Ambient Air Quality Impact Study Commissioned By

NSOVO ENVIRONMENTAL CONSULTING

Project Reference 0121-P021-NSO Vogelfontein AQIS

Date 7 May 2021

This report documents the results and findings of an air quality impact investigation pertaining to the proposed Vogelfontein Colliery located near Breyten in the Msukaligwa Local Municipality of the Mpumalanga Province.

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EXECUTIVE SUMMARY

EHRCON (Pty) Ltd (EHRCON) was commissioned by Nsovo Environmental Consulting (Nsovo Environmental) to assess the air quality impact associated with the proposed Vogelfontein Colliery located near Breyten in the Msukaligwa Local Municipality of the Mpumalanga Province.

Grammatikos Construction & Mining CC is planning to mine coal at Vogelfontein Colliery by means of underground mining methods over a period of between 8 and 12 years. An incline shaft will be located on Portion 5 of the Farm Vogelfontein 245 IS. The preliminary production schedule indicates approximately 120 000 to 150 000 tonnes per month. Current geological information indicates that about 35 million tonnes of coal can be mined at Vogelfontein Colliery.

The objectives of the air quality impact study were to describe the ambient emissions from the Vogelfontein Colliery and to assess the impact on the health of the receiving community. The findings of the study are aimed at providing Grammatikos Construction & Mining CC, the Gert Sibande District Municipality and other stakeholders with scientific data required in terms of present and future air quality management systems.

The assessment considered a review of the relevant health legislation, ambient air quality guidelines and standards. A process description was provided and an overview given of the prevailing meteorological conditions in the area. An overview was given of the available data on criteria air pollutant concentrations. A process emission inventory was compiled, founded on current emission factors.

An evaluation of the potential for human health and environmental impacts, centred on comparisons of modelled pollutant concentrations with relevant guidelines and standards was performed. An assessment of the contribution and outcome of the process on the current air quality, completed the study.

The air quality impact study concludes the following:

- The project falls within the Gert Sibande District Municipality and the Highveld Priority Area. Air Quality Management Plans have been drafted and baseline characterisation have been completed. The status of ambient air quality is classified as poor with elevated concentrations of criteria pollutants.
- Recent ambient monitoring data for the area and other national publications confirms the significant contribution of mining, material handling and mobile equipment operation to ambient fine particulate concentrations, correspondingly concluded from the emission inventory conducted for this project.
- Emission rates will remain reasonably stable throughout the life of the project, influenced mainly by fluctuations in throughput.
- A total controlled emission rates of 19.80 gram per second were calculated for steady, optimum operations.
- Material handling will most likely be the largest source of ambient pollution (54%), followed by mobile equipment (16%) and processing emissions (12%).
- Particulate matter comprises approximately 70% of the pollution load and gaseous pollutants associated with mobile equipment, 30%. PM_{10} is the criteria pollutant of concern and contributes about 13% of the pollution load. Total suspended particulates and $PM_{2.5}$ contribute 56% and 2% respectively.
- Potential emission reduction of up to 33% were calculated based on the effective use of water as dust suppressant on roads and marshalling areas.
- Dispersion of particulate emissions from the process was modelled using the ISC-AERMOD View model based on the standard Gaussian solution.
- The results present the spectrum from maximum ground level concentration to maximum impact area, and accounts for daily and annual reference periods.
- Meteorological data for the period 1 May 2016 to 30 April 2021 was incorporate in the assessment. Winds from the northern sector (36.86%) were mostly reported for the study area. Calm periods were the exception and wind speeds were most often moderate, between 2.1 and 3.6 m/s (35.2%). Light winds between 0.5 and 2.1 m/s were recorded 12.7%, brisk winds between 3.6 and 5.7 m/s were recorded 32.7% and strong winds above 5.7m/s, about 18.4% of the time.

- Predicted incremental and cumulative dust deposition rates during construction and rehabilitation are expected to remain at current levels beyond the mining boundary and at all the closest receivers.
- Predicted incremental daily and annual average $PM_{10/2.5}$ concentrations as a result of construction/rehabilitation will probably remain below 10% of the relevant standards at the closest receivers.
- Predicted cumulative dust deposition rates during the operational phase are expected to contravene the non-residential standard at the closest receiver, 480m east south-east (R2) of the shaft area.
- Normal operations are likely to cause maximum daily average PM_{10} concentrations above 25% of the standard at the nearest sensitive receivers east (R1 & R2). Incremental annual PM_{10} concentrations are predicted to remain below 10% of the standard at the nearest receivers.
- Predicted incremental maximum daily and annual average $PM_{2.5}$ concentrations will probably remain below 10% of the respective standards at the nearest receivers.
- NO_2, SO_2 and CO emissions (vehicle tailpipe emissions) were quantified at levels well below 10% of the respective standards for all phases of the project.
- The incremental impact of all pollutants during construction and rehabilitation is negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of total suspended particulate matter during normal operations is minor at Receptor 1 and 2 and negligible all other. Current industry standard techniques and administrative control measures should be maintained and supplemented with engineering measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of fine particulate matter ($PM_{10/2.5}$) during normal operations is negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The uncontrolled incremental impact of gaseous pollutants during normal operations is negligible. Current industry standard techniques should be maintained and supplemented with administrative

control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.

- Ambient monitoring should be used in combination with modelling and emission inventory to assess the effectiveness of control measures at source and receivers, on an annual basis.
- Strict monitoring of ambient air quality will assist effective air quality management and open communication to all stakeholders.

DECLARATION AND REPORT APPROVAL

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- it acts as an independent specialist.
- all results and related data have been obtained through careful and precise execution of recognised methods of evaluation and are related to the scope of work covered in this report and of prevailing conditions at the time of the assessment.
- the opinions and interpretations are embraced through judgment, discernment and comprehension to the best of available knowledge and are outside the scope of any accreditation.
- it performed the work relating to this project in an objective manner, notwithstanding the results, views and findings.
- it has expertise in conducting the specialist report relevant to this project, including knowledge of the Act, regulations and any guidelines that may have relevance.
- it complies with the Act, regulations and all other applicable legislation.
- it has no, and will not engage in, conflicting interests in the undertaking of the activity.
- it undertakes to disclose to the client and authorities all material information it possesses that reasonably has or may have the potential of objectively influencing any decision based on the results and finings of this project.
- all the particulars furnished by EHRCON in this report are true and correct; and any false declaration is a punishable offence.

Report compile by EHRCON (Pty) Ltd

7 May 2021

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1. INTRODUCTION

1.1 PROJECT OUTLINE

EHRCON (Pty) Ltd (EHRCON) was commissioned by Nsovo Environmental (Nsovo Environmental) to assess the air quality impact associated with the proposed Vogelfontein Colliery located near Breyten in the Msukaligwa Local Municipality of the Mpumalanga Province.

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The report was compiled with due consideration of all process information and specific conditions outlined by Nsovo Environmental and Grammatikos Construction & Mining CC.

1.2 PROJECT DESCRIPTION

The study area is located in the Msukaligwa Local Municipality, within the Gert Sibande District Municipality of the Mpumalanga Province. Current land use is dominated by farming and mining processes. Vogelfontein Colliery is situated 16 kilometre west of the town Breyten. (See **Figure 1**).

The assessment of the potential air quality impact associated with the Vogelfontein Colliery comprised the following terms of reference:

- A review of relevant health legislation, ambient air quality guidelines and standards.
- A process description.
- An overview of the prevailing meteorological conditions in the area.
- An overview of available data on criteria air pollutant concentrations in the area.
- Evaluation of the potential for human health and environmental impacts centred on comparisons of modelled pollutant concentrations with relevant guidelines and standards.
- Assessment of the contribution and outcome of the process on the current air quality parameters in the study area.

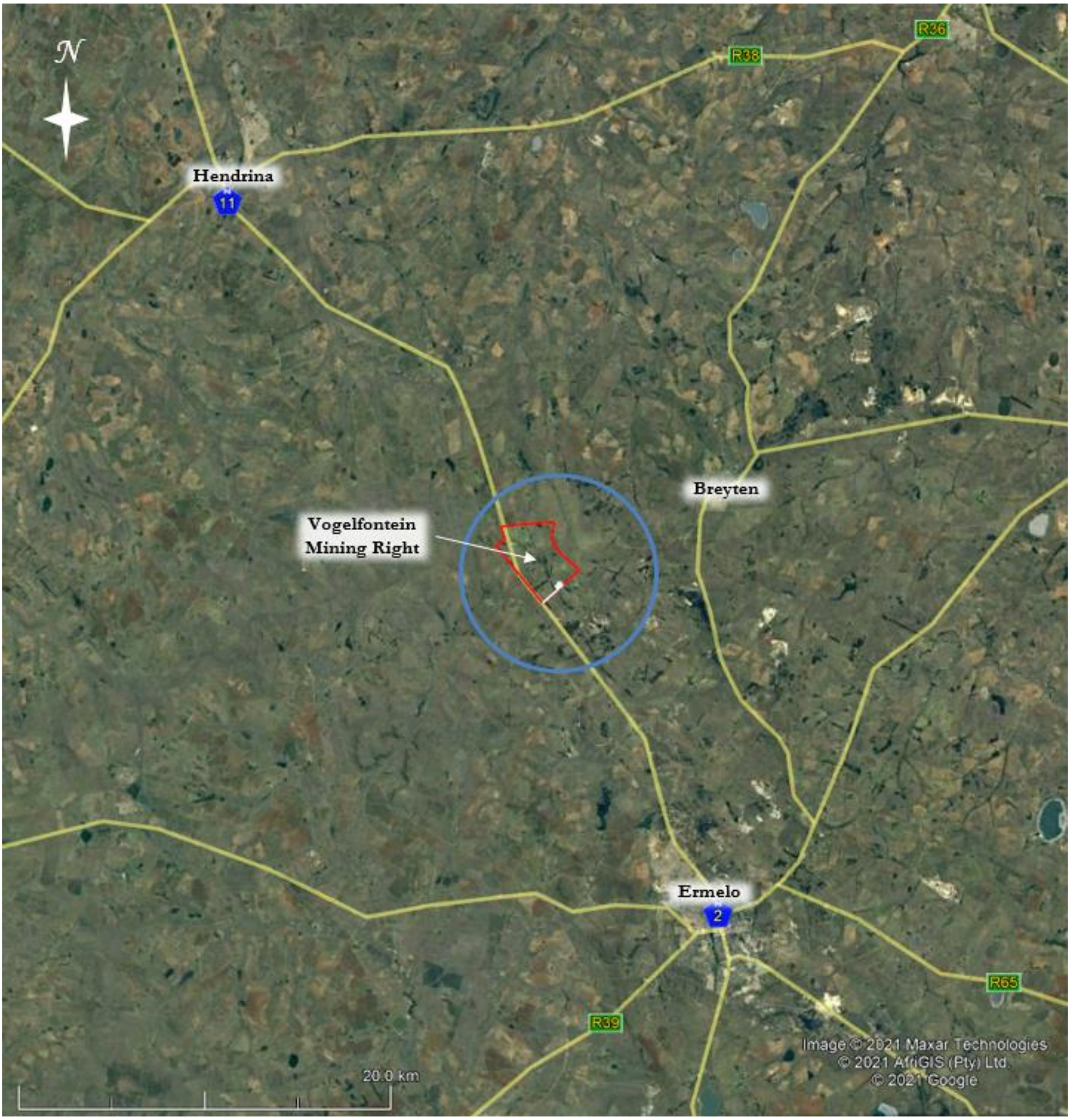

Figure 1: Vogelfontein Project Location

(Mining Right – Red Polygon, Surface Infrastructure – White Polygon and Study Area – Blue Circle)

1.3 METHODOLOGICAL OVERVIEW

The establishment of an emissions inventory formed the basis for assessing the impact from the Vogelfontein Colliery. This comprised the identification of sources of emission and the quantification of each source's contribution to ambient air concentrations. In the emissions inventory, dispersion simulation and impact assessment, reference was made to routine emissions from the process.

Process emission rates were obtained from emission factors which associate the quantity of a pollutant to the activity associated with its release. Due to the absence of locally generated emission factors, use was made of the comprehensive set of emission factors published by the United States Environmental Protection Agency (US-EPA) in its AP-42 document *Compilation of Pollution Emission Factors*.

National Pollution Inventory series document *Emission Estimation Technique Manual* published by the Australian Government Department of Sustainability, Environment, Water, Population and Communities was also used to supplement the study.

The simulation of emissions was performed through the application of the ISC-AERMOD View Model. AERMOD is a steady-state plume model, applicable to rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources (including, point, area and volume sources).

In the stable boundary layer (SBL), the concentration distribution is assumed to be Gaussian in both the vertical and horizontal. In the convective boundary layer (CBL), the horizontal distribution is assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function. Additionally, in the CBL, AERMOD treats "plume lofting", whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the CBL. AERMOD also tracks any plume mass that penetrates into elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate.

The dispersion simulations of emissions facilitated a preliminary or screening study of the potential for human health impacts. In order to assess the health implications, the simulated concentrations were compared to ambient air quality guidelines and standards.

1.4. ASSUMPTIONS, EXCLUSIONS AND LIMITATIONS

Data limitations and assumptions associated with the air quality impact study in support of the proposed Vogelfontein Colliery are listed below:

- Unified model meteorological data for the period 1 May 2016 to 30 April 2021, supplied by Meteoblue was used for dispersion modelling.
- No ambient monitoring data was available for the site.
- The impact assessment was limited to airborne particulates from mobile equipment operation, material handling and fugitive emissions. Vehicle tailpipe emissions were quantified for the operational phase of the project only.
- All transport trucks were assumed to have a 34-tonne load-carrying capacity.
- The dispersion model (AERMOD) cannot compute real time mining processes, therefore average mining process throughputs were utilised.
- Routine emissions for future operations were simulated based on average discard handling rates. Atmospheric releases occurring as a result of non-routine conditions were not accounted for.
- All sources were digitised from site layout diagram provided by Nsovo Environmental and Grammatikos Construction & Mining CC.
- The amount of surface area available to wind erosion for all stockpiles was conservatively assumed to be 85%.
- ROM production rate of approximately 150 000 tonnes per month.
- Contaminated coal handling of approximately 2.76%.

  The report was compiled with due consideration of all process information and specific conditions outlined by Nsovo Environmental and Grammatikos Construction & Mining CC.

2. LEGISLATION, GUIDELINES AND STANDARDS

2.1 AIR QUALITY ACT

The Department of Environment, Forestry and Fisheries (DEFF) have brought into effect the National Environmental Management: Air Quality Act (Act No. 39 of 2004, NEMAQA) on 11 September 2005 as part of a broad programme of air quality management reform.

The purpose of the Act is to set norms and standards that relate to institutional frameworks, roles and responsibilities; air quality management planning; air quality monitoring and information management; air quality management measures and general compliance and enforcement. Amongst other things, it is intended that the setting of norms and standards will achieve the following:

- The protection, restoration and enhancement of air quality in South Africa.
- Increased public participation in the protection of air quality and improved public access to relevant and meaningful information about air quality.
- The reduction of risks to human health and the prevention of the degradation of air quality.

A key aspect is the establishment of national ambient air quality standards. These standards provide the goals for air quality management plans and provide the yardstick by which the effectiveness of these management plans is measured. The Act provides for the identification of priority pollutants and the setting of ambient standards with respect to these pollutants.

The Act describes various regulatory tools that should be developed to ensure the implementation and enforcement of air quality management plans. These include:

- Priority Areas, which are air pollution "hot spots".
- Listed Activities, which are 'problem' processes that require an Atmospheric Emission Licence,
- Controlled Emitters, which includes the setting of emission standards for 'classes' of emitters, such as motor vehicles, incinerators, etc. and
- Control of Noise.
- Control of Odours.

2.2 AMBIENT AIR QUALITY STANDARDS

The exclusive use of source-based controls (e.g. emission limits) as an air quality management tool has been found to have important short-comings. Emission limits do not take the unique characteristics of the receiving environment into account, such as the dispersion potential, existence of other sources, existing ambient pollutant concentrations, and the sensitivity of the receiving environment. Such limits therefore provide no insurance that ambient air quality objectives will be achieved and that there will be no adverse effects on human health and welfare.

There has been a strong shift from air pollution control based exclusively on source-based methods (e.g. emission limits) to air quality management based on an effects-based approach (e.g. air quality objectives).

An effects-based approach requires the setting of ambient air quality guidelines and standards. Ambient air quality guidelines and standards are laid down by various countries, including South Africa, for the regulation of air concentrations of various criteria pollutants (e.g. sulphur dioxide, particulate matter, nitrogen oxides and lead). Such ambient guideline and standards define satisfactory air quality to ensure human health and welfare, thus providing objectives for air quality management.

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the receptor. These guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout the individual's entire lifetime. Air quality guidelines and standards are normally given for specific averaging periods, i.e. the duration over which the standard or guideline is applicable. Generally, five averaging periods are applicable, namely an instantaneous peak, 1-hour average, 24-hour average, 1-month average and annual average.

The NEMAQA is part of a broad programme of air quality management reform. The publication in May 2000 of government's Integrated Pollution and Waste Management Policy (IP & WM Policy) marked a turning point for pollution and waste governance in South Africa. The National Air Quality Management Plan (NAQMP), borne from the IP & WM Policy, has as its definition the NEMAQA.

Government's vision with respect to the NAQMP is that the programme will develop, implement and maintain an air quality management regime that contributes to sustainable development and a measurable improvement in the quality of life of all, by harnessing the energy and commitment of all South Africans for the effective prevention, minimisation and control of atmospheric pollution.

The DEFF is responsible for establishing a national framework for achieving the objectives of NEMAQA, which includes:

- Mechanisms, systems and procedures to attain compliance with ambient air quality standards.
- Mechanisms, systems and procedures to give effect to South Africa's obligations in terms of international agreements.
- National norms and standards for the control of emissions from point and non-point sources.
- National norms and standards for air quality monitoring.
- National norms and standards for air quality management planning.
- National norms and standards for air quality information management.
- Any other matter which the Minister considers necessary for achieving the objectives of the Act.

The establishment of national ambient air quality standards is achieved through NEMAQA and the South African Bureau of Standards (SABS) standard setting initiative. The National Ambient Air Quality Standards (NAAQS) have subsequently been published in the Government Gazette of 24 December 2009 and 29 June 2012.

The standards are summarised in **Table 1**.

Table 1: Ambient Air Quality Standards

Substance	Time weighted average (µg/m³)				
	10-minutes	1-hour	8-hour	24-hour	Annual
Ozone (O_3)	n.a.	n.a.	120[1]	n.a.	n.a.
Nitrogen dioxide (NO_2)	n.a.	200[2]	n.a.	n.a.	40
Sulphur dioxide (SO_2)	500[3]	350[2]	n.a.	125[4]	50
Lead (Pb)	n.a.	n.a.	n.a.	n.a.	0.5
Particulate matter (PM_{10})	n.a.	n.a.	n.a.	75[4]	40
Particulate matter ($PM_{2.5}$)	n.a.	n.a.	n.a.	40[4] 25[4]*	20 15*
Carbon monoxide (CO)	n.a.	30 000[2]	10 000[1]	n.a.	n.a.
Benzene (C_6H_6)	n.a.	n.a.	n.a.	n.a.	5

Notes:

µg/m³	:	microgram per cubic meter air @ 25°C and 101.3kPa
DEA	:	Department of Environmental Affairs, Forestry and Fisheries
1	:	Not to be exceeded more than 11 times per annum.
2	:	Not to be exceeded more than 88 times per annum.
3	:	Not to be exceeded more than 526 times per annum.
4	:	Not to be exceeded more than 4 times per annum.
5	:	Not to be exceeded more than 4 times per annum.
*	:	All standards are to be complied with immediately. Standards with an asterisk are to be complied with as from 1 January 2030.

2.3 DUST CONTROL REGULATIONS

National Dust Control Regulations was published on 1 November 2013 (Notice 827 of 2013). The purpose of the regulations is to prescribe general measures for the control of dust in all areas.

Standards for the acceptable dustfall rate for residential and non-residential areas is set out in **Table 2** below.

Table 2: Acceptable Dustfall Rate

Restriction Areas	Dustfall rate (D) (mg/m²/day, 30 days average)	Permitted frequency of exceeding dust fall rate
Residential Area	D < 600	Two within a year, not sequential months
Non-residential Area	600 < D > 1200	Two within a year, not sequential months

According to the regulations, any entity conducting any activity in such a way as to give rise to dust in quantities and concentrations that exceeded the dustfall standard set out in the regulation is impelled to, upon receipt of a notice from an air quality officer, implement a dustfall monitoring programme.

The method to be used for measuring the dustfall rate and the guideline for locating sampling points is the American Standards for Testing and Materials method, or an equivalent method approved by any internationally recognised body.

The regulation further states that an air quality officer could require any entity, through a written notice, to undertake a dustfall monitoring programme, if the officer reasonably suspected that the entity was contravening the regulations or that the activity being conducted required a fugitive dust emission management plan. An entity required to implement the programme must then, within a specified period, submit a dustfall monitoring report to the air quality officer.

A dustfall monitoring report must provide information on the location of sampling sites, classification of the area where samplers were located, as well as reference to the standard methods used for site selection, sampling and analysis. The report must also provide meteorological data for the sampling area, the dustfall monitoring results, including a comparison of current year and historical results for each site, as well as a tabular summary of compliance with the dustfall standard.

Any entity that exceeds the dustfall standard must, within three months after submission of the dustfall monitoring report, develop and submit a dustfall management plan to the air quality officer for approval. This management plan must identify all possible sources of dust within the affected site, detail the best practicable measures to be undertaken to mitigate dust emissions, identify the line management responsible for implementation and incorporate the dust fallout monitoring plan. Such a plan would need to be implemented within a month of the date of approval and an implementation progress report must be submitted to the air quality officer at agreed time intervals.

2.4 ATMOSPHERIC EMISSION REPORTING REGULATIONS

The National Atmospheric Emission Reporting Regulations came into effect on the 2 April 2015 (Notice 283 of 2015). The purpose of the regulations is to regulate the reporting of data and information from an identified point, non-point and mobile source of atmospheric emissions to the internet based National Atmospheric Emissions Inventory System (NAEIS) as to compile atmospheric emission inventories.

The following entities will be required to report in terms of the regulations:

- **Listed Activities:** Any entity that undertakes a NEMAQA air quality-related listed activity.
- **Controlled Emitters:** Any entity that undertakes a NEMAQA listed activity and uses an appliance or conducts an activity that has been declared a controlled emitter. To date small boilers, asphalt and temporary asphalt plants have been declared as controlled emitters.
- **Air quality officer:** Any air quality officer receiving emission reports in terms of Section 23 of NEMAQA.
- **Mines:** Any entity that holds a mining right or permit in terms of the Mineral and Petroleum Resources Development Act (Act No. 28 of 2002).
- **Facilities with Criteria Pollutants:** Any entity that operates facilities which generate criteria pollutants and who has been identified in accordance with the applicable municipal by-law. Criteria pollutants are those for which national ambient standards are prescribed in Schedule A to the NEMAQA.

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

2.5 ATMOSPHERIC IMPACT REPORT REGULATIONS

The Regulations Prescribing the Format of the Atmospheric Impact Report were published on 11 October 2013 (Notice 747 of 2013). The regulations prescribe the format of the impact reports and requires the submission of the following information:

- Full enterprise details.
- Location and extent of the plant.
- Atmospheric emission licences and other authorisations.
- The nature of the plant's processes and activities.
- Description of the surrounding areas.
- Raw materials used.
- Appliances and abatement equipment control technology used.
- Point sources parameters and maximum source emission rates.
- Fugitive emissions.
- Impact of the enterprise on human health and the environment.

2.6 AIR DISPERSION MODELLING REGULATIONS

Regulations Regarding Air Dispersion Modelling were promulgated in terms of NEMAQA on 11 July 2014 (Notice 533 of 2014).

Air dispersion modelling is defined as a series of mathematical simulations of how air pollutants disperse in the ambient atmosphere and is performed with computer programs that solve the mathematical equations and algorithms which simulate the dispersion of pollutants.

The Code of Practice for Air Dispersion Modelling applies in the development of:

- An air quality management plan.
- A priority area air quality management plan.
- An atmospheric impact report.
- A specialist air quality impact assessment study.

The air dispersion regulations standardise model applications for regulatory purposes. The Code of Practice recommends a suite of dispersion models to be applied for regulatory practices. It also provides guidance on modelling input requirements, protocols and procedures.

2.7 AIR QUALITY MANAGEMENT

2.7.1 Highveld Priority Area Air Quality Management Plan

The Minister declared the Highveld Priority Area (HPA) on 23 November 2007 as a National Priority Area. The HPA covers an area of 31 106 km2, including parts of Gauteng and Mpumalanga Provinces (see **Figure 2**).

Figure 2: Locality of the Highveld National Priority Area

The overall objective of the HPA AQMP is to achieve and maintain compliance with the ambient air quality standards across the area, using the Constitutional principle of progressive realisation of air quality improvements.

The overall objective of the HPA AQMP is to be realised through the attainment of seven related goals. These are:

- **Goal 1 Optimise organisational capacity in government to efficiently and effectively maintain, monitor and enforce compliance with ambient air quality standards (Deadline: 2015):** In achieving the goal, it is necessary to focus on institutional arrangements, resource availability, cooperation and collaboration as well as maximisation of regulatory and management tools. Capacity development in the AQMP is addressed holistically, looking at the necessary structures, systems, skills, incentives, inter-relationships and strategy.

- **Goal 2 Industries equitably reduce emissions to achieve compliance with ambient air quality standards and dust fallout limit values (Deadline: 2020):** The goal will be achieved through a combination of emission determination and reduction, technological improvement, improved resource allocation and information provision. The use of regulatory tools and best practice principles is also provided for. Political and social awareness, alternative energy and energy efficiency, fugitive dust emissions and greenhouse gas emission reduction are also promoted as aspects towards achieving the goal. The maintenance of vehicles and equipment on sites and industrial plants are addressed and spontaneous combustion is addressed as a contribution from the industrial mining sector.
- **Goal 3 Air quality in all low-income settlements is in full compliance with ambient air quality standards (Deadline: 2020):** Effective interventions, research, awareness raising, and education are major aspects in achieving the goal. Technological improvements are also critical, together with addressing the social and economic drivers of poor environmental practices.
- **Goal 4 All vehicles comply with the requirements of the National Vehicle Emission Strategy (Deadline: 2020):** Achieving the goal focuses on the implementation of the National Vehicle Emission Strategy, as it will provide direction on emission reduction, technological improvement and a conducive regulatory environment. Emission testing is recognised as a major driver for current reductions in vehicle emissions, which can be instituted by provincial and local authorities.
- **Goal 5 A measurable increase in awareness and knowledge of air quality exists (Deadline: 2020):** Achieving the goal is linked to access to information, resources, improving governance and authority's capacity and promoting air quality issues amongst stakeholders.
- **Goal 6: Biomass burning, and agricultural emissions will be 30% less than current (Deadline: 2020):** Management and regulatory tools are keys to achieving the goal, together with improved individual practices such as reduction of polluting inputs, awareness of unsuitable conditions and use of control measures.
- **Goal 7: Emissions from waste management are 40% less than current (Deadline: 2020):** In achieving the goal, it is necessary to improve waste processing, promote best practice principles and technological improvements, as well as address planning and delivery shortcomings and improves regulatory control of all aspects of waste management.

2.7.2 Gert Sibande District Municipality Integrated Development Plan

An Integrated Development Plan (IDP) is a five-year plan which Local Government is required to compile to determine the development needs of the Municipality. The projects within the IDP are linked to the municipality's budget. The most recent IDP for the Gert Sibande District Municipality (GSDM) covers the planning period 2017 to 2022.

The GSDM's environmental vision is to provide access to environmental services that improves the lives and safety of communities.

The GSDM environmental objectives include:

- Biodiversity and conservation management.
- Environmental pollution control, including environmental impact assessments, air quality management, climate change and greenhouse gas mitigation, awareness and regulations and waste management.
- Environmental management compliance monitoring and enforcement.
- Community and stakeholder capacity building and empowerment.

2.7.3 Gert Sibande District Municipality Air Quality Management By-law

The Council of Gert Sibande District Municipality enacted the Air Quality Management By-Law on 21 May 2014.

The purpose and objectives of this By-Law are to:

- Enable the Council and its local municipalities through its implementation organs or in partnership with other organs of state to protect, mitigate, intervene, regulate, control and promote the long-term health, well-being and safety of people in the jurisdiction area by providing, in conjunction with any other applicable law, an effective legal and administrative framework within which the Council can:
  - Prevent, manage, and regulate activities that have the potential to impact adversely on public or environmental health.
  - Require premises to be properly operated, maintained and managed.
  - Define the rights and obligations of the Council and the public in relation to this purpose.
- Give effect to the rights contained in Section 24 of the Constitution of the Republic of South Africa, 1996 by controlling air pollution within the area of the Council's jurisdiction.
- Ensure that air pollution is prevented, avoided, or where it cannot be altogether prevented, avoided, is minimised, controlled and remedied.

2.8 INTERNATIONAL AIR QUALITY GUIDELINES

2.8.1 World Health Organisation Air Quality Guidelines

Air pollution is the largest single environmental risk for health, recognised by the World Health Assembly (WHA) Resolution of May 2015.

The latest edition of World Health Organisation Air Quality Guidelines (WHO AQGs) for ambient air pollutants was published in 2006 and included recommendations for the classical air pollutants particulate matter (PM), ozone (O_3), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

Since then, the evidence base for adverse health effects related to short- and long-term exposure to these pollutants has become much larger and broader.

The WHA Resolution recognised the role of WHO AQGs for both ambient air quality and indoor air quality in providing guidance and recommendations for clean air that protect human health. As a result, in 2016 WHO has started the work towards the update of the Global Air Quality Guidelines. It is expected to provide up-to-date recommendations to continue protecting populations worldwide from the adverse health effects of ambient air pollution.

Particulate Matter

The WHO recommends an annual average for $PM_{2.5}$ of 10 $\mu g/m^3$ and a daily average of 25 $\mu g/m^3$. The historical mean $PM_{2.5}$ concentration in the Harvard Six-Cities study was 18 $\mu g/m^3$ (range, 11.0–29.6 $\mu g/m^3$) and 20 $\mu g/m^3$ (range, 9.0–33.5 $\mu g/m^3$) in the American Cancer Society's study. When evaluating the WHO AQGs and interim targets, it is generally recommended that the annual average take precedence over the 24-hour average.

The annual average for PM_{10} is 20 $\mu g/m^3$ and the 24-hour mean is 50 $\mu g/m^3$. Besides the guideline values, three annual and 24-hour interim targets (IT) are defined for $PM_{2.5}$ and PM_{10} (see **Figure 3** and **Figure 4**).

WHOair quality guidelines and interim targets for particulate matter: annual mean concentrations[a]

	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Basis for the selected level
Iinterim target-1 (IT-1)	70	35	These levels are associated with about a 15% higher long-term mortality risk relative to the AQG level.
Interim target-2 (IT-2)	50	25	In addition to other health benefits, these levels lower the risk of premature mortality by approximately 6% [2–11%] relative to theIT-1 level.
Interim target-3 (IT-3)	30	15	In addition to other health benefits, these levels reduce the mortality risk by approximately 6% [2-11%] relative to the -IT-2 level.
Air quality guideline (AQG)	**20**	**10**	These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to long-term exposure to $PM_{2.5}$

a The use of $PM_{2.5}$ guideline value is preferred.

Figure 3: WHO AQGs for Annual Mean Particulate Matter Concentrations

WHO air quality guidelines and interim targets for particulate matter: 24-hour concentrations[a]

	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Basis for the selected level
Interim target-1 (IT-1)	150	75	Based on published risk coefficients from multi-centre studies and meta-analyses (about 5% increase of short-term mortality over the AQG value).
Interim target-2 (IT-2)	100	50	Based on published risk coefficients from multi-centre studies and meta-analyses (about 2.5% increase of short-term mortality over the AQG value).
Interim target-3 (IT-3)*	75	37.5	Based on published risk coefficients from multi-centre studies and meta-analyses (about 1.2% increase in short-term mortality over the AQG value).
Air quality guideline (AQG)	**50**	**25**	Based on relationship between 24-hour and annual PM levels.

a 99th percentile (3 days/year).

* For management purposes. Based on annual average guideline values; precise number to be determined on basis of local frequency distribution of daily means. The frequency distribution of daily $PM_{2.5}$ or PM_{10} values usually approximates to a log-normal distribution.

Figure 4: WHO AQGs for Daily Mean Particulate Matter Concentrations

Sulphur dioxide

The WHO AQGs stipulates 20 µg/m^3 as a 24-hour mean and 500 µg/m^3 as a 10-minute mean for Sulphur Dioxide (SO_2). Besides the guideline values, two 24-hour and 10-minute interim targets (IT) are defined for SO_2 (see **Figure 5**).

WHO air quality guidelines and interim targets for SO_2: 24-hour and 10-minute concentrations			
	24-hour average ($\mu g/m^3$)	10-minute average ($\mu g/m^3$)	Basis for selected level
Interim target-1 (IT-1)[a]	125	–	
Interim target-2 (IT-2)	50	–	Intermediate goal based on controlling either motor vehicle emissions, industrial emissions and/or emissions from power production. This would be a reasonable and feasible goal for some developing countries (it could be achieved within a few years) which would lead to significant health improvements that, in turn, would justify further improvements (such as aiming for the AQG value).
Air quality guideline (AQG)	**20**	**500**	

[a] Formerly the WHO Air Quality Guideline (WHO, 2000).

Figure 5: WHO AQGs for Daily and 10-minute Average Sulphur Dioxide Concentrations

Nitrogen oxides

The current annual WHO AQG for NO_2 is 40 µg/m^3 and the 1-hour mean is 200 µg/m^3. Ambient concentrations of NO_2 in air are highly variable. Natural background concentrations can range from less than 0.4 µg/m^3 to more than 9 µg/m^3. In cities, ambient annual mean concentrations can range from 20 to 90 µg/m^3 with hourly maximum concentrations from 75 to 1 000 µg/m^3. In Johannesburg, annual average concentrations in excess of 70 µg/m^3 have been recorded regularly over the last twenty years.

Carbon monoxide

According to the WHO Natural ambient concentrations of CO range between 0.06 and 0.14 mg/m^3. In urban environments, mean concentrations over eight hours are usually less than 20 mg/m^3, and one-hour peak levels are usually less than 60mg/m^3. Highest concentrations are usually measured near major roads, as vehicles are the major source of CO (WHO, 2000).

Ozone

The WHO AQG sets the value for ozone levels at 100 µg/m^3 for an 8-hour daily average. Background one-hour average concentrations of O_3 in remote and relatively unpolluted parts of the world are often in the range of 40 to 70 µg/m^3. In cities maximum mean hourly concentrations can be as high as 300 to 400 µg/m^3. Besides the guideline value, an 8-hour interim target (IT) has been set for ozone (see **Figure 6**).

WHO air quality guideline and interim target for ozone: 8-hour concentrations

	Daily maximum 8-hour mean (µg/m^3)	Basis for selected level
High levels	240	Significant health effects; substantial proportion of vulnerable populations affected.
Interim target-1 (IT-1)	160	Important health effects; does not provide adequate protection of public health. Exposure to this level of ozone is associated with: • physiological and inflammatory lung effects in healthy exercising young adults exposed for periods of 6.6 hours; • health effects in children (based on various summer camp studies in which children were exposed to ambient ozone levels). • an estimated 3–5% increase in daily mortality[a] (based on findings of daily time-series studies).
Air quality guideline (AQG)	**100**	Provides adequate protection of public health, though some health effects may occur below this level. Exposure to this level of ozone is associated with: • an estimated 1–2% increase in daily mortality[a] (based on findings of daily time-series studies). • Extrapolation from chamber and field studies based on the likelihood that real-life exposure tends to be repetitive and chamber studies exclude highly sensitive or clinically compromised subjects, or children. • Likelihood that ambient ozone is a marker for related oxidants.

[a] Deaths attributable to ozone. Time-series studies indicate an increase in daily mortality in the range of 0.3–0.5% for every 10 µg/m^3 increment in 8-hour ozone concentrations above an estimated baseline level of 70 µg/m^3.

Figure 6: WHO AQGs and Interim Targets for 8-hour Average Ozone Concentrations

Lead

Levels of lead found in air, food, water and soil/dust vary widely throughout the world and depend on the degree of industrial development, urbanisation and other lifestyle factors. In cities of developing countries traffic-related lead levels range between 0.3 and 1 µg/m^3 with extreme annual mean values between 1.5 and 2 µg/m^3.

3. BACKGROUND ASSESSMENT

3.1 PROCESS DESCRIPTION

Grammatikos Construction & Mining CC is planning to mine coal at Vogelfontein Colliery by means of underground mining methods over a period of between 8 and 12 years. An incline shaft will be located on Portion 5 of the Farm Vogelfontein 245 IS. The preliminary production schedule indicates approximately 120 000 to 150 000 tonnes per month. Current geological information indicates that nearly 35 million tonnes of coal can be mined at Vogelfontein Colliery.

It is planned to access the underground reserves by means of a 9-degree decline shaft system entering the shallower B seam at a depth of approximately 70 metre below surface. Two secondary winzes will be constructed on the western side and southern side of the reserve area in order to access the C-Lower seam from within the B seam development 15m below the B seam. Two access winzes will be required due to the no-coal zone on the western side which divides the reserve area into two separate non-contiguous blocks.

The mining operation will be conducted by underground mechanised Bord and Pillar mining techniques. It is planned to mine both seams by means of Continuous Miners supported by mechanical ancillary equipment. The coal will be cut by Continues Miners, loaded onto shuttle cars and transported and deposited into mechanical feeder breakers for size reduction purposes. From here the coal will be transported on conveyor belts towards the surface stockpile area where a secondary crushing and screening operation will be conducted.

Coal transportation will mainly be done via conveyors. Section conveyors feed on to the trunk conveyors, feeding into the shaft bin, from where coal is fed onto the shaft conveyor to surface. ROM coal mined from underground operations < 175 mm in size will be introduced to a primary crusher where the coal will be crushed to a -50mm size fraction. The crushed coal will be introduced to a secondary crusher and sized to a -40 mm fraction.

A pre-qualification quality control system will be introduced after the crushing and screening facility on surface in order to ensure constant and compliant sales quality. Coal will be loaded onto surface trucks for transportation to the various contracted power stations.

The ROM crushed product is solely intended for the local power generation market.

Figure 7 contains the layout plan for the Vogelfontein Colliery.

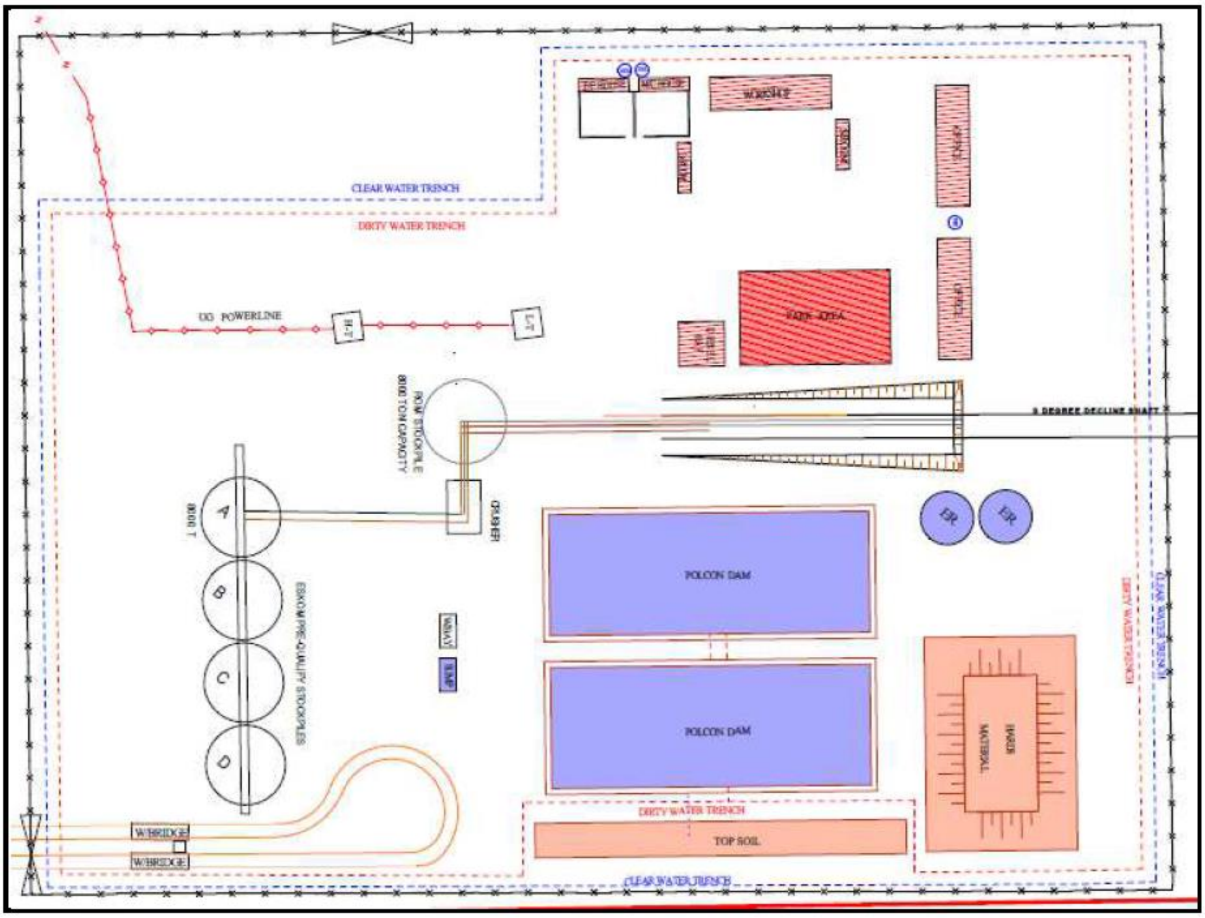

Figure 7: Vogelfontein Colliery Layout Plan

3.2 EMISSION INVENTORY

3.2.1 Construction

Heavy construction is a source of dust emissions that may have substantial temporary impact on local air quality. Building and road construction are two examples of construction activities with high emissions potential. Emissions during the construction of a building or road can be associated with land clearing, drilling and blasting, ground excavation, cut and fill operations (i.e., earth moving), and construction of a facility itself. Dust emissions often vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. A large portion of the emissions results from equipment traffic over temporary roads at the construction site.

The temporary nature of construction differentiates it from other fugitive dust sources as to estimation and control of emissions. Construction consists of a series of different operations, each with its own duration and potential for dust generation. In other words, emissions from any single construction site can be expected (1) to have a definable beginning and an end and (2) to vary substantially over different phases of the construction process. This contrasts with most other fugitive dust sources, where emissions are either relatively steady or follow a discernable annual cycle. Furthermore, there is often a need to estimate area-wide construction emissions, without regard to the actual plans of any individual construction project.

The quantity of dust emissions from construction operations is proportional to the area of land being worked and to the level of construction activity. By analogy to the parameter dependence observed for other similar fugitive dust sources, one can expect emissions from heavy construction operations to be positively correlated with the silt content of the soil (that is, particles smaller than 75 micrometers [µm] in diameter), as well as with the speed and weight of the average vehicle, and to be negatively correlated with the soil moisture content.

3.2.2 Material Handing and Stockpiling

Inherent in operations that use minerals in aggregate form is the maintenance of outdoor storage piles. Storage piles are usually left uncovered, partially because of the need for frequent material transfer into or out of storage. Dust emissions occur at several points in the storage cycle, such as material loading onto the pile, disturbances by strong wind currents, and load-out from the pile. The movement of trucks and loading equipment in the storage pile area is also a substantial source of dust.

The quantity of dust emissions from aggregate storage operations varies with the volume of aggregate passing through the storage cycle. Emissions also depend on 3 parameters related to the condition of the storage pile: age of the pile, moisture content, and proportion of aggregate fines.

When freshly processed aggregate is loaded onto a storage pile, the potential for dust emissions is at a maximum. Fines are easily disaggregated and released to the atmosphere upon exposure to air currents, either from aggregate transfer itself or from high winds. As the aggregate pile weathers, however, potential for dust emissions is greatly reduced. Moisture causes aggregation and cementation of fines to the surfaces of larger particles. Any significant rainfall soaks the interior of the pile resulting in a slow drying process.

Total dust emissions from aggregate storage piles result from several distinct source activities within the storage cycle:

- Loading of aggregate onto storage piles (batch or continuous drop operations).
- Equipment traffic in storage area.
- Wind erosion of pile surfaces and ground areas around piles.
- Load-out of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

Either adding aggregate material to a storage pile or removing it usually involves dropping the material onto a receiving surface. Truck dumping on the pile or loading out from the pile to a truck with a front-end loader are examples of batch drop operations. Adding material to the pile by a conveyor stacker is an example of a continuous drop operation.

3.2.3 Fugitive Dust Sources

Significant atmospheric dust arises from the mechanical disturbance of granular material exposed to the air. Dust generated from these open sources is termed "fugitive" because it is not discharged to the atmosphere in a confined flow stream. Common sources of fugitive dust include unpaved roads, agricultural tilling operations, aggregate storage piles, and heavy construction operations.

From the time a mining area is disturbed until new vegetation emerges, all disturbed areas are subject to wind erosion. For the above sources of fugitive dust, the dust-generation process is caused by 2 basic physical phenomena:

- Pulverisation and abrasion of surface materials by application of mechanical force through implements (wheels, blades, etc.).
- Entrainment of dust particles by the action of turbulent air currents, such as wind erosion of an exposed surface by wind speeds over 19 kilometers per hour (km/hr) (5.3 m/s).

The impact of a fugitive dust source on air pollution depends on the quantity and drift potential of the dust particles injected into the atmosphere. In addition to large dust particles that settle out near the source (often creating a local nuisance problem), considerable amounts of fine particles also are emitted and dispersed over much greater distances from the source.

The potential drift distance of particles is governed by the initial injection height of the particle, the terminal settling velocity of the particle, and the degree of atmospheric turbulence. Theoretical drift distance, as a function of particle diameter and mean wind speed, has been computed for fugitive dust emissions.

Results indicate that, for a typical mean wind speed of 16 km/hr (4.4 m/s), particles larger than about 100 µm are likely to settle out within 6 to 9 meters (20 to 30 feet) from the edge of the road or other point of emission. Particles that are 30 to 100 µm in diameter are likely to undergo impeded settling. These particles, depending upon the extent of atmospheric turbulence, are likely to settle within a few hundred feet from the source. Smaller particles, particularly TSP and PM-10, have much slower gravitational settling velocities and are much more likely to have their settling rate retarded by atmospheric turbulence.

Dust emissions may be generated by wind erosion of open aggregate storage piles and exposed areas within an industrial facility. These sources typically are characterized by nonhomogeneous surfaces impregnated with non-erodible elements (particles larger than approximately 1 centimeter in diameter).

Field testing of coal piles and other exposed materials using a portable wind tunnel has shown that:

- Threshold wind speeds exceed 5 meters per second (m/s) at 15 cm above the surface or 10 m/s at 7 m above the surface.
- Particulate emission rates tend to decay rapidly (half-life of a few minutes) during an erosion event.

In other words, these aggregate material surfaces are characterised by finite availability of erodible material (mass/area) referred to as the erosion potential. Any natural crusting of the surface binds the erodible material, thereby reducing the erosion potential.

3.2.4 Vehicle Transport Emissions

When a vehicle travels an unpaved road, the force of the wheels on the road surface causes pulverisation of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed.

The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. Field investigations also have shown that emissions depend on source parameters that characterize the condition of a road and the associated vehicle traffic. Characterisation of these source parameters allow for 'correction' of emission estimates to specific road and traffic conditions present on public and industrial roadways.

Dust emissions from unpaved roads have been found to vary directly with the fraction of silt (particles smaller than 75 micrometers in diameter) in the road surface materials.

Other variables are important in addition to the silt content of the road surface material. For example, at industrial sites, where haul trucks and other heavy equipment are common, emissions are highly correlated with vehicle weight.

3.3 EMISSION FACTORS

Data for this investigation were obtained from several sources within the Office of Air Quality Planning and Standards (OAQPS) of the United States Environmental Protection Agency. The AP-42 background files located in the *Emission Factor and Inventory Group (EFIG)* were reviewed for information on the industry, processes, and emissions.

National Pollution Inventory series document *Emission Estimation Technique Manual* published by the Australian Government Department of Sustainability, Environment, Water, Population and Communities was also used to supplement the study.

Table 3 summarises emission factors and **Table 4** the emission rates for the Vogelfontein Colliery project.

Table 3: Vogelfontein Colliery Emissions Factors

Activity	Emission unit	TSP	PM_{10}	$PM_{2.5}$	CO	NOx	SO_2
A. Construction							
1. Fugitive emissions	Mg/hectare/year	2.69E+00	1.40E+00	1.35E-01	-	-	-
B. Mining							
2. All underground activities	mg/m^3	1.16E+00	4.04E-01	5.78E-02	-	-	-
C. ROM Handling							
3. ROM stockpile feeding and discharge	kg/Mg	3.49E-02	5.43E-03	1.38E-04	-	-	-
4. ROM stockpile fugitive emissions	kg/hectare/hour	6.55E+00	9.37E-01	1.34E-01	-	-	-
D. Beneficiation							
5. Crushing and screening operations	kg/Mg	2.25E-02	8.30E-03	3.38E-03	-	-	-
6. Transport of overburden/ contaminated coal	kg/VKT & kg/kWh	1.70E+00	4.24E-01	4.24E-02	4.70E-03	1.10E-02	7.70E-05
7. Overburden/contaminated coal handling	kg/Mg	4.86E-02	6.96E-03	1.76E-04	-	-	-
8. Hards dump fugitive emissions	kg/hectare/hour	6.55E+00	3.28E+00	4.91E-01	-	-	-
E. Product Export							
9. Product overland conveyor	kg/Mg	3.49E-02	5.43E-03	1.38E-04	-	-	-
10. Product front-end loader operations	kg/Mg	3.49E-02	5.43E-03	1.38E-04	-	-	-
11. Product road export operations	kg/VKT & kg/kWh	2.28E+00	5.68E-01	5.68E-02	4.70E-03	1.10E-02	7.70E-05
12. Product stockpile fugitive emissions	kg/hectare/hour	6.55E+00	3.28E+00	4.91E-01	-	-	-
F. Auxiliary Services							
13. Toyota LDV 2.5 D-4D	kg/VKT & kg/kWh	4.97E-01	1.24E-01	1.24E-02	6.20E-03	1.50E-02	8.00E-06
14. CAT Wheel Dozer 934H	kg/VKT & kg/kWh	2.33E+00	5.80E-01	5.80E-02	4.70E-03	1.10E-02	7.70E-05
15. CAT Wheel Loader 966H	kg/VKT & kg/kWh	1.71E+00	4.26E-01	4.26E-02	3.60E-03	1.20E-02	7.50E-06
16. CAT Motor Grader 16M	kg/VKT & kg/kWh	1.78E+00	4.44E-01	4.44E-02	2.10E-03	9.60E-03	7.50E-06

Notes:

1 : US EPA, AP42, Volume I, 5 Edition, Chapter 13.2.3 Heavy Construction Operations.
2 : Australian Government, Emission Estimation Technique Manual for mining, Version 3.
3 : US EPA, AP42, Volume I, 5 Edition, Chapter 11.9 Western Surface Coal Mining. Conveyor transfer. Coal moisture content 10.4%.
4 : US EPA, AP42, Volume I, 5 Edition, Chapter 11.9 Western Surface Coal Mining. Active storage pile wind erosion and maintenance. Mean annual wind speed of 3.60m/s.
5 : US EPA, AP42, Volume I, 5 Edition, Chapter 11.24.
6 : US EPA, AP42, Volume I, 5 Edition, Chapter 13.2.2 Unpaved Roads. Calculated for a CAT 725 Articulated Truck, average vehicle weight of 34 tons and average road silt content 4.3%.
7 : US EPA, AP42, Volume I, 5 Edition, Chapter 11.9 Western Surface Coal Mining. Conveyor transfer. Coal moisture content 7.9%.
8 : US EPA, AP42, Volume I, 5 Edition, Chapter 11.9 Western Surface Coal Mining. Active storage pile wind erosion and maintenance. Mean annual wind speed of 3.60m/s.
9 : US EPA, AP42, Volume I, 5 Edition, Chapter 11.9 Western Surface Coal Mining. Conveyor transfer. Coal moisture content 10.4%.
10 : US EPA, AP42, Volume I, 5 Edition, Chapter 11.9 Western Surface Coal Mining. Front-end loader transfer. Coal moisture content 10.4%.
11 : US EPA, AP42, Volume I, 5 Edition, Chapter 13.2.2 Unpaved Roads. Calculated for a road truck with an average vehicle weight of 34 tons and average road silt content 4.3%.
12 : US EPA, AP42, Volume I, 5 Edition, Chapter 11.9 Western Surface Coal Mining. Active storage pile wind erosion and maintenance. Mean annual wind speed of 3.60m/s.
13 : US EPA, AP42, Volume I, 5 Edition, Chapter 13.2.2 Unpaved Roads. Calculated for a road truck with an average vehicle weight of 1.53 tons and average road silt content 4.3%.
14 : US EPA, AP42, Volume I, 5 Edition, Chapter 13.2.2 Unpaved Roads. Calculated for a road truck with an average vehicle weight of 47.11 tons and average road silt content 4.3%.
15 : US EPA, AP42, Volume I, 5 Edition, Chapter 13.2.2 Unpaved Roads. Calculated for a road truck with an average vehicle weight of 23.70 tons and average road silt content 4.3%.
16 : US EPA, AP42, Volume I, 5 Edition, Chapter 13.2.2 Unpaved Roads. Calculated for a road truck with an average vehicle weight of 26.06 tons and average road silt content 4.3%.

Table 4: Vogelfontein Colliery Emission Rates

Activity	Control factor	Emission rate (gram per second)					
		TSP	PM_{10}	$PM_{2.5}$	CO	NO_X	SO_2
A. Construction							
1. Fugitive emissions	1.00	6.63E-01	3.45E-01	3.31E-02	-	-	-
B. Mining							
2. All underground activities	1.00	2.31E-01	8.08E-02	1.16E-02	-	-	-
C. ROM Handling							
3. ROM stockpile feeding and discharge	1.00	1.99E+00	3.10E-01	7.85E-03	-	-	-
4. ROM stockpile fugitive emissions	1.00	9.28E-02	1.33E-02	1.90E-03	-	-	-
D. Beneficiation							
5. Crushing and screening operations	1.00	1.28E+00	4.74E-01	1.93E-01	-	-	-
6. Transport of overburden/ contaminated coal	0.25	1.12E-02	2.78E-03	2.78E-04	3.08E-01	7.21E-01	5.05E-03
7. Overburden/contaminated coal handling	1.00	7.65E-02	1.10E-02	2.78E-04	-	-	-
8. Hards dump fugitive emissions	1.00	5.33E-01	2.67E-01	4.00E-02	-	-	-
E. Product Export							
9. Product overland conveyor	1.00	1.94E+00	3.02E-01	7.64E-03	-	-	-
10. Product front-end loader operations	1.00	1.94E+00	3.02E-01	7.64E-03	-	-	-
11. Product road export operations	0.25	2.32E+00	5.79E-01	5.79E-02	3.08E-01	7.21E-01	5.05E-03
12. Product stockpile fugitive emissions	1.00	3.28E-01	1.64E-01	2.46E-02	-	-	-
F. Auxiliary Services							
13. Toyota LDV 2.5 D-4D	0.25	2.01E-02	5.01E-03	5.01E-04	2.24E-01	5.42E-01	2.89E-04
14. CAT Wheel Dozer 934H	0.25	6.27E-02	1.56E-02	1.56E-03	4.30E-01	1.01E+00	7.04E-03
15. CAT Wheel Loader 966H	0.25	1.15E-01	2.87E-02	2.87E-03	2.07E-01	6.90E-01	4.31E-04
16. CAT Motor Grader 16M	0.25	4.80E-02	1.20E-02	1.20E-03	1.26E-01	5.76E-01	4.50E-04

G. Mining Activity Summary							
1. Mining (ave. 16%)		0.231	0.081	0.012	0.000	0.000	0.000
		2%	3%	3%	0%	0%	0%
2. ROM Handling (ave. 10%)		2.086	0.323	0.010	0.000	0.000	0.000
		19%	13%	3%	0%	0%	0%
3. Beneficiation (ave. 37%)		1.905	0.754	0.233	0.308	0.721	0.005
		17%	29%	65%	19%	17%	28%
4. Product Export (ave. 21%)		6.527	1.346	0.098	0.308	0.721	0.005
		59%	52%	27%	19%	17%	28%
5. Auxiliary Services (ave. 30%)		0.246	0.061	0.006	0.986	2.813	0.008
		2%	2%	2%	62%	66%	45%
H. Source Summary							
1. Material Handling (ave. 16%)		5.945	0.924	0.023	0.000	0.000	0.000
		54%	36%	7%	0%	0%	0%
2. Processing (ave. 14%)		1.284	0.474	0.193	0.000	0.000	0.000
		12%	18%	54%	0%	0%	0%
3. Mobile Equipment (ave. 61%)		2.581	0.643	0.064	1.603	4.255	0.018
		23%	25%	18%	100%	100%	100%
4. Fugitive (ave. 13%)		1.185	0.525	0.078	0.000	0.000	0.000
		9%	20%	22%	0%	0%	0%
Maximum Controlled Emission Rate	**19.795**	**10.995**	**2.566**	**0.358**	**1.603**	**4.255**	**0.018**
	100%	**56%**	**13%**	**2%**	**8%**	**21%**	**0%**

Notes:

Estimated control factors from various mining operations obtained from Holmes Air Sciences (1998).

1 : Construction footprint of 7.77ha
2 : Ventilation shaft flowrate of 200 cubic meter per second.
3 : ROM of 150 000 tons per month.
4 : ROM area of 0.05ha.
5 : ROM of 150 000 tons per month.
6 : Onsite annual haul distance of 828km.
7 : Overburden/Contaminated coal of 2.76% of the ROM.
8 : Overburden/Contaminated coal dump area of 0.29ha.
9 : Product of 145 860 tons per month.
10 : Product of 145 860 tons per month.
11 : Product export annual haul distance of 128 700km.

12 : Product area of 0.18ha.
13 : 5 100 km/annum for LDV's.
14 : 3 400 km/annum for Wheel Dozers.
15 : 8 500 km/annum for Wheel Loaders.
16 : 3 400 km/annum for Motor Graders.

3.4 METEOROLOGY

The nature of local climate will determine what will happen to pollution when it is released into the atmosphere (Tyson and Preston-Whyte, 2000). Pollution levels fluctuate daily and hourly, in response to changes in atmospheric stability and variations in mixing depth. Similarly, atmospheric circulation patterns will have an effect on the rate of transport and dispersion of pollution.

The release of atmospheric pollutants into a large volume of air results in the dilution of those pollutants. This is best achieved during conditions of free convection and when the mixing layer is deep (unstable atmospheric conditions). These conditions occur most frequently in summer during the daytime. This dilution effect can however be inhibited under stable atmospheric conditions in the boundary layer (shallow mixing layer). Most surface pollution is thus trapped under a surface inversion (Tyson and Preston-Whyte, 2000).

Inversion occurs under conditions of stability when a layer of warm air lies directly above a layer of cool air. This layer prevents a pollutant from diffusing freely upward, resulting in an increased pollutant concentration at or close to the earth's surface. Surface inversions develop under conditions of clear, calm and dry conditions and often occur at night and during winter (Tyson and Preston-Whyte, 2000). Radiative loss during the night results in the development of a cold layer of air close to the earth's surface. These surface inversions are however, usually destroyed as soon as the sun rises and warms the earth's surface.

With the absence of surface inversions, the pollutants are able to diffuse freely upward. This upward motion may however still be prevented by the presence of elevated inversions. Elevated inversions occur commonly in high pressure areas. Sinking air warms adiabatically to temperatures in excess of those in the mixed boundary layer. The interface between the upper, gently subsiding air is marked by an absolutely stable layer or an elevated subsidence inversion. This type of elevated inversions is most common over Southern Africa (Tyson and Preston-Whyte, 2000).

The climate and atmospheric dispersion potential of South Africa is determined by atmospheric conditions associated with the continental high-pressure cell over the region. The continental high-pressure present over the region in the winter months results in fine conditions with little rainfall and light winds with a northerly flow. Elevated inversions are common in such high-pressure areas due to the subsidence of air. This reduces the mixing depth and suppresses the vertical dispersion of pollutants, causing increased pollutant concentrations (Tyson and Preston-Whyte, 2000).

Seasonal variations in the positions of the high-pressure cells have an effect on atmospheric conditions over the region. For most of the year the tropical easterlies cause an air flow with a north-easterly to north-westerly component. In the winter months the high-pressure cells move northward, displacing the tropical easterlies northward resulting in disruptions to the westerly circulation. The disruptions result in succession of cold fronts over the area in winter with pronounced variations in wind direction, wind speeds, temperature, humidity, and surface pressure. Airflow ahead of a cold front passing over the area has a strong north-north-westerly to north-easterly component, with stable and generally cloud-free conditions. Once the front has passed, the airflow is reflected as having a dominant southerly component (Tyson and Preston-Whyte, 2000).

Easterly and westerly wave disturbances cause a southerly wind flow and tend to hinder the persistence of inversions by destroying them or increasing their altitude, thereby facilitating the dilution and dispersion of pollutants. Pre-frontal conditions tend to reduce the mixing depth. The potential for the accumulation of pollutants during pre-frontal conditions is therefore enhanced (Tyson and Preston-Whyte, 2000).

The analysis of at least one year of hourly average meteorological data is required to facilitate a reasonable understanding of the ventilation potential of the site. The most important meteorological parameters to be considered are wind speed, wind direction, ambient temperature, atmospheric stability and mixing depth. Atmospheric stability and mixing depths are not routinely recorded and frequently need to be calculated from diagnostic approaches and prognostic equations, using as a basis routinely measured data, e.g. temperature, simulated solar radiation and wind speed.

Reference was made to Meteoblue Climate Diagrams, based on 30 years of hourly weather model simulations for Breyten. This data provides a good indication of typical climate patterns and expected conditions (temperature, precipitation, sunshine and wind).

3.4.1 Surface wind field

Dispersion comprises vertical and horizontal components of motion. The wind field largely determines the horizontal dispersion of pollution in the atmospheric boundary layer. 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, determine the general path pollutants will follow, and the extent of crosswind spreading.

On the whole winds for the Mpumalanga Highveld are light except for the short periods during thunderstorms. Very occasionally tornadoes do occur. Annual surface wind speeds vary between 1 m/s and 7 m/s, reaching highs of up to 8 m/s. Wind patterns are predominantly east north-easterly winds, followed by west north-westerly winds.

Winds from the northern sector (36.86%) were mostly reported for the study area. Calm periods were the exception and wind speeds were most often moderate, between 2.1 and 3.6 m/s (35.2%). Light winds between 0.5 and 2.1 m/s were recorded 12.7%, brisk winds between 3.6 and 5.7 m/s were recorded 32.7% and strong winds above 5.7m/s, about 18.4% of the time.

Wind roses comprise of 16 spokes which represents the direction from which the winds blew during the period under review. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The value given in the centre of the circle describe the frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s.

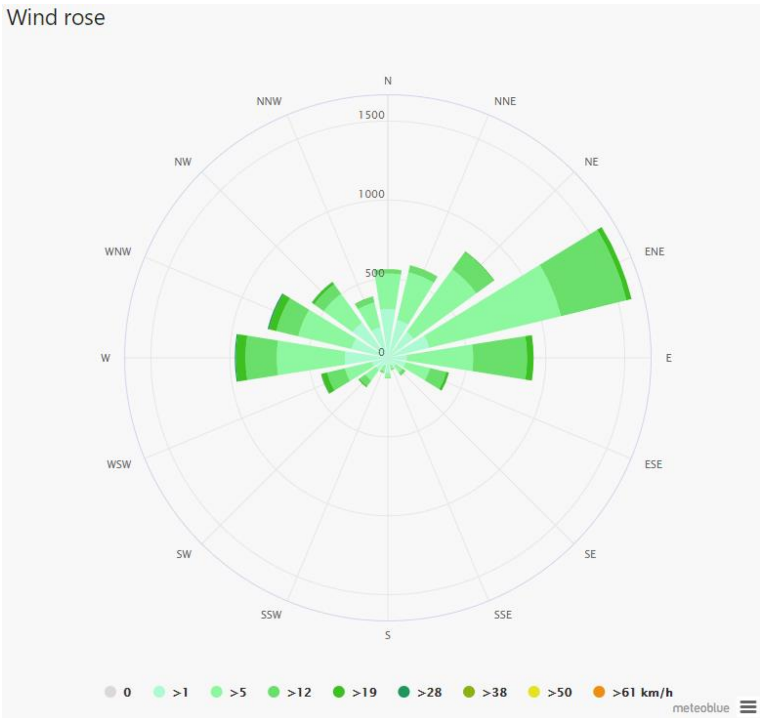

Figure 8: Breyten Wind Rose for the Period 1990 – 2020

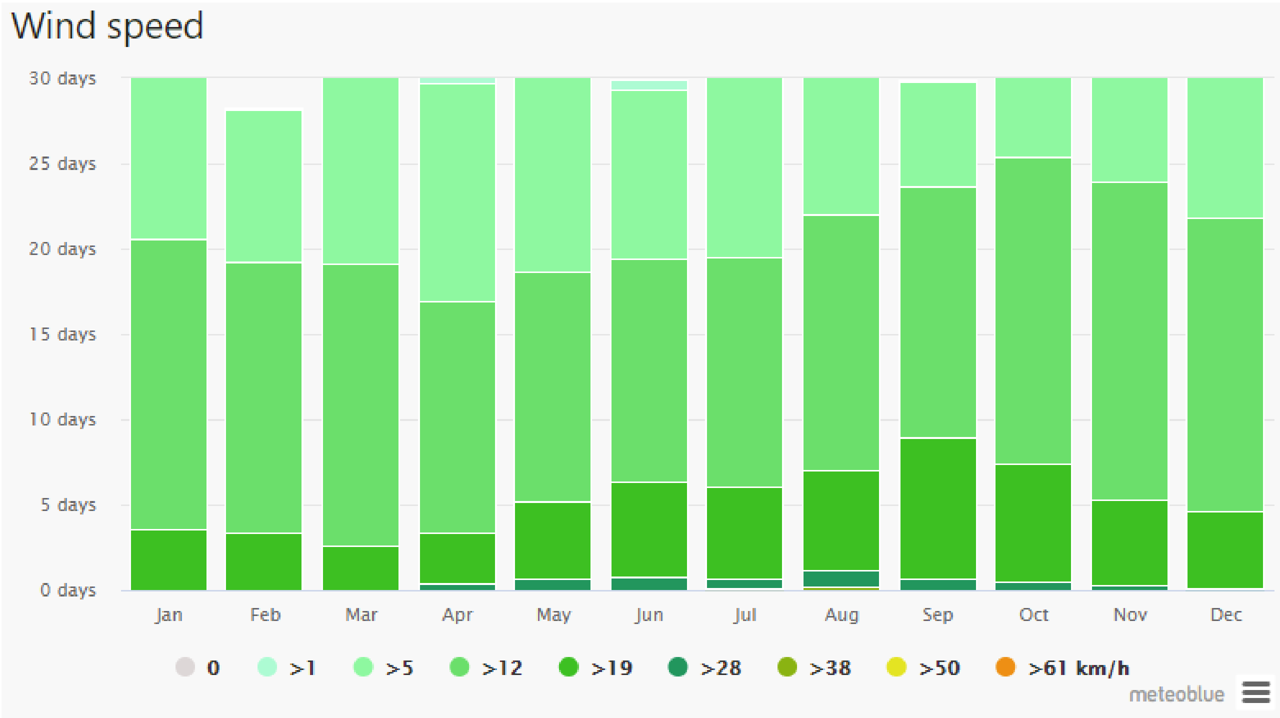

Figure 9: Breyten Average Wind Speed for the Period 1990 – 2020

Atmospheric processes at meso-scale were considered in the characterisation of the atmospheric dispersion potential of the study area. Reference was made to hourly average meteorological data modelled by Meteoblue for the Vogelfontein Colliery. Parameters that need to be considered in the characterisation of meso-scale ventilation potentials include wind speed, wind direction, extent of atmospheric turbulence, ambient air temperature and mixing depth.

Period, diurnal, and seasonal wind roses for the period 1 May 2016 to 30 April 2021 are presented in **Figure 10** to **Figure 17**.

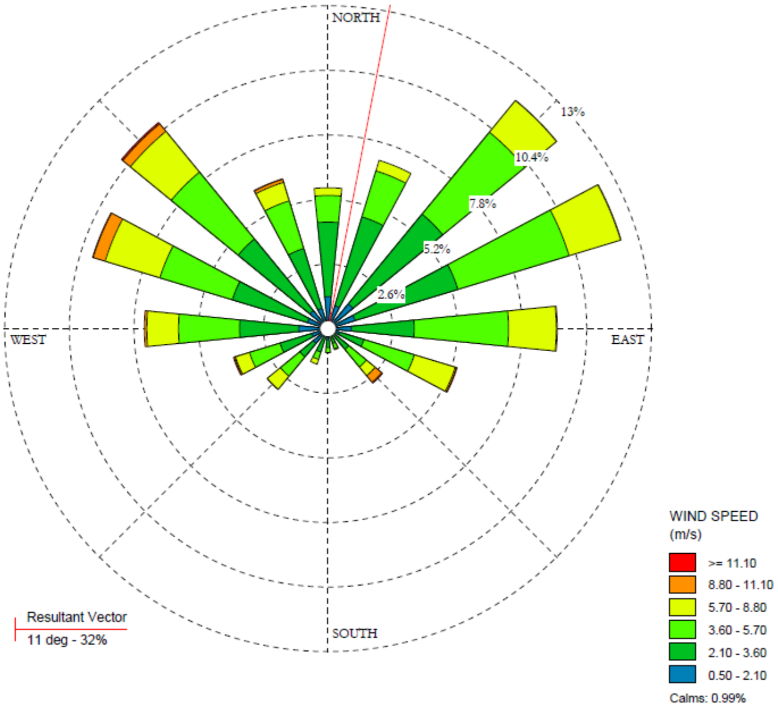

Figure 10: Period Wind Rose

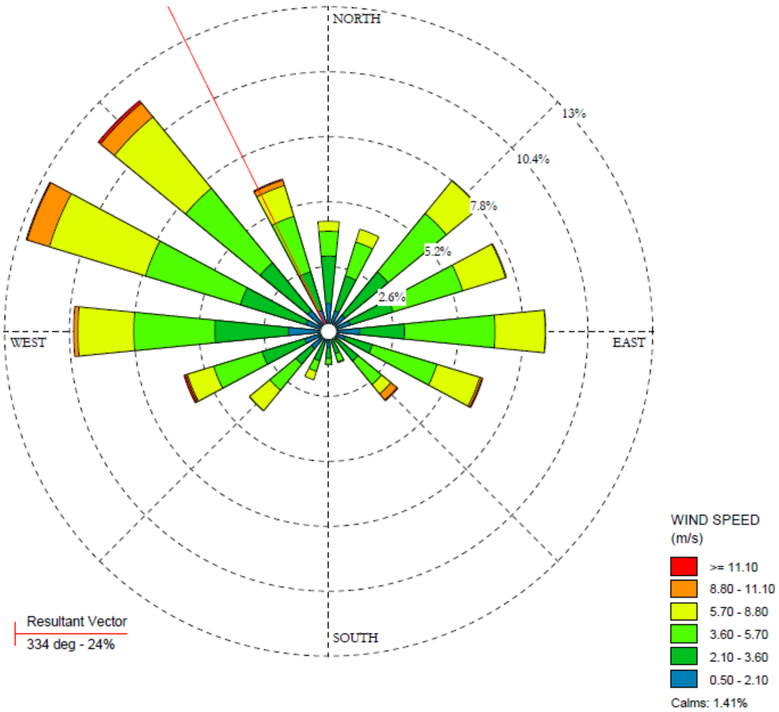

Figure 11: Day-time Wind Rose

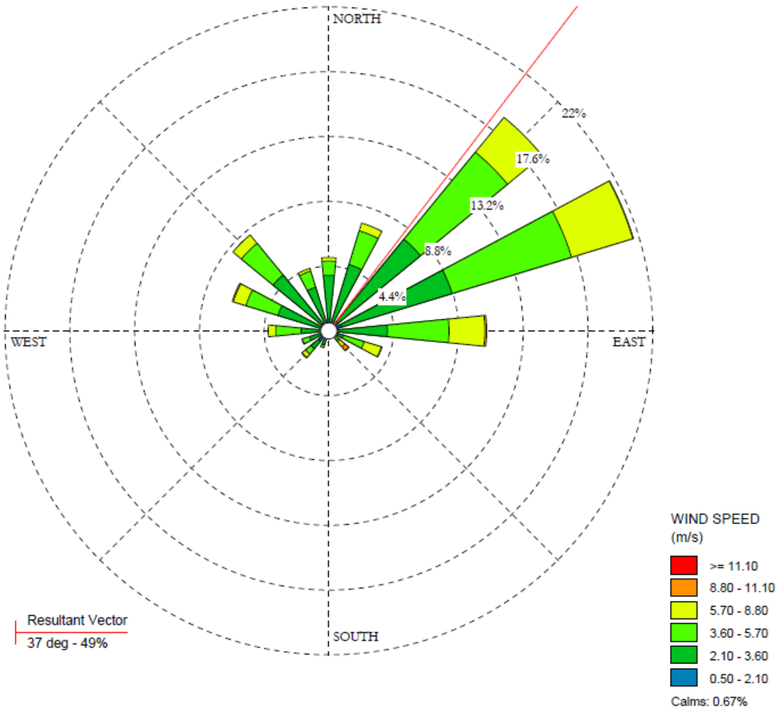

Figure 12: Evening Wind Rose

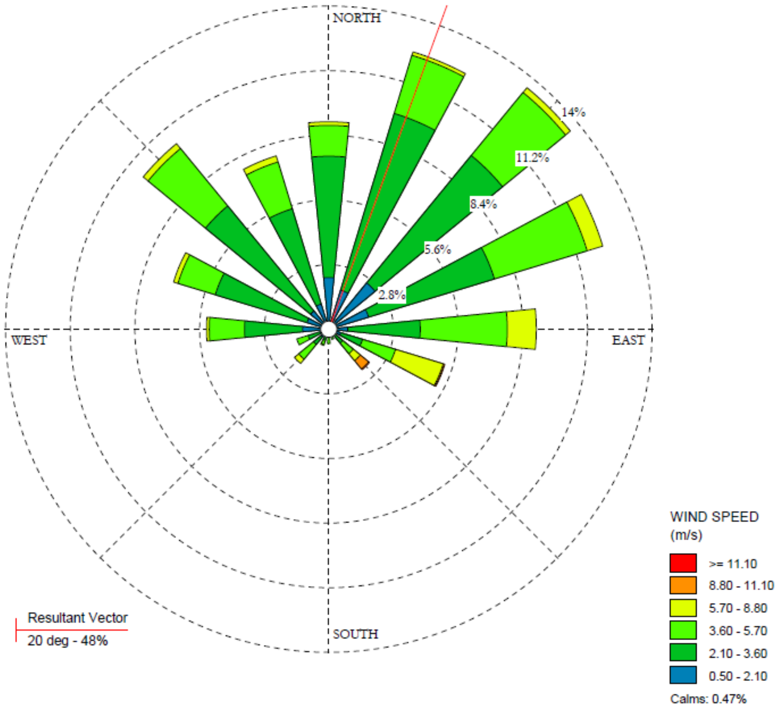

Figure 13: Night-time Wind Rose

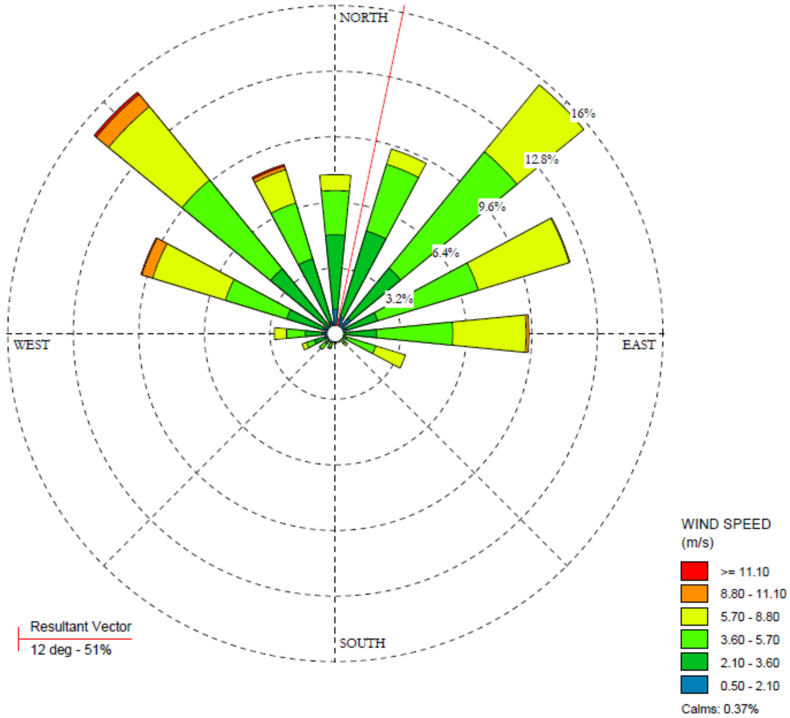

Figure 14: Spring Wind Rose

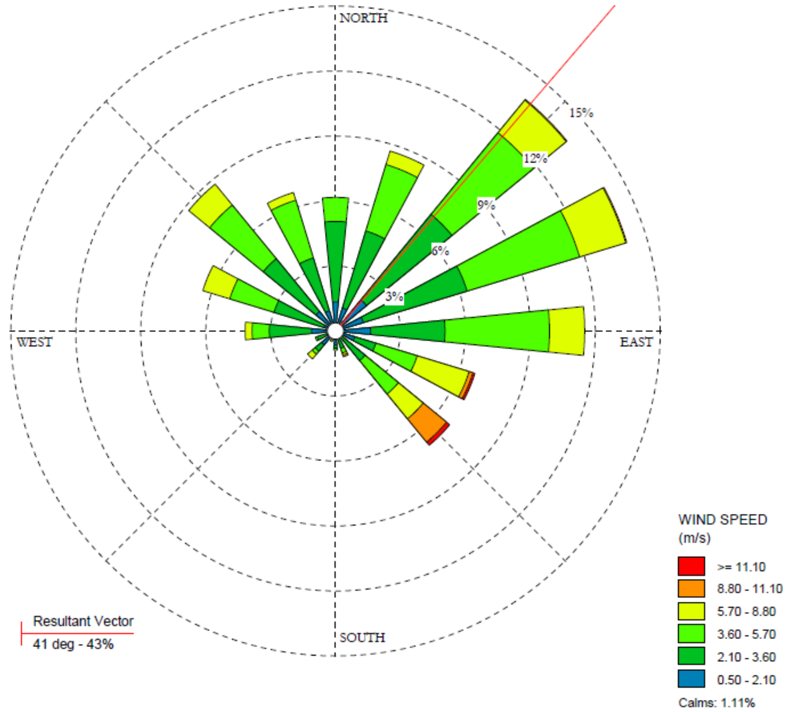

Figure 15: Summer Wind Rose

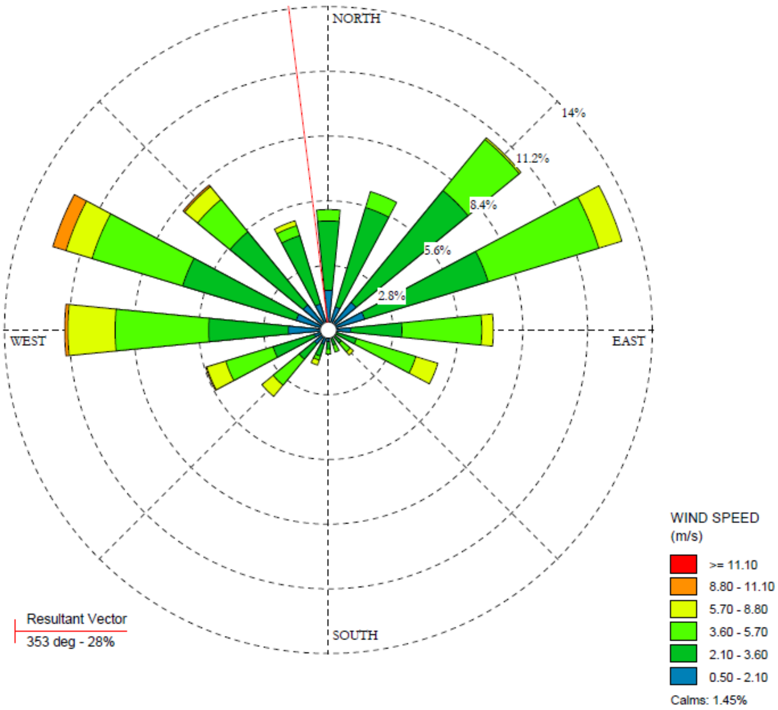

Figure 16: Autumn Wind Rose

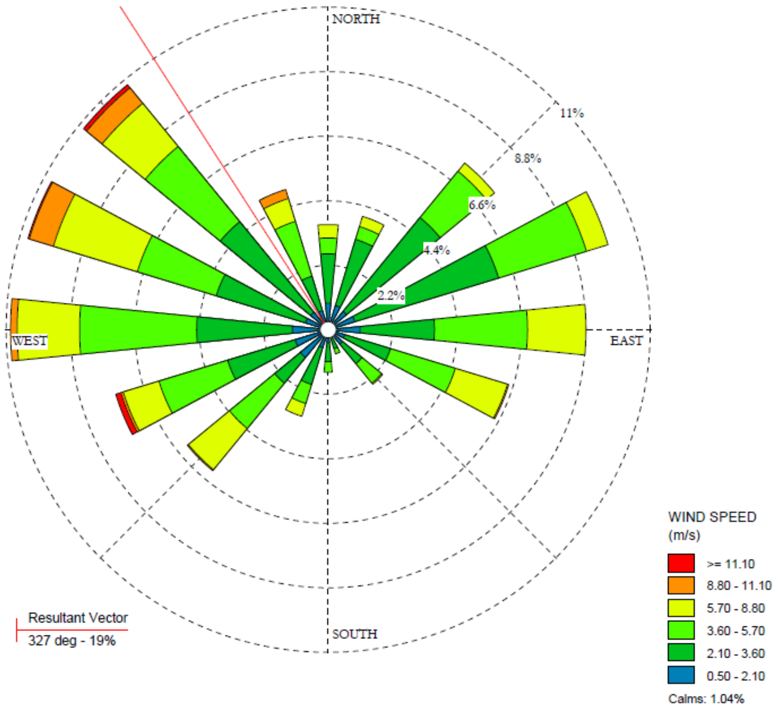

Figure 17: Winter Wind Rose

3.4.2 Temperature and humidity

Temperature affects the formation, action, and interactions of pollutants in various ways (Kupchella & Hyland, 1993). Chemical reaction rates tend to increase with temperature and the warmer the air, the more water it can hold and hence the higher the humidity. Temperature also provides an indication of the rate of development and dissipation of the mixing layer as well as determining the effect of plume buoyancy; the larger the temperature difference between the plume and ambient air, the higher the plume is able to rise.

Higher plume buoyancy will result in an increased lag time between the pollutant leaving the source and reaching the ground. This additional time will allow for greater dilution and ultimately a decrease in the pollutant concentrations when reaching ground level.

Humidity is the mass of water vapour per unit volume of natural air. When temperatures are at their highest the humidity is also high, the moisture is trapped inside the droplets of the water vapour. This makes the moisture content of the air high. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles (CEPA/FPAC Working Group, 1999). This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids, as well as secondary pollutants within the atmosphere.

Msukaligwa Local Municipality falls under the central Mpumalanga climatic zone characterized by warm, rainy summers and dry winters with sharp frosts.

The average daily maximum temperature in January (the hottest month) is 25.2°C and in July (the coldest month) is 16.7°C (Msukaligwa Local Municipality *Spatial Development Framework*, 2010). The period during which frost is likely to form lasts on the average for about 120 days from May to September.

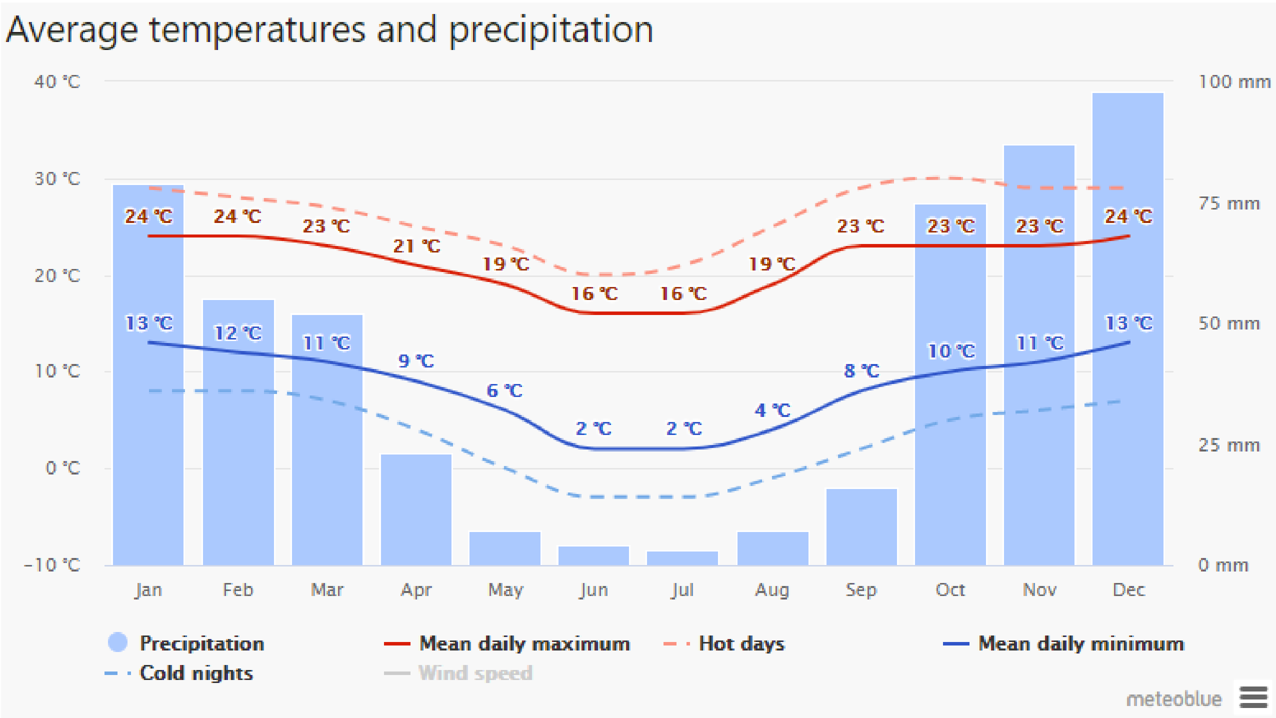

Figure 18: Breyten Average Temperature and Precipitation for the Period 1990 – 2020

3.4.3 Precipitation

Precipitation cleanses the air by washing out particles suspended in the atmosphere (Kupchella & Hyland, 1993). It is calculated that precipitation accounts for about 80-90% of the mass of particles removed from the atmosphere (CEPA/FPAC Working Group, 1999).

The average annual precipitation in the Highveld region varies from about 350 mm to 500 mm in. The rainfall is almost exclusively due to showers and thunderstorms and falls mainly in summer, from October to March, the maximum fall occurring during January. Rainstorms are often violent (up to 80mm per day) with severe lightning and strong winds, sometimes accompanied by hail. This region has about the highest hail frequency in South Africa; about 4 to 7 occurrences may be expected annually at any one spot. The winter months are droughty with the combined rainfall in June, July and August making up only 3.9% of the annual total (734mm).

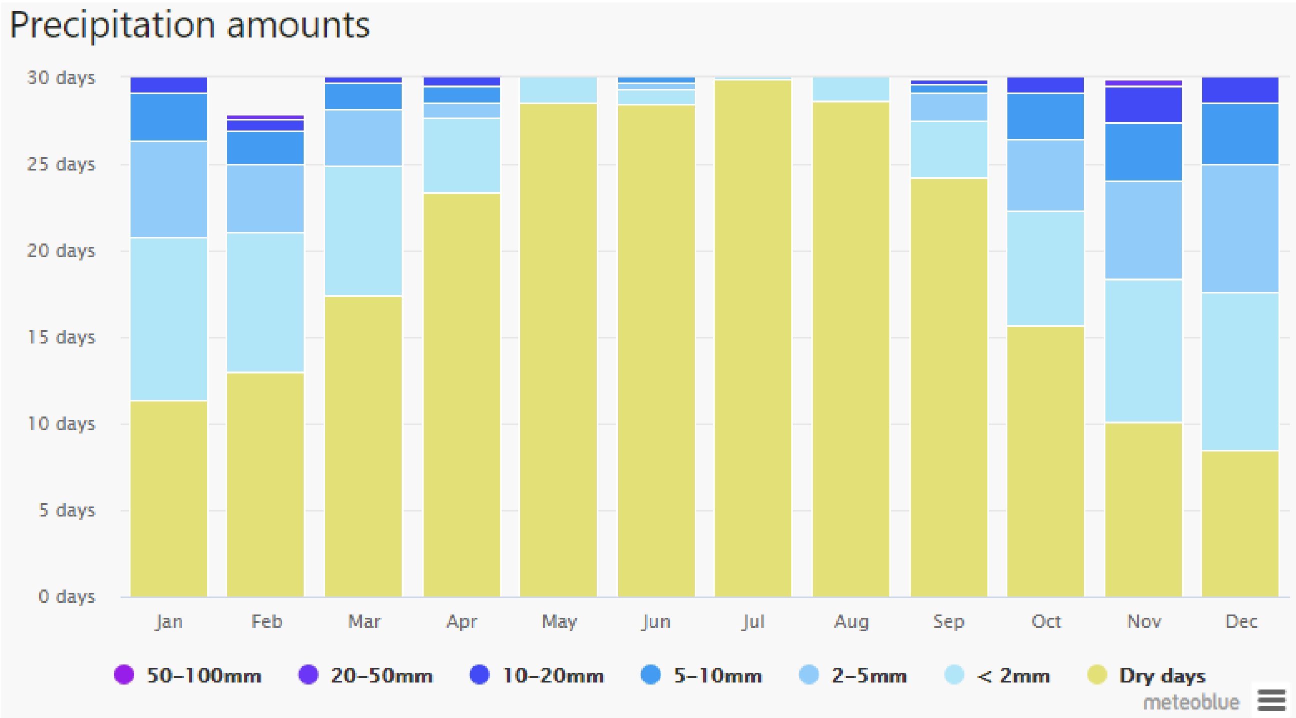

Figure 19: Breyten Average Monthly Rainfall for the Period 1990 – 2020

3.4.4 Mixing height and atmospheric stability

The vertical component of dispersion is a function of the extent of thermal turbulence and the depth of the surface mixing layer. Unfortunately, the mixing layer is not easily measured and must often be estimated using prognostic models that derive the thickness from some of the other parameters that are often measured, e.g. solar radiation and temperature.

During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated inversion. Radiative flux divergence during the night usually results in the establishment of ground-based inversions and the erosion of the mixing layer.

Day-time mixing heights were calculated with the prognostic equations of Batchvarova and Gryning, while night-time boundary layer heights were calculated from various diagnostic approaches for stable and neutral conditions. The mixing layer in the study area ranges from 0 metres (only a stable or neutral layer exists) during night-times to the base of the lowest-level elevated inversion during unstable, day-time conditions (Batchvarova and Gryning, 1990).

Atmospheric stability is commonly categorised into one of seven stability classes. These are briefly described in **Table 5**. The atmospheric boundary layer is usually unstable during the day due to turbulence caused by the sun's heating effect on the earth's surface. The depth of this mixing layer depends mainly on the amount of solar radiation, increasing in size gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. The degree of thermal turbulence is increased on clear warm days with light winds. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral. A neutral atmospheric potential neither enhances nor inhibits mechanical turbulences. An unstable atmospheric condition enhances turbulence, whereas a Stable atmospheric condition inhibits mechanical turbulence.

Table 5: Atmospheric Stability Classes.

Class	Stability	Description
Class A	Very unstable	Calm wind, clear skies, hot day-time conditions
Class B	Moderately unstable	Clear skies, day-time conditions
Class C	Slightly unstable	Moderate wind, slightly overcast day-time conditions
Class D	Neutral	High winds or cloudy days and nights
Class E	Slightly stable	Moderate wind, slightly overcast night-time conditions
Class F	Moderate stable	Low winds, clear skies, cold night-time conditions
Class G	Very stable	Calm winds, clear skies, cold clear night-time conditions

For elevated releases, the highest ground level concentrations would occur during unstable, day-time conditions. The wind speed resulting in the highest ground level concentration depends on the buoyancy. If the plume is considerably buoyant (high exit gas velocity and temperature) together with a low wind, the plume will reach the ground relatively far downwind. With stronger wind speed, on the other hand, the plume may reach the ground closer, but due to the increased ventilation, it will be more diluted. A wind speed between these extremes would therefore be responsible for the highest ground level concentrations.

The highest concentrations for low level releases would occur during weak wind speeds and stable atmospheric conditions. Air pollution episodes frequently occur just prior to the passage of a frontal system that is characterised by calm wind and stable conditions.

The region is characterised by mostly sunny days, followed by partly cloudy days. Overcast conditions are experience less than 5 days per month (see **Figure 20**).

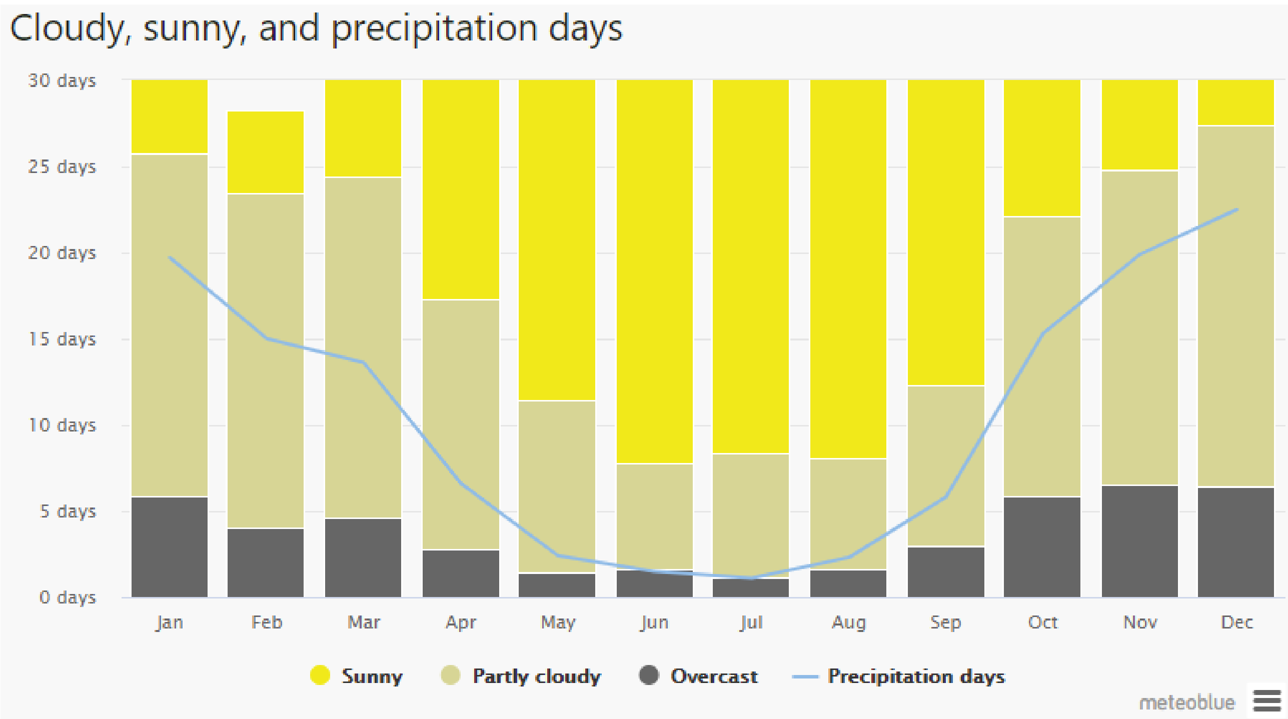

Figure 20: Breyten Cloudy, Sunny and Precipitation Days for the Period 1990 – 2020

3.5 TOPOGRAPHY AND LAND USE

GSDM is the largest of the three districts in the Mpumalanga Province at 31 841km², covering 40% of the Province's land mass. The western portion of the district mostly comprises typical Highveld vegetation and climate, with the eastern end of the district being more mountainous and characterised by extensive forestry and rural settlements, tribal villages dominates in the north-east. The district comprises seven local municipalities, including Chief Albert Luthuli, Dipaleseng, Lekwa, Msukaligwa, Mkhondo, Dr Pixley Isaka Ka Seme and Govan Mbeki.

Figure 21: Local Municipalities of the Gert Sibande District Municipality

Gert Sibande is the second largest contributor to the Mpumalanga Province economy. Manufacturing (57.4%), is the leading industry in terms of contribution to district's economy, followed by mining (14.1%) and community services (12.3%). Construction is the lowest with (2.1%).

The economy of Msukaligwa Local Municipality is predominantly based on coal mining, agriculture, forestry and timber processing. Tourism also contributes to economic growth of the municipality. Within the municipality, trade (23.7%), community services (19%) and agriculture (11.5%) are the largest industry contributors.

The topography of the Vogelfontein Colliery is relatively flat with an average area elevation of 1 800 meters above mean sea level (AMSL).

3.6 POLLUTION SOURCES AND RECEPTORS

The outdoor sources of air pollution resulting from human activities comprise three broad categories.

Stationary sources can be subdivided into; rural area sources, e.g. agriculture, mining and quarrying and industrial point and area sources, e.g. manufacturing of chemicals, non-metallic mineral products, basic metal industries and power generation.

Community sources i.e., heating of homes and buildings, municipal waste and sewage sludge incinerators, fireplaces, cooking facilities, laundry services and cleaning plants.

Mobile sources include sources such as combustion-engine vehicles, e.g. light duty petrol-powered cars, light and heavy-duty diesel-powered vehicles, motorcycles, aircraft and line sources such as fugitive emissions from vehicle traffic.

Within the GSDM, industries are ranked as a high priority, with Dipalaseng and Lekwa confirming the ranking. The district municipality lists petrochemical industries specifically as significant sources. Govan Mbeki did not provide a ranking but listed the Sasol plant, mines and small industries as sources. Lekwa identified a power station in the municipality. Msukaligwa and Pixley ka Seme municipalities ranked industries as a low priority, with small industries and dry-cleaning operations being respective local sources.

The district municipality also ranked motor vehicles as a high priority, particularly coal trucks, which were reiterated by Govan Mbeki, Lekwa and Msukaligwa. Govan Mbeki also listed daily spray activity as a related source. Pixley ka Seme experienced air quality issues related to CO emissions from heavy vehicles. Residential fuel burning is also a high priority for the district, with coal burning and stoves listed as a source in Govan Mbeki, Lekwa, Msukaligwa and Pixley ka Seme. Wood is an additional fuel used in Lekwa, and general fossil fuels are used in Pixley ka Seme. Wesselton is mentioned specifically as a problem area in Msukaligwa.

Mining and quarries are regarded as a medium priority source across the district and are associated with dust emissions. Gold and coal mining are significant activities in Govan Mbeki. Dipaleseng listed the power station as a source in this category, possibly alluding to the coal mining operations that support power generation activities. Lekwa also experienced deep mining.

Agricultural burning is a medium priority for the district, related to grazing fields, fire breaks and forestry. Dipaleseng and Pixley ka Seme experienced agricultural burning, with spontaneous veld fires being problematic in Pixley ka Seme. Tyre burning is regarded as a low priority in the district, with Govan Mbeki experiencing incidents with burning at dumpsites, and Pixley ka Seme recording incidents with small quantities of tyres burnt at landfill sites.

Odour is problematic at Govan Mbeki due to H_2S and Sasol Secunda Synfuels tar products, and at Lekwa from poultry abattoir and wastewater treatment works.

Vogelfontein Colliery Receptors

Receptors are sites (or areas) which may potentially be impacted by the process or activity. In this study, sensitive receptors were selected on the basis of proximity to the project and mainly comprise of isolated farmsteads/residences, commercial establishments and industrial/mining processes up to a distance of 5 km from the mining operations.

Table 6 and **Figure 22** provides a summary of the closest receptors associated with the Vogelfontein Colliery.

Table 6: Vogelfontein Colliery Receptors

Description	Direction from the ROM stockpile	Distance from the ROM stockpile
R1 – Residence Lat -26.354638°, Lon 29.904870°	East north-east (78°)	0.71 kilometres
R2 – Residence Lat -26.356839°, Lon 29.902662°	East south-east (101°)	0.48 kilometres
R3 – Residence Lat -26.371900°, Lon 29.900725°	South south-east (171°)	1.80 kilometres
R4 – Residence Lat -26.378922°, Lon 29.884994°	South south-west (206°)	2.86 kilometres
R5 – Residence Lat -26.364666°, Lon 29.872901°	West south-west (249°)	2.68 kilometres
R6 – Residence Lat -26.344318°, Lon 29.869884°	West north west (295°)	3.07 kilometres
R7 – Residence / Commerce Lat -26.335726°, Lon 29.874939°	North west (314°)	3.22 kilometres
R8 – Residence Lat -26.339461°, Lon 29.891083°	North north-west (340°)	1.94 kilometres

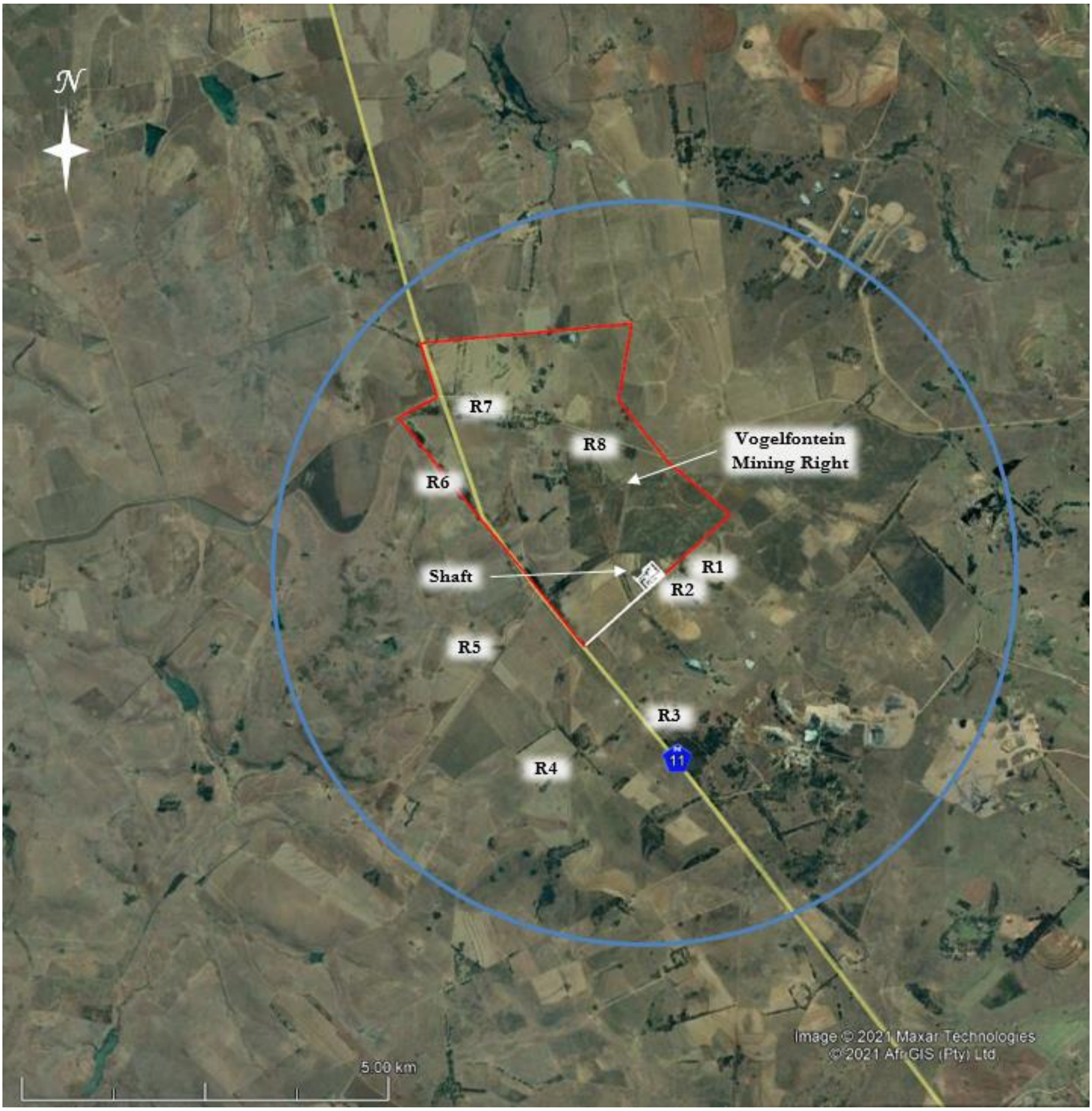

Figure 22: Vogelfontein Colliery Receptors and Study Area (blue circle)

3.7 HIGHVELD PRIORITY AREA

Criteria pollutants are pollutants commonly found from various sources and for which health-based criteria (science-based guidelines) have been established as the basis for setting permissible levels. Typical pollutants include particulates (including soot, fly ash and aerosols), sulphur oxides (SO_x), oxides of nitrogen (NO_x), carbon monoxide (CO), carbon dioxide (CO_2), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), methane (CH_4), ammonia (NH_3), hydrogen chloride (HCl), hydrogen sulphide (H_2S), ozone (O_3) and other photochemical oxidants (as secondary pollutants) and various trace elements. Organic compounds released include formaldehyde, benzene, poly-aromatic hydrocarbons, PCBs and dioxins and furans.

Five of the local municipalities in the GSDM fall within the Highveld Priority Area (Dipaleseng, Lekwa, Msukaligwa, Dr Pixley Isaka Ka Seme and Govan Mbeki). The HPA is associated with poor air quality, and elevated concentrations of criteria pollutants. The poor air quality results from a combination of emissions from different industrial sectors, residential fuel burning, motor vehicle emissions, mining, and biomass burning amongst other emissions sources, as well as cross-boundary transport of pollutants into the GSDM adding to the base loading.

According to the HPA AQMP, there are nine extensive areas identified where ambient air quality standards for SO_2, NO_2, PM_{10} and O_3 are exceeded. Four of the ten hot spot areas are located with the GSDM and include Ermelo, Secunda, Lekwa and Balfour).

The Ermelo Hot Spot in the Msukaligwa Local Municipality is relatively small and is characterised by modelled exceedances of the 1-hour and 24-hour ambient SO_2 air quality standard. Exceedances of the SO_2 standard at the Ermelo monitoring station is largely influenced by residential fuel burning sources. 24-hour PM_{10} exceedances also occur at the monitoring station. Modelled ambient NO_2 concentrations showed a gradual increase, with exceedances of the 8-hour O_3 standard recorded at Camden and Ermelo. These stations are well removed from the main precursor source region providing the necessary time for ozone chemistry to be effective, resulting in higher ozone concentrations downwind of the source region.

Monitoring in Wesselton in Ermelo shows a contributing SO_2 source from the north-east and a more significant source in the north-west. A south-easterly component is also present. The peak in the north-west is consistent with transported pollutants, particularly from the Secunda area, while the north-east has a collection of smaller industrial and agricultural sources. Contributions from the town are more notable in the winter periods, as observed in the south-easterly direction.

Monitoring in Wesselton shows clear contributions to PM_{10} concentrations from the north-east and westerly directions, which is consistent with SO_2 observations. Respective sources are small-scale industry and agriculture in the north-east, with westerly contributions from the Sasol complex and industries based in Secunda. The contribution of industries in the area dominates the source apportionment, showing clearly that residential fuel burning, motor vehicles and coal mining are far less significant in considering the total air quality loading for all pollutants.

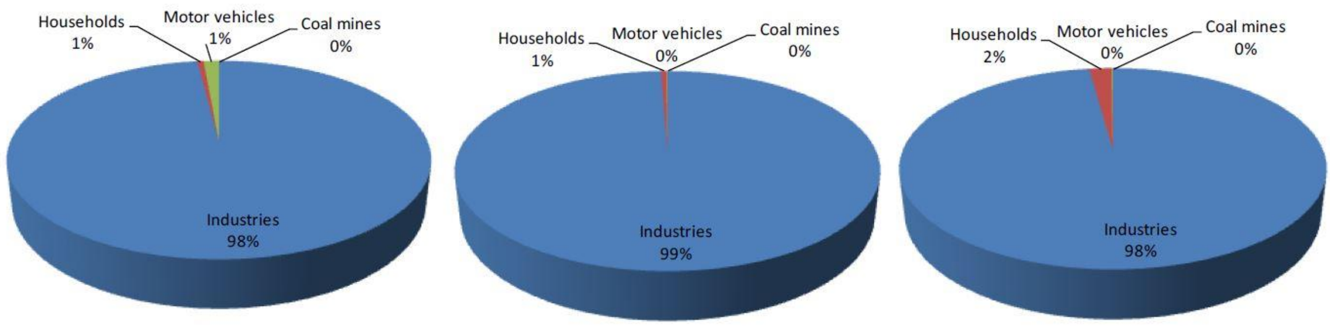

Figure 23: Sources of NOx (left), SO_2 (middle) and PM_{10} (right) in the Ermelo Hot Spot.

Hourly data was obtained from the South African Air Quality Information System (SAAQIS) and analysed to assess patterns in atmospheric concentrations, including seasonal and diurnal patterns of the ambient concentrations and to assess the impacts that such reported pollution concentration may have. Local source regions for SO_2, PM_{10}, $PM_{2.5}$, $NO_{2\text{ and}}$ O_3 were identified and trends discussed.

The Ermelo monitoring station, owned by the Department of Environment, Forestry and Fisheries forms part of the HPA monitoring network.

3.7.1 Particulate Matter

Particulate matter (PM) is a broad term used to describe the fine particles found in the atmosphere, including soil dust, dirt, soot, smoke, pollen, ash, aerosols and liquid droplets. The most distinguishing characteristic of PM is the particle size and the chemical composition. Particle size has the greatest influence on the behaviour of PM in the atmosphere with smaller particles tending to have longer residence times than larger ones. PM is categorised, according to particle size, into TSP, PM_{10} and $PM_{2.5}$.

Total suspended particulates (TSP) consist of all sizes of particles suspended within the air smaller than 100 micrometres (µm). TSP is useful for understanding nuisance effects of PM, e.g. settling on houses, deposition on and discoloration of buildings, and reduction in visibility.

PM_{10} describes all particulate matter in the atmosphere with a diameter equal to or less than 10µm. Sometimes referred to simply as coarse particles, they are generally emitted from motor vehicles (primarily those using diesel engines), factory and utility smokestacks, construction sites, tilled fields, unpaved roads, stone crushing, and burning of wood. Natural sources include sea spray, windblown dust and volcanoes. Coarse particles tend to have relatively short residence times as they settle out rapidly and PM_{10} is generally found relatively close to the source except in strong winds.

Figure 24 shows the daily average PM_{10} concentrations for the Ermelo monitoring station.

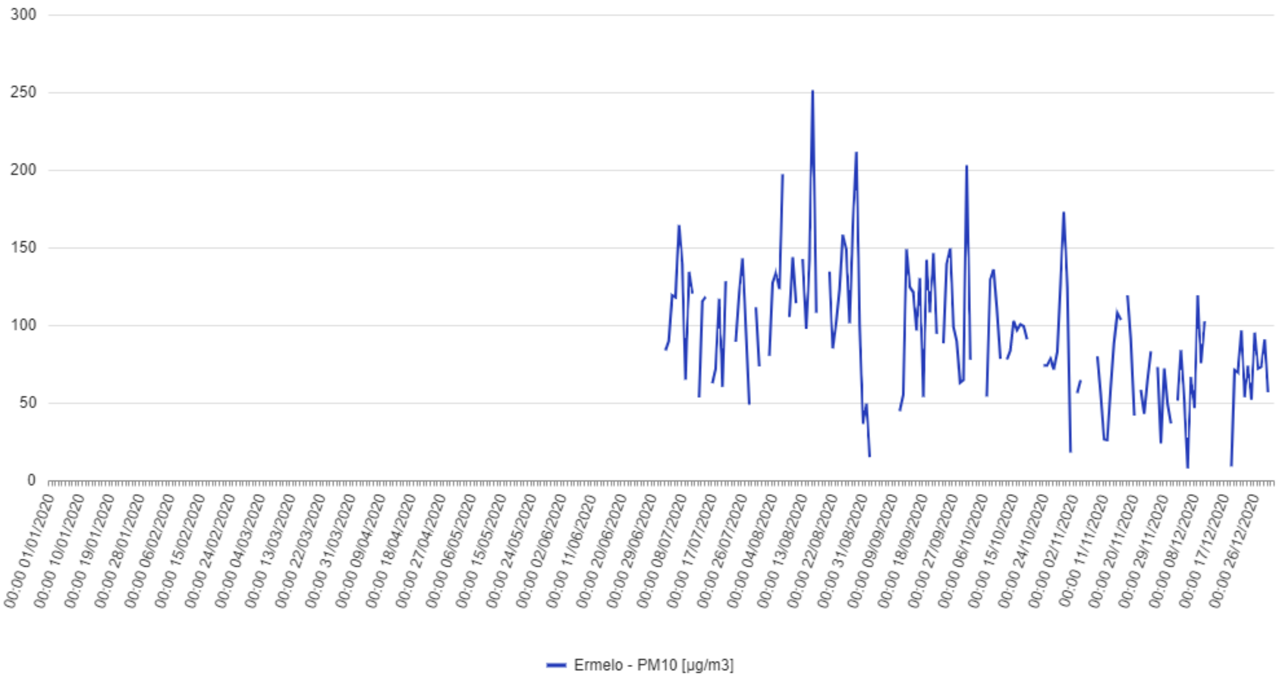

Figure 24: Ermelo Daily Average PM_{10} Concentration (SAAQIS, 2020).

$PM_{2.5}$ describes all particulate matter in the atmosphere with a diameter equal or less than 2.5µm. They are often called fine particles, and are mostly related to combustion (motor vehicles, smelting, incinerators), rather than mechanical processes as is the case with PM_{10}.

$PM_{2.5}$ may be suspended in the atmosphere for long periods and can be transported over large distances.

Fine particles can form in the atmosphere in three ways: when particles form from the gas phase, when gas molecules aggregate or cluster together without the aid of an existing surface to form a new particle, or from reactions of gases to form vapours that nucleate to form particles.

Figure 24 shows the daily average $PM_{2.5}$ concentrations for the Ermelo monitoring station.

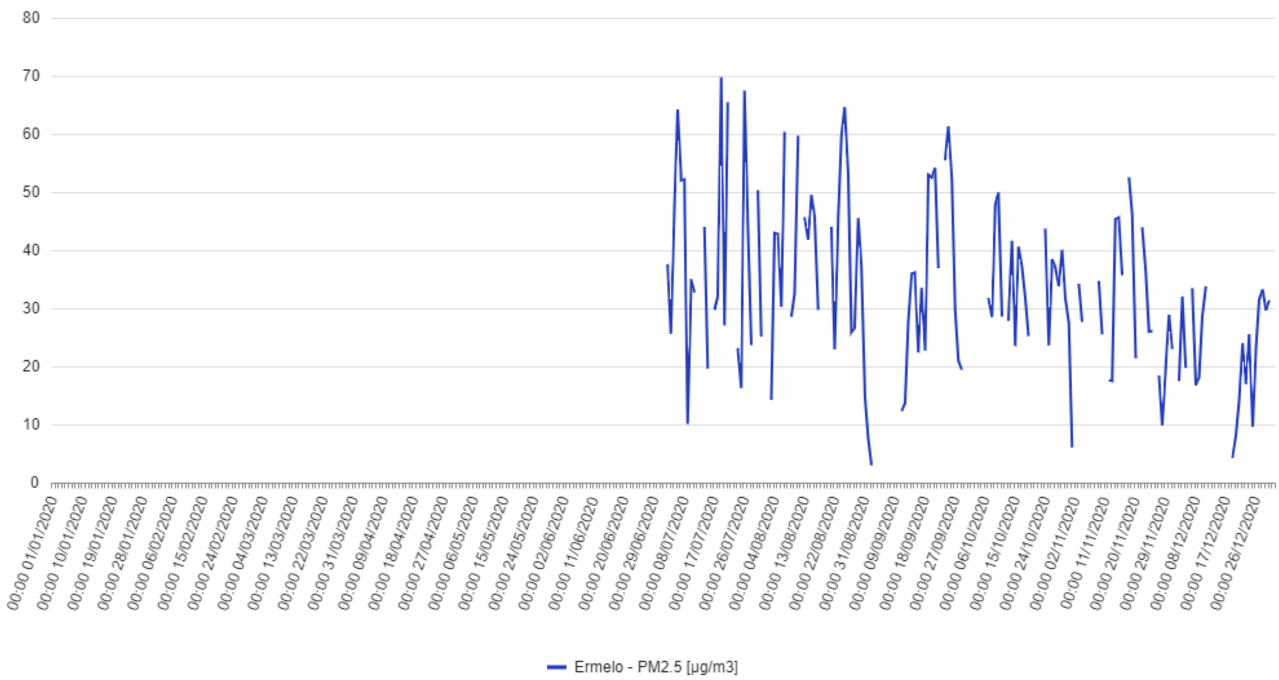

Figure 25: Ermelo Daily Average $PM_{2.5}$ Concentration (SAAQIS, 2020).

Particulate matter may contain both organic and inorganic pollutants. The extent to which particulates are considered harmful depends on their chemical composition and size, e.g. particulates emitted from diesel vehicle exhausts mainly contain unburned fuel oil and hydrocarbons that are known to be carcinogenic. Very fine particulates pose the greatest health risk as they can penetrate deep into the lung, as opposed to larger particles that may be filtered out through the airways' natural mechanisms.

In normal nasal breathing, particles larger than 10µm are typically removed from the air stream as it passes through the nose and upper respiratory airways, and particles between 3µm and 10µm are deposited on the mucociliary escalator in the upper airways. Only particles in the range of 1µm to 2µm penetrate deeper where deposition in the alveoli of the lung can occur (WHO, 2003).

Coarse particles (PM_{10} to $PM_{2.5}$) can accumulate in the respiratory system and aggravate health problems such as asthma. $PM_{2.5}$ which can penetrate deeply into the lungs, are more likely to contribute to the health effects (e.g. premature mortality and hospital admissions) than coarse.

People with existing health conditions such as cardiovascular disease and asthmatics, as well as the elderly and children, are more at risk to the inhalation of particulates than normal healthy people. Mortality outcomes calculated for South African urban areas estimate that outdoor air pollution caused 3.7% of total mortality from cardiopulmonary disease in adults aged 30 years and older, 5.1% of mortality attributable to cancers of the trachea, bronchus, and lung in adults, and 1.1% of mortality from acute respiratory infections in children under 5 years of age.

3.7.2 Sulphur dioxide

SO_2 is a colourless pungent, irritating, water-soluble and reactive gas. The major source of SO_2 is the combustion fossil fuels such coal, oil and diesel which contain sulphur.

On inhalation, most SO_2 only penetrates as far as the nose and throat as it is readily soluble in the moist lining of the upper respiratory system, with minimal amounts reaching the lungs, unless the person is breathing heavily, breathing only through the mouth, or if the concentration of SO_2 is high.

The acute response to SO_2 is rapid, within 10 minutes in people suffering from asthma (WHO, 2005). SO_2 reacts with cell moisture in the respiratory system to form sulphuric acid. This can lead to impaired cell function and effects such as coughing, broncho-constriction, exacerbation of asthma and reduced lung function.

Figure 26 shows the daily average SO_2 concentrations for the Ermelo monitoring station.

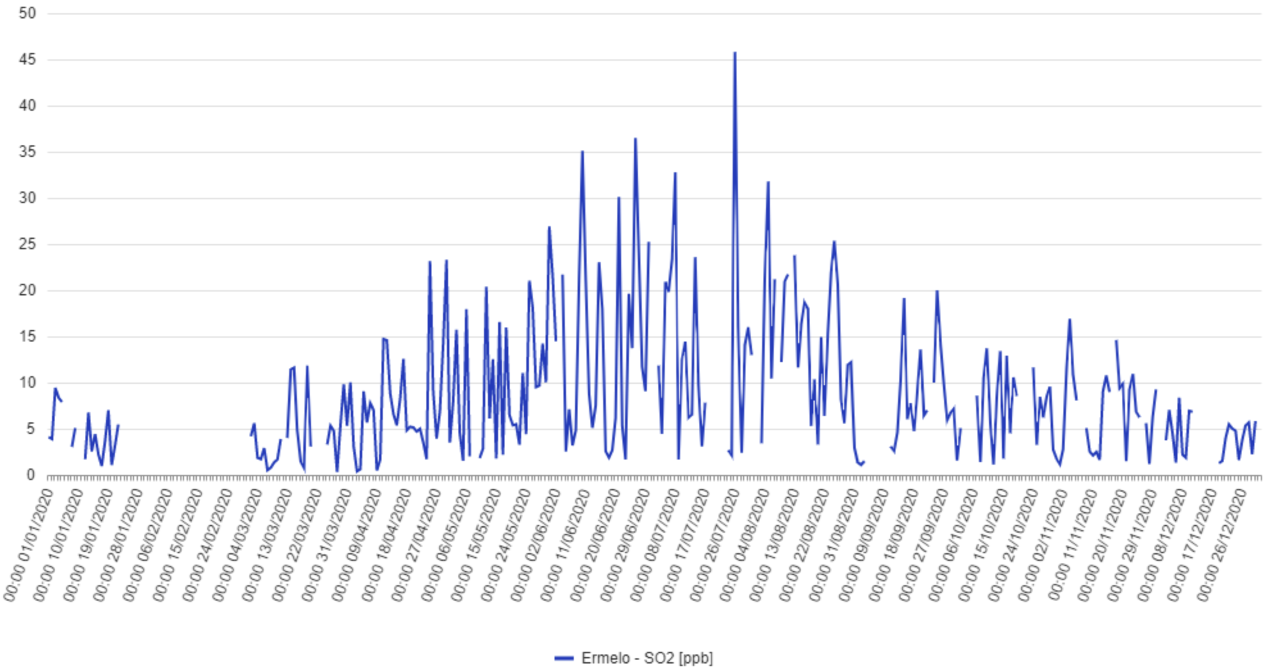

Figure 26: Ermelo Daily Average SO_2 Concentrations (SAAQIS, 2020).

Effects such as a reduction in lung function, an increase in airway resistance, wheezing and shortness of breath, are enhanced by exercise that increases the volume of air inspired, as it allows SO_2 to penetrate further into the respiratory tract (WHO, 1999). Due to its reactivity, SO_2 has a highly non-uniform dose distribution along the conductive airways of the respiratory tract. For low to moderate tidal volumes and nasal breathing, the penetration into the lungs is negligible. For larger tidal volumes and oral inhalation, doses of interest may extend into the segmental bronchi. SO_2 can only reach the gas-exchange region of the lungs after adsorption onto particulate matter.

Another special consideration for SO_2 is that there is great variation in susceptibility to bronchoconstrictive responses. Persons having asthma or atopy can be about ten times more responsive than healthy subjects.

3.7.3 Nitrogen oxides

Figure 27 shows the daily average NO_2 concentrations for the Ermelo monitoring station.

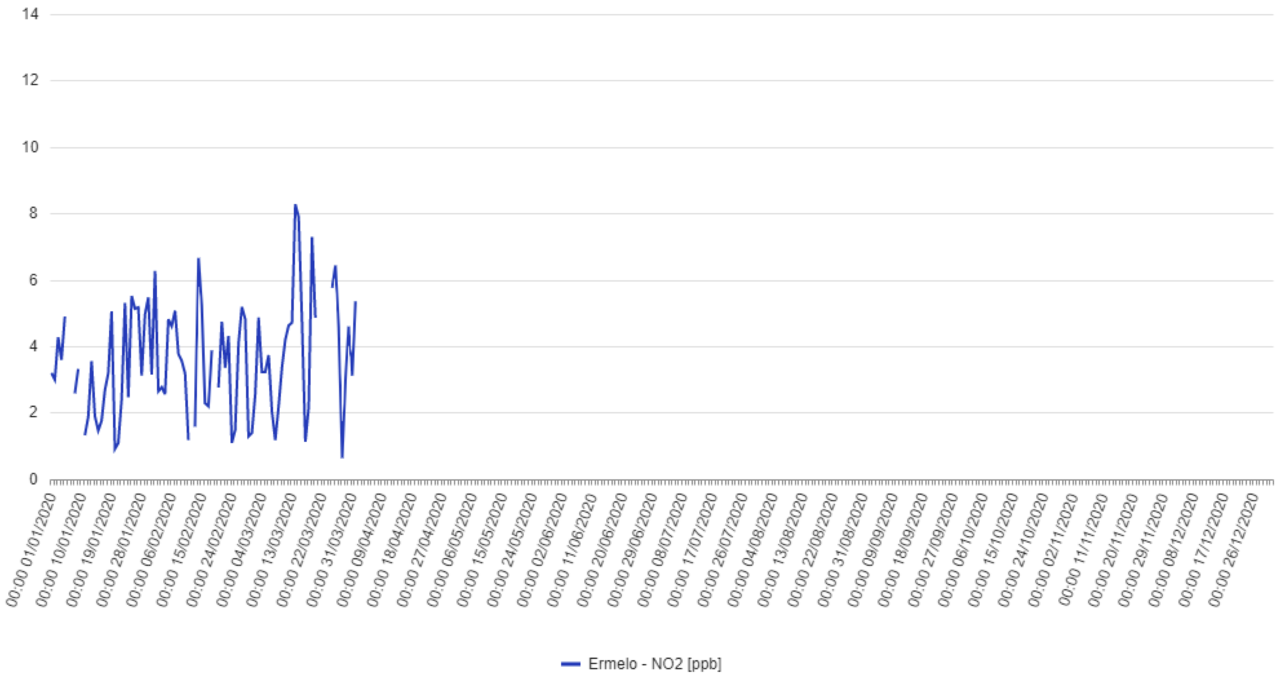

Figure 27: Ermelo Daily Average NO_2 Concentrations (SAAQIS, 2020).

Ambient concentrations of NO_2 in air are highly variable. Natural background concentrations can range from less than 0.4 µg/m^3 to more than 9 µg/m^3. In cities, ambient annual mean concentrations can range from 20 to 90 µg/m^3 with hourly maximum concentrations from 75 to 1 000µg/m^3. NO_2 is formed in combustion processes and other high temperature operations such as metallurgical furnaces, blast furnaces, and internal combustion engines.

In the atmosphere, NO_2 reacts with water vapour to produce nitric acid. This acidic pollution can be transported over long distances by wind and deposited as acid rain, causing the acidification of soils, lakes, and streams, accelerated corrosion of buildings and monuments and damages paintwork. NO_2 is also a major source of secondary fine particulate pollution, which decreases visibility, and contributes to surface ozone formation through its reaction with VOCs in the presence of sunlight.

The route of exposure to NO_2 is inhalation and the seriousness of the effects depends more on the concentration, than the length of exposure. The site of deposition for NO_2 is the distal lung as NO_2 does not readily dissolve in the moist upper respiratory system where it reacts with moisture in the fluids of the lower respiratory tract to form nitrous and nitric acids (WHO, 1997). About 80 to 90% of inhaled nitrogen dioxide is absorbed through the lungs (CCINFO, 1998). NO_2 present in the blood as the nitrite ion oxidises unsaturated membrane lipids and proteins, which result in the loss of cell permeability control. NO_2 causes decrements in lung function, particularly increased airway resistance. People with chronic respiratory problems and people who work, or exercise outside will be more at risk to NO_2 exposure.

3.7.4 Carbon monoxide

Carbon monoxide is a product of incomplete combustion of fossil fuels. It is predominantly formed in internal combustion engines of motor vehicles, but the combustion of any carbon-based material can release CO. Chemical reactions in the atmosphere may also lead to the formation of CO by the oxidation of other carbon-based gases such as methane. Decomposition of organic material within soils can also result in the release of CO.

Natural ambient concentrations of CO range between 0.06 and 0.14 mg/m^3. In urban environments, mean concentrations over eight hours are usually less than 20 mg/m^3, and one-hour peak levels are usually less than 60mg/m^3. Highest concentrations are usually measured near major roads, as vehicles are the major source of CO.

Figure 28 shows the daily average CO concentrations for the Ermelo monitoring station.

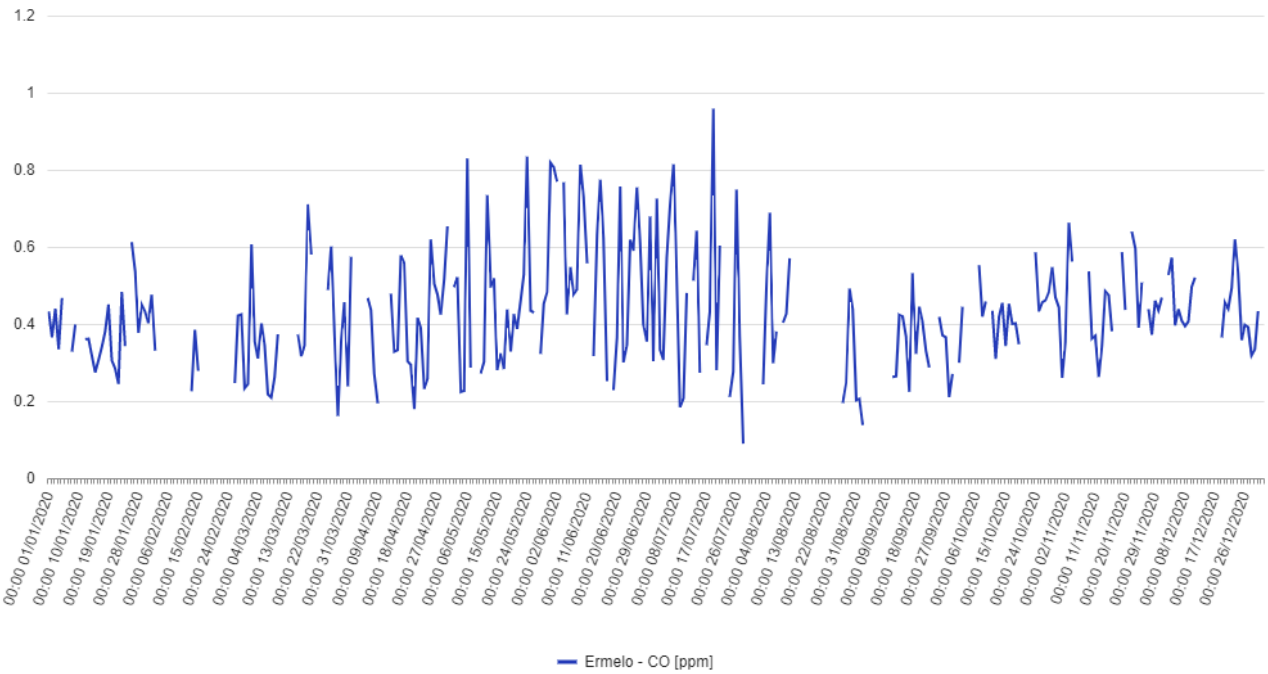

Figure 28: Ermelo Daily Average CO Concentrations (SAAQIS, 2020).

When inhaled, CO enters the blood stream by crossing the alveolar, capillary and placental membranes. In the bloodstream approximately 80-90% of absorbed CO binds with heamoglobin to form carboxyhaemoglobin. The haemoglobin affinity for CO is approximately 200-250 times higher than that of oxygen. Carboxyhaemoglobin reduces the oxygen carrying capacity of the blood and reduces the release of oxygen from haemoglobin, which leads to tissue hypoxia. This may lead to neurological effects and sometimes delayed severe neurological effects that may include impaired coordination, vision problems, reduced vigilance and cognitive ability, reduced manual dexterity, and difficulty in performing complex tasks (WHO, 1999).

3.7.5 Ozone

Figure 29 shows the daily average O_3 concentrations for the Ermelo monitoring station.

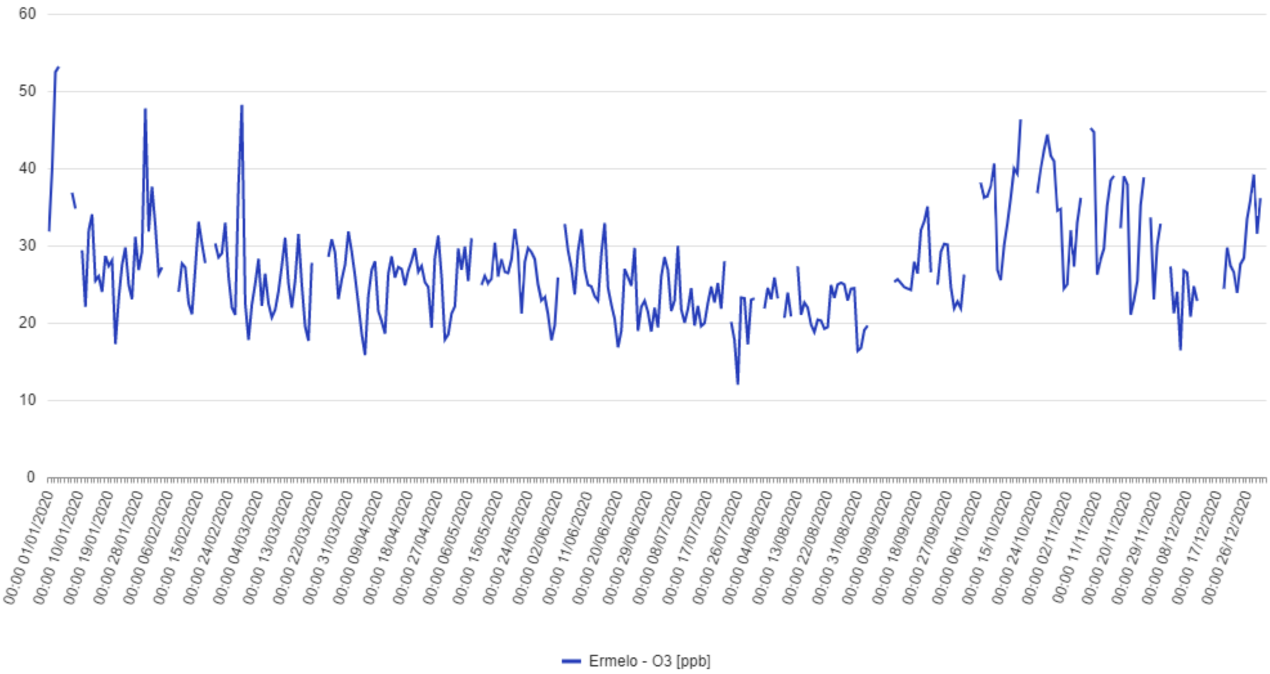

Figure 29: Ermelo Daily Average O_3 Concentrations (SAAQIS, 2020).

Ozone is a colourless gas which carries a harsh odour. It occurs naturally in the lower stratosphere as the ozone layer. This layer protects the earth from shortwave ultraviolet radiation. Near the earth's surface, ozone is a secondary pollutant and a major constituent of photochemical smog. The formation of ozone is dependent on the availability of NOx, VOCs and sunlight. Thus, ozone may not be related directly to any source. Rather it may be associated with the sources of its precursor gases (NOx and VOCs). Ozone may also reach the lower troposphere from the stratosphere, mostly associated with deep frontal systems or with deep convective storms.

Background one-hour average concentrations of O_3 in remote and relatively unpolluted parts of the world are often in the range of 40 to 70 µg/m^3. In cities maximum mean hourly concentrations can be as high as 300 to 400µg/m^3. High O_3 concentrations can persist for 8 to 12 hours per day for several days, when atmospheric conditions favour O_3 formation and poor dispersion conditions exists.

Ozone is a very reactive gas and a strong oxidant, associated with a number of health effects. Ozone toxicity occurs in a continuum in which higher concentrations, longer exposure duration and greater activity levels during exposure cause greater effects. These include respiratory system effects such as coughing, aggravation of asthma and reduced lung function.

3.7.6 Lead

Lead is a metal that occurs naturally in small amounts in the earth's crust. It is used in the production of some types of batteries, ammunition, metal products (such as solder and pipes) ceramic glazes and paint. Chemicals containing lead, such as tetraethyl lead and tetramethyl lead are used as gasoline additives. In the atmosphere, lead exists primarily in the particulate form and is removed from air by wet and dry deposition. Nearly all environmental exposure to lead is attributed to inorganic compounds.

Levels of lead found in air, food, water and soil/dust vary widely throughout the world and depend on the degree of industrial development, urbanisation and other lifestyle factors. In cities of developing countries traffic-related lead levels range between 0.3 and 1 $\mu g/m^3$ with extreme annual mean values between 1.5 and 2 $\mu g/m^3$.

Exposure to Pb may be through inhalation of contaminated air and ingestion of contaminated food, water and soil. Lead can accumulate in plants and animals. The half-life of lead in human blood (it affects haemoglobin synthesis in the blood) is 28 to 36 days, but lead accumulates in the bones and teeth where it can stay for decades and be released again. Children absorb more and excrete less of the absorbed lead than adults.

4. IMPACT ASSESSMENT

4.1 METHODOLOGY

4.1.1 Model Approach

Dilution of air contaminants in the atmosphere is an important process in preventing undesirable levels of pollutants in the ambient air. Atmospheric dispersion of air contaminants is the result of ventilation, atmospheric turbulence and molecular diffusion. However, gaseous and particulate air contaminants are primarily dispersed into the ambient air through wind action and atmospheric turbulence, much of it on the micro scale level. Depending on the relevant environmental and adiabatic lapse rates, various plume formation can be predicted. These include, looping, neutral, coning, fanning, lofting, fumigating and trapping.

Moisture content and form in the atmosphere can have a profound effect upon the air quality. The presence and amount of water vapour in the atmosphere affects the amount of solar radiation received and reflected by the earth.

Several dispersion models have been developed and are the mathematical description of the meteorological transport and dispersion of air contaminants.

In order to describe the position of the place where the concentration of contaminants will be estimated, relative to both the source and the ground, a standard Cartesian (x, y, z) co-ordinate system is used in which:

- the physical source is located at the origin,
- the x-axis lies along the mean wind direction,
- x is the distance from the source,
- y is the lateral distance from the mean wind direction,
- z is the height above ground level,
- h is the physical height of the source,
- Δh is the additional height by which the plume rises due to its buoyancy and/or momentum,
- H = h + Δh is the effective (plume) height of the release, and
- u is the mean wind speed at plume height.

Most models in use today assumes Gaussian distribution of emission pollutants, horizontally and vertically downwind of the source. With the assumption that the distributions in the y and z directions is normal with a standard deviation of σ_i, the concentration of a gas or aerosol (<20µm diameter particles) can be calculated at ground level for a distance downwind of the source:

$$C_{x,y} = \frac{Q}{\pi u \sigma_z \sigma_y} \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]$$

Where:

$C_{x,y}$	=	pollutant concentration in g/m³ with a maximum ground level concentration where $\sigma_z = 0.707H$,
Q	=	pollutant emission rate in g/s
π	=	constant pi = 3.14159
u	=	mean wind speed in m/s
σ_y	=	standard deviation of horizontal plume concentration at distance x in m,
σ_z	=	standard deviation of vertical plume concentration at distance x in m,
exp	=	base of natural logarithm = 2.71828183
H	=	effective stack height in m,
x	=	downwind distance along plume mean centreline from point source in m, and
y	=	crosswind distance from centreline of plume in m

The Gaussian equation contains explicit references to y and z, and also implicit references to x (since σ_y and σ_z are themselves functions of x). Empirical studies resulted in graphs where values for these constants could be obtained for different Pasquill stability categories. However, these graphs were inaccurate by nature and equations for the variation of σ_y and σ_z with stability class have been developed and are shown in **Table 7**.

Table 7: Equations for Variation of σy and σz

Pasquill stability class	σ_y	σ_z
A	0.22x(1+0.0001x)-0.5	0.20x
B	0.16x(1+0.0001x)-0.5	0.12x
C	0.11x(1+0.0001x)-0.5	0.08x(1+0.0002x)-0.5
D	0.08x(1+0.0001x)-0.5	0.06x(1+0.0015x)-0.5
E	0.06x(1+0.0001x)-0.5	0.03x(1+0.0003x)-1
F	0.04x(1+0.0001x)-0.5	0.016x(1+0.0001x)-1

Process stacks have exit velocity and buoyancy due to the temperature and density difference with the surrounding air that carries them up into the air. This would result in the effective plume height being greater than the physical stack height as presented below.

$$H = h + \Delta h$$

Where:

H = effective stack height in m,
h = height of the stack in m, and
Δh = plume rise in m.

One of the popular equations for the distance the flue gas rises before levelling out is Holland's empirical equation.

$$\Delta h = \frac{v_s d}{u}\left[1.5 + \left(2.68x10^{-3} p \frac{\Delta T d}{T_s}\right)\right]$$

Where:

Δh	=	rise of plume above the stack in m,
v_s	=	stack gas velocity in m/s,
d	=	inside stack diameter in m,
u	=	mean wind speed in m/s,
p	=	atmospheric pressure in millibars
ΔT	=	stack gas temperature minus air temperature in K, and
T_s	=	stack gas temperature

The above equation is suitable for neutral conditions. For unstable conditions, Δh should be increased by a factor of 1.1 to 1.2 and decreased by a factor of 0.8 to 0.9 for stable conditions. Holland's equation frequently underestimates the effective stack height, giving a conservative figure for design purposes. Although more complex models are available to determine the upward driving force in terms of a buoyancy flux, Holland's equation will suffice when insufficient information with regards the properties of the source is known.

The simplest Gaussian solution assumes that the plume is free to expand in all directions without constraint. In the usual situation of an elevated source at some height above the ground, downwind dispersion is always limited by the presence of the ground, while upward dispersion may be limited by an elevated inversion. Assuming that no pollutant is absorbed by the ground, any pollutant that reaches the ground is available for upward dispersion and the following equation considers reflection at the ground:

$$C_{x,y} = \frac{Q}{2\pi u \sigma_z \sigma_y} \exp\frac{-y^2}{2\sigma_y^2}\left[\exp-\frac{1}{2}\left(\frac{z-H}{\sigma_z^2}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z^2}\right)^2\right]$$

4.1.2 Model Input

The dispersion of emissions from the Vogelfontein Colliery was modelled using the following inputs:

- For the Control Pathway – Regulatory default options for gasses/PM_{10}, dry deposition options for TSP. Ozone Limiting Method for conversion of NOx to NO_2.
- Source Pathway – Plant loading area and all discard dumps were modelled as area sources. All haul roads were modelled as line sources. Source emission factors and rates contained in **Table 3** and **Table 4**.
- Receptor Pathway – Elevated terrain option. Uniform Cartesian 36km^2 grid with a resolution of 200m by 200m.
- Terrain Grid Pathway – SRTM1/SRTM3 digital elevation model data (~30m).
- Meteorology Pathway – Site specific Unified Model data supplied by Meteoblue for the period 1 May 2016 to 30 April 2021.
- Average annual background dust deposition rate of 250 mg/m^2/day for cumulative assessment.
- Average annual background PM_{10} concentration of 93.30 µg/m^3 for cumulative assessment.
- Average annual background $PM_{2.5}$ concentration of 32.96 µg/m^3 for cumulative assessment.
- Average annual background SO_2 concentration of 8.83 ppb for cumulative assessment.
- Average annual background NO_2 concentration of 3.75 ppb for cumulative assessment.
- Average annual background CO concentration of 0.43 ppb for cumulative assessment.

4.2 MODEL RESULTS AND DISCUSSION

This section contains the results of the predicted maximum and average ground level concentrations generated through the ISC-AERMOD VIEW model.

Prior to an analysis of the simulation results it is recommendable to briefly review areas of uncertainty which needs to be considered in the interpretation of the results. The range of uncertainty of the Gaussian plume model is given by the US-EPA as being in the range of -50% to +200% when used under the recommended conditions. Uncertainties are, however, not only associated with the mathematical model itself, but also with the generation of the meteorological and source data used as input data. It is well known that wind data errors are the major cause of poor agreement, especially for short-term predictions and long down-wind distances. The selection of a suitable meteorological data set for use in the simulation analysis is fundamental to the accuracy of the results. Errors in source strengths translate directly into errors of similar magnitudes in the model prediction.

There will always be some error in any geophysical model, but it is desirable to structure the model in such a way to minimise the total error. A model really 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.

Concentration and deposition isopleths reflect interpolated values for each receptor grid point for various averaging periods. It has generally been found that the accuracy of dispersion models improves with increased averaging periods. The prediction of instantaneous peaks is the most difficult and are normally performed with more complicated dispersion models specifically fine-tuned and validated for the process and location. For this reason, concentrations resulting from routine releases are given for at least three averaging periods, viz. hourly, daily and annual averages. No significant upset (intermittent release) sources are expected for the process.

The results presented reflect the spectrum from maximum ground level concentrations, occurring during very unstable conditions with low wind speeds, to low wind speeds during very stable conditions resulting in maximum impact area.

Dispersion results for the Vogelfontein Colliery are presented for the following scenarios:

- Construction of all surface infrastructure and upgrades to the main export road (Construction).
- Peak operation at a ROM production rate of 150 000 tonnes per month.

Please note that only modelling outcomes showing little or more impact (>10% of the standard) are reflected in the report.

4.2.1 Construction and Rehabilitation Phases

Dispersion model output plots for dust deposition during the construction and rehabilitation phases of the project are reflected in **Figure 30**. The results for the Vogelfontein Colliery were evaluated in terms of current South African National Standards and are presented for the project independently (i.e. incremental) and within the current air quality setting (i.e. cumulative).

NO_2, SO_2 and CO emissions (vehicle tailpipe emissions) were not quantified for these phases of the project due to the relatively low expected risk and since an acceptable construction vehicle inventory cannot be established at this stage.

Predicted incremental and cumulative dust deposition rates during construction and rehabilitation are expected to remain at current levels beyond the mining boundary and at all the closest receivers identified as shown in **Figure 30**.

Predicted incremental daily and annual average $PM_{10/2.5}$ concentrations as a result of construction/rehabilitation will probably remain below 10% of the relevant standards at the closest receivers (models not shown).

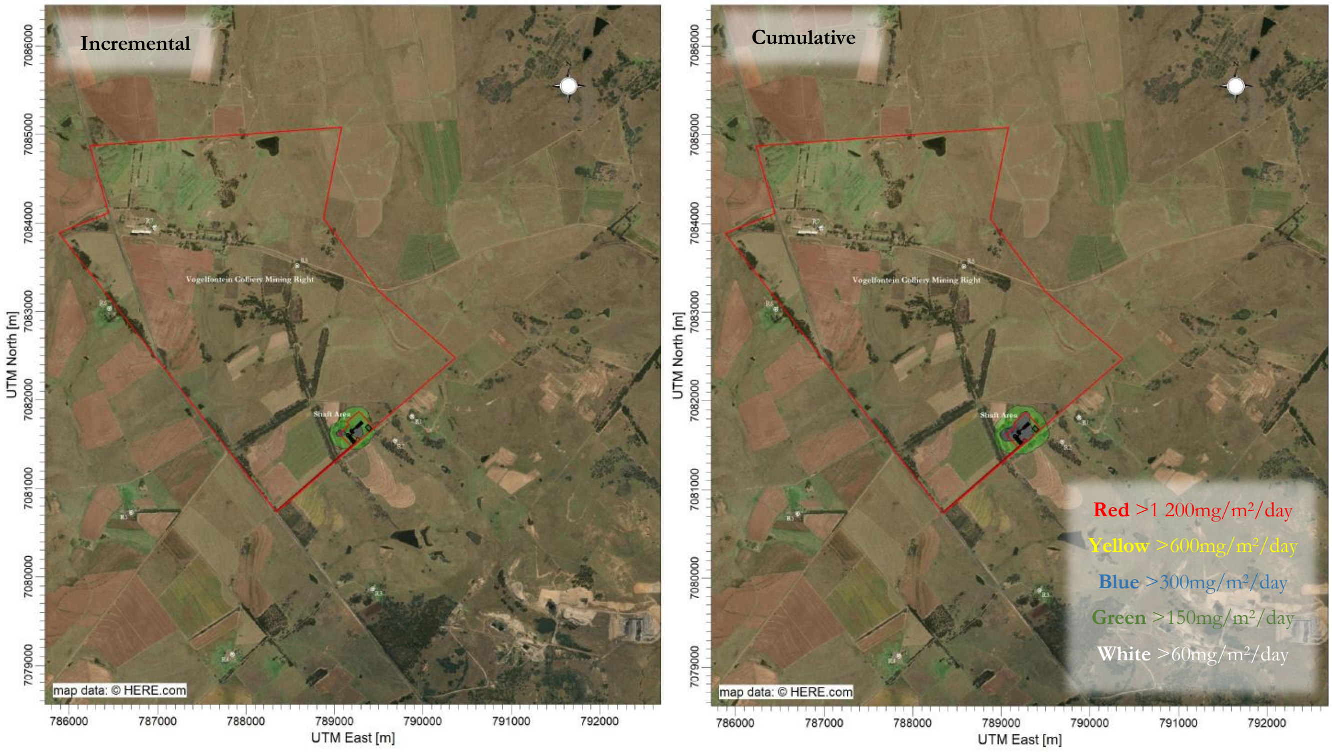

Figure 30: Daily Average Dust Deposition rate – Construction/Rehabilitation Phases (Non-residential Standard – 1 200mg/m²/day, Residential Standard – 600mg/m²/day)

4.2.2 Operational Phase

Dispersion model output plots for dust deposition, PM_{10} and $PM_{2.5}$ for the operational scenario are reflected in **Figure 31** to **Figure 33**. NO_2, SO_2 and CO emissions (vehicle tailpipe emissions) were quantified for this phase of the project, but the modelling outcomes are not reflected due to insignificant impact (<10% of the standard).

Predicted cumulative dust deposition rates during the operational phase are expected to contravene the non-residential standard at the closest receiver, 480m east south-east (R2) of the shaft area as shown in **Figure 31**.

The implementation of dust control measures during material handling activities in addition to standard dust control measures on all transport routes, will reduce the potential impact to satisfactory levels. The residual impact at the closest receivers is expected remain above 50% of the non-residential standard.

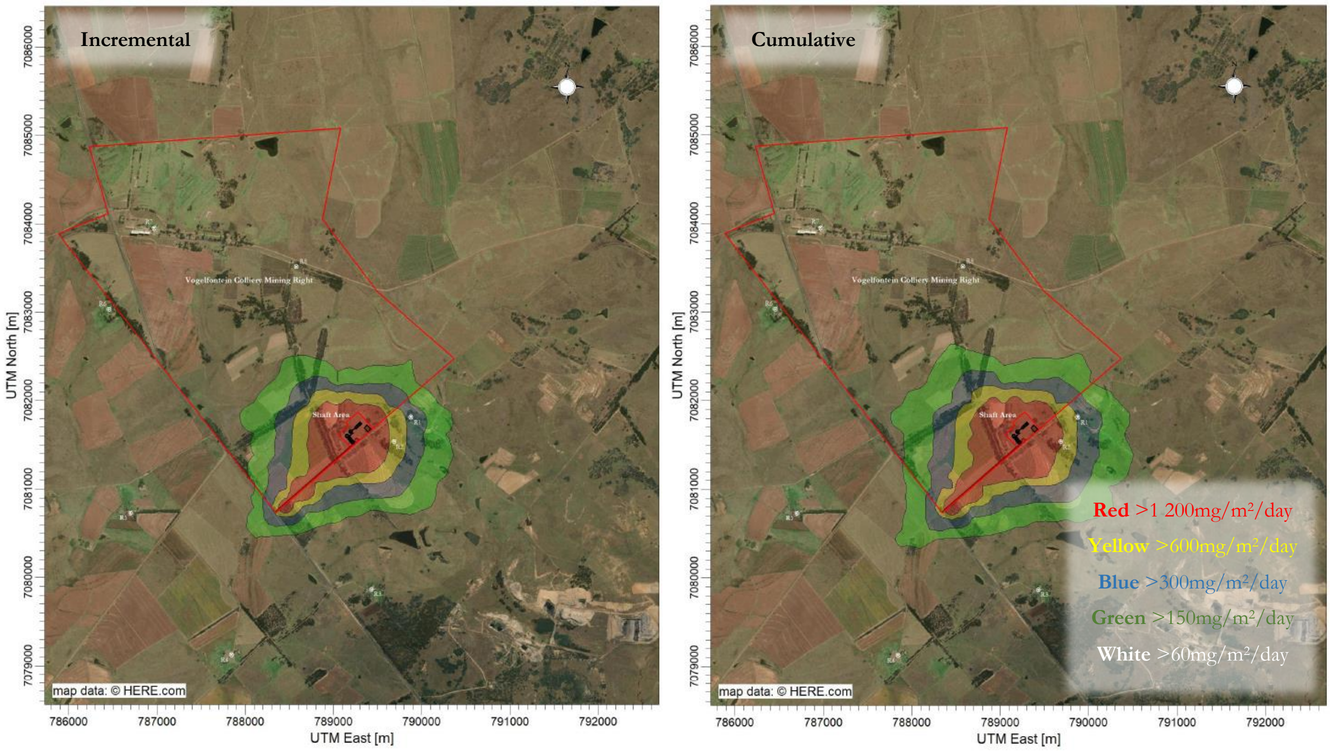

Figure 31: Daily Average Dust Deposition Rate – Operational Phase
(Non-residential Standard – 1 200 mg/m^2/day, Residential Standard – 600 mg/m^2/day)

PM_{10} concentrations, as a result of operations, are likely to cause maximum daily average PM_{10} concentrations above 25% of the standard at the nearest sensitive receivers east (R1 &R2) (see **Figure 32**). Incremental annual PM_{10} concentrations are predicted to remain below 10% of the standard at the nearest receivers.

Current ambient monitoring data for the area and other national publications confirm the significant contribution of mining, material handling and mobile equipment operation to ambient PM_{10} concentrations similarly concluded from the emission inventory conducted for this project. Mobile equipment will most likely be the largest source of ambient pollution (56%), followed by material handling (16%) and fugitive emissions (13%). Fugitive emissions from exposed stockpiles will be more apparent during peak pollution spells, associated with hot, dry and windy conditions.

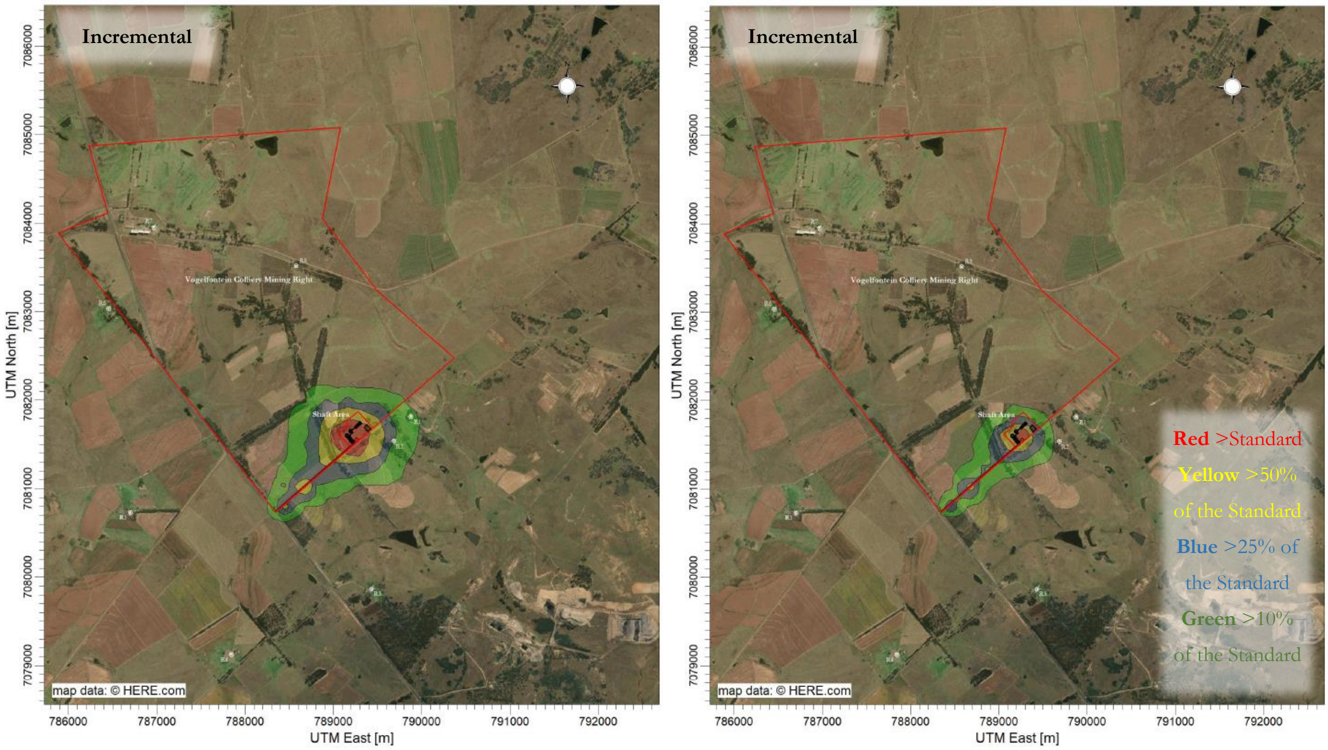

Figure 32: Maximum Daily and Annual Average PM_{10} Concentration – Operational Phase (South African National Daily Standard – 75 μg/m^3, South African National Annual Standard – 75 μg/m^3)

Predicted incremental maximum daily and annual average $PM_{2.5}$ concentrations will probably remain below 10% of the respective standards at the nearest receivers (**Figure 33**).

The modeling predictions of this study are based on the effective use of water as dust suppressant on roads and marshalling areas as indicated in **Table 4**.

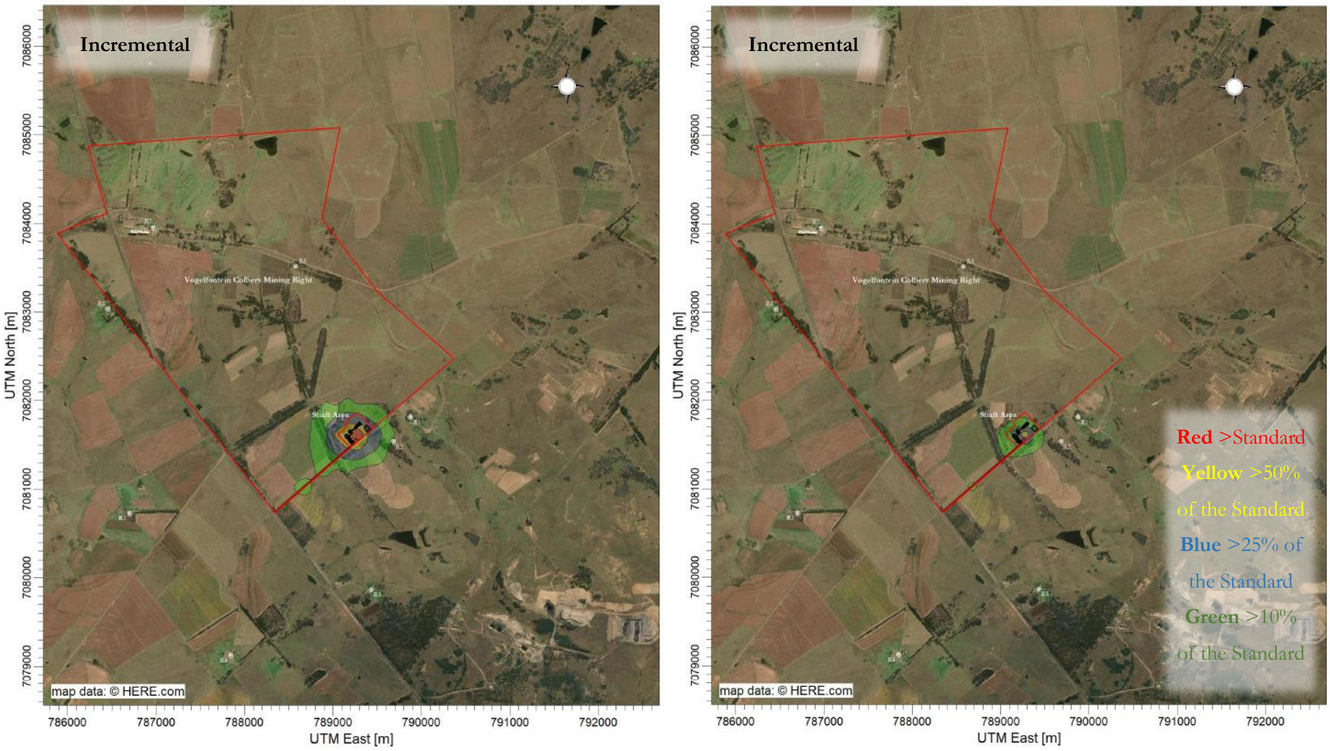

Figure 33: Maximum Daily and Annual Average $PM_{2.5}$ Concentration – Operational Phase (South African National Daily Standard – 40 µg/m^3, South African National Annual Standard – 20 µg/m^3)

4.3 SIGNIFICANSE ANALYIS

4.3.1 Significance Analysis Approach

The assessment of the significance of potential impact on ambient air quality was based on professional judgment, fieldwork and desktop analysis, as appropriate. Potential impacts were assessed using standardised and internationally recognised methodology adhering to ISO 14001, World Bank and International Finance Corporation requirements. For each predicted impact, criteria are applied to establish the significance of the impact based on likelihood and consequence.

The criteria that contribute to the consequence of the impact are intensity (the degree to which pre-development conditions are changed), duration (length of time that the impact will continue); and the extent (spatial scale) of the impact. The sensitivity of the receiving environment and/or sensitive receptors is incorporated into the consideration of consequence by appropriately adjusting the thresholds or scales of the intensity, duration and extent criteria, based on expert knowledge. For each impact, professional judgement is applied to ascribe a numerical rating for each criterion (see **Table 8**, **Table 9** and **Table 10**). The consequence is then established using the formula:

Consequence = intensity + duration + extent

Table 8: Definition of Intensity Ratings

Rating	Criteria	
	Negative impacts (Type of impact = -1)	**Positive impacts (Type of impact = + 1)**
7	Complete destruction (irreversible and irreplaceable loss) of natural or social systems, resources (e.g. species) and human health. No chance of these processes or resources ever being restored to their pre-impact condition.	Noticeable, sustainable benefits that improve the quality and extent of natural or social system or resources, including formal protection.
6	Very high degree of damage to natural or social systems or resources. These processes or resources may restore to their pre-project condition over very long periods of time (more than a typical human lifetime).	Great improvement to ecosystem or social processes and services or resources.
5	Serious damage to components of natural or social systems or resources and the contravention of legislated standards.	On-going and widespread benefits to natural or social systems or resources.
4	High degree damage to natural or social system components, species, or resources.	Average to intense positive benefits for natural or social systems or resources.
3	Moderate damage to natural or social system components, species, or resources.	Average, on-going positive benefits for natural or social systems or resources.
2	Minor damage to natural or social system components, species, or resources. Likely to recover over time. Ecosystems and valuable social processes not affected.	Low positive impacts on natural or social systems or resources.
1	Negligible damage to individual components of natural or social systems or resources, such that it is hardly noticeable.	Limited low-level benefits to natural or social systems or resources.

Table 9: Definition of Duration Ratings

Rating	Criteria
7	**Permanent:** The impact will remain indefinitely.
6	**Beyond project life**: The impact will remain for some time after the life of the project.
5	**Project life:** The impact will cease after the operational life span of the project.
4	**Long-term**: The impact will continue for 6-15 years.
3	**Medium-term:** The impact will continue for 2-5 years.
2	**Short-term:** The impact will continue for between 1 month and 2 years.
1	**Immediate**: The impact will continue for less than 1 month.

Table 10: Definition of Extent Ratings

Rating	Criteria
7	**International:** The effect will occur across international borders.
6	**National:** The impact will affect the entire country.
5	**Province/ Region:** The impact will affect the entire province or region
4	**Municipal Area:** The impact will affect the whole municipal area.
3	**Local:** The impact will extend across the site and to nearby properties.
2	**Limited:** The impact will be limited to the site.
1	**Very limited:** The impact will be limited to the footprint of the development and will not extend to the boundaries of the site.

Depending on the numerical result, the impact's consequence would be defined as either extremely, highly, moderately, or slightly detrimental; or neutral; or slightly, moderately, highly, or extremely beneficial. These categories are provided in **Table 11**.

Table 11: Application of Consequence Ratings

Range		Consequence Rating
-21	-18	Extremely detrimental
-17	-14	Highly detrimental
-13	-10	Moderately detrimental
-9	-6	Slightly detrimental
-5	5	Negligible
6	9	Slightly beneficial
10	13	Moderately beneficial
14	17	Highly beneficial
18	21	Extremely beneficial

To determine the significance of an impact, the probability (or likelihood) of that impact occurring is also considered. In assigning probability, the likelihood of occurrence and cognisance of uncertainty and detectability of the impact is taken into consideration. The most suitable numerical rating for probability is selected from **Table 12** and applied with the consequence according to the following equation:

Significance = consequence x probability

Table 12: Definition of Probability Ratings

Rating	Criteria
7	**Certain/ Definite:** There are sound scientific reasons to expect that the impact will definitely occur.
6	**Almost certain/Highly probable:** It is most likely that the impact will occur.
5	**Likely:** This impact has occurred numerous times here or elsewhere in a similar environment and with a similar type of development and could very conceivably occur.
4	**Probable:** This impact has occurred here or elsewhere in a similar environment and with a similar type of development and could conceivably occur.
3	**Unlikely:** This impact has not happened yet but could happen.
2	**Rare/ improbable:** The impact is conceivable, but only in extreme circumstances. The possibility of the impact manifesting is very low as a result of design, experience, or implementation of adequate mitigation measures.
1	**Highly unlikely/None:** The impact is expected never to happen or has a very low chance of occurring.

When assigning probability to an impact, it is vitally important to distinguish this from the concepts of frequency and confidence:

- **Probability** refers to the likelihood that an impact will occur.
- **Frequency** refers to the regularity with which an impact occurs.
- **Confidence** (**Table 14**) refers to the degree of certainty of a prediction. Confidence may be related to any of the impact assessment criteria (extent, intensity, duration, or probability) and is not necessarily only related to probability. Confidence may be influenced by any factors that introduce uncertainty into a prediction.

Depending on the numerical result of this calculation, the impact would fall into a significance category of negligible, minor, moderate, or major, and the type would be either positive or negative. Once the significance of an impact occurring without mitigation has been established, ratings are assigned for the same impact after the proposed mitigation has been implemented.

Table 13: Application of Significance Ratings

Range		Significance Rating	Action
-147	-109	Major - negative	Impact elimination since no cost-effective mitigation options are available to reduce the impact to the level of administrative control.
-108	-73	Moderate - negative	Substitution measures required to reduce impact to the level of administrative control.
-72	-36	Minor - negative	Engineering measures required to reduce impact to the level of administrative control.
-35	-1	Negligible - negative	Mitigation through administrative control and best industry practise.
0	0	Neutral	Additional mitigation to the point where the impact becomes beneficial.
1	35	Negligible - positive	Continuous improvement.
36	72	Minor - positive	Continuous improvement.
73	108	Moderate - positive	Continuous improvement.
109	147	Major - positive	Continuous improvement.

Despite attempts at ensuring objectivity and impartiality, environmental assessment remains an act of judgement and can never escape the subjectivity inherent in attempting to define significance. The determination of the significance of an impact depends on context (spatial and duration) and intensity of that impact. Since the rationalisation of context and intensity will ultimately be prejudiced by the observer, there can be no wholly objective measure by which to judge the components of significance, let alone how they are integrated into a single comparable measure.

This notwithstanding, to facilitate informed decision-making, air quality assessment must endeavour to come to terms with the impact significance.

Recognising this, EHRCON has attempted to address potential subjectivity for the current study as follows:

- Being explicit about the difficulty of being completely objective in the determination of significance, as outlined above.
- Developing an explicit methodology for assigning significance to impacts and outlining this methodology in detail. Having an explicit methodology not only forces the specialist to come to terms with the various facets that contribute to significance (thereby avoiding arbitrary assessment), but also provides the reader with a clear summary of how the specialist derived the significance.
- Wherever possible, differentiating between the significance of potential environmental impacts as experienced by the various affected parties.
- Utilising a team approach and internal review of the assessment to facilitate a rigorous and defendable system.

Although these measures may not eliminate subjectivity, they provide an explicit context within which to review the assessment of impacts. EHRCON has empirical knowledge of ambient air quality management and can comment on the confidence its findings based on the availability of data and the certainty of their findings (see **Table 14**).

Table 14: Definition of Confidence Ratings

Rating	Criteria
Low	Judgement is based on intuition and there some major assumptions used in assessing the impact may prove to be untrue.
Medium	Determination is based on common sense and general knowledge. The assumptions made, whilst having a degree of uncertainty, are fairly robust.
High	Substantive supportive data or evidence exists to verify the assessment.

4.3.2 Significance Analysis Assessment

An impact can be defined as any change in the physical-chemical, biological, cultural and/or socio-economic environmental system that can be attributed to human activities related to alternatives under study for meeting a project need.

Table 15: Emissions Significance Analysis – Construction/Rehabilitation

Item/Receptor	Impact of controlled total suspended particulate, fine particulate and gaseous emissions during construction/ rehabilitation	Consequence Intensity + Duration + Extent				Significance Consequence x Probability			Motivation
		Intensity	Duration	Extent	Rating	Consequence	Probability	Rating	
All	Incremental	-0	-4	-3	Slight	-7	4	-28	No predicted damage to natural or social systems or resources. Impact could continue for between 6 and 15 years. The impact could extend across the mining boundary to nearby properties. Mitigation through administrative control and best industry practise (see Section 5.2). Residual impact at background levels. High assessment confidence.
	Cumulative	-5	-4	-3	Moderate	-12	4	-48	

Table 16: Nuisance Dust Emissions Significance Analysis – Operations

Item/Receptor	Impact of controlled total suspended particulate emissions during normal operation	Consequence Intensity + Duration + Extent				Significance Consequence x Probability			Motivation
		Intensity	Duration	Extent	Rating	Consequence	Probability	Rating	
R1	Incremental	-2	-4	-3	Slight	-9	4	-36	No to high degree of damage to natural or social systems or resources. Impact could continue for between 6 and 15 years. The impact could extend across the mining boundary to nearby properties. Mitigation through administrative control and best industry practise, supplemented with engineering measures where required (see Section 5.2). Residual impact at background levels. High assessment confidence.
	Cumulative	-3	-4	-3	Moderate	-10	4	-40	
R2	Incremental	-3	-4	-3	Moderate	-10	4	-40	
	Cumulative	-4	-4	-3	Moderate	-11	4	-44	
R3 to R8	Incremental	-0	-4	-3	Slight	-7	4	-28	
	Cumulative	-2	-4	-3	Slight	-9	4	-36	

Table 17: PM$_{10/2.5}$ Emissions Significance Analysis – Operations

Item/Receptor	Impact of controlled fine particulate emissions during normal operation	Consequence: Intensity + Duration + Extent				Significance: Consequence x Probability			Motivation
		Intensity	Duration	Extent	Rating	Consequence	Probability	Rating	
R1	Incremental	-1	-4	-3	Slight	-8	4	-32	Negligible degree of damage to natural or social systems or resources. Impact could continue for between 6 and 15 years. The impact could extend across the mining boundary to nearby properties. Mitigation through administrative control and best industry practise (see Section 5.2). Residual impact at background levels. High assessment confidence.
	Cumulative	-5	-4	-3	Moderate	-12	4	-48	
R2	Incremental	-1	-4	-3	Slight	-8	4	-32	
	Cumulative	-5	-4	-3	Moderate	-12	4	-48	
R3 to R8	Incremental	-0	-4	-3	Slight	-7	4	-28	
	Cumulative	-5	-4	-3	Moderate	-12	4	-48	

Table 18: Gaseous Emissions Significance Analysis – Operations

Item/Receptor	Impact of controlled gaseous emissions during normal operation	Consequence Intensity + Duration + Extent				Significance Consequence x Probability			Motivation
		Intensity	Duration	Extent	Rating	Consequence	Probability	Rating	
All	Incremental	-0	-4	-3	Slight	-7	4	-28	No predicted damage to natural or social systems or resources. Impact could continue for between 6 and 15 years. The impact could extend across the mining boundary to nearby properties. Mitigation through administrative control and best industry practise (see Section 5.2). Residual impact at background levels. High assessment confidence.
	Cumulative	-5	-4	-3	Moderate	-12	4	-48	

In support of an emission reduction strategy, Vogelfontein Colliery must confirm or, where necessary revise, the current understanding of the significance of specific pollutants and sources. In order to fulfil this objective, emissions were ranked based on the emissions inventory and the impact significance analysis. From the emissions inventory for the Vogelfontein Colliery the following observations can be made:

- Emission rates will remain reasonably stable throughout the life of the project, influenced mainly by fluctuations in throughput.
- A total controlled emission rates of 19.80 gram per second were calculated for steady, optimum operations.
- Material handling will most likely be the largest source of ambient pollution (54%), followed by mobile equipment (16%) and processing emissions (12%).
- Particulate matter comprises approximately 70% of the pollution load and gaseous pollutants associated with mobile equipment, 30%. PM_{10} is the criteria pollutant of concern and contributes about 13% of the pollution load. Total suspended particulates and $PM_{2.5}$ contribute 56% and 2% respectively.
- Potential emission reduction of up to 33% were calculated based on the effective use of water as dust suppressant on roads and marshalling areas.

From the impact significance analysis for the Vogelfontein Colliery the following observations can be made:

- The incremental impact of all pollutants during construction and rehabilitation is negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of total suspended particulate matter during normal operations is minor at Receptor 1 and 2 and negligible all other. Current industry standard techniques and administrative control measures should be maintained and supplemented with engineering measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of fine particulate matter ($PM_{10/2.5}$) during normal operations is negligible. Current industry standard techniques should be maintained and supplemented with administrative

control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.

- The uncontrolled incremental impact of gaseous pollutants during normal operations is negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.

5. EPILOGUE

5.1 AIR QUALITY MANAGEMENT APPROACH

Vogelfontein Colliery's vision and policy on air quality management should essentially reflect the vision, principles and approach defined in the National Air Quality Management Plan (NAQMP). This includes a commitment to:

- Establishing goals and strategies for air quality improvement.
- The establishment and continued implementation of a comprehensive air quality monitoring and management system.
- Involving and educating people with the purpose of minimising pollution and facilitating the effective participation in air quality governance.
- Making greater use of innovative approaches to reducing pollution.
- Effectively using new information technologies.
- Responding creatively and vigorously to air quality challenges and emerging issues.

A shift from end-of-pipe air pollution control through the exclusive implementation of command-and-control measures to effects-based air quality management using proactive, flexible, varied and fair measures should be supported at all times.

The key approaches that are to be implemented in order to achieve policy objectives may be individually listed as follows:

- Adoption of a receiving environment approach which requires conformance to air quality standards. The standards define what constitutes satisfactory air quality to ensure human health and welfare, the protection of the natural and build environment, and finally the prevention of significant decline.
- Establishment of a sound technical basis for air quality management and planning. This would include the building of technical expertise and the development and implementation of various tools such as an emissions inventory, a meteorological and air pollution monitoring network, atmospheric dispersion model, impact assessment methodologies et cetera.
- Control and management of all significant sources of air pollution relative to their contributions to ambient air pollutant concentrations. This will ensure that improvements in air quality are secured in the most timely, even-handed and cost-effective manner.
- The integration of a wide range of emission reduction measures is required given the complexity of the process and the diversity of the receiving environment. Such approach will ensure innovative and flexible plans of action tailored to suit the specific source in the local circumstances.
- Identification and implementation of emission reduction measures that are: (i) environmentally beneficial taking all media into account, (ii) technically feasible, (iii) economically viable, and (iv) socially and politically acceptable.
- Provision will be made for the integration of air quality issues into the local community planning process to ensure that air quality issues are addressed in the long term.
- Empowerment of communities by providing easy access to ambient air quality information, including information on air pollution concentrations and environmentally harmful practices.
- Facilitation of public consultation and encouragement of public participation in the air quality management and planning process.

An air quality management plan cannot be successfully implemented and revised in the absence of an effective air quality management system. Vogelfontein Colliery must therefore have as a key focus the establishment and support of such a system. Air quality guidelines represent one important air quality management "tool".

Such guidelines need to comprise, as a minimum, guideline or limit values and permissible timeframes for bringing air quality into compliance with such values. Other essential tools in any air quality management system are emissions inventory, air quality and meteorological monitoring and atmospheric dispersion modelling (**Figure 34**).

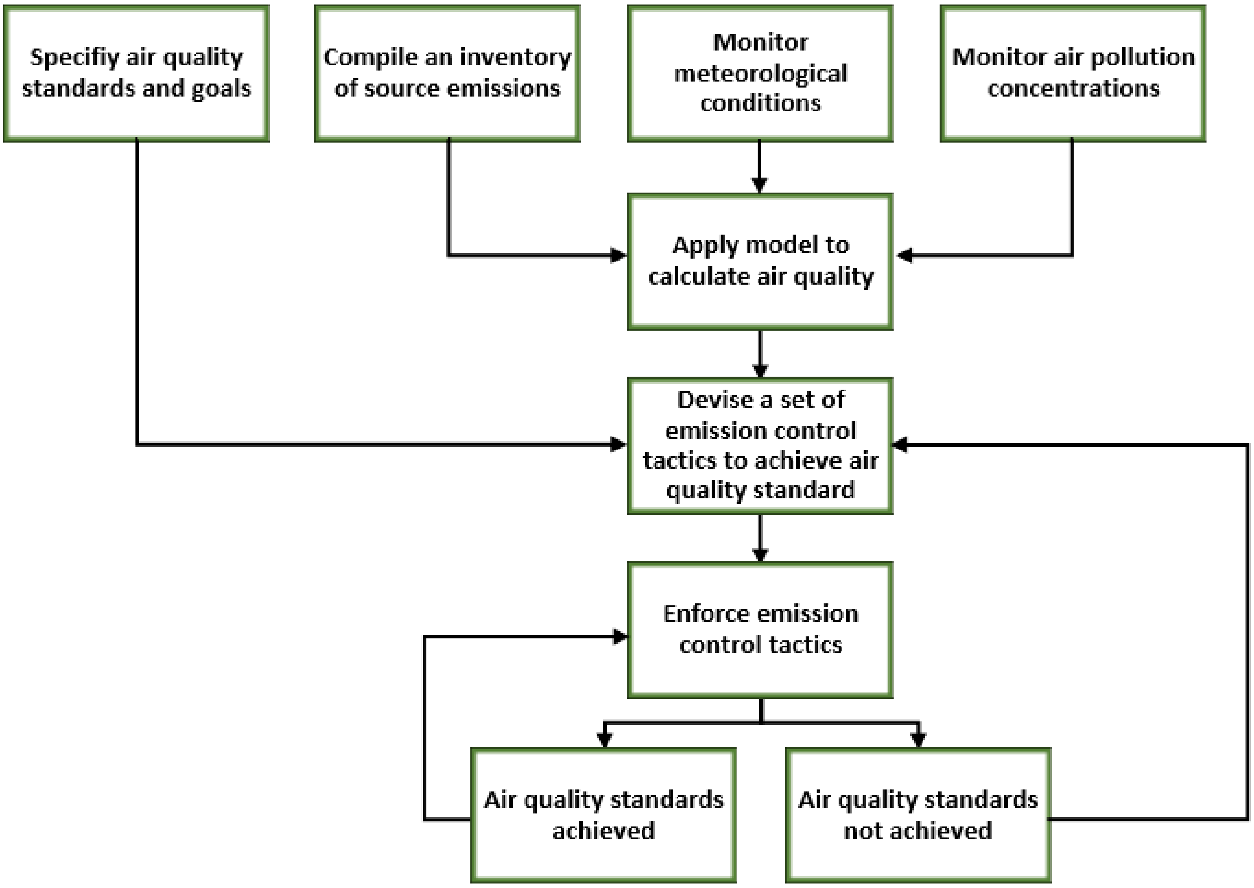

Figure 34: Air Quality Management Strategy

On the basis of a comprehensive emissions inventory, the application of monitoring, in combination with modelling, facilitates the effective characterisation of spatial and temporal variations in air pollutant concentrations. Such concentrations are evaluated based on local guideline values to determine the need for devising emission control strategies. Dispersion modelling is used to predict ambient air pollutant reductions possible through the implementation of specific emission control strategies.

Emission control strategies may then be selected which are able to ensure compliance with the local guideline value, the socioeconomic acceptability and technological feasibility of such strategies having been assessed. The control measures selected need to be enforced, and if the standards are achieved, they need continued enforcement. If the standards are not achieved after a reasonable period of time (i.e. within the permissible timeframe stipulated), the emission control measures may need to be revised.

An integrated air quality management system, which comprises components such as an emissions inventory and air quality monitoring and modelling therefore, forms the basis of effective air pollution control and air quality management.

Air quality management components currently implemented by Vogelfontein Colliery include the following:

- Emissions inventory.
- Atmospheric dispersion modelling.
- Public liaison and consultation mechanisms.

Based on the outputs of the air quality management system, health risk assessments and damage assessments could be undertaken and future impacts quantified in the medium-term (3 to 5 years). Such assessment may be undertaken in the following ways: (i) in-house, through the selection and acquisition of suitable models and acquisition and preparation of locally derived input data, (ii) in-house, though the application of manual calculations based on locally derived data and international protocols, or (iii) externally, through the appointment of consultants on a project-by-project basis.

5.2 RECOMMENDATIONS

5.2.1 Administrative Measures and Monitoring

According to SANS 1929:2009 the concentrations of specific pollutants within an area shall be evaluated against the following thresholds to determine applicable assessment methods:

- Upper assessment threshold, i.e. the 99th percentile pollutant levels represent a pollutant value exceeding 70% of a limit value (considering limit values for all periods which have been used to derive averages).
- Lower assessment threshold, i.e. the 99th percentile pollutant levels represent a pollutant value below 50% of all limit values (considering limit values for all periods which have been used to derive averages).

Provision should be made for three air pollutant concentration assessment methods, based on the classification pollutant concentrations relative to the upper and lower assessment thresholds. These methods are:

- Mandatory monitoring, which may be supplemented by modelling techniques to provide an adequate level of information on ambient air quality. This method should be implemented where the upper assessment threshold for a specific pollutant is exceeded.
- A combination of measurement and modelling techniques should be implemented in areas and for pollutants for which concentrations are between the upper and lower assessment thresholds.
- The sole use of modelling or objective estimation techniques is permissible for pollutant concentrations below the lower assessment threshold.

The classification to determine applicable assessment methods should be based on air pollutant concentrations recorded during the previous five years where data is available.

Results from measurement campaigns of short duration during the period of a year and at locations likely to be typical of the highest pollution levels may be combined with information from emission inventories and modelling to provide the concentration data required. Classification should be reviewed earlier than every five years in the event of significant changes in activities relevant to ambient air pollutant concentrations.

In view of the predicted ambient pollutant concentrations resulting from emissions from the Vogelfontein Colliery, the installation of at least eight dust deposition gauges is recommended. The proposed receptor monitoring stations are indicated in **Figure 35**. Baseline monitoring at these sites should commence at least one year prior to the onset of the construction phase. Additional dust deposition gauges should be installed at key sources onsite during the operational phase of the project. The following locations should be considered:

- ROM stockpile
- Screening and sizing plant
- Truck load-out area
- Overburden stockpile
- Main export road

The ultimate purpose of monitoring is not merely to collect data, but to provide information necessary to make informed decisions on managing and improving the environment. Monitoring fulfils a central role in this process, providing the necessary sound scientific basis for policy and strategy development, objective setting, compliance measurement against targets and enforcement action.

However, the limitations of monitoring should be recognised. In many circumstances, measurements alone may be insufficient, or impractical for the purpose of fully defining population exposure. No monitoring programme, however well-funded and designed, can comprehensively quantify patterns of air pollution in both space and time.

At best monitoring provides an incomplete, but useful, picture of current environmental air quality. Monitoring often needs to be used in conjunction with other objective assessment techniques, including modelling, emission measurement and inventories, interpolation and mapping.

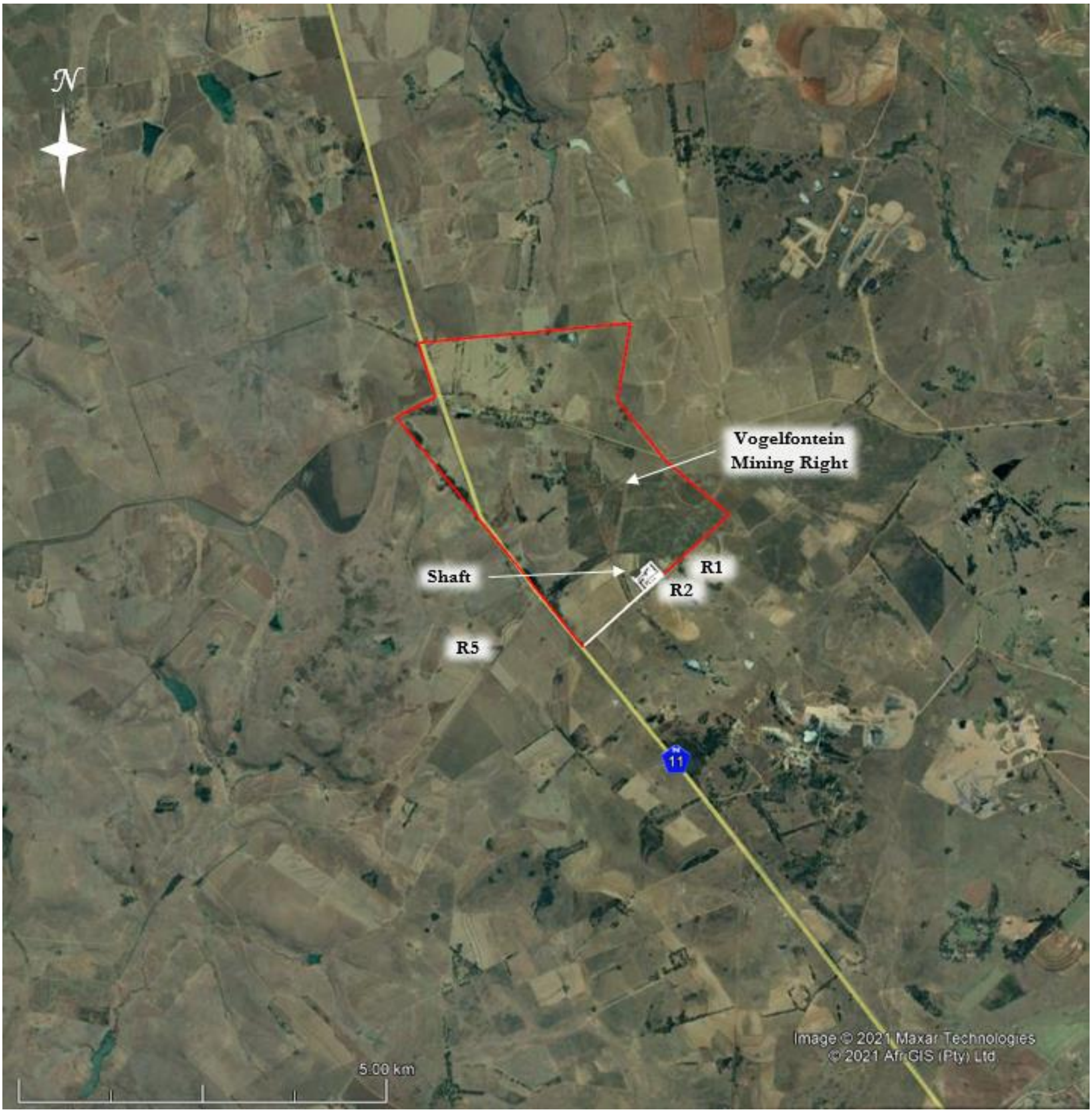

Figure 35: Proposed Receptor Dust Deposition Monitoring Matrix

5.2.2 Best Available Industry Techniques

The location of dust generating activities will change during the different phases of the project and therefore, the relationship with receivers around the site. It is important that the minimisation of dust through site design is addressed at each phase of the operation.

Control techniques for fugitive dust sources, generally involve watering, chemical stabilisation and the reduction of surface wind speed through the use of windbreaks and vegetation. Watering represents a commonly used, relatively inexpensive option, but provides only temporary control. Although the chemical treatment of exposed surfaces is more expensive, it provides for longer suppression. The use of chemicals may, however, have adverse effects on the receiving biophysical environment if not carefully selected.

Control efficiencies of greater than 60% could be achieved by the effective implementation of watering, chemical stabilisation and vegetation. Maximum control efficiencies due to wet suppression are generally in the order of 70% whereas the addition of chemical suppressants could result in control efficiencies of 90%.

The construction of windbreaks is seldom practical due to the size of most fugitive dust sources.

Unpaved roads were identified as significant sources of dust emissions in this study. Three types of measures may be taken to reduce emissions from unpaved roads; measured aimed at reducing the extend of unpaved roads such as paving, traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds and measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilisation. These and other more specific control measures are summarised in **Table 19**. However, the most common method of mitigation on unpaved road surfaces remains watering.

Permanent improvements in road surfaces, such as paving, results in continuous control efficiencies. The control efficiencies obtained by wet suppression and chemical stabilisation are cyclic as efficiency decays over time, requiring periodic re-application to maintain. On paved surfaces preventative measures aimed at the reduction of the source extend, or process modifications and adjusted work practices, may also reduce fugitive emissions. Measures aimed at reducing the extent of the source of fugitive dust include the reduction in the amount of material being handled and the elimination of track-on. Measures to which entail periodic removal of deposited material, i.e. broom and vacuum sweeping, may also be adopted to reduce dust generation.

Table 19: Vogelfontein Colliery Dust Control Measures

Aspect	**Control Measure**
Vehicle entrained dust	Set speed limits of 40km/hr or less for site traffic. Speed control has a linear effect on dust emissions. Thus, by reducing speed from 40 to 20km/hr, emissions can be reduced by 50%.
	Wet suppression of unpaved areas should be applied during dry windy periods, using a water car and/or sprinklers at a rate of more than 2.0l/m^2/hour.
	Chemical suppression can also be used in conjunction with wet suppression. This involves the use of chemical additives in the water, which aids the formation of a binding crust. Repeated treatment is normally required.
	Inspect road integrity and repair frequently.
	Provide firm marshalling areas.
	Reduce track-on through the use of a wheel wash-bay.
	Reduce unnecessary traffic.
	Limit load size.
	Minimise travelling distance through good layout and process design.
Fugitive emissions	Limit the area of operation to what is absolutely necessary.
	Rehabilitation should be performed on an ongoing basis.
Beneficiation process and coal handling equipment emissions	Custom designed and purposely built local exhaust ventilation systems on key process equipment

5.3 KEY FINDINGS

The air quality impact study concludes the following:

- The project falls within the Gert Sibande District Municipality and the Highveld Priority Area. Air Quality Management Plans have been drafted and baseline characterisation have been completed. The status of ambient air quality is classified as poor with elevated concentrations of criteria pollutants.
- Recent ambient monitoring data for the area and other national publications confirms the significant contribution of mining, material handling and mobile equipment operation to ambient fine particulate concentrations, correspondingly concluded from the emission inventory conducted for this project.
- Emission rates will remain reasonably stable throughout the life of the project, influenced mainly by fluctuations in throughput.
- A total controlled emission rates of 19.80 gram per second were calculated for steady, optimum operations.
- Material handling will most likely be the largest source of ambient pollution (54%), followed by mobile equipment (16%) and processing emissions (12%).
- Particulate matter comprises approximately 70% of the pollution load and gaseous pollutants associated with mobile equipment, 30%. PM_{10} is the criteria pollutant of concern and contributes about 13% of the pollution load. Total suspended particulates and $PM_{2.5}$ contribute 56% and 2% respectively.
- Potential emission reduction of up to 33% were calculated based on the effective use of water as dust suppressant on roads and marshalling areas.
- Dispersion of particulate emissions from the process was modelled using the ISC-AERMOD View model based on the standard Gaussian solution.
- The results present the spectrum from maximum ground level concentration to maximum impact area, and accounts for daily and annual reference periods.
- Meteorological data for the period 1 May 2016 to 30 April 2021 was incorporate in the assessment. Winds from the northern sector (36.86%) were mostly reported for the study area. Calm periods were the exception and wind speeds were most often moderate, between 2.1 and 3.6 m/s (35.2%). Light

winds between 0.5 and 2.1 m/s were recorded 12.7%, brisk winds between 3.6 and 5.7 m/s were recorded 32.7% and strong winds above 5.7m/s, about 18.4% of the time.

- Predicted incremental and cumulative dust deposition rates during construction and rehabilitation are expected to remain at current levels beyond the mining boundary and at all the closest receivers.
- Predicted incremental daily and annual average $PM_{10/2.5}$ concentrations as a result of construction/rehabilitation will probably remain below 10% of the relevant standards at the closest receivers.
- Predicted cumulative dust deposition rates during the operational phase are expected to contravene the non-residential standard at the closest receiver, 480m east south-east (R2) of the shaft area.
- Normal operations are likely to cause maximum daily average PM_{10} concentrations above 25% of the standard at the nearest sensitive receivers east (R1 & R2). Incremental annual PM_{10} concentrations are predicted to remain below 10% of the standard at the nearest receivers.
- Predicted incremental maximum daily and annual average $PM_{2.5}$ concentrations will probably remain below 10% of the respective standards at the nearest receivers.
- NO_2, SO_2 and CO emissions (vehicle tailpipe emissions) were quantified at levels well below 10% of the respective standards for all phases of the project.
- The incremental impact of all pollutants during construction and rehabilitation is negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of total suspended particulate matter during normal operations is minor at Receptor 1 and 2 and negligible all other. Current industry standard techniques and administrative control measures should be maintained and supplemented with engineering measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of fine particulate matter ($PM_{10/2.5}$) during normal operations is negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.

- The uncontrolled incremental impact of gaseous pollutants during normal operations is negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- Ambient monitoring should be used in combination with modelling and emission inventory to assess the effectiveness of control measures at source and receivers, on an annual basis.
- Strict monitoring of ambient air quality will assist effective air quality management and open communication to all stakeholders.

5.4 ABBREVIATIONS

AEL	:	Atmospheric emission licence
AQIS	:	Air quality impact study
AQMP	:	Air quality management plan
BTEX	:	Benzene, Ethylbenzene, Toluene & Xylene
°C	:	Degree Celsius
CH_4	:	Methane
CO	:	Carbon monoxide
CO_2	:	Carbon dioxide
DEFF	:	Department of Environmental Affairs, Forestry and Fisheries
EIA	:	Environmental impact assessment
EMP	:	Environmental management plan
H_2	:	Hydrogen
HAPs	:	Hazardous air pollutants
km	:	Kilometre
km/h	:	Kilometre per hour
LPG	:	Liquid Petroleum Gas
mg	:	Milligrams
$mg/m^2/day$	:	Milligrams per square metre per day
mm	:	Millimetres
Nm^3/h	:	Normal cubic metres per hour
m/s	:	Meters per second
NAAQS	:	National Ambient Air Quality Standards

NEMAQA	:	National Environmental Management: Air Quality Act (Act no. 39 of 2004)
NO	:	Nitrogen oxide
NO_2	:	Nitrogen dioxide
NO_x	:	Oxides of nitrogen
NPI	:	National Pollutant Inventory
O_3	:	Ozone
Pb	:	Lead
$PM_{2.5}$	:	Inhalable particulate matter with a mean aerodynamic diameter less than 2.5 micrometre
PM_{10}	:	Inhalable particulate matter with a mean aerodynamic diameter less than 10 micrometre
RfC	:	Inhalation Reference Concentration
REL	:	Recommended Exposure Limit
SANS	:	South African National Standards
SAWS	:	South African Weather Service
SO_2	:	Sulphur dioxide
TLV	:	Threshold Limit Value
TSP	:	Total Suspended Particulates
t/h	:	Tonnes per hour
µg	:	Microgram
$\mu g/m^3$	:	Microgram per cubic metre
USEPA	:	United States Environmental Protection Agency
VOCs	:	Volatile organic compounds
WHO	:	World Health Organisation

5.5 GLOSSARY

Act means the National Environmental Management: Air Quality Act, 2004 (Act No.39 of 2004).

Air pollution means any change in the composition of the air caused by smoke, soot, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances.

Air quality management plan means a plan referred to in section 15 of the **Act**.

Air quality officer means an officer appointed in terms of section 14 of the **Act**.

Air-shed means a geographical area that are defined according to topographical, meteorological, political, or other criteria in order to address air quality issues that are common to the area.

Alternative fuels and resources means general and hazardous wastes which are used to substitute conventional or primary fossil fuels and/or virgin raw materials in cement kilns and other industrial thermal processes.

Ambient air means environmental air excluding indoor air and air regulated by the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

Ambient air quality standards are values that define targets for air quality management and establish the permissible amount or concentration of a particular substance in or property of discharges to air based on what a particular receiving environment can tolerate without significant deterioration.

Atmospheric emission or **emission** means any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution.

Atmospheric emission licence means an atmospheric emission licence contemplated in Chapter 5 of the **Act**.

ASTM D1739 means the American Standard for Testing and Materials method D1739, which is the standard test method for the collection and measurement of dust fall.

Averaging period means a period over which an average value is determined.

Baseline air quality assessment means a compilation of existing or current data and knowledge on air quality in a particular area. It forms an essential input into the subsequent formulation of the air quality management plan. It comprises an assessment of the current ambient air quality status; an assessment of current organisational structures for air quality management; and an assessment of current air quality initiatives to reduce air pollution.

Biomass means non fossilised and biodegradable organic material originating from plants, animals and micro-organisms excluding (a) sewage; and (b) treated or coated wood waste which may contain halogenated organic compounds or heavy metals.

Bottom loading means the transfer of compounds in a liquid state to a suitable vessel by filling from the bottom by means of bottom valve or from the top utilising a transfer pipe extended to the bottom of the vessel.

Boundary layer in terms of the earth's planetary boundary layer means the air layer near the ground affected by diurnal heat, moisture, or momentum to or from the surface.

Continuous sampling means ambient air quality sampling conducted by drawing air into sampling equipment with real time analysis of concentrations using accepted reference methods. Measurement and recording is done in a continuous manner.

Cost- Benefit analysis means the process that involves weighing the total accepted costs against the total expected benefits in order to choose the best option.

Controlled emitter means any appliance or activity declared as a controlled emitter in terms of Section 23 of the **Act**.

Compliance date means the date on which compliance with the standard is required.

Design capacity means capacity as installed.

Dispersion modelling means a computer-based model that simulates the dispersion or movement of pollutants in the atmosphere based on a set of equations that are determined by the meteorological conditions of the atmosphere. The output is a set of predicted values of a pollutant for a defined location and time period.

Dispersion potential means the potential a pollutant has of being transported from the source of emission by wind or upward diffusion. Dispersion potential is determined by wind velocity, wind direction, height of the mixing layer, atmospheric stability, presence of inversion layers and various other meteorological conditions.

Dust means solid materials suspended in the atmosphere in the form of small irregular particles, many of which are microscopic in size.

Dust (or settleable particulate matter) means any material composed of particles small enough to pass through a 1 mm screen and large enough to settle by virtue of their weight into the sampling container from the ambient air.

Dustfall means the deposition of dust.

Dustfall monitoring programme means monitoring of the dustfall on a continuous basis.

Emission means pollution discharged into the atmosphere from a range of stationary and mobile sources. These include smokestacks, vents and surface areas of commercial or industrial facilities; residential sources; motor vehicles and other transport related sources.

Emission control technology means technology that aims to reduce emissions into the atmosphere.

Emission inventory means a listing or register of the amount of pollution entering the atmosphere from all sources within a given time and geographic boundaries.

Emission rate means the rate at which a pollutant is emitted from a source of pollution.

Emission factor means a representative value, relating the quantity of a pollutant to a specific activity resulting in the release of the pollutant to atmosphere.

Emission reduction strategy means an intervention designed to reduce emissions into the atmosphere.

Emission standard means a specific limit to the amount of pollutant that can be released to the atmosphere by a specified source.

Environment means the surroundings within which humans exist and that are made up of (i) the land, water and atmosphere of the earth; (ii) micro-organisms, plant and animal life; (iii) any part or combination of (i) and (ii) and the interrelationships among and between them; and (iv) the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being.

Environmental management systems means a part of the management system of an organisation in which specific competencies, behaviours, procedures and demands for the implementation of an environment policy are defined.

Exceedance means a situation in which a measured ambient air quality concentration (or emission rate) of a particular pollutant exceeds the ambient air quality guideline or standard (or emission limit) for that pollutant. Exceedances are normally expressed as a total number per time period and give an indication of the severity of the air pollution problem.

Existing plant unless where specified, shall mean any plant or process that was legally authorised to operate before 01 April 2010 or any plant where an application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), was made before 01 April 2010.

Flare means a combustion device that uses an open flame to burn combustible gases with combustion air provided by ambient air around the flame. Combustion may be steam or air assisted. Flares may be either continuous or intermittent. This term includes both ground and elevated flares.

Frequency of exceedance means a frequency (number/time) related to a limit value representing the tolerated exceedance of that limit value, i.e. if exceedances of limit value are within the tolerances, then there is still compliance with the standard. This exceedance is applicable to a calendar year.

Fugitive emissions means emissions that are difficult to identify and quantify, such as gases that "escape" from badly managed or maintained processes, e.g. leak in pipes.

Greenhouse gas means gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation, and includes carbon dioxide, methane and nitrous oxide.

Incineration means any method, technique, or process to convert waste to flue gases and residues by means of oxidation.

Inversion means an increase of atmospheric temperature with an increase in height.

Licensing authority means an authority referred to in sections 36(1), (2), (3) or (4) responsible for implementing the licensing system set out in Chapter 5 of the **Act**.

Listed activity means any activity listed in terms of Section 21 of the **Act**.

Mitigation measures means attempt to prevent pollution or to reduce the effects of pollution that occur.

Mixing layer means the layer of air within which pollutants are mixed by turbulence. Mixing depth is the height of this layer from the earth's surface.

Mobile source means a single identifiable source of atmospheric emission which does not emanate from a fixed location.

Monitoring means periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.

New plant unless where specified, shall mean any plant or process where the application for authorisation in terms of the National Environmental Management Act 1998, (Act No. 107 of 1998), was made on or after 01 April 2010.

Normal operating condition means any condition that constitutes operation as designed.

Non-point source means a source of atmospheric emissions which cannot be identified as having emanated from a single identifiable source or fixed location, and includes veld, forest and open fires, mining activities, agricultural activities and stockpiles.

Non- residential area means any area not classified for residential use as per local town planning scheme.

Non-thermal treatment of volatile organic compounds means the removal of volatile organic compounds through non combustion processes including but not limited to cryogenic cooling, scrubbing and vapour recovery.

Offensive odour means any smell which is considered to be malodorous or a nuisance to a reasonable person.

Ozone-depleting substance means a substance having chemical or physical properties which, by its release into the atmosphere, can cause a depletion of the stratospheric ozone layer.

Oxides of nitrogen (NO_X) means the sum of nitrogen oxide (NO) and nitrogen dioxide (NO_2) expressed as nitrogen dioxide (NO_2)

Particulate matter (PM) means total particulate matter, that is the solid matter contained in the gas stream in the solid state as well as the insoluble and soluble solid matter contained in entrained droplets in the gas stream.

The collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface and includes dust, smoke, soot, pollen and soil particles.

Passive sampling means air quality monitoring by means of exposure of the sampler to ambient air and adsorption of the pollution into the sampling medium. Sampling is over longer time periods and subsequent analysis is required to determine concentrations.

Petrochemicals means ethylene and its polymers, ethylene oxide, ethylene glycol, glycol ethers, ethoxylates, vinyl acetate, 1,2dichloroethane, trichloroethylene, tetrachloroethylene, vinyl chloride, propylene, propyl alcohols, acrylonitrile, propylene oxide, isomers of butylene, butyl ethers, butadienes, polyolefins and alphaolefins, all alcohols (except those produced during the production of beverages), acrylic acid, allyl chloride, epichlorohydrin, benzene and alkylbenzenes, toluene, o, m and p-xylene, ethylbenzene, styrene, cumene, phenols, acetone, cyclohexane, adipic acid, nitrobenzene, chlorobenzene, aniline, methylene diphenyl diisocyanate (mdi), toluene di isocyanate or other di isocynates of comparable volatility, benzoic acid.

Point source means a single identifiable source and fixed location of atmospheric emission and includes smokestacks and residential chimneys.

Point of compliance means any point within the off gas line, where a sample can be taken, from the last vessel closest to the point source of an individual listed activity to the open end of the point source or in the case of a combinations of listed activities sharing a common point source, any point from the last vessel closest to the point source up to the point within the point source prior to the combination/interference from another Listed Activity.

Precipitation means ice particles or water droplets large enough to fall at least 100 m below the cloud base before evaporating.

Priority Area means an area declared as such in terms of Section 18 of the **Act**.

Priority pollutant means pollutants which, through ambient concentrations, bioaccumulation, deposition or in any other way, present a threat to health, well-being, or the environment. Factors that may influence whether a pollutant is identified as such include: its toxicity; the volume of emissions; or the proximity of the emission relative to sensitive receptors.

Pyrolysis means the decomposition of a material by heat in the absence of oxygen.

Residential area means any area classified for residential use in terms of the local town planning scheme.

SANAS means the South African National Accreditation System established by Section 3 of the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act No. 19 of 2006).

Sulphur recovery plant means a unit that processes sulphur containing gases obtained from the processing of crude mineral oil or the coking or gasification of coal and produces a final product of sulphur containing compounds.

Thermal treatment means incineration, co processing and other high temperature treatment of hazardous and general waste.

Total volatile organic compounds means organic compounds listed under US EPA Compendium Method TO-14.

Upset conditions means any temporary failure of air pollution control equipment or process equipment or failure of a process to operate in a normal or usual manner that leads to an emission standard being exceeded.

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