Air Quality Impact Assessment for the Motuoane Exploration Right Application (ER386), Free State Province

Project done on behalf of **Environmental Impact Management Services (Pty) Ltd**

Project Compiled by:

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Report No: 24EIM15A Rev 0 | **Date:** May 2026

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Report Details

Status	Rev 3
Report Title	Air Quality Impact Assessment for the Motuoane Exploration Right Application (ER386), Free State Province
Report Number	24EIM15A
Date	May 2026
Client	Environmental Impact Management Services (Pty) Ltd
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Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
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Revision Record

Revision Number	**Date**	**Reason for Revision**
Rev 0	April 2026	For internal review
Rev 1	April 2026	For client review
Rev 2	April 2026	Grammatical changes
Rev 3	May 2026	Inclusion of client’s comments

EXECUTIVE SUMMARY

Introduction

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by Environmental Impact Management Services (Pty) Ltd (EIMS) to undertake an Air Quality Impact Assessment (AQIA) for the proposed Motuoane Exploration Right Application (ER386) (hereafter referred to as the project).

The aim of the investigation was to quantify the possible impacts resulting from the project activities on the surrounding environment and human health. To achieve this, a good understanding of the local dispersion potential of the site is necessary and subsequently an understanding of existing sources of air pollution in the region and the resulting air quality.

Study Approach and Methodology

The investigation followed the methodology required for a specialist report, as prescribed in the National Environmental Management Act (Act 107 of 1998) (NEMA) Environmental Impact Assessment (EIA) Regulations (Government Notice [GN] R982 in Government Gazette [GG] 38282 of 14 December 2014).

Baseline Assessment

The baseline study encompassed the identification of air quality sensitive receptors, atmospheric dispersion potential and ambient air quality within the study area. Air quality sensitive receptors were identified from available satellite imagery. Measured meteorological data from the Welkom South African Weather Service (SAWS) Station for the period 2023 to 2025 was used for the assessment.

No publicly accessible ambient air quality measurements were available.

Impact Assessment Criteria

Pollutants of concern due to project activities include particulates (specifically thoracic particulate matter with an aerodynamic diameter of equal to or less than 10 µm or PM_{10} and inhalable particulate matter with an aerodynamic diameter equal to or less than 2.5 µm or $PM_{2.5}$), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and volatile organic compounds (VOCs). With the exception of VOCs, these pollutants are classified as criteria pollutants, with National Ambient Air Quality Standards (NAAQS) having been established in South Africa to regulate ambient concentrations. For the current study, the impacts were assessed against published NAAQS. Impacts due to VOC ground level concentrations were conservatively screened against comfort levels.

Emissions Inventory

Emission inventories provide the source input required for the simulation of ambient air concentrations. Emissions due to project activities were quantified and included in the assessment.

Impact Prediction Study

Gaseous and particulate concentrations due to the project activities were simulated using the United States Environmental Protection Agency (US EPA) approved AERMET/AERMOD dispersion modelling suite. Ambient concentrations were simulated to ascertain highest hourly and daily levels occurring as a result of the project activities.

Management of Uncertainties

The main assumptions, exclusions and limitations are summarised below:

- Project information required to calculate emissions for the project activities were provided by EIMS. Where necessary, assumptions were made based on common industry practice and experience.
- Only routine emissions for the exploration phase (project activities) were estimated and simulated. Atmospheric releases occurring as a result of non-routine conditions were not accounted for.
- Emission factors were used to estimate fugitive emissions resulting from land clearing. These emission factors are based on field measurements of total suspended particulates (TSP) for construction activities and are a conservative estimate for particulate impacts for land clearing.
- Project activities were assumed to be from 06:00 to 18:00.
- The impact assessment was limited to airborne particulates (including PM_{10} and $PM_{2.5}$) and gaseous pollutants from well emissions (including non-methane VOCs (NMVOC)) and combustion machinery, including CO, oxides of nitrogen (NOx), VOCs and SO_2.
- Nitrogen monoxide (NO) emissions are rapidly converted in the atmosphere into NO_2. NO_2 impacts where calculated by using the Dispersion Modelling Guideline for Tier 2: Ambient Ratio Method (ARM) (DFFE, 2014). This method assumes a national ratio of NO_2/NO of 0.8.
- The maximum short-term ground level concentrations due to criteria pollutants were conservatively screened against NAAQS which allows for a number of exceedances per year (i.e. 88 hours for hourly NAAQS and 4 days for daily NAAQS). The maximum daily VOC concentrations were also conservatively screened against comfort levels (not health effect levels).
- No measured ambient air concentrations were available for inclusion into the AQIA.

Findings

The main findings from the baseline assessment were as follows:

- The predominant wind direction is from the northeastern sector.
- Numerous individual homesteads and residential areas are located within the study area.

The main findings from the impact assessment due to project activities were as follows:

- Target areas:
  - Construction:
    - Maximum daily PM_{10} ground level concentrations due to drill activities and land clearing, exceeds the daily PM_{10} NAAQ limit up to a distance of 50 m from the drill and 35 m from the target area site respectively. It should be noted, however, that the daily NAAQS allows for 4 exceedances of the limit per calendar year. Land clearing (up to 35 m from the target area) and drilling activities (up to 50 m from the drill) would thus exceed the NAAQS if activities are longer than 4 days per target area per year.
    - Maximum daily $PM_{2.5}$ ground level concentrations due to truck and drill activities, exceeds the daily $PM_{2.5}$ NAAQ limit up to a distance of 30 m from the truck and 60 m from the drill respectively. Given that the NAAQS allows for 4 daily exceedances of the limit per year, the $PM_{2.5}$ NAAQS may be exceeded up to 60 m from the drill if drill activities are for more than 4 days per target area per year.
    - Maximum hourly NO_2 ground level concentrations due to truck and drill activities, exceeds the hourly NO_2 NAAQ limit up to a distance of 260 m from the truck and 520 m from the drill respectively. The NAAQS allows for 88 hourly exceedances of the limit per year. Given that the trucks are moving sources, it is unlikely that this source would result in an exceedance of the NAAQS at any one location. Similarly, the drills would operate for 54 hours and 10 minutes as a worst case. The drilling activity would thus not result in an hourly NO_2 NAAQS exceedance.
    - Maximum daily VOC ground level concentrations due to drill activities, exceeds the comfort level of 200 µg/m³ up to a distance of 25 m from the drill. It should be noted that the VOC comfort level used for screening is not a health effect level or a NAAQS.
    - Significance rating:
      - Without mitigation: high-medium negative significance rating as there could be exceedances of the PM NAAQS up to 35 m from the target area due to land clearing and up to 60 m from the drill if these activities are for more than 4 days per target area per year.
      - With mitigation: low negative significance rating. Mitigation measures would include having target areas and exploration wells at least 35 m and 60 m from sensitive receptors respectively.
      - Overall significance rating: low negative significance rating.
  - Operation:
    - Maximum daily VOC ground level concentrations due to testing well gaseous releases, exceeds the comfort level of 200 µg/m³ up to a distance of 150 m from the source. It should be noted that the VOC comfort level used for screening is not a health effect level or a NAAQS.
    - Significance rating:
      - Without mitigation: medium-low negative significance rating. The significance rating is based on a comfort level and not a health effect level. The magnitude

of the impact is thus given as low providing an overall significance rating of medium-low.

            - With mitigation: low negative significance rating. Mitigation measures would include robust Leak Detection and Repair programs.
            - Overall significance rating: low negative significance rating.

    - Closure:
        - Assuming impacts due to rehabilitation activities to be similar to construction (i.e. land clearing), maximum daily PM_{10} ground level concentrations exceed the daily PM_{10} NAAQ limit up to a distance of 35 m from the target area site. Given that the daily PM_{10} NAAQS allows for 4 exceedances of the limit per year, the activities should be limited to less than 4 days per target area per year to avoid exceedances of the NAAQS.
        - The testing wells must be capped and sealed and should not have any gaseous releases if properly managed.
        - Significance rating:
            - Without mitigation: high-medium negative significance rating, as there could be exceedances of the PM NAAQS up to 35 m from the target area due to rehabilitation activities.
            - With mitigation: low negative significance rating. Mitigation measures would include limiting rehabilitation activities to less than 4 days per target area per year.
            - Overall significance rating: low negative.

- Seismic transects:
    - Construction:
        - No air quality impacts expected.
    - Operation:
        - Maximum daily $PM_{2.5}$ ground level concentrations due to truck activities, exceeds the daily $PM_{2.5}$ NAAQ limit up to a distance of 30 m from the source.
        - Maximum hourly NO_2 ground level concentrations due to truck activities, exceeds the hourly NO_2 NAAQ limit up to a distance of 260 m from the source.
        - Given the nature of the activity and that the truck will not be operating continuously or in the same location, it is unlikely that the NO_2 and $PM_{2.5}$ NAAQS (which allows for 88 hours or 4 days of exceedance of the hourly and daily limit per year respectively) will be exceeded.
        - Significance rating:
            - Without mitigation: low negative significance rating.
            - With mitigation: low negative significance rating.
            - Overall significance rating: low negative.
    - Closure:
        - No air quality impacts expected.

Recommendations

Based on the findings of the AQIA, it is the specialist's opinion that the project can be authorised, provided that the following recommendations are taken into account:

- All exploration activities are limited to day-time hours (i.e. 06:00 to 18:00).
- All residents within 600 m of drilling areas and 300 m of seismic surveys are consulted regarding the exploration activities.
- Scheduling of activities are communicated and co-ordinated with nearby residents.
- An air quality complaints register is kept. If complaints are received, they must be promptly investigated, recorded and addressed. Channels for logging of complaints should be communicated to all residents within 600 m of target areas and 300 m of seismic transects.
- Mitigation and monitoring measures as discussed in Section 6 be considered.

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LIST OF ACRONYMS AND SYMBOLS

Airshed	Airshed Planning Professionals (Pty) Ltd
AQIA	Air Quality Impact Assessment
AWD	Accelerated Weight Drop
°C	Degrees Celsius
C	Carbon
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
ECA	European Collaborative Action
EIA	Environmental Impact Assessment
EIMS	Environmental Impact Management Services
ER	Exploration Right
µg	Micro gram
GG	Government Gazette
GN	Government Notice
ha	Hectare
H_2S	Hydrogen sulfide
IPCC	Intergovernmental Panel on Climate Change
kg	Kilogram
kW	Kilo watt
LDAR	Leak Detection and Repair
LMo	Monin-Obukhov length
m	Metre
mm	Millimetre
m^3	Cubic metre
m^2	Square metre
NAAQS	National Ambient Air Quality Standard
NACA	National Association for Clean Air
NEM:AQA	National Environmental Management: Air Quality Act
NH_3	Ammonia
NMVOC	Non-methane volatile organic compound
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NOx	Oxides of nitrogen
NPI	National pollution inventory
PAHs	Polycyclic aromatic hydrocarbons
PEGs	Propelled Energy Generators
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10μm
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5μm
SACNASP	South African Council for Natural Scientific Professions
SAWS	South African Weather Service
SO_2	Sulfur Dioxide
TSP	Total suspended particles
TVOC	Total volatile organic compound

US EPA	United States Environmental Protection Agency
VOC	Volatile organic compound
%	Percent

Note:

The spelling of "sulfur" has been standardised to the American spelling throughout the report. The International Union of Pure and Applied Chemistry, the international professional organisation of chemists that operates under the umbrella of UNESCO, in 1990 published a list of standard names for all chemical elements. It was decided that element 16 should be spelled "sulfur". This compromise was to ensure that in future searchable data bases would not be complicated by spelling variants. (IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: http://goldbook.iupac.org (2006) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8.doi: 10.1351/goldbook)"

1 INTRODUCTION

Motuoane proposes to explore all saleable gases including but not limited to methane, carbon dioxide, helium, and nitrogen in the licensed area. Due to the large area and complex exploration methodology, the Exploration Right (ER) will be required for an initial period of three years with the option to renew three additional periods of two years resulting in a total of nine years. The accepted application for an exploration right (ER386) is located over an area of approximately 58 000 hectares (ha), covering various farm portions near the towns of Virginia, Welkom, Hennenman and Odendaalsrus in the Free State Province.

The main activities are core / percussion exploration drilling and seismic survey activities. The proposed approach is to first determine and map the geographic extent of all boreholes currently emitting gas on and near the ER area. Then measure rates and monitor pressures where possible and perform gas composition analysis. The geophysical wireline logging of existing boreholes (where possible) will include monitoring of water levels. If no existing gas emitting boreholes are identified near a target area, new drilling activities are proposed within that area using percussion or rotary drilling method. Five target areas and nine seismic transects, shown in **Figure 1-1**, are included in the application. Each exploration well will have an overall depth of approximately 650 m and a maximum width of 350 mm, commencing with a 6 m x 323 mm spud hole section, followed by 80 m x 254 mm conductor hole section, then an intermediate hole section of 450 m x 203 mm and finally an open hole section of 650 m x 144 mm. The actual casing sizes and configurations will vary depending on the specific geological characteristics and functional requirements. Each borehole will be steel cased and have cement barriers to prevent leaks as well as plugged at the end of exploration to prevent groundwater seepage.

The seismic survey activities are proposed throughout the exploration right as and when necessary. Motuoane will search records at the Council for Geoscience and the Petroleum Agency for seismic data that was acquired on the Exploration Right in the past. If no data are available, Motuoane will either acquire its own seismic or telluric data on the property, following proper environmental protocols and with the written permission of the landowner. The preliminary proposed transects for seismic / telluric survey are over 70 km long around known structures and possible drill locations. Seismic and/or telluric locations and lengths are subject to be changed as knowledge increases.

Although the Vibroseis technique is the likely method to be undertaken for the seismic activities, there is also a potential alternative to the Vibroseis known as the Propelled Energy Generators (PEGs), more commonly referred to as the Accelerated Weight Drop Seismic (AWD) which Motuoane may consider over the Vibroseis.

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by Environmental Impact Management Services (Pty) Ltd (EIMS) to undertake an Air Quality Impact Assessment (AQIA) for the proposed Motuoane Exploration Right Application (ER386) (hereafter referred to as the project). This report details the findings of the AQIA undertaken for the project.

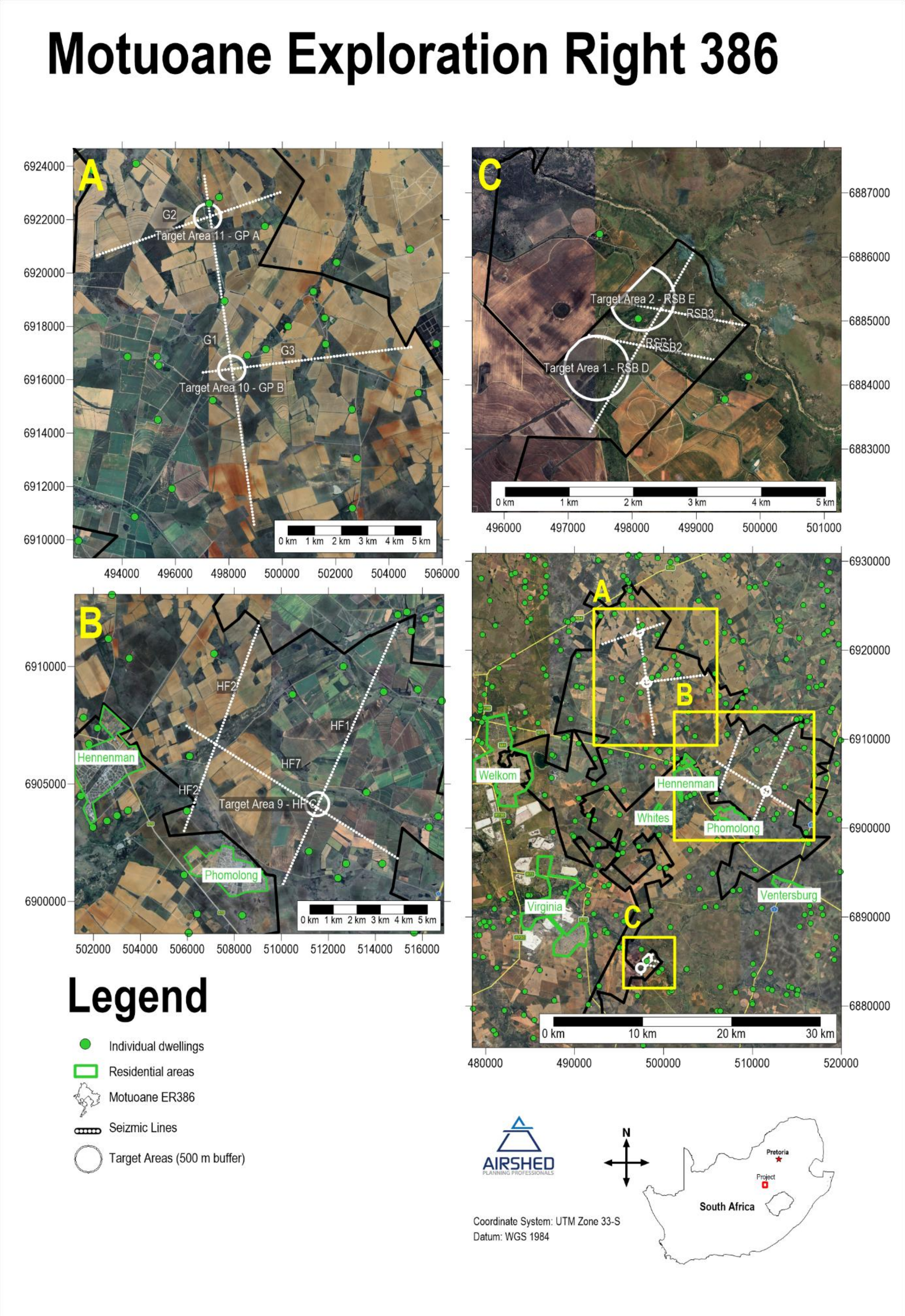

Figure 1-1: Location of the project site

1.1 Purpose/ Objectives

The main objective of this study is to determine the significance of the predicted impacts from the project on the surrounding environment and on human health.

1.2 Terms of Reference/Scope of Work

The terms of reference for the assessment are as follows:

- A baseline air quality characterisation, including the assessment of:
    - The regional climate and site-specific atmospheric dispersion potential using available meteorological data;
    - Preparation of hourly average meteorological data for the model input;
    - Characterisation of ambient air quality in the area based on available measured ambient data recorded; and
    - Describing the regulatory requirements.
- An air impact assessment including the following:
    - Compilation of an air emissions inventory, comprising the identification and quantification of all potential routine sources of emission;
    - Dispersion simulations of ambient respirable particulate and gaseous concentrations from project activities;
    - Analysis of dispersion modelling results from the project activities;
    - Evaluation of potential for human health and environmental impacts;
    - Recommendation of mitigation measures where required; and,
    - Specialist air impact assessment report.

1.3 Deliverables

At the core of the study is the provision of a mathematical tool (i.e. the dispersion model) that credibly describes the fluxes and dispersion of air emissions from the project through the incorporation of meteorological and emission configuration complexities. The final deliverables are ground level particulate and applicable gaseous air concentration predictions.

1.4 Specialist Details

1.4.1 Statement of Independence

Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.

1.4.2 Competency Profiles

1.4.2.1 RG von Gruenewaldt (MSc (Meteorology), BSc, Pr. Sci Nat.)

Reneé von Gruenewaldt is a Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP) and a member of the National Association for Clean Air (NACA).

Following the completion of her bachelor's degree in atmospheric sciences in 2000 and honours degree (with distinction) with specialisation in Environmental Analysis and Management in 2001 at the University of Pretoria, her experience in air pollution started when she joined Environmental Management Services (now Airshed Planning Professionals) in 2002. Reneé von Gruenewaldt became partner of Airshed Planning Professionals in September 2006. She completed her Master's Degree (with distinction) in Meteorology at the University of Pretoria in 2009.

Airshed Planning Professionals is a technical and scientific consultancy providing scientific, engineering and strategic air pollution impact assessment and management services and policy support to assist clients in addressing a wide variety of air pollution related risks and air quality management challenges.

She has extensive experience on the various components of air quality management including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Reneé has been the principal air quality specialist and manager on several Air Quality Impact Assessment projects between 2006 to present and her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality.

A comprehensive curriculum vitae of Reneé von Gruenewaldt is provided in Appendix A.

The declaration of independence for Reneé von Gruenewaldt is provided in Appendix B.

1.5 Approach and Methodology

The approach and methodology for tasks are provided in the following section.

1.5.1 Receiving Environment

1.5.1.1 Air Quality Sensitive receptors

Air quality sensitive receptors are identified based on human exposure where the public is exposed to ambient air quality impacts from the project. This included the identification of all dwellings including farmsteads and residential areas identified using Google Earth™ aerial imagery.

1.5.1.2 Climate and Atmospheric Dispersion Potential

It is important to have a good understanding of the meteorological parameters governing the rate and extent of dilution and transportation of air pollutants that are generated by the project. The primary meteorological parameters to obtain from measurement include wind speed, wind direction and ambient temperature. Other meteorological parameters that influence the air concentration levels include rainfall (washout) and a measure of atmospheric stability. The latter is not normally measured and are derived from other parameters such as the vertical height temperature difference or the standard deviation of wind direction. The depth of the atmosphere in which the pollutants are able to mix is similarly derived from other meteorological parameters by means of mathematical parameterizations.

Available data for the Welkom South African Weather Service (SAWS) station was used to establish baseline meteorological conditions for the project site and for use in dispersion modelling. The dataset included a minimum of hourly average wind speed, wind direction and temperature. For the purposes of establishing the local climatology, it is necessary to analyse at least one year of on-site data; and at least three years of off-site data (DFFE, 2014). For the AQIA data for the period January 2023 to December 2025 was used.

1.5.1.3 Existing Sources of Emissions and Ambient Air Quality

Sources of air pollution in the area were identified. However, no publicly accessible ambient measurements in the vicinity of the project were available for incorporation in the AQIA.

1.5.2 Impact Assessment

The impact assessment followed with the tasks below:

- Preparation of the model control options and input files for the AERMOD dispersion modelling suite. This included the compilation of:
    - the AERMET (hourly average meteorological data) file;
    - surrounding information (land use, albedo and surface roughness);
    - source input; and
    - grid definitions.
- Preparation of an emissions inventory for the project activities. Project activities result in gaseous emissions from point sources (i.e. engine exhaust emissions) and fugitive particulate emissions. 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). In the quantification of fugitive dust, use was made of emission factors which associate the quantity of a pollutant with the activity associated with the release of that pollutant. Emissions as provided from emission reports or calculated using a comprehensive set of emission factors and equations as published by the United States Environmental Protection Agency (US EPA) was used.
- Using the emissions inventory, where the emissions were quantified for project activities, simulations were conducted using the AERMOD dispersion modelling suite.

- The legislative and regulatory context, including ambient air quality guidelines and health effect screening levels were used to assess the impact and recommend air quality mitigation measures where necessary. The model results were analysed against the National Ambient Air Quality Standards (DFFE, 2009; DFFE, 2012). For non-criteria pollutants, impacts were screened against the internationally published health effect screening levels.

1.5.2.1 Data Gathering

All project information required to calculate emissions for the project activities were provided by EIMS via electronic mail, including list of equipment and operating times.

1.5.2.2 Data Analysis for Air Dispersion Modelling

Use was made of the US EPA approved AERMOD atmospheric dispersion modelling suite for the simulation of ambient air pollutant concentrations. AERMOD is a Gaussian plume model, which is best used for near-field applications where the steady-state meteorology assumption is most likely to apply. The AERMOD model is one of the most widely used Gaussian plume model. AERMOD is a model developed with the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective has been to include state-of the-art science in regulatory models (Hanna, Egan, Purdum, & Wagler, 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

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

The dispersion of PM_{10} (inhalable particulate matter of less than 10 µm in diameter), $PM_{2.5}$ (inhalable particulate matter of less than 2.5 µm in diameter), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and volatile organic compounds (VOCs) was modelled for an area covering 4 km (north-south) by 4 km (east-west). The simulation area was divided into a grid with a resolution of 20 m (north-south) by 20 m (east-west). AERMOD simulates ground-level concentrations for each of the receptor grid points. AERMET executable version 23132 and AERMOD executable version 22112 was used for the assessment.

1.5.2.3 Dispersion Results

The dispersion model uses the specific input data to run various algorithms to estimate the dispersion of pollutants between the source and receptor. The model output is in the form of a simulated time-averaged concentration at the receptor. These simulated concentrations are added to suitable background concentrations and compared with the relevant ambient air quality standard or guideline. The post-processing of air concentrations at discrete receptors as well as the regular grid points.

Ground level concentration isopleths plots presented in this report depict interpolated values from the concentrations simulated by AERMOD for each of the receptor grid points specified. Plots reflecting hourly or daily averaging periods contain the highest simulated ground level concentrations, for those averaging periods, over the entire period for which simulations were undertaken. It is therefore possible that even though a high hourly or daily average concentration is simulated at certain locations, this may only be true for one hour or day during the period. It should also be noted that ambient air quality guidelines and limits are not occupational health indicators but applicable to areas where the general public has access, i.e. off-site.

1.5.2.4 Uncertainty of Modelled Results

There will always be some error in any geophysical model; however, modelling is recognised as a credible method for evaluating impacts, but it is desirable to structure the model in such a way to minimise the total error. A model represents the most likely outcome of an ensemble of experimental results. The total uncertainty can be thought of as the sum of three components: the uncertainty due to errors in the model physics; the uncertainty due to data errors; and the uncertainty due to stochastic processes (turbulence) in the atmosphere.

The stochastic uncertainty includes all errors or uncertainties in data such as source variability, observed concentrations, and meteorological data. Even if the field instrument accuracy is excellent, there can still be large uncertainties due to unrepresentative placement of the instrument (or taking of a sample for analysis). Model evaluation studies suggest that the data input error term is often a major contributor to total uncertainty. Therefore, accurate input data is essential.

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

1.6 Management of Uncertainties

The following important limitation applies to the study and should be noted:

- Project information required to calculate emissions for the project activities were provided by EIMS. Where necessary, assumptions were made based on common industry practice and experience.

- Only routine emissions for the exploration phase (project activities) were estimated and simulated. Atmospheric releases occurring as a result of non-routine conditions were not accounted for.
- Emission factors were used to estimate fugitive emissions resulting from land clearing. These emission factors are based on field measurements of total suspended particulates (TSP) for construction activities and are a conservative estimate for particulate impacts for land clearing.
- Project activities were assumed to be from 06:00 to 18:00.
- The impact assessment was limited to airborne particulates (including PM_{10} and $PM_{2.5}$) and gaseous pollutants from well emissions (including non-methane VOCs (NMVOC)) and combustion machinery, including CO, oxides of nitrogen (NOx), VOCs and SO_2.
- Nitrogen monoxide (NO) emissions are rapidly converted in the atmosphere into nitrogen dioxide (NO_2). NO_2 impacts where calculated by using the Dispersion Modelling Guideline for Tier 2: Ambient Ratio Method (ARM) (DFFE, 2014). This method assumes a national ratio of NO_2/NO of 0.8.
- The maximum short-term ground level concentrations due to criteria pollutants were conservatively screened against NAAQS which allows for a number of exceedances per year (i.e. 88 hours for hourly NAAQS and 4 days for daily NAAQS). The maximum daily VOC concentrations were also conservatively screened against comfort levels (not health effect levels).
- No measured ambient air concentrations were available for inclusion into the AQIA.

2 REGULATORY CONTEXT, IMPACT ASSESSMENT CRITERIA AND LITERATURE REVIEW

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

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

This section summarises legislation for criteria pollutants relevant to the current study. A discussion on inhalation health risk for VOCs is also provided.

2.1 Screening Criteria

2.1.1 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 National Ambient Air Quality Standards (NAAQS) for SO_2, NO_2, PM_{10}, CO, ozone (O_3), benzene (C_6H_6), and lead (Pb) were published on 13 March 2009. Standards for $PM_{2.5}$ were published on 24 June 2012. All standards are listed in **Table 2-1**.

Table 2-1: National Ambient Air Quality Standards for criteria pollutants

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

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
	8-hour	10 000	8 700	11	Currently enforceable
Benzene (C_6H_6)	1-year	5	1.6	-	Currently enforceable
Ozone (O_3)	8 hours (running)	120	61	11	Currently enforceable
Lead (Pb)	1-year	0.5	-	-	Currently enforceable

2.1.2 Inhalation Health Criteria for Volatile Organic Compounds (VOCs)

Volatile Organic Compounds are a class of several hundred carbon-based chemical compounds that evaporate easily into the air. The sources of VOCs include fuel additives, fuel evaporation, and incomplete combustion. Some VOCs have little or no known direct human health effects, while others are extremely toxic and/or carcinogenic. Very little is known about how various VOCs combine in the atmosphere or in the human body, or what the cumulative impacts of exposure might be.

As the term VOC refers to a group of pollutants, generally guidelines are not available for comparison to determine the health impacts due to exposure to these pollutants. To estimate the probable health impacts a breakdown of the types of pollutants, which dominate in a specific area is required, whereby their respective toxicities can be determined.

Although standards for exposure to VOCs in non-industrial settings do not exist, a number of exposure limits have been recommended. The European Collaborative Action (ECA) Report No. 11 titled Guidelines for Ventilation Requirements in Buildings (European Concerted Action, 1992) lists the following Total VOC (TVOC) concentration ranges as measured with a flame ionisation detector calibrated to toluene. These recommendations are based on Mølhave's toxicological work on mucous membrane irritation (Mølhave, 1990).

Comfort range : <200 µg/m³

Multifactoral exposure range : 200 to 3 000 µg/m³

Discomfort range : 3 000 to 25 000 µg/m³

Toxic range : >25 000 µg/m³

The same European report also lists a second method based on Seifert's work (Seifert, 1990). This method established TVOC guidelines based on the ten most prevalent compounds in each of seven chemical classes. The concentrations in each of these classes should be below the maximums listed below.

Alkanes : 100 µg/m³.

Aromatic hydrocarbons : 50 µg/m³.

Terpenes : 30 µg/m³.

Halocarbons	:	30 µg/m³.
Esters	:	20 µg/m³.
Aldehydes and ketones (excluding formaldehyde)	:	20 µg/m³.
Other	:	50 µg/m³.

The VOC concentration is calculated by adding the totals from each class. Seifert gives a target TVOC concentration of 300 µg/m³, which is the sum of the above-listed target concentrations. The author also states that no individual compound concentration should exceed 50% of the guideline for its class or 10 percent of the TVOC guideline concentration. However, Seifert states that *"…the proposed target value is not based on toxicological considerations but – to the author's best judgment."*

The criteria selected for this study is 200 µg/m³. This criterion is conservatively used to screen the simulated maximum daily VOC concentrations. It should be noted that this screening criteria is only a guideline and not a legal requirement.

2.2 Regulations regarding Air Dispersion Modelling

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Regulations regarding Air Dispersion Modelling were promulgated by DFFE (Government Notice (GN) 533 in Government Gazette (GG) 37804 on 11 July 2014) (Dispersion Modelling Regulations) and recommend a suite of dispersion models to be applied for regulatory practices and give guidance on modelling input requirements, protocols, and procedures to be followed. They are applicable in the development of the following in terms of the sections of the National Environmental Management: Air Quality Act (NEM:AQA) (Act 39 of 2004) specified below:

(a) Air quality management plan (Chapter 3);
(b) Atmospheric impact report (section 30);
(c) Specialist AQIA (Chapter 5); and,
(d) Priority area air quality management plan (section 19), which currently is not applicable to Spitzkop Mine.

The Dispersion Modelling Regulations have been applied to the development of this AQIA. The first step in the dispersion modelling exercise requires a clear objective of the modelling exercise and thereby gives direction to the choice of the dispersion model most suited for the purpose. Chapter 2 of the Dispersion Modelling Regulations present the typical levels of assessments; technical summaries of the prescribed models (SCREEN3, AERSCREEN, AERMOD, SCIPUFF, and CALPUFF); and good practice steps to be taken for modelling applications. The project falls under a Level 2 assessment – described as follows:

- The distribution of pollutants concentrations and depositions are required in time and space.
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. The model specifically to be used in this AQIA is AERMOD.

- Emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km) downwind.

Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Chapter 3 of the Dispersion Modelling Regulations prescribe the source data input to be used in the models. Dispersion modelling can typically be used in the:

- Apportionment of individual sources for installations with multiple sources. In this way, the individual contribution of each source to the maximum ambient predicted concentration can be determined. This may be extended to the study of cumulative impact assessments where modelling can be used to model numerous installations and to investigate the impact of individual installations and sources on the maximum ambient pollutant concentrations.
- Analysis of ground level concentration changes due to different release conditions (e.g., by changing stack heights, diameters and operating conditions such as exit gas velocity and temperatures).
- Assessment of variable emissions due to process variations, start-up, shut-down or abnormal operations.
- Specification and planning of ambient air monitoring programs which, in addition to the location of sensitive receptors, are often based on the prediction of air quality hotspots.

The above options can be used to determine the most cost-effective strategy for compliance with the NAAQS. Dispersion models are particularly useful under circumstances where the maximum ambient concentration approaches the ambient air quality limit value and provide a means for establishing the preferred combination of mitigation measures that may be required including:

- Stack height increases;
- Reduction in pollutant emissions using air pollution control systems or process variations;
- Switching from continuous to non-continuous process operations or from full to partial load.

Chapter 4 of the Dispersion Modelling Regulations prescribe meteorological data input from onsite observations to simulated meteorological data. It also gives information on how missing data and calm conditions are to be treated in modelling applications. Meteorology is fundamental for the dispersion of pollutants because it is the primary factor determining the diluting effect of the atmosphere. Therefore, it is important that meteorology is carefully considered when modelling.

Topography is also an important geophysical parameter. The presence of terrain can lead to significantly higher ambient concentrations than would occur in the absence of the terrain feature, particularly where there is a significant relative difference in elevation between the source and off-site receptors large ground level concentrations can result. Thus, the accurate determination of terrain elevations in air dispersion models is very important.

The modelling domain would normally be decided on the expected zone of influence; the latter extent being defined by the predicted ground level concentrations from initial model runs. It must include all areas where the ground level concentration is significant when compared to the air quality limit value (or other guideline). Air dispersion models require a receptor grid at which ground-level concentrations can be calculated. The receptor grid size should include the entire modelling domain to ensure that the maximum ground-level concentration is captured and the grid resolution (distance between grid points) sufficiently small to ensure that areas of maximum impact adequately covered. No receptors however should be located within the property line as health and safety legislation (rather than ambient air quality standards) is applicable within the site.

Chapter 5 provides general guidance on geophysical data, model domain and coordinates system required in dispersion modelling, whereas Chapter 6 elaborates more on these parameters and the inclusion of background air concentration data. The Chapter also provides guidance on the treatment of NO_2 formation from NO_x emissions, chemical transformation of sulfur dioxide into sulfates and deposition processes.

Chapter 7 of the Regulations outline how the plan of study and modelling assessment reports are to be presented to the competent authorities.

The first step in the dispersion modelling exercise requires a clear objective of the modelling exercise and thereby gives clear direction to the choice of the dispersion model most suited for the purpose. Accordingly, a Level 2 assessment is considered suitable for the project.

2.3 Regulations Regarding Report Writing

The impact assessment complies with the requirements of the National Environmental Management Act, 1998 (NEMA, No. 107 of 1998) and the Environmental Impact Assessment (EIA) regulations (GN R982 as amended by GN 326 of 7 April 2017; GN 706 of 13 July 2018; GN 320 of 20 March 2020 and GN 517 of 11 June 2021).

Table 2-2: Specialist report requirements in terms of Appendix 6 of the EIA Regulations

A specialist report prepared in terms of the Environmental Impact Regulations must contain:	Relevant section in report
Details of the specialist who prepared the report	Section 1.4
The expertise of that person to compile a specialist report including a curriculum vitae	Section 1.4.2 Appendix A
A declaration that the person is independent in a form as may be specified by the competent authority	Section 1.4.1 Appendix B
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.2
An indication of the quality and age of base data used for the specialist report;	Section 3.2
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 4
The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 3.2
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 1.5

A specialist report prepared in terms of the Environmental Impact Regulations must contain:	Relevant section in report
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternative;	Section 3.1
An identification of any areas to be avoided, including buffers	Figure 1-1 Table 6-1
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Figure 1-1
A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.6
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	Section 4.2
Any mitigation measures for inclusion in the EMPr	Section 6
Any conditions for inclusion in the environmental authorisation	Section 6 Section 7.2
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 6.2
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 7.2
Regarding the acceptability of the proposed activity or activities; and	Section 4.2
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 Section 7.2
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	Comments received are captured in the EIA.
Any other information requested by the competent authority.	None received

2.4 Dust Management Plan

As per the National Dust Control Regulations, as gazetted on 31 March 2026 (Government Gazette: 54440), any holder of a right or permit related to exploration must, within 60 days of the coming into operation, develop and submit a dust management plan to the relevant licencing authority.

3 RECEIVING ENVIRONMENT

3.1 Air Quality Sensitive Receptors

Potential sensitive receptors within the project area (indicated in **Figure 1-1**), include individual households and residential areas (i.e., Welkom, Hennenman, Virginia, Whites, Phomolong and Ventersburg).

3.2 Topography

The study area is characterised by a flat surface with sparse vegetation. An analysis of topographical data indicated a slope of less than 1:10 from over most of the project area. Dispersion modelling guidance recommends the inclusion of topographical data in dispersion simulations only in areas where the slope exceeds 1:10 (US EPA, 2004). The topography for the study area is provided in **Figure 3-1**.

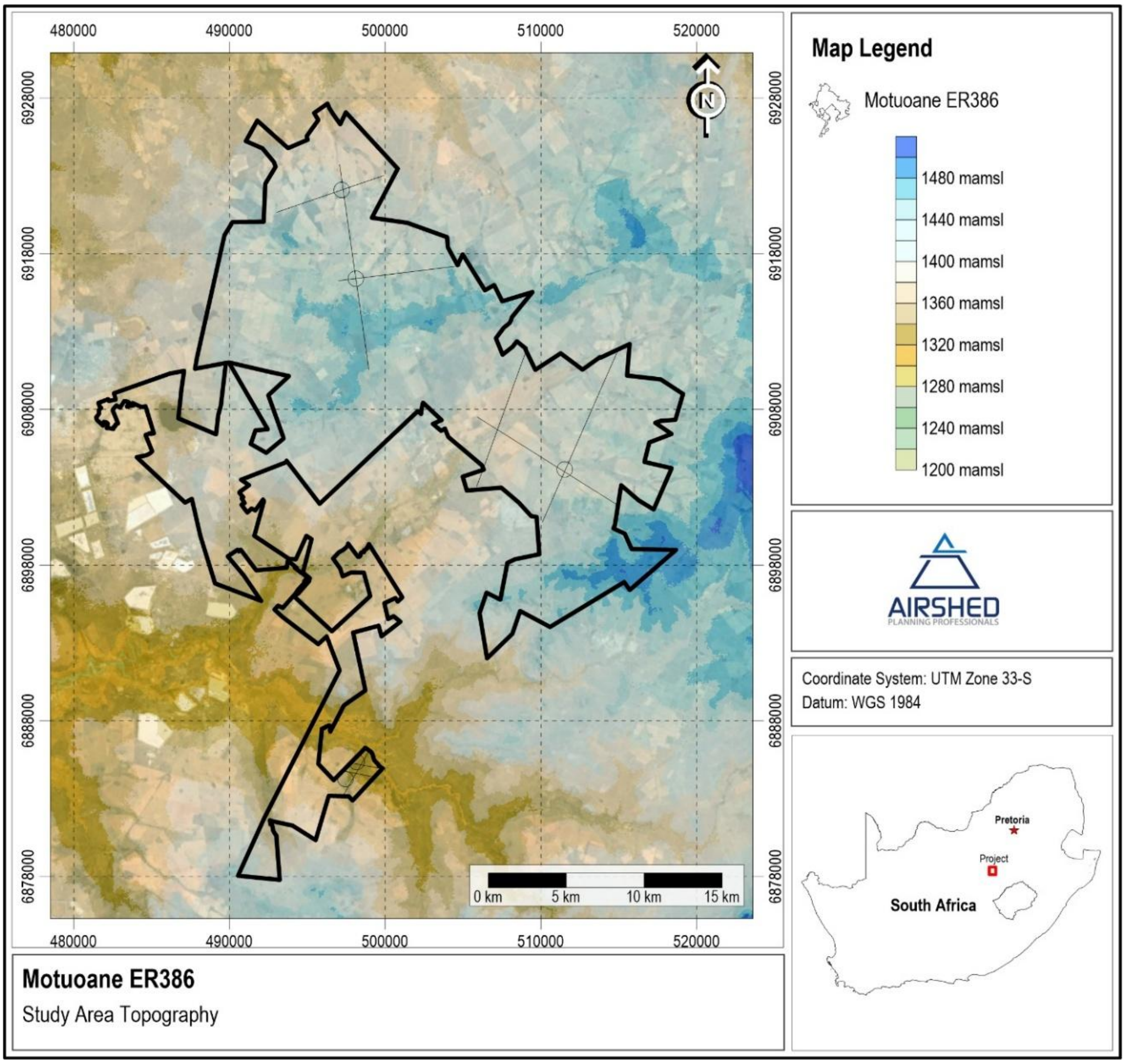

Figure 3-1: Topography for the study area

3.3 Climate and Atmospheric Dispersion Potential

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

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

Data from the Welkom SAWS station for the period 2023 to 2025 was used for the assessment.

3.3.1 Local Wind Field

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

Period and diurnal wind roses drawn from the Welkom SAWS station shown in **Figure 3-2**. During the period 2023 to 2025, the wind field was dominated by winds from the northeastern sector. Calm conditions occurred for 2.5% of the time. Wind speeds decreased during night-time conditions with an increase in calms to 3.5%.

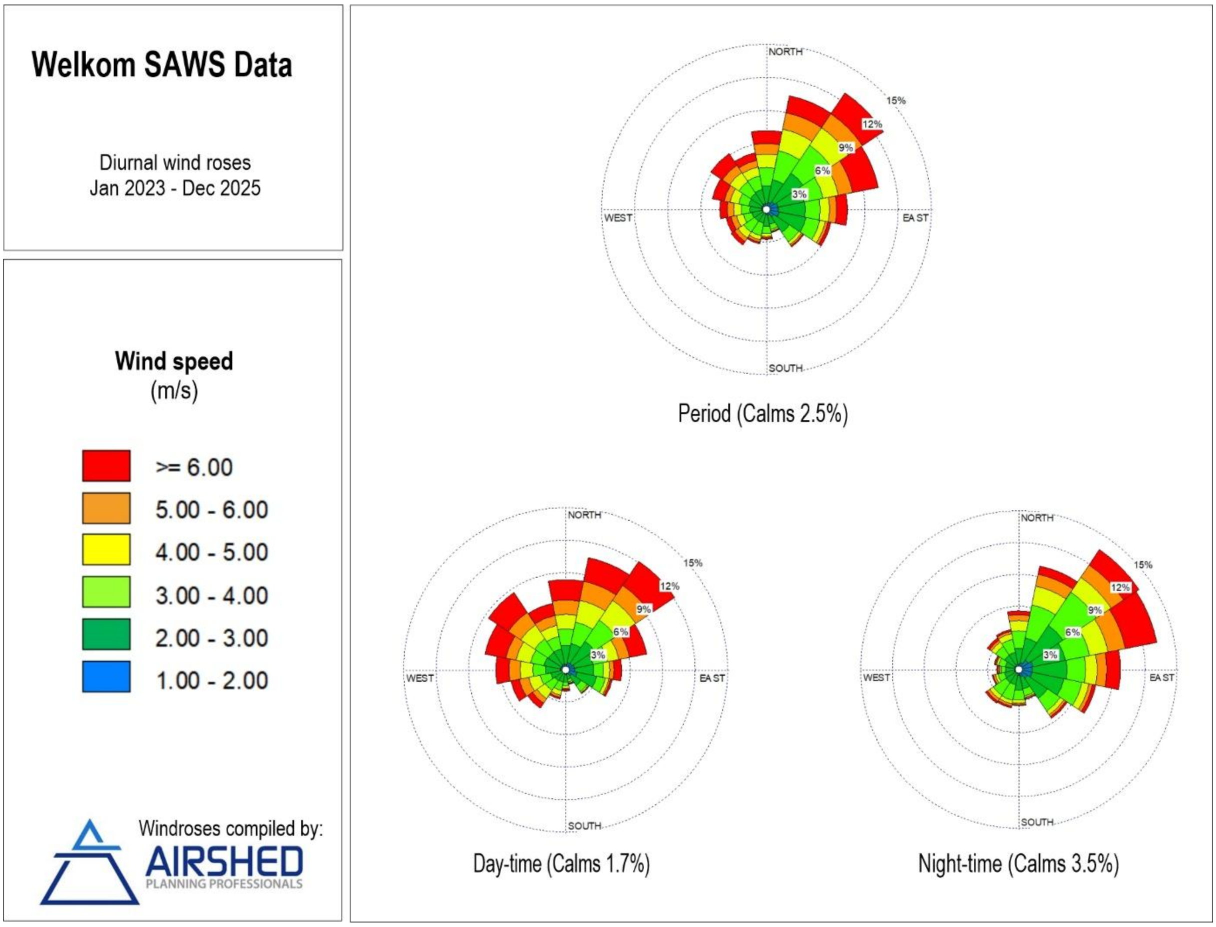

Figure 3-2: Period average, daytime and night-time wind roses (measured data; January 2023 to December 2025; SAWS Welkom monitoring station)

3.3.2 Ambient Temperature

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

Monthly mean, maximum and minimum temperatures are given in **Table 3-1**. Diurnal temperature variability is presented in **Figure 3-3**. Average monthly temperatures ranged between 10.7°C and 23.6°C. During the day, temperatures increase to reach maximum at about 15:00 in the late afternoon. Ambient air temperature decreases to reach a minimum at 06:00, i.e., just before sunrise.

Table 3-1: Monthly average temperature summary (SAWS Welkom Data, 2023 to 2025)

Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Minimum	17.4	17.5	16.1	11.9	8.1	4.2	3.6	6.5	10.2	12.9	15.5	17.2
Average	23.6	22.9	21.9	17.6	15.2	10.9	10.7	14.4	17.6	20.2	21.9	23.3
Maximum	30.2	29.4	29.0	24.6	23.8	19.6	19.7	23.6	26.1	28.2	28.6	29.6

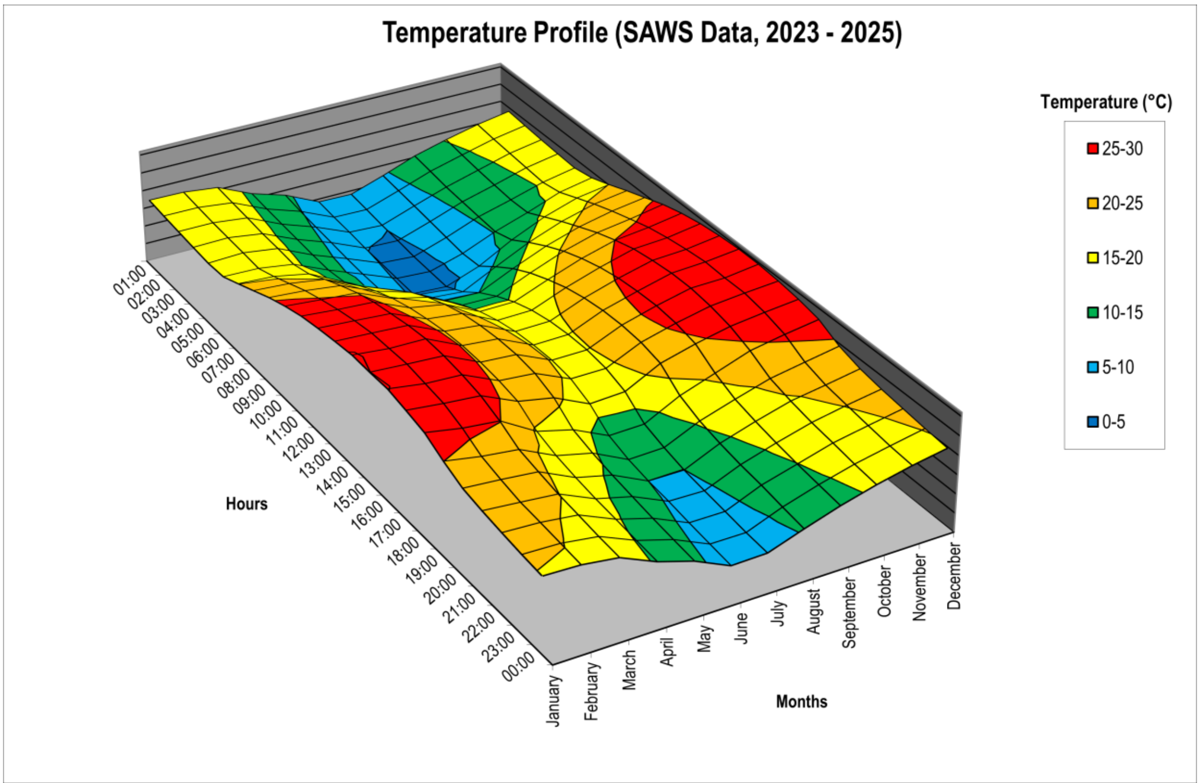

Figure 3-3: Diurnal temperature profile (SAWS Welkom Data, 2023 to 2025)

3.3.3 Atmospheric Stability and Mixing Depth

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 (LMo) 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 the 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 less dilution potential. During windy and/or cloudy conditions, the atmosphere is normally neutral. For low level releases, the highest ground level concentrations would occur during weak wind speeds and stable (night-time) atmospheric conditions.

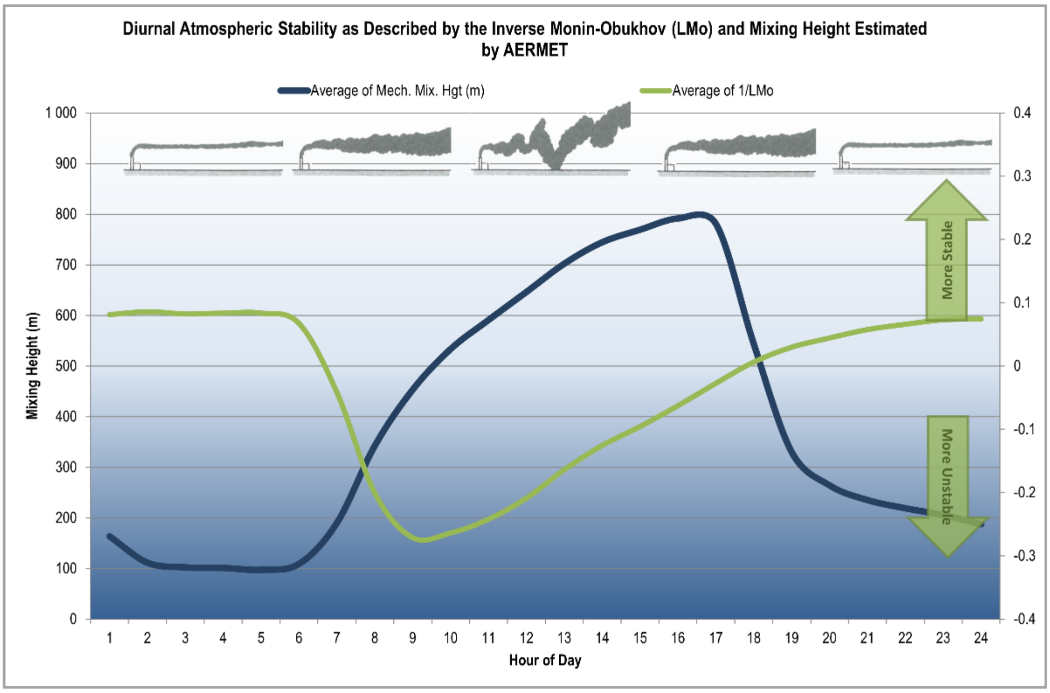

Figure 3-4: Diurnal atmospheric stability as described by the inverse of the measured Monin-Obukhov length (SAWS Welkom Data: 2023 to 2025)

3.4 Ambient Air Quality within the Region

3.4.1 Sources of Pollution in the Region

Neighbouring land-use in the surrounding of the proposed project comprises predominantly of agriculture activities. These land-uses contribute to baseline pollutant concentrations via fugitive and process emissions, vehicle exhaust emissions, household fuel combustion, biomass burning and windblown dust from exposed areas.

3.4.1.1 Agriculture

Agriculture is a major land-use activity within and beyond the Project boundary. These activities include crop farming such as maize, and livestock farming. Particulate matter is the main pollutant of concern from agricultural activities as particulate emissions are derived from windblown dust, burning crop residue, and dust entrainment as a result of vehicles travelling along dirt roads. In addition, pollen grains, mould spores and plant and insect parts from agricultural activities all contribute to the particulate load. Should chemicals be used for crop spraying, they would typically result in odiferous emissions. Crop residue burning is also an additional source of particulate emissions and other toxins.

Livestock farms, especially cattle, are also significant sources of fugitive dust especially when feedlots are used and the cattle trample in confined areas. Pollutants associated with dairy production for instance include ammonia (NH_3), hydrogen sulfide (H_2S), methane (CH_4), carbon dioxide (CO_2), NO_x and odour related trace gasses. According to the US-EPA, cattle emit methane through a digestive process that is unique to ruminant animals called enteric fermentation. The calf-cow sector of the beef industry was found to be the largest emitter of methane emissions. Where animals are densely confined the main pollutants of concern include dust from the animal movements, their feed and their manure, NH_3 from the animal urine and manure, and H_2S from manure pits.

Organic dust includes dandruff, dried manure, urine, feed, mould, fungi, bacteria and endotoxins (produced by bacteria, and viruses). Inorganic dust is composed of numerous aerosols from building, materials and the environment. Since the dust is biological it may react with the defence system of the respiratory tract. Odours and VOCs associated with animal manure is also a concern when cattle are kept in feedlots. The main impact from methane is on the dietary energy due to the reduction of carbon from the rumen. Dust and gasses levels are higher in winter or whenever animals are fed, handled or moved.

3.4.1.2 Mining Sources

Particulates represent the main pollutant of concern at mining operations, whether it is underground or opencast. The amount of dust emitted by these activities depends on the physical characteristics of the material, the way in which the material is handled and the weather conditions (e.g. high wind speeds, rainfall, etc.). Mining of gold, including ore extraction, processing plants, waste rock dumps and tailings storage facilities are all commercial activities situated in the region of the project.

3.4.1.3 Domestic Fuel Combustion

Domestic households are known to have the potential to be one the most significant sources that contribute to poor air quality within residential areas. Individual households are low volume emitters, but their cumulative impact is significant. It is likely that households within the local communities or settlements utilize coal, paraffin and/or wood for cooking and/or space heating (mainly during winter) purposes. Pollutants arising from the combustion of wood include respirable particulates, CO and SO_2 with trace amounts of polycyclic aromatic hydrocarbons (PAHs), in particular benzo(a)pyrene and formaldehyde. Particulate emissions from wood burning have been found to contain about 50% elemental carbon and about 50% condensed hydrocarbons.

Coal is relatively inexpensive in the region and is easily accessible due to the proximity of the region to coal mines and the well-developed coal merchant industry. Coal burning emits a large amount of gaseous and particulate pollutants including SO_2, heavy metals, PM including heavy metals and inorganic ash, CO, PAHs (recognized carcinogens), NO_2 and various toxins. The main pollutants emitted from the combustion of paraffin are NO_2, particulates, CO and PAHs.

3.4.1.4 Biomass Burning

Biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Within the project vicinity, crop-residue burning and wildfires (locally known as veld fires) may represent significant sources of combustion-related emissions. The frequency of wildfires in the grasslands varies between annual and triennial.

Biomass burning is an incomplete combustion process (Cachier, 1992), with carbon monoxide, methane and nitrogen dioxide gases being emitted. Approximately 40% of the nitrogen in biomass is emitted as nitrogen, 10% is left in the ashes, and it may be assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds (Held, et al., 1996). The visibility of the smoke plumes is attributed to the aerosol (particulate matter) content. In addition to the impact of biomass burning within the vicinity of the project activity, long-range transported emissions from this source can be expected to impact on the air quality between the months of August to October. It is impossible to control this source of atmospheric pollution loading; however, it should be noted as part of the background or baseline condition before considering the impacts of other local sources.

3.4.1.5 Fugitive Dust Sources

These sources are termed fugitive because they are not discharged to the atmosphere in a confined flow stream. Sources of fugitive dust identified in the study area include paved and unpaved roads and wind erosion of sparsely vegetated surfaces.

3.4.1.6 Unpaved and Paved Roads

Emissions from unpaved roads constitute a major source of emissions to the atmosphere in the South African context. When a vehicle travels on an unpaved road the force of the wheels on the road surface causes pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong turbulent air shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. Dust emissions from unpaved roads vary in relation to the vehicle traffic and the silt loading on the roads. Unpaved roads in the region are mainly haul and access roads.

Emissions from paved roads are significantly less than those originating from unpaved roads, however they do contribute to the particulate load of the atmosphere. Particulate emissions occur whenever vehicles travel over a paved surface. The fugitive dust emissions are due to the re-suspension of loose material on the road surface. Paved roads in the region include the N1, R70, R73 and the R34.

3.4.1.7 Wind Erosion of Open Areas

Windblown dust generates from natural and anthropogenic sources. For wind erosion to occur, the wind speed needs to exceed a certain threshold, called the threshold velocity. This relates to gravity and the inter-particle cohesion that resists removal. Surface properties such as soil texture, soil moisture and vegetation cover influence the removal potential. Conversely, the friction velocity or wind shear at the surface is related to atmospheric flow conditions and surface aerodynamic properties. Thus, for particles to become airborne, its erosion potential has to be restored; that is, the wind shear at the surface must exceed the gravitational and cohesive forces acting upon them, called the threshold friction velocity. Every time a surface is disturbed, its erosion potential is restored (US EPA, 2006). Erodible surfaces may occur as a result of agriculture and/or grazing activities.

3.4.1.8 Vehicle Exhaust Emissions

Emissions resulting from motor vehicles can be grouped into primary and secondary pollutants. While primary pollutants are emitted directly into the atmosphere, secondary pollutants form in the atmosphere as a result of chemical reactions. Significant primary pollutants emitted combustion engines include carbon dioxide (CO_2), carbon (C), SO_2, oxides of nitrogen (mainly NO), particulates and lead. Secondary pollutants include NO_2, photochemical oxidants such as ozone, sulfur acid, sulphates, nitric acid, and nitrate aerosols (particulate matter). Vehicle type (i.e. model-year, fuel delivery system), fuel (i.e. oxygen content), operating (i.e. vehicle speed, load) and environmental parameters (i.e. altitude, humidity) influence vehicle emission rates.

3.4.2 Air Quality Sampling Results

There are no publicly accessible ambient measurements in the vicinity of the project.

4 IMPACTS FROM THE PROJECT OPERATIONS ON THE RECEIVING ENVIRONMENT

4.1 Atmospheric Emissions Inventory

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts from the project on the receiving environment. The project activities will consist of the exploration phase only. Emissions are quantified for pollutants associated with exploration activities and can be divided into two categories, namely, fugitive emissions and point source emissions. 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 point source emissions (IFC, 2007).

A discussion on the expected activities for the project is provided in the sections below.

4.1.1 Well Construction

Fugitive particulate emissions due to testing well construction includes land clearing activities. Emissions due to these activities were calculated using an area wide average particulate generation emission factor (US EPA AP-42, Section 13.2.3 (US EPA, 1995)).

The US-EPA documents emissions factors which aim to provide a general rule-of-thumb as to the magnitude of emissions which may be anticipated from construction operations. The quantity of dust emissions is assumed to be proportional to the area of land being worked. The approximate emission factors for general construction activity operations are given as:

E = 2.69 Mg/hectare/month of activity (269 g/m^2/month)

The PM_{10} fraction is given as ~39% of the US-EPA total suspended particulate factor. These emission factors are most applicable to construction operations with (i) medium activity levels, (ii) moderate silt contents, and (iii) semiarid climates. The emission factor for TSP considers 42 hours of work per week of construction activity. Test data were not sufficient to derive the specific dependence of dust emissions on correction parameters.

The dimensions of sources used in the model, footprint area (in m^2), estimated construction periods (in days) for the well exploration areas and estimated average emissions (in kg/hr) due to general land clearing are presented are given in **Table 4-1**.

Table 4-1: Estimated fugitive particulate emissions due to general land clearing

Location of Emission	Dimensions	Area (m^2)	Calculated PM_{10} Emissions (kg/day)
Well exploration area (single)	50 m x 50 m	2 500	22

4.1.2 Engine Exhaust Emissions

Engine exhaust emissions cover a wide variety of industrial applications of both gasoline and diesel internal combustion engines, including mobile (road sources, i.e. buses, trucks, etc. and non-road sources, such as forklifts, backhoes, etc.) and non-mobile sources (such as engines). The Australian National Pollutant Inventory (NPI) (2008) manual for combustion engines were used to estimate emission rates for this equipment.

Engine exhaust emissions were quantified through the application of emission factors (specified in **Table 4-3**) as published by the Australian NPI, to the diesel usage (LGV), power output and loading factor of each type of equipment (specified in **Table 4-2**). Estimated average emissions (in kg/day) due to engine exhaust emissions are presented in **Table 4-4**.

Table 4-2: Description of equipment per project activity

Project Activity	Description of Equipment	Diesel Usage (litres per week)[b]	Capacity (kW)	Load Factor	Number of Equipment	No of Equipment Hours per Well per Year[a]
Target Areas and Drilling Operations	Trucks		250	50%	3	336
	Drill rig		250	100%	1	336
	Light goods vehicle	50	100	25%	2	336
Seismic Transects	Seismic vibrator		250	50%	1	336
	Light goods vehicle	50	100	25%	2	336

(a) The well test will be for a duration of 14 days per year, with 2-4 wells drilled per year

(b) Provided for LGV, as information is required for the emission factor

Table 4-3: Emission factors for diesel engine exhaust emissions

Description of Equipment	Emission factor						
	PM_{10}	$PM_{2.5}$	VOC	CO	NOx	SO_2	Units
Light Goods Vehicle (LGV)[a]	2.4	2.3	0.42	19	8.9	0.017	kg/m³
Off-highway truck[b]	0.00067	0.00062	0.0005	0.0047	0.011	0.0000077	kg/kWh
Stationary small (less than 450 kW) diesel engines[c]	0.0013	0.0013	0.0013	0.0041	0.019	0.0000043	kg/kWh

Notes:

(a) Australian NPI Table 15: Emission factors for diesel vehicle exhaust emissions

(b) Australian NPI Table 33: Emission factors for diesel industrial vehicle (off-highway truck) exhaust emissions

(c) Australian NPI Table 49: Emission factors for stationary small (less than 450 kW) diesel engines

Table 4-4: Calculated diesel engine exhaust emissions

Project Activity	Description of Equipment	Emissions (kg/day)					
		PM_{10}	$PM_{2.5}$	VOC	CO	NOx	SO_2
Target Areas and Drilling Operations	Trucks	1.68	1.55	1.25	11.8	27.5	0.019
	Drill rig	3.25	3.25	3.25	10.3	47.5	0.011
	Light goods vehicle	0.024	0.023	0.0042	0.19	0.089	0.00017
Seismic Transects	Seismic vibrator	1.68	1.55	1.25	11.8	27.5	0.019
	Light goods vehicle	0.024	0.023	0.0042	0.19	0.089	0.00017

4.1.3 Emissions from Well Releases

The NMVOC emissions from well releases during exploration activities was quantified using the 2019 refinement to the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 2019). The emission factors used and the quantified NMVOC emissions per well is provided in **Table 4-5**.

Table 4-5: Non-methane volatile organic compound emissions due to testing well gaseous releases

Project Activity	Pollutant	IPCC Emission Factor (tonne per conventional well drilled in a year)	Emission Rate per Well (kg/day)
Well exploration and testing	NMVOC	0.87	62

4.2 Dispersion Simulation Results and Compliance Assessment

Pollutants with the potential to result in human health impacts which are assessed in this study include PM_{10}, $PM_{2.5}$, CO, SO_2, NO_2 and VOC. Dispersion simulations were undertaken using the AERMOD dispersion model and results are presented in as profile graphs. The maximum ground level concentrations are conservatively screened against the NAAQS and VOC comfort levels. Due to the short duration of activities, only short-term ground level concentrations were assessed.

4.2.1 Testing Well Construction Activities

The exact location of the testing wells will only be determined during the exploration phase as more data becomes available to guide the positioning of further wells. The construction site for the testing wells was provided to be 50 m x 50 m for equipment movement and setup.

Daily PM_{10} NAAQ limits are exceeded up to 35 m from the testing well construction site (**Figure 4-1**). Given that the NAAQS allows for 4 daily exceedances of the limit, land clearing activities would exceed the PM_{10} NAAQS up to 35 m from the construction site if the activities continued for longer than 4 days.

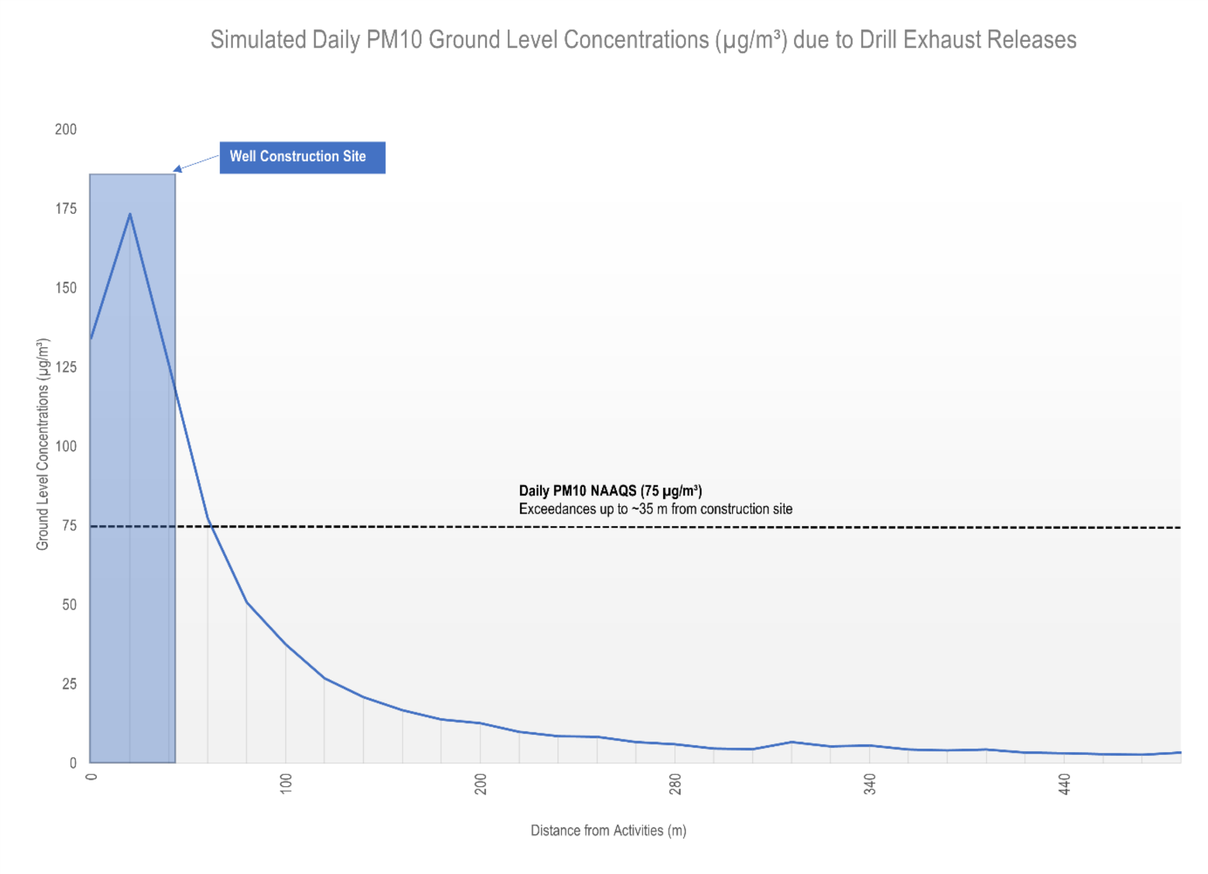

Figure 4-1: Profile for the simulated maximum daily PM_{10} ground level concentrations due to testing well construction activities

4.2.2 Light Vehicle Activities

It is assumed that light vehicles will be present in the target areas as well as the seismic transects. The simulated ground level concentrations due to vehicle activity are provided as a function of distance and are illustrated in **Figure 4-2** to **Figure 4-7**. No exceedances of NAAQS are expected due to light vehicle activity.

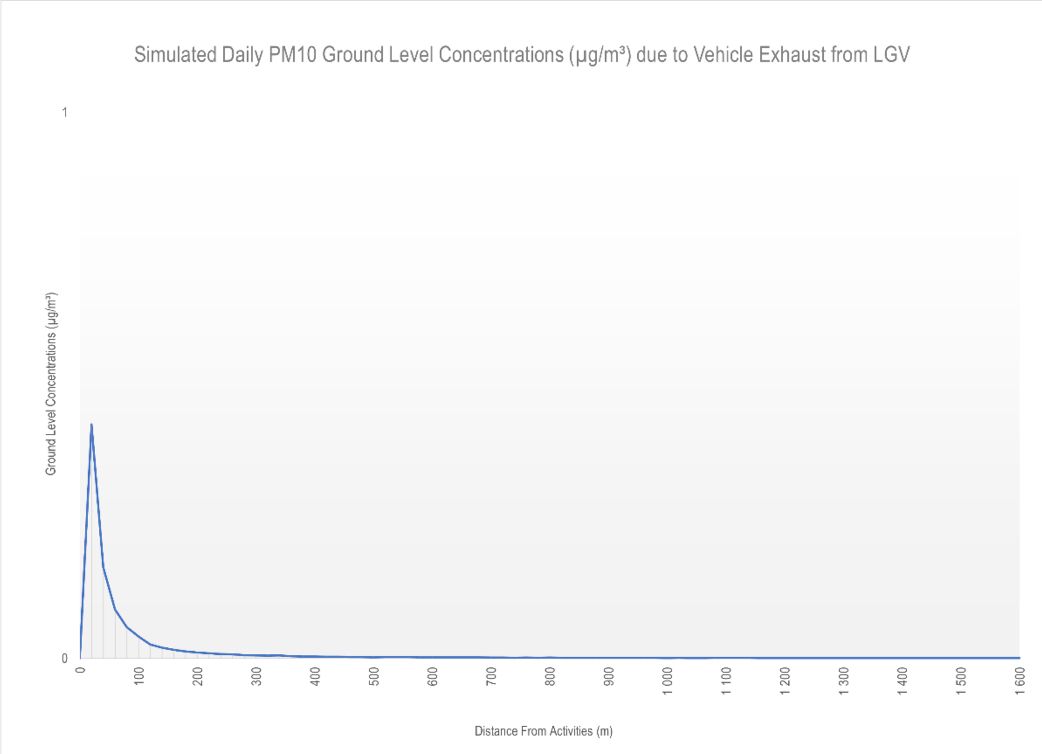

Figure 4-2: Profile for the simulated maximum daily PM_{10} ground level concentrations due to light vehicle activities

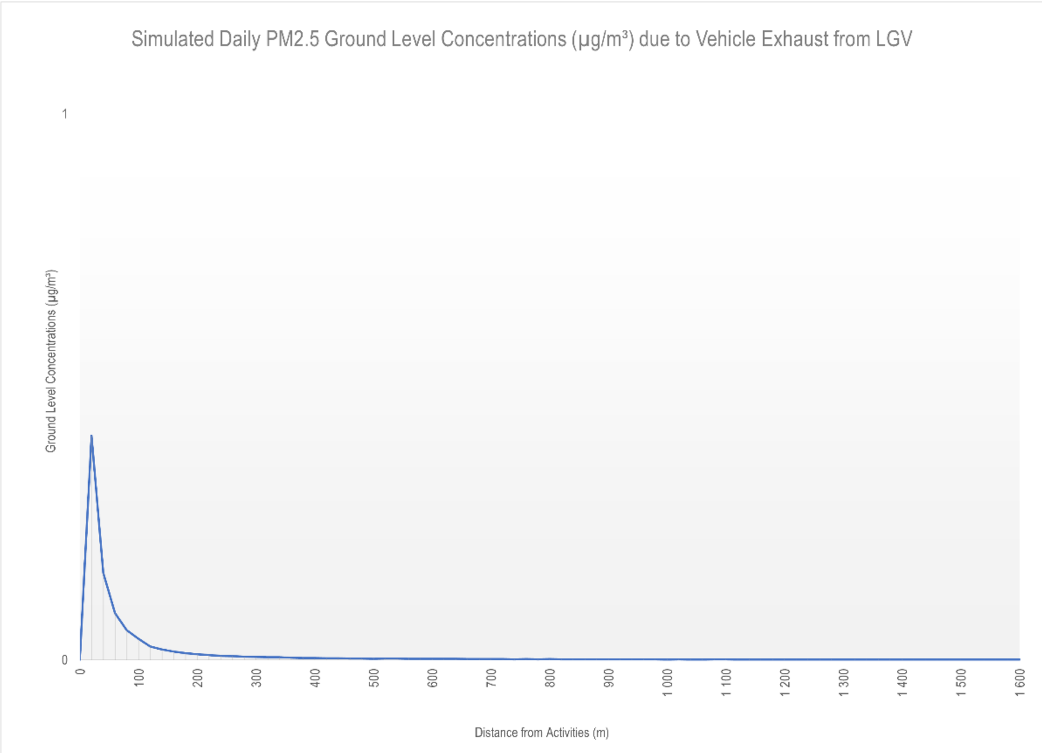

Figure 4-3: Profile for the simulated maximum daily $PM_{2.5}$ ground level concentrations due to light vehicle activities

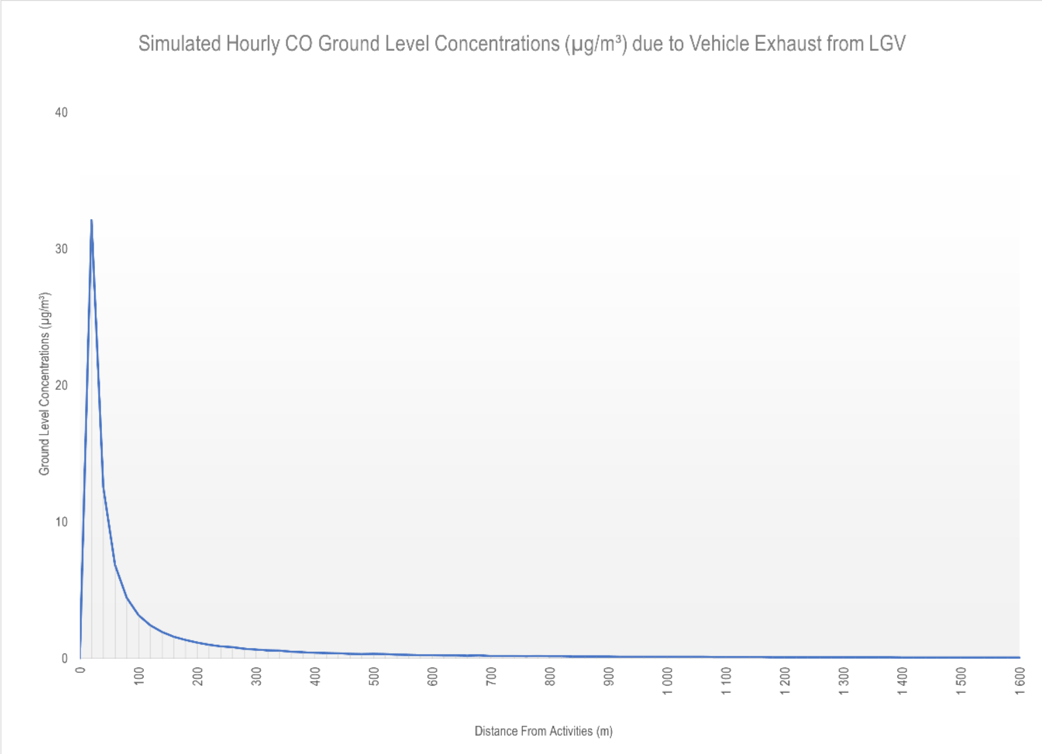

Figure 4-4: Profile for the simulated maximum hourly CO ground level concentrations due to light vehicle activities

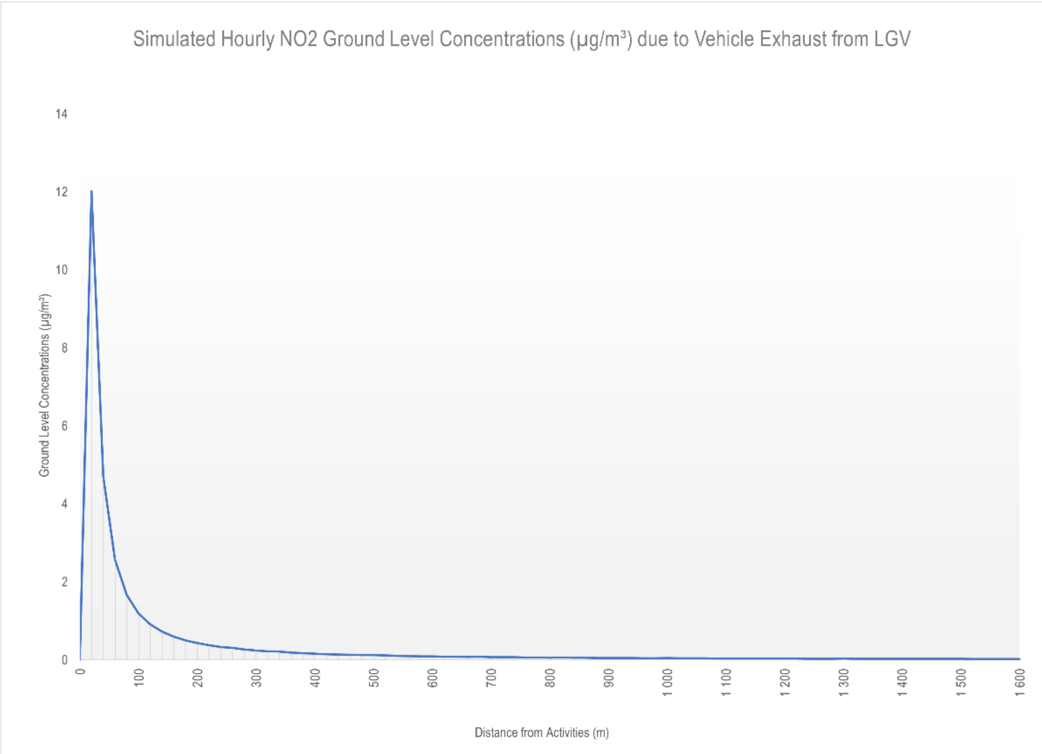

Figure 4-5: Profile for the simulated maximum hourly NO_2 ground level concentrations due to light vehicle activities

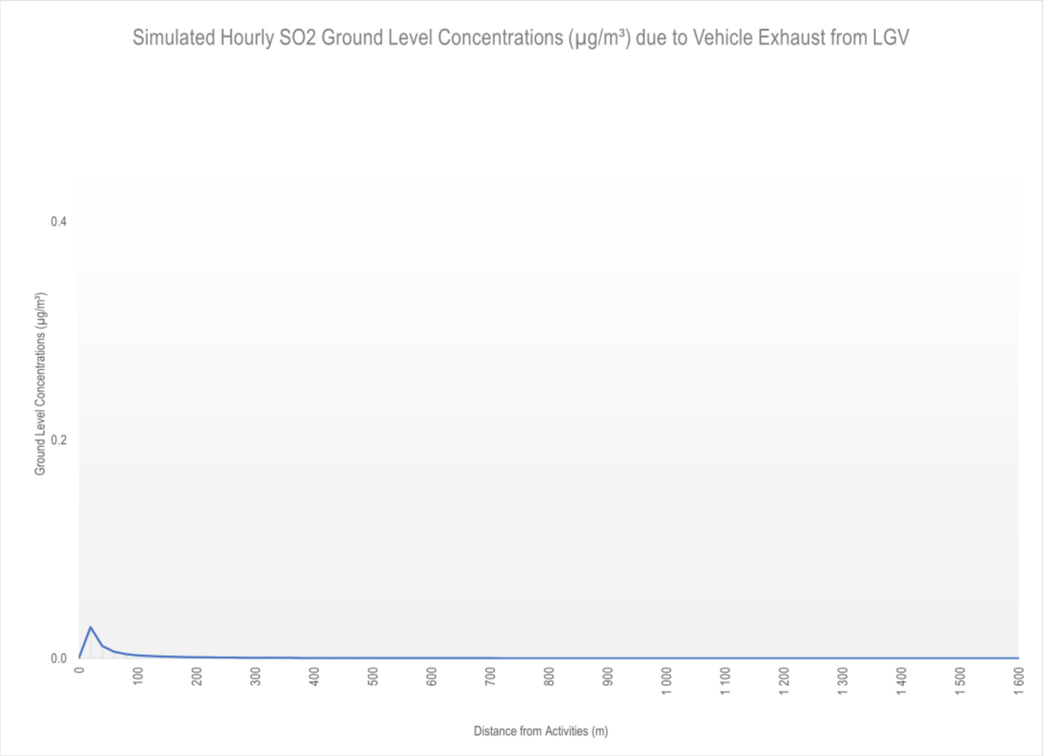

Figure 4-6: Profile for the simulated maximum hourly SO_2 ground level concentrations due to light vehicle activities

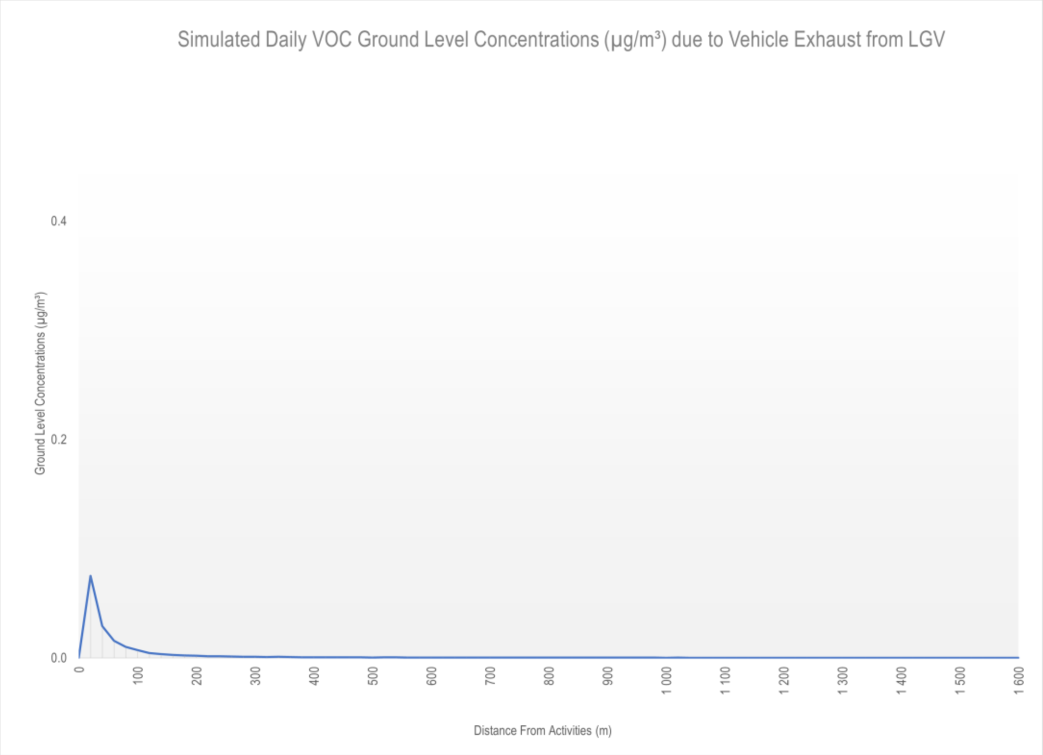

Figure 4-7: Profile for the simulated maximum daily VOC ground level concentrations due to light vehicle activities

4.2.3 Truck Activities

It is assumed that trucks would be in the target areas and the seismic transects (i.e. truck for the seismic vibrator). The simulated ground level concentrations due to truck activity are provided as a function of distance and are illustrated in **Figure 4-8** to **Figure 4-13**. The daily $PM_{2.5}$ NAAQ limits are exceeded up to a distance of 30 m from source and hourly NO_2 NAAQ limit is exceeded up to a distance of 260 m from source. Given that the seismic vibrator moves along the seismic transects and will not result in continuous exhaust emissions in one area, it is unlikely that NAAQS would be exceeded in one area due to this activity. Similarly, trucks within the target areas are unlikely to stay in one area for long periods of time or run continuously for 12 hours and will therefore not likely result in exceedances of NAAQS.

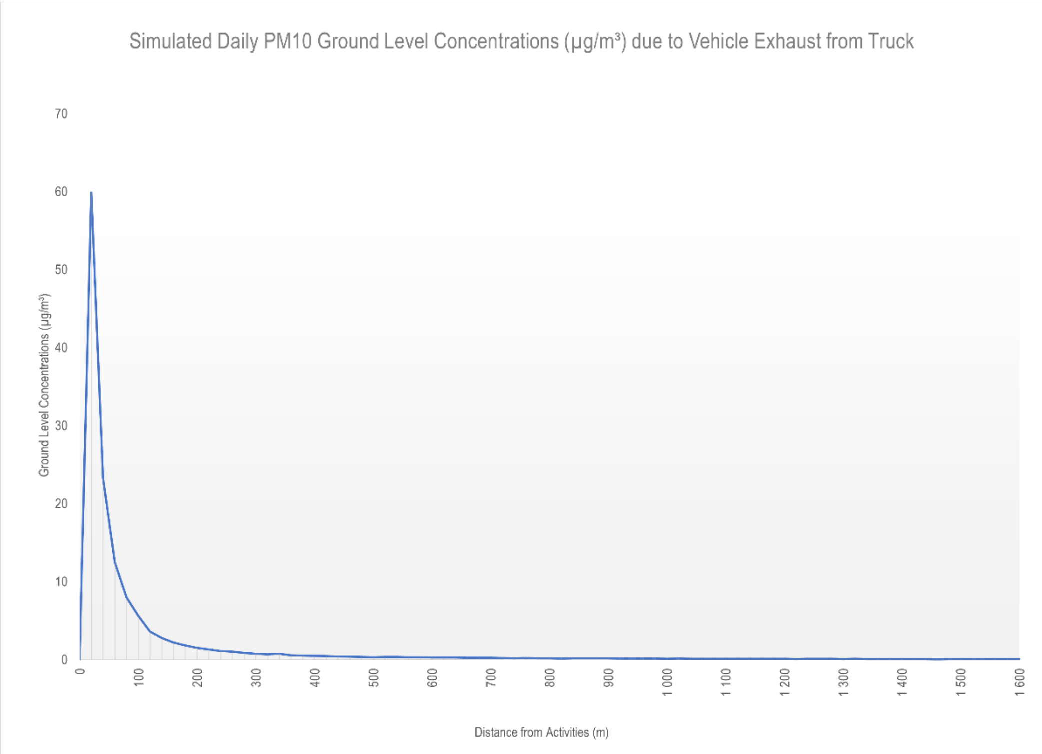

Figure 4-8: Profile for the simulated maximum daily PM_{10} ground level concentrations due to truck activities

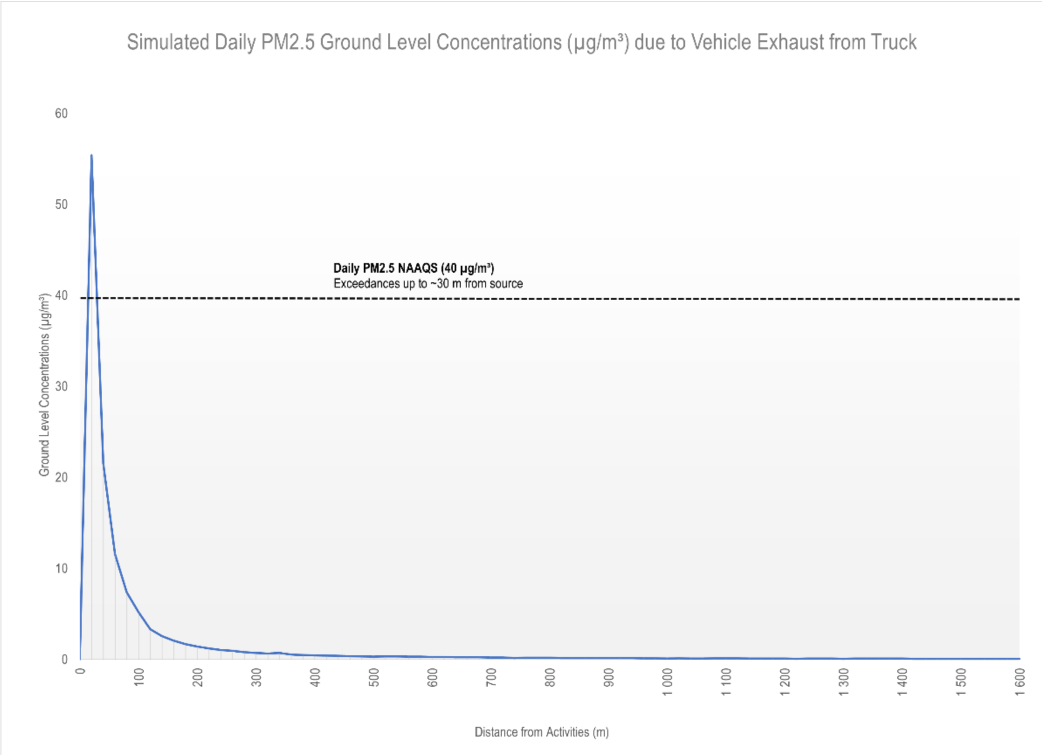

Figure 4-9: Profile for the simulated maximum daily $PM_{2.5}$ ground level concentrations due to truck activities

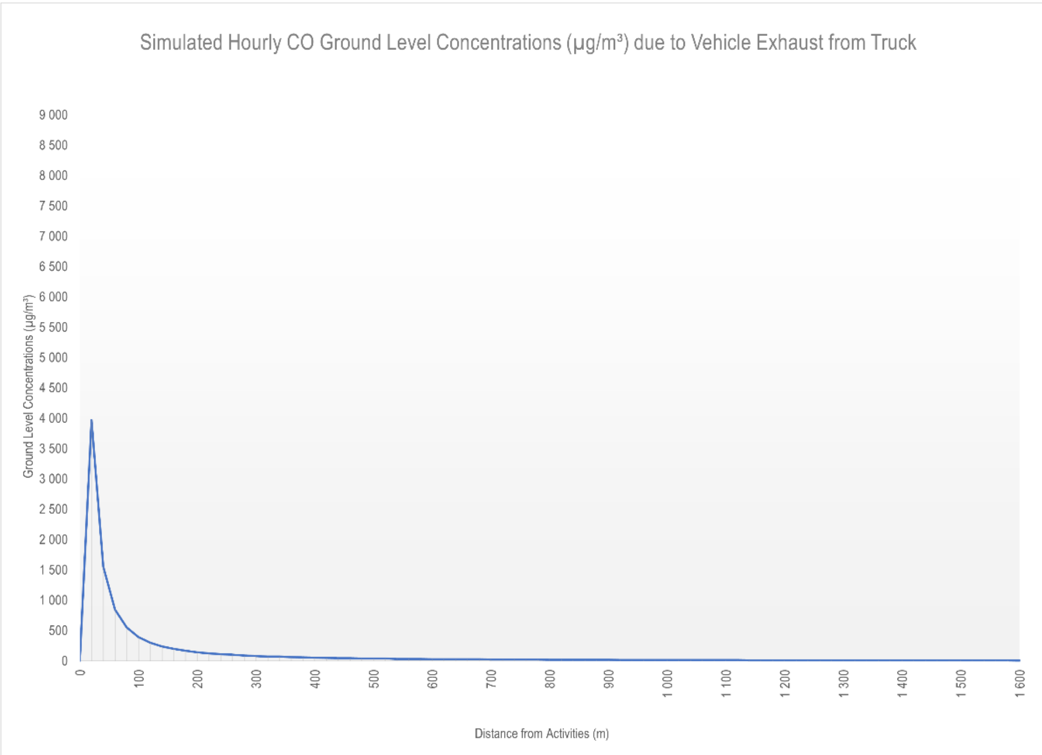

Figure 4-10: Profile for the simulated maximum hourly CO ground level concentrations due to truck activities

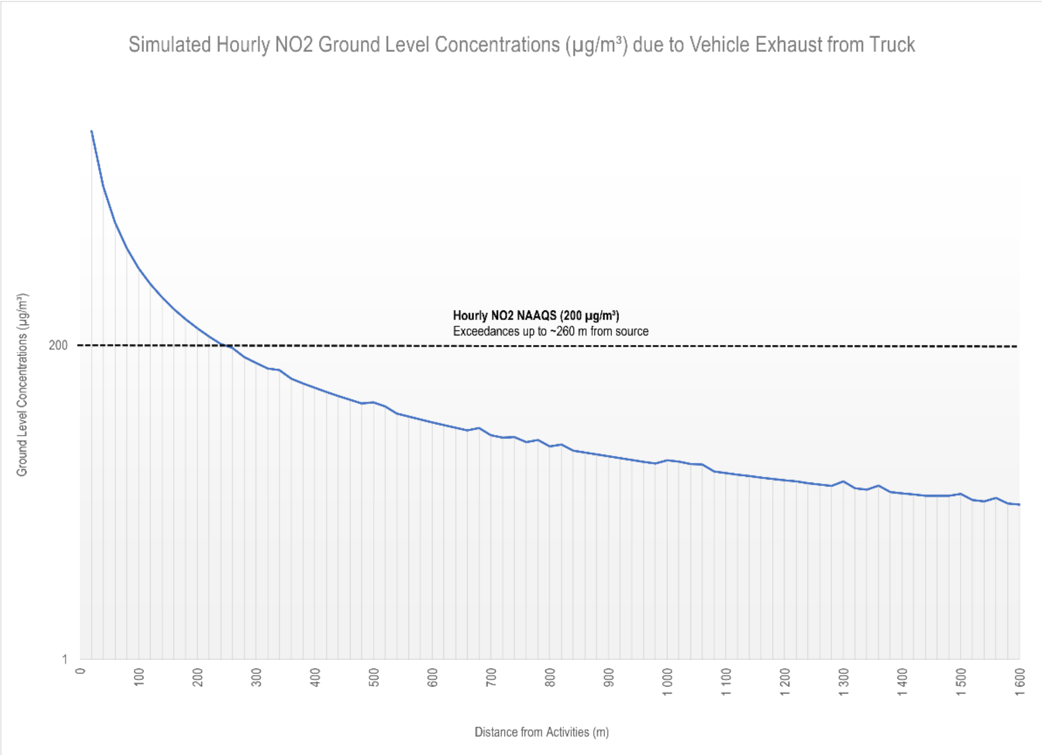

Figure 4-11: Profile for the simulated maximum hourly NO_2 ground level concentrations due to truck activities

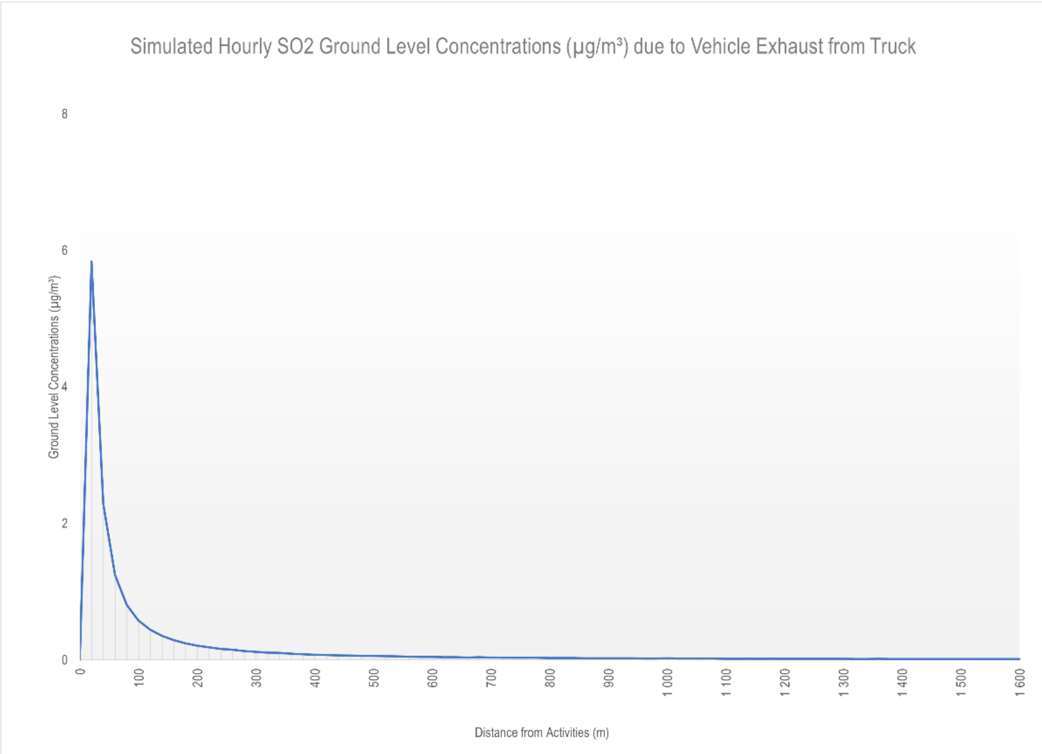

Figure 4-12: Profile for the simulated maximum hourly SO_2 ground level concentrations due to truck activities

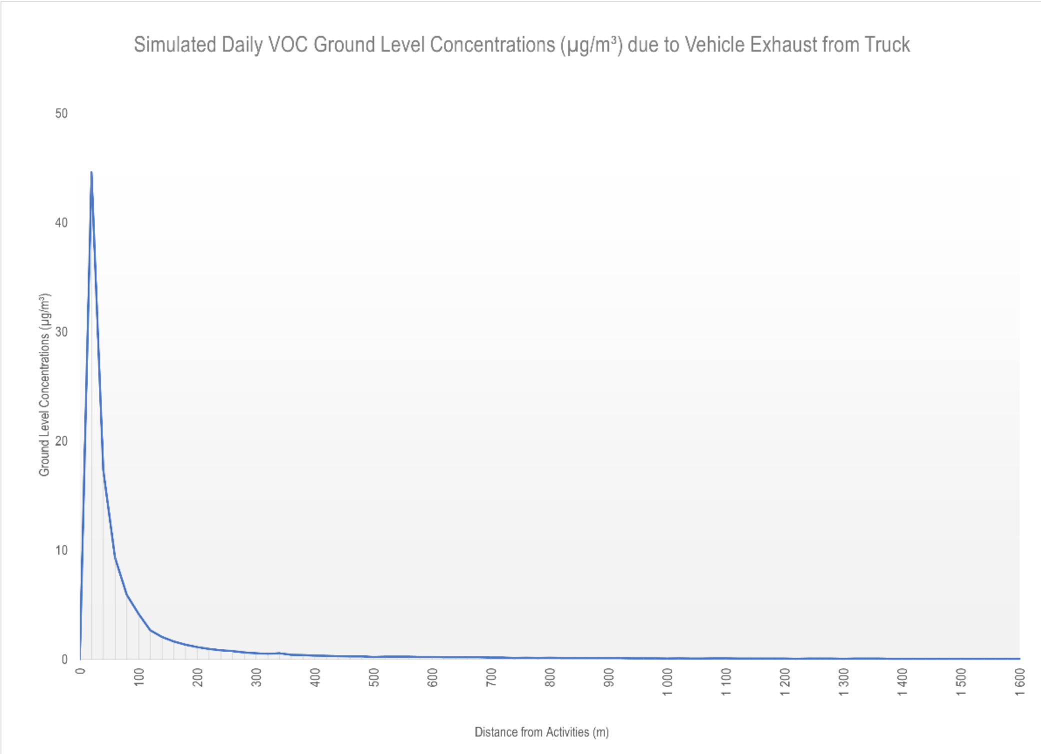

Figure 4-13: Profile for the simulated maximum daily VOC ground level concentrations due to truck activities

4.2.4 Well Drilling

As the exact location of the testing wells are not known, the ground level concentrations due to exhaust releases from drills are provided as a function of distance and are illustrated in **Figure 4-14** to **Figure 4-19**. The daily PM_{10} and $PM_{2.5}$ NAAQ limits are exceeded up to a distance of 50 m and 60 m from the source respectively and hourly NO_2 NAAQ limit is exceeded up to a distance of 520 m from source. When comparing the daily maximum VOC concentrations to the comfort level of 200 µg/m³, the distance of exceedance is 25 m from the source.

The drilling of the wells will consist of drilling through the Karoo formation at 30 m per hour and drilling through the Wits formation at 12 m per hour. With each exploration well drilling to a depth of 650 m, the worst-case drill scenario would take 54 hours and 10 minutes. From start to finish, the drilling activities take 2 weeks to complete per drilling site.

Given that the NAAQS allows for 88 hours of exceedance of the limits per year and given that drilling could be up to 54 hours, the hourly NO_2 NAAQS will not be exceeded due to this activity. Given that the NAAQS allows for 4 days of exceedance of the limits per year, the daily PM_{10} and $PM_{2.5}$ NAAQS due to drilling activities could be exceeded up to 50 m and 60 m respectively from the source if activities extend beyond 4 days.

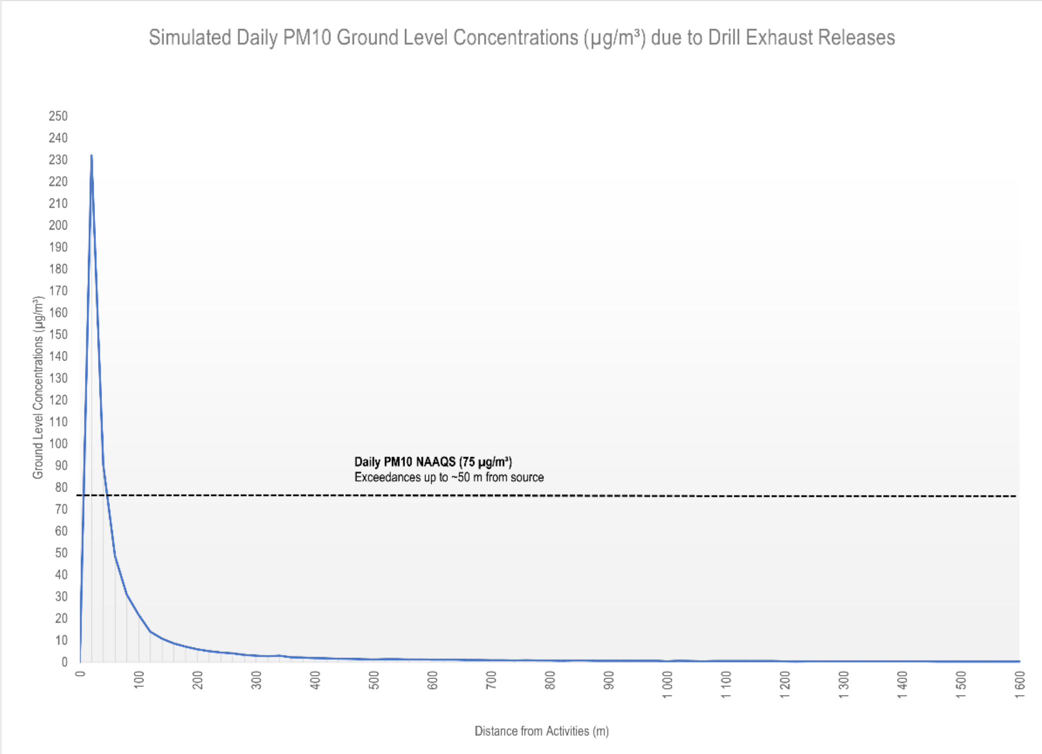

Figure 4-14: Profile for the simulated maximum daily PM_{10} ground level concentrations due to drill exhaust releases

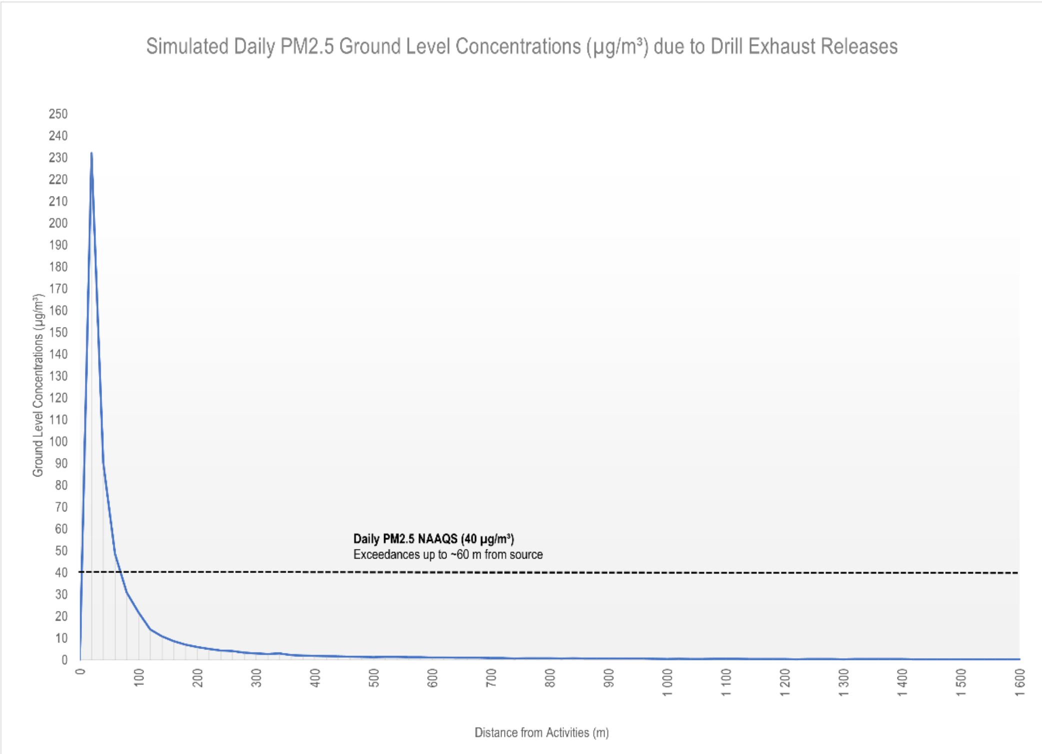

Figure 4-15: Profile for the simulated maximum daily $PM_{2.5}$ ground level concentrations due to drill exhaust releases

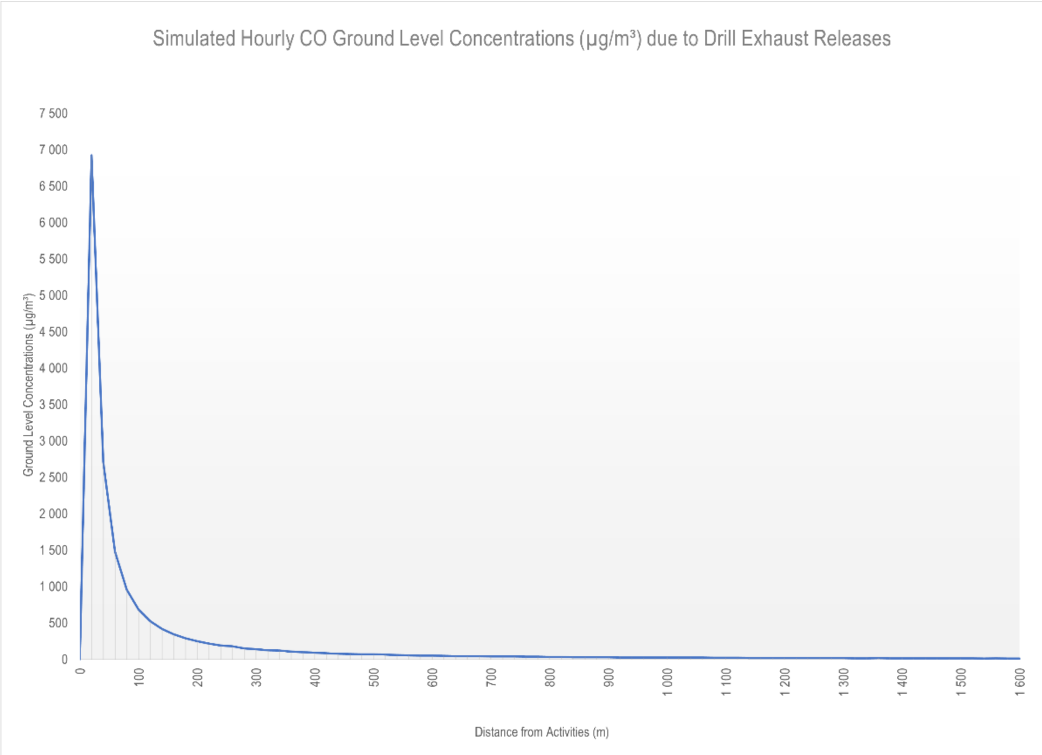

Figure 4-16: Profile for the simulated maximum hourly CO ground level concentrations due to drill exhaust releases

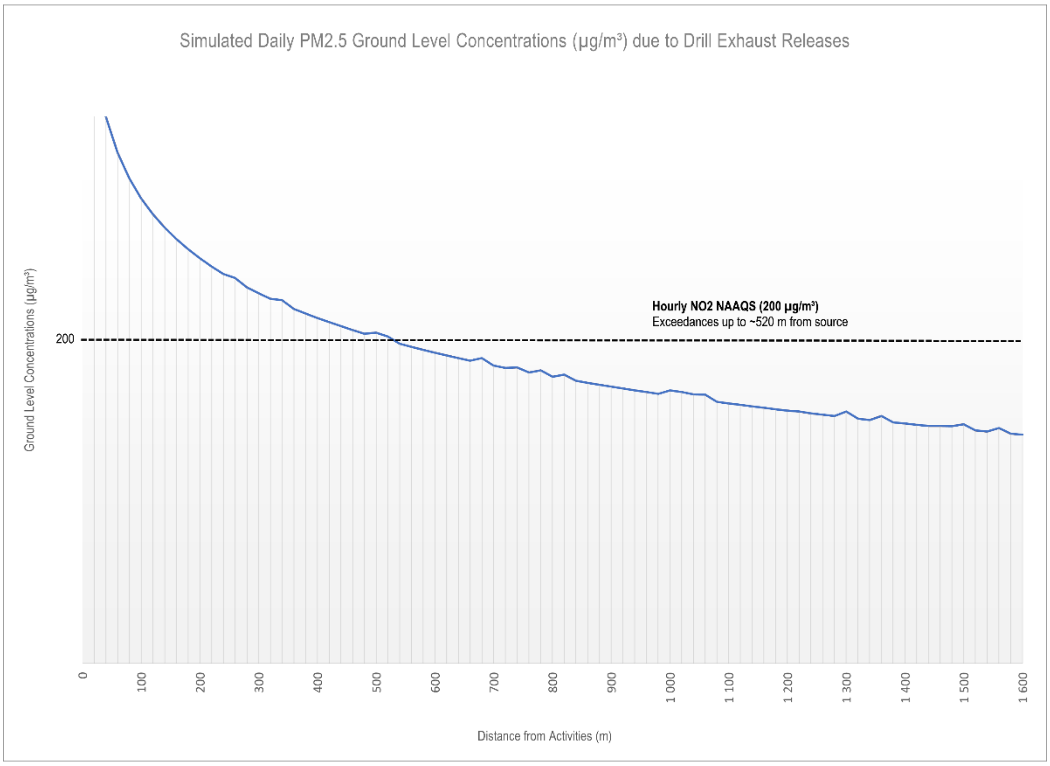

Figure 4-17: Profile for the simulated maximum hourly NO_2 ground level concentrations due to drill exhaust releases

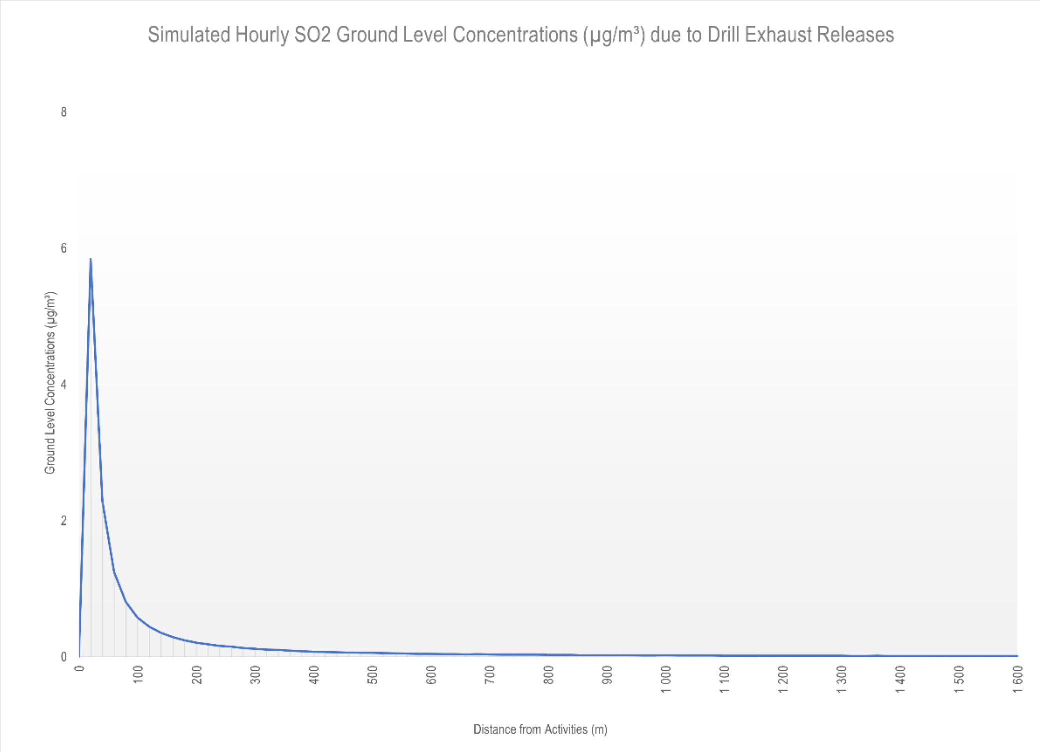

Figure 4-18: Profile for the simulated maximum hourly SO_2 ground level concentrations due to drill exhaust releases

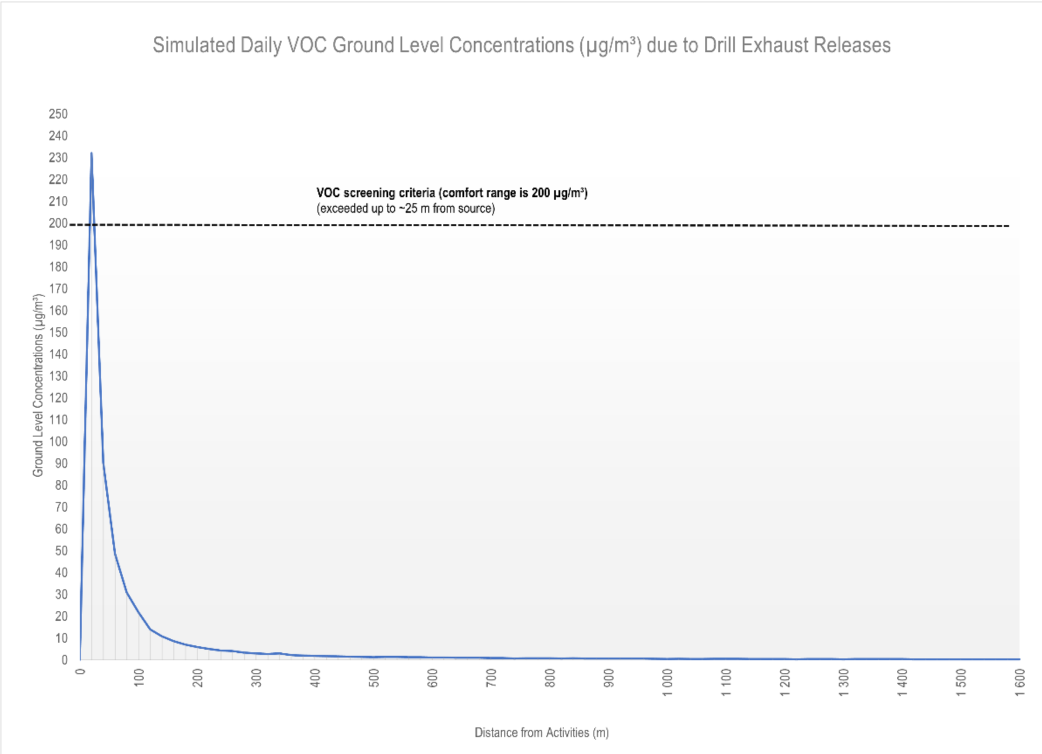

Figure 4-19: Profile for the simulated maximum daily VOC ground level concentrations due to drill exhaust releases

4.2.5 Testing Well Gaseous Release

The simulated daily NMVOC ground level concentrations due to testing well releases is provided as a function of distance and is illustrated in **Figure 4-20**. When conservatively comparing the daily maximum NMVOC concentrations to the comfort level of 200 µg/m³, the distance of exceedance is 150 m from the source.

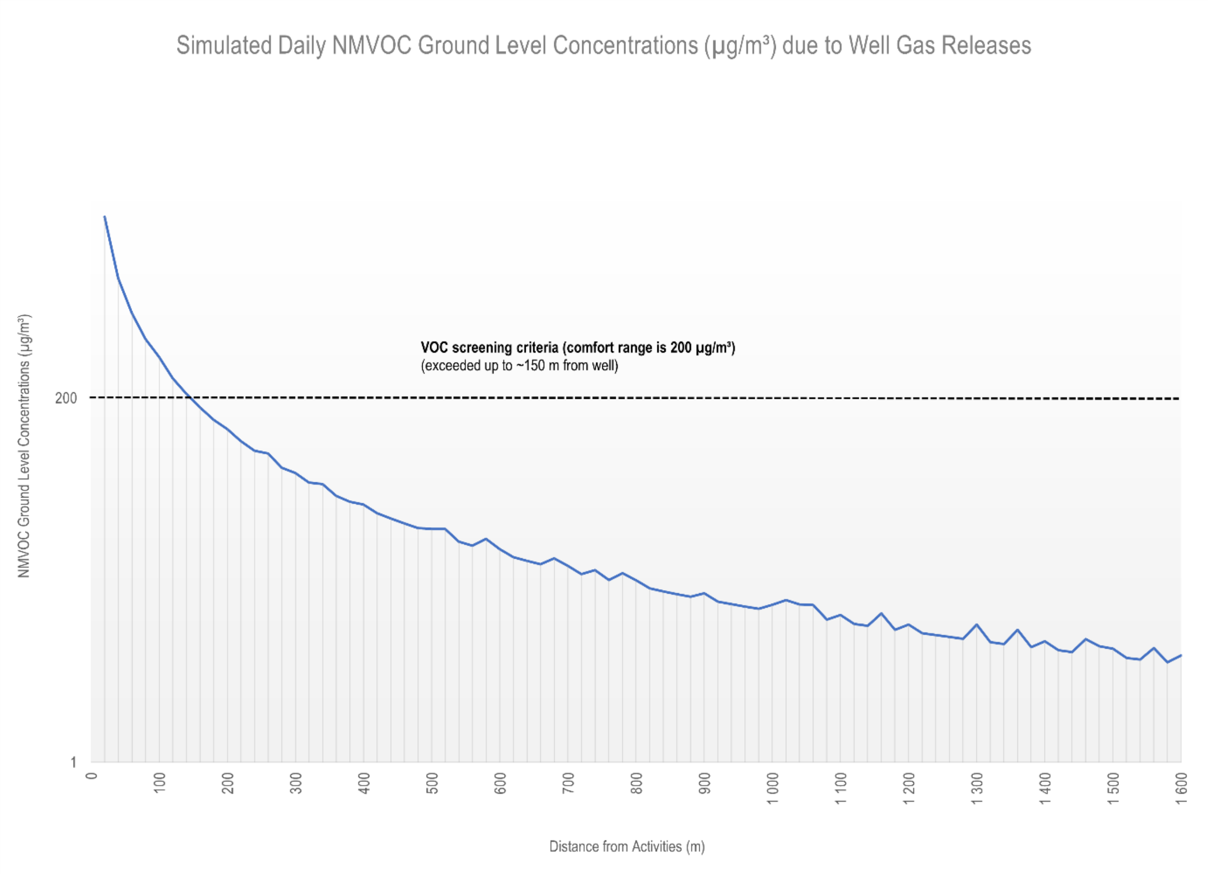

Figure 4-20: Profile for the simulated maximum daily VOC ground level concentrations due to testing well releases

4.2.6 Summary of Results

A summary of the exceedance of the assessment criteria as a distance from the project activities is provided in **Table 4-6**. The potential sensitive receptors that may be impacted by the project activities is summarised in **Table 4-6** with the receptors referenced in **Figure 4-21**.

Table 4-6: Summary of the exceedances of the assessment criteria as a distance from the project activities

<table>
<tr><th>Project Area</th><th>Project phase</th><th>Source</th><th>Pollutant</th><th>Averaging period</th><th>NAAQS/ screening criteria (µg/m³)</th><th>Exceedance of NAAQS/ screening criteria as a distance from the source (m)</th><th>Potential sensitive receptors that may be impacted due to project activities</th><th>Distance of source from target areas (TA) or transects</th></tr>
<tr><td rowspan="11">Target Areas</td><td rowspan="8">Construction</td><td>Construction of site (land clearing)</td><td>PM_{10}</td><td>Daily</td><td>75</td><td>35</td><td>A</td><td>Within TA11 (Map A)</td></tr>
<tr><td>Truck (engine exhaust releases)</td><td colspan="6">No exceedances of the NAAQS expected for this activity</td></tr>
<tr><td rowspan="6">Drill (exhaust releases)</td><td rowspan="2">PM_{10}</td><td rowspan="2">Daily</td><td rowspan="2">75</td><td rowspan="2">50</td><td>A</td><td>Within TA11 (Map A)</td></tr>
<tr><td>F</td><td>Within TA2 (Map C)</td></tr>
<tr><td rowspan="2">$PM_{2.5}$</td><td rowspan="2">Daily</td><td rowspan="2">40</td><td rowspan="2">60</td><td>A</td><td>Within TA11 (Map A)</td></tr>
<tr><td>F</td><td>Within TA2 (Map C)</td></tr>
<tr><td rowspan="2">VOC</td><td rowspan="2">Daily</td><td rowspan="2">200[(b)]</td><td rowspan="2">25</td><td>A</td><td>Within TA11 (Map A)</td></tr>
<tr><td>F</td><td>Within TA2 (Map C)</td></tr>
<tr><td rowspan="2">Operation</td><td rowspan="2">Testing well gaseous releases</td><td rowspan="2">NMVOC</td><td rowspan="2">Daily</td><td rowspan="2">200[(b)]</td><td rowspan="2">150</td><td>A</td><td>Within TA11 (Map A)</td></tr>
<tr><td>F</td><td>Within TA2 (Map C)</td></tr>
<tr><td>Closure[(a)]</td><td>Rehabilitation with topsoil[(a)]</td><td>PM_{10}</td><td>Daily</td><td>75</td><td>35</td><td>A</td><td>Within TA11 (Map A)</td></tr>
<tr><td rowspan="3">Seismic Transects</td><td>Construction</td><td colspan="7">No construction activity required</td></tr>
<tr><td>Operation</td><td>Truck (engine exhaust releases)</td><td colspan="6">No exceedances of the NAAQS expected for this activity</td></tr>
<tr><td>Closure[(a)]</td><td colspan="7">No closure activity required</td></tr>
</table>

(a) Impacts due to closure were assumed to be similar to construction of site (land clearing)
(b) The VOC screening criteria is a comfort level and not a health effect screening level.

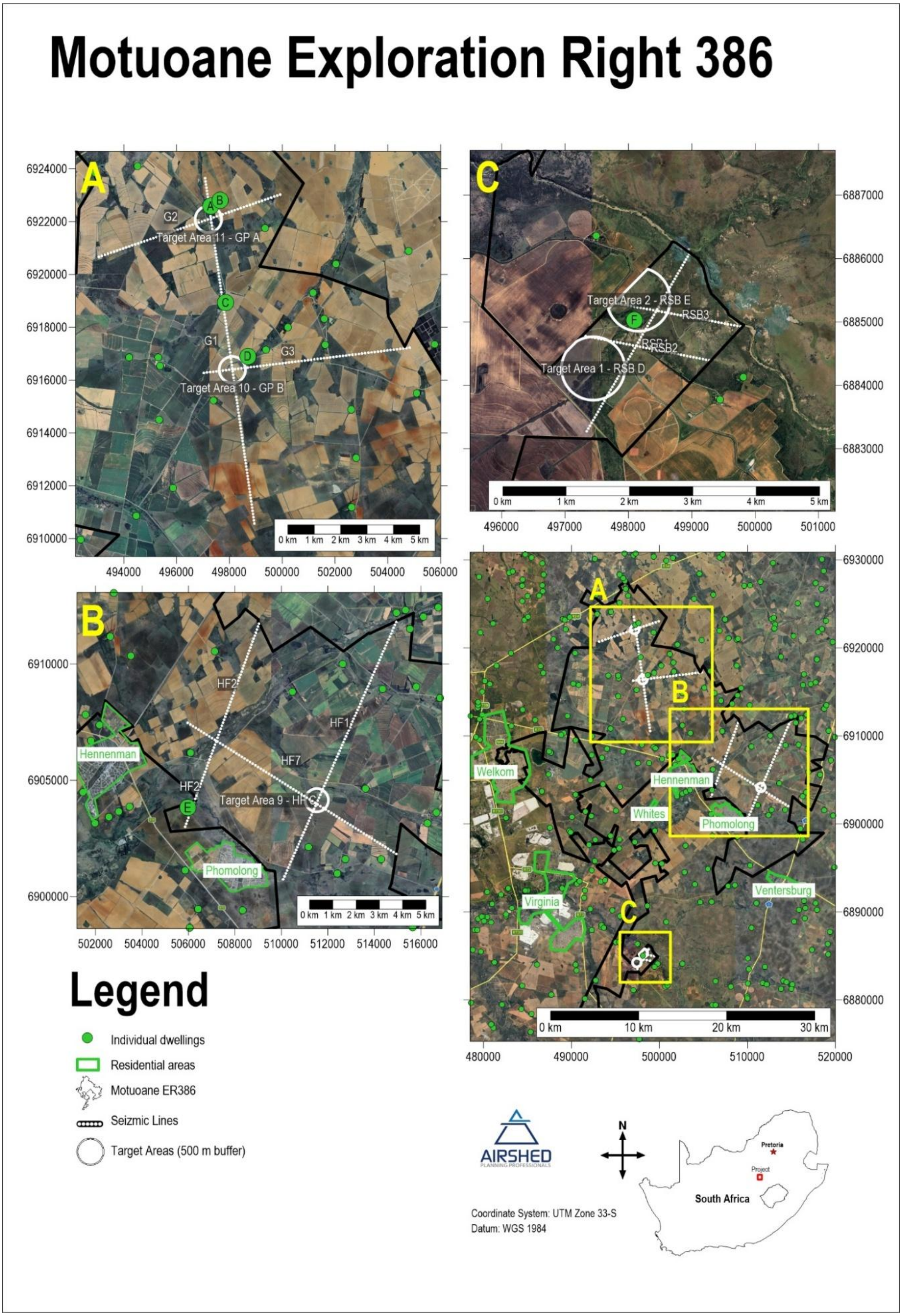

Figure 4-21: Potential sensitive receptors that may be impacted due to project activities

5 IMPACT SIGNIFICANCE RATING

The 2014 EIA Regulations require that impacts be assessed in terms of the nature, significance, consequence, extent, duration and probability of the impacts; including the degree to which these impacts can be reversed, may cause irreplaceable loss of resources, and can be avoided, managed or mitigated. The significance ranking methodology used in this AQIA is provided in Appendix C.

The project is expected to have the following significance rating (**Table 5-1**):

- Target areas:
  - Construction Phase:
    - Without mitigation: high-medium negative significance rating.
    - With mitigation: low negative significance rating.
    - Overall significance rating: low negative significance rating.
  - Operation Phase:
    - Without mitigation: medium-low negative significance rating.
    - With mitigation: low negative significance rating.
    - Overall significance rating: low negative significance rating.
  - Decommissioning Phase:
    - Without mitigation: high-medium negative significance rating.
    - With mitigation: low negative significance rating.
    - Overall significance rating: low negative significance rating.
- Seismic transects:
  - Operation Phase:
    - Without mitigation: low negative significance rating.
    - With mitigation (good housekeeping practices): low negative significance rating.
    - Overall significance rating: low negative significance rating.

Table 5-1: Significance rating for potential air quality impacts due to the project activities

Impact Description		Pre-Mitigation						Pre-mitigation significance	Post Mitigation						Post-mitigation significance	Confidence	Priority Factor Criteria		Priority Factor	Final score
Impact	Phase	Nature	Extent	Duration	Magnitude	Reversibility	Probability		Nature	Extent	Duration	Magnitude	Reversibility	Probability			Cumulative Impact	Irreplaceable loss		
Ambient air quality at target areas[(a)]	Construction	-1	2	2	4	2	4	-10 (high-medium)	-1	2	2	2	2	2	-4 (low)	Medium	1	1	1	-4
	Operation	-1	2	2	2	2	4	-6 (medium-low)	-1	2	2	2	2	2	-4 (low)	Medium	1	1	1	-4
	Decommissioning	-1	2	2	4	2	4	-6 (high-medium)	-1	2	2	2	2	2	-4 (low)	Medium	1	1	1	-4
Ambient air quality at seismic transects[(b)]	Operation	-1	2	2	2	1	1	-3.5 (low)	-1	2	2	2	1	2	-3.5 (low)	Medium	1	1	1	-3.5

(a) Mitigation measures would include setback distances from activities to potential sensitive receptors to prevent exceedances at NAAQS at receptors
(b) Mitigation measures for the seismic transect areas would include good housekeeping practices.

6 RECOMMENDED AIR QUALITY MANAGEMENT MEASURES

In the quantification of air emissions and simulation of impacts as a result of the project, it was found that environmental air quality evaluation criteria for residential, educational, and institutional receptors may be exceeded at air quality sensitive receptors in close proximity to target areas and seismic transects.

The measures discussed in this section are measures typically applicable to industrial sites and are considered good practice. It should be noted that not all mitigation measures are to be implemented, but should the need arise the mitigation measures as discussed in this section can be considered.

6.1 Proposed Mitigation Measures

The following air quality measures are recommended during project exploration activities:

- Exploration activities should be limited to day-time hours (i.e. 06:00 – 18:00).
- During construction of target areas, the exposed areas must remain moist through water spraying during dry, windy periods.
- In order to ensure lower exhaust emissions from vehicles and machinery, equipment suppliers or contractors should be required to ensure compliance with appropriate emission standards. Also, maintenance and repair of diesel engines should be carried out as prescribed by manufacturer in order to maximise combustion and reduce gaseous emissions.
- Fuel efficient driving practices on site may also help lower exhaust emissions from vehicles and machinery, such as stipulating a maximum speed on all unpaved roads. In addition, other fuel-efficient practices that may lower exhaust emissions include limiting idling of machinery, driving in an upper gear rather than a lower gear as much as possible, ensuring tire pressure are always adequate etc.
- All residents within 600 m of the target areas and 300 m of the seismic transects should be notified before project activities take place.
- An air quality complaints register must be established and maintained throughout the project activities. Channels for logging of complaints should be communicated to all residents within 600 m of the target areas and 300 m of the seismic transects. If complaints are received, they must be promptly investigated, recorded and addressed.

Sector-specific mitigation in gas exploration is focused on mitigating emissions from the testing wells. Key strategies include the following:

- Robust Leak Detection and Repair (LDAR) Programs:
    - Advanced LDAR programs can include visual checks, utilising infrared cameras (optical gas imaging), drones, satellites, and sensors to detect, locate, and quantify gas leaks from wells.
    - Leading practices recommend frequent (quarterly or even continuous) inspection, particularly for high-emitting components.
    - Upon detection, leaks must be repaired promptly to minimise fugitive emissions.

- Reducing methane releases during well testing
- Proper capping and abandonment
    - To prevent leaks from abandoned or inactive wells, wells must be plugged following modern, robust standards, rather than simply sealed with a basic cap.
    - Regular monitoring of capped wells is necessary to identify and remediate leakage from degraded cement or casing, which is a major source of gas seepage.

6.2 Air Quality Monitoring

Methane emissions can be monitored during well testing to assist with the greenhouse gas quantification.

6.3 Impact Zones

Table 6-1 provides setback zones for potential air quality impacts. These are conservative buffer zones in consideration of air quality impacts in the project region. Therefore, these are seen as management zones where the potential for air quality impacts can be mitigated and managed.

Table 6-1: Recommended setback distances

Project areas	Setback distance (m)	Indicator Pollutant	Description
Target Area	200 (from drill)	VOC	Setback distance represents a single exceedance of a VOC comfort level, not a health screening criteria. The setback distance for this pollutant is for management of VOC releases from the well itself and not a buffer zone distance from sensitive receptors.
Target Area	60 (from drill)	$PM_{2.5}$	Setback distance represents a single exceedance of the $PM_{2.5}$ daily NAAQ limit. The placement of wells should be placed at least 60 m from sensitive receptors to prevent exceedances of PM NAAQS at receptors.

7 FINDINGS AND RECOMMENDATIONS

7.1 Findings

An air quality impact assessment was conducted for the project activities. The main objective of this study was to determine the significance of the predicted impacts from the project activities on the surrounding environment and on human health. Emission rates were quantified for the project activities and dispersion modelling executed.

The main findings from the baseline assessment were as follows:

- The predominant wind direction is from the northeastern sector.
- Numerous individual homesteads and residential areas are located within the study area.

The main findings from the impact assessment due to project activities were as follows:

- Target areas:
    - Construction:
        - Maximum daily PM_{10} ground level concentrations due to drill activities and land clearing, exceeds the daily PM_{10} NAAQ limit up to a distance of 50 m from the drill and 35 m from the target area site respectively. It should be noted, however, that the daily NAAQS allows for 4 exceedances of the limit per calendar year. Land clearing (up to 35 m from the target area) and drilling activities (up to 50 m from the drill) would thus exceed the NAAQS if activities are longer than 4 days per target area per year.
        - Maximum daily $PM_{2.5}$ ground level concentrations due to truck and drill activities, exceeds the daily $PM_{2.5}$ NAAQ limit up to a distance of 30 m from the truck and 60 m from the drill respectively. Given that the NAAQS allows for 4 daily exceedances of the limit per year, the $PM_{2.5}$ NAAQS may be exceeded up to 60 m from the drill if drill activities are for more than 4 days per target area per year.
        - Maximum hourly NO_2 ground level concentrations due to truck and drill activities, exceeds the hourly NO_2 NAAQ limit up to a distance of 260 m from the truck and 520 m from the drill respectively. The NAAQS allows for 88 hourly exceedances of the limit per year. Given that the trucks are moving sources, it is unlikely that this source would result in an exceedance of the NAAQS at any one location. Similarly, the drills would operate for 54 hours and 10 minutes as a worst case. The drilling activity would thus not result in an hourly NO_2 NAAQS exceedance.
        - Maximum daily VOC ground level concentrations due to drill activities, exceeds the comfort level of 200 µg/m³ up to a distance of 25 m from the drill. It should be noted that the VOC comfort level used for screening is not a health effect level or a NAAQS.
        - Significance rating:
            - Without mitigation: high-medium negative significance rating as there could be exceedances of the PM NAAQS up to 35 m from the target area due to land clearing and up to 60 m from the drill if these activities are for more than 4 days per target area per year.

        - With mitigation: low negative significance rating. Mitigation measures would include having target areas and exploration wells at least 35 m and 60 m from sensitive receptors respectively.
        - Overall significance rating: low negative significance rating.
  - Operation:
    - Maximum daily VOC ground level concentrations due to testing well gaseous releases, exceeds the comfort level of 200 µg/m³ up to a distance of 150 m from the source. It should be noted that the VOC comfort level used for screening is not a health effect level or a NAAQS.
    - Significance rating:
      - Without mitigation: medium-low negative significance rating. The significance rating is based on a comfort level and not a health effect level. The magnitude of the impact is thus given as low providing an overall significance rating of medium-low.
      - With mitigation: low negative significance rating. Mitigation measures would include robust LDAR programs.
      - Overall significance rating: low negative significance rating.
  - Closure:
    - Assuming impacts due to rehabilitation activities to be similar to construction (i.e. land clearing), maximum daily PM_{10} ground level concentrations exceeds the daily PM_{10} NAAQ limit up to a distance of 35 m from the target area site. Given that the daily PM_{10} NAAQS allows for 4 exceedances of the limit per year, the activities should be limited to less than 4 days per target area per year to avoid exceedances of the NAAQS.
    - The testing wells must be capped and sealed and should not have any gaseous releases if properly managed.
    - Significance rating:
      - Without mitigation: high-medium negative significance rating, as there could be exceedances of the PM NAAQS up to 35 m from the target area due to rehabilitation activities.
      - With mitigation: low negative significance rating. Mitigation measures would include limiting rehabilitation activities per target area to within 4 days per year.
      - Overall significance rating: low negative.

- Seismic transects:
  - Construction:
    - No air quality impacts expected.
  - Operation:
    - Maximum daily $PM_{2.5}$ ground level concentrations due to truck activities, exceeds the daily $PM_{2.5}$ NAAQ limit up to a distance of 30 m from the source.
    - Maximum hourly NO_2 ground level concentrations due to truck activities, exceeds the hourly NO_2 NAAQ limit up to a distance of 260 m from the source.

        - Given the nature of the activity and that the truck will not be operating continuously or in the same location, it is unlikely that the NO_2 and $PM_{2.5}$ NAAQS (which allows for 88 hours or 4 days of exceedance of the hourly and daily limit per year respectively) will be exceeded.
        - Significance rating:
            - Without mitigation: low negative significance rating.
            - With mitigation: low negative significance rating.
            - Overall significance rating: low negative.
    - Closure:
        - No air quality impacts expected.

7.2 Recommendations

Based on the findings of the AQIA, it is the specialist's opinion that the project can be authorised without significant impact on the surrounding potentially sensitive receptors, provided that the following recommendations are taken into account:

- All exploration activities are limited to day-time hours (i.e. 06:00 to 18:00).
- All residents within 600 m of drilling areas and 300 m of seismic surveys are consulted regarding the exploration activities.
- Scheduling of activities are communicated and co-ordinated with nearby residents.
- An air quality complaints register is kept. If complaints are received, they must be promptly investigated, recorded and addressed. Channels for logging of complaints should be communicated to all residents within 600 m of target areas and 300 m of seismic transects.
- Mitigation and monitoring measures as discussed in Section 6 be considered.

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APPENDIX A - COMPREHENSIVE CURRICULUM VITAE OF THE AUTHOUR OF THE CURRENT ASSESSMENT

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	Reneé von Gruenewaldt (*nee* Thomas)
Profession	Air Quality and Environmental Noise Scientist
Position	Principal consultant
Date of Birth	13 May 1978
Years with Firm	Since January 2002
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP)
- Member of the National Association for Clean Air (NACA)

KEY QUALIFICATIONS

Reneé von Gruenewaldt (Air Quality Scientist): Reneé joined Airshed Planning Professionals (Pty) Ltd (previously known as Environmental Management Services cc) in 2002. She has, as a Specialist, attained over twenty (20) years of experience in the Earth and Natural Sciences sector in the field of Air Quality and nine (9) years of experience in the field of environmental noise assessments. As an environmental practitioner, she has provided solutions to both large-scale and smaller projects within the mining, minerals, and process industries.

She has developed technical and specialist skills in various air quality modelling packages including the AMS/EPA Regulatory Models (AERMOD and AERMET), UK Gaussian plume model (ADMS), EPA Regulatory puff-based model (CALPUFF and CALMET), puff-based HAWK model and line-based models, Lagrangian GRAL model. Her experience with air emission models includes Tanks 4.0 (for the quantification of tank emissions), WATER9 (for the quantification of wastewater treatment works) and GasSim (for the quantification of landfill emissions). Noise propagation modelling proficiency includes CONCAWE, South African National Standards (SANS 10210) for calculating and predicting road traffic noise and CadnaA for propagation of industrial, road and rail noise sources.

Having worked on projects throughout Africa (i.e., South Africa, Mozambique, Malawi, Kenya, Angola, Democratic Republic of Congo, Namibia, Madagascar and Egypt for Air Quality Impact Assessments and Mozambique, Namibia, Botswana, Kenya, Ghana, Suriname and Afghanistan for Environmental Noise Impact Assessments) Reneé has developed a broad experience base. She has a good understanding of the laws and regulations associated with ambient air quality and emission limits in South Africa and various other African countries, as well as the World Bank Guidelines, European Community Limits and World Health Organisation.

RELEVANT EXPERIENCE (AIR QUALITY)

Mining and Ore Handling

Reneé has undertaken numerous air quality impact assessments and management plans for coal, platinum, uranium, copper, cobalt, chromium, fluorspar, bauxite, manganese and mineral sands mines. These include: compilation of emissions databases for Landau and New Vaal coal collieries (SA), impact assessments and management plans for numerous mines over Mpumalanga (viz. Schoonoord, Belfast, Goedgevonden, Mbila, Evander South, Driefontein, Hartogshoop, Belfast, New Largo, Geluk, etc.), Mmamabula Coal Colliery (Botswana), Moatize Coal Colliery (Mozambique), Revuboe Coal Colliery (Mozambique), Toliera Sands Heavy Minerals Mine and Processing (Madagascar), Corridor Sands Heavy Minerals Mine monitoring assessment, El Burullus Heavy Minerals Mine and processing (Egypt), Namakwa Sands Heavy Minerals Mine (SA), Tenke Copper Mine and Processing Plant (DRC), Rössing Uranium (Namibia), Lonmin platinum mines including operations at Marikana, Baobab, Dwaalkop and Doornvlei (SA), Impala Platinum (SA), Pilannesburg Platinum (SA), Aquarius Platinum, Hoogland Platinum Mine (SA), Tamboti PGM Mine (SA), Sari Gunay Gold Mine (Iran), chrome mines in the Steelpoort Valley (SA), Mecklenburg Chrome Mine (SA), Naboom Chrome Mine (SA), Kinsenda Copper Mine (DRC), Kassinga Mine (Angola) and Nokeng Flourspar Mine (SA), etc.

Mining monitoring reviews have also been undertaken for Optimum Colliery's operations near Hendrina Power Station and Impunzi Coal Colliery with a detailed management plan undertaken for Morupule (Botswana) and Glencor (previously known as Xstrata Coal South Africa).

Air quality assessments have also been undertaken for mechanical appliances including the Durban Coal Terminal and Nacala Port (Mozambique) as well as rail transport assessments including BHP-Billiton Bauxite transport (Suriname), Nacala Rail Corridor (Mozambique and Malawi), Kusile Rail (SA) and WCL Rail (Liberia).

Metal Recovery

Air quality impact assessments have been carried out for Highveld Steel, Scaw Metals, Lonmin's Marikana Smelter operations, Saldanha Steel, Tata Steel, Afro Asia Steel and Exxaro's Manganese Pilot Plant Smelter (Pretoria).

Chemical Industry

Comprehensive air quality impact assessments have been completed for NCP (including Chloorkop Expansion Project, Contaminated soils recovery, C3 Project and the 200T Receiver Project), Revertex Chemicals (Durban), Stoppani Chromium Chemicals, Foskor (Richards Bay), Straits Chemicals (Coega), Tenke Acid Plant (DRC), and Omnia (Sasolburg).

Petrochemical Industry

Numerous air quality impact assessments have been completed for Sasol (including the postponement/exemption application for Synfuels, Infrachem, Natref, MIBK2 Project, Wax Project, GTL Project, re-commissioning of boilers at Sasol Sasolburg and Ekandustria), Engen Emission Inventory Functional Specification (Durban), Sapref refinery (Durban), Sasol (at Elrode) and Island View (in Durban) tanks quantification, Petro SA and Chevron (including the postponement/exemption application).

Pulp and Paper Industry

Air quality studies have been undertaken or the expansion of Mondi Richards Bay, Multi-Boiler Project for Mondi Merebank (Durban), impact assessments for Sappi Stanger, Sappi Enstra (Springs), Sappi Ngodwana (Nelspruit) and Pulp United (Richards Bay).

Power Generation

Air quality impact assessments have been completed for numerous Eskom coal fired power station studies including the ash expansion projects at Kusile, Kendal, Hendrina, Kriel and Arnot; Fabric Filter Plants at Komati, Grootvlei, Tutuka, Lethabo and Kriel Power Stations; the proposed Kusile, Medupi (including the impact assessment for the Flue Gas Desulphurization) and Vaal South Power Stations. Reneé was also involved and the cumulative assessment of the existing and return to service Eskom power stations assessment and the optimization of Eskom's ambient air quality monitoring network over the Highveld.

In addition to Eskom's coal fired power stations, various Eskom nuclear power supply projects have been completed including the air quality assessment of Pebble Bed Modular Reactor and nuclear plants at Duynefontein, Bantamsklip and Thyspunt.

Apart from Eskom projects, power station assessments have also been completed in Kenya (Rabai Power Station) and Namibia (Paratus Power Plant).

Waste Disposal

Air quality impact assessments, including odour and carcinogenic and non-carcinogenic pollutants were undertaken for the Waste Water Treatment Works in Magaliesburg, proposed Waterval Landfill (near Rustenburg), Tutuka Landfill, Mogale General Waste Landfill (adjacent to the Leipardsvlei Landfill), Cape Winelands District Municipality Landfill, the Tsoeneng Landfill (Lesotho) and the FG Landfill (near the Midstream Estate). Air quality impact assessments have also been completed for the BCL incinerator (Cape Town), the Ergo Rubber Incinerator and the Ecorevert Pyrolysis Plant.

Cement Manufacturing

Impact assessments for ambient air quality have been completed for the Holcim Alternative Fuels Project (which included the assessment of the cement manufacturing plants at Ulco and Dudfield as well as a proposed blending platform in Roodepoort).

Management Plans

Reneé undertook the quantification of the baseline air quality for the first declared Vaal Triangle Airshed Priority Area. This included the establishment of a comprehensive air pollution emissions inventory, atmospheric dispersion modelling, focusing on impact area "hotspots" and quantifying emission reduction strategies. The management plan was published in 2009 (Government Gazette 32263).

Reneé has also been involved in the Provincial Air Quality Management Plan for the Limpopo Province.

RELEVANT EXPERIENCE (GREENHOUSE GAS EMISSION FOOT-PRINTING AND CLIMATE CHANGE IMPACT STATEMENTS)

Mining and Tailings Storage Facilities

Reneé has quantified the direct and indirect (Scope 2 and Scope 3) emissions for numerous mines over the highveld of South Africa and the Democratic Republic of Congo. She has also assessed the climate risks and vulnerabilities of the project and surrounding communities due to increasing ambient temperatures, water scarcity, risk of intense storms.

Gas to Power Plants

Reneé has quantified the direct and indirect (Scope 2 and Scope 3) emissions for gas to power plants proposed for South Africa. She has also assessed the climate risks and vulnerabilities of the project and surrounding communities due to increasing ambient temperatures, water scarcity, risk of intense storms.

RELEVANT EXPERIENCE (NOISE)

Mining

Reneé has undertaken numerous environmental noise assessments for mining operations. These include environmental noise impact assessments including baseline noise surveys for numerous coal, platinum, manganese, tin and zinc mines. Projects include, but are not limited to, Balama (Mozambique), Masama Coal (Botswana), Lodestone (Namibia), Osino (Namibia), Kurmuk (Ethiopia), Gamsberg (SA), Prieska (SA), Kolomela (SA), Heuningkranz (SA), Syferfontein (SA), South 32 (SA), Mamatwan (SA), Alexander (SA) and Marula Platinum Mine (SA), etc.

Power Generation

Environmental noise assessments have been completed for numerous Eskom coal fired power station studies in SA including the Kriel Fabric Filter Plant, Kendal ash facility, Medupi ash facility. Apart from Eskom projects, power plant assessments have also been completed in Botswana (Morupule), Kenya (geothermal power plants), Suriname (EBS power plant) and SA (combined cycle power plants and thermal power plants).

Process Operations

Environmental noise assessments have been undertaken for various process operations including waste disposal facilities (Bon Accord in Gauteng), bottling and drink facilities (Imali and Isanti Project in Gauteng) and Smelter (Gamsberg in Northern Cape).

Transport

An environmental noise assessment was completed for the Obetsebi road expansion and flyover project in Ghana, the Scorpion Zinc Mine transport route in Namibia and the Sisian-Kajaran (North-South Corridor) Road Project in Armenia.

Gas Pipelines

An environmental noise assessment was completed for the Sheberghan gas pipeline in Afghanistan.

Baseline Noise Surveys

Baseline noise surveys have been undertaken for numerous mining and process operation activities (including Raumix quarries, Kolomela and Sibanye Stillwater Platinum Mines (SA)) in support of onsite Environmental Management Programmes.

OTHER EXPERIENCE (2001)

Research for B.Sc. Honours degree was part of the "Highveld Boundary Layer Wind" research group and was based on the identification of faulty data from the Majuba Sodar. The project was THRIP funded and was a joint venture with the University of Pretoria, Eskom and Sasol (2001).

EDUCATION

M.Sc. Earth Sciences	University of Pretoria, RSA, Cum Laude (2009) Title: *An Air Quality Baseline Assessment for the Vaal Airshed in South Africa*
B.Sc. Hons. Earth Sciences	University of Pretoria, RSA, Cum Laude (2001) Environmental Management and Impact Assessments
B.Sc. Earth Sciences	University of Pretoria, RSA, (2000) Atmospheric Sciences: Meteorology

ADDITIONAL COURSES

CALMET/CALPUFF	Presented by the University of Johannesburg, RSA (March 2008)
Air Quality Management	Presented by the University of Johannesburg, RSA (March 2006)

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Botswana, Ghana, Suriname, Afghanistan, Malawi, Liberia, Kenya, Angola, Democratic Republic of Congo, Ethiopia, Afghanistan, Lesotho, Namibia, Madagascar, Egypt, Suriname and Iran.

EMPLOYMENT RECORD

January 2002 - Present

Airshed Planning Professionals (Pty) Ltd, (previously known as Environmental Management Services cc until March 2003), Principal Air Quality and Environmental Noise Scientist, Midrand, South Africa.

2001

University of Pretoria, Demi for the Geography and Geoinformatics department and a research assistant for the Atmospheric Science department, Pretoria, South Africa.

Department of Environmental Affairs and Tourism, assisted in the editing of the Agenda 21 document for the world summit (July 2001), Pretoria, South Africa.

1999 - 2000

The South African Weather Services, vacation work in the research department, Pretoria, South Africa.

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- Understanding the Synoptic Systems that lead to Strong Easterly Wind Conditions and High Particulate Matter Concentrations on The West Coast of Namibia, H Liebenberg-Enslin, R von Gruenewaldt, H Rauntenbach and L Burger. National Association for Clean Air (NACA) conference, October 2017.
- Topographical Effects on Predicted Ground Level Concentrations using AERMOD, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2011.
- Emission Factor Performance Assessment for Blasting Operations, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2009.
- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007.
- A High-Resolution Diagnostic Wind Field Model for Mesoscale Air Pollution Forecasting, R.G. Thomas, L.W. Burger, and H Rautenbach. National Association for Clean Air (NACA) conference, September 2005.
- Emissions Based Management Tool for Mining Operations, R.G. Thomas and L.W. Burger. National Association for Clean Air (NACA) conference, October 2004.
- An Investigation into the Accuracy of the Majuba Sodar Mixing Layer Heights, R.G. Thomas. Highveld Boundary Layer Wind Conference, November 2002.

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Fair	Fair	Fair

CERTIFICATION

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

_______________ 11/02/2026

Signature of staff member Date (Day / Month / Year)

Full name of staff member: Reneé Georgeinna von Gruenewaldt

APPENDIX B - DECLARATION OF INDEPENDENCE

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: Reneé von Gruenewaldt
Name of Registration Body: South African Council for Natural Scientific Professions
Professional Registration No.: 400304/07

Declaration of independence and accuracy of information provided:
Air Quality Impact Assessment for the Motuoane Exploration Right Application (ER386), Free State Province

I, René von Gruenewaldt, declare that I am independent of the applicant. I have the necessary expertise to conduct the assessments required for the report and will perform the work relating the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. I will disclose to the applicant and the air quality officer all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the air quality officer. The additional information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at Pretoria on this 17th of April 2026

SIGNATURE
Principal Noise Scientist
CAPACITY OF SIGNATORY

APPENDIX C – SIGNIFICANCE RATING METHODOLOGY

The impact significance rating methodology, as presented herein and utilised for all EIMS Impact Assessment Projects, is guided by the requirements of the NEMA EIA Regulations 2014 (as amended). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/ likelihood (P) of the impact occurring. The ER is determined for the pre- and post-mitigation scenario. In addition, other factors, including cumulative impacts and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S). The impact assessment will be applied to all identified alternatives.

<u>Determination of Environmental Risk:</u>

The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER). The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and Reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$C = \frac{(E + D + M + R) * N}{4}$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in **Table C-1** below.

Table C-1: Criteria for determining impact consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. Highly localised, limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property or site boundary, or the area within a few hundred meters of the site)
	3	Local (i.e. beyond the site boundary within the Local administrative boundary (e.g. Local Municipality) or within consistent local geographical features, or the area within 5 km of the site)
	4	Regional (i.e. Far beyond the site boundary, beyond the Local administrative boundaries within the Regional administrative boundaries (e.g. District Municipality), or extends into different distinct geographical features, or extends between 5 and 50 km from the site)
	5	Provincial / National / International (i.e. extends into numerous distinct geographical features, or extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)

Aspect	Score	Definition
	2	Short term (1-5 years)
	3	Medium term (6-15 years)
	4	Long term (15 – 65 years, the impact will cease after the operational life span of the project)
	5	Permanent (> 65 years, no mitigation measure of natural process will reduce the impact after construction/operation/decommissioning)
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected)
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected)
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way)
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease)
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease)
Reversibility	1	Impact is reversible without any time and cost
	2	Impact is reversible without incurring significant time and cost
	3	Impact is reversible only by incurring significant time and cost
	4	Impact is reversible only by incurring prohibitively high time and cost
	5	Irreversible Impact

Once the C has been determined the significance is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/scored as per **Table C-2**.

Table C-2: Probability scoring

Probability	1	Improbable (Rare, the event may occur only in exceptional circumstances, the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <5% chance)
	2	Low probability (Unlikely, impact could occur but not realistically expected; >5% and <20% chance)
	3	Medium probability (Possible, the impact may occur; >20% and <50% chance)
	4	High probability (Likely, it is most probable that the impact will occur- > 50 and <90% chance)
	5	Definite (Almost certain, the impact is expected to, or will, occur, >90% chance)

The result is a qualitative representation of relative significance (S) associated with the impact. S is therefore calculated as follows:

$$S = C \times P$$

Table C-3: Determination of significance

Consequence	5 – very high	5	10	15	20	25
	4 - high	4	8	12	16	20
	3 - medium	3	6	9	12	15
	2 - low	2	4	6	8	10
	1 – very low	1	2	3	4	5
		1 - improbable	2 - low	3 - possible	4 - probable	5 - definite
	Probability					

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These S scores are then grouped into respective classes as described in **Table C-4**.

Table C-4: Significance scores

Significance Scores	
Value	Description
≤4.25	Low (i.e. where this impact is unlikely to be a significant environmental risk/ reward)
>4,25, ≤8.5	Low-Medium (i.e. where the impact could have a significant environmental risk/ reward)
>8.5, ≤13.75	High-Medium (i.e. where the impact could have a significant environmental risk/ reward)
>13.75	High (i.e. where the impact will have a significant environmental risk/ reward)

The impact significance will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/mitigated.

Impact Prioritisation:

Further to the assessment criteria presented in the section above, it is necessary to assess each potentially significant impact in terms of:

- Cumulative impacts; and
- The degree to which the impact may cause irreplaceable loss of resources.

To ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact significance (post mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the significance score based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table C-5: Criteria for determining prioritisation

Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable loss of resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table C-5. The impact priority is therefore determined as follows:

$$Priority = Cl + LR$$

The result is a priority score which ranges from 2 to 6 and a consequent PF ranging from 1 to 1.5 (refer to **Table C-6**).

Table C-6: Determination of prioritisation factor

Priority	Prioritisation Factor
2	1
3	1.125
4	1.25
5	1.375
6	1.5

In order to determine the final impact significance (FS), the PF is multiplied by the significance of the post mitigation scoring. The ultimate aim of the PF is an attempt to increase the post mitigation environmental risk rating by a factor of 0.5, if all the priority attributes are high (i.e. if an impact comes out with a high medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

Table C-7: Final environmental significance rating

Significance Rating	Description
< -25	Very High (Impacts in this class are extremely significant and pose a very high environmental risk. In certain instances, these may represent a fatal flaw. They are likely to have a major influence on the decision and may be difficult or impossible to mitigate. Offset's may be necessary.
-13.75 to -25	High negative (These impacts are significant and must be carefully considered in the decision-making process. They have a high environmental risk or impact and require extensive mitigation measures).
-8.5 to -13.75	Medium-High negative (i.e. Impacts in this class are more substantial and could have a significant environmental risk. They may influence the decision to develop in the area and require more robust mitigation measures).
-4.25 to -8.5	Medium- Low negative (i.e. These impacts are slightly more significant than low impacts but still do not pose a major environmental risk. They might require some mitigation measures but are generally manageable).
-1 to -4.25	Low negative (i.e. Impacts in this class are minor and unlikely to have a significant environmental risk. They do not influence the decision to develop in the area and are typically easily mitigated.
0	No impact
1 to 4.25	Low positive
4.25 to 8.5	Medium-Low positive
8.5 to 13.75	Medium-High positive
>13.75	High positive

The significance ratings and additional considerations applied to each impact will be used to provide a quantitative comparative assessment of the alternatives being considered. In addition, professional expertise and opinion of the specialists and the environmental consultants will be applied to provide a qualitative comparison of the alternatives under consideration. This process will identify the best alternative for the proposed project.