



Air Quality Impact Assessment for the D3 Energy Production Right Application, Free State Province

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

Project Compiled by:

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Revision Record

Revision Number	Date	Reason for Revision
Rev 0	June 2026	For internal review
Rev 0.1	22 June 2026	Change to stack parameters to power plant
Rev 1	August 2026	Comments from EIMS and D3 Energy
Rev 2	September 2026	Comments from EIMS

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 planned new Production Right (PR) area (hereafter referred to as the project). The proposed PR area falls within a portion of the previously assessed ER315 (exploration right). Further, some of the activities being proposed by D3 to be included in the production right overlap with those previously assessed and authorised for the ER315 Amendment.

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 PM₁₀ and inhalable particulate matter with an aerodynamic diameter equal to or less than 2.5 µm or PM_{2.5}), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), 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.

Construction of the wells and the plant would result in PM emissions.

Fugitive emissions are the dominant source of VOC emissions. VOC emissions during the exploration phase are estimated to be 10 tpa. Once the wells have been drilled, estimated VOC emissions during production, gathering and processing amount to 101 tonnes per annum (tpa), versus the 0.86 tpa from the combustion emissions.

For the combustion emissions, the pollutant with the maximum emissions is NO₂, mostly from the combustion of natural gas in the power plant (84% of the total 15.7 tpa emissions).

For the combustion emissions, the PM₁₀ emissions are split between vehicles and drill rigs at the wells (0.11 tpa) and stationary combustion sources at the plant (0.08 tpa).

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, highest daily and annual average 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.
- 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 operating 24 hours per day, 7 days per week.
- The impact assessment was limited to airborne particulates (including PM₁₀ and PM_{2.5}) and gaseous pollutants from well emissions (including non-methane VOCs (NMVOC)) and combustion machinery, including CO, oxides of nitrogen (NO_x), VOCs and SO₂.
- Nitrogen monoxide (NO) emissions are rapidly converted in the atmosphere into nitrogen dioxide (NO₂). NO₂ impacts were calculated by using the Dispersion Modelling Guideline for Tier 1: total conversion method (DFFE, 2014). This method assumes a total conversion of NO to NO₂.
- The ground level concentrations due to criteria pollutants were screened against the 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:

- Construction and Exploration:
 - Maximum daily PM₁₀ ground level concentrations due to land clearing exceeds the daily PM₁₀ NAAQS for an area of approximately 1 km by 1 km around the plant and 130 m from the drill sites respectively.
 - Annual average VOC ground level concentrations due to exploration activities, are well within the comfort level of 200 µg/m³.
 - Significance rating:
 - Without mitigation: medium-low negative significance rating.
 - With mitigation: medium-low negative significance rating.
 - Overall significance rating: medium-low negative significance rating.
- Operation (at plant and at the wells):
 - Maximum hourly NO₂ ground level concentrations due to combustion sources are well within the hourly NO₂ NAAQS, with maximum levels at the power plant of around 60 µg/m³. As the three options for the site are close to each other, and because the impact is simulated to be below NAAQS, from an air quality perspective there is no preferred site option.
 - Annual average VOC ground level concentrations due to production activities are well within the comfort level of 200 µg/m³.
 - Significance rating:
 - Without mitigation: medium-low negative significance rating.
 - With mitigation: medium-low negative significance rating.
 - Overall significance rating: medium-low negative.
- Closure:
 - Assuming impacts due to rehabilitation activities to be similar to construction (i.e. land clearing), maximum daily PM₁₀ ground level concentrations may exceeds the daily PM₁₀ NAAQS for a limited area around the plant and well sites.
 - The testing wells must be capped and sealed and should not have any gaseous releases if properly managed.
 - Significance rating:
 - Without mitigation: medium-low negative significance rating.
 - With mitigation: medium-low negative significance rating.
 - Overall significance rating: medium-low negative.

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:

- Implement dust suppression measures in all areas that will be affected by construction activities and where dust will be generated. Dust suppression must also be undertaken during windy and dry weather conditions.
- All residents within 600 m of drilling areas and 300 m of seismic surveys should be notified before project activities take place.
- The Grievance Mechanism must be established and maintained throughout the project activities to indicate air quality complaints and responses. 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.
- Mitigation and monitoring measures as discussed in Section 6 should be considered.

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LIST OF ACRONYMS AND SYMBOLS

Airshed	Airshed Planning Professionals (Pty) Ltd
AQIA	Air Quality Impact Assessment
°C	Degrees Celsius
C	Carbon
CH ₄	Methane
CNG	Compressed natural gas
CO	Carbon monoxide
CO ₂	Carbon dioxide
DFFE	Department of Forestry, Fisheries and the Environment
ECA	European Collaborative Action
ECSA	Engineering Council of South Africa
EIA	Environmental Impact Assessment
EIMS	Environmental Impact Management Services
EMPr	Environmental Management Program
ER	Exploration Right
µg	Micro gram
GG	Government Gazette
GGFR	Global Gas Flaring Reduction Public-Private Partnership program
GN	Government Notice
ha	Hectare
H ₂ S	Hydrogen sulfide
IPCC	Intergovernmental Panel on Climate Change
kg	Kilogram
kW	Kilo watt
LDAR	Leak Detection and Repair
LMo	Monin-Obukhov length
LNG	Liquified natural gas
m	Metre
mm	Millimetre
m ³	Cubic metre
m ²	Square metre
NAAQS	National Ambient Air Quality Standard
NACA	National Association for Clean Air
NDCR	National Dust Control Regulations
NEMA	National Environmental Management Act
NEM:AQA	National Environmental Management: Air Quality Act
NH ₃	Ammonia
NMVOC	Non-methane volatile organic compound
NO	Nitrogen oxide
NO ₂	Nitrogen dioxide
NO _x	Oxides of nitrogen
NPI	National pollution inventory
O ₃	Ozone
PAHs	Polycyclic aromatic hydrocarbons

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
PR	Production Right
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

Environmental Impact Management Services (Pty) Ltd (EIMS) were requested by D3 Energy (Pty) Ltd (D3) to undertake an Environmental Impact Assessment (EIA) process for their planned new Production Right (PR) area. The proposed PR area falls within a portion of the previously assessed ER315 (exploration right). Further, some of the activities being proposed by D3 to be included in the production right overlap with those previously assessed and authorised for the ER315 Amendment (specifically the northwestern part of the PR area). In brief the production activities will include the following:

- Provision for ongoing exploration drilling and seismic activities (preliminary seismic transects defined by the blue dashed lines in **Figure 1-1**).
- Existing wells may be 'worked over' and possibly included as production sites.
- Drilling and producing from approximately 43 production wells within the 4 identified well production corridors (as indicated in **Figure 1-1**). The intention being to assess these corridors in detail during the EIA process to allow for drilling and production within these corridors (assume a corridor width of 500 m).
- The installation of trenched sub-surface gas gathering pipelines (as indicated in **Figure 1-1**).
- The pipeline network will transport gas to a local production plant (either option A, B or C) located at approximately the positions indicated by the blue stars in **Figure 1-1**. The gas will be compressed to deliver compressed helium and methane and/or as an alternative where the gas will be liquified to produce Liquefied Natural Gas (LNG) and Liquefied Helium (LHe).
- Gas to power capacity of approximately 3 MW.

An alternative layout is also proposed (**Figure 1-2**).

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by EIMS to undertake an Air Quality Impact Assessment (AQIA) for the proposed D3 Production Right Application (ER315) (hereafter referred to as the project). This report details the findings of the AQIA undertaken for the project.

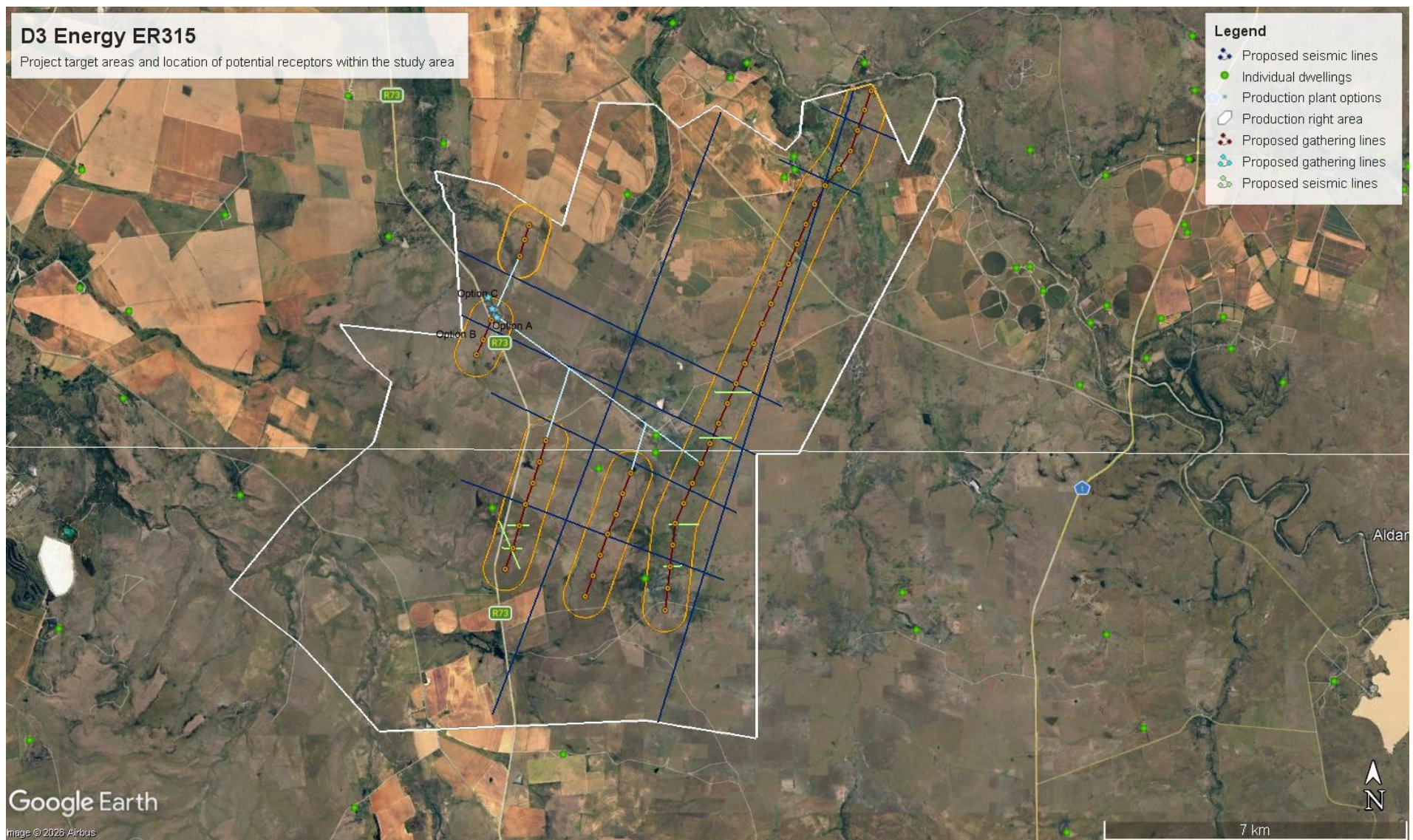


Figure 1-1: Location of the project site

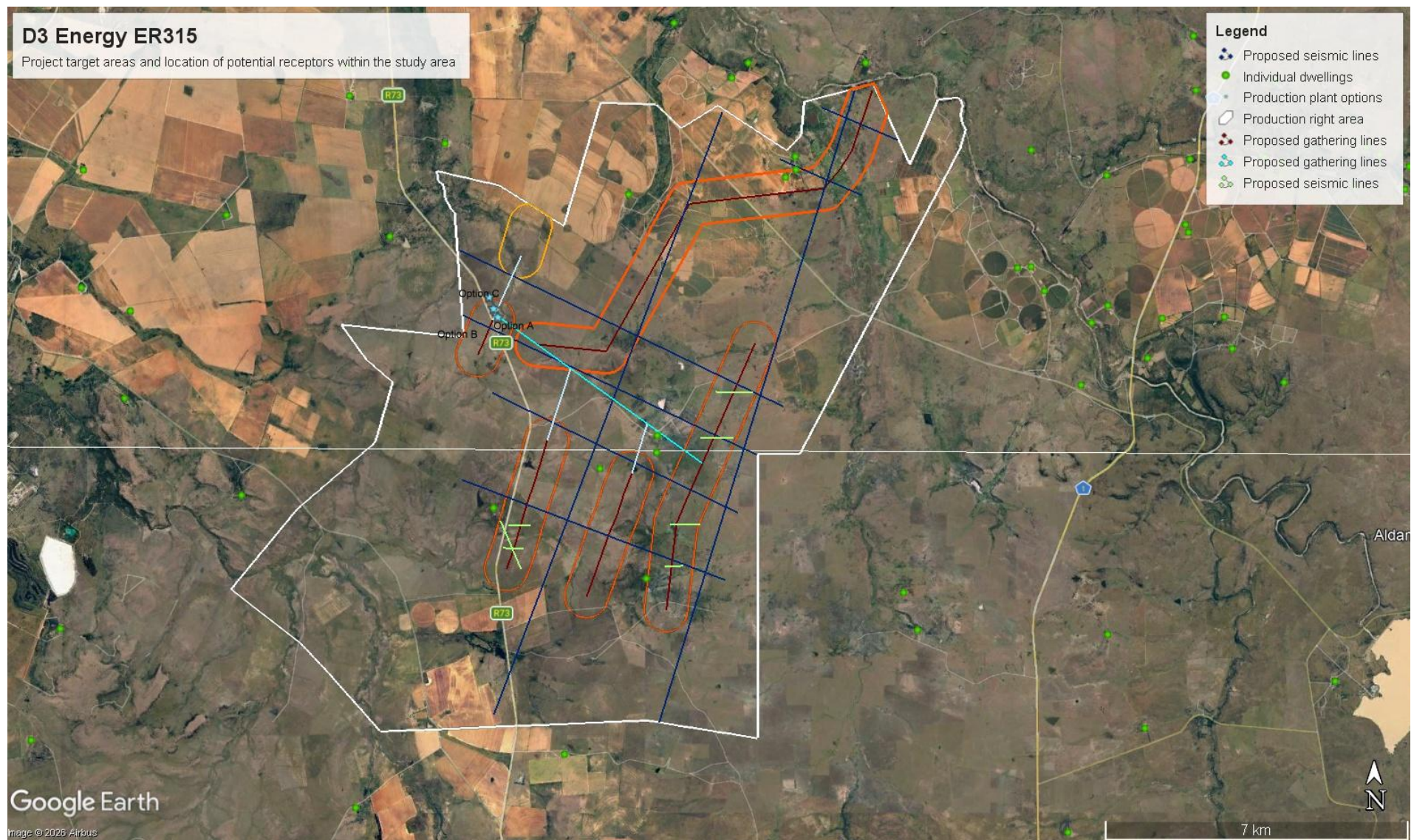


Figure 1-2: Location of the project site (alternative 1)

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,
 - A 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 Gillian Petzer (Pr. Eng., BEng Chemical (University of Pretoria))

Gillian Petzer started her professional career in Air Quality in 2000 when she joined British Research Establishment (BRE) in the UK after completing her Bachelor's Degree in Chemical Engineering at the University of Pretoria. She joined Airshed Planning Professionals in 2003, and is now a principal consultant at the company.

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. 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.

Gillian is also actively involved in the National Association for Clean Air (NACA), is a member of the Institution of Chemical Engineers (IChemE) and is a registered Professional Engineer with the Engineering Council of South African (ECSA) (registration no. 20170315).

A comprehensive curriculum vitae of Gillian Petzer is provided in Appendix A.

The declaration of independence for Gillian Petzer is provided in Appendix B.

1.5 Approach and Methodology

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

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 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 (NAAQS) (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 gas production rates, number of active wells, 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 PM₁₀ (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 (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), and volatile organic compounds (VOCs) was modelled for an area covering 17 km (north-south) by 22 km (east-west). The simulation area was divided into a grid with a resolution of 100 m (north-south) by 100 m (east-west). AERMOD simulates ground-level concentrations for each of the receptor grid points. AERMET executable version 23132 and AERMOD executable version 24142 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 AERMOD 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.
- 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 operating 24 hours per day, 7 days per week.

- The impact assessment was limited to airborne particulates (including PM₁₀ and PM_{2.5}) and gaseous pollutants from the exploration, production, processing, transmission and storage of natural gas (including non-methane VOCs (NMVOC)) and combustion sources, including CO, oxides of nitrogen (NO_x), VOCs and SO₂.
- Nitrogen monoxide (NO) emissions are rapidly converted in the atmosphere into nitrogen dioxide (NO₂). NO₂ impacts were calculated by using the Dispersion Modelling Guideline for Tier 1: total conversion method (DFFE, 2014). This method assumes a total conversion of NO to NO₂.
- The ground level concentrations due to criteria pollutants were screened against the 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 National Minimum Emission Limits (MES)

The Minister, in terms of *Section 21* of the National Environmental Management: Air Quality Act (NEM:AQA) (Act 39 of 2004), published a list of activities which result in atmospheric emissions, and which are believed to have significant detrimental effects on the environment, human health and social welfare. The *Listed Activities and Minimum National Emission Standards* were first published on the 31st of March 2010 (Government Gazette No. 33064), with a revision of the schedule on the 22nd of November 2013 (Government Gazette No. 37054) and an amendment of certain sections and annexure A on the 31st of October 2018 (Government Gazette No. 42013). The project is not expected to trigger a listed activity.

2.2 Screening Criteria

2.2.1 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 SO₂, NO₂, PM₁₀, CO, ozone (O₃), benzene (C₆H₆), 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 ($\mu\text{g}/\text{m}^3$)	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
	8-hour	10 000	8 700	11	Currently enforceable
Benzene (C ₆ H 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

2.2.2 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/m ³
Multifactoral exposure range	:	200 to 3 000 µg/m ³
Discomfort range	:	3 000 to 25 000 µg/m ³
Toxic range	:	>25 000 µg/m ³

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/m ³ .
Aromatic hydrocarbons	:	50 µg/m ³ .
Terpenes	:	30 µg/m ³ .
Halocarbons	:	30 µg/m ³ .
Esters	:	20 µg/m ³ .
Aldehydes and ketones (excluding formaldehyde)	:	20 µg/m ³ .
Other	:	50 µg/m ³ .

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 annual average VOC concentrations. It should be noted that this screening criteria is only a guideline and not a legal requirement.

2.3 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 the Department of Forestry, Fisheries and the Environment (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 NEM:AQA 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).

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 NO₂ 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.

2.4 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 3.3
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 3.3
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
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
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers	Section 4
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

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., Virginia (suburbs of Meloding and Calabria) as well as surrounding mines' (Beatrix and Harmony Joel) residential areas.

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 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).

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 3-1**. 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%.

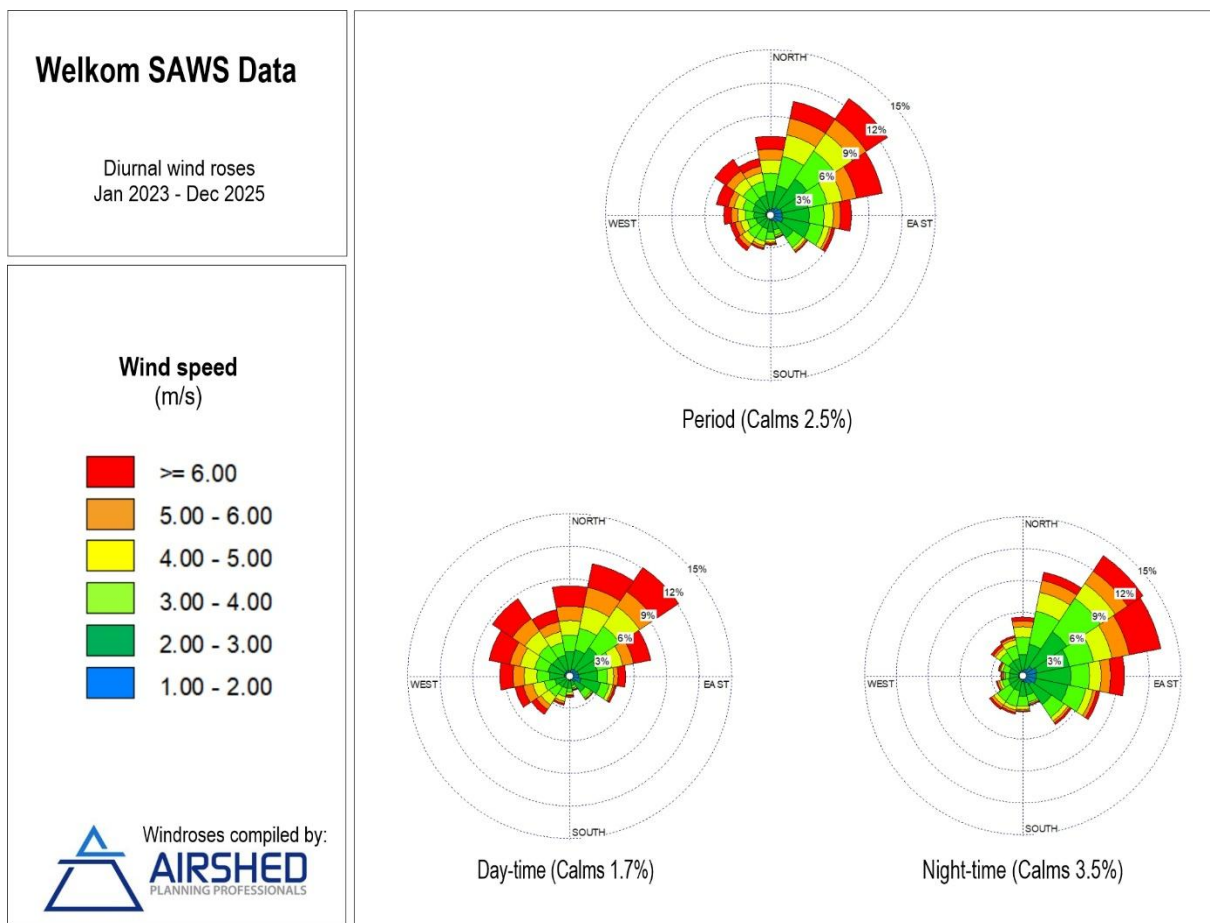


Figure 3-1: Period average, daytime and night-time wind roses (measured data; January 2023 to December 2025; SAWS Welkom monitoring station)

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 3-2**. 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

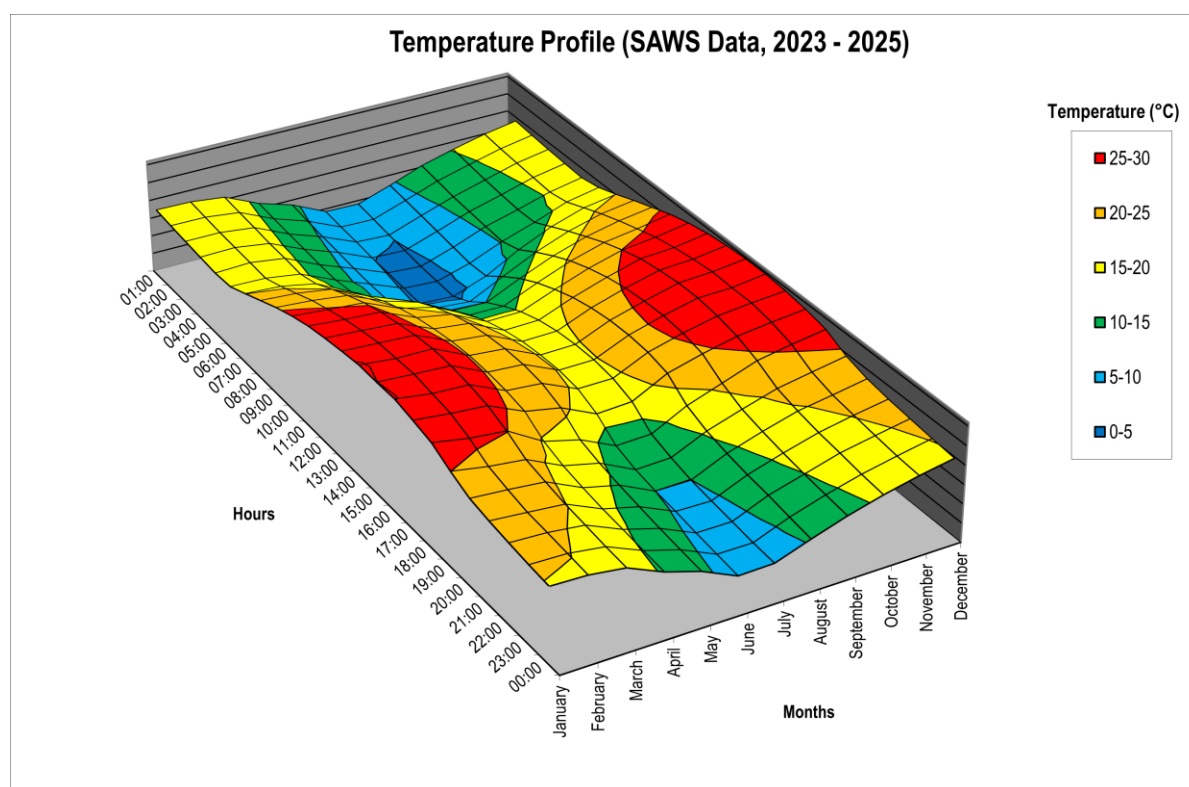


Figure 3-2: Diurnal temperature profile (SAWS Welkom Data, 2023 to 2025)

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 (L_{Mo}) provides a measure of the importance of buoyancy generated by the heating of the ground and

mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During 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.

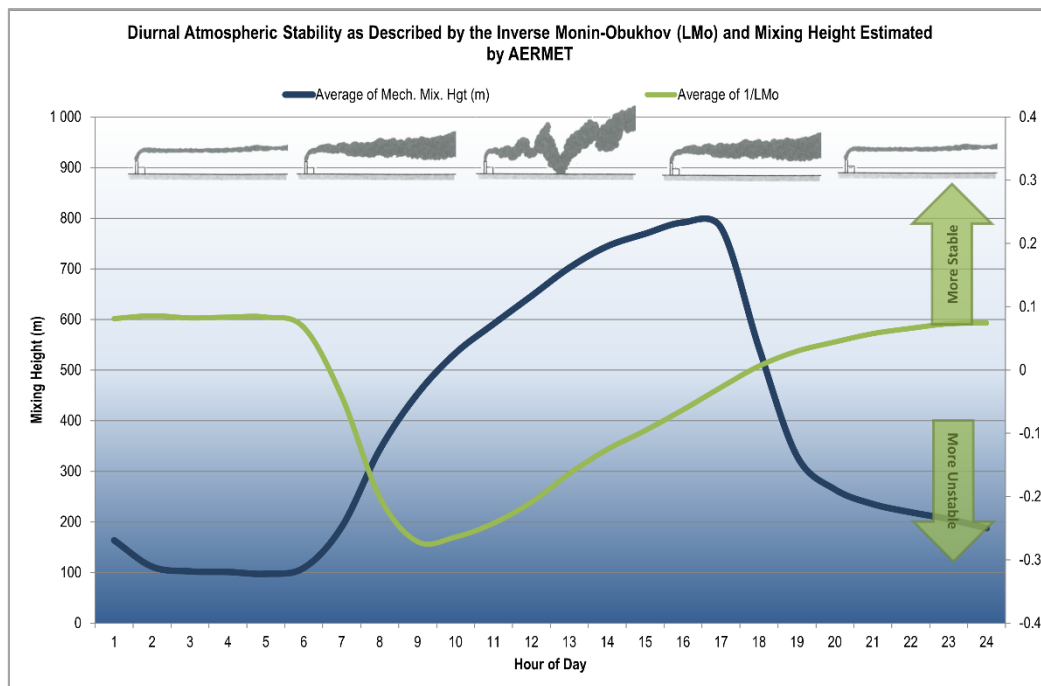


Figure 3-3: Diurnal atmospheric stability as described by the inverse of the measured Monin-Obukhov length (SAWS Welkom Data: 2023 to 2025)

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 SO₂, heavy metals, PM including heavy metals and inorganic ash, CO, PAHs (recognized carcinogens), NO₂ and various toxins. The main pollutants emitted from the combustion of paraffin are NO₂, 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 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, farm 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.

3.4.1.6 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.

3.4.1.7 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 CO₂, carbon (C), SO₂, oxides of nitrogen (mainly NO), particulates and lead. Secondary pollutants include NO₂, 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 Available Ambient Air Quality Monitoring Data

In accordance with the NEM:AQA, the responsibility for ambient air quality monitoring in South Africa is shared across national, provincial, and local spheres of government, supported by industrial and research entities.

The scope of work for the AQIA was to use existing measured ambient air quality data if available. Unfortunately, measured ambient air quality is not available for the area which was indicated as a limitation in section 1.6.

It should also be noted that the Dispersion Modelling Guidelines (section 2.3) constitute recommendations rather than mandatory standards, thereby permitting professional judgement flexibility. The ambient background concentrations are discussed under general modelling considerations in the Dispersion Modelling Guidelines. It stipulates that for isolated facilities, the background concentrations may only consist of regional background and might be negligible for many pollutants, except for PM₁₀ levels. Assessment for compliance with NAAQS must follow procedures as follows: annual average concentrations must be less than the NAAQS, no exceedances allowed; short-term (99th percentile) concentrations must be less than the NAAQS.

Given that the specific project activities are in areas with no other industrial operations in close proximity, it was considered isolated activities.

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. Emissions are quantified for pollutants associated with the exploration and production 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 Construction

Fugitive particulate emissions due to plant and 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:

$$E = 2.69 \text{ Mg/hectare/month of activity (269 g/m}^2\text{/month)}$$

The PM₁₀ 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 m²), estimated construction periods (in days) for the well and production plant 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)	Period (months)	Calculated PM ₁₀ Emissions (kg/day)
Well area (single)	50 m x 50 m	2 500	0.5	22
Production plant area	150 m x 150 m	22 500	1	200
Total (assuming 43 wells)				1 146

4.1.2 Combustion 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) (NPI, 2008) manual for combustion engines were used to estimate emission rates for this equipment. The NPI (NPI, 2013) manual for oil and gas extraction and production were used to estimate emission rates for flaring.

Combustion emissions were quantified through the application of emission factors (specified in **Table 4-2**) as published by the Australian NPI, based on the annual diesel usage and amount of gas flared (specified in **Table 4-3**). Estimated average emissions (in kg/day) due to engine exhaust and flaring emissions are presented in **Notes**:

(a) Of the 12 870 litres/year, 1 694 litres/year is used for seismic purposes

Table 4-4.

Table 4-2: Emission factors for combustion engines

Description of Equipment	Emission factor						Units
	PM ₁₀	PM _{2.5}	VOC	CO	NO _x	SO ₂	
Light Goods Vehicle (LGV) ^(a)	2.4	2.3	0.42	19	8.9	0.017	kg/m ³
Heavy Goods Vehicle (HGV) ^(b)	1.8	1.7	1.8	6.8	23	0.017	kg/m ³
Bus ^(c)	2.1	2.1	1.2	9.1	30	0.017	kg/m ³
Large (greater than 450 kW) diesel engines ^(d)	1.6	1.6	1.3	14	53	0.0425	kg/m ³
Gas turbines natural gas engines ^(e)	0.0000029	0.0000029	0.0000033	0.00013	0.0005	0.00000079	kg/kWh
Flaring ^(f)	-	-	15	8.7	1.5	-	kg/tonne of gas

Notes:

- (a) Australian NPI Combustion Engines Table 15: Emission factors for diesel vehicle exhaust emissions
- (b) Australian NPI Combustion Engines Table 21: Emission factors for diesel vehicle exhaust emissions
- (c) Australian NPI Combustion Engines Table 23: Emission factors for diesel vehicle exhaust emissions
- (d) Australian NPI Combustion Engines Table 43: Emission factors for stationary large (greater than 450 kW) diesel engines
- (e) Australian NPI Combustion Engines Table 51: Emission factors for uncontrolled gas turbines natural gas engines
- (f) Australian NPI Oil and Gas Extraction and Production Table 8: Emission factors for flaring

Table 4-3: Description of equipment

Project Activity	Description of Equipment	Quantity	Units
Mobile combustion (diesel)	LDV	12 870 ^(a)	litres/year
Mobile combustion (diesel)	HDV	7 150	litres/year
Mobile combustion (diesel)	Bus	6 435	litres/year
Stationary combustion (diesel)	Drill rig	33 000	litres/year
Stationary combustion (diesel)	Diesel generator	5 000	litres/year
Stationary combustion (natural gas)	Gas generator	3	MW
Flaring	Flare	55 000	m ³ /year

Notes:

(a) Of the 12 870 litres/year, 1 694 litres/year is used for seismic purposes

Table 4-4: Calculated combustion emissions

Project Activity	Description of Equipment	Emissions (kg/year)					
		PM ₁₀	PM _{2.5}	VOC	CO	NO _x	SO ₂
Combustion at well areas (diesel)	Vehicles, drill rigs	106	104	68	782	2 206	2
Combustion at well areas (seismic activity)	Vehicles	4	4	1	32	15	0.03
Stationary combustion (diesel)	Diesel generator	8	8	7	70	265	0.2
Stationary combustion (natural gas)	Gas generator	76	76	87	3 416	13 140	21
Flaring	Flare	-	-	701	407	70	-
Total		194	192	864	4 707	15 696	23

4.1.3 Fugitive Emissions

The term fugitive emissions is broadly applied here to mean all emissions from oil and gas systems except contributions from fuel combustion. Fugitive emissions include vented emissions, leak emissions, and flaring emissions. Oil and natural gas systems comprise all infrastructure required to produce, collect, process or refine and deliver natural gas and petroleum products to market, and includes abandoned oil and gas wells. The system begins during the exploration process, which includes all fugitive emissions associated with activities such as prospecting and/or exploratory drilling, well testing, field development and well development, and ends at the consumer (Figure 4-1).

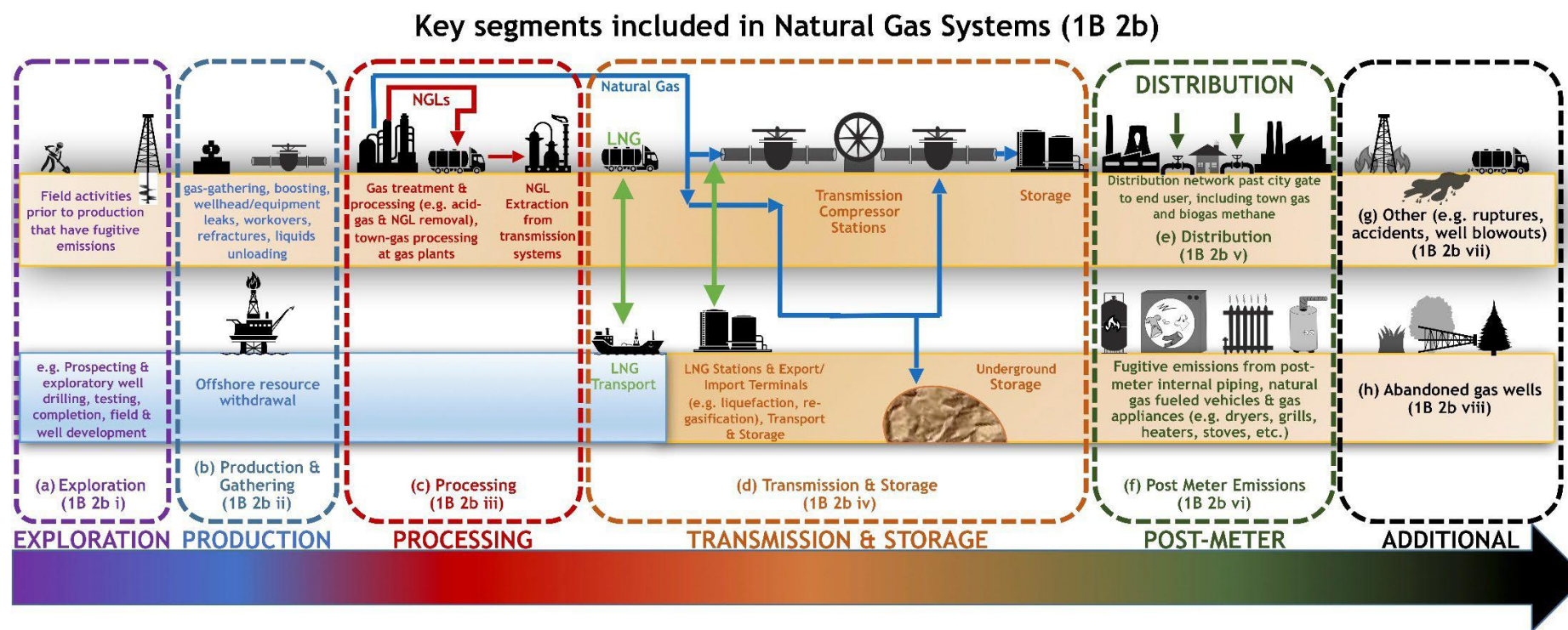


Figure 4-1: Key segments of fugitive emissions in natural gas systems (IPCC, 2019)

The NMVOC emissions during exploration and production activities were 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 (EF) used and the quantified NMVOC emissions is provided in **Table 4-5**. The IPCC emission factors used are aggregates of venting, flaring, and leak emissions. For gas exploration the EF is not disaggregated to drilling, testing and servicing operation; the EF is applied to the whole exploration process.

Table 4-5: Non-methane volatile organic compound fugitive emissions

Project Activity	Pollutant	EF (tonne per well drilled)	Wells drilled per year (max)	EF (tonne per active gas well)	Active wells per year	EF (tonne per million cubic metres of gas produced)	Million cubic metres of gas produced per year	Emission Rate (tpa)
Gas exploration	NMVOC	0.87 ^(a)	11	-	-	-	-	10 ^(b)
Gas production	NMVOC	-	-	1.7 ^(a)	43	-	-	73 ^(c)
Gas gathering	NMVOC	-	-	-	-	0.77 ^(a)	32	24 ^(d)
Gas processing	NMVOC	-	-	-	-	0.13 ^(a)	32	4 ^(e)
Total	NMVOC	-	-	-	-	-	-	111

Notes:

- (a) The IPCC emission factors used are aggregates of venting, flaring, and leak emissions.
- (b) Disaggregated emissions for exploration amount to 9.5 tpa venting and 0.1 tpa flaring emissions.
- (c) Disaggregated emissions for production amount to 8 tpa leaks and 65 tpa venting emissions.
- (d) Disaggregated emissions for gathering amount to 2.7 tpa leaks and 21.7 tpa venting emissions.
- (e) Disaggregated emissions for processing amount to 0.2 tpa leaks and 3.9 tpa venting emissions.

4.1.4 Summary of Emissions

Construction of the wells and the plant would result in PM emissions.

Fugitive emissions are the dominant source of VOC emissions. VOC emissions during the exploration phase (well drilling, testing and servicing operation) are estimated to be 10 tpa. Once the wells have been drilled, estimated VOC emissions during production, gathering and processing amount to 101 tpa, versus the 0.86 tpa from the combustion emissions. The majority of these emissions (100 tpa) are from venting, with 11 tpa from leaks and 0.1 tpa from flaring.

For the combustion emissions, the pollutant with the maximum emissions is NO₂, mostly from the combustion of natural gas in the power plant (84% of the total 15.7 tpa emissions).

For the combustion emissions, the PM₁₀ emissions are split between vehicles and drill rigs at the wells (0.11 tpa) and stationary combustion sources at the plant (0.08 tpa).

4.1.5 Cumulative Emissions

Other gas exploration and production activities in the Free State Province include Tetra4 (production) as well as Rhino Oil and Gas (exploration). The production and exploration right areas are shown in **Figure 4-2**.

Table 4-6: Cumulative emissions

Company	Type of right	PM emissions (tpa)	VOC emissions (tpa)	NO ₂ emissions (tpa)	Number of wells	Gas processed or produced/year (million m ³)
D3 Energy	Exploration and production	0.2	112	16	43	32
Tetra4	Exploration and production	11.5	264	49	300	204
Motouane ER386	Exploration	0.4	3.8	5.7	3	NA
Rhino Oil and Gas ER377	Exploration	unknown	unknown	unknown	20	NA
Rhino Oil and Gas ER378	Exploration	-	3.5	5.8	20	NA
Total	-	12.1	383	76.5	-	-

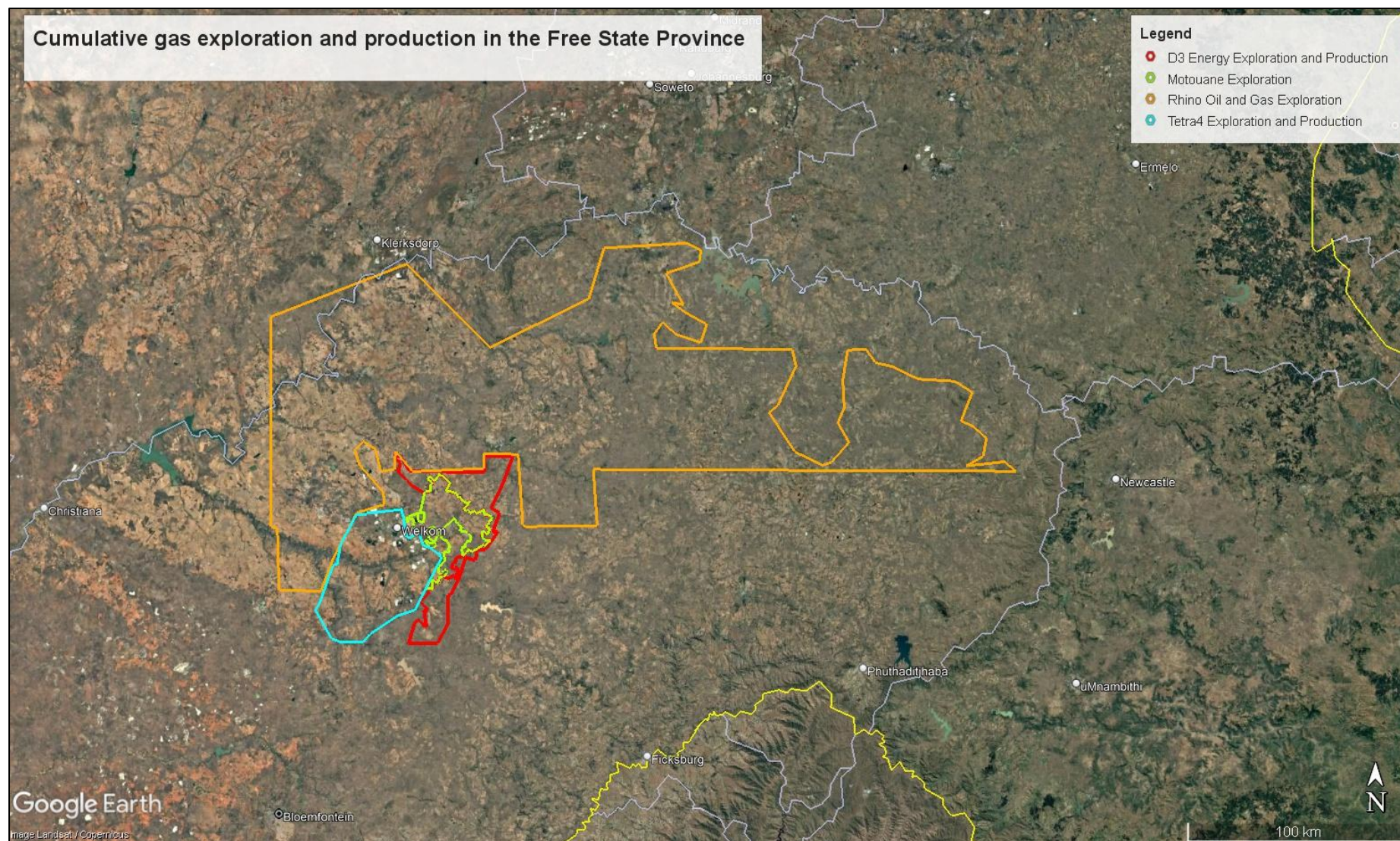


Figure 4-2: Cumulative gas exploration and production in the Free State Province

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 PM₁₀, NO₂ and VOC. Dispersion simulations were undertaken using the AERMOD dispersion model and results are presented as isopleth plots. The ground level concentrations are screened against the NAAQS and VOC comfort levels.

4.2.1 Construction Activities

The construction site for the each well was assumed to be 50 m x 50 m for equipment movement and setup. The construction site for the plant was assumed to be 150 m x 150 m. Option C was selected as it is the closest option to the nearest AQSRs.

Daily PM₁₀ NAAQs are exceeded in the vicinity of the construction sites, but not at any of the nearest AQSRs (Figure 4-3).

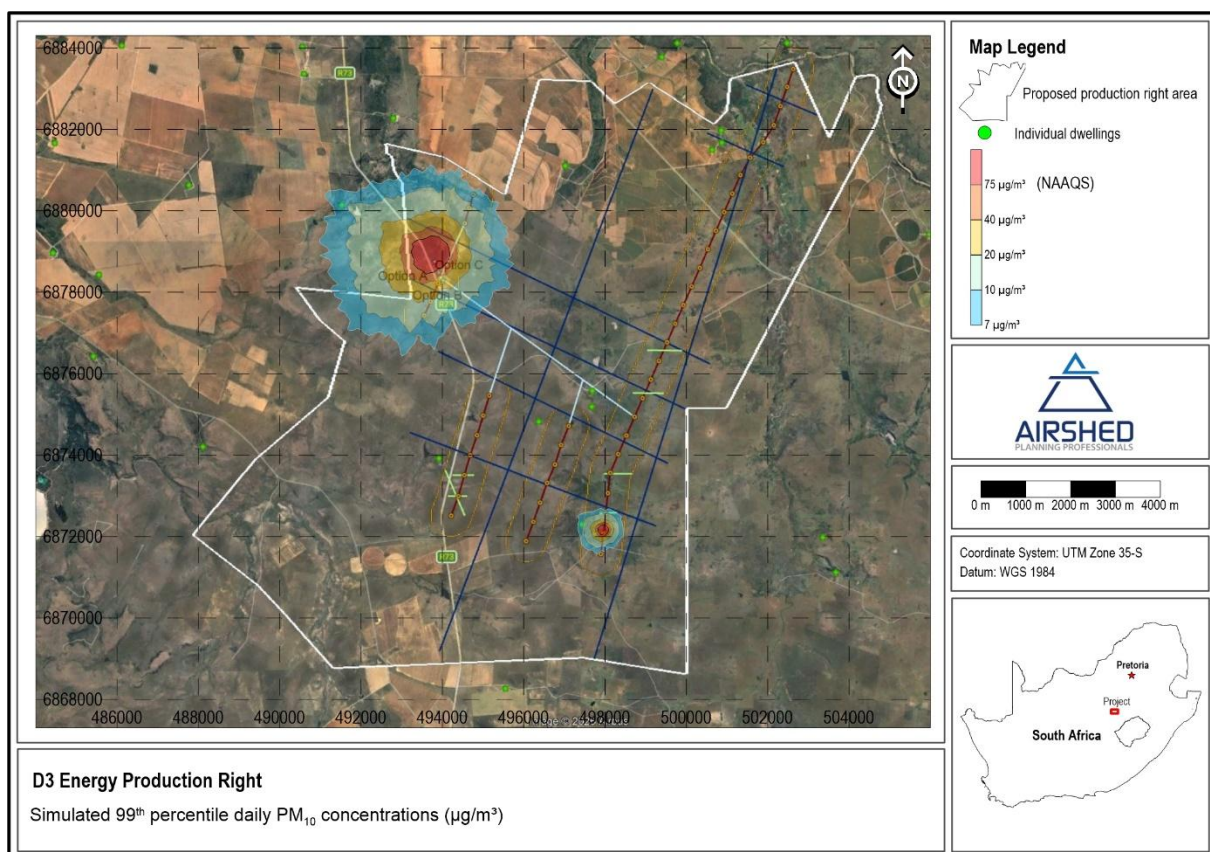


Figure 4-3: Simulated 99th percentile daily PM₁₀ ground level concentrations due to construction activities

4.2.2 Exploration Activities (Fugitive)

It was assumed that the exploration activities would occur at the wells (maximum 11 in a given year). The simulated annual NMVOC ground level concentrations due to exploration are illustrated in **Figure 4-4**. The annual NMVOC concentrations are well below the comfort level of $200 \mu\text{g}/\text{m}^3$.

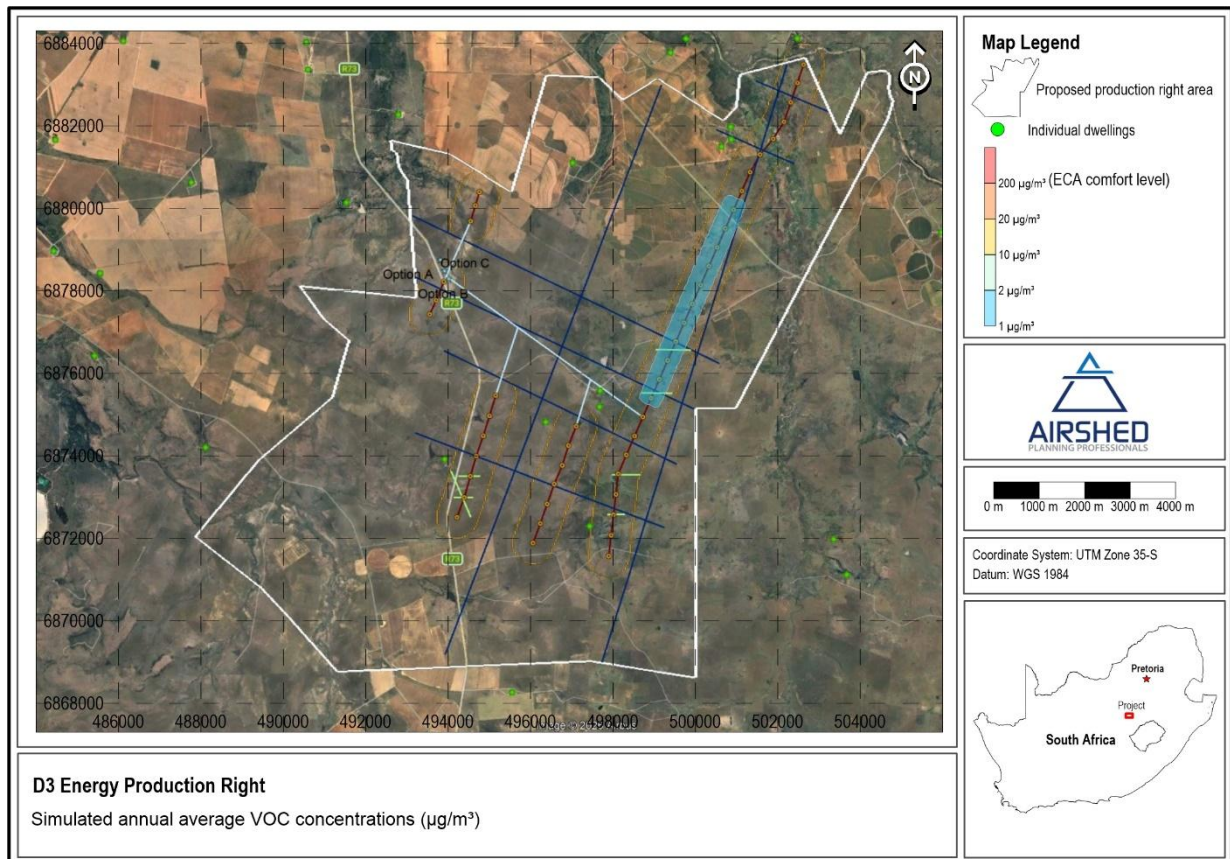


Figure 4-4: Simulated annual average VOC ground level concentrations due to exploration activities

4.2.3 Production Activities (Fugitive and Combustion)

Stack parameters used in the dispersion model for the point sources are provided in **Table 4-7**.

Table 4-7: Point source stack parameters

Point source	Stack height (m)	Stack diameter (m)	Temperature (°C)	Velocity (m/s)
Diesel generator	3	0.2	465	77
Gas 3MW power plant	5	0.6	425	12

NMVOC impact

It was assumed that the gas production and gathering would be distributed over all the active wells (maximum 43 in a given year), and that the gas processing would happen at the plant. The plant would also be the location for the diesel generator and the gas power plant. The simulated annual NMVOC ground level concentrations due to production, gathering and processing activities as well as fuel combustion processes are illustrated in **Figure 4-5**. The annual NMVOC concentrations are well below the comfort level of 200 µg/m³.

Even conservatively assuming all the VOCs are benzene, the annual NAAQS for benzene of 5 µg/m³ would not be exceeded at the nearest sensitive receptor.

NO₂ impact

The simulated ground level concentrations due to the gas power plant are illustrated in **Figure 4-6**. Option C was selected as the site to be simulated as it is the closest option to the nearest AQSRs. The maximum hourly ground level concentration of 60 µg/m³ in the vicinity of the plant is well below the hourly NAAQS of 200 µg/m³.

PM₁₀ impact

It was assumed that the mobile combustion sources would be distributed over all the active well areas (maximum 43 in a given year). The simulated ground level concentrations due to the combustion sources (both mobile and stationary) and fugitive sources are illustrated in **Figure 4-7**. The maximum daily ground level concentrations are well below the daily NAAQS of 75 µg/m³.

A summary of the impacts at the nearest AQSRs is given in Table 4-8. It was conservatively assumed that all VOCs are benzene. In reality benzene concentrations would be much lower.

Table 4-8: Simulated concentrations at the nearest AQSR

Phase	PM ₁₀ 99 th daily percentile (µg/m ³)	NO ₂ 99 th hourly percentile (µg/m ³)	VOC annual average (µg/m ³)	Benzene annual average (µg/m ³)
Construction	10	-	-	-
Exploration	-	-	<1	<1
Operation (plant and wells)	0.005	4.5	2	2
NAAQS/Guideline	75	200	200	5

There are no official, specific ambient PM₁₀ concentration thresholds set by South African legislation to protect crop yields or livestock. Field observations and global agricultural research show that crops begin experiencing physical and chemical stress when ambient PM₁₀ levels consistently exceed standard human health guidelines. As the simulated PM₁₀ impacts are compliant with NAAQS at the nearest receptors, no significant impact is anticipated for livestock or crops.

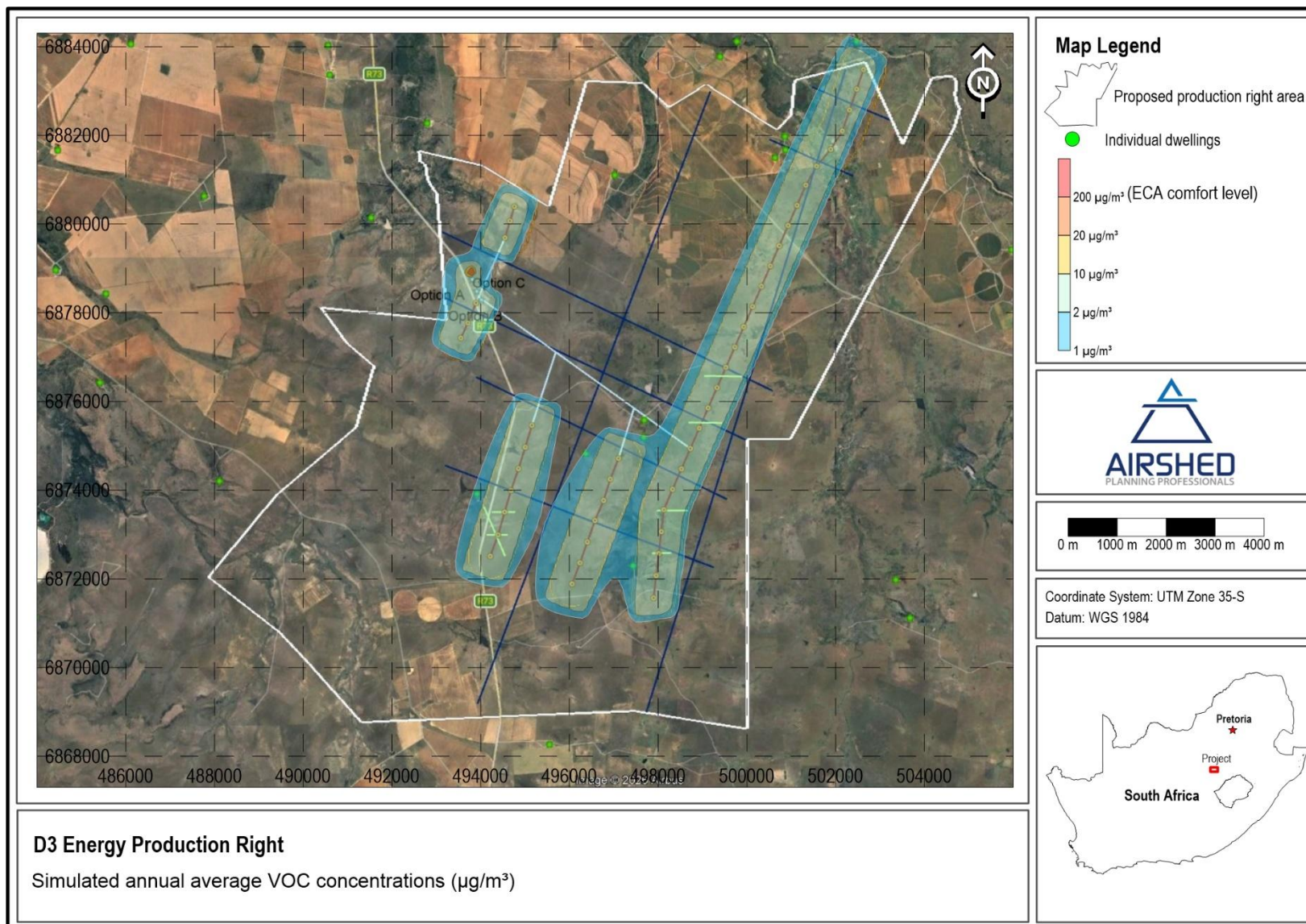


Figure 4-5: Simulated annual average VOC ground level concentrations due to fugitive and combustion activities

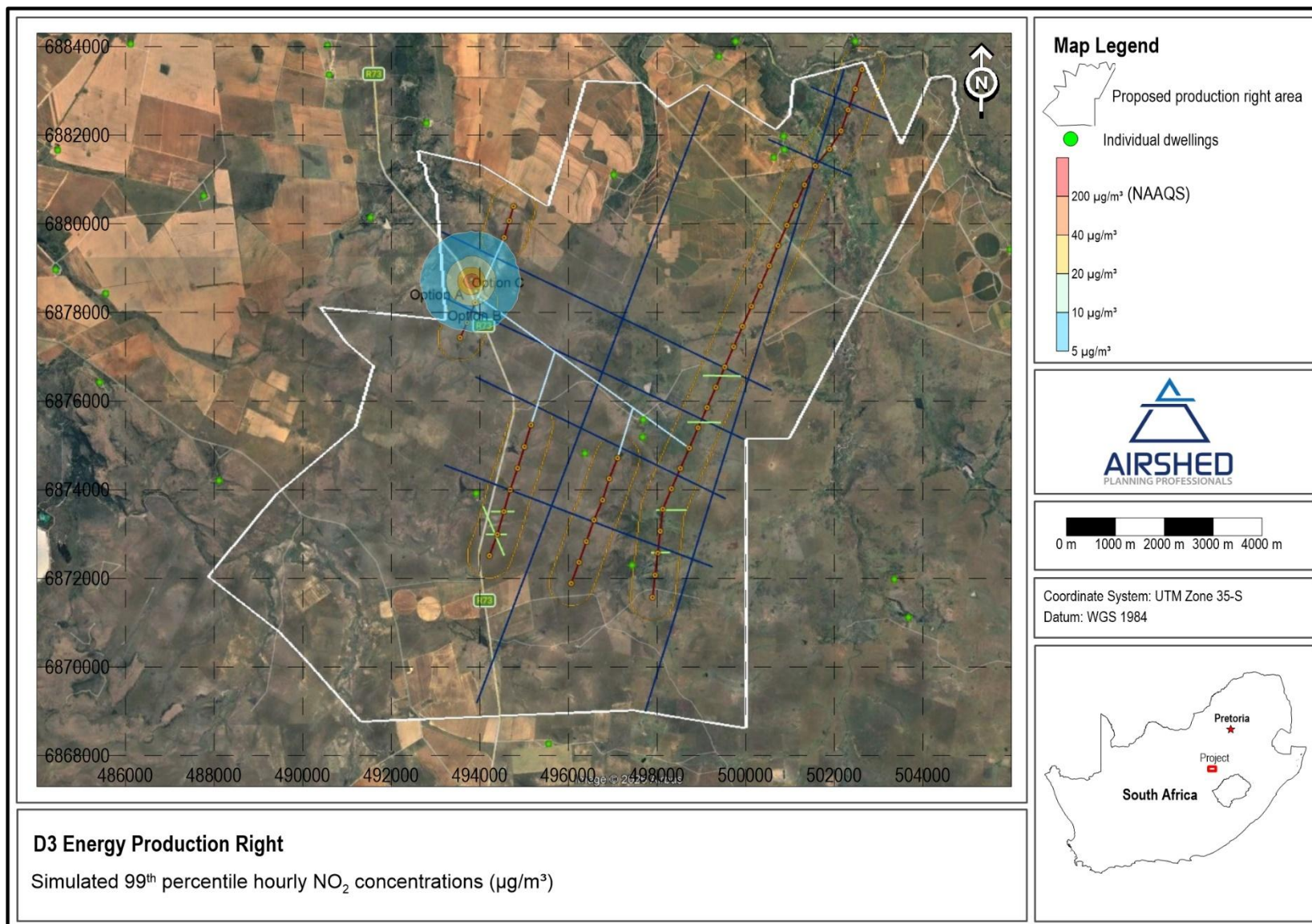


Figure 4-6: Simulated 99th percentile hourly NO₂ ground level concentrations due to combustion activities

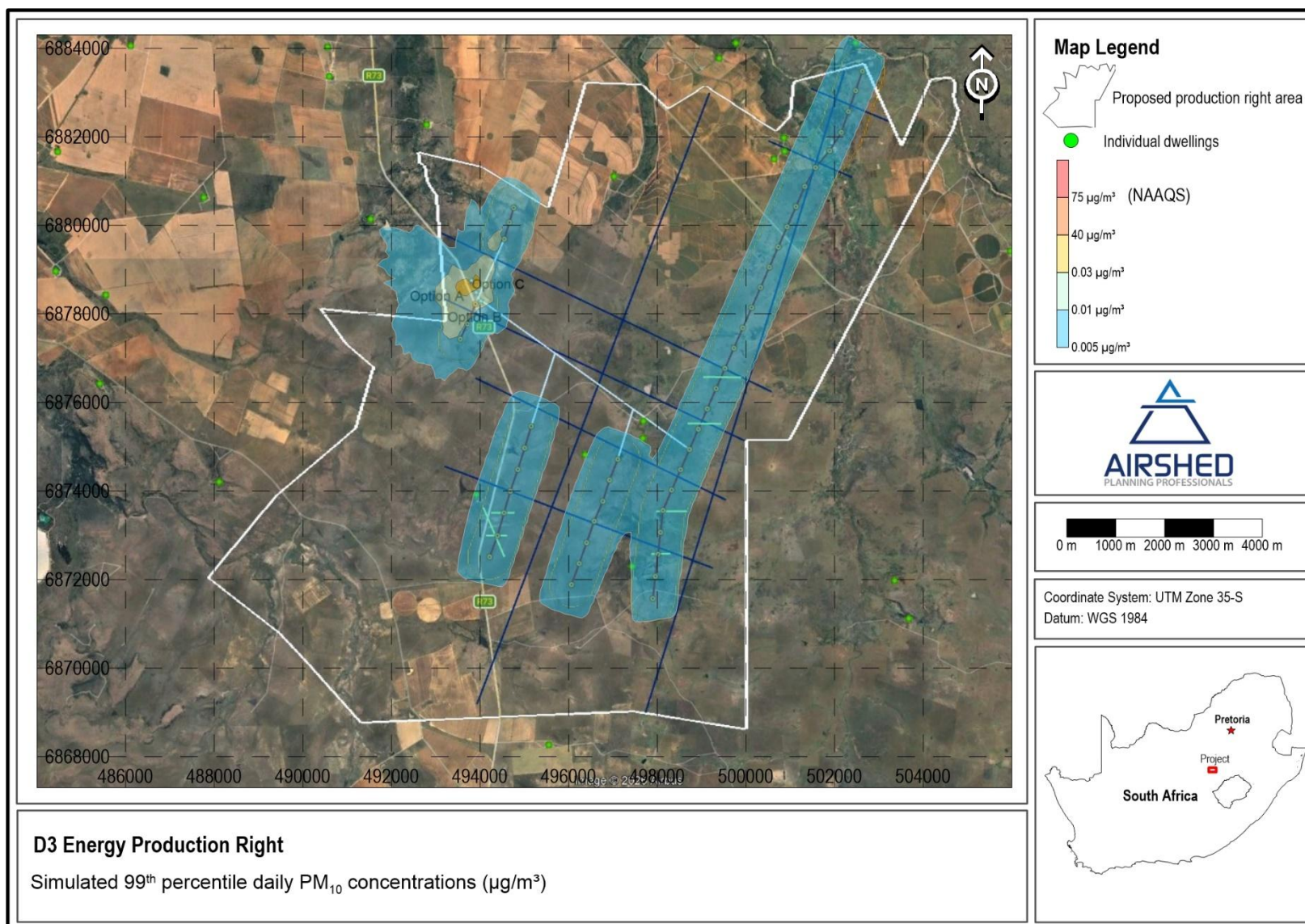


Figure 4-7: Simulated 99th percentile daily PM_{10} ground level concentrations due to combustion activities

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 and plant:
 - Construction Phase:
 - Without mitigation: medium-low negative significance rating.
 - With mitigation: medium-low negative significance rating.
 - Overall significance rating: medium-low negative significance rating.
 - Operation Phase (exploration - well drilling, testing and servicing operation):
 - Without mitigation: medium-low negative significance rating.
 - With mitigation: medium-low negative significance rating.
 - Overall significance rating: medium-low negative.
 - Operation Phase (seismic activity):
 - Without mitigation: medium-low negative significance rating.
 - With mitigation: medium-low negative significance rating.
 - Overall significance rating: medium-low negative.
 - Operation Phase (production):
 - Without mitigation: medium-low negative significance rating.
 - With mitigation: medium-low negative significance rating.
 - Overall significance rating: medium-low negative.
 - Decommissioning Phase:
 - Without mitigation: medium-low negative significance rating.
 - With mitigation: medium-low negative significance rating.
 - Overall significance rating: medium-low negative.

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	Construction	-1	2	2	3	2	3	-6.75 (medium-low)	-1	2	2	2	2	3	-6 (medium-low)	Medium	1	1	1	-6
	Operation – exploration (well drilling, testing and servicing operation)	-1	2	2	2	2	3	-6 (medium-low)	-1	2	2	1	2	3	-5.25 (medium-low)	Medium	1	1	1	-5.25
	Operation – seismic activity	-1	2	2	2	2	3	-6 (medium-low)	-1	2	2	1	2	3	-5.25 (medium-low)	Medium	1	1	1	-5.25
	Operation – production (at plant and at wells)	-1	2	4	3	2	3	-8.25 (medium-low)	-1	2	4	2	2	3	-7.5 (medium-low)	Medium	1	1	1	-7.5
	Decommissioning	-1	2	2	3	2	3	-6.75 (medium-low)	-1	2	2	2	2	3	-6 (medium-low)	Medium	1	1	1	-6

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 in close proximity to target areas.

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 activities:

- 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 the 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 drilling areas and 300 m of seismic surveys should be notified before project activities take place.
- The Grievance Mechanism must be established and maintained throughout the project activities to indicate air quality complaints and responses. 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 and production include the following (IFC, 2007):

- Exhaust gas emissions produced by the combustion of gas in turbines and other engines for power generation can be the most significant source of air emissions from onshore facilities. Air emission specifications must be considered during all equipment selection and procurement. The equipment with the best specifications must be used as far as possible.
- Flaring or venting are also important safety measures used on onshore gas facilities to ensure gas and other hydrocarbons are safely disposed of in the event of an emergency, power or equipment failure, or other plant upset condition. Measures consistent with the Global Gas Flaring and Venting Reduction Voluntary Standard (part of the World Bank Group's Global Gas Flaring Reduction Public-Private

Partnership (GGFR program) should be adopted when considering flaring and venting options for onshore activities. Core goals of the standard include: eliminating venting, reduce flaring, minimize waste and promote transparency by regular data tracking and open public reporting.

- Fugitive emissions at onshore facilities may be associated with cold vents, leaking pipes and tubing, valves, connections, flanges, packings, open-ended lines, pump seals, compressor seals, pressure relief valves, and hydrocarbon loading and unloading operations. Methods for controlling and reducing fugitive emissions should be considered and implemented in the design, operation, and maintenance of facilities. The selection of appropriate valves, flanges, fittings, seals, and packings should consider safety and suitability requirements as well as their capacity to reduce gas leaks and fugitive emissions. Additionally, leak detection and repair programs should be implemented. Records of selection process, leak detection systems / monitoring and repair programs must be kept on file.
- 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.
- During well testing, flaring of produced hydrocarbons should be avoided wherever practical and possible, and especially near local communities or in environmentally sensitive areas.
- 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

As there is currently a lack of baseline ambient air quality data, it is recommended that prior to construction a one-month passive ambient campaign is carried out for VOCs to determine baseline conditions.

An air quality monitoring programme can be implemented to as shown in

Table 6-2 and Table 6-2. Methane emissions (for climate change) can be monitored during well exploration, production and processing as well as decommissioning to assist with the greenhouse gas quantification as well as tracking fugitive leaks.

Table 6-1: Recommended air quality monitoring for the plant

Project phase	Activity	Pollutant	Performance indicator	Frequency
Construction	Construction of access roads and the plant	Dustfall	< 1200 mg/m ² /day	Monthly dust fallout
Operation	Combustion and process emissions at the plant	VOCs NO ₂	Benzene – 5 µg/m ³ NO ₂ – 40 µg/m ³ VOC – 200 µg/m ³	Quarterly or biannual passive sampling campaign for two weeks (VOC and NO ₂) Stationary sensors can be supplemented with periodic mobile gas imaging to spot fugitive emission hot-spots (LDAR for VOCs)

Table 6-2: Recommended air quality monitoring for the well sites

Project phase	Activity	Pollutant	Performance indicator	Frequency
Exploration	Well drilling and testing	VOCs	Benzene – 5 µg/m ³ VOC – 200 µg/m ³	Stationary sensors can be supplemented with periodic mobile gas imaging to spot fugitive emission hot spots (LDAR)
Operation	Fuel combustion emissions of drill rigs at the wells Fugitive emissions at the wells	VOCs NO ₂	Benzene – 5 µg/m ³ NO ₂ – 40 µg/m ³ VOC – 200 µg/m ³	Quarterly or biannual passive sampling campaign for two weeks (at the relevant active wells) Stationary sensors can be supplemented with periodic mobile gas imaging to spot fugitive emission hot-spots (LDAR for VOCs)

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:

- Construction and Exploration:
 - Maximum daily PM₁₀ ground level concentrations due to land clearing exceeds the daily PM₁₀ NAAQS for an area of approximately 1 km by 1 km around the plant and 130 m from the drill sites respectively.
 - Annual average VOC ground level concentrations due to exploration activities are well within the comfort level of 200 µg/m³.
 - Significance rating:
 - Without and with mitigation: medium-low negative significance rating.
 - Overall significance rating: medium-low negative significance rating.
- Operation:
 - Maximum hourly NO₂ ground level concentrations due to combustion sources, are well within the hourly NO₂ NAAQS, with maximum levels at the power plant of around 50 µg/m³. As the three options for the site are close to each other, and because the impact is simulated to be below NAAQS, from an air quality perspective there is no preferred site option.
 - Annual average VOC ground level concentrations due to production activities, are well within the comfort level of 200 µg/m³.
 - Significance rating:
 - Without and with mitigation: medium-low negative significance rating.
 - Overall significance rating: medium-low negative.
- Closure:
 - Assuming impacts due to rehabilitation activities to be similar to construction (i.e. land clearing), maximum daily PM₁₀ ground level concentrations may exceeds the daily PM₁₀ NAAQS for a limited area around the plant and well sites.
 - The testing wells must be capped and sealed and should not have any gaseous releases if properly managed.
 - Significance rating:

- Without and with mitigation: medium-low negative significance rating.
- Overall significance rating: medium-low negative.

7.2 Recommendations

Based on the findings of the AQIA, it is the specialist's opinion that the project can be authorised as there is no significant impact (fatal flaw) on the surrounding potentially sensitive receptors, provided that the following recommendations are taken into account:

- During construction of target areas, the exposed areas must remain moist through water spraying during dry, windy periods.
- All residents within 600 m of drilling areas and 300 m of seismic surveys should be notified before project activities take place.
- The Grievance Mechanism must be established and maintained throughout the project activities to indicate air quality complaints and responses. 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.
- Mitigation and monitoring measures as discussed in Section 6 should be considered.

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

CURRICULUM VITAE	GILLIAN PETZER
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CURRICULUM VITAE

Name	Gillian Petzer (née Möhle)
Date of Birth	1 December 1975
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Principal Consultant and Project Manager
Profession	Chemical Engineer employed as an Air Quality and Climate Change Impact Assessment Consultant
Years with Firm	20+ years

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- South African Institute of Chemical Engineers, 2003 to present
- Institution of Chemical Engineers (IChemE) - Membership number 99964317
- National Association for Clean Air (NACA), 2003 to present
- Professional Engineer – Registration number 20170315

EXPERIENCE

Gillian has over twenty years of experience in air quality impact assessment and management and ten years in greenhouse gas quantification and climate change impact assessments. She is an employee of Airshed Planning Professionals (Pty) Ltd and is involved in the compilation of emission inventories, air pollution mitigation and management, and air pollution and climate change impact work.

A list of projects completed in various sectors is given below.

Air Quality Management

- Richards Bay Air Quality Management Plan
- Tshwane Air Quality Management Plan
- Dust Management Plan for various mines

Mining Sector

Lusthof Colliery, South Deep Mine, Kangra, MacWest, Sishen Iron Ore Mine, Kolomela Mine, SA Chrome, Esaase Gold Project (Ghana), Mampon Gold Mine (Ghana), Navachab (Namibia), Skorpion Zinc mine (Namibia), Debswana Diamond Mines (Botswana). Quarries: Afrisam Pietermaritzburg, AMT operations (Rustenburg and Wonderstone).

Industrial Sector

Various Brickworks, Middelburg Ferrochrome, Impala Platinum (Springs), Delta EMD Project, PetroSA, Alfluorco Aluminium Fluoride Project, PPC, Rand Carbide, Vanchem, BCL incinerator, AEL, Namakwa Sands Plant, Liquid Natural Gas Refinery (Equatorial Guinea), Phalaborwa Mining Company, Asphalt plants, Ceramic facilities, Arcelor Mittal.

Energy Sector

Walvis Bay Power Station Project (Namibia), various small power stations (Eritrea, Nigeria, Mauritania, Kenya), Matimba Power Station, Mossel Bay OCGT Power Station, Sese Power Station (Botswana), Geothermal Power Station (Kenya), Kusile Power Station.

Waste Disposal and Treatment Sector

Rosslyn and Chloorkop Waste Disposal Sites, Organic waste disposal site.

Transport and Logistics Sector

Kolomela Iron Ore Railway Line, Guinea Port and Railway Project (Guinea), Grindrod Coal Terminal, VALE Port Project (Mozambique), various fuel depots.

Greenhouse Gas Emissions Inventories and Climate Change Impact Assessments

Van Eck Power Station (Namibia), Sheberghan Gas Fields (Afghanistan), Cabinda Refinery (Angola), Oil and gas offshore exploration (West Coast of SA), review of coal and gold mines climate change impact assessments.

Ambient Air Quality and Noise Sampling

- Gravimetric Particulate Matter (PM) and dustfall sampling
- Passive diffusive gaseous pollutant sampling

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), CALINE, GASSIM, TANKS
- Graphical Processing: Surfer, ArcGIS (basic proficiency)
- Other: MS Word, MS Excel, MS Outlook

EDUCATION

- BEng: (Chemical Engineering), 2002, University of Pretoria

RECENT COURSES COMPLETED AND CONFERENCES ATTENDED

- Conference: IUAPPA (October 2013), Attended
- Course: Climate change and carbon management. Presented by Environmental & Sustainability Solutions (July 2014)
- Conference NACA (October 2016), Attended
- Conference NACA (October 2017), Attended
- Process Vessel and Tank Design Course (May 2019)
- Multi-Variable Problems and Solutions Course (May 2020)
- Knowledge Management, Communication and Report Writing Course (June 2020)
- Materials Design Course (June 2020)
- Excel for Engineers and Other Built Environment Professionals (August 2022)
- IAIA Impact Assessment and Climate Change Symposium (September 2022), Attended and presented a climate change impact assessment
- IAIA Impact Assessment Conference (August 2023), Attended
- Conference NACA (October 2024), Attended

COURSES PRESENTED

- National Environmental Management: Air Quality Act and its Implementation (course arranged by the North-West University - NWU)

COUNTRIES OF WORK EXPERIENCE

South Africa, Namibia, Botswana, Ghana, Eritrea, Mauritania, Mozambique, Kenya, Guinea, Equatorial Guinea, Nigeria, Angola and Afghanistan.

LANGUAGES

Language	Proficiency
English	Native language
Afrikaans	Full professional proficiency

REFERENCES

Name	Position	Contact Number
Dr Lucian Burger	Director at Airshed Planning Professionals	+27 (82) 491 0385 lucian@airshed.co.za
Dr. Hanlie Liebenberg Enslin	Managing Director at Airshed Planning Professionals	+27 (83) 416 1955 hanlie@airshed.co.za

CERTIFICATION

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



13/03/2025

APPENDIX B - DECLARATION OF INDEPENDENCE

Project Details

Project Name	Air Quality Impact Assessment for the D3 Production Right Application (PR16), Free State Province
Applicant	
Competent Authority	

Specialist Details

Specialist Company	Airshed Planning Professionals			
Specialist Name	Gillian Petzer			
Contact details	Tel	011 805 1940	Cell	083 4793412
	E-mail	gillian@airshed.co.za		
	Postal Address	Postnet Suite 006, Private Bag X2, Raslouw, 0109		
	Physical Address	62 Constantia Road, Mnandi AH, Centurion, 0157		

General Declaration

By signing this form, I hereby declare that:

- I act as an independent specialist in this application.
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant.
- I declare that there are no circumstances that may compromise my objectivity in performing such work.
- I have expertise in conducting undertaking the specialist work as required, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity.
- I will comply with the Act, Regulations, and all other applicable legislation.
- I have not, and will not engage in, conflicting interest in the undertaking of the activity.
- I understand to disclose to the applicant and competent authority 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 competent authority; and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority.
- I have taken into account, to the extent possible, the matters referred to in Regulation 18 when preparing the report, plan or document.
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.
- All the particulars furnished by me this form are true and correct.

- I will perform all other obligations as expected from an environmental assessment practitioner in terms of the Regulations.
- I am aware of what constitutes an offence in terms of Regulation 48 and that a person convicted of an offence in terms of Regulation 48(1) is liable to the penalties as contemplated in Section 49B of the Act.

Disclosure of Vested Interest

- I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remunerative for work performed in terms of the Regulations.

Undertaking Under Oath/Affirmation

By signing this form, I swear under oath/affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

Signatures

Specialist					
Name	Gillian Petzer	Signature		Date	19/06/2026
Commissioner of Oaths					
Name		Signature		Date	
Commissioner of Oaths Official Stamp					

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.

Determination of Environmental Risk:

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:

$$Priority = CI + LR$$

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.