E.g., 4
Duration	E.g., 2
Extent	E.g., 4
Subtotal	10
Total consequence: (subtotal divided by 3)	**3.3**

Determination of likelihood

The determination of likelihood is a combination of frequency and probability. Each factor is assigned a rating of 1 to 5, as described below.

Determination of frequency

Frequency means "how often" the activity related to the event, aspect or impact is undertaken (Table 9.3.2.5).

Table 9.3.2.5: Criteria for the rating of frequency.

Rating	Description
1	Once a year or once/more during operation
2	Once/more in 6 months
3	Once/more a month
4	Once/more a week
5	Daily

Determination of probability

Probability refers to "how often" the activity or aspect has an impact on the environment (Table 9.3.2.6).

Table 9.3.2.6: Criteria for the rating of probability.

Rating	Description
1	Almost never / almost impossible
2	Very seldom / highly unlikely
3	Infrequent / unlikely / seldom
4	Often / regularly / likely / possible
5	Daily / highly likely / definitely

Overall likelihood

Overall likelihood is calculated by adding the factors determined above and summarized below (Table 9.3.2.7) and then dividing the sum by 2.

Table 9.3.2.7: Example of calculating overall likelihood.

Consequence	Rating
Frequency	E.g., 4
Probability	E.g., 2
Subtotal	6
Total likelihood (subtotal divided by 2)	**3**

Determination of overall environmental significance

The multiplication of overall consequence with overall likelihood provides the environmental significance:

Environmental Significance = Overall Consequence x Overall Likelihood

Environmental significance is a number that is categorised into a range of **Low, Low-Medium, Medium, Medium-High** or **High**, as shown in Table 9.3.2.8.

Table 9.3.2.8: Determination of overall environmental significance.

Significance or risk	Low	Low-Medium	Medium	Medium-High	High
Overall consequence X Overall likelihood	1 - 4.9	5 - 9.9	10 - 14.9	15 – 19.9	20 - 25

Qualitative description or magnitude of environmental significance

This qualitative description is an indication of the nature or magnitude of the environmental significance category (Table 9.3.2.9). It also guides the prioritisations and decision making-process associated with this event, aspect or impact.

Table 9.3.2.9: Description of environmental significance and related action required.

Significance	Low	Low-Medium	Medium	Medium-High	High
Impact Magnitude	Impact is of very low order and therefore likely to have very little real effect. Acceptable.	Impact is of low order and therefore likely to have little real effect. Acceptable.	Impact is real, and potentially substantial in relation to other impacts. Can pose a risk to company	Impact is real and substantial in relation to other impacts. Pose a risk to the company. Unacceptable	Impact is of the highest order possible. Unacceptable. Fatal flaw.
Action Required	Maintain current management measures. Where possible improve.	Maintain current management measures. Implement monitoring and evaluate to determine potential increase in risk. Where possible improve	Implement monitoring. Investigate mitigation measures and improve management measures to reduce risk, where possible.	Improve management measures to reduce risk.	Implement significant mitigation measures or implement alternatives.

Based on the above, the significance rating scale has been determined as follows:

- **High:** Of the highest order possible within the bounds of impacts which could occur.
  In the case of negative impacts, there would be no possible mitigation and / or remedial activity to offset the impact at the spatial or time scale for which it was predicted. In the case of positive impacts, there is no real alternative to achieving the benefit.

- **Medium-High:** Impacts of a substantial order.
  In the case of negative impacts, mitigation and / or remedial activity would be feasible but difficult, expensive, time-consuming or some combination of these. In the case of positive impacts, other means of achieving this benefit would be feasible, but these would be more difficult, expensive, time-consuming or some combination of these.

- **Medium:** Impact would be real but not substantial within the bounds of those, which could occur.
  In the case of negative impacts, mitigation and / or remedial activity would be both feasible and fairly easily possible, In case of positive impacts; other means of achieving these benefits would be about equal in time, cost and effort.

- **Low-Medium:** Impact would be of a low order and with little real effect.
  In the case of negative impacts, mitigation and/or remedial activity would be either easily achieved of little would be required, or both. In case of positive impacts alternative means for achieving this benefit would likely be easier, cheaper, more effective, less time-consuming, or some combination of these.

- **Low:** Impact would be negligible.
  In the case of negative impacts, almost no mitigation and or remedial activity would be needed, and any minor steps, which might be needed, would be easy, cheap, and simple. In the case of positive impacts, alternative means would almost all likely be better, in one or a number of ways, than this means of achieving the benefit.

- **Insignificant:** No impact at all – not even a very low impact on the system or any of its parts.

9.4 Health impact rating results

9.4.1 Construction phase

Specific impacts of the construction phase on air quality where not considered in the AIR (Yellow Tree Environmental 2025), likely because the operational phase was considered of primary importance to air quality impacts. Therefore, a health impact rating associated with the impact via air quality is not offered for the construction phase.

The Hydrological Assessment (Nakhooda 2025b) assessed construction phase impacts on surface water quality and quantity, resulting from potential uncontrolled domestic waste and sewage, and hydrocarbons and hazardous materials entering the Soutloop River. Chemical and microbiological details of the potential contamination are not available; thus, a health impact rating associated with the impact via water quality is not proposed for the construction phase. However, a comprehensive groundwater monitoring plan/protocol is recommended for the construction phase. Therefore, continued water quality monitoring, and appropriate actions if water quality should deteriorate, would conceivably limit health impacts to “low”.

9.4.2 Operational phase

The health impact assessment is focused on the potential negative health impacts due to the proposed mining activities, resulting in:

- Exposure to the PM2.5 fraction of dust emissions, impacting on health via potential increases in the incidences of:
  - Mortality due to all natural causes.
  - Cardiovascular (including stroke) hospital admissions.
  - Acute bronchitis symptoms in children.
  - Chronic bronchitis incidence in adults aged 27+.
  - Lung cancer incidence in adults aged 30+.
- Potential changes in surface- and groundwater quality, which might impact the health of water consumers in various ways, depending on the chemical or biological properties of the potential contaminants.

The impact assessments are presented in Tables 9.4.2.1 to 9.4.2.6.

Table 9.4.2.1: Operational phase air quality impact on health: all-cause (natural) mortality.

Potential impact: increased all-cause (natural) mortality		
Criteria	**Without mitigation (scenario 1) (Baseline dust suppression)**	**With mitigation (scenario 2) (Additional dust suppression)**
Severity	1	1
Duration	1	1
Extent	1	1
Overall consequence	3/3 = 1	3/3 = 1
Frequency	1	1
Probability	1	1
Overall likelihood	2/2 = 1	2/2 = 1
Overall significance	1 x 1 = 1	1 x 1 = 1
	Low	Low
Character	Neutral (no effect)	Neutral (no effect)
Vulnerability	Updated (post-2020) age-standardised provincial mortality rates are not available for comparison; thus, conclusions about vulnerability are not possible.	
Impact description	Insignificant risks of increased all-cause (natural) mortality due to exposure to the PM2.5 fraction of dust emitted from proposed mining activities.	
Mitigation and management measures	Baseline dust suppression: • Spraying water on all haul roads 2x per day. • Application of a chemical dust suppressant on Route 3 (the haul road to the main gate). Additional dust suppression: • Windbreaks or three-sided enclosures around the ore stockpile, waste rock dump and open pits to reduce wind-blown dust. • Chemical dust suppressant in addition to water spraying on Route 2.	

Table 9.4.2.2: Operational phase air quality impact on health: cardiovascular hospital admissions.

Potential impact: increased cardiovascular hospital admissions		
Criteria	**Without mitigation (scenario 1) (Baseline dust suppression)**	**With mitigation (scenario 2) (Additional dust suppression)**
Severity	1	1
Duration	1	1
Extent	1	1
Overall consequence	3/3 = 1	3/3 = 1
Frequency	1	1
Probability	1	1
Overall likelihood	2/2 = 1	2/2 = 1
Overall significance	1 x 1 = 1	1 x 1 = 1
	Low	Low
Character	Neutral (no effect)	Neutral (no effect)
Vulnerability	The all-ages population and those aged 65+ are slightly more vulnerable to the cardiovascular effects of air pollution	
Impact description	Insignificant risks of increased hospitalisation for cardiovascular health effects due to exposure to the PM2.5 fraction of dust emitted from proposed mining activities	
Mitigation and management measures	Baseline dust suppression: • Spraying water on all haul roads 2x per day. • Application of a chemical dust suppressant on Route 3 (the haul road to the main gate). Additional dust suppression: • Windbreaks or three-sided enclosures around the ore stockpile, waste rock dump and open pits to reduce wind-blown dust. • Chemical dust suppressant in addition to water spraying on Route 2.	

Table 9.4.2.3: Operational phase air quality impact on health: chronic bronchitis.

Potential impact: increased diagnoses of chronic bronchitis		
Criteria	**Without mitigation (scenario 1) (Baseline dust suppression)**	**With mitigation (scenario 2) (Additional dust suppression)**
Severity	2	1
Duration	5	1
Extent	2	1
Overall consequence	9/3 = 3	3/3 = 1
Frequency	2	1
Probability	3	1
Overall likelihood	5/2 = 2.5	2/2 = 1
Overall significance	3 x 2.5 = 7.5	1 x 1 = 1
	Low-Medium	Low
Character	Negative	Neutral (no effect)
Vulnerability	The population (regardless of age) is moderately more vulnerable to the respiratory effects of air pollution.	

Potential impact: increased diagnoses of chronic bronchitis		
Criteria	**Without mitigation (scenario 1) (Baseline dust suppression)**	**With mitigation (scenario 2) (Additional dust suppression)**
Impact description	Without mitigation (Scenario 1: baseline dust suppression): • Low risks of marginal concern of increased diagnoses of chronic bronchitis in adults due to exposure to the PM2.5 fraction of dust emitted from proposed mining activities. With mitigation (Scenario 2: additional dust suppression): Insignificant risks.	
Mitigation and management measures	Baseline dust suppression: • Spraying water on all haul roads 2x per day. • Application of a chemical dust suppressant on Route 3 (the haul road to the main gate). Additional dust suppression: • Windbreaks or three-sided enclosures around the ore stockpile, waste rock dump and open pits to reduce wind-blown dust. • Chemical dust suppressant in addition to water spraying on Route 2.	

Table 9.4.2.4: Operational phase air quality impact on health: acute bronchitis in children.

Potential impact: increased occurrence of acute bronchitis symptoms in children		
Criteria	**Without mitigation (scenario 1) (Baseline dust suppression)**	**With mitigation (scenario 2) (Additional dust suppression)**
Severity	2	1
Duration	4	4
Extent	2	2
Overall consequence	8/3 = 2.7	7/3 = 2.3
Frequency	1	1
Probability	3	2
Overall likelihood	4/2 = 2	3/2 = 1.5
Overall significance	2.7 x 2 = 5.4	2.3 x 1.5 = 3.5
	Low-Medium	**Low**
Character	Negative	Negative
Vulnerability	The population (regardless of age) is moderately more vulnerable to the respiratory effects of air pollution.	
Impact description	Without mitigation (Scenario 1: baseline dust suppression): • Low risks of increased symptoms of acute bronchitis due to exposure to the PM2.5 fraction of dust emitted from proposed mining activities. With mitigation (Scenario 2: additional dust suppression): • Low risks of marginal concern.	
Mitigation and management measures	Baseline dust suppression: • Spraying water on all haul roads 2x per day. • Application of a chemical dust suppressant on Route 3 (the haul road to the main gate). Additional dust suppression: • Windbreaks or three-sided enclosures around the ore stockpile, waste rock dump and open pits to reduce wind-blown dust. • Chemical dust suppressant in addition to water spraying on Route 2.	

Table 9.4.2.5: Operational phase air quality impact on health: lung cancer in adults.

Potential impact: increased diagnoses of lung cancer in adults		
Criteria	**Without mitigation (scenario 1) (Baseline dust suppression)**	**With mitigation (scenario 2) (Additional dust suppression)**
Severity	2	2
Duration	4	4
Extent	2	2
Overall consequence	8/3 = 2.7	8/3 = 2.7
Frequency	1	1
Probability	3	2
Overall likelihood	4/2 = 2	3/2 = 1.5
Overall significance	2.7 x 2 = 5.4	2.7 x 1.5 = 4.1
	Low-Medium	**Low**
Character	Negative	Negative
Vulnerability	Provincial lung cancer incidence rates are not available for comparison; thus, conclusions about vulnerability are not possible	
Impact description	Without mitigation (Scenario 1: baseline dust suppression): • Low risks of increased diagnoses of lung cancer in adults due to exposure to the PM2.5 fraction of dust emitted from proposed mining activities. With mitigation (Scenario 2: additional dust suppression): • Low risks of marginal concern.	
Mitigation and management measures	. Baseline dust suppression: • Spraying water on all haul roads 2x per day. • Application of a chemical dust suppressant on Route 3 (the haul road to the main gate). Additional dust suppression: • Windbreaks or three-sided enclosures around the ore stockpile, waste rock dump and open pits to reduce wind-blown dust. • Chemical dust suppressant in addition to water spraying on Route 2.	

Table 9.4.2.6: Operational phase water quality impact on health.

Potential impact: potential health impacts due to contamination of surface- and groundwater used for human, livestock or irrigation use		
Criteria	**Without mitigation**	**With mitigation**
Severity	2	1
Duration	2	1
Extent	2	2
Overall consequence	6/3 = 2	4/3 = 1.3
Frequency	2	1
Probability	3	2
Overall likelihood	5/2 = 2.5	3/2 = 1.5
Overall significance	2 x 2.5 = 5	1.3 x 1.5 = 2
	Low-Medium	**Low**
Character	Negative	Negative

Potential impact: potential health impacts due to contamination of surface- and groundwater used for human, livestock or irrigation use		
Criteria	**Without mitigation**	**With mitigation**
Vulnerability	Surface water streams are non-perennial (Eco-Thunder 2025) and it is thus unlikely that dependence on these for household drinking water, livestock and crop watering will be sustainable. Users of groundwater are also described as “remote” in the waste classification report (Digby Wells Environmental 2025). In conclusion, the vulnerability of users of these water sources to health impacts is likely to be low, since large-scale dependence of communities on these water sources is unlikely.	
Impact description	Health effects due to a deterioration in chemical and biological water quality. The water quality impact is rated as “low-medium” at most by the relevant water quality impact specialists, based on the assessment of the characteristics of waste rock generated by mining operations (Digby Wells Environmental 2025), of activities during the construction phase (Nakhooda 2025b) and the groundwater impact assessment (Groundwater Complete 2025).	
Mitigation and management measures	• Waste rock management with standard engineered barriers and recommended surface- and groundwater monitoring. • Storm water management according to the SWMP. • Groundwater quality is to be protected by a sealing layer underneath the stockpiles and WRD and by routine maintenance of the sewage system.	

9.4.3 Closure phase

Specific impacts of the closure phase on air quality where not considered in the AIR (Yellow Tree Environmental 2025), likely because air quality impacts in the operational phase were considered of primary importance. Therefore, a health impact rating associated with the impact via air quality is not offered for the closure phase.

The water quality impact during the operational phase is rated as “low-medium” at most by the relevant water quality impact specialists. It is unlikely that the water quality impact would be more severe during the closure phase, because the properties of the waste rock stored in the dumps is unlikely to change, and because the mine would create a continuous sink to contain the movement of a potential contamination plume (Groundwater Complete 2025).

9.4.4 Cumulative impacts on health

The cumulative health impact is assessed as the accumulated impact of the proposed project and the current (existing) baseline health status, which is impacted by all relevant background factors, such as:

- General ambient pollution sources, e.g., veld fires, burning of wood and coal for household energy needs.
- Lifestyle factors such as smoking and lack of exercise.
- Other pre-existing health conditions, such as asthma or tuberculosis (“TB”).

The health effect impacts of the modelled incremental increases in ambient PM2.5 concentrations in the receptor populations are negligible at all except the most proximate receptor to the north of the proposed mine, as shown in Table 2. Therefore, the cumulative impact on health is generally insignificantly different from the current impact on health.

Regarding cumulative health effects due to cumulative effects on surface- and groundwater quality, it is noted that active operations at other mine(s) in the broader study area occur at remote sites not close enough for any cumulative impacts to apply (Section 6.2).

The health status of the largest section of the receptor communities will not be changed after the implementation of the envisioned project.

9.5 RAHIA and the issuing of a project EA

9.5.1 Reasoned Opinion Regarding the Acceptability of the Proposed Activity (and the Issuing of an EA)

Based on the rapid appraisal health impact assessment presented in this report:

- Dust emissions health effects, assessed in terms of modelled PM2.5 concentrations in air, are predicted to have at most a *Low-Medium negative* impact if only the mitigation measures currently proposed by the mine are indicated (Scenario 1).
- If additional dust suppression measures as proposed in the AIR (Scenario 2) are implemented, all impacts on health are rated as *Low*.
- Surface water streams are non-perennial (Eco-Thunder 2025) and it is thus unlikely that these are continuously used for household drinking water.
- Nonetheless, impacts on health via impacts on water quality are rated as *low* in terms of the rating process used for the RAHIA, provided that:
    - The waste rock dump is managed with standard engineered barriers and recommended surface- and groundwater monitoring is conducted.
    - Storm water management is done according to the SWMP.
    - Routine maintenance of the sewage system is done to decrease the risk of failure and spillage that may contaminate surface- and groundwater.

Therefore, an EA may be issued for the proposed development of the Makganyane Iron Ore Mine, and proposed operations may commence, provided that:

- Scenario 2 (enhanced) dust mitigation measures recommended in the AIR and in this RAHIA report are implemented as strictly as possible, in order to reduce dust emissions at the proposed mine (see Section 9.5.2).
- Ground- and surface water mitigation measures are implemented, and provided that monitoring continues as recommended in the SWMP, the waste rock assessment report, the surface water hydrological report and the groundwater impact report.

9.5.2 Specific mitigation measures to be included

Specific mitigation measures applicable to the generation of dust, which are to be included in the EA and in the EMPR, are the baseline and enhanced dust mitigation measures proposed in the AIR (Yellow Tree Environmental 2025) and supported by the RAHIA:

- Spraying water on all haul roads twice per day.
- Application of a chemical dust suppressant on Route 3 (the haul road to the main gate).
- Windbreaks or three-sided enclosures around the ore stockpile, waste rock dump and open pits to reduce wind-blown dust.
- Application of a chemical dust suppressant in addition to water spraying on Route 2.

Mitigation and monitoring measures to protect ground- and surface water sources from contamination due to mining activities are proposed in the report on the assessment of expected waste rock (Digby Wells Environmental 2025), in the proposed SWMP (Nakhooda 2025a), the hydrological surface water assessment (Nakhooda 2025b) and in the groundwater report (Groundwater Complete 2025):

- Ongoing groundwater and surface water quality monitoring downstream of the waste rock dump, as well as periodic updates of geochemical, surface- and groundwater models in line with monitoring data to proactively identify changes in environmental and potential health risks.
- Routine maintenance of the sewage system to decrease the risk of failure and spillage.
- A sealing layer can be constructed beneath the stockpile and waste rock dumps in order to seal it off from groundwater. However, due to the expected inertness of the materials, this is not deemed necessary (Groundwater Complete 2025) and are thus not included as a compulsory mitigation measure.

9.5.3 Specific conditions to be included in the EA

None with regard to health

9.5.4 Monitoring requirements from a health perspective

Surface- and groundwater monitoring as discussed in Section 9.5.2. Routine air quality monitoring.

9.5.5 Fatal flaws

No fatal flaws are identified.

9.5.6 Summary of desktop verification outcome

According to the National Environmental Management Act, 1998 (Act No. 107 of 1998) (“NEMA”) and Environmental Impact Regulations, 2014 (as amended) (EIA Regs), site sensitivity and desktop verification must be undertaken to inform the Scoping Phase and EIA process for any proposed development, where applicable. However, site sensitivity and desktop verification are not specified for RAHIAs, as these have not been developed for the South African screening tool.

The HHRA and the RAHIA are based on the dispersion modelling results of the AIR, on current water-use patterns in surrounding communities, on the assessment of risks of surface- and groundwater contamination by the relevant specialists, and on the baseline health of the receptor communities (Section 9.2). Based on these, a post-mitigation outcome statement is provided in the summary table below.

Screening tool sensitivity	Verified sensitivity	Post-mitigation outcome statement	Relevant section motivating verification
Health Impact Assessment			
N/A	N/A	Low negative to negligible impacts are associated with the proposed development (see Section 9.4)	N/A

10 References

American Lung Association. 2022. Trends in Morbidity and Mortality: Pneumonia, Influenza, and Acute Respiratory Conditions. American Lung Association, Best Practices and Program Services, Epidemiology and Statistics Unit. http://www.lungusa.org/data/pi/PI_1.pdf

Chen Z, Salam MT, Eckel SP, Breton CV, Gilliland FD. 2015. Chronic effects of air pollution on respiratory health in Southern California children: findings from the Southern California Children's health study. J Thorac Dis, 7(1):46. Cited in Millar et al. (2022).

COMEAP. 2007. Cardiovascular disease and air pollution. London: UK Department of Health Committee on the Medical Effects of Air Pollutants.

Department of Environmental Affairs. 2004. National Environmental Management: Air Quality Act (Act No. 39 of 2004), Gazette No. 27318, No. R 163.

Digby Wells Environmental. 2025. Makganyane Iron Ore Mine: Waste Classification Assessment Report (Revision 01, 26 June 2025). Prepared for MDP Iron Ore (Pty) Ltd.

Eco-Thunder. 2025. Socio-Economic Impact Assessment for the Proposed Makganyane Mining Right near Postmasburg, Northern Cape Province. ETC Reference: ETC0605. Eco-Thunder Consulting (Pty) Ltd. 30th April 2025.

ECTF. 2022. Expert Consensus Task Force, Shi X, Duan G. Recommendations of Controlling and Preventing Acute Health Risks of Fine Particulate Matter Pollution - China, 2021. China CDC Wkly, Apr 22;4(16):329-341. doi: 10.46234/ccdcw2022.078. PMID: 35548322; PMCID: PMC9081889.

Greenmined. 2025. Proposed Mining Right Over Portion 2 (A Portion Of Portion 1), Remainder Portion, Remainder Portion of Portion 1 and Portion 3 of the Farm Makganyane No 667, Tsantsabane Local Municipality, Northern Cape. Final Scoping Report. Departmental Reference Number: NC 30/5/1/2/2/10255 MR. Greenmined Environmental (Pty) Ltd. JANUARY 2025.

IFC. 2007. Environmental, Health and Safety Guidelines for Mining. International Finance Corporation, World Bank Group. https://www.ifc.org/en/home.

Lake L, Shung-King M, Hendricks M, Heywood M, Nannan N, Laubscher R, et al. 2019. Prioritising child and adolescent health: a human rights imperative. Child and adolescent health. In: Shung-King M, Lake L, Sanders D, Hendricks M, editors. South African child gauge 2019 chapter: part 2. Cape Town: Children's Institute, University of Cape Town. Cited in Millar et al. (2022).

Millar DA, Kapwata T, Kunene Z, Mogotsi M, Wernecke B, Garland RM, Mathee A, Theron L, Levine DT, Ungar M, Batini C, John C, Wright CY. 2022. Respiratory health among adolescents living in the Highveld Air Pollution Priority Area in South Africa. BMC Public Health, 21;22(1):2136. doi: 10.1186/s12889-022-14497-8. PMID: 36411414; PMCID: PMC9677637.

Nakhooda Z. 2025a. Stormwater Management Plan: Proposed Makganyane Iron Ore Mine, Tsantsabane Municipality, Northern Cape, South Africa. Prepared by The Biodiversity Company for Assmang (Pty) Ltd. Report Version 10/07/2025.

Nakhooda Z. 2025b. Hydrological Assessment: Proposed Makganyane Iron Ore Mine, Tsantsabane Municipality, Northern Cape, South Africa. Prepared by The Biodiversity Company for Assmang (Pty) Ltd. Report Version 10/07/2025.

NICD. 2019. The National Institute for Communicable Diseases (NICD). Cancer in South Africa 2019. Full Report 2019. https://www.nicd.ac.za/wp-content/uploads/2019/12/2014-NCR-tables.pdf.

Republic of South Africa. 2014. Environmental Impact Assessment Regulation, 2014. Pretoria (Gauteng): Government Printing Works.

Stats SA. Online. Statistics by place. https://census.statssa.gov.za/#/province/5/2

Stats SA. 2025. Mortality and causes of death in South Africa, 2021: Findings from death notification. Statistical release P0309.3. Pretoria: Statistics South Africa. http://www.statssa.gov.za/publications/P03093/P030932021.pdf. Appendices available at https://www.statssa.gov.za/?page_id=1854&PPN=P0309.3.

Stats SA. 2023. Census 2022 Municipal fact sheet. Report no. 03-01-82. ISBN 978-0-621-51626-5. 37 pp. https://census.statssa.gov.za/assets/documents/2022/Census_2022_Municipal_factsheet-web.pdf

USEPA. 2019. Integrated Science Assessment for Particulate Matter. Report number EPA/600/R-19/188. December 2019, Contains Errata Sheet created September 2021. Research Triangle Park, NC: US Environmental Protection Agency. www.epa.gov/isa.

USEPA. 2009. Integrated Science Assessment for Particulate Matter. Report number EPA/600/R-08/139F. Research Triangle Park, NC: US Environmental Protection Agency.

WHO. Online. https://www.who.int/classifications/icd/icdonlineversions/en/.

WHO. 2021. WHO global air quality guidelines. Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Geneva: World Health Organization. Licence: CCBY-NC-SA 3.1IGO

WHO. 2018. Air pollution and child health: prescribing clean air. Summary. Geneva: World Health Organization (WHO/CED/PHE/18.01). Licence: CC BY-NC-SA 3.0 IGO. https://www.who.int/publications/i/item/air-pollution-and-child-health.

WHO. 2016. International Statistical Classification of Diseases and Related Health Problems, 10th edition. Geneva: World Health Organization.

WHO. 2013(a). Review of evidence on health aspects of air pollution – REVIHAAP project. Copenhagen, Denmark: World Health Organisation Regional Office for Europe.

WHO. 2013(b). Health risks of air pollution in Europe – HRAPIE project. Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide. Copenhagen, Denmark: World Health Organisation Regional Office for Europe.

WHO. 2005. WHO Air Quality Guidelines Global Update. Meeting Report. Geneva: World Health Organization.

WRAP. 2006. Fugitive Dust Handbook. Western Regional Air Partnership (WRAP), prepared by ENVIRON International Corporation. Available at: https://www.env.nm.gov/wp-content/uploads/sites/2/2017/02/WRAP_FDHandbook_Rev_06.pdf. Cited by Yellow Tree Environmental 2025.

Yellow Tree Environmental. 2025. Atmospheric Impact Assessment for the Proposed Makganyane Mine. Report date: 11 July 2025. Prepared for Green Mined Environmental.

11 Annexure 1: Causality and the choice of pollutant-outcome pairs

11.1 Background

Causality determinations are based on the evaluation and synthesis of evidence from across scientific disciplines. The USEPA (2017 and 2019) assessment system has five hierarchical levels:

1. Causal relationship
2. Likely to be causal relationship
3. Suggestive of, but not sufficient to infer, a causal relationship
4. Inadequate to infer the presence or absence of a causal relationship
5. Not likely to be a causal relationship

A causal relationship is assigned if the consistency and coherence of evidence integrated across scientific disciplines and related health outcomes are sufficient to rule out chance, confounding, and other biases with reasonable confidence. If evidence is sufficient to conclude that a causal relationship is likely to exist with relevant pollutant exposures, but important uncertainties remain, the relationship is referred to as "*likely to be causal*". This means that chance and bias can be ruled out with reasonable confidence, but potential issues may remain (USEPA 2017 and 2019). The "*causal*" and "*likely to be causal*" relationships are associated with most certainty and are the focus of this report. The USEPA conclusions regarding short and long-term exposure to PM2.5 (USEPA 2019) and key health effects for which causality is accepted are summarised in Section 13.2.

The WHO (2021) health outcome prioritization framework assigned a high level of priority to the causality assessments of the USEPA, giving priority to further assessment of pollutant-outcome pairs accepted as *causally* or *likely causally* related. The WHO also determined that the causality assessment would supersede the severity of a particular health outcome under assessment. The WHO applied the precautionary principle when determining which additional most-severe health outcomes should be included amongst those judged as *suggestive to be causal*.

The WHO (2021) conducted systematic reviews and meta-analyses of the identified priority pollutant-outcome pairs. The purpose of the meta-analysis is to obtain summary pooled estimates of the risk for an adverse health outcome per unit increase in exposure to a given air pollutant. The systematic reviews included the grading of the certainty of the overall body of evidence, with a focus on the validity and precision of effect estimates. Grading was performed according to the GRADE[1] approach, which has been adopted as the basis for evidence review in support of WHO guideline development. Grading outcomes are referred to in Section 13.2

The International Agency for Research on Cancer (IARC 2016) has classified outdoor air pollution, including PM, as a Group 1 carcinogen (carcinogenic to humans). Studies evaluated in the IARC assessment examined individual PM components and specific PM size fractions. The IARC conclusion was based primarily on epidemiology studies of ambient PM2.5 exposures and lung cancer incidence and mortality, on inhalation studies in mice exposed to ambient air PM10, and on evidence from mechanistic studies using PM of various size fractions. Therefore, the IARC assessment confirms the link of PM2.5 with lung cancer

[1] GRADE: Grading of Recommendations Assessment, Development and Evaluation.

11.2 PM2.5 causality assessment

The USEPA's conclusions regarding short- and long-term exposure to PM2.5 and the key health effects for which causality has been accepted (USEPA 2019) are summarised in Tables 11.2.1 and 11.2.2.

Table 11.2.1: USEPA (2019) causality determination for short-term PM2.5 exposure.

Health effects	Causality	Associated health endpoints
Respiratory effects	Likely to be causal	Emergency Department (ED) visits and hospital admissions (HAs) for: • *Asthma exacerbation in asthmatic adults and children • Chronic obstructive pulmonary disease (**COPD) • Respiratory infections
Cardiovascular effects	Causal	ED visits and hospital admissions for: • Cardiac conditions • Stroke or thrombo-embolic disease
Mortality	Causal	All-cause: total from all natural causes (excludes accidents, self-harm or homicide)
		Mortality due to the above cardiovascular effects (strong evidence)
		Mortality due to the above respiratory effects (limited evidence)
*Asthma exacerbation:, it is to be noted that asthma exacerbation does not mean the development of asthma in a child, but the exacerbation of asthma symptoms in a child already diagnosed with asthma. **COPD: Chronic inflammatory lung disease that causes obstructed airflow from the lungs, causing difficulty in breathing. The most common COPDs are chronic bronchitis and emphysema.		

Table 11.2.2: USEPA (2019) causality determination for long-term PM2.5 exposure.

Health effects	Causality	Associated health endpoints
Respiratory effects	Likely to be causal	Decrements in lung function
		Asthma incidence and prevalence increase in children
Cardiovascular effects	Causal	Cardiac heart disease or stroke in those with pre-existing disease
Nervous system effects	Likely to be causal	Reduced cognitive function and neurodegeneration in adults (consistent evidence)
		Neurodevelopmental effects in children (limited and inconsistent)
Reproductive effects	Suggestive of, but not sufficient to infer	Male and female reproduction and fertility Pregnancy and birth outcomes
Cancer	Likely to be causal	Lung cancer
Mortality	Causal	Mortality, natural all-cause, all ages
		Cardiovascular disease (consistent)
		Respiratory disease (generally consistent)
		COPD (modest and generally less precise)

With reference to Table 11.2.2, lung cancer (likely to be causal) is included in the health assessment, but not nervous system effects, also likely to be causal. The reason is that concentration-response functions (CRFs) are available for lung cancer mortality (see Section 12.3), but not for any particular or collective neurological health endpoints.

The WHO (2021) systematic reviews include GRADE assessments (see Section 11.1) to evaluate the certainty of the overall body of evidence, with a focus on the validity and precision of effect estimates. A summary of the assessments involving PM2.5 is given in Table 11.2.3.

The Review of Evidence on Health Aspects of Air Pollution, the REVIHAAP report, compiled by the WHO (2013a) also provides evidence for the causality of health effects of exposure to PM2.5. Pairs of health outcomes and causally related air pollutants were identified in the report Health Risks of Air Pollution in Europe (HRAPIE) (WHO 2013b) and recommended for inclusion in cost-benefit analyses of air pollution abatement and related prevention of health effects. These are summarised in Table 11.2.4. Meta-analyses with GRADE assessments were not performed in the 2013 assessments; therefore, WHO (2021) assessments are given precedence if effect estimates for pollutant-outcome pairs are provided in both the 2021 and the 2013 assessment reports. However, if effect estimates are not available from the 2021 assessments, estimates from the 2013 assessments are used.

USEPA and WHO effect estimates are discussed and presented in Section 12 (Annexure 2).

Table 11.2.3: WHO (2021) outcomes involving PM2.5.

Health outcome	GRADE assessment of certainty of evidence	Meta-analysis authors
Short-term exposure – PM2.5, daily mean		
Mortality, natural all-cause	High	Orellano et al. (2020)
Mortality due to: • Cardiovascular causes • Respiratory causes • Cerebrovascular causes (including stroke)	High	Orellano et al. (2020)
Long-term exposure – PM2.5, annual mean		
Mortality: all-cause (natural)	High	Chen and Hoek (2020)
Mortality due to: • Cardiovascular (circulatory system) diseases • Ischaemic heart disease • Stroke • Chronic obstructive pulmonary disease (COPD) • Acute lower respiratory infections (ALRI) • Lung cancer	High	Chen and Hoek (2020)
Mortality due to respiratory diseases	Moderate	Chen and Hoek (2020)

The HRAPIE report (WHO 2013b) classified recommended pollutant-outcome pairs, for which causality are accepted, into two categories, groups A and B:

- Group A: pollutant-outcome pairs for which sufficient data are available to enable reliable quantification of effects. In the case of daily mean and long-term exposure, the PM2.5 pairs were all assigned to group A.

- Group B: pollutant-outcome pairs for which there is less certainty about the precision of the data used for quantification of effects. Daily mean and long-term PM2.5 pairs were not assigned to this group.

The PM2.5 group A pair not covered in the WHO 2021 assessment, but which is required for the RAHIA, is given in Table 11.2.4.

Table 11.2.4: WHO (2013(b)) outcomes involving PM2.5.

Health outcome
Short-term exposure – PM2.5, daily mean
Hospital admissions, cardiovascular diseases (CVDs) (includes stroke), all ages

CRFs proposed for short- and long term PM2.5 exposure by the USEPA and WHO are discussed in Annexure 2 (Section 11).

11.3 References to Annexure 1

Chen J and Hoek G. 2020. Long-term exposure to PM and all-cause and cause-specific mortality: a systematic review and meta-analysis. Environ Int. 143:105974.
doi: 10.1016/j.envint.2020.105974. License: CC BY-NC-ND. Cited in WHO (2021).

IARC. 2016. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Outdoor air pollution. IARC monographs on the evaluation of carcinogenic risks to humans, volume 109. International Agency for Research on Cancer, Lyon, France: World Health Organization.

Orellano P, Reynoso J, Quaranta N, Bardach A, Ciapponi A. 2020. Short-term exposure to particulate matter (PM10 and PM2.5), nitrogen dioxide (NO2), and ozone (O3) and all-cause and cause-specific mortality: Systematic review and meta-analysis. Environment International, 142:105876. ISSN 0160-4120.

USEPA. 2019. Integrated Science Assessment for Particulate Matter. Report number EPA/600/R-19/188. December 2019, Contains Errata Sheet created September 2021. Research Triangle Park, NC: US Environmental Protection Agency. www.epa.gov/isa.

WHO. 2021. WHO global air quality guidelines. Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Geneva: World Health Organization. Licence: CCBY-NC-SA 3.1IGO.

WHO. 2013(a). Review of evidence on health aspects of air pollution – REVIHAAP project. Copenhagen, Denmark: World Health Organisation Regional Office for Europe.

WHO. 2013(b). Health risks of air pollution in Europe – HRAPIE project. Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide. Copenhagen, Denmark: World Health Organisation Regional Office for Europe.

12 Annexure 2: Health effect quantification

12.1 Methods of quantification

In general, predicted (modelled) or measured (monitored) impacts of mining and industrial emissions on air concentrations are used as a basis to quantify impacts on health. This is achieved by calculating the potential increase in or contribution to hospital admissions or mortality due to specific causes, associated with air concentrations of PM2.5. These calculations are based on results of epidemiological studies reported in the international scientific literature in which statistical methods were used to compare changes in hospitalisation or mortality rates with changes in air quality. Current statistical methods use the concept of relative risk (RR) to derive the potential percentage increase in or contribution to effects.

Health risks are quantified as the attributable fraction (AF) of mortalities or morbidities. Morbidities are health symptoms or health consequences, such as asthma exacerbation or hospitalisation due to a cardiovascular issue, observed in a population.

The AF is defined as the fraction of current mortalities or morbidities in the receptor population, which may be added to the current disease burden due to the planned Phase 2 operations. The AF is calculated on the condition that air pollutant concentrations are to increase incrementally as modelled in the Phase 2 scenario. Therefore, the AF is the potential increase in the disease burden risk once the planned Phase 2 operations are implemented, that may be attributable to the planned operations.

The *AF* may be considered as the fraction of the health effect incidence in the exposed population that could be prevented if exposure to the pollutant was eliminated (Last et al. 2000) and is calculated as follows:

$$AF = \frac{(RR-1)}{RR} \qquad (12.1.1)$$

Where:

RR	The relative risk of mortality or morbidity due to exposure to the pollutant

In cases where incremental changes in pollutant concentrations (Δp) are estimated, the relative risk of mortality or morbidity (*RR*) in the exposed population may be calculated.

The equation for the calculation of the RR is as follows (Ostro 2004 and USEPA 2022):

$$RR = exp[\beta\ (X - X_0)] \qquad (12.1.2)$$

Where:

Exp	Is the constant (*e*), the base of the natural logarithm
β	Is the coefficient of the pollutant concentration in the function describing the exposure-response curve
$X - X_0$	The modelled incremental change (Δp) in the pollutant concentration (μg/m^3)

Epidemiological studies often report a RR for a given Δp, rather than the coefficient, *β*.

β can be derived from Equation 12.1.3 as:

$$\beta = [Ln(RR)] / \Delta p \qquad (12.1.3)$$

Where:

β	Is the coefficient of the pollutant concentration in the function describing the exposure-response curve
Ln	Is the natural logarithm
RR	The RR reported in the epidemiological study
Δp	The modelled incremental change reported in the epidemiological study

12.2 Concentration-response functions and β-values for health effect quantification

Concentration-response functions (CRFs) yield numerical effect predictor values, namely, RRs and β-values, used for health effect quantification, discussed in Section 12.1.

Both the USEPA and the WHO have paid considerable attention to the CRF and the β-values derived from the CRF. The β-values used in the USEPA software tool *Benefits Mapping and Analysis Program - Community Edition* (BenMAP-CE) (USEPA 2021), which is freely downloadable from the USEPA website, and available from the BenMAP-CE user's manual (USEPA 2022) are presented in the various tables below.

The WHO/Europe's software tool AirQ+, which enables quantification of the health effects of exposure to air pollution (WHO 2019), the WHO (2021) guidelines report and the WHO (2013b) HRAPIE report, provides similar information, recorded in the various tables.

The health effects of interest to the HHRA are:

- Cardiovascular hospital admissions
- Acute bronchitis symptoms incidence (the risk of a member of the exposed community experiencing symptoms of acute bronchitis in a one year period)
- Chronic bronchitis (the risk of a member of the exposed community being diagnosed with chronic bronchitis in a one year period)
- Asthma exacerbation, assessed as hospital admissions and emergency room visits for asthma
- Infant and adult mortality
- Lung cancer incidence (the risk of a new lung cancer case being diagnosed in the exposed community in a one year period)

CRFs developed by the USEPA and the WHO are both considered, and the choice of CRF to be used is motivated for each pollutant-outcome pair in the relevant tables.

In order to avoid double-counting of the mortality effect, only the risks applicable to all-cause natural mortality (non-accidental, non-homicidal, non-self-harm), will be calculated by INFOTOX, not the cause-specific mortalities. That is, cardiovascular, respiratory and lung cancer mortality risks are not also quantified, since these are already included in the all-cause mortality risks.

Cardiovascular hospital admissions, asthma exacerbation, acute and chronic bronchitis incidence and lung cancer incidence (number of new cases diagnosed per year) are quantified.

12.3 International CRFs

This section presents CRFs derived by the USEPA and the WHO. Short-term PM2.5 CRFs and β-values are summarised in Table 12.3.1 and long-term PM2.5 values in Table 12.3.2. If only RRs are provided in the original source, the β-values are calculated with Equation 12.1.3. Adjustment of the effect estimates (RRs or β-values) for the effects of co-exposure to other pollutants is also noted.

CRFs for specific pollutant-outcome pairs are usually available from both agencies. The most suitable CRF for a specific pair, for the purposes of the HHRA, is indicated in such cases. A brief motivation for the choice is also provided. Only the health effects of interest to the RAHIA are included.

Table 12.3.1: Short-term (24-hour mean) PM2.5 CRF RRs and β-values.

Identified outcome	Pollutant	RR	β-value	Source
Cardiovascular HAs				
Cardiovascular (including stroke) HAs	PM2.5	1.0091 per 10 μg/m^3	0.00091	WHO (2013)
Cardiovascular HAs	PM2.5	A summary measure (pooled RRs or β-values) from a meta-analysis is not available. Multiple β-values are provided for various US cities.		USEPA (2021)
Choice of CRF: Cardiovascular (including stroke) HAs	PM2.5	The WHO (2013) pooled RR is used. This avoids the generation of multiple results, with a wider range of uncertainty, if the multiple β-values provided by the USEPA were to be used.		
Asthma exacerbation				
Asthma exacerbation as cough, shortness of breath and wheeze, respectively	PM2.5	A summary measure (pooled RRs or β-values) from a meta-analysis is not available. Separate β-values are provided for three symptoms of asthma exacerbation (cough, shortness of breath and wheeze, respectively) for 2 US cities.		USEPA (2021)
All-cause (natural) mortality				
All-cause (natural) mortality, all ages	PM2.5	1.0065 per 10 μg/m^3	0.00065	WHO (2021)
All-cause (natural) mortality, all ages	PM2.5	β-value is provided	0.00033	Baxter et al. (2017) cited in USEPA (2021) and (2022)
Choice of CRF: All-cause (natural) mortality (all ages)	Regarding assessment of long-term vs. short-term PM2.5 to obtain the burden of disease for the purpose of a CBA, the WHO (2013) indicates a preference for the assessment of long-term exposure (Table 1 in the HRAPIE document recommending CRFs for cost–benefit analysis of particulate matter, WHO (2013)). Assessment of total mortality based on long-term PM2.5 only (not short-term PM2.5 as well) also avoids double-counting of cases.			

HA: Hospital admissions ER: Emergency room

Table 12.3.2: Long-term (annual mean) PM2.5 CRF RRs and β-values.

Identified outcome(s)	Pollutant	RR	β-value	Source
Acute bronchitis				
Acute bronchitis	PM2.5	Not assessed		WHO 2013 and 2021
Acute bronchitis symptoms, ages 8 to 12	PM2.5	β-value derived by USEPA (2021) is used	0.0272	USEPA (2021 & 2022) from Dockery et al. (1996)
Choice of CRF: Acute bronchitis symptoms, ages 8 to 12	PM2.5	The USEPA (2021 and 2022) β-value derived from Dockery et al (1996) is used.		
Chronic bronchitis				
Chronic bronchitis incidence in age group 27+	PM2.5	β-value derived by USEPA (2021) is used	0.0137	USEPA (2021 & 2022), derived from Abbey et al. (1995)
Choice of CRF: Chronic bronchitis incidence, ages 27+	PM2.5	The USEPA (2021 and 2022) β-value derived from Abbey et al (1995) is used. It should be noted that the study group was Seventh-Day Adventists (SDAs), non-smokers who had resided since 1966 in the vicinity of nine airports throughout California (n = 1 868). Thus, the potential for accurate extrapolation of this study results to South African populations is limited.		
All-cause (natural) mortality, all ages				
All-cause (natural) mortality, all ages	PM2.5	1.08 per 10 μg/m^3	0.0077	WHO (2021)
All-cause (natural) mortality, all ages	PM2.5	Not available for all-ages, only for incremental age groups		USEPA (2021 and 2022)
Choice of CRF: All-cause (natural) mortality, all ages	PM2.5	The CRF derived by the WHO (2021) is used, since: • it is a pooled value from a meta-analysis • it is not restricted to specific geographic areas • it is adjusted for confounding effects of co-pollutants • it is not limited to a specific age group		
Lung cancer incidence				
Lung cancer as chronic disease sufferers (ages 30+)	PM2.5	β-value is provided	0.0378	Gharibvand et al. (2017) cited in USEPA (2021 and 2022)
Choice of CRF: Lung cancer: diagnosis as a chronic disease (incidence) (ages 30+)	PM2.5	The study by Gharibvand et al. (2017) is used to estimate the incidence of persons suffering from lung cancer.		

12.4 References to Annexure 2

Abbey DE, Ostro BE, Petersen F and Burchette RJ. 1995. Chronic Respiratory Symptoms Associated with Estimated Long-Term Ambient Concentrations of Fine Particulates Less Than 2.5 Microns in Aerodynamic Diameter (PM2.5) and Other Air Pollutants. J Expo Anal Environ Epidemiol, 5(2):137-159. Cited in USEPA (2021 and 2022).

Baxter LK, Crooks JL and Sacks JD. 2017. Influence of exposure differences on city-to-city heterogeneity in PM2.5-mortality associations in US cities. Environ Health 16:1. Cited in USEPA (2021 and 2022).

Burnett R, Chen H, Szyszkowicz M, Fann N, et al. 2018. Global estimates of mortality associated with long-term exposure to outdoor fine particulate matter. Proc Natl Acad Sci USA, 115(38):9592-9597. doi: 10.1073/pnas.1803222115. Epub 2018 Sep 4. PMID: 30181279; PMCID: PMC6156628.

Dockery DW, Cunningham J, Damokosh AI, et al. 1996. Health Effects of Acid Aerosols on North American Children - Respiratory Symptoms. Environmental Health Perspectives, 104(5):500-505. Cited in USEPA (2021 and 2022).

Gharibvand L, Shavlik D, Ghamsary M, et al. 2017. The association between ambient fine particulate air pollution and lung cancer incidence: results from the AHSMOG-2 study. Environ Health Perspect 125 (3): 378–384. Cited in USEPA (2021 and 2022).

Last JM (Ed), Spasoff RA, Harris SS and Thuriaux MC (Ass Eds). 2000. A Dictionary of Epidemiology. 4th Edition. New York: Oxford University Press.

Ostro B. 2004. Assessing the environmental burden of disease at national and local levels. Geneva: World Health Organization.

Groundwater Complete. 2025. Makganyane Proposed Iron Ore Mine: Report on Geohydrological Investigation as Specialist Risk Assessment. July 2025.

USEPA. 2022. Environmental Benefits Mapping and Analysis Program – Community Edition User's Manual. January 2022. Updated for BenMAP-CE Version 1.5.8. https://www.epa.gov/benmap/benmap-community-edition.

USEPA. 2021. Benefits Mapping and Analysis Program (BenMAP) Community Edition 1.5. US Environmental Protection Agency. https://www.epa.gov/benmap/benmap-community-edition.

USEPA. 2019. Integrated Science Assessment for Particulate Matter. Report number EPA/600/R-19/188. December 2019, Contains Errata Sheet created September 2021. Research Triangle Park, NC: US Environmental Protection Agency. www.epa.gov/isa.

USEPA. 2009. Integrated Science Assessment for Particulate Matter. Report number EPA/600/R-08/139F. Research Triangle Park, NC: US Environmental Protection Agency.

USEPA. 2022. Environmental Benefits Mapping and Analysis Program – Community Edition User's Manual. January 2022. Updated for BenMAP-CE Version 1.5.8. https://www.epa.gov/benmap/benmap-community-edition.

WHO. 2021. WHO global air quality guidelines. Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Geneva: World Health Organization. Licence: CCBY-NC-SA 3.1IGO

WHO. 2019. AirQ+: software tool for health risk assessment of air pollution. Bonn (Germany): World Health Organization Regional Office for Europe, European Centre for Environment and Health. http://www.euro.who.int/en/health-topics/environment-and-health/air-qualityactivities/airq-software-tool-for-health-risk-assessment-of-air-pollution.

WHO. 2013(a). Review of evidence on health aspects of air pollution – REVIHAAP project. Copenhagen, Denmark: World Health Organisation Regional Office for Europe.

WHO. 2013(b). Health risks of air pollution in Europe – HRAPIE project. Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide. Copenhagen, Denmark: World Health Organisation Regional Office for Europe.

WHO. 2005. WHO Air Quality Guidelines Global Update. Meeting Report. Geneva: World Health Organization.

13 Annexure 3: CVs of HIA specialists

CURRICULUM VITAE

Dr WCA VAN NIEKERK

Dr Willie van Niekerk holds BSc, Hons BSc and MSc degrees from the University of Potchefstroom (South Africa), and a PhD from the University of South Africa. He is the Managing Director of INFOTOX (Pty) Ltd. INFOTOX is a specialist company in the discipline of Health Sciences. Dr Van Niekerk is a Qualified Environmental Professional (QEP)[2], Environmental Toxicologist, certified by the Institute of Professional Environmental Practice (IPEP) in the USA, and a registered Professional Natural Scientist (Pr Sci Nat, Environmental Science) in South Africa. He has specialised in environmental toxicology and health risk assessment, but has experience in many other areas in the disciplines of analytical and environmental sciences. Among these are health-risk based contaminated land investigations, the assessment of exposure to the criteria air pollutants and other airborne toxicants, sampling and chemical analysis of soil, water and other materials for industrial or environmental characterisation, statistical interpretation of analytical data, and the development of quality assurance documentation for scientific studies. Clarification of the association and causality of exposure to toxic substances and the manifestation of adverse health effects in communities is a key competence of INFOTOX.

In human health risk assessment, cancer risks are quantified and non-cancer risks are interpreted for acute and chronic exposure to hazardous substances. Quantitative exposure assessment and an understanding of the toxicology and mode of action of hazardous chemicals and mixtures of chemicals are fundamental in the health risk assessment approach. This is in particular important in the assessment of health risks associated with hazardous elements in inorganic materials such as mineralogical ores, slag and soils, where exposure and health risks are determined by the fraction of an element that is available for absorption into the human circulatory system from the matrix material.

Dr Van Niekerk conducted several community health risk assessments for exposure to dioxins, including full food chain health risk assessments based on analytical dioxin data. He managed and assessed several studies on waste combustion, covering various incineration studies, assessment of pyrolysis followed by thermal destruction, and combustion of waste in cement kilns.

[2] The Qualified Environmental Professional (QEP) certification is the first and only credential of its kind in the USA. It is a multi-media, multi-disciplinary, board-certified credential that requires environmental professionals to view “the big picture” and to have the skills and knowledge to resolve “real world problems”. It is international in scope and has received accreditation by the Council of Engineering and Scientific Specialty Boards (CESB). The CESB is an independent organization which accredits engineering, scientific, and technology certification programs. The QEP certification is now administered by the Board for Global EHS Credentialing (Credential Number 7960160).

It is notable that Dr Van Niekerk wrote a chapter on human and wildlife risk assessment in the Risk Assessment Manual for Abandoned Mines in Namibia, which was funded by the German Federal Ministry for Economic Cooperation and Development, through the Federal Institute for Geosciences and Natural Resources. The project was coordinated under the Ministry of Mines and Energy of the Government of the Republic of Namibia. INFOTOX also conducted an assessment of reproductive effects of sulfur dioxide on commercial wildlife farming, health effects of chlorine on domestic animals, and an equine screening health risk assessment for exposure to petroleum contaminants. Last year INFOTOX compiled a document on cattle deaths and nitrate contamination of water at a mining site, and an ecological and biomechanistic review of potential causes of death in cattle.

Dr Van Niekerk conducted health risk assessments for corrective action for multiple pollutants at the AECI Somerset West site over several years, and derived health-risk based cleanup target levels for corrective action. He also conducted the due diligence for the law firm Cliffe Dekker Hofmeyr on behalf of the City of Cape Town prior to the city purchasing the site from AECI in 20015.

As a specialist in asbestos health risk assessment, he conducted a health-risk based due diligence for the purchase of an asbestos-product manufacturing facility in 2020.

As part-time Professor in Vista University in Pretoria, he lectured for three years on the chemistry and toxicology of hazardous waste.

Dr Van Niekerk has worked with several law firms on environmental health risk projects and has acted as expert witness in litigation cases. Dr Van Niekerk assisted Dr Marlene Fourie of INFOTOX in preparing health-risk based defense of class actions on behalf of law firms in London. He is currently conducting a number of health risk assessment projects under legal privilege. Several of these studies are structured in anticipation of potential class actions.

QUALIFICATIONS

- BSc (Chemistry), Potchefstroom, 1965.
- Hons BSc (Chemistry), Potchefstroom, 1966.
- MSc (Chemistry), Potchefstroom, 1967.
- PhD (Chemistry), UNISA, 1973.
- QEP (Qualified Environmental Professional), IPEP, USA, 1996.
-

INTERNATIONAL EXPERIENCE

Over several years Dr Van Niekerk visited research institutes and other organisations in the USA, England, Belgium, The Netherlands, Germany, Switzerland and Italy. He reviewed health-risk based studies for occupational exposure to toxic substances in the Copperbelt Province of Zambia, including site vits to mining and smelting operations at Chingola and Kitwe. He also conducted health-risk based environmental studies in Namibia.

PROFESSIONAL INSTITUTIONS

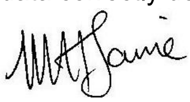
- Member of the South African Chemical Institute (SACI), Council member 1987 to1988 and 1992 to 1993, Chairman of Northern Transvaal Section 1992 to 1993, member of committee, 1980 to 1995. Active member until 1996.

- Founder member of the South African Association for Mass Spectrometry (SAAMS), first chairman and member of the committee, 1981 to 1991. Active member until 1996.
- Member of the Chromatography Association of South Africa (ChromSA). Active member until 1996.
- Member of the National Association for Clean Air (NACA).
- Member of the Toxicology Society of South Africa (TOXSA).

CURRICULUM VITAE

Dr MH FOURIE

Name of Firm:	INFOTOX (Pty) Ltd	**Name of Staff:**	Marlene (Martha Helena) Fourie
Years with Firm:	23	**Profession:**	Toxicological Scientist
Date of Birth:	19/09/1964	**Nationality:**	South African
Professional Registration	• The South African Council for Natural Scientific Professions (SACNASP): Professional Natural Scientist (Pr Sci Nat) Toxicological Science, No 400190/14		
Membership of Professional Societies:	• Toxicology Society of South Africa (TOXSA)		
Detailed Tasks Assigned:	Environmental Human Health Risk Assessment according to: • Hazard assessment of relevant chemical substances • Exposure assessment of human receptor communities • Dose-response assessment • Noncancer (systemic) human health risk quantification • Cancer risk quantification, if applicable • Risk characterisation		
Key Qualifications:	• BSc (Biochemistry), University of Stellenbosch, 1985. • BSc (Hons) (Biochemistry), University of Stellenbosch, 1986. • MSc (Reproductive Biology), University of Pretoria, 1996. • PhD (Reproductive Biology), University of Pretoria, 1999. • MSc (Epidemiology), University of Pretoria, 2009.		
Employment record:	• Medical Natural Scientist at the Andrology Unit, Department of Urology, University of Pretoria and the Pretoria Academic Hospital, 1987 to 2001. Duties were laboratory and toxicological research to conduct technique development with the aim of improving the diagnosis and treatment of male infertility. • Toxicological Scientist, INFOTOX (Pty) Ltd, 2001 to present. Duties are environmental human health risk assessment, assessment of effects of environmental contaminants on domestic animal and wildlife health and welfare, food chain health risk assessment, hazard classification of chemical substances and waste according to the United Nations Globally Harmonised System for Hazard Classification and Labelling of Chemical Substances.		
Selected experience:	Dr Fourie is a registered Professional Natural Scientist (Pr Sci Nat, Toxicological Science). She has specialised in environmental toxicology, human health risk assessment and human health impact assessments. Dr Fourie is also competent in other areas of expertise including epidemiology, community health baseline assessments, data processing, statistical interpretation of analytical data, radionuclide risk assessment and chemical hazard classification according to international criteria. Dr Fourie has in-depth practical experience in the assessment of health risks associated with exposure to the criteria air pollutants (including particulates) and other airborne toxicants. She is proficient in health-risk based contaminated site investigations with single- or multi-pathway risk assessment of contaminated soil, water and food. Clarification of the association and causality of exposure to toxic substances and the manifestation of adverse health effects in communities is a key competence of INFOTOX.		

	Dr Fourie has conducted community health risk assessments for a wide range of exposures associated with airborne emissions from industries. This includes acute-duration exposures (e.g., hydrogen sulfide, ammonia, hydrogen fluoride) and chronic exposures to non-cancer systemic toxicants and carcinogens. She has experience in dioxin risk assessment and assessment of hazards in the category Unknown or Variable Composition, Complex Reaction Products or Biological Materials (UVCB) group, which is characteristic of petroleum industries. Dr Fourie has also conducted Rapid Health Impact Assessments (RHIAs), according to the Good Practice guidance of the International Finance Corporation (IFC), a member of the World Bank Group. She has extensive experience in full community health risk assessments, including quantitative food chain health risk assessment, based on soil or water contamination, uptake into food commodities and assessment of health risks based on food consumption rates characteristic of particular communities. The above competencies has placed Dr Fourie in the ideal position to review health risk assessment documentation and community health impact claims of plaintiffs in class actions. She has acted in this function, advising and consulting legal teams for the plaintiffs and the defence in separate previous class actions. Dr Fourie has extensive experience in the application of the GHS system and has completed the UNITAR training course on GHS classifications. She has conducted classifications for many waste streams of organic and inorganic nature, new veterinary medicines, agricultural products, and more. Full-time participation in INFOTOX projects has been on a continuous basis since 2002 to the present date.
Publications and Conferences	• Due to the confidential nature of work done for clients, few of the client reports illustrating professional competence in Toxicology are available in the public domain. • Conferences are attended on a regular basis as required for SACNASP registration.
Certification:	I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describes me, my qualifications and my experience.  June 2024