Air Quality Specialist Report for the Proposed COZA Iron Ore Project in the Farm Driehoekspan in the Tsantsabane Local Municipality of the Northern Cape Province

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

Report compiled by:
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Report Details

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Revision Record

Version	Date	Section(s) Revised	Summary Description of Revision(s)
v.2	24 June 2016	Section 3.1	Table 6 with sensitive receptors included.

NEMA Regulation (2014), Appendix 6

NEMA Regulations (2014) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report.	Report Details (page i)
The expertise of that person to compile a specialist report including curriculum vitae.	Section 8: Annex A – Specialist's Curriculum Vitae (page 66)
A declaration that the person is independent in a form as may be specified by the competent authority.	Report Details (page i)
An indication of the scope of, and the purpose for which, the report was prepared.	Section 1.1: Purpose (page 1) Section 1.2: Scope of Work (page 1)
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	A site investigation was not included in the scope of work. Ambient data representative of all seasons were available. Section 3.2 and 3.3 (page 12 and 17)
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 1.4 (page 4)
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 3: Description of the Receiving Environment (page 12)
An identification of any areas to be avoided, including buffers.	Not applicable
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Section 1.3: Description of Activities from an Air Quality Perspective, Figure 1 (page 3)
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.5 (page 5)
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 4: Impact Assessment (page 21)
Any mitigation measures for inclusion in the EMPr.	Section 6: Recommended Air Quality Management Measures (page 52)
Any conditions for inclusion in the environmental authorisation	Section 6: Recommended Air Quality Management Measures (page 52)
Any monitoring requirements for inclusion in the EMPr or environmental authorisation.	Section 6: Recommended Air Quality Management Measures (page 52)
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If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan.	Section 6: Recommended Air Quality Management Measures (page 52)
A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable.
A summary and copies if any comments that were received during any consultation process.	No comments received.
Any other information requested by the competent authority.	Not applicable.

Glossary and Abbreviations

AEL	Atmospheric Emission Licence
AERMIC	AMS/EPA Regulatory Model Improvement Committee
Airshed	Airshed Planning Professionals (Pty) Ltd
ASG	Atmospheric Studies Group
ASTM	American Society for Testing and Materials
CAL EPA	California Environmental Protection Agency
CPV	Cancer Potency Value
CO	Carbon Monoxide
DE	Diesel Exhaust
DEA	Department of Environmental Affairs (South Africa)
DPM	Diesel Particulate Matter
EETM	Emissions Estimation Technique Manual
EMPr	Environmental Management Programme
GLCC	Global Land Cover Characterisation
HSE	Health, Safety and Environment
IFC	International Finance Corporation
IRIS	Integrated Risk Information System (US EPA)
MEI	Maximally Exposed Individual
MRL	Minimal Risk Level
NAAQS	National Ambient Air Quality Standards (South Africa)
NAEIS	National Atmospheric Emissions Inventory System
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
NPI	National Pollutant Inventory (Australia)
O_3	Ozone
PM_{10}	Thoracic particulate matter with an aerodynamic diameter of less than 10 μm
$PM_{2.5}$	Inhalable particulate matter with an aerodynamic diameter of less than 2.5 μm
REL	Reference Effect Level
RfC	Reference Concentration
RoM	Run of Mine
SA	South Africa(n)
SO_2	Sulphur Dioxide
SRTM	Shuttle Radar Topography Mission
TSP	Total Suspended Particulates
URF	Unit Risk Factor
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compound(s)

WHO	World Health Organization

Executive Summary

An air quality impact assessment was conducted for the proposed activities at Driehoekspan which forms part of the COZA Iron Ore Project in addition to already assessed Doornpan activities. The main objective of this study was to establish baseline/pre-development air quality in the study area and to quantify the extent to which ambient pollutant levels will change as a result of the project. The baseline and impact study then informed the air quality management and mitigation measures recommended as part of the Air Quality Management Plan (AQMP).

To achieve this objective, the following tasks were included in the scope of work (SoW):

1. A **review** of proposed project activities in order to identify sources of emission and associated pollutants.
2. A study of **regulatory requirements and health thresholds** for identified key pollutants against which compliance need to be assessed and health risks screened.
3. A study of the **receiving environment** in the vicinity of the project; including:
    a. The identification of potential air quality sensitive receptors (AQSRs);
    b. A study of the atmospheric dispersion potential of the area taking into consideration local meteorology, land-use and topography; and
    c. The analysis of all available ambient air quality information/data to determine pre-development ambient pollutant levels and dustfall rates.
4. The compilation of a comprehensive **emissions inventory** which included:
    a. Fugitive dust emissions from operational phase activities;
    b. Combustion emissions (PM and gaseous pollutants) released by stationary and mobile diesel equipment;
    c. Bulk fuel storage emissions if applicable.
5. **Atmospheric dispersion modelling** to simulate ambient air pollutant concentrations and dustfall rates.
6. A **screening** assessment to determine:
    a. Compliance of criteria pollutants with ambient air quality standards;
    b. Compliance of dustfall rates to dust control standards;
    c. Potential health risks as a result of exposure to non-carcinogenic non-criteria pollutants; and
    d. Potential increased lifetime cancer risks as a result of exposure to carcinogenic pollutants.
7. The compilation of a comprehensive air quality specialist report detailing the study approach, limitations, assumption, results and recommendations of mitigation and management of air quality impacts as per the reporting requirements of the National Environmental Management Act (NEMA) Regulations of 2014.
8. The completion of the Atmospheric Emission Licence (AEL) application form for bulk fuel storage if required.

The main findings of the baseline/pre-development assessment were:

- The area is dominated by winds from the north-north-east. Frequent winds also occur from the western sector but mostly during the day. Long term air quality impacts are therefore expected to the most significant to the south-south-west of operations.
- The main sources likely to contribute to baseline PM concentrations include vehicle entrained dust from local roads, mining and windblown dust from exposed areas.
- Ambient air quality monitoring near Postmasburg indicated:
    - Low nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and $PM_{2.5}$ concentrations that are within National Ambient Air Quality Standards (NAAQS);
    - Elevated PM_{10} concentrations in exceedance of NAAQS.
- Baseline dustfall data was not available for inclusion in the study.

- The nearest communities to the proposed operations include scattered farm residences/buildings. AQSR most likely to be affected by Driehoekspan activities include a farmstead on the Driehoekspan farm and one located less than 500 m directly downwind (to the south-west) of the Driehoekspan farm boundary.

The main findings of the impact assessment are as follows:

- Particulate matter (PM) and gaseous emissions will be released during the construction, operational and closure phases of the project. Only the operational phase air quality impacts were quantified since construction and decommissioning phase impacts will be highly variable but less significant than operational phase impacts.
- Operational phase PM emissions ($PM_{2.5}$, PM_{10} and TSP) and gaseous emissions - carbon monoxide (CO), diesel exhaust (DE), NO_x, SO_2 and volatile organic compounds (VOC) - were quantified.
- Due to low emission rates, CO, SO_2 and VOC concentrations were not simulated and impacts expected to be immaterial.
- PM_{10} emissions were found to result in the most notable air quality impacts, especially when only partially mitigated.
- Simulated PM_{10} concentrations exceeded the NAAQS off-site and at several AQSRs. Additional mitigation measures have been shown to reduce concentrations to levels that exceeded only the 24-hour NAAQS off-site and three of the nearby AQSRs.
- A source group contribution analysis indicated that vehicle entrained dust and crushing and screening are the main contributors to simulated average PM_{10} concentrations at AQSRs.
- Cumulative off-site PM_{10} concentrations in exceedance of NAAQSs are likely since baseline PM_{10} concentrations are already in exceedance of NAAQSs.
- 1-hour NO_2 concentrations were found to exceed the NAAQS over a small area to the south-west boundary of the mine rights area but not at any AQSRs.
- Low baseline NO_2 concentrations make cumulative impacts unlikely.
- Simulated dustfall rates and DE concentrations were found to be low, very localised and within selected air quality criteria outside the mine rights area.
- Excess lifetime cancer risk associated with DE exposure is considered low.

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

- The mitigation of sources of emission;
- The management of associated air quality impacts; and
- Ambient air quality monitoring.

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

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1 INTRODUCTION

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by SLR Consulting (Africa) (Pty) Ltd (SLR) to undertake an air quality impact assessment for the proposed COZA Mining (Pty) Ltd Iron Ore Project (the project) to be located within the Tsantsabane Local Municipality of the Northern Cape Province.

The project is a green-fields project that will comprise mining from three separate pits located on the farms Driehoekspan 435 (Remaining Extent), Doornpan 445 (Portion 1) and Jenkins. The three farms are situated between Postmasburg and Kathu, with Jenkins located furthest north (approximately 30 km south of Kathu), Doornpan furthest south and Driehoekspan in between (approximately 30 km south of Jenkins).

The product from open cast iron ore mining operations is estimated at 1.5 – 2 million tonnes per annum (Mt/a) Run of Mine (RoM). The mining method will consist of truck and shovel operations and beneficiation at a washing and screening plant to be located at the Jenkins portion. The Life of Mine (LoM), is estimated at 7 years, from 2017 to 2023. Pre-stripping of overburden is scheduled for the first half of 2017 and start of production aimed for the second half of 2017. The Jenkins portion will be mined for the duration of the LoM, while Driehoekspan will be mined in year 4 and Doornpan from year 5 to mine closure.

The focus of this assessment is on air quality impacts associated with proposed activities at Driehoekspan and, due to its proximity to Doornpan also the potential for cumulative air quality impacts. Airshed completed the air quality specialist study for proposed Doornpan activities in February 2014 (report reference no 12SYN14 Final v.1). The Jenkins portion is considered too far north from Driehoekspan to add to cumulative impacts.

1.1 Purpose

The main purpose of the air quality specialist study was to determine the potential impact on the atmospheric environment and air quality sensitive receptors (AQSRs) given mining activities proposed as part of the Driehoekspan portion in addition to Doornpan. The proposed Driehoekspan site layout is included in Figure 1.

1.2 Scope of Work

The following tasks, typical of an air quality impact assessment, were included in the scope of work (SoW):

9. A **review** of proposed project activities in order to identify sources of emission and associated pollutants.
10. A study of **regulatory requirements and health thresholds** for identified key pollutants against which compliance need to be assessed and health risks screened.
11. A study of the **receiving environment** in the vicinity of the project; including:
    a. The identification of potential AQSRs;
    b. A study of the atmospheric dispersion potential of the area taking into consideration local meteorology, land-use and topography; and
    c. The analysis of all available ambient air quality information/data to determine pre-development ambient pollutant levels and dustfall rates.
12. The compilation of a comprehensive **emissions inventory** which included:
    a. Fugitive dust emissions from operational phase activities;
    b. Combustion emissions (PM and gaseous pollutants) released by stationary and mobile diesel equipment;
    c. Bulk fuel storage emissions if applicable.

13. **Atmospheric dispersion modelling** to simulate ambient air pollutant concentrations and dustfall rates.
14. A **screening** assessment to determine:
    a. Compliance of criteria pollutants with ambient air quality standards;
    b. Compliance of dustfall rates to dust control standards;
    c. Potential health risks as a result of exposure to non-carcinogenic non-criteria pollutants; and
    d. Potential increased lifetime cancer risks as a result of exposure to carcinogenic pollutants.
15. The compilation of a comprehensive air quality specialist report detailing the study approach, limitations, assumption, results and recommendations of mitigation and management of air quality impacts as per the reporting requirements of the National Environmental Management Act (NEMA) Regulations of 2014.
16. The completion of the Atmospheric Emission Licence (AEL) application form for bulk fuel storage if required.

1.3 Description of Activities from an Air Quality Perspective

Open pit mining at Driehoekspan will be undertaken by means of truck and shovel. Topsoil will be stripped and stockpiled and the overburden will be placed on waste rock dumps located near to the pits within the infrastructure area. Ore will be trucked to a RoM stockpile area for crushing and screening. Ore will then be trucked from site using existing access roads that link to the R325. From the R325 ore will be trucked to the Jenkins portion for further processing.

The infrastructure that will be developed includes access roads with entrance controls, mine fencing, water management infrastructure (pollution control dams and water supply dams), power supply, offices, a change house, workshops, sewage treatment, temporary waste storage facilities and areas for the storage of explosives and fuel.

During the construction phase, workers will be accommodated at the temporary construction village on site. Once operations at the mine commence, staff will be accommodated within surrounding towns. Power for the mine will be sourced from diesel generators during the construction phase and later a power supply line will be constructed to link to an existing Eskom line.

Airborne emissions may occur during the construction and operational phases of the mining cycle. The most significant sources include fugitive particulate matter (PM) from drilling, blasting, bulk earthworks, materials handling, crushing and screening, windblown dust from exposed surfaces such as stockpiles and waste dumps, hauls roads and infrastructure. Fugitive emissions refer to emissions that are spatially distributed over a wide area and not confined to a specific discharge point as would be the case for process related emissions (IFC, 2007). Gases from the storage and combustion of fuels in stationary and mobile equipment also add to airborne emissions but to a lesser extent.

In the discussion, regulation and estimation of PM emissions and impacts a distinction is made between different particle size fractions, *viz*. TSP, PM_{10} and $PM_{2.5}$. PM_{10} is defined as particulate matter with an aerodynamic diameter of less than 10 µm and is also referred to as thoracic particulates. Inhalable particulate matter, $PM_{2.5}$, is defined as particulate matter with an aerodynamic diameter of less than 2.5 µm. Whereas PM_{10} and $PM_{2.5}$ fractions are taken into account to determine the potential for human health risks, total suspended particulate matter (TSP) is included to assess nuisance dustfall.

Main combustion emissions include PM_{10} and $PM_{2.5}$, carbon monoxide (CO), formaldehyde, nitrogen oxides (NO_x), sulphur dioxide (SO_2) and volatile organic compounds (VOCs). PM emitted from diesel combustion will mostly be in the form of black carbon, commonly referred to as diesel particulate matter or diesel exhaust (DPM or DE). Diesel fuel storage may result in VOC emissions.

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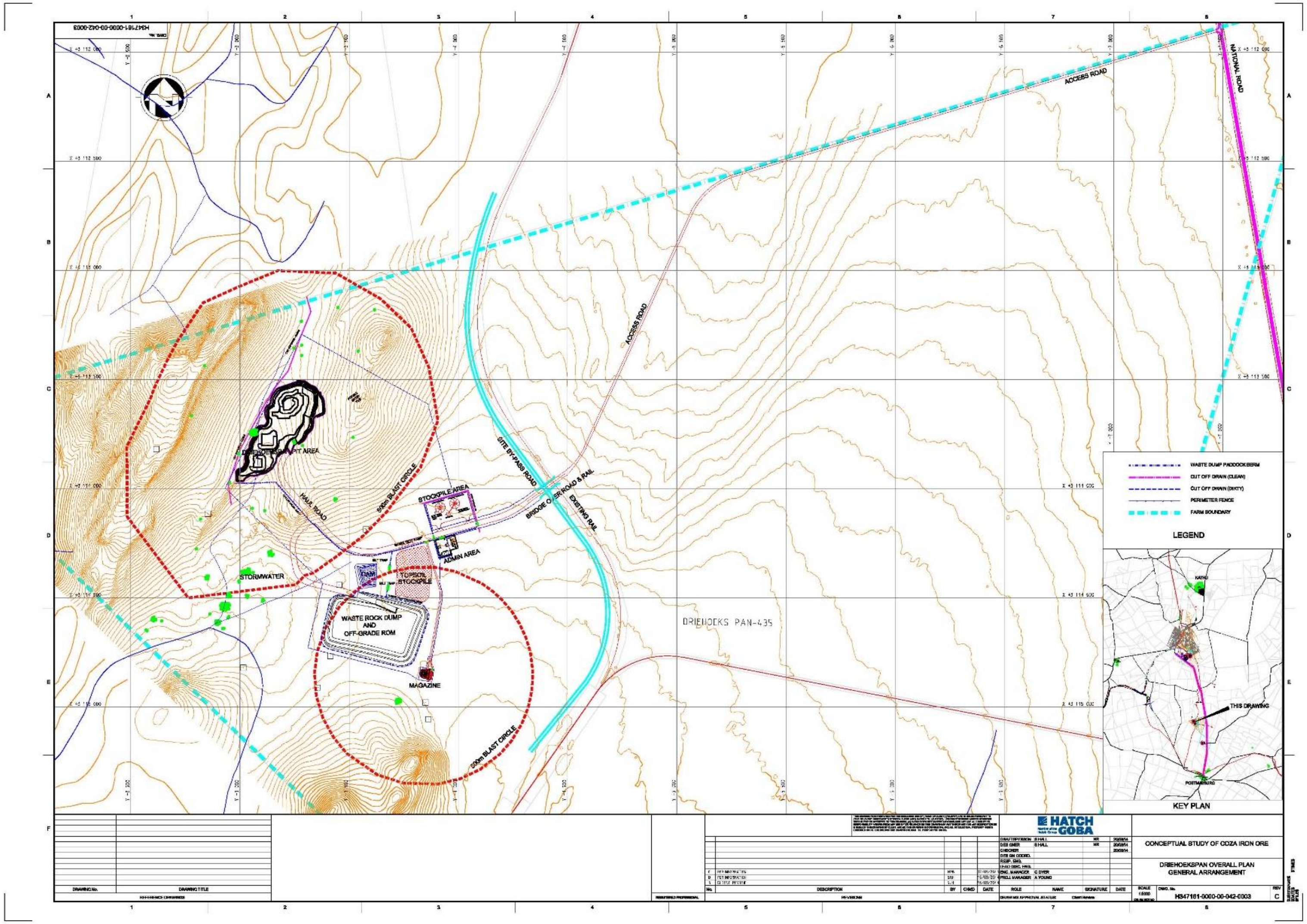


Figure 1: Proposed mine layout (layout provided by SLR)

1.4 Approach and Methodology

The approach to, and methodology followed in the completion of tasks that formed part of the SoW are discussed.

1.4.1 Project Information and Activity Review

Al project related information referred to in this study was provided by SLR. It included Chapter 4 of COZA Iron Ore Concept Phase Report compiled by COZA Mining (Pty) Ltd as well as site layout maps and mine production calculations supplied by SLR.

1.4.2 The Identification of Regulatory Requirements and Health Thresholds

In the evaluation air emissions and ambient air quality impacts reference was made to:

- National Minimum Emission Standards (NMES), National Ambient Air Quality Standards (NAAQS), National Dust Control Regulations (NDCR) and National Code of Practice for Air Dispersion Modelling as set out in the National Environmental Management Air Quality Act (Act No. 39 of 2004) (NEMAQA).
- Screening levels for non-criteria pollutants published by various internationally recognised organisations.

1.4.3 Study of the Receiving Environment

Physical environmental parameters that influence the dispersion of pollutants in the atmosphere include terrain, land cover and meteorology.

Readily available terrain and land cover data was obtained from the Atmospheric Studies Group (ASG) via the United States Geological Survey (USGS) web site at (ASG, 2011). Use was made of Shuttle Radar Topography Mission (SRTM) (90 m, 3 arc-sec) data and Global Land Cover Characterisation (GLCC) data for Africa.

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. In the absence of on-site meteorological data (that is required for atmospheric dispersion modelling), use was made of data recorded near Postmasburg by Anglo American’s Kolomela Mine in cooperation with the Northern Cape Province for a period between 2011 and 2014.

Ambient air pollutant concentrations are also recorded at this station and were used in the description of existing ambient air pollutant levels in the area. Potential AQSRs were identified from Google Earth imagery.

1.4.4 Determining the Impact of the Project on the Receiving Environment

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts from the Driehoekspan emissions on the receiving environment. In the quantification of emissions, use was made of emission factors which associate the quantity of a pollutant to the activity associated with the release of that pollutant. Emissions were calculated using comprehensive sets of emission factors and equations as published by the United States Environmental Protection Agency (US EPA) and Australian Department of Environment (ADE) National Pollutant Inventory (NPI).

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

1.4.5 Compliance Assessment and Health Risk Screening

Compliance was assessed by comparing simulated ambient criteria pollutant concentrations (CO, NO_2, $PM_{2.5}$, PM_{10} and SO_2) and dustfall rates to NAAQS's and NDCR's. Health risk screening was done through the comparison of simulated non-criteria pollutant concentrations (VOC and DE) to inhalation screening levels. Increased lifetime cancer risk as a result of exposure to carcinogenic pollutants (DE) were calculated from simulated pollutant concentrations and cancer unit risk factors (URFs) and compared to international criteria.

1.4.6 Recommendation of Air Quality Management Measures

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

1.5 Assumptions, Exclusions and Limitations

The following important assumptions, exclusions and limitations to the specialist study should be noted:

1. Although the focus of this assessment is on mining activities at Driehoekspan, the COZA Iron Ore Project includes mining on the farms Doornpan and Driehoekspan. The potential for cumulative impacts as a result of mining activities at their peak on both farm portions were considered.
2. The quantification of sources of emission was restricted to proposed operations at Driehoekspan and Doornpan. Although other existing sources of emission within the area were identified, such sources were not quantified.
3. The Doornpan emissions inventory compiled by Airshed in 2014 was updated with more recent and more detailed project information. The updated emissions inventory differs mainly from the 2014 inventory in terms of reduced fugitive dust emissions from unpaved haul roads. Newly available project information indicated that watering of roads is included in the mine plan (van Rensburg, 2015).
4. All project information required to calculate emissions for proposed operations were provided by SLR and AMSA.
5. Routine emissions from mining operations were estimated and modelled.
6. In the absence of on-site meteorological data, use was made of data recorded near Postmasburg.
7. A minimum of 1 year, and typically 3 to 5 years of meteorological data are generally recommended for use in atmospheric dispersion modelling for air quality impact assessment purposes. Approximately 3 years of meteorological data were available for use in atmospheric dispersion modelling simulations.
8. The impact assessment was limited to airborne particulates (including TSP, PM_{10} and $PM_{2.5}$) and gaseous pollutants from vehicle exhausts, including CO, DE, NO_x, VOCs and SO_2.
9. Nitrogen monoxide (NO) emissions are rapidly converted in the atmosphere into the much more poisonous nitrogen dioxide (NO_2). NO_2 impacts where calculated by AERMOD using the ozone limiting method assuming constant monthly average background ozone concentrations of ranging between 51 and 78 µg/m3 (as obtained from the Postmasburg monitoring station data set) and a NO_2/NO_x emission ratio of 0.2 (Howard, 1988).

10. The 2014 assessment of Doornpan indicated that CO, SO_2 and VOC concentrations as a result of diesel vehicle exhaust emissions are generally very low and only a fraction of associated air quality criteria (von Reiche, 2014). Although emissions were quantified, dispersion simulations were not conducted for these pollutants.
11. Construction and decommissioning phase impacts were not quantified. Impacts associated with this phase are highly variable and less significant than operational phase impacts as shown in the assessment for Doornpan (von Reiche, 2014). Mitigation and management measures recommended for the operational phase are however also applicable to the construction and closure phases.
12. The estimation of greenhouse gas (GHG) emissions was not included in the SoW but reference made to draft GHG emission reporting regulations.
13. Dustfall is not at present sampled in project area. Since dustfall is a localised impact, sampled dustfall rates further afield, such as those sampled near Kolomela Mine, would therefore not be representative of the project area.

2 AIR QUALITY REGULATIONS AND ASSESSMENT CRITERIA

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

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

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality standards and guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging or exposure periods.

This section summarises national legislation for criteria pollutants relevant to the current study and dustfall. A discussion on inhalation health risk and cancer risk associated with DE (not considered a criteria pollutant) is also provided.

2.1 National Minimum Emission Standards

The minister must in accordance with the NEMAQA (Act No. 39 of 2004) publish a list of activities which result in atmospheric emissions and which is believed to have significant detrimental effects on the environment and human health and social welfare. All scheduled processes as previously stipulated under the Air Pollution Prevention Act (APPA) are included as listed activities with additional activities being added to the list. The most recent Listed Activities and NMES's were published on the 22nd of March 2013 (Government Gazette No. 37054).

Only the on-site storage of diesel, proposed as part of the project, is considered a listed activity. Subcategory 2.4, *'the storage and handling of petroleum products'*, are however only applicable to permanent immobile liquid storage facilities at a single site with a combined storage capacity of more than 1 000 m^3.

According to the project description the total installed storage capacity will be 74 m^3 and it does therefore not trigger Subcategory 2.4 NMES's or the need for an AEL application.

2.2 National Ambient Air Quality Standards

Criteria pollutants are considered those pollutants most commonly found in the atmosphere, that have proven detrimental health effects when inhaled and are regulated by ambient air quality criteria. South African NAAQS for CO, NO_2, PM_{10} and SO_2 were published on 13 March 2009. On 24 December 2009 standards for $PM_{2.5}$ were also published. These standards are listed in Table 1.

Table 1: National Ambient Air Quality Standards for criteria pollutants

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
CO	1-hour	30 000	26 000	88	Immediate
NO_2	1 hour	200	106	88	Immediate
	1 year	40	21	0	Immediate
$PM_{2.5}$	24 hour	65	-	4	Immediate – 31 Dec 2015
	24 hour	40	-	4	1 Jan 2016 – 31 Dec 2029
	24 hour	25	-	4	1 Jan 2030
	1 year	25	-	0	Immediate – 31 Dec 2015
	1 year	20	-	0	1 Jan 2016 – 31 Dec 2029
	1 year	15	-	0	1 Jan 2030
PM_{10}	24 hour	120	-	4	Immediate – 31 Dec 2014
	24 hour	75	-	4	1 Jan 2015
	1 year	50	-	0	Immediate – 31 Dec 2014
	1 year	40	-	0	1 Jan 2015
SO_2	10 minutes	500	191	526	Immediate
	1 hour	350	134	88	Immediate
	24 hour	125	48	4	Immediate
	1 year	50	19	0	Immediate

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

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

1. Inhalation RfCs and URFs published by the US EPA IRIS
2. Reference Exposure Levels (RELs) and Cancer Potency Values (CPV) published by the California Environmental Protection Agency (CAL EPA)
3. The Texas Commission on Environmental Quality (TCEQ)

Chronic inhalation criteria and URFs for pollutants considered in the study are summarised in Table 2 (The University of Tennessee, 2013) (WHO, 2000). Increased lifetime cancer risk is calculated by applying the unit risk factors to predicted long term (annual average) pollutant concentrations.

Table 2: Chronic and acute inhalation screening criteria and cancer unit risk factors

Pollutant	Chronic Screening Criteria (µg/m³)	Acute Screening Criteria (µg/m³)	Inhalation URF (µg/m³)⁻¹
Diesel Exhaust	5 (US EPA IRIS)	Not Specified	3E-04 (CAL EPA)
VOC (*Diesel fuel* used as used as indicator)	100 (TCEQ)	1 000 (TCEQ)	Not Specified

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

Whilst it is perhaps inappropriate to make a judgment about how much risk should be acceptable, through reviewing acceptable risk levels selected by other well-known organizations, it would appear that the US EPA’s application is the most suitable, i.e. *“If the risk to the maximally exposed individual (MEI) is no more than* $1x10^{-6}$*, then no further action is required. If not, the MEI risk must be reduced to no more than* $1x10^{-4}$*, regardless of feasibility and cost, while protecting as many individuals as possible in the general population against risks exceeding* $1x10^{-6}$*”*. Some authorities tend to avoid the specification of a single acceptable risk level. Instead a “risk-ranking system” is preferred.

For example, the New York State Department of Health (NYSDOH) produced a qualitative ranking of cancer risk estimates, from very low to very high (Table 3). Therefore, if the qualitative descriptor was "low", then the excess lifetime cancer risk from that exposure is in the range of greater than one per million to less than one per ten thousand.

Table 3: Excess Lifetime Cancer Risk (as applied by NYSDOH)

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

2.4 National Dust Control Regulations

NDCR were published on the 1st of November 2013 (Government Gazette No. R. 827). Acceptable dustfall rates according to the Regulation are summarised in Table 4.

Table 4: Acceptable dustfall rates

Restriction areas	Dustfall rate (D) in mg/m^2-day over a 30 day average	Permitted frequency of exceedance
Residential areas	D < 600	Two within a year, not sequential months.
Non-residential areas	600 < D < 1 200	Two within a year, not sequential months.

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

2.5 Reporting of Atmospheric Emissions

The National Atmospheric Emission Reporting Regulations (Government Gazette No. R283) came into effect on 2 April 2015.

The purpose of the regulations is to control the reporting of data and information from an identified point, non-point and mobile sources of atmospheric emissions to an internet-based National Atmospheric Emissions Inventory System (NAEIS), towards the compilation of atmospheric emission inventories. The NAEIS is a component of the South African Air Quality Information System (SAAQIS); its objective is to provide all stakeholders with relevant, up to date and accurate information on South Africa's emissions profile for informed decision making.

Emission sources and data providers are classified according to groups A to D (listed in Table 5). According to Table 5 the COZA Iron Ore Project would be classified under Group C. The Regulation specifies that data providers as classified in Table 5 who commences with an activity or activities after the commencement of these Regulations must register on the NAEIS within 30 days after commencing with such an activity or activities. Data providers must inform the relevant authority of changes if there are any:

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

A data provider must submit the required information for the **preceding calendar year** to the NAEIS **by 31 March** of each year. Records of data submitted must be kept for a period of 5 years and must be made available for inspection by the relevant authority.

Table 5: Summary of NAEIS reporting categories

Group	Emission Source	Data Provider	NAEIS Reporting Requirements	Relevant Authority
A	Listed activity published in terms of section 21(1) of the Act.	Any person that undertakes a listed activity in terms of section 21(1) of the Act.	Emission reports must be made in the format required for NAEIS and should be in accordance with the atmospheric emission license or provisional atmospheric emission license.	Licensing authority.
B	Controlled emitter declared in terms of section 23(1) of the Act.	Any person that undertakes a listed activity in terms of section 21(1) of the Act and uses an appliance or conducts an activity which has been declared a controlled emitter in terms of section 23(1) of the Act. Any relevant air quality officer receiving emission reports as contemplated under notice made in terms of section 23 of the Act.	Any information that is required to be reported in terms of the notice published in the Gazette in term of section 23 of the Act.	The relevant air quality officer as contemplated under the notice made in terms of section 23 of the Act.
C	Mines.	Any person, that holds a mining right or permit in term of the Mineral and Petroleum Resources	Emission reports must be made in the format required for NAEIS.	Relevant air quality officer.

		Development Act, 2002 (Act 28 of 2002).		
D	Facilities identified in accordance with the applicable municipal by-law.	Any person that operates facilities which generate criteria pollutants, and has been identified in accordance with the applicable municipal By-law.	Emission reports must be made in the format required for NAEIS.	Relevant air quality officer.

2.6 Greenhouse Gas Emissions

Draft regulations pertaining to GHG reporting using the NAEIS was published in May 2015 (Government Gazette 38779, Notice 411 of 11 May 2015).

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

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

The NAEIS web-based monitoring and reporting system will also be used to collect GHG information in a standard format for comparison and analyses. The system forms part of the National Atmospheric Emission Inventory component of SAAQIS.

The DEA is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the Intergovernmental Panel on Climate Change's (IPCC) default emission figures may be used to populate the SAAQIS GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors. It has been indicated that these factors will only be published towards the end of 2015 (Jongikhaya, 2015).

Also, a draft carbon tax bill will be introduced later this year (2015) for a further round of public consultation. The Carbon Tax Policy Paper (CTPP) (Department of National Treasury, 2013) stated consideration will be given to sectors where the potential for emissions reduction is limited. Also in draft is that GHG in excess of 0.1 Mt, measured as $CO_{2\text{-eq}}$, is required to submit a pollution prevention plan to the Minister for approval.

3 DESCRIPTION OF THE RECEIVING ENVIRONMENT

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

- Local AQSR;
- The atmospheric dispersion potential; and
- Sampled baseline or pre-development ambient air pollutant levels.

3.1 Air Quality Sensitive Receptors

AQSRs generally include places of residence and areas where members of the public may be affected by atmospheric emissions generated by mining/industrial activities. The nearest towns to the proposed Driehoekspan pit include Postmasburg, Lohathla and Beeshoek all more than 10 km away.

More likely AQSRs in the project area include scattered farmsteads/homesteads (Table 6). These are indicated in Figure 2 in relation to the farms Driehoekspan and Doornpan. The closest of these to proposed activities on the farm Driehoekspan lie approximately 600 m to the south-east and 1.4 km to the south-west of the mine perimeter fence (no. 3 and no. 4).

Table 6: Sensitive receptors

Receptor	Description	Longitude	Latitude
1	Farmstead/homestead	23° 00’ 23.61”	28° 10’ 15.56”
2 (Palingpan)	Farmstead/homestead	23° 00’ 50.79”	28° 10’ 28.42”
3	Farmstead/homestead	23° 01’ 12.16”	28° 09’ 04.10”
4	Farmstead/homestead	23° 02’ 38.15”	28° 09’ 14.32”
5	Farmstead/homestead	23° 02’ 56.21”	28° 06’ 41.95”
6	Farmstead/homestead	23° 05’ 13.35”	28° 07’ 59.47”
7	Farmstead/homestead	23° 06’ 19.08”	28° 08’ 45.33”
8 (Manganore)	Farmstead/homestead	23° 06’ 12.77”	28° 09’ 19.91”
9	Farmstead/homestead	23° 05’ 34.00”	28° 12’ 51.85”
10	Farmstead/homestead	23° 01’ 56.98”	28° 14’ 16.48”

3.2 Atmospheric Dispersion Potential

Meteorological mechanisms govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The analysis of hourly average meteorological data is necessary to facilitate a comprehensive understanding of the dispersion potential of the site.

Anglo American operates a weather and ambient air quality monitoring station in Postmasburg as part of their Kolomela operations. Reference is made to data recorded between 11 November 2011 and 13 October 2014. Parameters useful in describing the dispersion and dilution potential of the site i.e. wind speed, wind direction, temperature and atmospheric stability, are subsequently discussed.

3.2.1 Surface Wind Field

Wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the red area, for example, representing winds in between 6 and 10 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

The period wind field and diurnal variability in the wind field are shown in Figure 3. During the recording period, the wind field was dominated by winds from the north-east with an average wind speed of 3.4 m/s. The strongest winds (more than 6 m/s) were from the northern to north-western sectors and occurred mostly during the day. The average wind speed decreased from 4.1 m/d during the day to 2.7 m/s during the night.

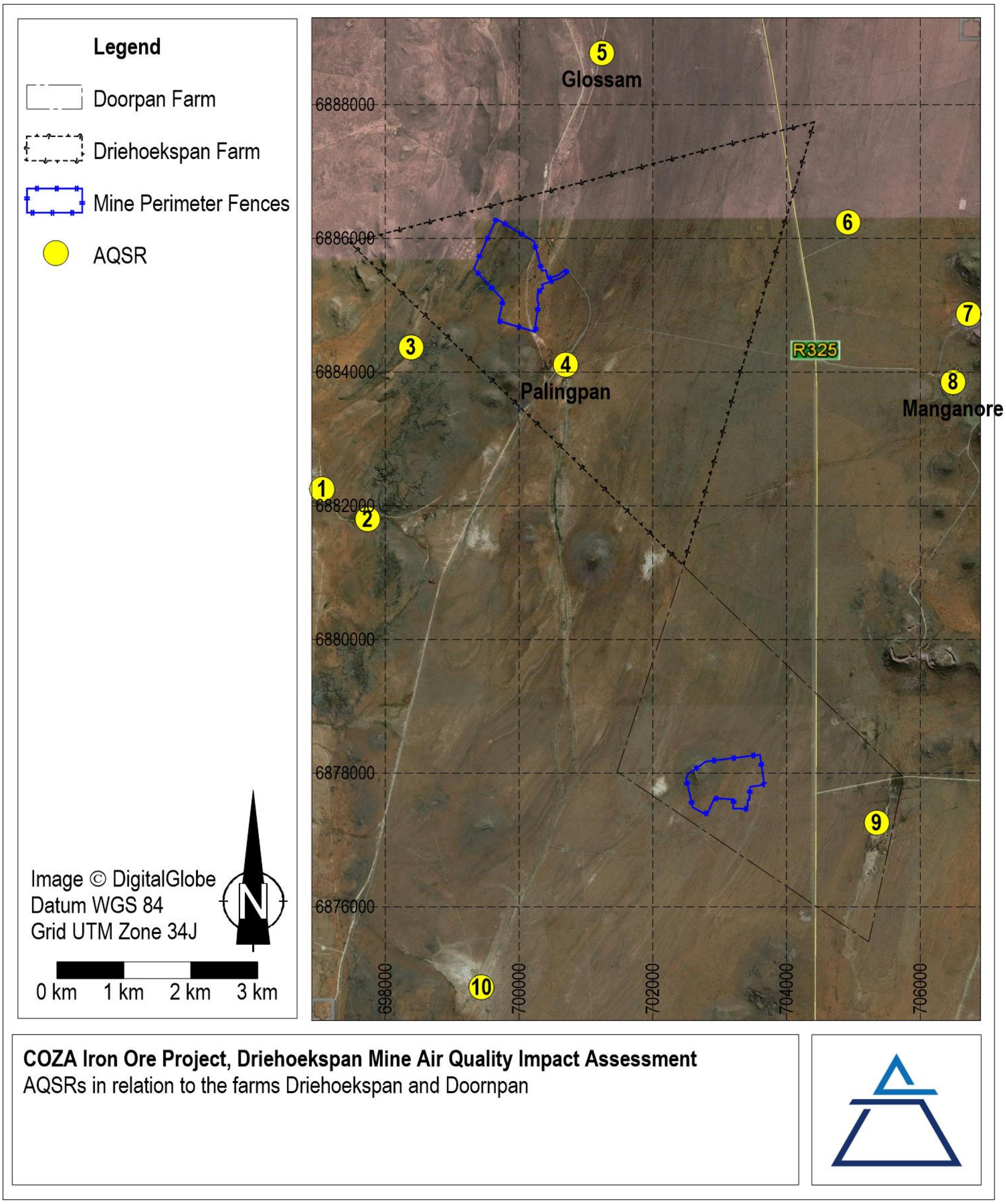
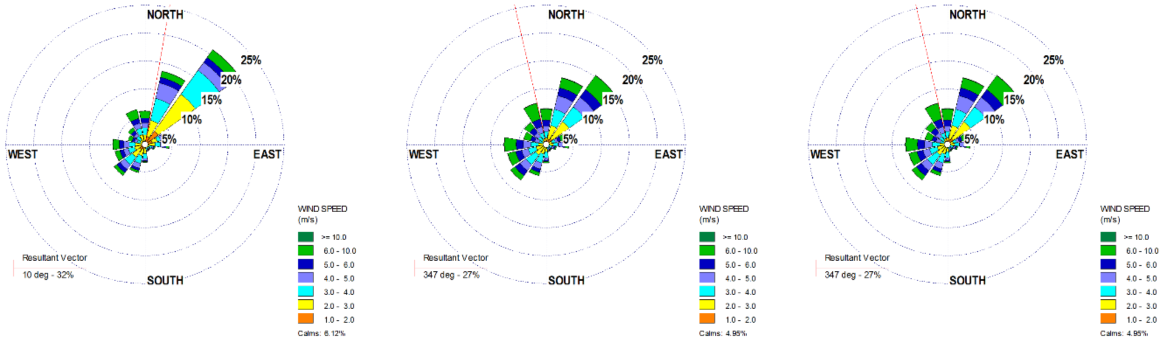


Figure 2: Location of AQSRs



(a) Period average wind field **(b) Day-time wind field (06:00 to 18:00)** **(b) Night-time wind field (18:00 to 06:00)**

Figure 3: Wind field (Postmasburg, Nov 2011 to Oct 2014)

3.2.2 Temperature

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

Diurnal and average monthly temperature trends are presented in Table 7. Monthly mean and hourly maximum and minimum temperatures are included in Table 7. Temperatures ranged between -7.3 °C and 40 °C. The highest temperatures occurred in December, January and February and the lowest in June, July and August. During the day, temperatures increase to reach maximum at around 15:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 07:00 i.e. just before sunrise.

Table 7: Monthly temperature summary (Postmasburg, Nov 2011 to Oct 2014)

Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Minimum	8.9	7.8	5.0	1.8	-5.0	-6.1	-7.3	-6.1	-5.0	1.1	2.3	6.1
Maximum	40.0	38.9	37.8	32.8	32.3	27.3	28.3	32.3	35.0	36.1	37.8	40.0
Average	26.6	25.2	22.6	17.0	14.6	10.0	10.3	12.7	16.3	20.1	23.5	24.3

3.2.3 Atmospheric Stability

The new generation air dispersion models differ from the models traditionally used in a number of aspects, the most important of which are the description of atmospheric stability as a continuum rather than discrete classes. The atmospheric boundary layer properties are therefore described by two parameters; the boundary layer depth and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill Class.

The Monin-Obukhov length (L_{Mo}) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night-times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and lower dilution potential.

Diurnal variation in atmospheric stability, as calculated from on-site data, and described by the inverse Monin-Obukhov length and the boundary layer depth is provided in Figure 5. The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions. For elevated releases, unstable conditions can result in very high concentrations of poorly diluted emissions close to the stack. This is called *looping* (Figure 5 (c)) and occurs mostly during daytime hours. Neutral conditions disperse the plume fairly equally in both the vertical and horizontal planes and the plume shape is referred to as *coning* (Figure 5 (b)). Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called *fanning* (Figure 5 (a)) (Tiwary & Colls, 2010).

For ground level releases such as those associated with the COZA Iron Ore Project, the highest ground level concentrations occur during stable night-time conditions.

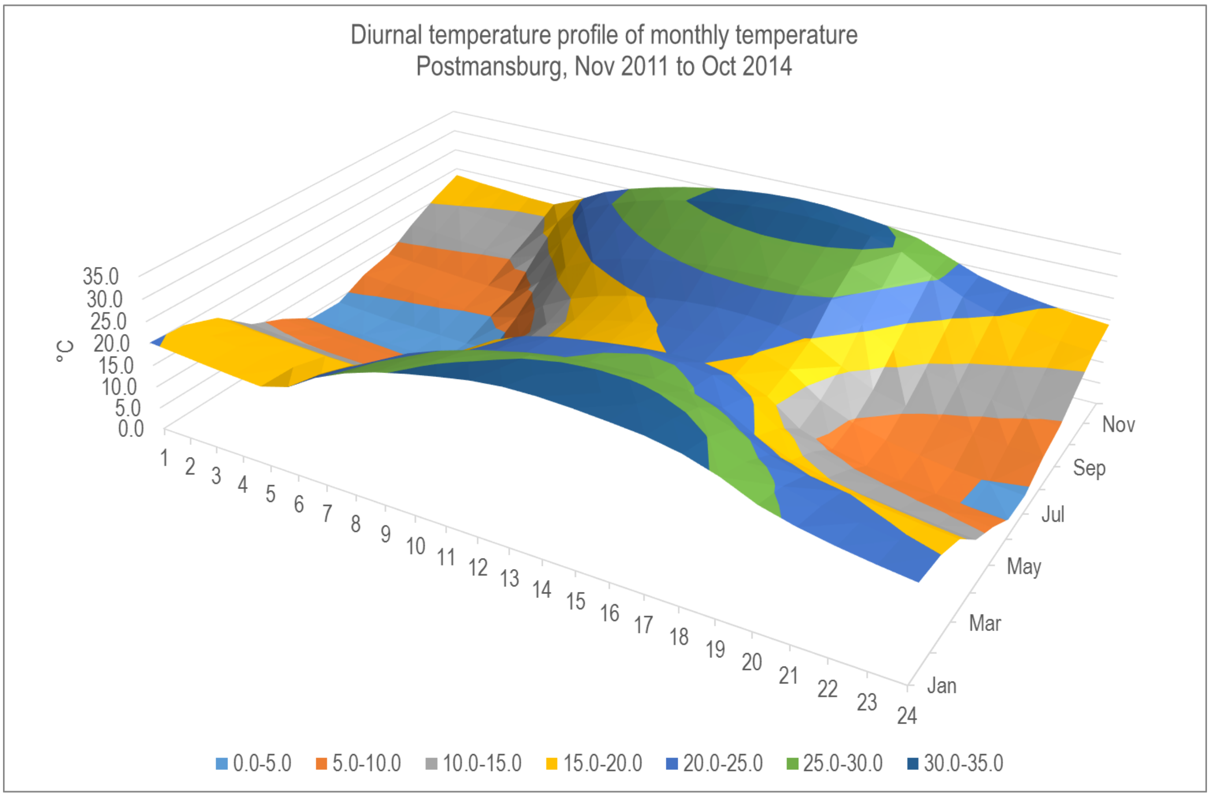


Figure 4: Diurnal profile of average temperatures per month (Postmasburg, Nov 2011 to Oct 2014)

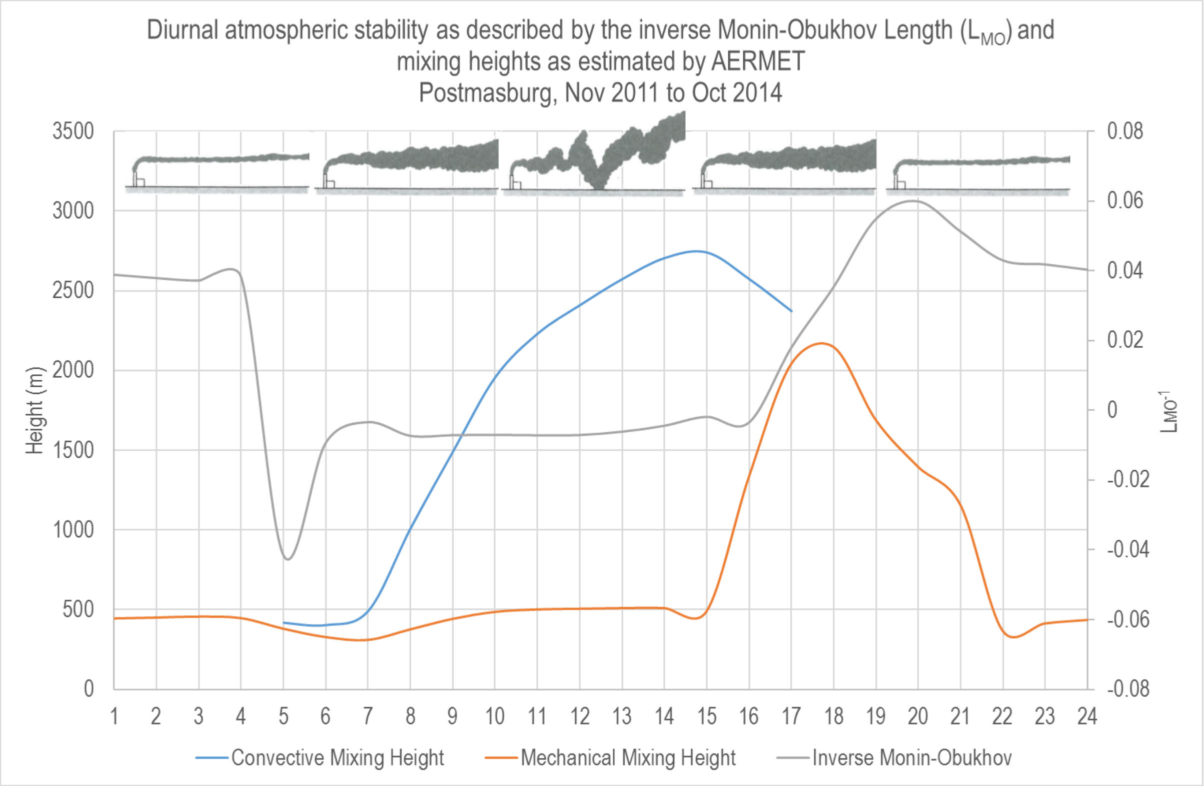


Figure 5: Diurnal atmospheric stability as estimated by AERMET (Postmasburg, Nov 2011 to Oct 2013)

3.3 Existing Ambient Air Quality and Air Pollutant Concentrations

Ambient NO_2, O_3, PM_{10}, $PM_{2.5}$ and SO_2 concentrations are recorded at the Postmasburg ambient monitoring station. Reference is made to data recorded between September 2011 and March 2013 in describing existing (or pre-development) ambient pollutant concentrations for the project.

3.3.1 Measured Ambient NO2 Concentrations

Hourly average NO_2 concentrations were analysed to determine a representative background/pre-development concentration for use in determining the potential for cumulative impacts. A summary of recorded and calculated average and median concentrations are provided in Table 8.

Ambient NO_2 concentrations during the recording period were low, the maximum 1-hour concentrations being less than 22% of the hourly NAAQS limit value of 200 µg/m^3. Average and median concentrations of 2.6 and 2 µg/m^3 were calculated from the data set. The median concentration is considered a representative ambient annual average NO_2 concentration for the Postmasburg area. Neither the hourly nor the calculated annual average NO_2 concentrations therefore exceed NAAQSs.

Table 8: Summary of ambient NO_2 concentrations recorded near Postmasburg

Parameter	Value
Data Availability	92%
Hourly Minimum NO_2 Concentration	0 µg/m^3

Parameter	Value
Hourly Maximum NO_2 Concentration	42 µg/m^3
Exceedances of the NAAQS Limit Value of 200 µg/m^3	0 hours
Average NO_2 Concentration	2.60 µg/m^3
Median NO_2 Concentration	2.00 µg/m^3

3.3.2 Measured Ambient O_3 Concentrations

Although O_3 is not assessed in this air quality investigation, ambient O_3 concentrations were used in the simulation of ambient NO_2 concentrations. Monthly variations in O_3 concentrations, as applied in NO_2 simulations, are shown in Figure 6.

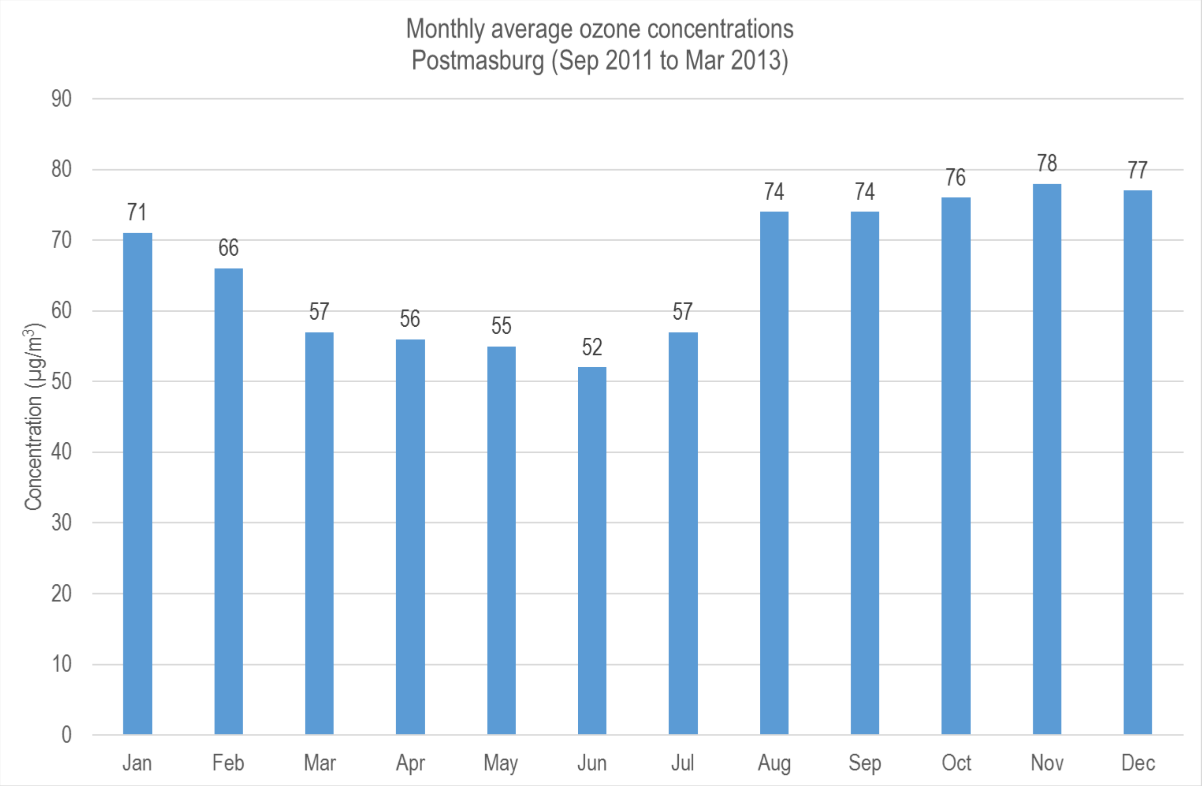


Figure 6: Monthly average ambient O_3 concentrations (Postmasburg, Sep 2011 to Mar 2013)

3.3.3 Measured Ambient $PM_{2.5}$ Concentrations

Hourly average $PM_{2.5}$ concentrations were analysed to determine 24-hour average concentrations and a representative background/pre-development concentration for use in determining the potential for cumulative impacts. A summary of calculated average and median $PM_{2.5}$ concentrations are provided in Table 9.

24-hour average ambient $PM_{2.5}$ concentrations ranged between 2.91 and 29.7 µg/m^3. Average and median concentrations of 9.53 and 8 µg/m^3 were calculated from the data set. The median concentration is considered a representative ambient annual average $PM_{2.5}$ concentrations for the Postmasburg area. 24-hour and annual average $PM_{2.5}$ concentrations in the area were therefore within NAAQSs.

Table 9: Summary of ambient $PM_{2.5}$ concentrations recorded near Postmasburg

Parameter	Value
Data Availability	89%
24-hour Average Minimum $PM_{2.5}$ Concentration	2.91 µg/m^3
24-hour Average Maximum $PM_{2.5}$ Concentration	29.7 µg/m^3
Exceedances of the NAAQS Limit Value of 40 µg/m^3 in 2011	0 days of 92 days (0%)
Exceedances of the NAAQS Limit Value of 40 µg/m^3 in 2012	0 days of 352 days (0%)
Exceedances of the NAAQS Limit Value of 40 µg/m^3 in 2013	0 days of 87 days (0%)
Average $PM_{2.5}$ Concentration	9.53 µg/m^3
Median $PM_{2.5}$ Concentration	8.00 µg/m^3
Data Availability	89%

3.3.4 Measured Ambient PM_{10} Concentrations

Hourly average PM_{10} concentrations were analysed to determine 24-hour average concentrations and a representative background/pre-development concentration for use in determining the potential for cumulative impacts. A summary of calculated average and median PM_{10} concentrations are provided in Table 10. 24-hour average ambient PM_{10} concentrations ranged between 5.83 and 93.9 µg/m^3. The NAAQS limit value of 75 µg/m3 was exceeded a total of 8 days during 2012. Average and median concentrations of 30 and 22 µg/m^3 were calculated from the data set. The median concentration is considered a representative ambient annual average PM_{10} concentration for the Postmasburg area.

Table 10: Summary of ambient PM_{10} concentrations recorded near Postmasburg

Parameter	Value
Data Availability	91%
24-hour Average Minimum PM10 Concentration	5.83 µg/m3
24-hour Average Maximum PM10 Concentration	93.9 µg/m3
Exceedances of the NAAQS Limit Value of 75 µg/m3 in 2011	0 days of 101 days (0%)
Exceedances of the NAAQS Limit Value of 75 µg/m3 in 2012	8 days of 352 days (2%)
Exceedances of the NAAQS Limit Value of 75 µg/m3 in 2013	0 days of 87 days (0%)
Average PM10 Concentration	30.0 µg/m3
Median PM10 Concentration	22.0 µg/m3

3.3.5 Measured Ambient SO_2 Concentrations

Hourly average SO_2 concentrations were analysed to determine 24-hour average concentrations and a representative background/pre-development concentration for use in determining the potential for cumulative impacts. A summary of calculated average and median SO_2 concentrations are provided in Table 11. Hourly SO_2 concentrations of up to 32 µg/m^3 were recorded. 24-hour average ambient SO_2 concentrations ranged between 0.38 and 14.5 µg/m^3. Average and median concentrations of 2.18 and 2 µg/m^3 were calculated from the data set. Neither the short term, nor the annual average NAAQSs for SO_2 were therefore exceeded during the recording period. The median concentration is considered a representative ambient annual average SO_2 concentration for the Postmasburg area.

Table 11: Summary of ambient SO_2 concentrations recorded near Postmasburg

Parameter	**Value**
Data Availability	88%
1-hour Average Minimum SO_2 Concentration	0 µg/m^3
1-hour Average Maximum SO_2Concentration	32 µg/m^3
Exceedances of the 1-hour NAAQS Limit Value of 350 µg/m^3	0 hours
24-hour Average Minimum SO_2 Concentration	0.38 µg/m^3
24-hour Average Maximum SO_2 Concentration	14.5 µg/m^3
Exceedances of the 24-hour NAAQS Limit Value of 125 µg/m^3	0 days
Average SO_2 Concentration	2.18 µg/m^3
Median SO_2 Concentration	2.00 µg/m^3

4 IMPACT ASSESSMENT

4.1 Atmospheric Emissions

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts of the project's activities on the Driehoekspan portion on the receiving environment.

Sources of emission and associated pollutants considered in the emissions inventory included:

- Fugitive dust emissions:
  - Blasting – $PM_{2.5}$, PM_{10} and TSP
  - Crushing and screening – $PM_{2.5}$, PM_{10} and TSP
  - Drilling – $PM_{2.5}$, PM_{10} and TSP
  - Handling of ore and waste rock – $PM_{2.5}$, PM_{10} and TSP
  - Transport of ore and waste rock, vehicle entrained dust from road surfaces (paved and unpaved) – $PM_{2.5}$, PM_{10} and TSP
  - Windblown dust – $PM_{2.5}$, PM_{10} and TSP[1]
- Vehicle exhaust emissions - CO, DE, NO_x, $PM_{2.5}$, PM_{10}, SO_2 and VOC

Fugitive dust (TSP, PM_{10} and $PM_{2.5}$) emissions from blasting, crushing and screening, drilling, materials handling, unpaved haul roads, paved public roads and windblown dust from exposed areas were determined through the application of emission factors published by the US EPA and the ADE. A summary of fugitive dust sources quantified, emissions estimation techniques applied, and source input parameters are summarised in Table 12. Where dust mitigation is included in the project design, such control efficiencies were included in the estimation. As part of the management of dust emissions, the efficiencies of some additional mitigation measure were also quantified. Estimated annual average emissions, per source group, are presented in Table 13 and Figure 7. For comparison purposes Table 13 also includes total annual emission rates estimated for Doornpan.

The following is noted with regards to the emissions inventory:

- Vehicle entrained dust from unpaved roads, crushing and screening and materials handling will contribute most notably to TSP, PM_{10} and $PM_{2.5}$ emissions during Driehoekspan's operational phase.
- Annual PM emissions can be reduced significantly (55% to 65%) through the application of the most basic mitigation i.e. water spays and chemical dust suppressants/binding agents.

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[1] The nature of the ore being mined i.e. density and particle size, makes windblown dust from these sources unlikely. Windblown dust emissions were considered initially but not included in the emissions inventory. Only windblown dust from topsoil storage was considered.

Table 12: Emission estimation techniques and parameters for Driehoekspan

Source Group	Emission Estimation Technique	Input Parameters
Blasting	NPI emission factor equation (NPI, 2011) $$EF = k \cdot 0.00022 \cdot A^{1.5}$$ Where EF is the emission factor in kg/blast k is the particle size multiplier (k_{TSP} – 1, k_{PM10} – 0.52, $k_{PM2.5}$ – 0.03) A is the area of a blast in m^2.	The **blast area of ~723 m^3** was estimated from mining rates and blast information supplied by SLR. It was assumed blasting will occur once a day. **Blast Frequency:** 1 blast per day, 299 days per year **Mitigation:** None
Crushing and Screening	NPI single valued emission factors for low moisture ore (NPI, 2011) TSP – 0.2 kg/tonne (crushing), 0.08 kg/tonne (screening) PM_{10} – 0.02 kg/tonne (crushing), 0.06 kg/tonne (screening) $PM_{2.5}$ – *assumed* to be 0.002 kg/tonne (crushing), 0.045 kg/tonne (screening)	Maximum primary **crushing and screening rate ~105 tonnes/hour**. **Hours of operation:** 299 days per year, 24 hours per day **Design Mitigation:** None **Additional Mitigation:** 50% control achieved through effective water sprays (NPI, 2011)
Drilling	NPI single valued emission factors (NPI, 2011) TSP – 0.59 kg/hole PM_{10} – 0.31 kg/hole $PM_{2.5}$ – 0.16 kg/hole	From the blasting and drilling info supplied it was estimated that **~80 holes will be drilled per day**. **Hours of operation:** 299 days per year, 24 hours per day **Design Mitigation:** None **Additional Mitigation:** 70% control achieved through effective water sprays (NPI, 2011)
Materials Handling	US EPA emission factor equation (US EPA, 2006) $$EF = k \cdot 0.0016 \cdot \left(\frac{U}{2.3}\right)^{1.3} \cdot \left(\frac{M}{2}\right)^{-1.4}$$ Where EF is the emission factor in kg/tonne material handled k is the particle size multiplier (k_{TSP} – 0.74, k_{PM10} – 0.35, $k_{PM2.5}$ – 0.053) U is the average wind speed in m/s M is the material moisture content in %	Ore and waste handling activities occur mainly in the pit, at the ore stockpile and at the waste rock dump. The number of handlings steps and **maximum** material handling rates used in the estimation of emissions are: Ore, 4 handling steps, handling rate ~**105 tonnes/hour** Waste, 4 handling steps, handling rate ~**746 tonnes/hour** An average **wind speed of 3.4 m/s** was determined from the Postmasburg data set A **moisture content of 1%** was conservatively assumed for both ore and waste material **Hours of operation:** 299 days per year, 24 hours per day **Design Mitigation:** None **Additional Mitigation**: 50% control achieved through effective water sprays (NPI, 2011)

Vehicle Entrained Dust from Paved Roads	US EPA emission factor equation (US EPA, 2011) $EF = k \cdot (sL)^{0.91} \cdot (W)^{1.02}$ Where EF is the emission factor in g/vehicle kilometer travelled (VKT) k is the particle size multiplier (k_{TSP} – 3.23, k_{PM10} – 0.62, $k_{PM2.5}$ – 0.15) sL is the road surface material silt loading in g/m^2 W is the average weight vehicles in tonnes	Transport activities include the transport crushed ore from the crusher area to the Jenkins portion. VKT were calculated from road lengths (limited to simulation areas), truck capacities and the number of trips required to transport ore were assumed. **Ore**, truck capacity 25 tonnes, average vehicle weight 38.5 tonnes, ~4 return trips/hour, ~18 VKT/h. A default road **surface silt loading of 0.6 g/m^3** for paved public roads (US EPA, 2011) was applied in calculations. **Hours of operation:** 299 days per year, 24 hours per day **Design Mitigation:** None **Additional Mitigation**: None
Vehicle Entrained Dust from Unpaved Roads	US EPA emission factor equation (US EPA, 2006) $E = k \cdot \left(\frac{s}{12}\right)^{a} \cdot \left(\frac{W}{3}\right)^{0.45} \cdot 281.9$ Where EF is the emission factor in g/vehicle kilometer travelled (VKT) k is the particle size multiplier (k_{TSP} – 4.9, k_{PM10} – 1.5, $k_{PM2.5}$ – 0.15) a is an empirical constant (a_{TSP} – 0.7, a_{PM10} – 0.9, $a_{PM2.5}$ – 0.9) s is the road surface material silt content in % W is the average weight vehicles in tonnes	Transport activities include the transport ore from the pit to the crushing plant and the transport of waste from the pit to the waste rock dump. VKT were calculated from road lengths, truck capacities and the number of trips required to transport ore and waste. **Ore**, truck capacity 25 tonnes, average vehicle weight 48.5 tonnes, ~4 return trips/hour, ~33 VKT/h. **Waste**, truck capacity 90 tonnes, average vehicle weight 119 tonnes ~10 return trips/hour, ~89 VKT/h A default road **surface silt content of 8.4%** (US EPA, 2006) was applied in calculations **Hours of operation:** 299 days per year, 24 hours per day **Design Mitigation**: 75% control achieved through effective water sprays at an application rate of more than 2 l/m^2-hour (NPI, 2011) **Additional Mitigation**: 90% total control achieved through effective water sprays with chemical dust suppressant/binding agent.
Vehicle/Equipment Exhaust Emissions	NPI single valued emission factors (NPI, 2008) CO – 1.85E-02 kg/l NOx – 4.44E-02 kg/l $PM_{2.5}$ (and DE) – 3.33E-03 kg/l PM_{10} – 3.63E-03 kg/l SO_2 – 1.20E-04 kg/l VOC – 4.05E-03 kg/l	Diesel consumption of ~5 490 l/day, as supplied, were used in calculations. Note that sulphur content of diesel fuel was assumed to be 50 ppm. **Hours of operation:** 299 days per year, 24 hours per day **Design Mitigation:** None **Additional Mitigation**: None
Windblown Dust	NPI single valued emission factors (NPI, 2011) TSP – 0.4 kg/ha-h PM_{10} – 0.2 kg/ha-h $PM_{2.5}$ – 0.1 kg/ha-h (assumed)	Topsoil stockpile area ~35 ha. **Hours of emission:** Continuous **Design Mitigation:** None **Additional Mitigation**: 50% control achieved through effective water sprays (NPI, 2011)

Table 13: Estimated annual emission rates from Driehoekspan per source group

Source Group	Annual emission rates (t/a)								Annual emission rates (t/a) with additional mitigation		
Driehoekspan:	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**CO**	**DE**	**NO_x**	**SO_2**	**VOC**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Blasting	1.28	0.663	0.0384	-	-	-	-	-	1.28	0.663	0.0384
Crushing	210	60	17.1	-	-	-	-	-	105	30	8.57
Drilling	14.1	7.4	3.89	-	-	-	-	-	4.23	2.22	1.17
Materials Handling	134	63.3	9.58	-	-	-	-	-	100	47.4	7.18
Paved Roads	13.7	2.63	0.635	-	-	-	-	-	13.7	2.63	0.635
Unpaved Roads	786	224	22.4	-	-	-	-	-	196	56	5.6
Vehicle Exhaust	6.01	6.01	5.52	30.6	6.01	73.6	0.198	6.71	6.01	6.01	5.52
Windblown Dust	12.1	6.06	3.03	-	-	-	-	-	6.06	3.03	1.52
Total (Driehoekspan)	**1 180**	**370**	**62.2**	**30.6**	**6.01**	**73.6**	**0.198**	**6.71**	**433**	**148**	**30.2**
Total (Doornpan)	**567**	**176**	**35.6**	**30.3**	**5.46**	**72.8**	**0.196**	**6.64**	**231**	**80.1**	**19.6**

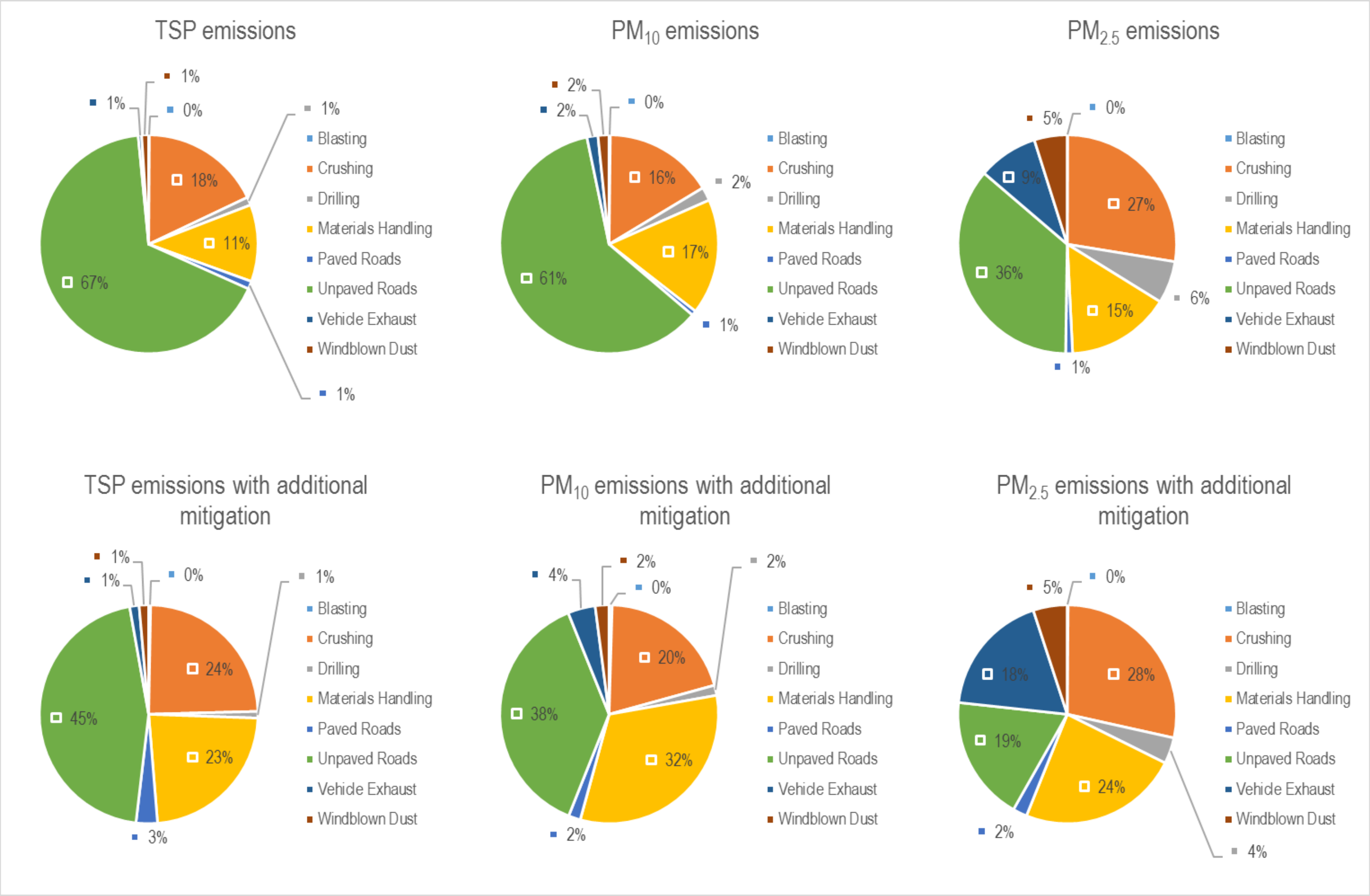


Figure 7: Source group contributions to estimated annual PM emissions from Driehoekspan activities

4.2 Atmospheric Dispersion Modelling

The assessment of the impact of the project's operations on the environment is discussed in this Section. To assess impact on human health and the environment the following important aspects need to be considered:

- The criteria against which impacts are assessed (Section 2);
- The potential of the atmosphere to disperse and dilute pollutants emitted by the project (Section 3.2);
- Existing ambient pollutant concentrations (3.3); and
- Atmospheric emissions (Section 4.1)

Dispersion models simulate ambient pollutant concentrations and dustfall rates as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from the emissions of various sources. Increasing reliance has been placed on concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and emission control requirements. It is therefore important to carefully select a dispersion model for the purpose.

4.2.1 Dispersion Model Selection

Gaussian-plume models are best used for near-field applications where the steady-state meteorology assumption is most likely to apply. One of the most widely used Gaussian plume model is the US EPA AERMOD model that was used in this study. AERMOD is a model developed with the support of AERMIC, whose objective has been to include state-of the-art science in regulatory models (Hanna, et al., 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

AERMOD is an advanced new-generation model. It is designed to predict pollution concentrations from continuous point, flare, area, line, and volume sources. AERMOD offers new and potentially improved algorithms for plume rise and buoyancy, and the computation of vertical profiles of wind, turbulence and temperature however retains the single straight line trajectory limitation. AERMET is a meteorological pre-processor for AERMOD. Input data can come from hourly cloud cover observations, surface meteorological observations and twice-a-day upper air soundings. Output includes surface meteorological observations and parameters and vertical profiles of several atmospheric parameters. AERMAP is a terrain pre-processor designed to simplify and standardise the input of terrain data for AERMOD. Input data includes receptor terrain elevation data. The terrain data may be in the form of digital terrain data. The output includes, for each receptor, location and height scale, which are elevations used for the computation of air flow around hills.

A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Input data types required for the AERMOD model include: source data, meteorological data (pre-processed by the AERMET model), terrain data and information on the nature of the receptor grid.

Version (version 7.9) of AERMOD and its pre-processors were used in the study.

4.2.2 Meteorological Requirements

For the purpose of the current study use was made of hourly surface data for the period Nov 2011 to Oct 2014 (Section 3.2). Upper air meteorological data was extrapolated by AERMET.

4.2.3 Source Data Requirements

The AERMOD model is able to model point, jet, area, line and volume sources. Sources at Driehoekspan were modelled as follows:

- In pit emissions – modelled as area sources;
- Crushing and screening – modelled as volume sources;
- Materials handling – modelled as volume sources;
- Unpaved and paved roads – modelled as line sources;
- Vehicle exhaust – modelled as area/line sources; and
- Windblown dust – modelled as area sources

4.2.4 Simulation Domain

The dispersion of pollutants expected to arise from current operations was simulated for an area covering 10 km (east-west) by 15 km (north-south) and included both Driehoekspan and Doornpan activities. The area was divided into a grid matrix with a resolution of 250 m. The nearest community areas were included as AQSR. AERMOD calculates ground-level (1.5 m above ground level) concentrations and dustfall rates at each grid and discrete receptor point.

4.2.5 Presentation of Results

Dispersion simulations was undertaken to determine highest hourly, highest daily and annual average ground level concentrations and dustfall rates for each of the pollutants considered in the study as well as the frequency at which short term criteria are exceeded. Averaging periods were selected to facilitate the comparison of predicted pollutant concentrations to relevant ambient air quality and inhalation health criteria as well as dustfall regulations.

Ground level concentration (GLC) isopleths plots presented in this section depict interpolated values from the concentrations predicted by AERMOD for each of the receptor grid points specified. Plots reflecting hourly (daily) and averaging periods contain only the 99.99th (99.73th) percentile of predicted ground level concentrations, for those averaging periods, over the entire period for which simulations were undertaken. It is therefore possible that even though a high hourly (daily) average concentration is predicted to occur at certain locations, that this may only be true for one hour (day) during the year. Results are also provided in tabular form as discrete values predicted at specific sensitive receptors locations.

Ambient air quality criteria apply to areas where the Occupational Health and Safety regulations do not apply, thus outside the property or lease area. Ambient air quality criteria are therefore not occupational health indicators but applicable to areas where the general public has access i.e. off-site. Section 4.3 deals with impacts on human health. Dustfall is assessed for nuisance impact on the environment (Section 4.4) and not inhalation health impact.

4.3 Screening of Simulated Human Health Impacts

Pollutants with the potential to result in human health impacts and included in the simulations for this study include DE, NO_x, $PM_{2.5}$ and PM_{10}. It should be noted that predicted concentrations only reflect those associated with atmospheric emissions from the project (Driehoekspan in addition to the already assessed Doornpan) as quantified in Section 4.1.

4.3.1 Simulated Ambient DE Concentrations

A summary of simulated results for DE at AQSRs are presented in Table 14. Simulated annual average ambient DE concentrations exceeded the US EPA IRIS RfC of 5 µg/m^3 only on site (Figure 8). The CAL EPA cancer URF 3E-4 (µg/m^3)$^{-1}$ was applied to simulated annual average concentrations to provide a conservative estimate of excess lifetime cancer risk (Figure 9). Excess lifetime cancer risk at most AQSR were less than 1 in 10 000 and is considered "low risk" by the NYSDOH. "Moderate risk" may occur at AQSRs 1 and 3 which are situated directly downwind of Driehoekspan.

Table 14: Summary of simulation results of DE at AQSRs

Pollutant	**DE**					
Averaging Period	1 Year			1 Year		
Reporting Unit	Concentration in µg/m^3			Excess Lifetime Cancer Risk, URF 3 x 10^{-4} (µg/m^3)$^{-1}$		
Criteria	5 µg/m^3			Not available		
AQSR/Source Group	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**
1	0.33	0.033	0.37	Low	Low	Low/Moderate
2	0.24	0.046	0.29	Low	Low	Low
3	1.6	0.014	1.6	Moderate	Low	Moderate
4	0.24	0.015	0.26	Low	Low	Low
5	0.35	0.0079	0.35	Low/Moderate	Low	Low/Moderate
6	0.052	0.018	0.07	Low	Low	Low
7	0.024	0.075	0.099	Low	Low	Low
8	0.018	0.055	0.073	Low	Low	Low
9	0.011	0.074	0.085	Low	Low	Low
10	0.006	0.32	0.33	Low	Low	Low

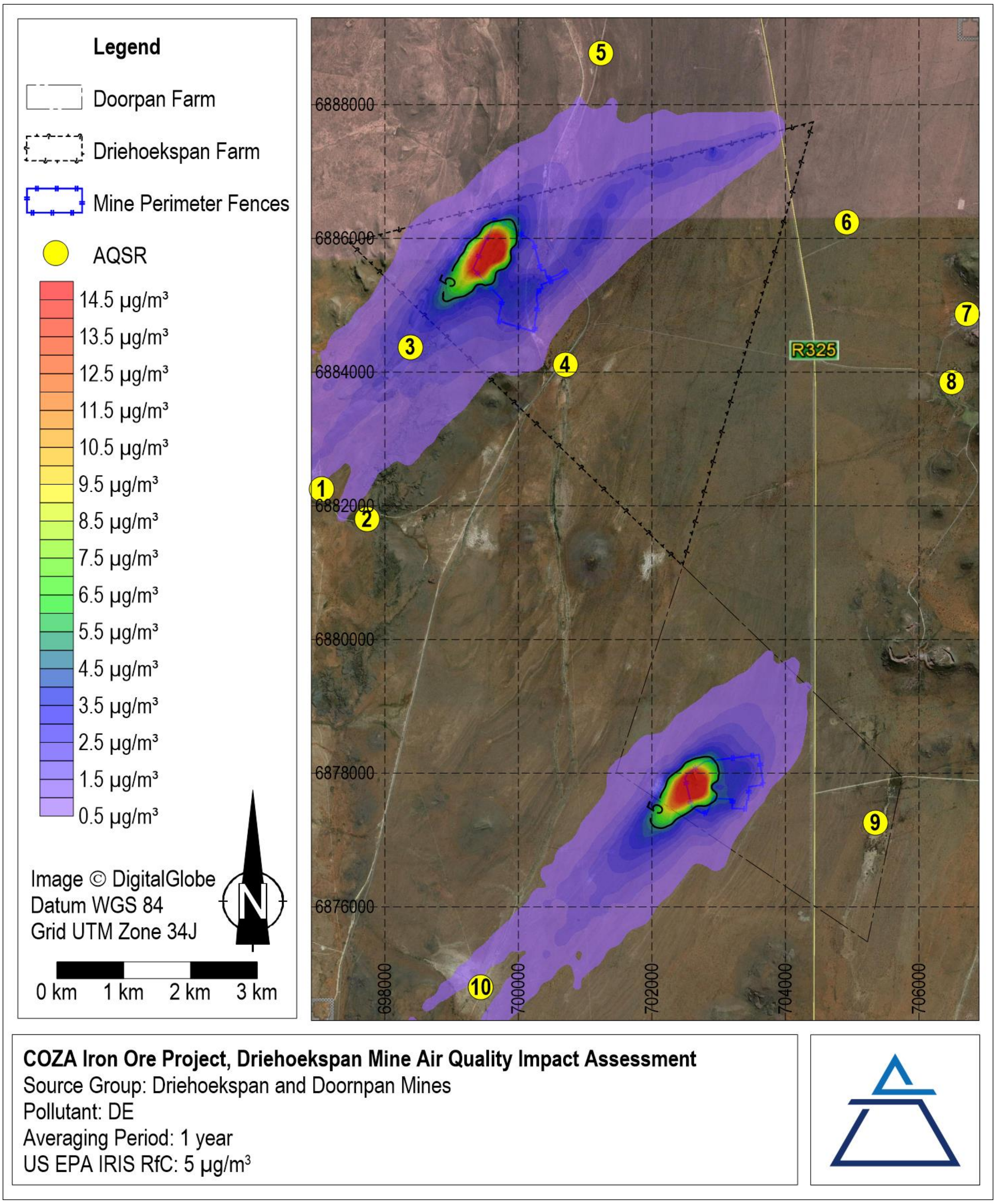
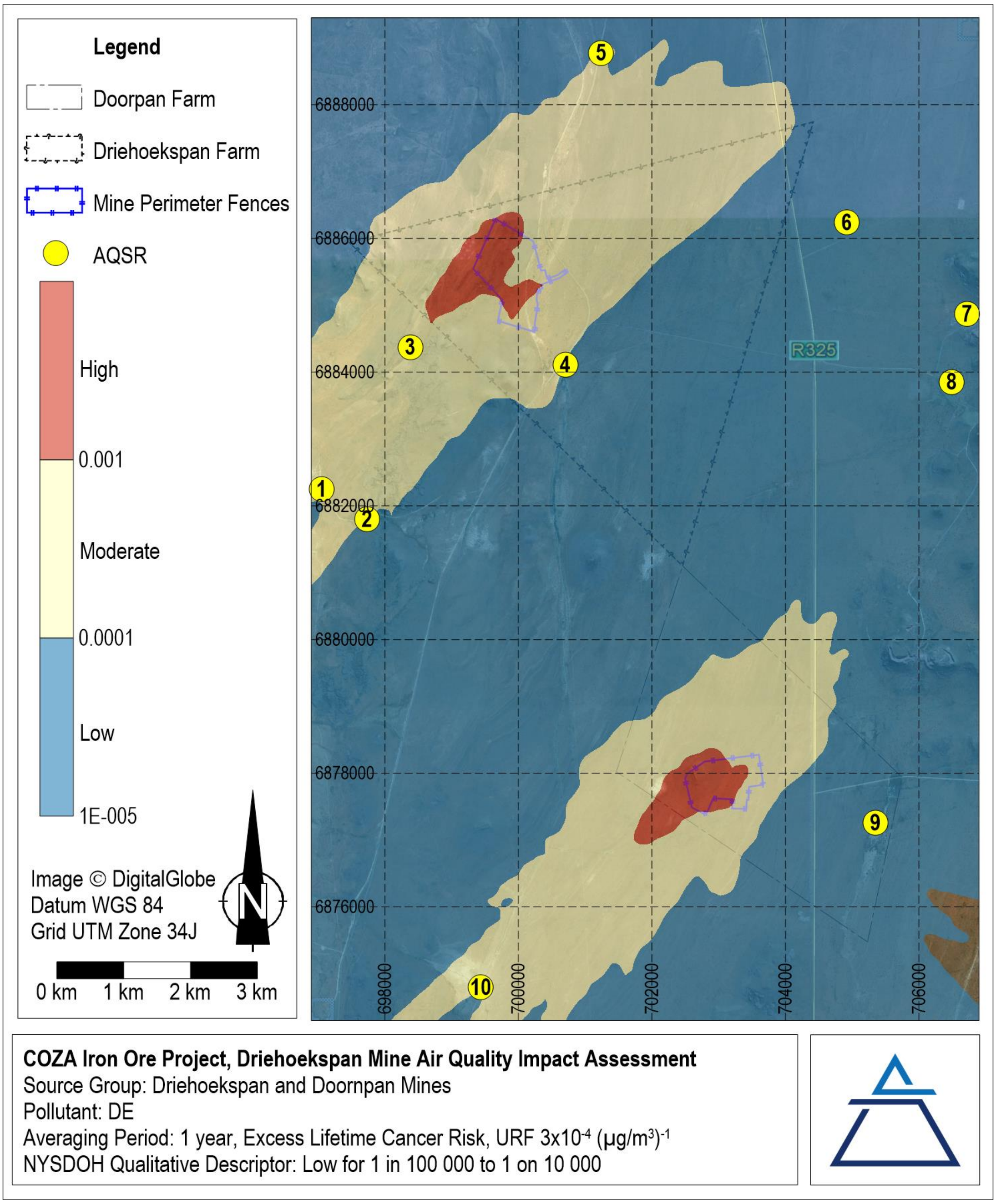


Figure 8: Simulated 1 year average DE concentrations



COZA Iron Ore Project, Driehoekspan Mine Air Quality Impact Assessment
Source Group: Driehoekspan and Doornpan Mines
Pollutant: DE
Averaging Period: 1 year, Excess Lifetime Cancer Risk, URF 3x10^{-4} (µg/m^3)$^{-1}$
NYSDOH Qualitative Descriptor: Low for 1 in 100 000 to 1 on 10 000

Figure 9: Simulated excess lifetime cancer risk associated with DE

4.3.2 Simulated Ambient NO_2 Concentrations

The reader is reminded that NO emissions are rapidly converted in the atmosphere into harmful NO_2 which is regulated by NAAQSs. NO_2 impacts where calculated by AERMOD using the ozone limiting method and applying monthly varying background O_3 concentrations shown in Figure 6. A vehicle exhaust NO_2/NO_x emission ratio of 0.2 (Howard, 1988) was used.

A summary of simulated results for NO_2 at AQSRs are presented in Table 15. Simulated annual average NO_2 concentrations were very low with no exceedances of the NAAQS of 40 µg/m³ off-site (Figure 10). The 1-hour NAAQS (88 hours of exceedance of 200 µg/m³) was however exceeded at along the northern Driehoekspan farm boundary (along the access road) and the south-western mine rights boundary of Doornpan but not at any AQSRs (Figure 11).

Table 15: Summary of simulation results of NO_2 at AQSRs

Pollutant	**NO_2**					
Averaging Period	1 year			1 hour		
Reporting Unit	Concentration in µg/m³			Frequency of exceedance in 'hours per year'		
Criteria	40 µg/m³			88 hours of exceedance of 200 µg/m³		
AQSR/Source Group	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**
1	2	0.27	2.2	0	0	0
2	1.2	0.32	1.5	2	1	1
3	8.1	0.13	8.3	25	0	25
4	1.1	0.13	1.2	7	0	7
5	1.8	0.064	1.8	12	0	12
6	0.25	0.17	0.42	0	0	0
7	0.16	0.65	0.81	0	0	0
8	0.11	0.42	0.52	0	0	0
9	0.056	0.46	0.52	4	4	0
10	0.024	2.5	2.6	0	0	0

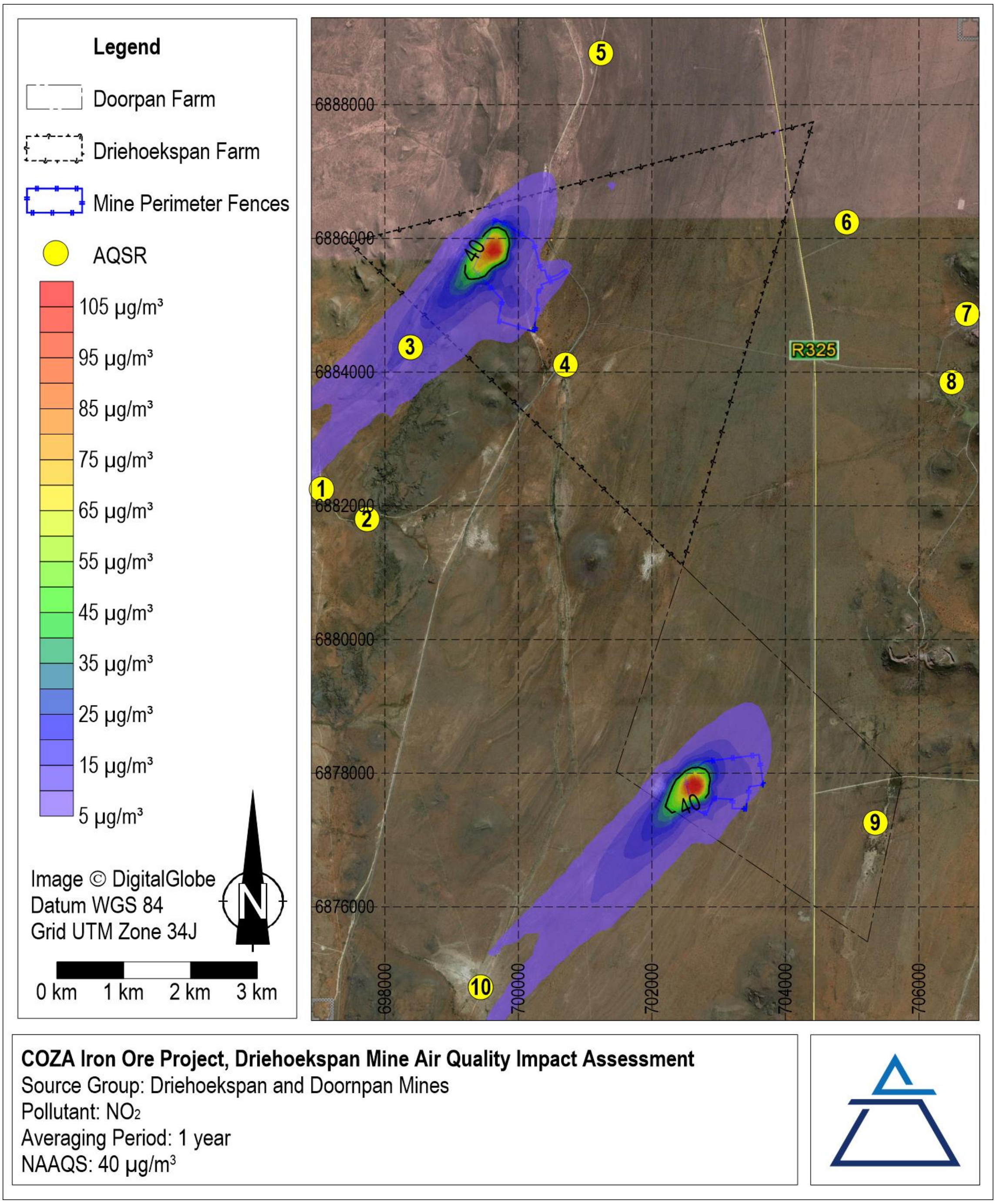


Figure 10: Simulated 1 year average NO_2 concentrations

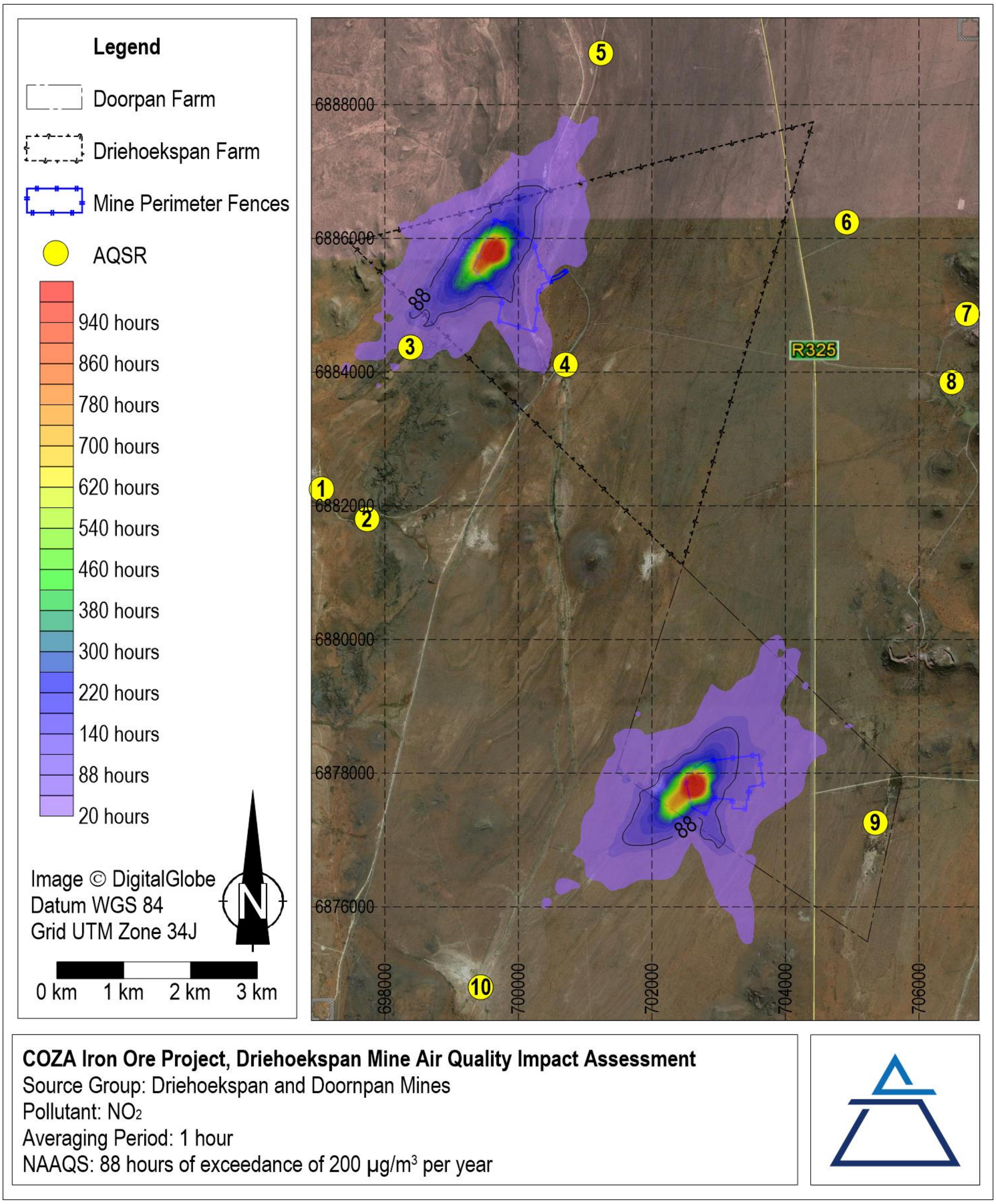


Figure 11: Simulated hours of exceedance of the 1 hour average NO_2 NAAQS limit value

4.3.3 Simulated Ambient $PM_{2.5}$ Concentrations

A summary of simulated results for $PM_{2.5}$ at AQSRs are presented in Table 16. Simulated annual average $PM_{2.5}$ concentrations were very low with marginal exceedances of the NAAQS of 20 µg/m³ off-site to the south-west of activities (Figure 13). The 24-hour NAAQS (4 days of exceedance of 40 µg/m³) was however exceeded over the south-western mine rights boundary at AQSRs no. 3 and 4 near Driehoekspan (Figure 14). With additional mitigation measures in place neither annual nor 24-hour NAAQS are exceeded off-site (Table 17, Figure 15 and Figure 16).

A source group contribution analysis indicated vehicle entrained dust, crushing and screening, vehicle exhaust and materials handling as the main contributors to simulated annual average $PM_{2.5}$ concentrations. With additional mitigation, the potential for cumulative off-site $PM_{2.5}$ concentrations in exceedance of NAAQSs is low considering that both the baseline (Section 3.3.3) and simulated ambient $PM_{2.5}$ concentrations are low and within NAAQSs.

Table 16: Summary of simulation results of $PM_{2.5}$ at AQSRs

Pollutant	**$PM_{2.5}$**					
Averaging Period	1 year			24 hour		
Reporting Unit	Concentration in µg/m³			Frequency of exceedance in 'days per year'		
Criteria	20 µg/m³			4 days of exceedance of 40 µg/m³		
AQSR/Source Group	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**
1	3.8	0.2	4	0	0	0
2	2.5	0.27	2.8	0	0	0
3	13	0.11	13	**14**	0	**14**
4	3.4	0.17	3.6	**7**	0	**7**
5	2.3	0.082	2.4	2	0	2
6	0.6	0.2	0.79	0	0	0
7	0.3	0.45	0.69	0	0	0
8	0.25	0.46	0.69	0	0	0
9	0.18	0.69	0.83	0	0	0
10	0.26	2.5	2.6	0	0	0

Table 17: Summary of simulation results of $PM_{2.5}$, with additional mitigation, at AQSRs

Pollutant	**$PM_{2.5}$ with additional mitigation**					
Averaging Period	1 year			24 hour		
Reporting Unit	Concentration in µg/m^3			Frequency of exceedance in 'days per year'		
Criteria	20 µg/m^3			4 days of exceedance of 40 µg/m^3		
AQSR/Source Group	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**
1	2	0.12	2.1	0	0	0
2	1.3	0.17	1.5	0	0	0
3	7.2	0.067	7.2	2	0	2
4	1.8	0.11	1.9	1	0	1
5	1.4	0.047	1.4	0	0	0
6	0.31	0.14	0.45	0	0	0
7	0.15	0.27	0.4	0	0	0
8	0.13	0.26	0.38	0	0	0
9	0.086	0.39	0.46	0	0	0
10	0.096	1.4	1.4	0	0	0

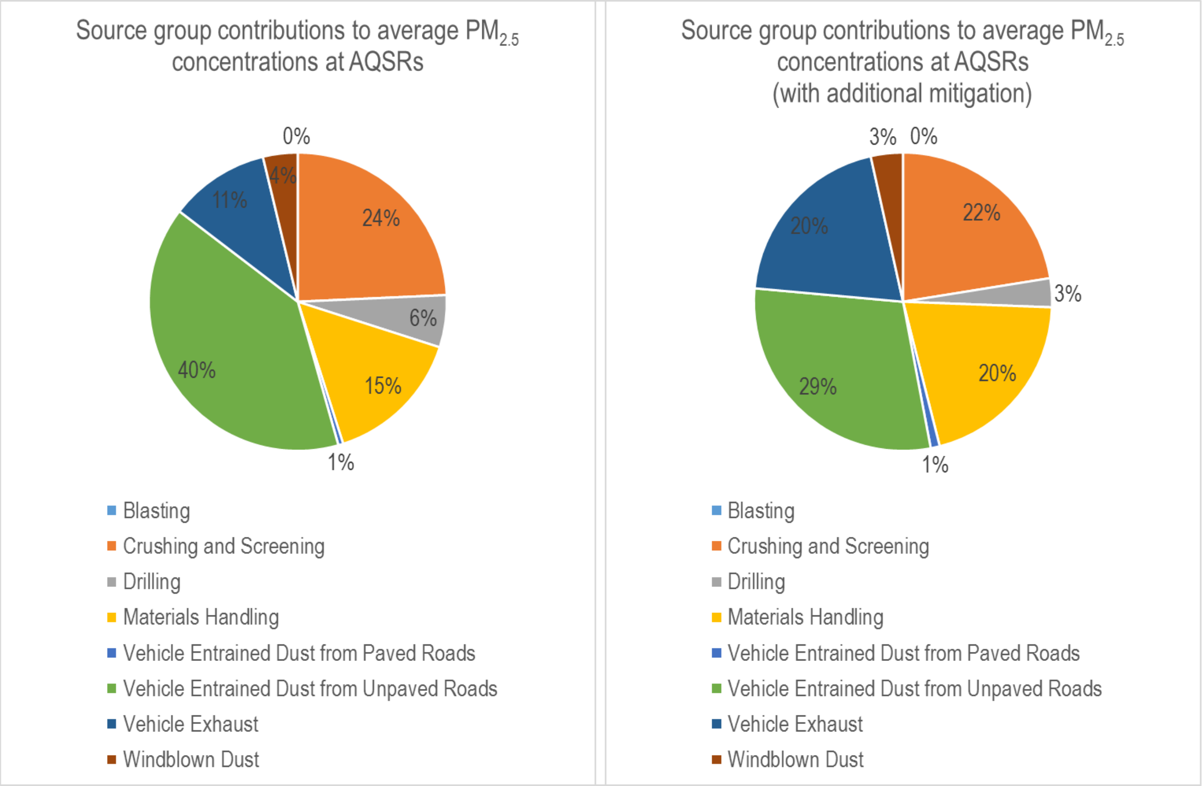


Figure 12: Source group contributions to average $PM_{2.5}$ concentrations at AQSRs due to activities at Driehoekspan

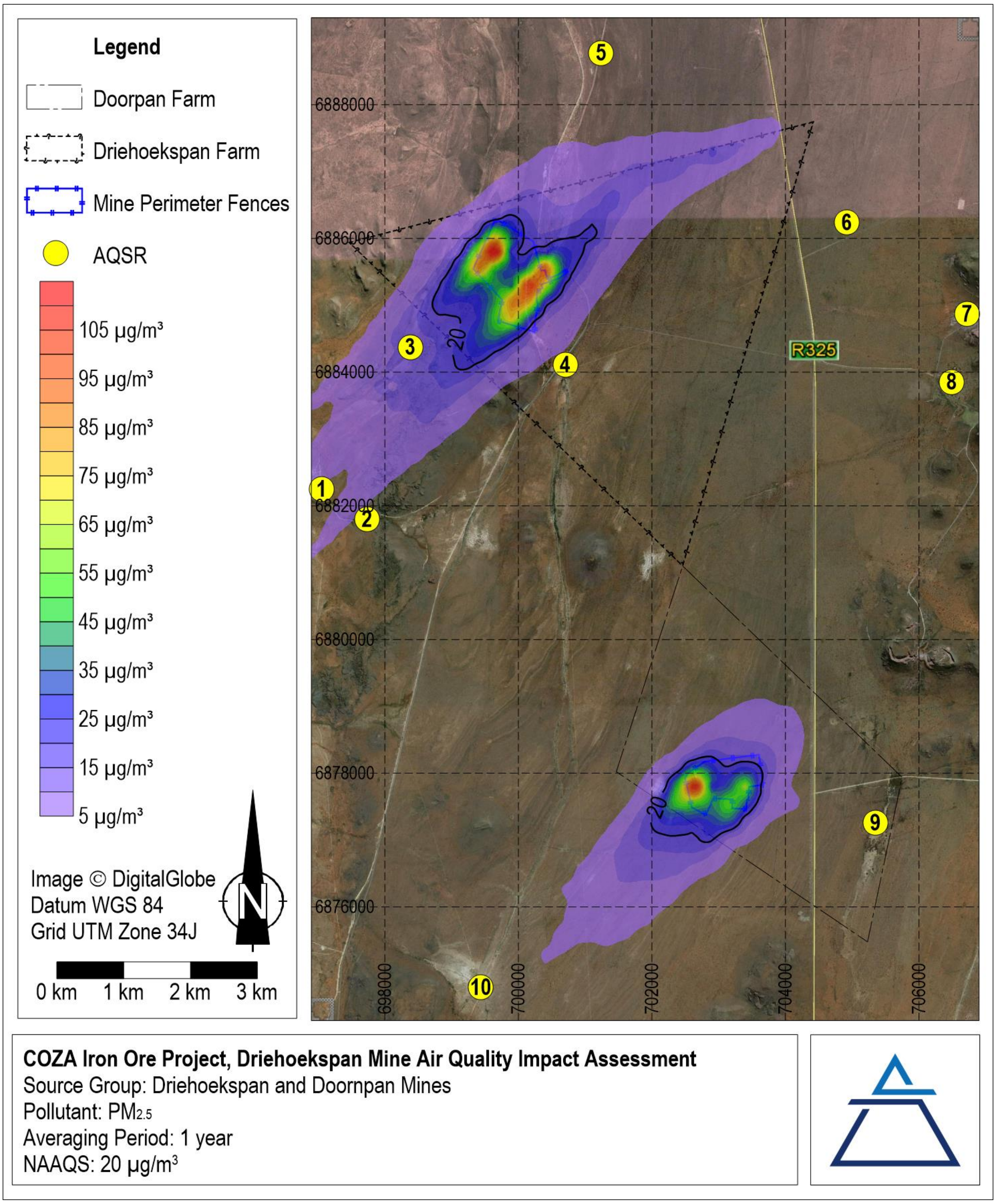


Figure 13: Simulated 1 year average $PM_{2.5}$ concentrations

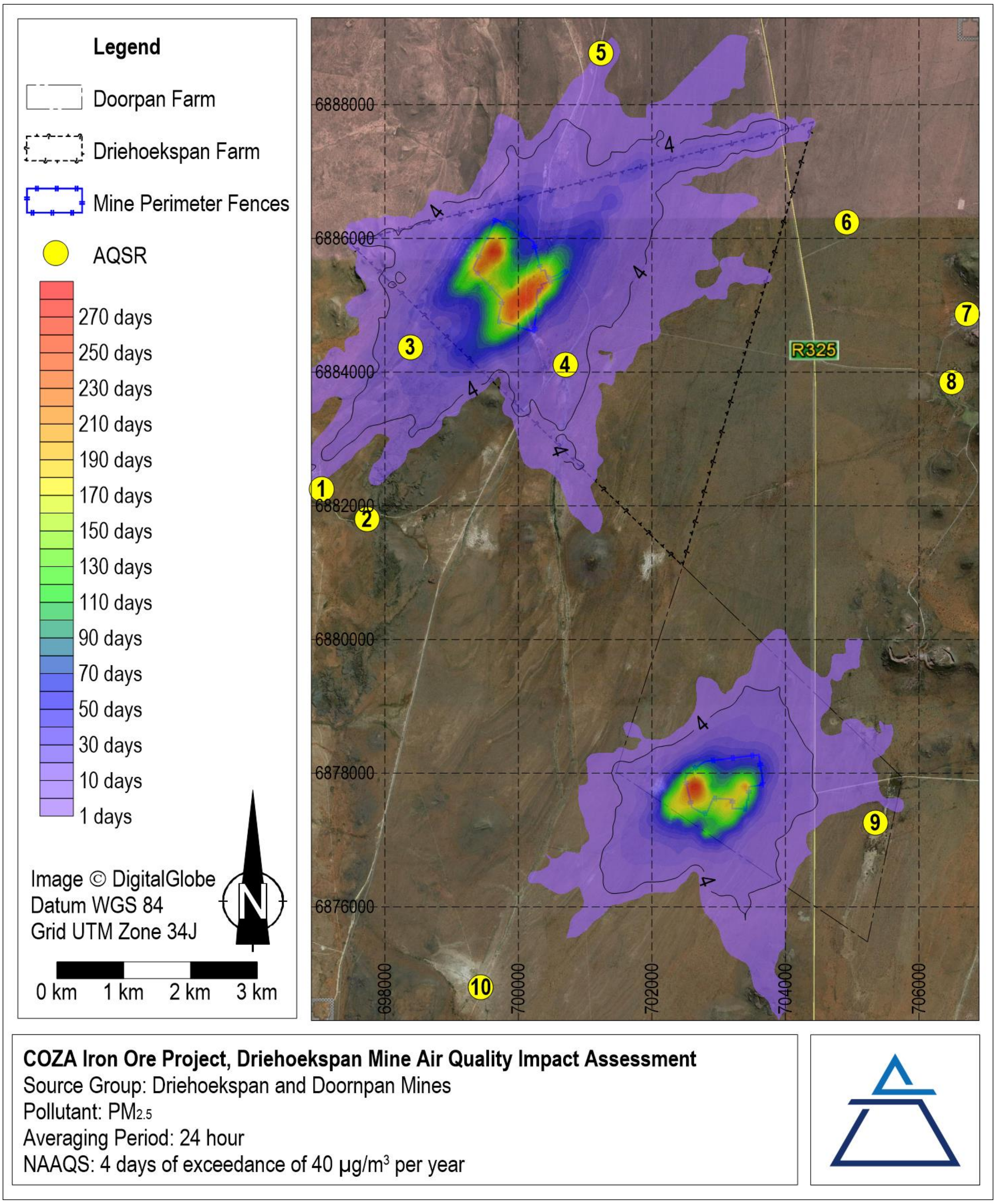
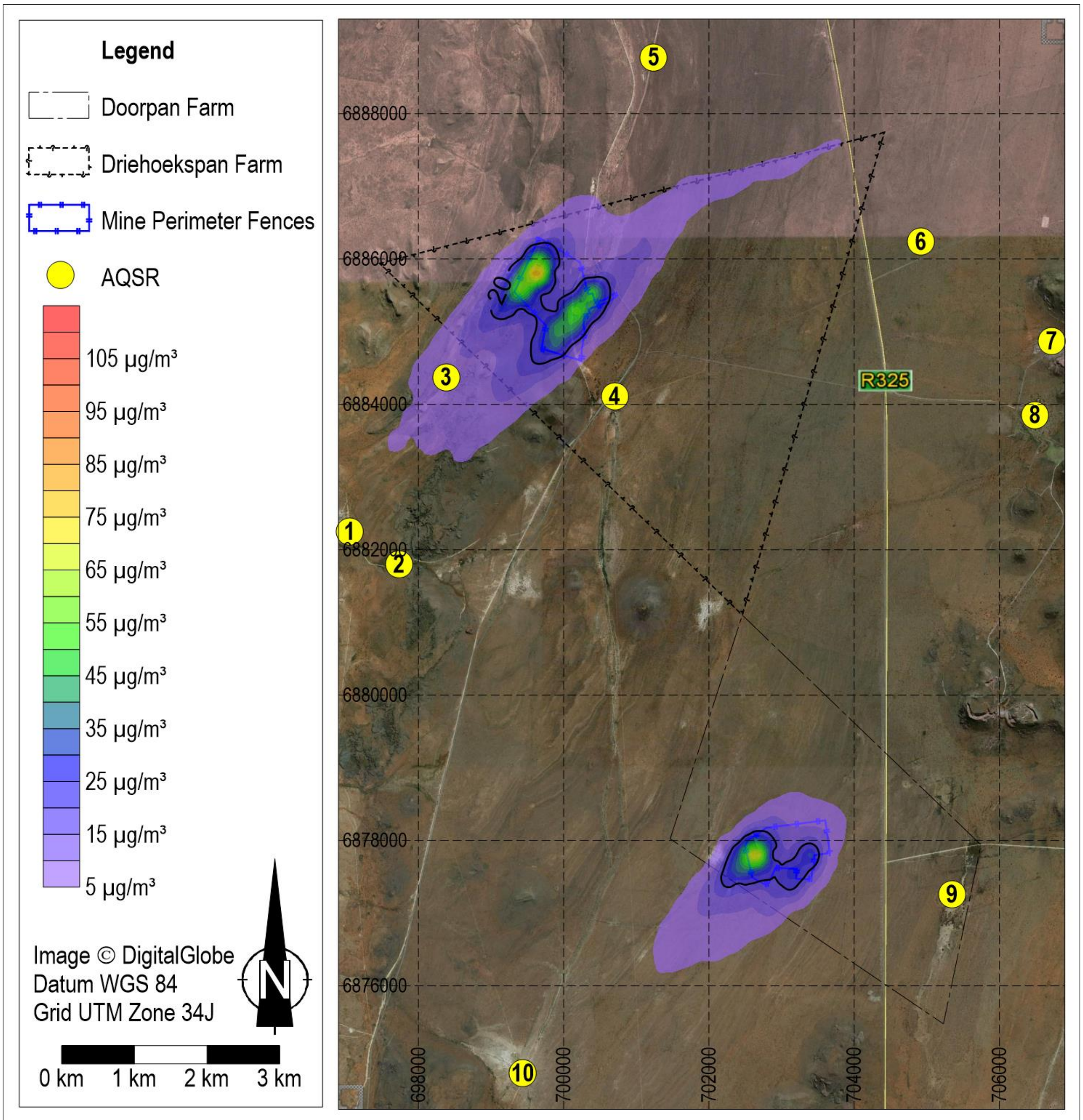
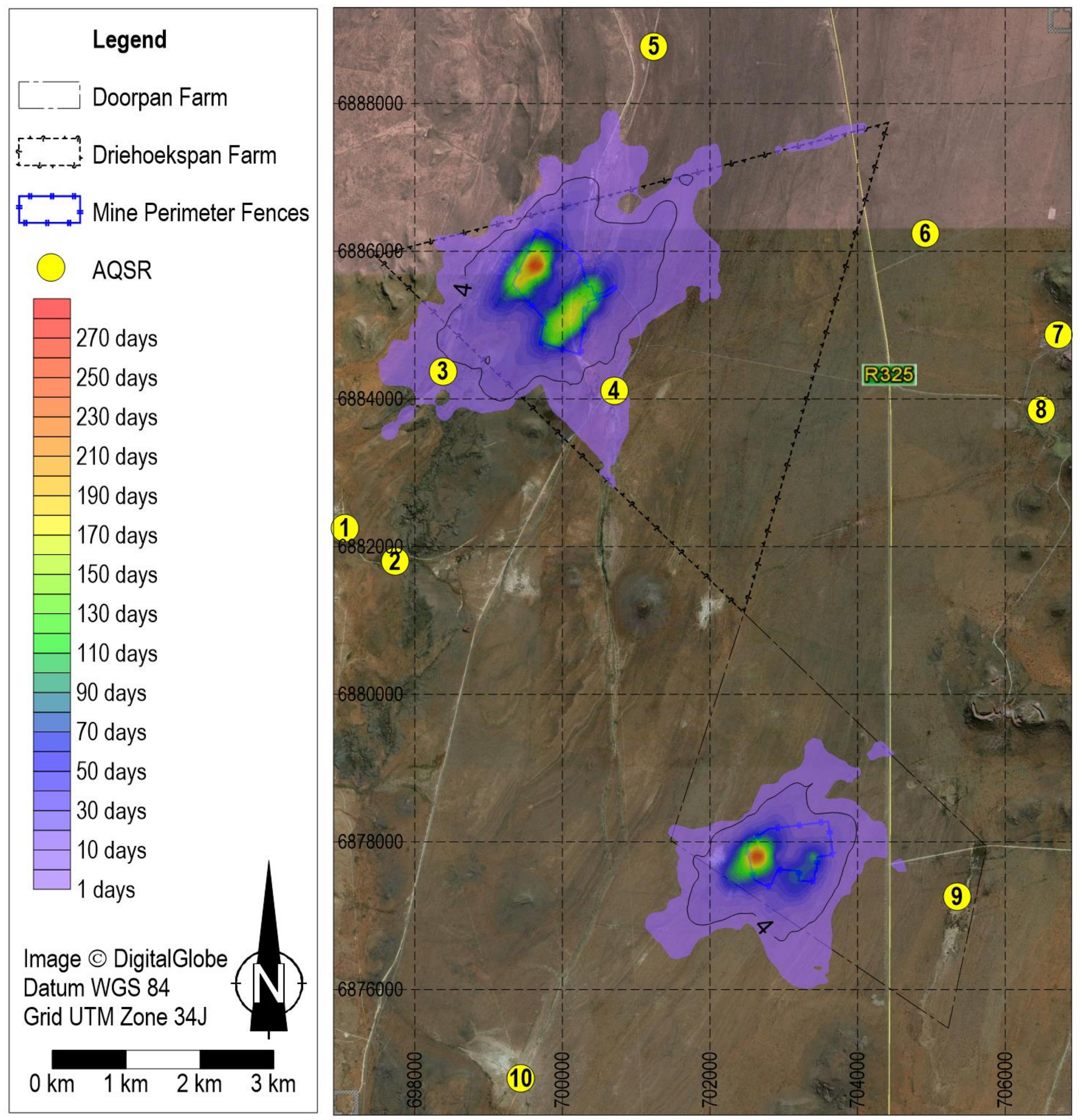


Figure 14: Simulated days of exceedance of the 24 hour average $PM_{2.5}$ NAAQS limit value



COZA Iron Ore Project, Driehoekspan Mine Air Quality Impact Assessment
Source Group: Driehoekspan and Doorpan Mines with additional mitigation
Pollutant: $PM_{2.5}$
Averaging Period: 1 year
NAAQS: 20 µg/m³

Figure 15: Simulated 1 year average $PM_{2.5}$ concentrations (with additional mitigation)



COZA Iron Ore Project, Driehoekspan Mine Air Quality Impact Assessment
Source Group: Driehoekspan and Doornpan Mines with additional mitigation
Pollutant: $PM_{2.5}$
Averaging Period: 24 hour
NAAQS: 4 days of exceedance of 40 µg/m^3 per year

Figure 16: Simulated days of exceedance of the 24 hour average $PM_{2.5}$ NAAQS limit value (with additional mitigation)

4.3.4 Simulated Ambient PM_{10} Concentrations

A summary of simulated results for PM_{10} at AQSRs are presented in Table 18. Simulated annual average PM_{10} concentrations exceeded the NAAQS of 40 µg/m^3 off-site to the south-west of both Driehoekspan and Doornpan activities and at AQSR no 3 (Figure 18). The 24-hour NAAQS (4 days of exceedance of 75 µg/m^3) is also exceeded at off-site and at several AQSRs (Figure 19). Additional mitigation measures reduce concentrations to levels that exceeded only the 24-hour NAAQS off-site (Table 19, Figure 20 and Figure 21).

A source group contribution analysis indicated that vehicle entrained dust was the main contributor to simulated annual average PM_{10} concentrations (Figure 17). Furthermore, the potential for cumulative off-site PM_{10} concentrations in exceedance of NAAQSs is notable since baseline PM_{10} concentrations are already in exceedance of NAAQSs (Section 3.3.4).

Table 18: Summary of simulation results of PM_{10} at AQSRs

Pollutant	**PM_{10}**					
Averaging Period	1 year			24 hour		
Reporting Unit	Concentration in µg/m^3			Frequency of exceedance in 'days per year'		
Criteria	40 µg/m^3			4 days of exceedance of 75 µg/m^3		
AQSR/Source Group	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**
1	25	0.91	26	**12**	0	**11**
2	15	1.3	17	**5**	0	**5**
3	**82**	0.5	**82**	**123**	0	**123**
4	19	0.88	20	**32**	0	**32**
5	13	0.44	14	**15**	0	**15**
6	3.5	1	4.5	3	0	2
7	1.5	2.2	3.6	2	0	1
8	1.4	2.6	3.9	1	1	0
9	0.82	3.6	4.3	**7**	**7**	0
10	0.78	13	14	2	2	0

Table 19: Summary of simulation results of PM_{10}, with additional mitigation, at AQSRs

Pollutant	**PM_{10} with additional mitigation**					
Averaging Period	1 year			24 hour		
Reporting Unit	Concentration in µg/m³			Frequency of exceedance in 'days per year'		
Criteria	40 µg/m³			4 days of exceedance of 75 µg/m³		
AQSR/Source Group	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**
1	12	0.51	12	1	0	1
2	7.2	0.7	7.9	0	0	0
3	40	0.28	40	**44**	0	**42**
4	8.9	0.5	9.4	**9**	0	**8**
5	7	0.23	7.2	**6**	0	**6**
6	1.6	0.63	2.2	0	0	0
7	0.7	1.2	1.9	0	0	0
8	0.64	1.3	1.9	0	0	0
9	0.38	1.8	2.2	3	2	0
10	0.31	6.5	6.7	0	0	0

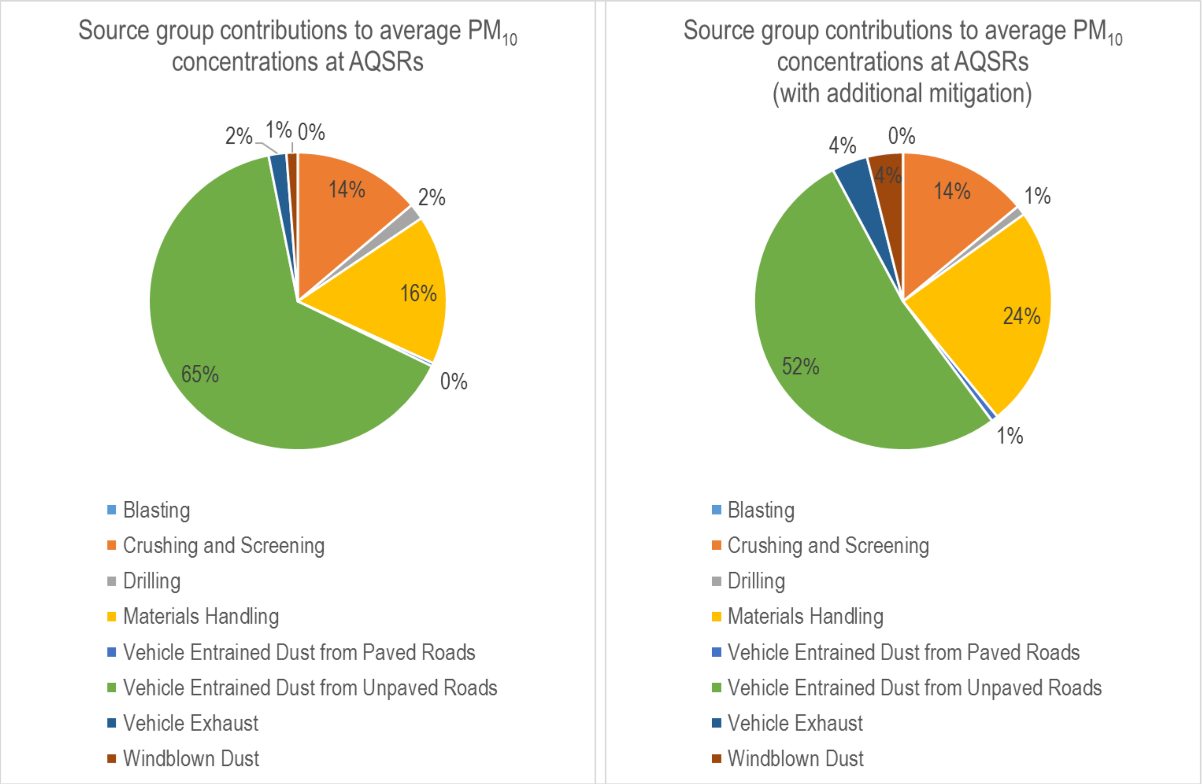


Figure 17: Source group contributions to average PM_{10} concentrations at AQSRs due to activities at Driehoekspan

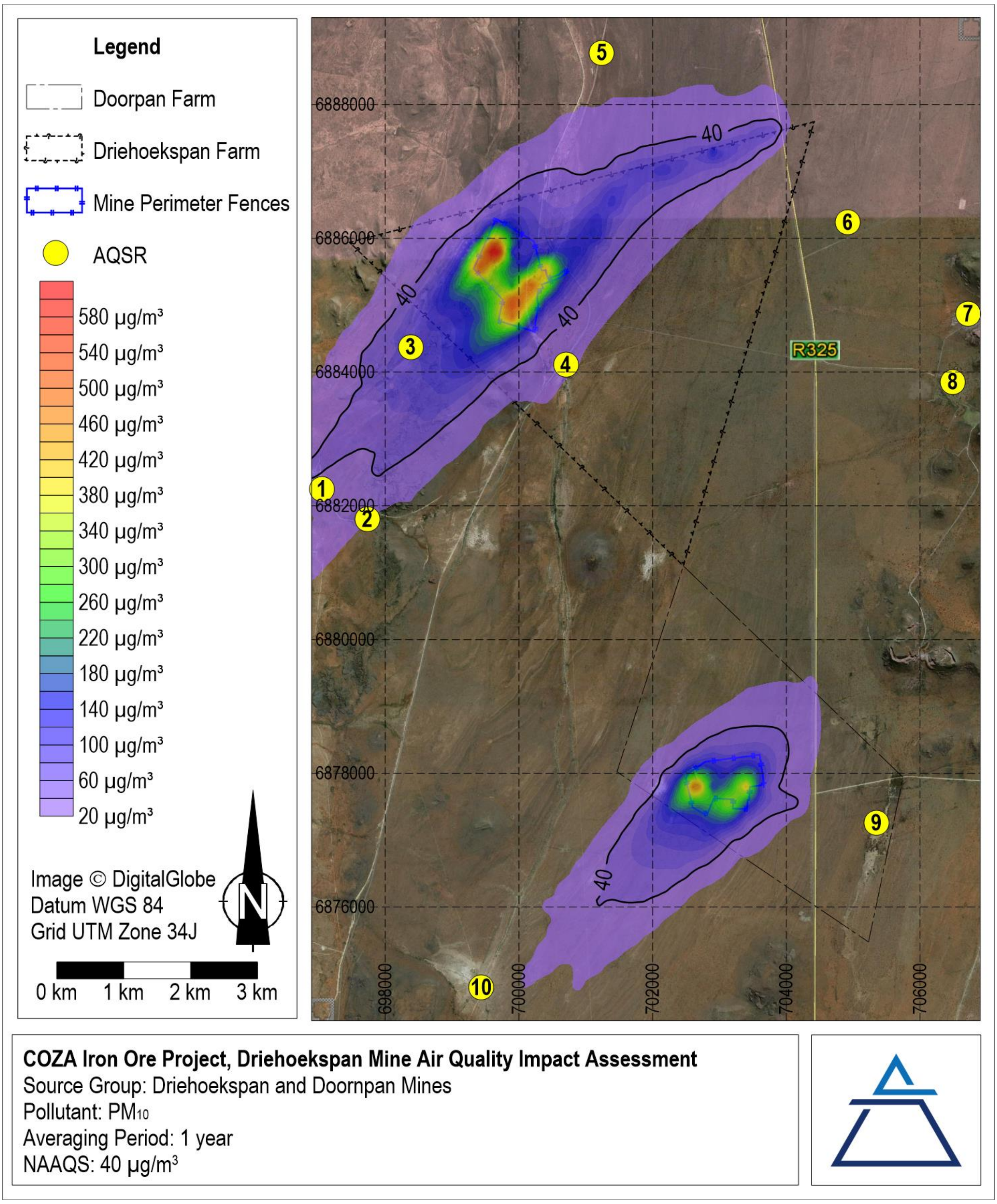


Figure 18: Simulated 1 year average PM_{10} concentrations

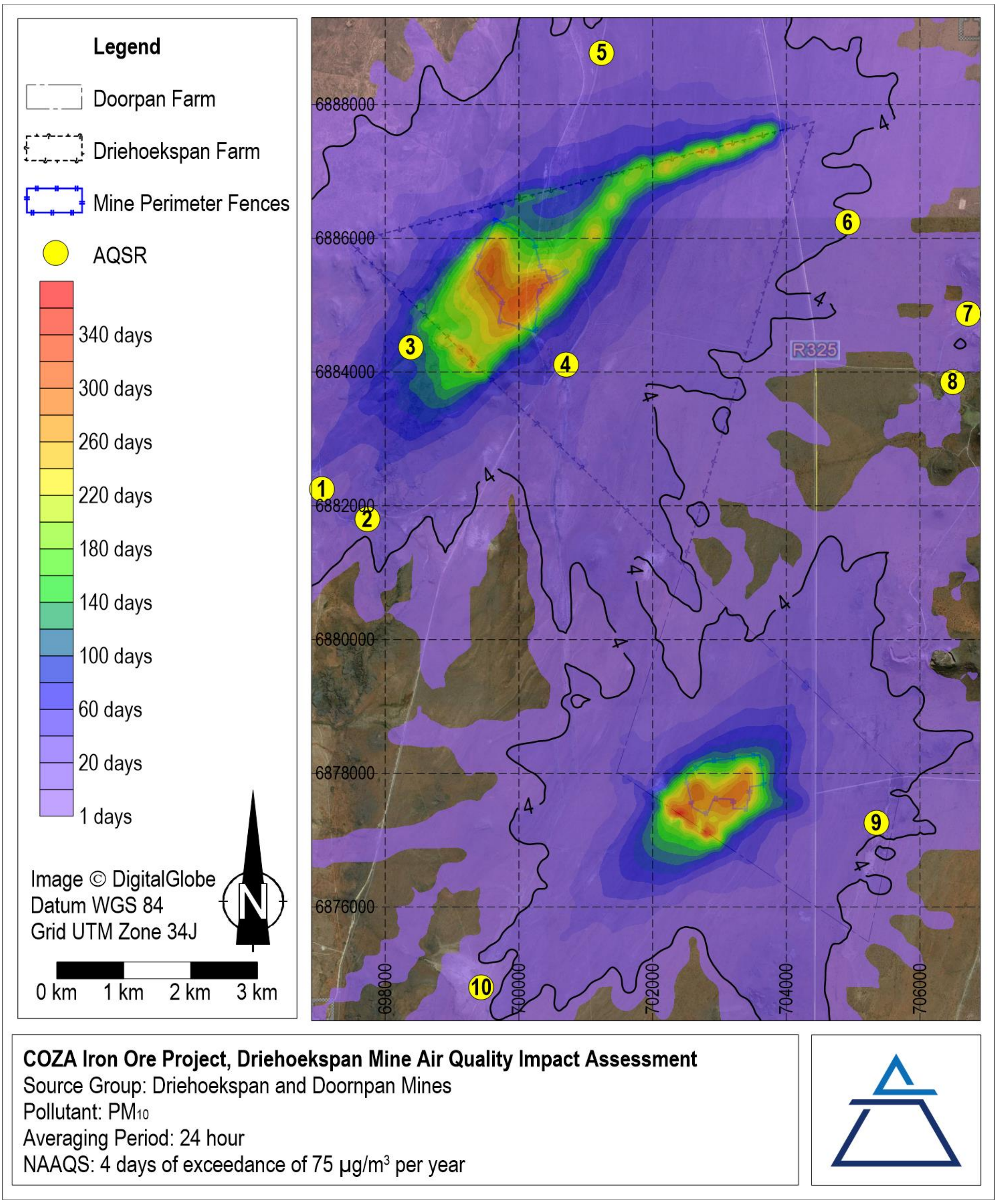


Figure 19: Simulated days of exceedance of the 24 hour average PM_{10} NAAQS limit value (with additional mitigation)

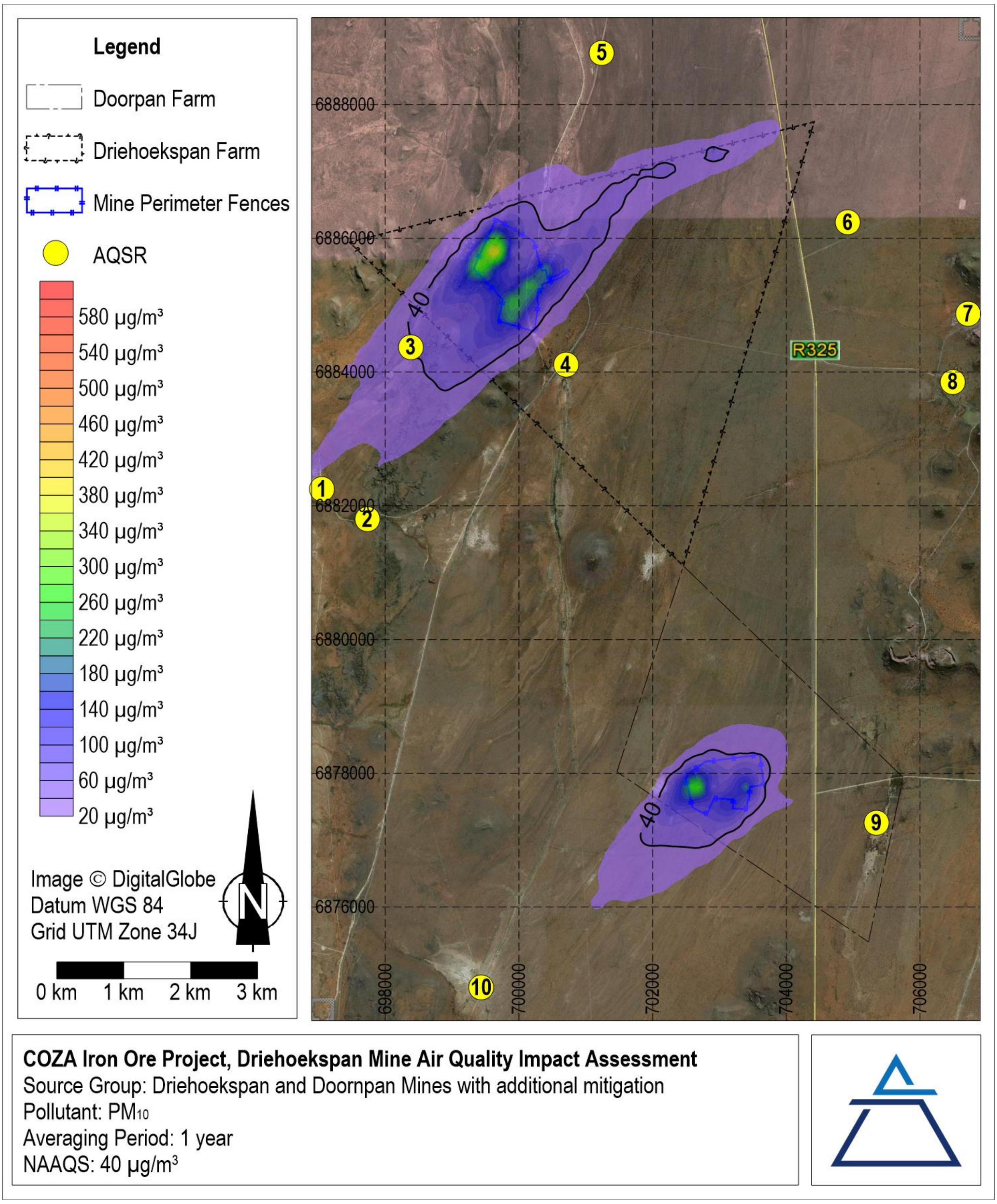


Figure 20: Simulated 1 year average PM_{10} concentrations (with additional mitigation)

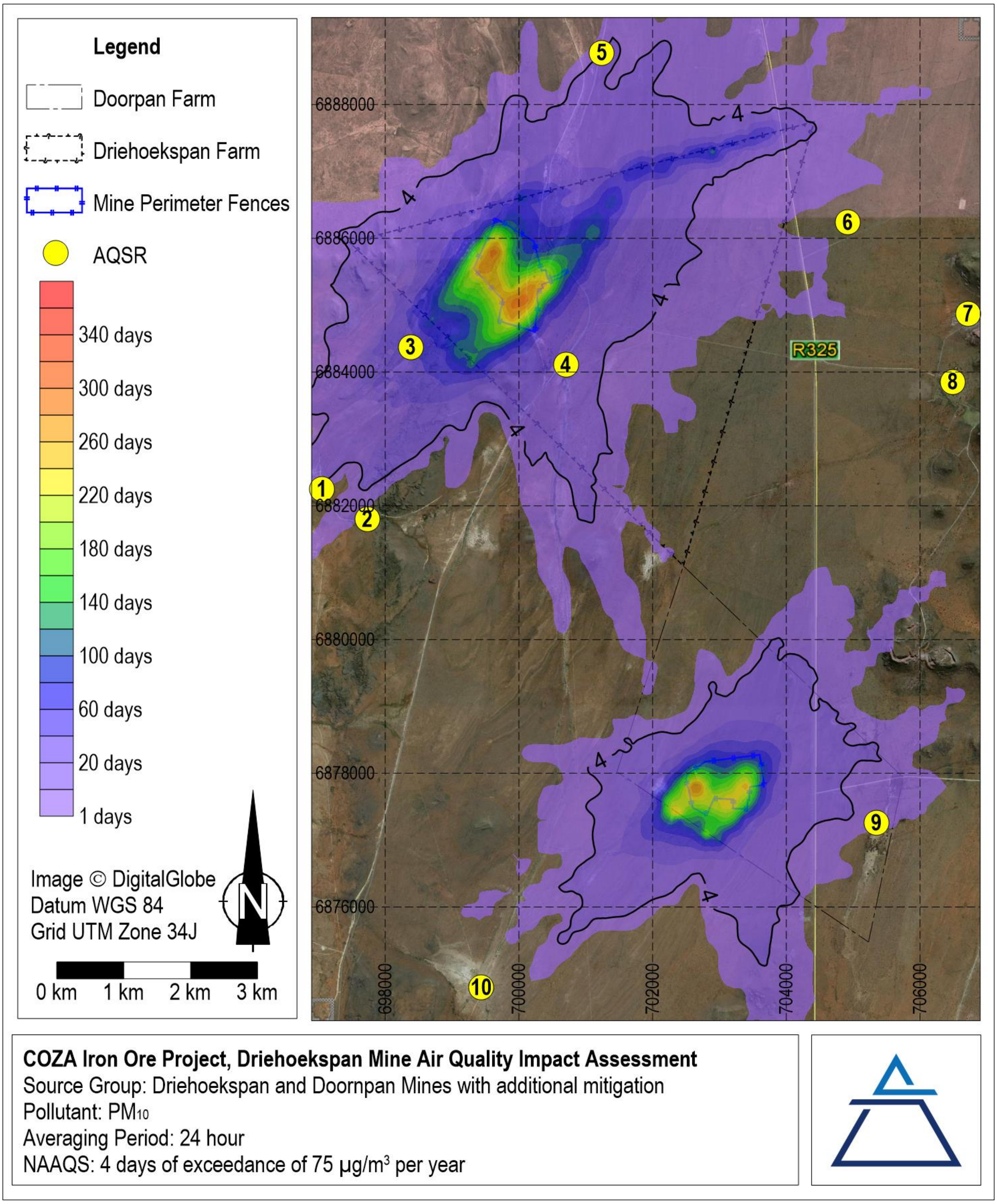


Figure 21: Simulated days of exceedance of the 24 hour average PM_{10} NAAQS limit value (with additional mitigation)

4.4 Analysis of Emissions' Impact on the Environment (Dustfall)

A summary of simulated results for dustfall (without and with additional mitigation) at AQSRs are presented in Table 20. Operational phase activities were found to result in dustfall rates in exceedance of 600 mg/m^2-day, the limit for residential areas, only in very close proximity to areas of disturbance (Figure 23 and Figure 24) and not at any of the AQSRs. In the absence of sampled baseline/pre-development dustfall rates, the potential for cumulative dustfall in exceedance of NDCR could not be gauged.

A source group contribution analysis indicated that vehicle entrained dust and crushing & screening were the main contributors to simulated dustfall rates (Figure 22).

Table 20: Summary of simulation results of dustfall, without and with additional mitigation, at AQSRs

Pollutant	**TSP**			**TSP (with additional mitigation)**		
Averaging Period	1 month (simulation)			1 month (simulation)		
Reporting Unit	Dustfall rate in mg/m^2-day			Dustfall rate in mg/m^2-day		
Criteria	600 mg/m^2-day in residential areas			600 mg/m^2-day in residential areas		
AQSR/Source Group	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**	**Driehoekspan**	**Doornpan**	**Driehoekspan and Doornpan**
1	9	0.34	9.1	0.38	0.35	0.73
2	10	0.43	10	0.39	0.38	0.77
3	26	0.25	26	0.37	0.42	0.8
4	16	0.34	16	0.34	0.5	0.84
5	8	0.17	8.1	0.3	0.63	0.93
6	3.3	0.62	4	0.25	0.74	0.99
7	1.1	1.3	2.1	0.21	0.83	1
8	0.83	1.6	2.3	0.17	0.97	1.1
9	0.58	6	6.2	0.13	1.2	1.3
10	0.38	3.1	3.3	0.11	1.5	1.6

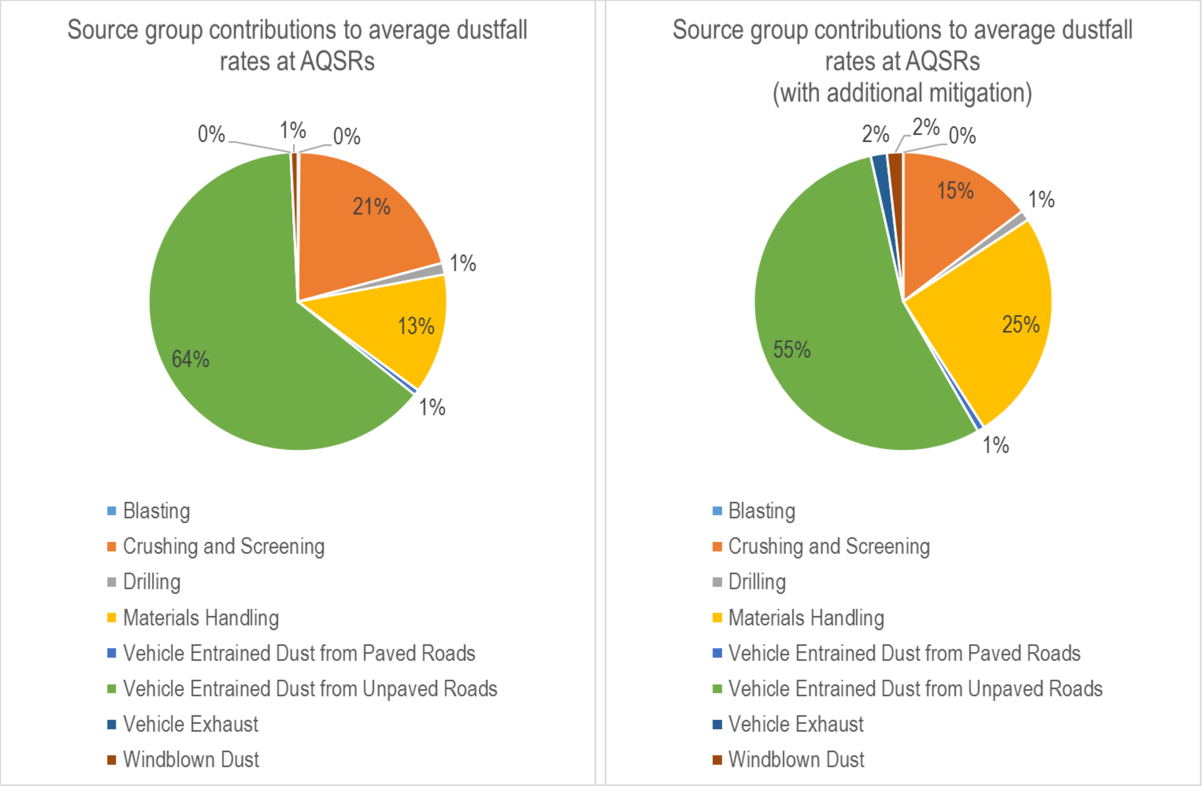


Figure 22: Source group contributions to average dustfall rates at AQSRs due to activities at Driehoekspan

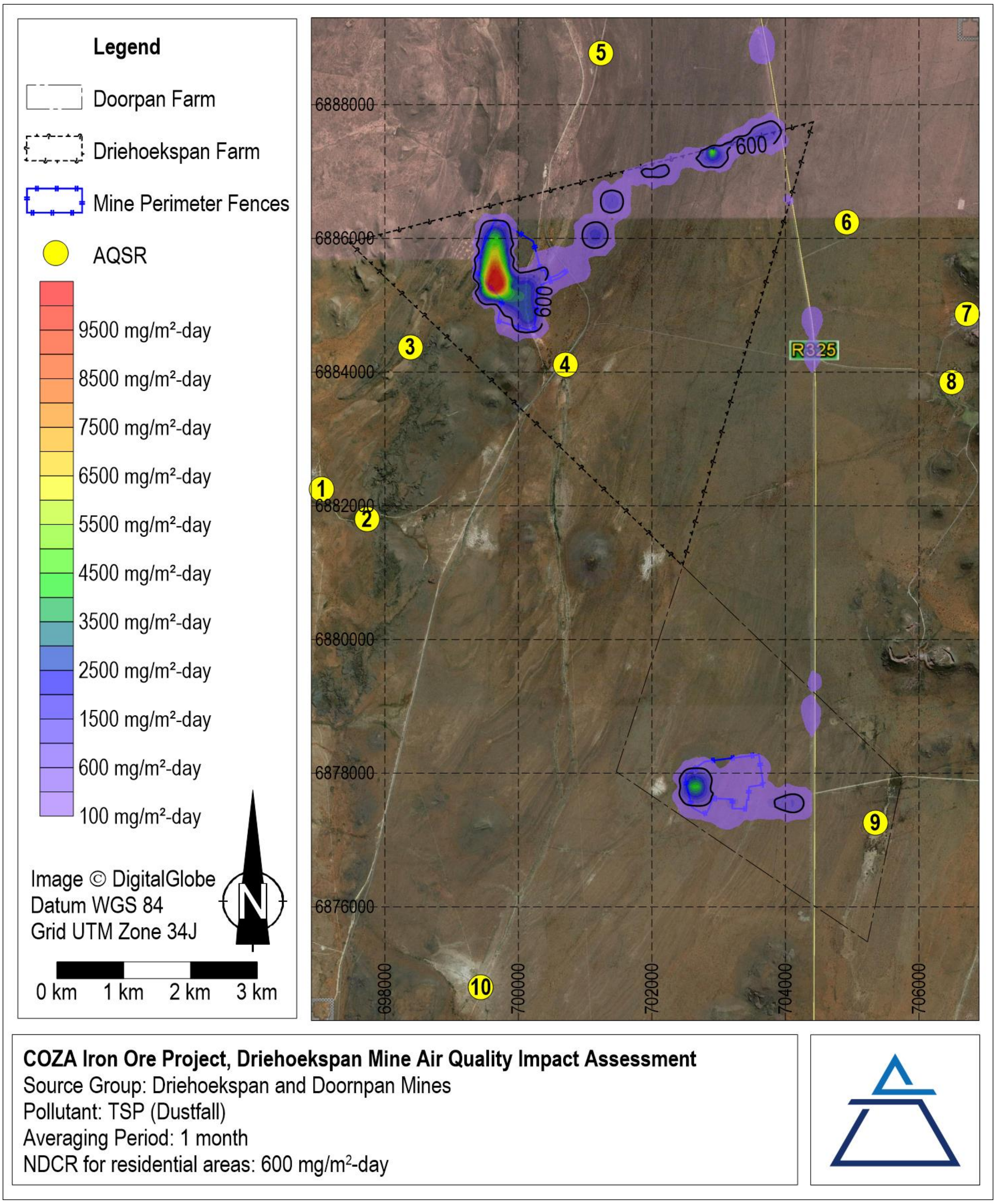


Figure 23: Simulated dustfall rates

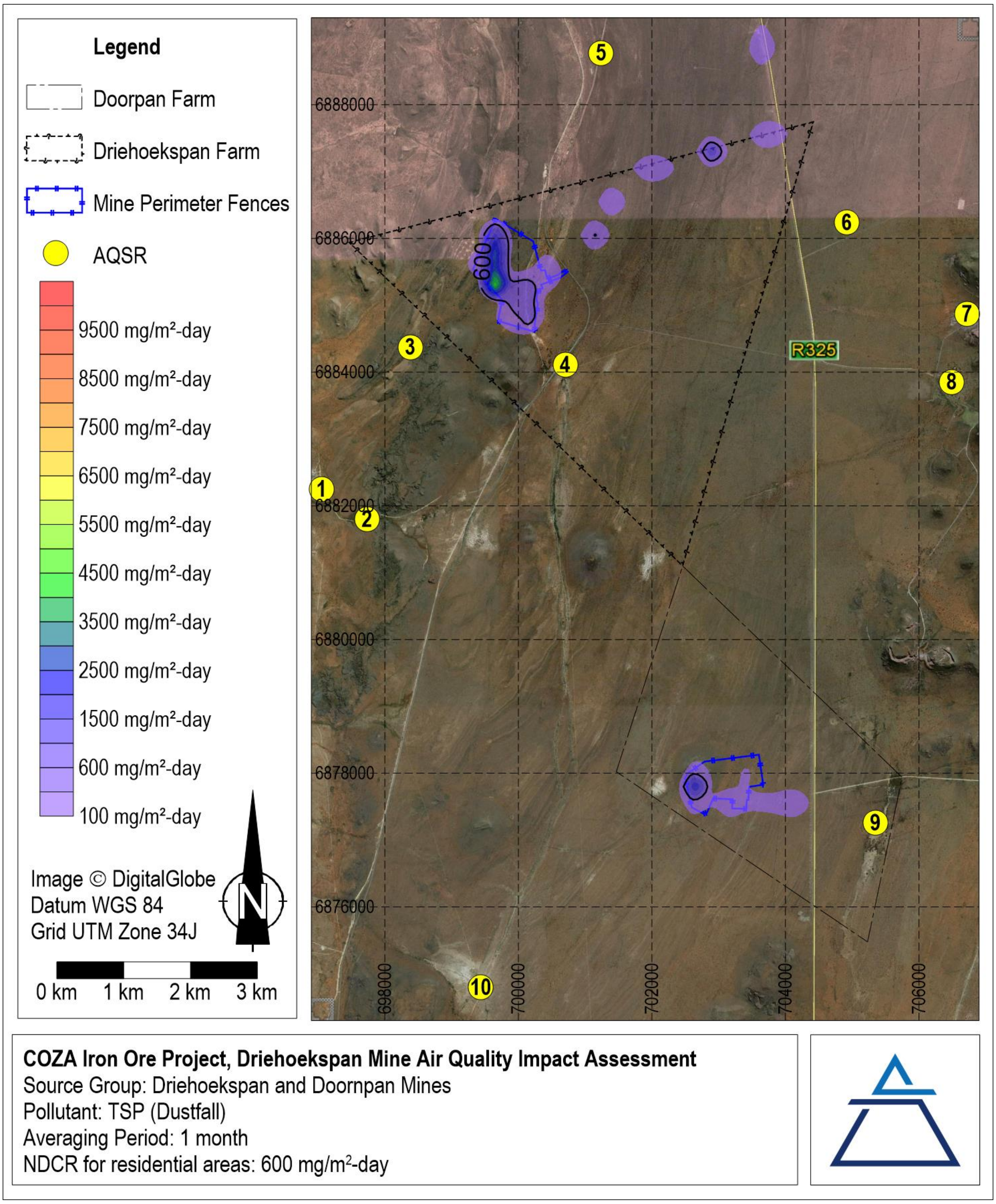


Figure 24: Simulated dustfall rates (with additional mitigation)

4.5 Assessment of Site Alternatives

No alternatives were considered in this assessment.

5 MAIN FINDINGS

An air quality impact assessment was conducted for the proposed activities at Driehoekspan which forms part of the COZA Iron Ore Project in addition to Doornpan activities. The main objective of this study was to establish baseline/pre-development air quality in the study area and to quantify the extent to which ambient pollutant levels will change as a result of the project. The baseline and impact study then informed the air quality management and mitigation measures recommended as part of the Air Quality Management Plan (AQMP). This section summarises the main findings of the baseline and impact assessments.

The main findings of the baseline/pre-development assessment are:

- The area is dominated by winds from the north-north-east. Frequent winds also occur from the western sector but mostly during the day. Long term air quality impacts are therefore expected to the most significant to the south-south-west of operations.
- The main sources likely to contribute to baseline PM concentrations include vehicle entrained dust from local roads, mining and windblown dust from exposed areas.
- Ambient air quality monitoring near Postmasburg indicated:
    - Low NO_2, SO_2 and $PM_{2.5}$ concentrations that are within NAAQS;
    - Elevated PM_{10} concentrations in exceedance of NAAQS.
- Baseline dustfall data was not available for inclusion in the study.
- The nearest communities to the proposed operations include scattered farm residences/buildings. AQSR most likely to be affected by Driehoekspan activities include a farmstead on the Driehoekspan farm and one located less than 500 m directly downwind (to the south-west) of the Driehoekspan farm boundary.

The main findings of the impact assessment are as follows:

- PM and gaseous emissions will be released during the construction, operational and closure phases of the project. Only the operational phase air quality impacts were quantified since construction and decommissioning phase impacts will be highly variable but less significant than operational phase impacts.
- Operational phase PM emissions ($PM_{2.5}$, PM_{10} and TSP) and gaseous emissions (CO, DE, NO_x, SO_2 and VOC) were quantified.
- Due to low emission rates, CO, SO_2 and VOC concentrations were not simulated and impacts expected to be immaterial.
- PM_{10} emissions were found to result in the most notable air quality impacts, especially when only partially mitigated.
- Simulated PM_{10} concentrations exceeded the NAAQS off-site and at several AQSRs. Additional mitigation measures have been shown to reduce concentrations to levels that exceeded only the 24-hour NAAQS off-site and three of the nearby AQSRs.
- A source group contribution analysis indicated that vehicle entrained dust and crushing and screening are the main contributors to simulated average PM_{10} concentrations at AQSRs.
- Cumulative off-site PM_{10} concentrations in exceedance of NAAQSs are likely since baseline PM_{10} concentrations are already in exceedance of NAAQSs.
- 1-hour NO_2 concentrations were found to exceed the NAAQS over a small area to the south-west boundary of the mine rights area but not at any AQSRs.
- Low baseline NO_2 concentrations make cumulative impacts unlikely.
- Simulated dustfall rates and DE concentrations were found to be low, very localised and within selected air quality criteria outside the mine rights area.

- Excess lifetime cancer risk associated with DE exposure is considered low.

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

- The mitigation of sources of emission;
- The management of associated air quality impacts; and
- Ambient air quality monitoring.

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

6 RECOMMENDED AIR QUALITY MANAGEMENT MEASURES

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

6.1 Air Quality Management Objectives

The main objective of the proposed air quality management measures for the project is to ensure that operations at Driehoekspan as well as Doornpan cumulatively result in ambient air concentrations that are within the relevant ambient air quality criteria off-site. In order to define site specific management objectives, the main sources of pollution needed to be identified. Sources area ranked based on source strengths (emissions) and impacts (concentrations). Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

The ranking of sources serves to confirm the current understanding of the significance of specific sources, and to evaluate the emission reduction potentials required for each. Sources of emissions at the proposed Driehoekspan operations are ranked based on:

- Emissions; based on the comprehensive emissions inventory established for the operations, and,
- Impacts; based on the predicted dustfall levels and particulate concentrations.

6.1.1 Ranking of Sources by Emissions

Sources of **particulate matter emissions** are ranked as follows from most to least significant:

1. Vehicle entrained dust from unpaved roads
2. Crushing and screening
3. Materials handling
4. Vehicle exhaust
5. Drilling
6. Blasting

6.1.2 Ranking of Sources by Impact

Sources of **particulate matter impacts** are ranked as follows from most to least significant:

1. Vehicle entrained dust from unpaved roads
2. Crushing and screening
3. Materials handling
4. Vehicle exhaust
5. Drilling
6. Blasting

6.1.3 Conclusion with Regards to Source Ranking

From the preceding it can be concluded that measures aimed at reducing emissions from unpaved roads and crushing and screening must be considered to most significantly reduce impacts on the environment. In the following section, source specific management and mitigation measures are recommended specifically for unpaved roads as well as crushing and screening. Other sources of emission are also addressed.

6.1.4 Source Specific Management and Mitigation Measures

6.1.4.1 Dust Control Options for Unpaved Roads

Three types of measures may be taken to reduce emissions from unpaved roads:

- Measures aimed at reducing the extent of unpaved roads, e.g. paving;
- Traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds; and
- Measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilization (Cowherd, et al., 1988).

The main dust generating factors on unpaved road surfaces include:

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

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

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

Chemical suppressant has been proven to be affective due to the binding of fine particulates in the road surface, hence increasing the density of the surface material. In addition, dust control additives are beneficial in the fact that it also improves the compaction and stability of the road. The effectiveness of a dust palliative includes numerous factors such as the application rate, method of application, moisture content of the surface material during application, palliative concentrations, mineralogy of aggregate and environmental conditions. Thus, for different climates and conditions you need different chemicals, one chemical might not be as effective as another under the same conditions and each product comes with various advantages and limitations of each own. In general, chemical suppressants are given to achieve a PM_{10} control efficiency of 80% when applied regularly on the road surfaces (Stevenson, 2004).

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

Spillage and track-on from the surrounding unpaved areas may result in the deposition of materials onto the chemically treated or watered road resulting in the need for periodic "housekeeping" activities (Cowherd, et al., 1988). In addition, the gradual abrasion of the chemically treated surface by traffic will result in loose material on the surface which would have to be controlled. The minimum frequency for the reapplication of watering or chemical stabilizers thus depends not only on the control efficiency of the suppressant but also on the degree of spillage and track-on from adjacent areas, and the rate at which the treated surface is abraded. The best way to avoid dust generating problems from unpaved roads is to properly maintain the surface by grading and shaping for cross sectional crowing to prevent dust generation caused by excessive road surface wear (Stevenson, 2004).

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

6.1.4.2 Crushing and Screening Operations

Enclosure of crushing operations is very effective in reducing dust. The ADE NPI (NPI, 2011) indicates that a telescopic chute with water sprays would ensure 75% control efficiency and enclosure of storage piles where tipping occur would reduce the emissions by 99%. In addition, chemical suppressants or water sprays on the primary crusher and dry dust extraction units with wet scrubbers on the secondary and tertiary crushers and screens will assist in the reduction of the cumulative dust impacts. According to the Australian NPI, water sprays can have up to 50% control efficiency and hoods with scrubbers up to 75%. If in addition, the scrubbers and screens were to be enclosed; up to 100% control efficiency can be achieved. Hooding with fabric filters can result in control efficiencies of 83%. It is important that these control equipment be maintained and inspected on a regular basis to ensure that the expected control efficiencies are met (NPI, 2011).

It is recommended that a method with at least 75% control efficiency be selected for the crusher plant.

6.1.4.3 Materials Handling Dust Control Options

Control techniques applicable to materials handling are generally classifiable as source extent reduction, source improvement related to work practices and transfer equipment, and surface treatment. These control options may be summarised as follows:

- Source extent reduction:
    - Mass transfer reduction
- Source improvement:

    - Drop height reduction
    - Wind sheltering
    - Moisture retention
- Surface treatment:
    - Wet suppression
    - Air atomising suppression

The efficiency of these controls may be estimated through the relationships between climatic parameters, material properties and quantities of material transferred demonstrated in the predictive emission factor equation.

Good operational practices frequently represent the **most cost effective and efficient means** of reducing emissions. The variation of the height from which stacking occurs to suit the height of the storage pile would limit drop heights and therefore reduce the potential for the entrainment of fines by the wind.

Wet suppression systems use either liquid sprays or foam to suppress the formation of airborne dust. Emissions are prevented through agglomerate formation by combining fine particulates with larger aggregate or with liquid droplets. The key factors which affect the extent of agglomeration and therefore the efficiency of the system are the coverage of the material by the liquid and the ability of the liquid to "wet' small particles. The only wet suppression systems considered in this section is liquid sprays.

Liquid spray suppression systems may use only water or a combination of water and a chemical surfactant as the wetting agent. Surfactants reduce the surface tension of the water thus allowing particles to more easily penetrate the water particle and reducing the quantity of water needed to achieve the control efficiency required. General engineering guidelines which have been shown to be effective in improving the control efficiency of liquid spray systems are as follows:

- of the various nozzle types, the use of hollow cone nozzles tends to afford the greatest control for bulk materials handling applications whilst minimising clogging;
- optimal droplet size for surface impaction and fine particle agglomeration is about 500 µm; finer droplets are affected by drift and surface tension and appear to be less effective; and,
- application of water sprays to the underside of conveyor belts have been noted by various studies to improve the efficiency of water suppression systems and belt-to-belt transfer points.

The control efficiency of pure water suppression can be estimated based on the US EPA emission factor which relates material moisture content to control efficiency. This relationship is illustrated in Figure 25.

It is important to note that the improvements in dust control efficiencies are marginal following increases in material moisture contents by 400%. To obtain control efficiencies of greater than 90%, it would be more feasible and cost effective to consider either alternative systems (e.g. foam suppression) or supplementary methods (e.g. addition of chemical surfactants to water).

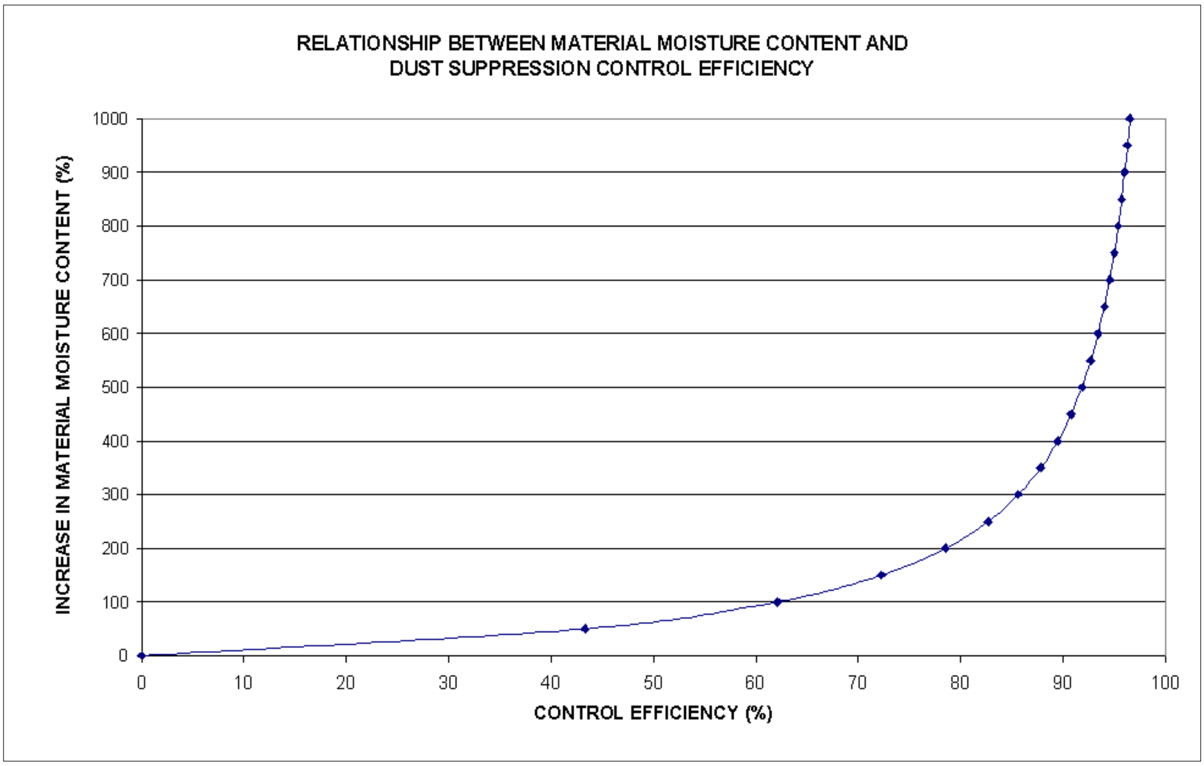


Figure 25: Relationship between the moisture content and the dust control efficiency

Wind sheltering techniques are widely applied for dust minimization during stacking and loading operations, particularly in cases where the application of wet suppression is not a viable alternative. The application of transfer chutes represents one of the most common of such wind sheltering methods.

Transfer chutes can be used at belt-to-belt transfer points. Chutes provide the potential for dust control due to wind sheltering, and prevention of spillages, which could give rise to dust emissions through wind or vehicle entrainment. Spillage, material degradation, conveyor belt damage, blockage and high maintenance costs have been noted as commonly re-occurring problems at transfer chute operating sites. Considerable improvements on conventional transfer chute design over the past few years have, however, resulting in solutions to many of these problems.

As an example, the South African developed Weba Chute is reported by its developer, M & J Engineering (Pty) Ltd, to have been installed in dolomite, iron ore, coal, manganese, kimberlite, phosphate and agricultural product operations. This transfer chute technology is described as being able to be applied in transfer of lumpy, sticky, and slightly wet materials. Spillage avoidance, dust minimization and noise abatement represent the main environmental benefits of the Weba Chute. Examples of Weba chutes are given in Figure 26.

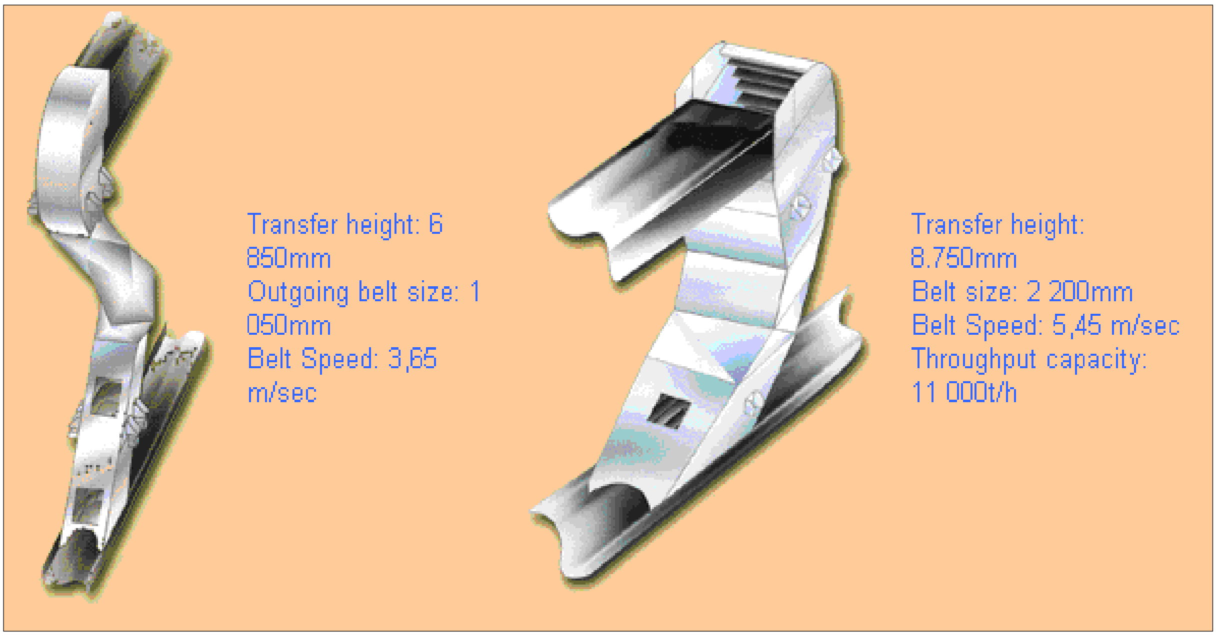


Figure 26: Examples of Weba chutes, developed by M & J Engineering (M&J Engineering, 2011)

Significant developments have been made in the field of air atomising spray systems. These systems use water and compressed air to produce micron sized droplets that are able to suppress respirable dust without adding any detectable moisture to the process. As such, such systems may be suitable for implementation at transfer points beyond the sampling plant. No information could be obtained on the control efficiency of such spray systems.

6.1.4.4 Options for Reducing Windblown Dust Emissions

As for materials handling, the main techniques adopted to reduce windblown dust potential include source extent reduction, source improvement and surface treatment methods:

- Source extent reduction:
    - Disturbed area reduction.
    - Disturbance frequency reduction.
    - Dust spillage prevention and/or removal.
- Source Improvement:
    - Disturbed area wind exposure reduction, e.g. wind fences and enclosure of source areas.
- Surface Treatment:
    - Wet suppression
    - Chemical stabilisation
    - Covering of surface with less erodible aggregate material
    - Vegetation of open areas

The suitability of the dust control techniques indicated will depend on the specific source to be addressed, and will vary between dust spillage, material storage and open areas. The NPI recommends the following methods for reducing windblown dust:

- Primary rehabilitation - 30%
- Vegetation established but not demonstrated to be self-sustaining. Weed control and grazing control - 40%
- Secondary rehabilitation - 60%

- Re-vegetation - 90%
- Fully rehabilitated (release) vegetation - 100%

Stockpiles and waste rock dumps at Doornpan would not likely generate windblown dust. Efforts should however be made to minimise areas of disturbance where surface soils may be entrained under strong wind conditions.

6.1.4.5 Options for Reducing Vehicle Exhaust Emissions

Diesel emission reduction technologies, some of which may also be applicable to petrol engines, will generally increase or decrease the substance emissions (NPI, 2008). These technologies are categorised according to:

- Fuel modifications;
- Engine modifications; and
- After-exhaust treatment.

For the project, regular maintenance and emission testing is recommended on all mobile and stationary diesel combustion sources. Use should also be made of low sulphur fuel.

6.1.4.6 Drilling

It is recommended that water sprays applied at all operational drill rigs. According to the NPI, a 70% reduction in dust is achievable with water sprays (NPI, 2011).

6.2 Performance Indicators

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

Performance indicators are usually selected to reflect both the source of the emission directly (source monitoring) and the impact on the receiving environment (ambient air quality monitoring). Ensuring that no visible evidence of wind erosion exists represents an example of a source-based indicator, whereas maintaining off-site dustfall levels to below 600 mg/m²-day represents an impact- or receptor-based performance indicator.

Except for vehicle/equipment emission testing, source monitoring at opencast mining activities can be challenging due to the fugitive and wind-dependant nature of particulate emissions. The focus is therefore rather on receptor based performance indicators i.e. compliance with ambient air quality standards and dustfall regulations. It is recommended that NAAQS listed in Table 1 and dustfall regulations in Table 4, be adopted by COZA Iron Ore as receptor-based objectives.

6.2.1 Source Monitoring

It is recommended that exhaust emissions testing be done on all mobile and stationary diesel combustion sources as part of equipment maintenance schedules.

6.2.2 Ambient Air Quality Monitoring

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

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

It is recommended that, as a minimum, continuous dustfall, PM_{10} and $PM_{2.5}$ sampling be conducted as part of the project's air quality management plan. Recommended sampling locations are shown in Figure 27. These locations were selected for the reasons given in Table 21.

Table 21: Sampling locations and parameters

No.	Description	Parameter to be Sampled	Reasoning
1	South western farm boundary location	Dustfall, PM_{10} and $PM_{2.5}$	Downwind of operations in area of simulated maximum impact near the most affected AQSR
2	SW operational location	Dustfall	On SW operational fence line, downwind of activities
3	NW operational location	Dustfall	On NW operational fence line
4	NE operational location	Dustfall	On NE operational fence line
5	SE operational location	Dustfall	On SE operational fence line, near topsoil storage area
7	Access road location	Dustfall	Along access road on farm boundary

The following cost effective sampling methods are recommended:

- For dustfall, the NDCR specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be ASTM D1739 (1970), or equivalent method approved by any internationally recognized body.
- For PM_{10} and $PM_{2.5}$ the method as set out by British Standards (BS EN 12341) is recommended.

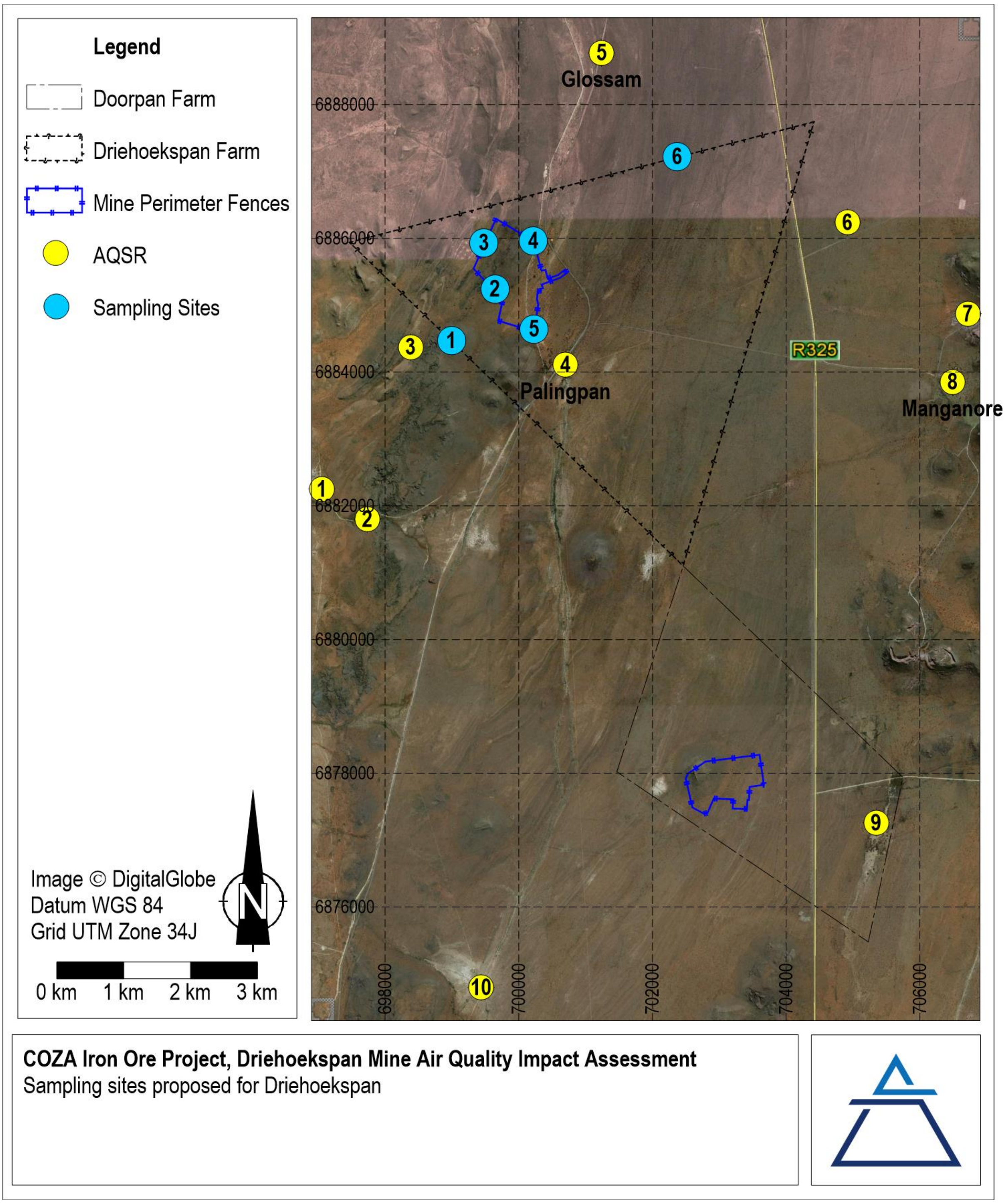


Figure 27: Recommended sampling locations

6.2.2.1 Dustfall Sampling

The ASTM method covers the procedure of collection of dustfall and its measurement and employs a simple device consisting of a cylindrical container (not less than 150 mm in diameter) exposed for one calendar month (30 ±2 days). Even though the method provides for a dry bucket, de-ionised (distilled) water can be added to ensure the dust remains trapped in the bucket.

The bucket stand includes wind shield at the level of the rim of the bucket to provide an aerodynamic shield. The bucket holder is connected to a 2 m galvanized steel pole, which is either planted and cemented or directly attached to a fence post (Figure 28). This allows for a variety of placement options for the fallout samplers. Two buckets are usually provided for each dust bucket stand. Thus, after the first month, the buckets get exchanged with the second set.

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

6.2.2.2 PM10/PM2.5 Sampling

Ambient PM_{10}/$PM_{2.5}$ concentrations can be determined through the use a MiniVol sampler (Figure 29). In summary, the monitoring methodology is as follows:

- The MiniVol sampler is programmed to draw air over a pre-weighed filter at a constant rate over a 24-hour period.
- At an interval of 1 in 2 days or 1 in 3 days, the used filter is removed, a new filter put in place, the battery exchanged (each MiniVol is equipped with two batteries) and the MiniVol re-programmed.
- The used filter is removed from the filter holder assembly in a clean environment and sealed in its dish.
- At each exchange, the date, location, filter number, pump run time etc. need to be noted in the data sheet that will be sent to the laboratory with the sealed samples for analysis.

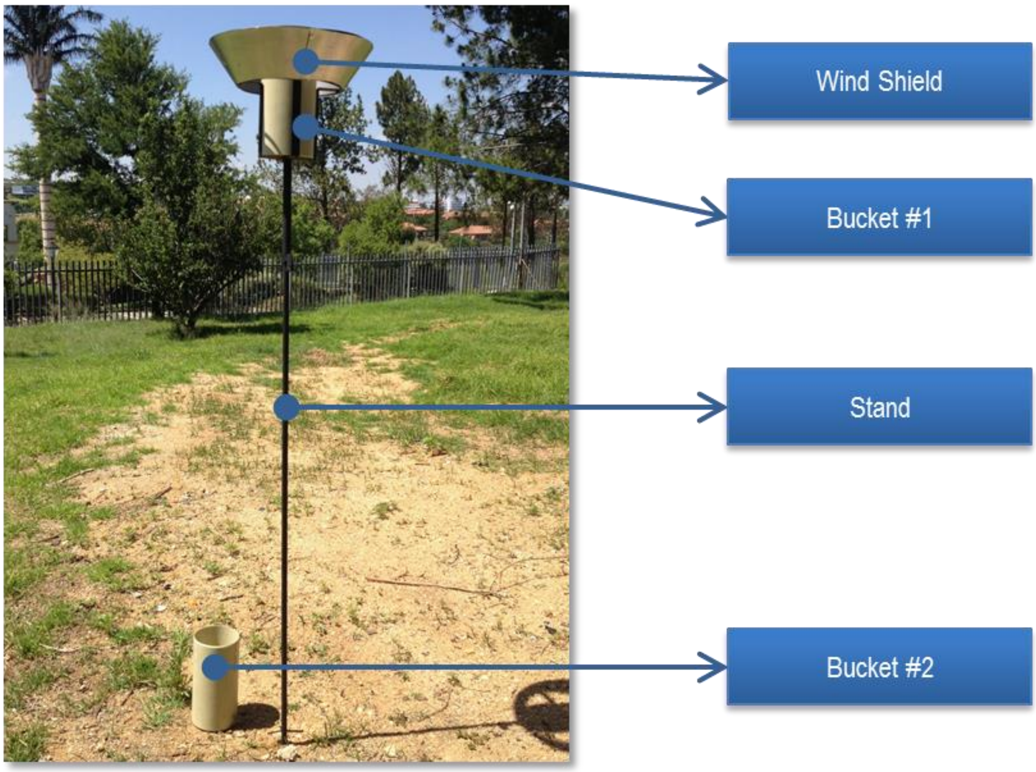


Figure 28: Dustfall collection unit example

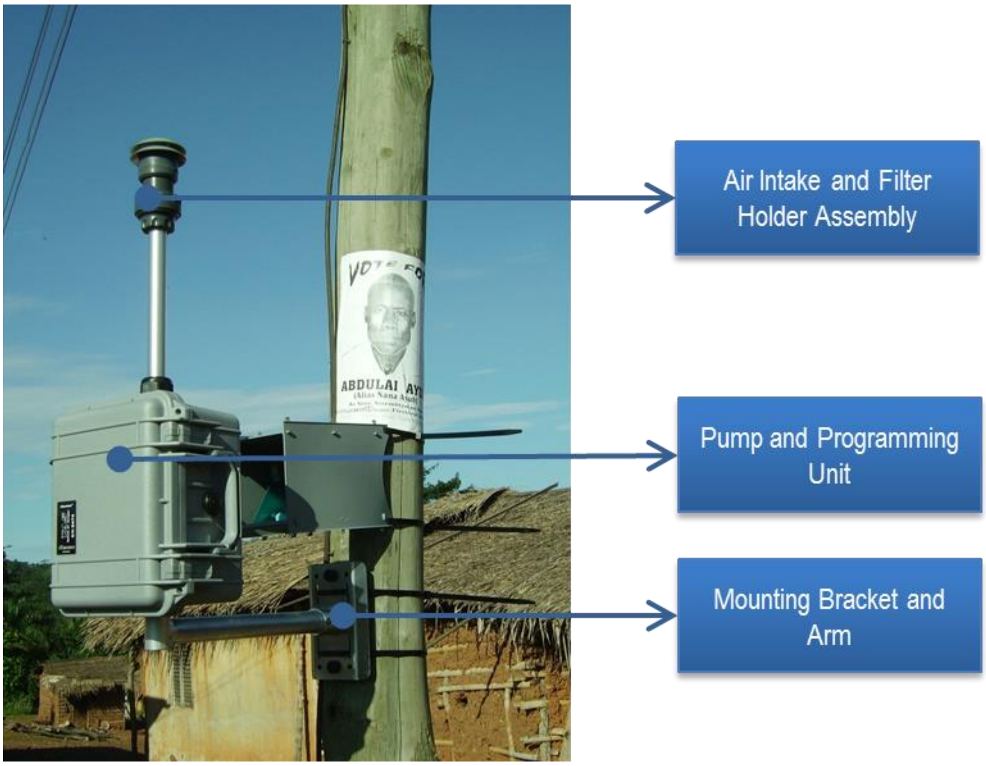


Figure 29: Example of typical PM_{10} MiniVol setup

6.3 Record-keeping, Environmental Reporting and Community Liaison

6.3.1 Periodic Inspections and Audits

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

The criteria to be taken into account in the inspections and audits must be made transparent by way of minimum requirement checklists included in the management plan. Corrective action or the implementation of contingency measures must be proposed to the stakeholder forum in the event that progress towards targets is indicated by the quarterly/annual reviews to be unsatisfactory.

6.3.2 Liaison Strategy for Communication with I&APs

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

6.3.3 Financial Provision

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

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8 ANNEX A – SPECIALIST'S CURRICULUM VITAE

CURRICULUM VITAE

Name	Nicolette von Reiche (nee Krause)
Date of Birth	22 October 1982
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Principal Consultant and Project Manager
Profession	Mechanical Engineer employed as a Air Quality and Environmental Noise Assessment Consultant
Years with Firm	9 Years

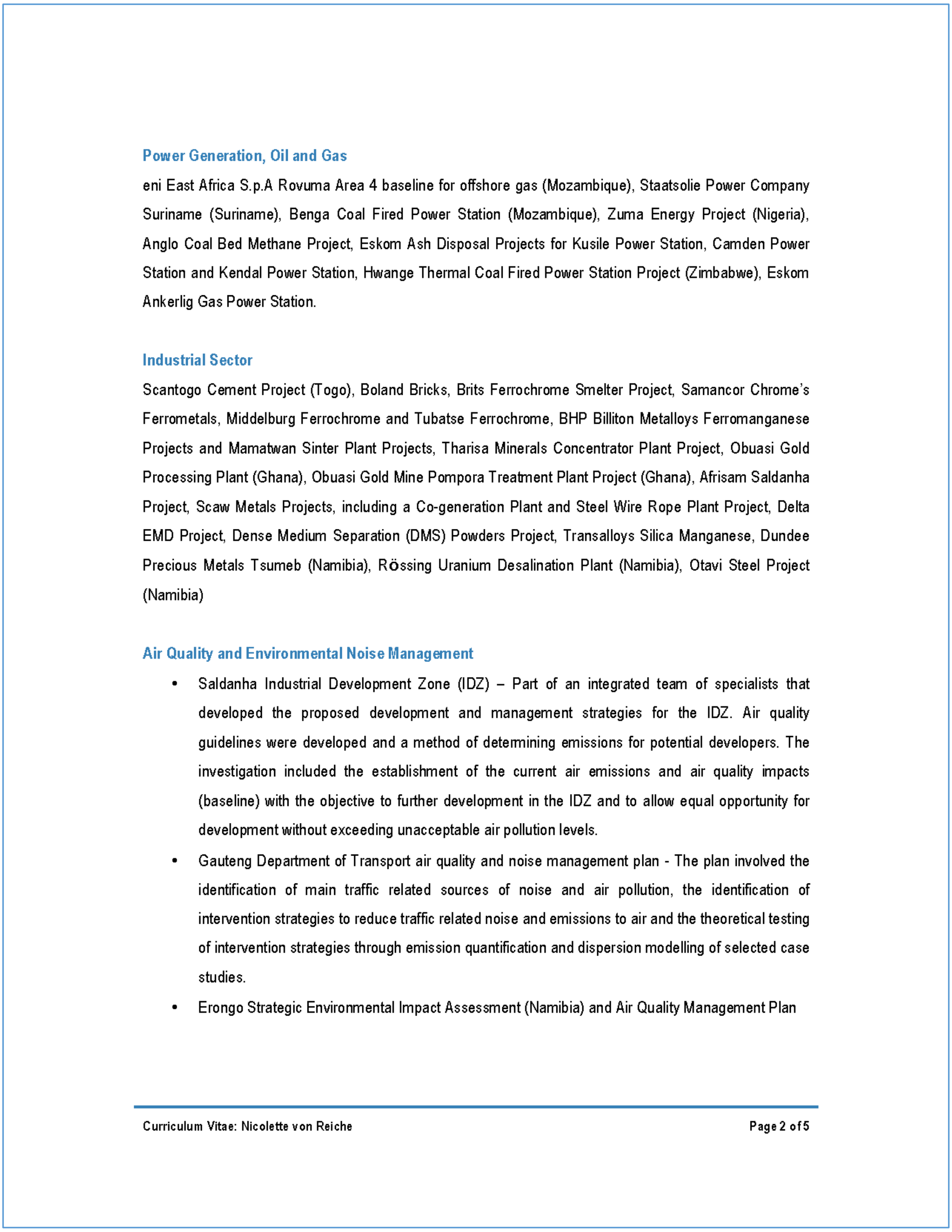
MEMBERSHIP OF PROFESSIONAL SOCIETIES

- South African Acoustic Institute (SAAI), 2006 to present
- National Association for Clean Air (NACA), 2006 to present
- International Institute for Acoustics and Vibration (IIAV), 2014 to present

EXPERIENCE

Nicolette has over nine years of experience in both air quality and noise impact assessment and management. She is an employee of Airshed Planning Professionals (Pty) Ltd and is involved in the compilation of emission inventories, atmospheric dispersion modelling, air pollution mitigation and management, and air pollution impact work. Airshed Planning Professionals is affiliated with Francois Malherbe Acoustic Consulting cc and in assisting with numerous projects she has gained experience in environmental noise measurement, modelling and assessment as well.

A list of projects competed in various sectors is given below:



Power Generation, Oil and Gas

eni East Africa S.p.A Rovuma Area 4 baseline for offshore gas (Mozambique), Staatsolie Power Company Suriname (Suriname), Benga Coal Fired Power Station (Mozambique), Zuma Energy Project (Nigeria), Anglo Coal Bed Methane Project, Eskom Ash Disposal Projects for Kusile Power Station, Camden Power Station and Kendal Power Station, Hwange Thermal Coal Fired Power Station Project (Zimbabwe), Eskom Ankerlig Gas Power Station.

Industrial Sector

Scantogo Cement Project (Togo), Boland Bricks, Brits Ferrochrome Smelter Project, Samancor Chrome's Ferrometals, Middelburg Ferrochrome and Tubatse Ferrochrome, BHP Billiton Metalloys Ferromanganese Projects and Mamatwan Sinter Plant Projects, Tharisa Minerals Concentrator Plant Project, Obuasi Gold Processing Plant (Ghana), Obuasi Gold Mine Pompora Treatment Plant Project (Ghana), Afrisam Saldanha Project, Scaw Metals Projects, including a Co-generation Plant and Steel Wire Rope Plant Project, Delta EMD Project, Dense Medium Separation (DMS) Powders Project, Transalloys Silica Manganese, Dundee Precious Metals Tsumeb (Namibia), Rössing Uranium Desalination Plant (Namibia), Otavi Steel Project (Namibia)

Air Quality and Environmental Noise Management

- Saldanha Industrial Development Zone (IDZ) – Part of an integrated team of specialists that developed the proposed development and management strategies for the IDZ. Air quality guidelines were developed and a method of determining emissions for potential developers. The investigation included the establishment of the current air emissions and air quality impacts (baseline) with the objective to further development in the IDZ and to allow equal opportunity for development without exceeding unacceptable air pollution levels.
- Gauteng Department of Transport air quality and noise management plan - The plan involved the identification of main traffic related sources of noise and air pollution, the identification of intervention strategies to reduce traffic related noise and emissions to air and the theoretical testing of intervention strategies through emission quantification and dispersion modelling of selected case studies.
- Erongo Strategic Environmental Impact Assessment (Namibia) and Air Quality Management Plan

Mining Sector

- **Coal mining:** Elders Colliery, Grootgeluk Colliery, Inyanda Colliery, Boschmanspoort Colliery, Benga Mine (Mozambique), Vangatfontein Colliery Dust Monitoring, T-Project Underground Coal Mine, Lusthof Colliery
- **Metalliferous mines:** Samancor Chrome's Eastern and Western Chrome Mines, Kinsenda Copper Mine (DRC), Bannerman Uranium Mine (Namibia), Sadiola Gold Mine Deep Sulphides Project (Mali), Kolomela Iron Ore Mine Noise Monitoring, Mamatwan Manganese Mine, Ntsimbintle Manganese Mine, Tharisa Minerals Chrome and Platinum Group Metals Open-pit Mine Project, Obuasi Gold Mine (Ghana), Omitiomire Copper Mine (Namibia), Perkoa Zinc Project (Burkina Faso), Tschudi Copper Mine (Namibia), Rössing Uranium Mine (Namibia), WCL Iron Ore Mines (Liberia), Fekola Gold Project (Mali), Esaase Gold Project (Ghana), Xstrata Paardekop and Amersfoort Underground Coal Mines, Mampon Gold Mine (Ghana), Husab Uranium Mine (Namibia), Mkuju River Uranium Project (Tanzania), Impala Platinum Mine, Angola Exploration Mining Resources Project (Angola), Kanyika Niobium Mine (Malawi)
- **Quarries:** Scantogo Limestone Quarry, Lion Park Quarries Dustfall Monitoring

Waste Disposal and Treatment Sector

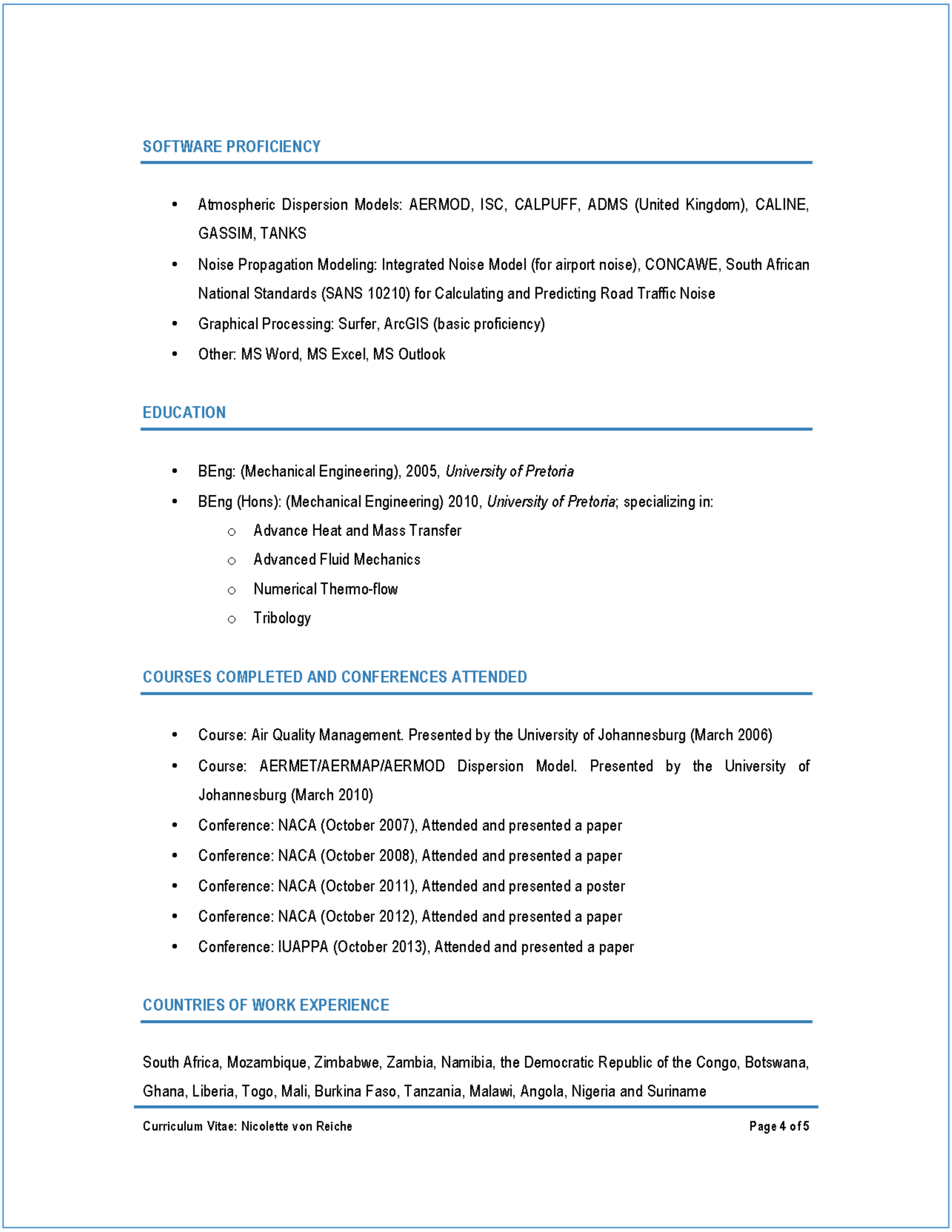
Aloes Hazardous Waste Disposal Site, Holfontein Hazardous Waste Disposal Site, Shongweni Hazardous Waste Disposal Site, Coega General and Hazardous Waste Disposal Site, Umdloti Waste Water Treatment Works, Waltloo Medical Waste Incinerator

Transport and Logistics Sector

Saldanha Iron Ore Port Projects and Railway Line, Gautrain Environmental Noise Monitoring Project, Guinea Port and Railway Project (Guinea), Kenneth Kaunda International Airport Expansion (Zambia), Zambia Dry Port Project in Walvis Bay (Namibia)

Ambient Air Quality and Noise Sampling

- Gravimetric Particulate Matter (PM) and dustfall sampling
- Passive diffusive gaseous pollutant sampling
- Environmental noise sampling
- Source noise measurements



SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), CALINE, GASSIM, TANKS
- Noise Propagation Modeling: Integrated Noise Model (for airport noise), CONCAWE, South African National Standards (SANS 10210) for Calculating and Predicting Road Traffic Noise
- Graphical Processing: Surfer, ArcGIS (basic proficiency)
- Other: MS Word, MS Excel, MS Outlook

EDUCATION

- BEng: (Mechanical Engineering), 2005, *University of Pretoria*
- BEng (Hons): (Mechanical Engineering) 2010, *University of Pretoria*; specializing in:
  - Advance Heat and Mass Transfer
  - Advanced Fluid Mechanics
  - Numerical Thermo-flow
  - Tribology

COURSES COMPLETED AND CONFERENCES ATTENDED

- Course: Air Quality Management. Presented by the University of Johannesburg (March 2006)
- Course: AERMET/AERMAP/AERMOD Dispersion Model. Presented by the University of Johannesburg (March 2010)
- Conference: NACA (October 2007), Attended and presented a paper
- Conference: NACA (October 2008), Attended and presented a paper
- Conference: NACA (October 2011), Attended and presented a poster
- Conference: NACA (October 2012), Attended and presented a paper
- Conference: IUAPPA (October 2013), Attended and presented a paper

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Zimbabwe, Zambia, Namibia, the Democratic Republic of the Congo, Botswana, Ghana, Liberia, Togo, Mali, Burkina Faso, Tanzania, Malawi, Angola, Nigeria and Suriname

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Excellent	Excellent	Excellent

REFERENCES

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Dr. Gerrit Kornelius	Associate of Airshed Planning Professionals	+27 (82) 925 9569 gerrit@airshed.co.za
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CERTIFICATION

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

N von Reiche

28/03/2015