Ambient Air Quality Impact Study Commissioned By

ZUTARI NDODANA JOINT VENTURE

ON BEHALF OF OMMP-BRWSP MOKOPANE WATER TREATMENT WORKS

Project Reference 0723-P004-ZUT OMMP BRWSP MOK AQIS

Date 26 September 2023

This report documents the results and findings of an air quality impact investigation resulting from the construction and operation of the Olifants Management Model Programme Bulk Raw Water Study Phase (OMMP-BRWSP) Mokopane Water Treatment Works near Mokopane, in the Limpopo Province.

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EXECUTIVE SUMMARY

EHRCON (Pty) Ltd (EHRCON) was commissioned by the Zutari Ndodana Joint Venture (ZNJV) to assess the air quality impact associated with the Olifants Management Model Programme Bulk Raw Water Study Phase (OMMP-BRWSP) Mokopane Water Treatment Works (WTW). The Mokopane WTW is situated on Potion 80 of farm Piet Potgietersrust 44 and Portion 69 of farm Maribashoek 50 in the Mokgalakwena Local Municipality of the Waterberg District Municipality of the Limpopo Province.

The OMMP-BRWSP bulk infrastructure plan makes provision for the construction of raw water pipeline systems. The relevant bulk pipe that would augment raw water to the Mogalakwena system is the proposed Phase 2B pipeline, the pipeline from Flag Boshielo Dam to Pruissen near Mokopane. The Mokopane WTW is located along the alignment of Phase 2B+. This phase is an extension of Phase 2B and spans from the Pruissen reservoir to Piet-se-Kop. The Mokopane WTW will service the Mokopane Town with an ultimate capacity of 28 megalitres per day (Ml/day).

The objectives of this study were to characterise and describe ambient emissions from the construction, operation and rehabilitation of the Mokopane WTW and to assess the impact on the health of the receiving community. The findings of the study are aimed at providing ZNJV, the Waterberg 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. An overview was given of the prevailing meteorological conditions as well as available data on criteria air pollutant concentrations in the area. A process description and emission inventory were 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 process falls within the Mokgalakwena Local Municipality (MLM), in the Waterberg District Municipality (WDM) of the Limpopo Province.
- Ambient monitoring data from the WBPA Mokopane station was included in the study.
- A total emission rate of 0.29 gram per second was calculated for operations.
- The disinfection process, utilising chlorine gas, will most likely be the largest source of ambient pollution (67.1%).
- Particulate matter comprises approximately 32.9% of the pollution load. PM_{10} is the criteria pollutant of concern and contributes about 4.98% of the pollution load. Total suspended particulates and $PM_{2.5}$ contribute 26.72% and 1.2% respectively.
- Dispersion of 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 annual averages.
- Ground level concentrations were predicted for atmospheric conditions based on local meteorological data for the period 1 July 2022 to 30 June 2023.
- For the reporting period winds were mostly from the north easterly sector 60.47%. Calm periods were the exception (1.2%) and wind speeds were most often brisk above 3.6m/s (42.4%). Moderate winds between 2.1 and 3.6m/s occurred 37.6% and light winds, between 0.5 and 2.1m/s 18.6%.
- Predicted incremental dust deposition rates during construction/rehabilitation are expected to remain at current levels and at all the closest receivers. Incremental daily and annual average $PM_{10/2.5}$ concentrations will probably remain below 10% of the relevant standards.
- Predicted incremental dust deposition rates during operations are expected to remain at background levels at all sensitive receivers beyond the project boundary.
- Predicted incremental annual average chlorine concentrations will probably exceed 10% of the adopted guideline at the nearest receivers south of the preferred site and south west of the alternative site.

- Incremental daily and annual average total suspended particulates and $PM_{10/2.5}$ concentrations during normal operations will probably remain below 10% of the relevant standards at the closest sensitive receivers.
- The incremental impact of all pollutants during construction/rehabilitation is expected to be 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 particulate pollutants during normal operations is expected to be 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 gaseous pollutants during normal operations is expected to be negligible to minor. Current industry standard techniques should be maintained and supplemented with administrative control measures and engineering control to maintain the residual impact at the nearest sensitive receivers at current background levels.
- Both the preferred and alternative sites will have a similar impact on the surrounding community.
- Emission inventory and dispersion modelling should be used in combination to assess the effectiveness of control measures at source and receivers, on an annual basis.
- Monitoring of ambient air quality will assist effective air quality management and open communication to all stakeholders.

DECLARATION AND REPORT APPROVAL

Report 0723-P004-ZUT OMMP-BRWSP MOK AQIS issued on this day, 26 September 2023, is the sole property of the Zutari Ndodana Joint Venture and supersedes any previous versions. No part of this report may be reproduced or transmitted in any form or by any means, unless in full and with the exclusive permission, in writing, from the author. EHRCON declares that:

- 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

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EHRCON (Pty) Ltd (EHRCON) was commissioned by the Zutari Ndodana Joint Venture (ZNJV) to assess the air quality impact associated with the Olifants Management Model Programme Bulk Raw Water Study Phase (OMMP-BRWSP) Mokopane Water Treatment Works (WTW). The Mokopane WTW is situated on Potion 80 of farm Piet Potgietersrust 44 and Portion 69 of farm Maribashoek 50 in the Mokgalakwena Local Municipality of the Waterberg District Municipality of the Limpopo Province.

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The assessment considered a review of the relevant health legislation, ambient air quality guidelines and standards. An overview was given of the prevailing meteorological conditions as well as available data on criteria air pollutant concentrations in the area. A process description and emission inventory were 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 report was compiled with due consideration of all process information and specific conditions outlined by the ZNJV.

1.2 PROJECT DESCRIPTION

The study area is located in the Mokgalakwena Local Municipality of the Waterberg District Municipality in the Limpopo Province. Current land use includes commercial, municipal services, mining and agricultural processes and residential developments. The Mokopane WTW is situated on Potion 80 of farm Piet Potgietersrust 44 and Portion 69 of farm Maribashoek 50 (See **Figure 1**).

The study area is classified as agricultural rural (A2) based on the Auer method recommended for selecting atmospheric dispersion coefficients.

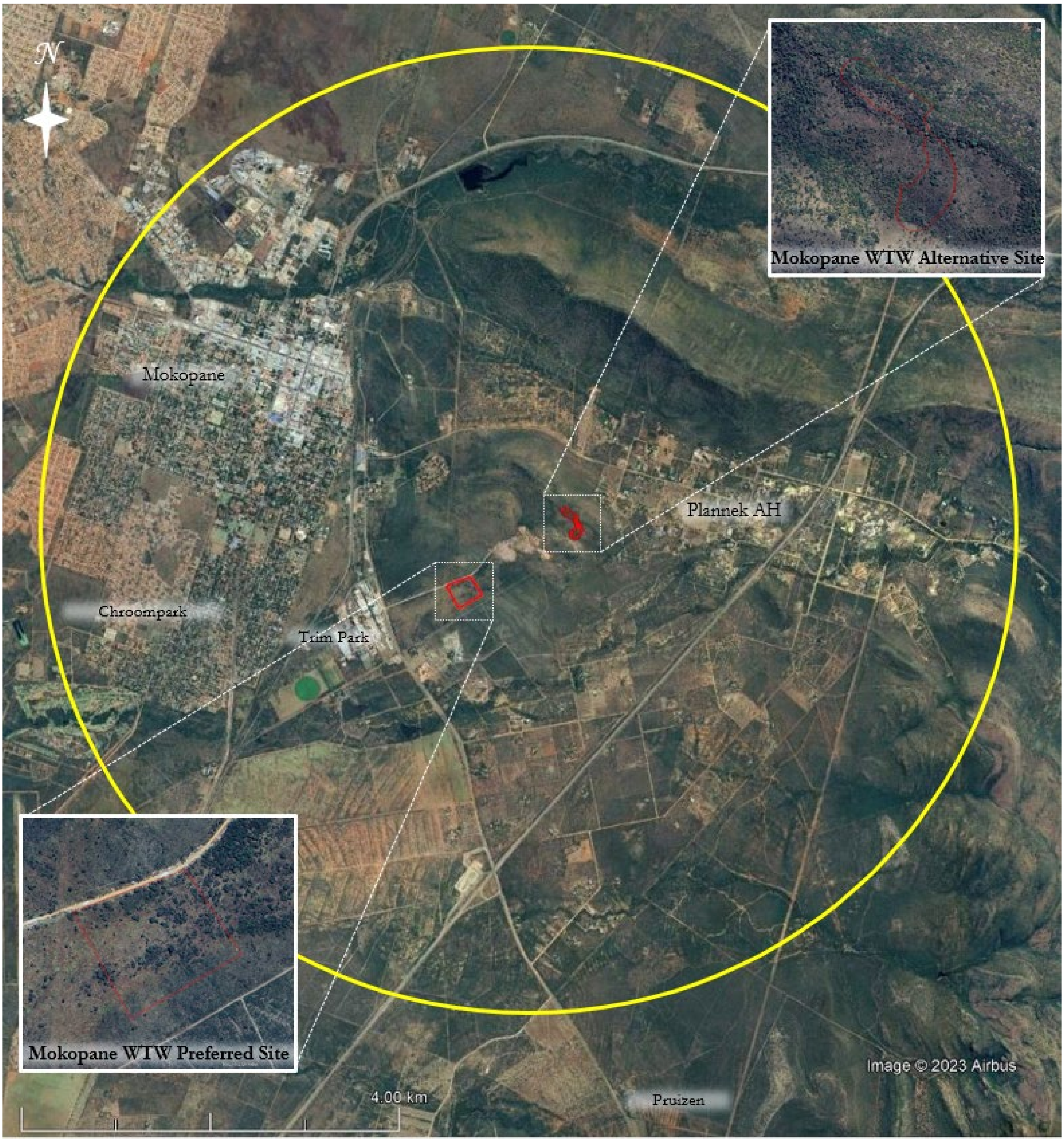

Figure 1: Mokopane WTW Location (red polygon) and 5km Study Area (yellow circle).

The assessment of the potential air quality impact associated with the water treatment works comprised the following terms of reference:

- A review of relevant health legislation, ambient air quality guidelines and standards.
- A process description and emission inventory.
- 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.

1.3 METHODOLOGICAL OVERVIEW

The establishment of an emissions inventory formed the basis for assessing the impact from Mokopane Water Treatment Works. This comprised the identification of sources of emissions 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* and the National Pollutant Inventory *Emission Estimation Technique Manual.*

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 Mokopane Water Treatment Works are listed below:

- Ambient monitoring data from the WBPA Mokopane station was included in the study.
- Unified model meteorological data supplied by Meteoblue was used for dispersion modelling.
- Dispersion simulations were based on the process descriptions and predicted production data provided by the ZNJV.
- All sources were digitised from layout drawings provided by the ZNJV.

2. LEGISLATION, GUIDELINES AND STANDARDS

2.1 AIR QUALITY ACT

The Department of Forestry, Fisheries and the Environment (DFFE) has 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.
- 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 DFFE 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
DFFE	:	Department of Forestry, Fisheries and the Environment.
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 were 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 are 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 licenses 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 Limpopo Province Air Quality Management Plan

The Limpopo Department of Economic Development, Environment and Tourism (LEDET) developed a Provincial Air Quality Management Plan (AQMP) in accordance with the NEMAQA. The main aim is to provide the Province with an implementable AQMP that complements the existing District Municipality AQMPs and comply with National requirements.

The Provincial AQMP is primarily directed at protecting air quality in the Province and ensuring the quality of air that protects human health and well-being.

The vision of the AQMP is to work towards 'clean air throughout the Limpopo Province' and the mission is to 'ensure air quality that protects human health and the environment through enhanced air quality management systems and programs.

The principal goals of the plan are to:

- Establish and maintain sustainable air quality management practices within the Province incorporating all relevant stakeholders and role players.
- Establish an effective Air Quality Management System in the Province.
- Manage and control atmospheric emissions from major sources in the Province.

Limpopo Province consist of five District Municipalities (DMs): Capricorn, Waterberg, Vhembe, Mopani and Sekhukhune.

2.7.2 Waterberg-Bonjanala National Priority Area

The Minister declared the Waterberg–Bojanala Priority Area (WBPA) on 15 June 2012 as the third National Priority Area (DEA, 2012a), crossing the North West and Limpopo provincial borders. The WBPA covers an area of 67 837 km2, bordering with Botswana.

It includes the Waterberg District Municipality (WDM) in Limpopo Province and parts of the Bojanala Platinum District Municipality (BPDM) in the North West Province, with nine Local Municipalities (see **Figure 2**).

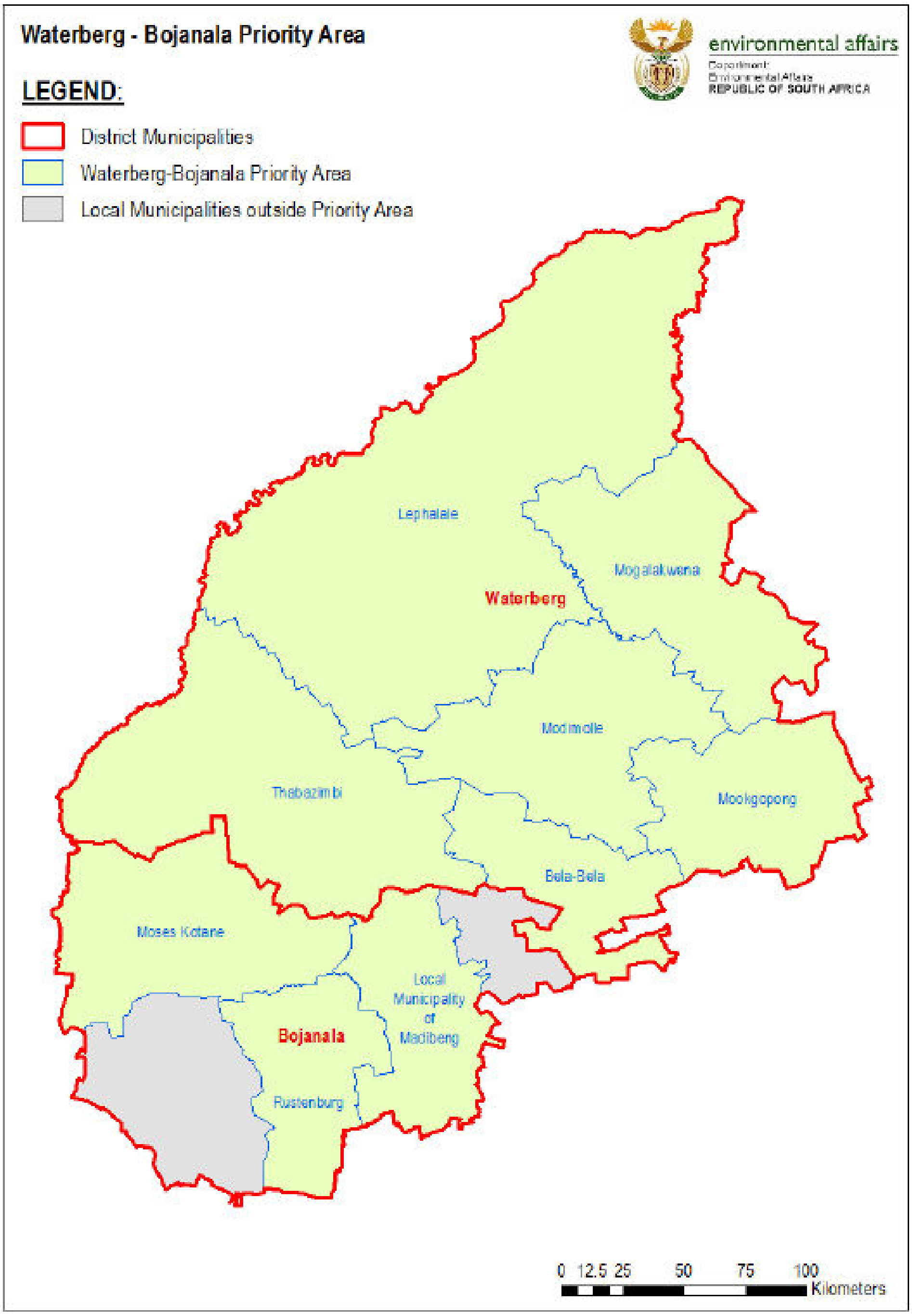

Figure 2: Locality of the Waterberg-Bonjanala National Priority Area (DFFE 2012)

The overall objective of the WBPA AQMP is to bring ambient air quality in the Waterberg Bojanala Priority Area into full compliance with national ambient air quality standards by 2020 and to maintain the state as the region develops. The objective is to be realised through the attainment of five related goals. These are:

- **Goal 1 Cooperative governance in the WBPA promotes the implementation of the AQMP:** This goal aims to address the shortcomings in cooperative governance by ensuring the appropriate structures and mechanisms are in place at the respective levels of governance for effective implementation of the AQMP.
- **Goal 2 Air quality management in the WBPA is supported by effective systems and tools:** This goal aims to improve the systems and tools required for effective air quality management in the WBPA, including emission inventories, ambient monitoring and modelling, and enforcement.
- **Goal 3 Ambient concentrations of air pollutants comply with the NAAQS in the WBPA because of emission reductions:** This goal focuses on emission control and reduction across all sectors to ensure that there is compliance with the NAAQS in the WBPA.
- **Goal 4 Air quality decision making in the WBPA is informed by sound research:** This goal aims to ensure appropriate research establishes the health baseline, which improves the Threat Assessment and prioritises emission reduction interventions to inform air quality management and planning in the WBPA.
- **Goal 5 Knowledge and the understanding of air quality amongst stakeholders in the WBPA is enhanced:** This goal aims to improve communication and current levels of knowledge of air quality amongst stakeholders in the WBPA.

2.7.3 Waterberg District Municipality Air Quality Management Plan

NEMAQA requires Municipalities to introduce AQMP that sets out what will be done to achieve the prescribed air quality standards. The Waterberg District Municipality (WDM) comprises of Bela–Bela, Lephalale, Modimolle, Mogalakwena, Mookgophong and Thabazimbi local municipalities. Mining, agriculture and tourism are the main economic activities in the District with manufacturing on a smaller scale.

The main aims of the Waterberg District Air Quality Management Plan are:

- To ensure sustainable implementation of air quality standards throughout the six Local Municipalities within the District Municipality.
- To comply with the Bill of Rights as enshrined in the Constitution of every citizen having the right to live in an environment where pollution is controlled.
- To devise methodology and processes for the monitoring of pollution parameters consistent with National, Provincial and Local norms and standards.
- To evaluate the existing air quality monitoring system in the Municipality and make recommendations for an effective air quality monitoring program.
- Reviewing the present locations of the monitoring stations taking into consideration the meteorological variables.
- Reviewing protocol for data collection, processing, quality control and assurance, interpretation and archiving reporting.
- To identify emission sources and their emissions in the District.
- Re-establishing the emission inventory in the study area by identifying sources and quantifying pollution and capturing these on the Geographic Information System (GIS).
- To identify air quality levels and set standards that are responsive to air quality levels within the area.
- Initiation the development of an air pollution dispersion modelling system.
- To ensure the provision of sustainable air quality management support and services to all stakeholders within the District.

2.8 INTERNATIONAL AIR QUALITY GUIDELINES

2.8.1 World Health Organisation Air Quality Guidelines

The WHO air quality guidelines were last published in 2006: *Air quality guidelines - global update 2005. Particulate matter, ozone, nitrogen dioxide and sulphur dioxide*. Since they were issued, air pollution has become recognised as the single biggest environmental threat to human health based on its notable contribution to disease burden. This is particularly true for PM (both $PM_{2.5}$ and PM_{10}). However, other commonly measured air pollutants such as ozone (O_3), nitrogen dioxide (NO_2),sulphur dioxide (SO_2) and carbon monoxide (CO) are also of concern, as are other components of air pollution.

The latest edition of World Health Organisation Global Air Quality Guidelines (WHO GAQGs) for ambient air pollutants was published in 2021 and included recommendations for the classical air pollutants particulate matter (PM), ozone (O_3), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

The overall objective of these guidelines is to offer quantitative health-based recommendations for air quality, expressed as long- or short-term concentrations of a number of key air pollutants. The goal of these guidelines is to provide guidance to help reduce levels of air pollutants in order to decrease the enormous worldwide health burden resulting from exposure to air pollution.

Particulate Matter

The WHO recommends an annual average for $PM_{2.5}$ of 5 $\mu g/m^3$ and a short-term, 24-hour average of 15 $\mu g/m^3$. 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 15 µg/m^3 and the 24-hour mean is 45 µg/m^3. Besides the guideline values, four annual and 24-hour interim targets (IT) are defined for $PM_{2.5}$ and PM_{10} (see **Figure 3**, **Figure 4**, **Figure 5** and **Figure 6**).

Interim targets are proposed as incremental steps in a progressive reduction of air pollution and are intended for use in areas where pollution is high.

Recommendation	$PM_{2.5}$ (µg/m^3)
Interim target 1	35
Interim target 2	25
Interim target 3	15
Interim target 4	10
AQG level	**5**

Figure 3: WHO AQGs for Annual $PM_{2.5}$

Recommendation	$PM_{2.5}$ (µg/m^3)
Interim target 1	75
Interim target 2	50
Interim target 3	37.5
Interim target 4	25
AQG level	**15**

Figure 4: WHO AQGs for Short Term (24-hour) $PM_{2.5}$

Recommendation	PM_{10} (µg/m³)
Interim target 1	70
Interim target 2	50
Interim target 3	30
Interim target 4	20
AQG level	**15**

Figure 5: WHO AQGs for Annual PM_{10}

Recommendation	PM_{10} (µg/m³)
Interim target 1	150
Interim target 2	100
Interim target 3	75
Interim target 4	50
AQG level	**45**

Figure 6: WHO AQGs for Short Term (24-hour) PM_{10}

Sulphur dioxide

The WHO AQGs stipulates 40 µg/m³ as a 24-hour mean for Sulphur Dioxide (SO_2), while the 10-minute AQG of 500 µg/m³ remains valid. Besides the guideline values, two 24-hour interim targets (IT) are defined for SO_2 (see **Figure 7**).

Recommendation	SO_2 (μg/m³)
Interim target 1	125
Interim target 2	50
AQG level	**40**

Figure 7: WHO AQGs for Annual SO_2

Nitrogen dioxide

The current annual WHO AQG for NO_2 is 10 μg/m³ and a short-term, 24-hour average of 25 μg/m³. The 1-hour AQG of 200 μg/m³ remains valid. Besides the guideline values, three annual and two 24-hour interim targets (IT) are defined.

Recommendation	NO_2 (μg/m³)
Interim target 1	40
Interim target 2	30
Interim target 3	20
AQG level	**10**

Figure 8: WHO AQGs for Annual NO_2

Recommendation	NO_2 (µg/m³)
Interim target 1	120
Interim target 2	50
AQG level	**25**

Figure 9: WHO AQGs for Short Term (24-hour) NO_2

Carbon monoxide

The current short-term, 24-hour average for CO is 4 mg/m^3, while the15 minute AQG of 100 mg/m^3, 1-hour AQG of 35 mg/m^3 and the 8-hour AQG of 10 mg/m^3 remain valid. Besides the guideline value, one 24-hour interim target (IT) is defined.

Recommendation	CO (mg/m³)
Interim target 1	7
AQG level	4

Figure 10: WHO AQGs for Annual CO

Ozone

The WHO AQG sets the value for ozone levels at 60 µg/m^3 for an 8-hour daily average. Besides the guideline value, an 8-hour interim target (IT) has been set for ozone (see **Figure 11**).

Recommendation	O_3 (µg/m³)
Interim target 1	100
Interim target 2	70
AQG level	**60**

Figure 11: WHO AQGs for Ozone

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 PROJECT DESCRIPTION

The OMMP-BRWSP bulk infrastructure plan makes provision for the construction of raw water pipeline systems. The relevant bulk pipe that would augment raw water to the Mogalakwena system is the proposed Phase 2B pipeline, the pipeline from Flag Boshielo Dam to Pruissen near Mokopane. The Mokopane WTW is located along the alignment of Phase 2B+. This phase is an extension of Phase 2B and spans from the Pruissen reservoir to Piet-se-Kop.

The Mokopane WTW will service the Mokopane Town with an ultimate capacity of 28Ml/day.

3.1 PROCESS DESCRIPTION

The selected treatment process for the Mokopane WTW is direct filtration with combined dissolved air flotation and comprises of the following principle unit processes:

- Coagulation.
- Flocculation
- Media filtration.
- Dissolved air flotation.
- Disinfection.
- Stabilisation.

Coagulation

The addition of a coagulant, which neutralises the repelling electrostatic charges between suspended particles, will allow colloidal particles to come into contact with each other, aggregating into floc particles. The coagulant will also facilitate the precipitation of natural organic matter, which will be captured into the flocs.

Flocculation

The suspension will then gently be mixed in the flocculation stage, where flocs will collide and grow into filterable flocs. The flocculation duration will be shorter and the intensity higher than for plants that incorporate a sedimentation phase, as large settleable flocs are undesirable. Smaller pin-point flocs are required, which will not blind the filters and will be captured throughout the full depth of the filter media beds.

Media Filtration

The water will be passed directly through media filtration under gravity to remove the floc particles that are in suspension. This rapid gravity sand filtration process will involve the removal of solids by attachment in a bed of filter media; usually silica sand, as is proposed for Mokopane WTW. In some instances anthracite or other media are used in combination with sand, which may be considered for future modifications to the plant.

The effective size of the sand for direct filtration is courser and the filter media bed is deeper than if sedimentation is included upstream in the process train. This will allow depth penetration of the flocs and greater storage capacity and will counter the tendency for surface blinding. The courser media will allow higher filtration rates with a more compact footprint.

The filters will have to be backwashed regularly (generally once a day), to remove the accumulated solids. The backwash water will typically be directed to backwash recovery tanks, where the solids will settle, allowing the supernatant to be recovered to the inlet of the plant. The solids will then be directed to process silt lagoons for drying.

Dissolved Air Flotation

The filters will be designed to accommodate dissolved air flotation within the filter bay. This additional process will specifically target algae removal. The process is known as dissolved air flotation/filtration.

Dissolved air flotation works by releasing air micro-bubbles into the main inlet flow to each of the filters. The micro-bubbles attach to algae cells and other floc particles, floating them to the surface forming a "float" scum. The float is relatively stable on the surface and will be removed during normal backwashing. The float will flow out with the spent backwash water.

A side-stream of treated water will be recycled through a pressure vessel (saturator), into which compressed air will be pumped. Air will dissolve into the water in the saturator. The water (known as white water) will then be injected into the main flow at the inlet to each filter, whereupon the sudden pressure drop will cause the precipitation of micro-bubbles.

Disinfection

The filtered water will be disinfected by gaseous chlorine and passed through a contact tank to allow time for the disinfectant to act before final stabilisation.

A single chlorine contact tank will provide the contact time required to achieve the log reductions in pathogens. The scale of operations at Mokopane WTW will require the use of 1 tonne liquid chlorine drums. The chlorine will be drawn from the drums as a gas via a vacuum created by a venturi system. The pumped filtered water stream passing through the venturi will draw the chlorine out of the drums and will create a high-strength chlorine solution. The vacuum-based system will reduce the chance of chlorine gas leaks.

Stabilisation

Stabilisation of the water will be achieved by the dosing of caustic soda to add alkalinity and increase pH so that the thermodynamic stability will achieve a slightly positive calcium carbonate precipitation potential (CCPP). The caustic soda will be dosed into a small mixing tank at the end of the chlorine contact tank. Depending on the prevailing raw water quality and the chemical dosing control for all chemicals, the CCPP will range from slightly negative to slightly positive (say -4 to +4 mg/ℓ as $CaCO_3$).

Caustic soda will be used not only as it meets the treatment objectives, but because of the ease of operation. The chemical can be delivered in bulk solution, stored on-site in bulk storage tanks, and will be dosed directly from the storage tanks by simple dosing pumps.

Backwash Water Recovery

Spent backwash water will be directed to a backwash water recovery plant designed to accommodate one backwash cycle per filter per day. An emergency backup will be available in case of heavy loading on the filters which will, in turn, necessitate temporarily more frequent backwashing. The backwash water recovery plant will consist of three adjacent batch-type recovery tanks, each sized to accommodate the volume of water from one backwash cycle, a shared supernatant pump sump, as well as a shared supernatant recycle pump station.

Once a recovery tank will be filled from a backwash, an adjustable period of time will be allowed for the solids to settle, where after the supernatant will be drawn from the top of the tank and pumped back to the head of the works. The design of the system will be such that the return of supernatant from successive backwash cycles will spread as evenly as possible over the day, so that the loading on the WTW is kept relatively stable and coagulation dosing requirements will be controlled. The decanting of the supernatant from the recovery tank will be limited by a hydraulic level and may be stopped if the operator notes elevated turbidity in the recycle line.

After the supernatant will be decanted from a recovery tank, the settled "process residual" remaining in the tank will be drained to residual drying lagoons.

Lagoons

At the end of each backwash water recovery cycle, the settled process silt from the recovery tank will be discharged under gravity to a series of four residual lagoons. One of the lagoons will be used for a period of approximately six months, where after it will be isolated for dry out. Thereafter the dried solids will be removed and disposed of off-site.

The process flow diagram for the Mokopane WTW is included in **Figure 11**.

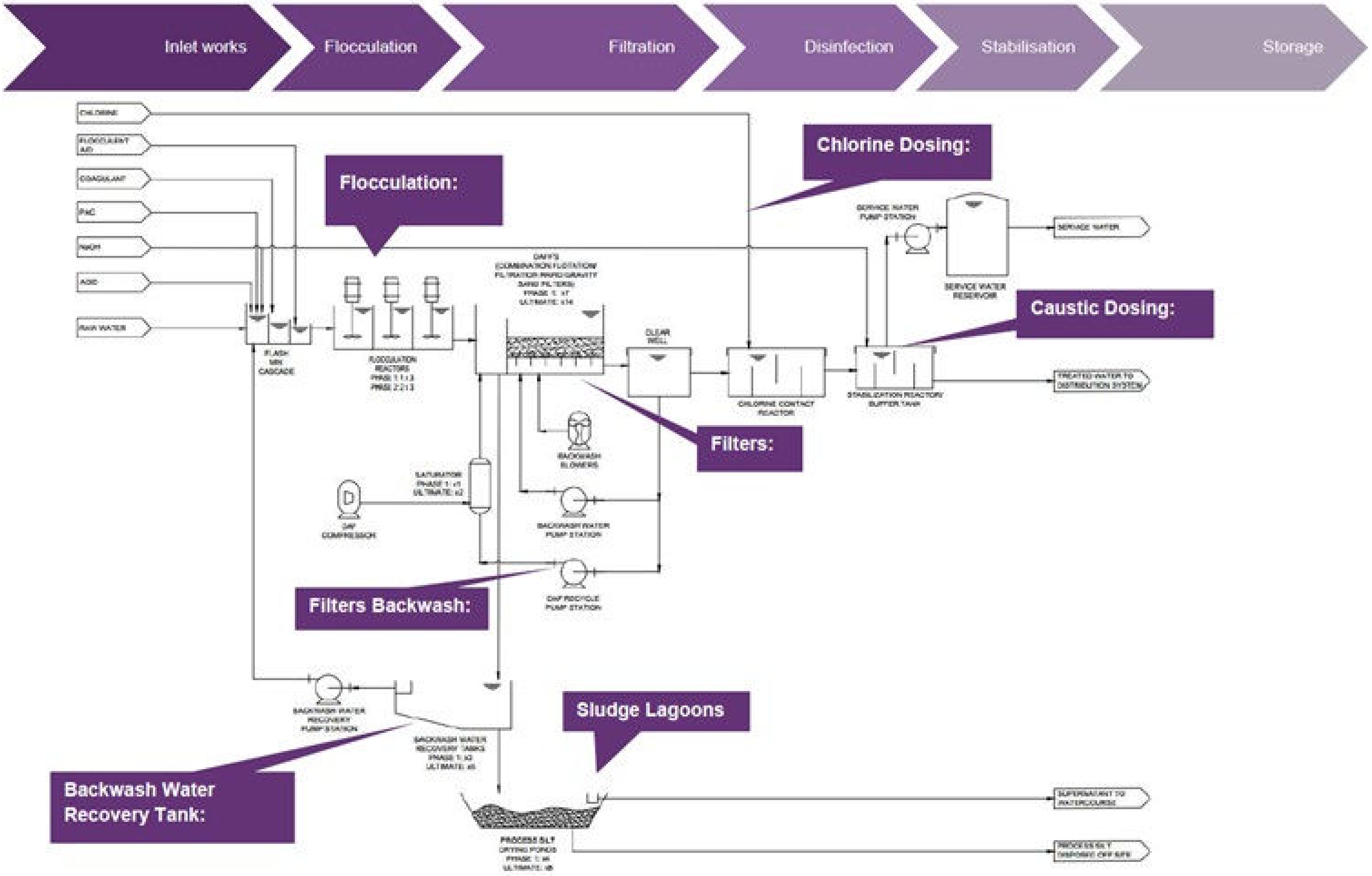

Figure 12: Mokopane WTW Process Flow Diagram

3.3 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 result 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 on 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 Process Emissions

In the initial stages of water treatment, hydrogen sulphide might be stripped from raw water by aeration. Non-routine or accidental releases to air may occur. Chlorine and ammonia are the most likely substances to be lost fugitively to air from water treatment.

Water treatment processes vary considerably and some additional substances may be emitted in very small quantities. Releases from storage and handling of treatment chemicals could occur, but normally such flows would be negligible. For the majority of water treatment facilities fugitive emissions are most likely to emanate from disinfection stages in the treatment process.

3.2.3 Vehicle Transport Emissions

Particulate emissions occur whenever vehicles travel over a paved surface such as a road or parking area. Particulate emissions from paved roads are due to direct emissions from vehicles in the form of exhaust, brake wear and tire wear emissions and resuspension of loose material on the road surface. In general terms, re-suspended particulate emissions from paved roads originate from, and result in the depletion of, the loose material present on the surface (i.e., the surface loading). In turn, that surface loading is continuously replenished by other sources. At industrial sites, surface loading is replenished by spillage of material and track-out from unpaved roads and staging areas.

In the absence of continuous addition of fresh material, paved road surface loading should reach an equilibrium value in which the amount of material re-suspended matches the amount replenished. The equilibrium surface loading value depends upon numerous factors. The most important factors are mean speed of vehicles traveling on site; the average daily traffic volume, the fraction of heavy vehicles and the presence/absence of curbs, storm sewers and marshalling areas.

3.3 EMISSION FACTORS

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* and the National Pollution Inventory *Emission Estimation Technique Manual.*

Table 3 summarises emission factors, **Table 4** includes the emission rates for the Mokopane WTW. The emission parameters are included in **Table 5**.

Table 3: Mokopane WTW Emission Factors

Activity	Emission unit	TSP Emission Factor	PM_{10} Emission Factor	$PM_{2.5}$ Emission Factor	Cl Emission Factor
A. Construction/Rehabilitation					
1. Fugitive emissions	Mg/hectare/month	2.69E+00	1.40E+00	1.35E-01	-
B. Operations					
2. Delivery of liquid chemicals	kg/VKT	1.10E+00	2.11E-01	5.11E-02	-
3. Delivery of dry chemicals and chlorine gas	kg/VKT	3.36E-01	6.44E-02	1.56E-02	-
4. Disinfection with chlorine gas	mg/L	-	-	-	6.00E-01
5. Removal of dried lagoon solids with front-end loader	kg/Mg	1.59E-02	3.02E-03	7.64E-05	-
6. Dump truck transport of dried lagoon solids	kg/VKT	1.70E+00	4.24E-01	4.24E-02	-
C. Auxiliary Services					
7. Light vehicle traffic	kg/VKT	3.94E-02	1.83E-03	1.83E-03	-

Notes:

1: US EPA, AP42, Volume I, 5 Edition, Chapter 13.2.3 Heavy Construction Operations.
2: US EPA, AP42, Volume I, 5 Edition Chapter 13.2.1. Paved Roads.
3: US EPA, AP42, Volume I, 5 Edition Chapter 13.2.1. Paved Roads.
4: Australian Government Department of Environment, Water, Heritage and the Arts. National Pollutant Inventory Emission Estimation Technique Manual for Potable Water Treatment. Version 2.0.
5: US EPA, AP42, Volume I, 5 Edition, Chapter 11.9 Western Surface Coal Mining. Truck loading front-end loader. US EPA Appendix B.2 Generalized Particle Size Distributions, Category 3 Mechanically Generated, Aggregate, Unprocessed Ores, PM10 and PM2.5.
6: US EPA, AP42, Volume I, 5 Edition Chapter 13.2.1. Paved Roads.
7: US EPA, AP42, Volume I, 5 Edition Chapter 13.2.1. Paved Roads.

Table 4: Mokopane WTW Emission Rates

Activity	Emission rate				Totals	
	TSP	PM_{10}	$PM_{2.5}$	Cl		
A. Construction/Rehabilitation						
1. Fugitive emissions	1.74E+00	9.06E-01	8.70E-02	-	2.73E+00	-
B. Operations						
2. Delivery of liquid chemicals (3 deliveries per month)	5.57E-02	1.07E-02	2.59E-03	-	6.90E-02	23.82%
3. Delivery of dry chemicals and chlorine gas (2 deliveries per month)	1.13E-02	2.18E-03	5.27E-04	-	1.40E-02	4.85%
4. Disinfection with chlorine gas	-	-	-	1.94E-01	1.94E-01	67.10%
5. Removal of dried lagoon solids with front-end loader (2 removals per annum)	1.64E-05	3.11E-06	7.88E-08	-	1.96E-05	0.01%
6. Dump truck transport of dried lagoon solids	5.27E-03	1.31E-03	1.31E-04	-	6.71E-03	2.32%
C. Auxiliary Services						
7. Light vehicle traffic (3 vehicles)	5.06E-03	2.35E-04	2.35E-04	-	5.53E-03	1.91%
Annual Total	**7.74E-02**	**1.44E-02**	**3.48E-03**	**1.94E-01**	**0.29**	**100%**
	26.72%	**4.98%**	**1.20%**	**67.10%**		

Table 5: Mokopane WTW Emission Parameters

Activity	Unit	Value
Construction/Rehabilitation Footprint	hectare	6.80
TSP Particle Size Multiplier for Paved Road Equation	unitless	3.23
PM10 Particle Size Multiplier for Paved Road Equation	unitless	0.62
PM2.5 Particle Size Multiplier for Paved Road Equation	unitless	0.15
Paved surfaces silt loading	percent	9.70
Unpaved surfaces silt loading	percent	4.30
Liquid chemical transport vehicle weight	tonnes	40.00
Dry chemical and chlorine gas transport vehicle weight	tonnes	12.50
Articulated truck weight	tonnes	23.52
LDV weight	tonnes	1.53
Paved delivery traffic (return)	kilometres/trip	3.70
Unpaved waste export traffic (return)	kilometres/trip	2.40
Paved light vehicle traffic (return)	kilometres/day	3.70
Articulated truck payload	tonnes	24.00
Water treatment capacity	megalitres/day	28.00
Lagoon solids density (after drying)	percent	20.00
Lagoon dried solids removed	kilogram	40680.00
Lagoon dried solids removed	tonnes	40.68
Operating days per annum	days	365.00
Days per month	days	30.00
Operating hours per annum	hours	8760.00
Operating hours per month	hours	730.00
Operating seconds per year	seconds	31536000.00

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 Mokopane. 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.

The winds in the northern WBPA show a predominant easterly tendency and the winds are light and generally under 6 m/s. Over the central parts of the WBPA, at Thabazimbi and Mokopane, winds are predominantly northerly, with occasional north westerly winds. Again, all winds are light and rarely exceed 6 m/s. This predominant northerly wind is also evident at Bela-Bela, the eastern edge of the WBPA. There are several monitoring stations in the southern part of the WBPA, in the area between Brits and Rustenburg. In this part of the WBPA, the winds are more varied, but rarely blow from the west. Northerly to north westerly winds are common, as are winds from the south to southeast. Easterly winds also occur in the southern WBPA.

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.

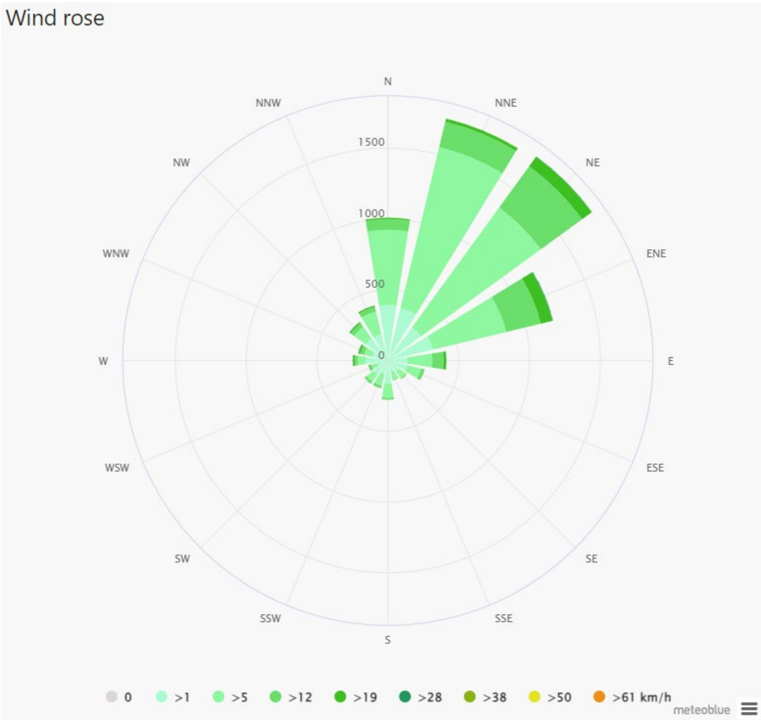

Figure 13: Mokopane Wind Rose for the Period 1992 – 2022

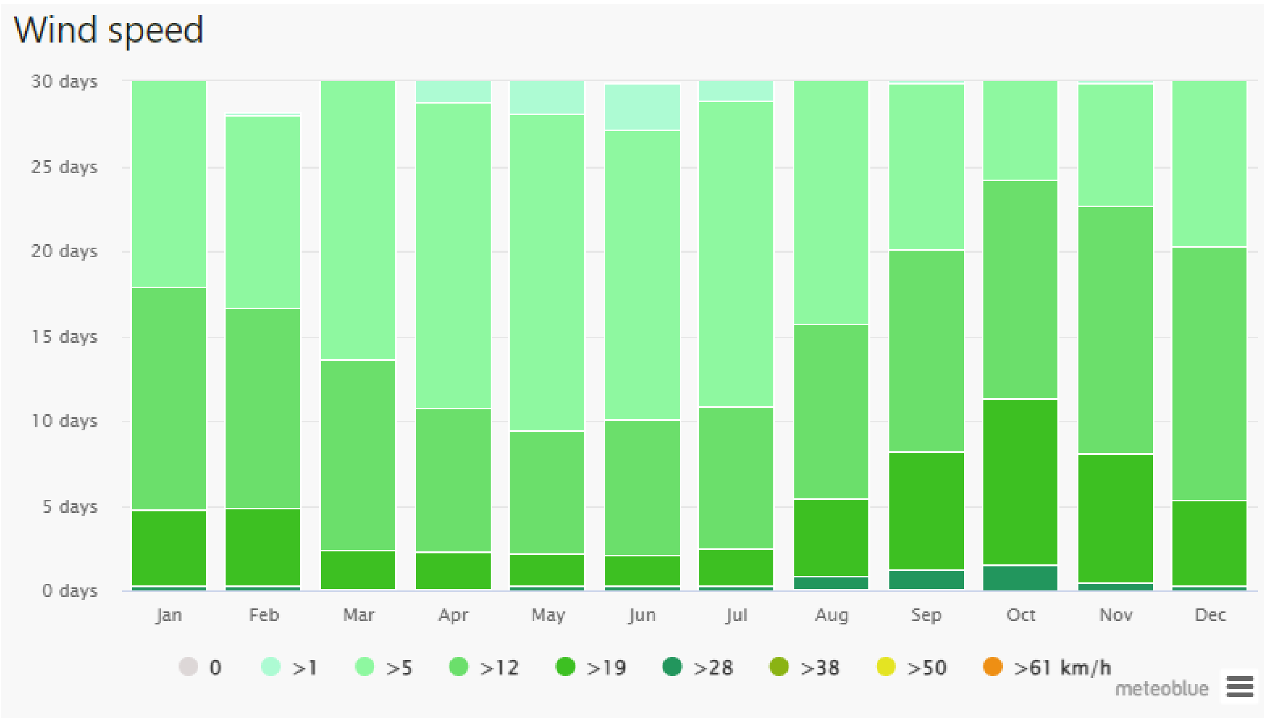

Figure 14: Mokopane Average Wind Speed for the period 1992 – 2022

Atmospheric processes at meso-scale were considered in the characterisation of the atmospheric dispersion potential of the study area. For on-site data, hourly average Unified Model (UM) surface model data supplied by Meteoblue was used. 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.

Ground level concentrations were predicted for atmospheric conditions based on local meteorological data for the period 1 July 2022 to 30 June 2023. For the period, winds were mostly from the north easterly sector 60.47%. Calm periods were the exception (1.2%) and wind speeds were most often brisk above 3.6m/s (42.4%). Moderate winds between 2.1 and 3.6m/s occurred 37.6% and light winds, between 0.5 and 2.1m/s 18.6%.

Period, diurnal, and seasonal wind roses are presented in **Figure 15** to **Figure 22**.

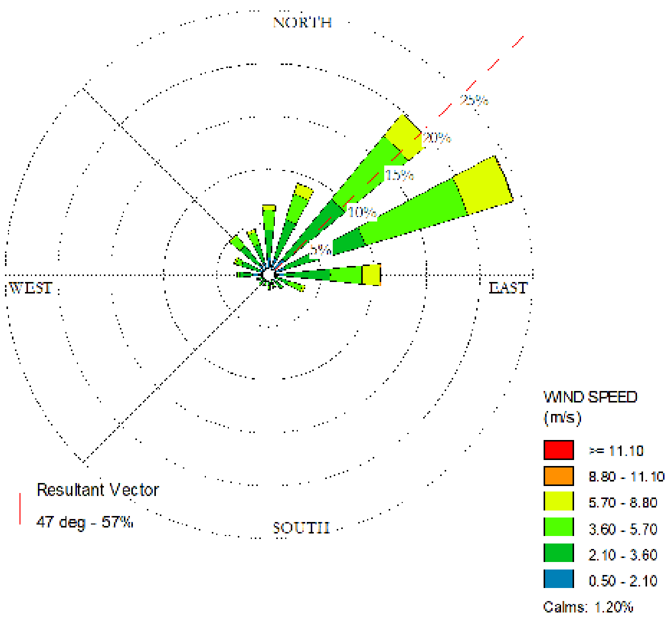

Figure 15: Mokopane - Period Wind Rose

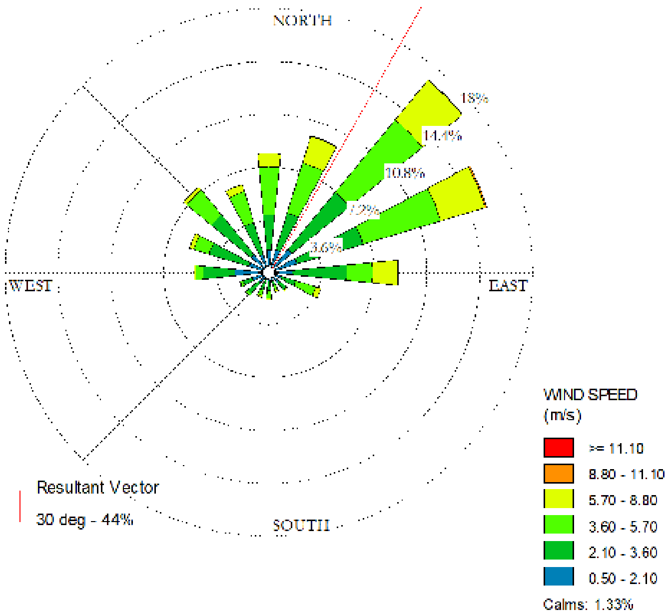

Figure 16: Mokopane - Day-time Wind Rose

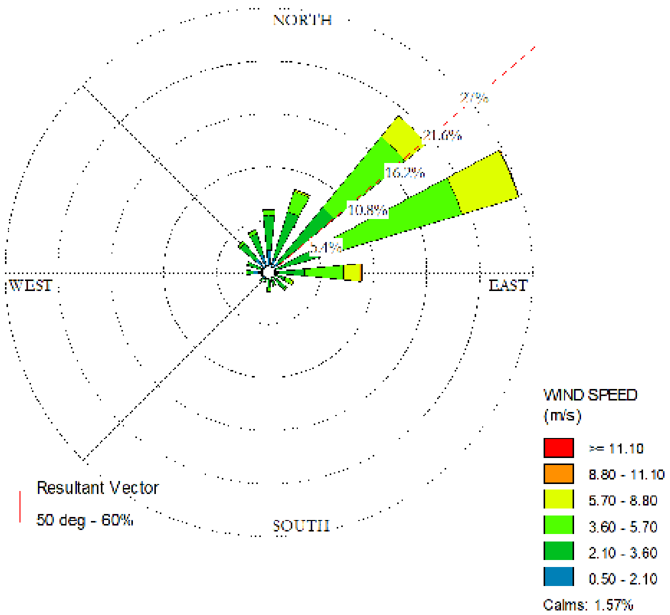

Figure 17: Mokopane - Evening Wind Rose

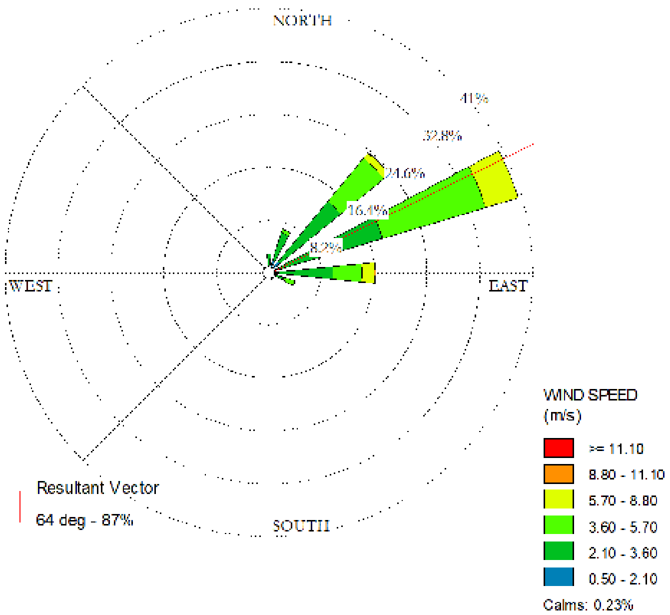

Figure 18: Mokopane - Night-time Wind Rose

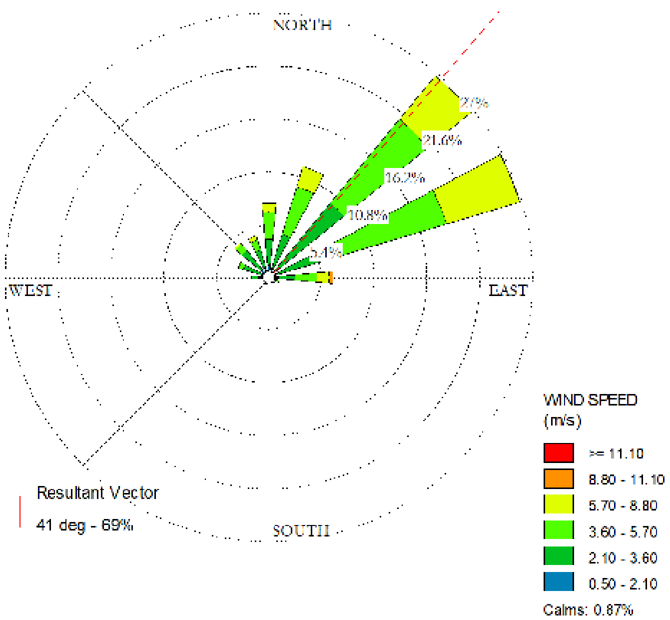

Figure 19: Mokopane - Spring Wind Rose

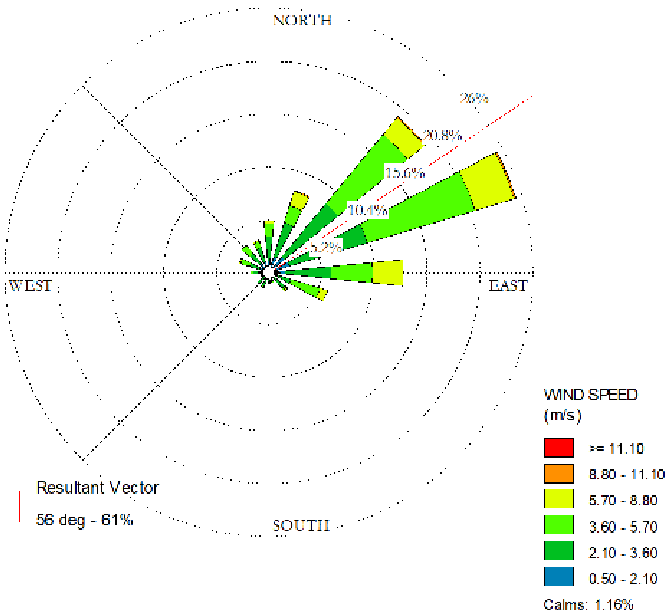

Figure 20: Mokopane - Summer Wind Rose

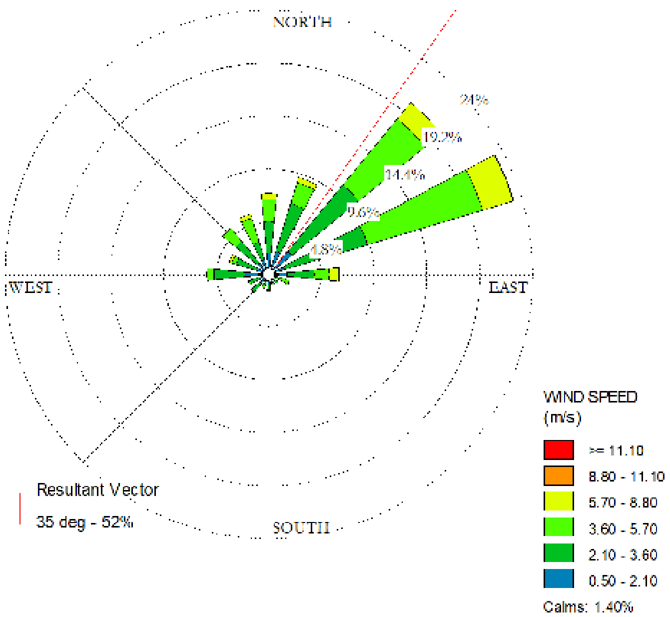

Figure 21: Mokopane - Autumn Wind Rose

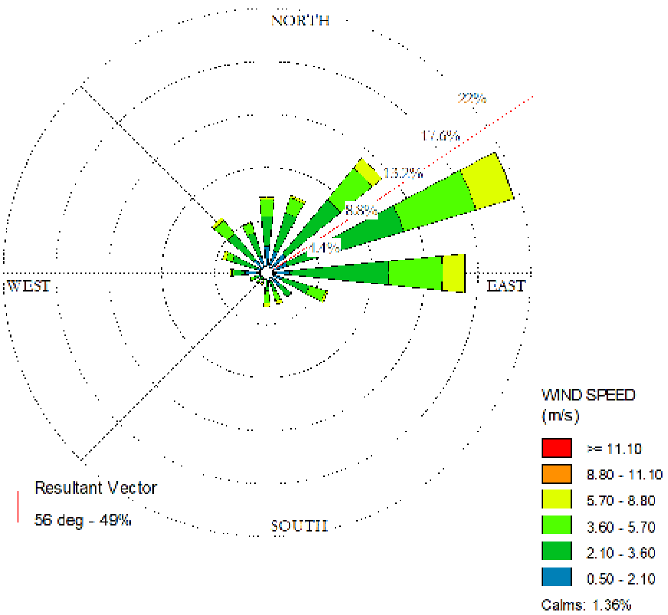

Figure 22: Mokopane - Winter Wind Rose

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.

The WBPA experiences a temperate climate. Winters are generally mild and dry, but cold at night. Summers are hot, but mild at night. The western and northern parts of the WBPA are generally warmer than the eastern and southern parts and receive less rainfall. The annual average maximum temperature increases from 26.4°C at Rustenburg in the south to 27.9°C at Thabazimbi and 29.1°C further north at Lephalale.

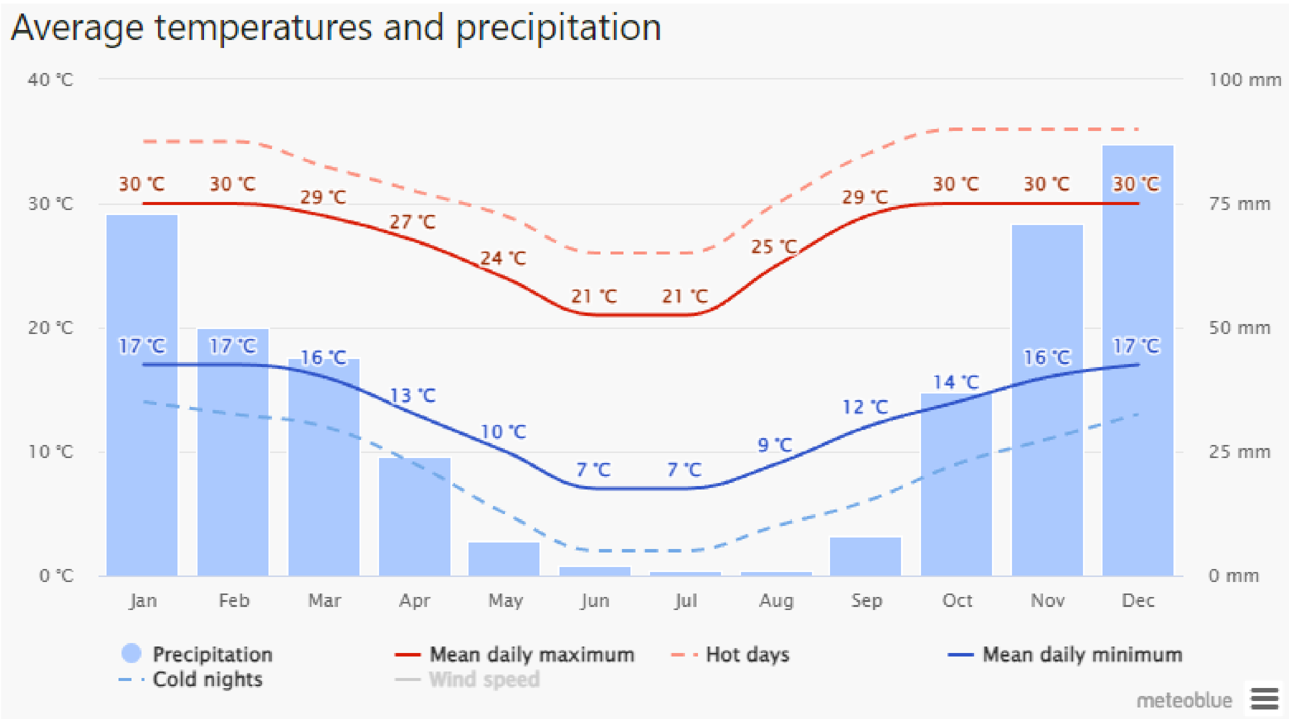

Figure 23: Mokopane Average Temperature and Precipitation for the Period 1992 – 2023

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).

Rainfall occurs almost exclusively in summer in the form of convective showers or thundershowers because of low-pressure troughs over the central plateau. As the WBPA is a very large area, the climate varies across the region. The northern and western parts of the WBPA receive less rainfall than the southern and eastern parts. Annual average rainfall varies from 435 mm at Lephalale in the north to 574 mm at Thabazimbi, and 633 mm at Bela-Bela in the east and 680 mm at Rustenburg in the south of the WBPA.

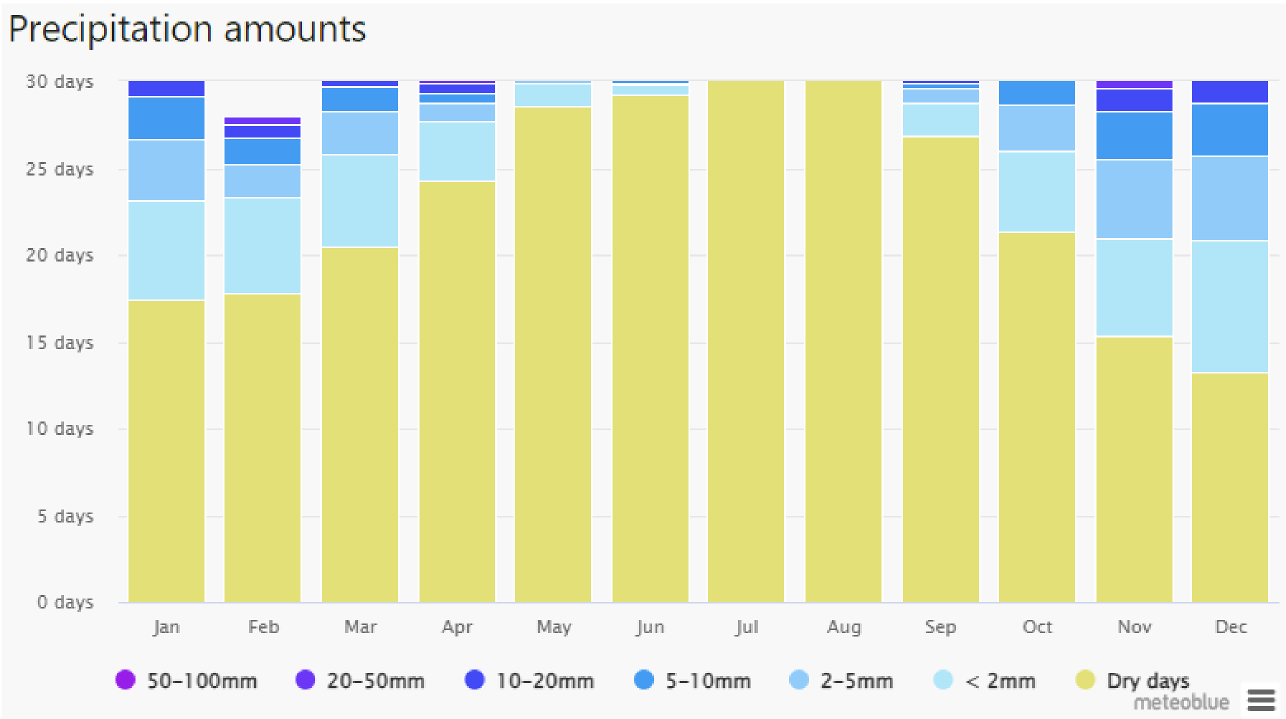

Figure 24: Mokopane Average Monthly Rainfall for the Period 1992 – 2022

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 6**. 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 6: 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 experienced less than 5 days per month (see **Figure 25**).

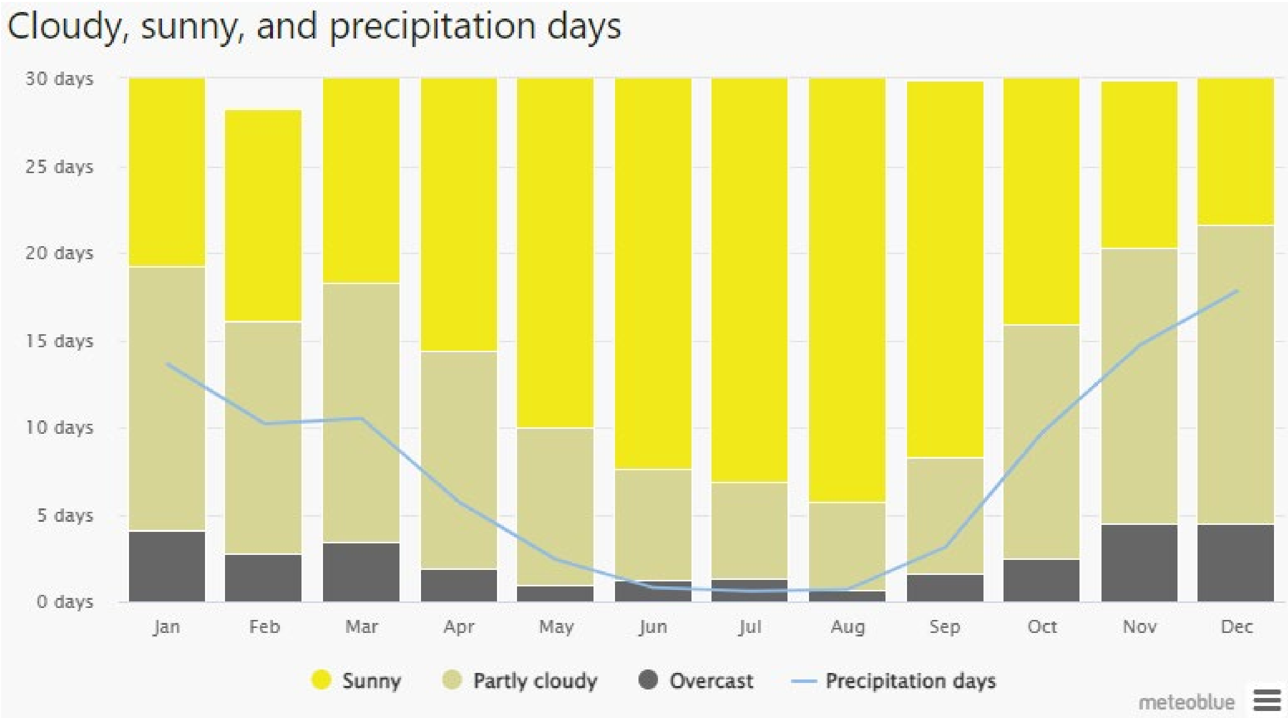

Figure 25: Mokopane Cloud Cover and Precipitation Days for the Period 1992 – 2022

3.5 TOPOGRAPHY AND LAND USE

The simplified geology of the Waterberg District can be classified into five distinct geology types, namely the Transvaal Super Group, Karoo Super Group, Waterberg Group, Bushveld Igneous Complex, and the Archaean Granite/Gneiss and Swazian Complex. The Karoo Super Group contains coal deposits while Bushveld Igneous Complex harbours important sources of platinum and chromium. The Waterberg Group contains no minerals of economic value. The Transvaal Super Group has iron ore deposits.

The landscape of the Waterberg District is a unique feature that distinguishes it from any other place in South Africa. There are four main landscape features in the Waterberg District, namely the Waterberg Plateau, the Transvaal Plateau Basin, the Pietersburg Plain and the Limpopo Depression.

Prominent economic activities include mining, agriculture and tourism. The mining industry is a major contributor to economic development and the district is the largest platinum production area in the Limpopo Province. Coal mining and petroleum development in Lephalale has also increased. The coal resource in the Waterberg field is estimated at 76 billion tonnes, which is more than 40% of the national coal reserve. There is also the manufacture of cement and mining for iron in the municipal area.

Figure 26: Local Municipalities of the Waterberg District Municipality

The Waterberg area hosts 70% of the Limpopo Province's platinum reserves. The platinum mining activity is concentrated at Mogalakwena and Thabazimbi. South Africa's largest opencast coal mine is found in Lephalale, and currently the Matimba Power Station is the largest dry-cooled power station in the world. Bela-Bela, Modimolle and Mookgophong are associated with mixed dryland agricultural activities.

The topography of the Mokopane WTW preferred site ranges from 1145m to 1155m Above Mean Sea Level (AMSL), while the alternative site ranges from1290m to 1270m AMSL.

SRTM1/SRTM3 digital elevation model data was incorporated into the study using the appropriate terrain pre-processing options provided by AERMOD.

3.6 POLLUTION SOURCES AND RECEPTORS

3.6.1 Pollution Sources

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.

Air pollutants are traditionally classified into suspended particulate matter (dusts, fumes, mists and smokes), gaseous pollutants (gases and vapours) and odours.

Limpopo Province Air Quality

The source groups per District Municipality for the Limpopo Province include industry, domestic fuel burning and mining, with differences in contribution by each source across the Districts. Other sources within the Province contributing to air pollution include domestic fuel burning, vehicle tailpipe emissions, and biomass burning.

The main sources of SO_2 and NOx within the Limpopo Province are the power generation sources within the Waterberg District Municipality. Small boilers, followed by mining operations (both coal and metallurgical), are the main contributing sources to total suspended particulate matter (TSP) with boilers (assuming all TSP to be PM_{10}) the main source of PM_{10}. Wood processing is the second most significant source of PM_{10}. The main contributor within the Province to fine particulate matter ($PM_{2.5}$) and CO is biomass burning. Vehicle tailpipe emissions are the main source of hydrocarbons specifically within the Districts of Waterberg, Capricorn and Vhembe. VOCs show to be primarily from wood treatment works and these are mainly restricted to Mopani District Municipality. Small boilers, where quantified, also indicated to be potential significant sources of CO_2.

Four "hot-spot" areas were selected for dispersion modelling based on the current understanding of the air quality within the Province, the location of significant sources as well as available emissions data.

These are:

- **Polokwane region**: a region with a high number of sources and no up-to-date ambient air quality data to determine the current state of air.
- **Lephalale region**: the only region within the Province with power stations and large-scale coal mining activities.
- **Phalaborwa region**: the only area with fertiliser manufacturing, a copper smelter and large opencast mining operations.
- **Steelpoort Valley**: an area with significant number of mining activities.

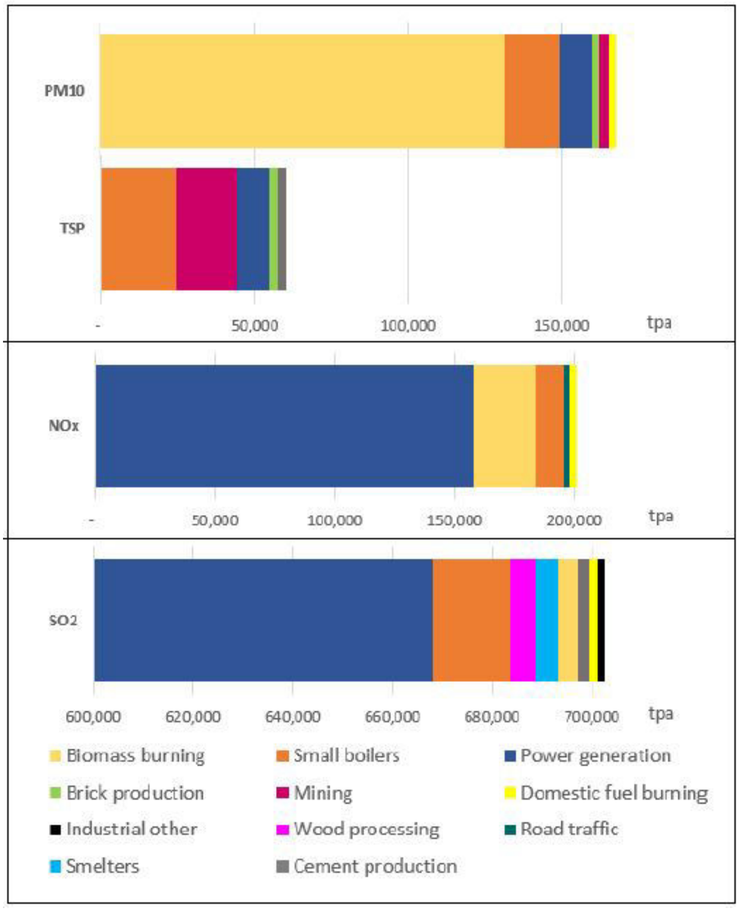

Figure 27: Limpopo Province Emission Per Source Group

Some of the concerns identified were:

- The predicted impacts within the Polokwane area are mainly localised.
- The area around Lephalale is of concern, due to the planned development rather than the current situation. Current Ground Level Concentrations (GLCs) PM_{10} are however a concern around the opencast mines in the area where it is predicted to exceed standards at nearby settlements.
- The main area of concern is around Phalaborwa due to very high SO_2 concentrations impacting the town.
- The Steelpoort area due to the numerous mining operations within proximity to villages and homesteads resulting in high PM_{10} GLCs.

Table 7: Predicted Impact at the Four "Hot-spot" Areas within the Limpopo Province.

Identified Areas	Main Pollutant	Main Sources of Concern	Significance
Polokwane	PM_{10}	Brickworks and asphalt plants	Medium
	SO_2	Smelters	Medium
Lephalale	PM_{10}	Mining operations	High
	SO_2	Power plants	Medium
Phalaborwa	PM_{10}	Mining operations	Medium
	SO_2	Smelter and fertiliser production	High
Steelpoort	PM_{10}	Mining operations	High

All source groups were ranked in order of significance employing a typical Environmental Impact Assessment significance ranking methodology.

The significance ranking for the areas of concern showed the following:

- Wood processing, mainly based on the number of activities, was ranked first in Mopani and in Vhembe. There are, however, far more wood processing activities in Mopani than in Vhembe.
- The smelting and fertiliser operations at Phalaborwa, even though both ranked fourth, are significant impacting sources.
- Mining resulted in a significant source at Sekhukhune and Waterberg DMs. At Waterberg DM the main concern is around the coal mining operations and at Sekhukhune it is around the numerous platinum mines within the Steelpoort Valley area.
- Brickworks and other industrial sources were flagged as significant contributing emission sources in the Capricorn DM.

Table 8: Ranked Significance of Source Groups in Each District Municipality

Source Group	Capricorn	Mopani	Sekhukhune	Vhembe	Waterberg
Brick production	1	3	-	3	2
Cement industry	3	-	-	-	5
Fertiliser	-	4	3	-	-
Fuel depot	-	7	5	-	-
Incinerators	-	-	-	-	-
Industrial stockpiles	7	-	-	-	-
Industrial other	1	6	4	4	3
Mining	3	2	1	2	1
Power generation	-	-	-	-	4
Small boilers	-	-	-	-	-
Smelter	5	4	2	-	-
Wood processing	6	1	-	1	-

Notes:
Ranking based on number of sources of each type and the total impact score.

The 2007 National Framework lists District and Metropolitan Municipalities where the ambient air is regarded as poor or potentially poor. For Limpopo Province, the ambient air in the Capricorn, Mopani and Waterberg District Municipalities are listed as "potentially poor" with the definition as "air quality poor at times or deteriorating".

The National Framework describes, *inter alia*, the implementation of ambient air quality standards. In this discussion five zones of control are described, each summarised briefly below.

Green Zone: Class 1 Air Quality Area: The areas where ambient air quality remains within Target Levels and no substantive corrective air quality management interventions are required other than basic good air quality governance.

Target Levels – The ambient air quality targets for South Africa that provide an adequate "development buffer" between air that is harmful and air that is not harmful to health and well-being. Target levels are likely to be set at 80% of the National ambient air quality standards.

Blue Zone: Class 2 Air Quality Area: The areas where ambient air quality remains within Alert Levels, but "pre-emptive" air quality management interventions are required other than basic good air quality governance.

Alert Levels – will be the levels of ambient air quality where "pre-emptive" governance interventions are triggered that provide an adequate "intervention development buffer" between air that is harmful and air that is not harmful to health and well-being. Alert levels are likely to be set at 90% of the National ambient air quality standards.

Purple Zone: Class 3 Air Quality Area: The areas where ambient air quality remains within the standards, but sustained air quality management interventions are required to, at least, maintain or improve this situation.

The Ambient Air Quality Standards will be the levels of ambient air quality where immediate governance interventions are triggered with the aim of, at least, bringing the area into compliance with the standard. This standard is the boundary between air that is potentially harmful and air that is not harmful to health and well-being.

Orange Zone: Class 4 Air Quality Area: The areas where ambient air quality represents a possible threat to health and well-being and requires immediate and sustained air quality management interventions to, at least, bring the area into compliance with the standards within agreed time frames.

In order for Government to prioritise efficient and effective air quality interventions, although immediate interventions are required, Class 4 Air Quality Areas need not necessarily be declared as priority areas in terms of the AQA.

Red Zone: Class 5 Air Quality Area: The areas where ambient air quality represents a possible threat to health and well-being and requires immediate and sustained air quality management interventions to, at least, bring the area into compliance with the standards within agreed time frames. Class 5 Air Quality Areas must immediately be declared National or Provincial priority areas in terms of the AQA.

Dispersion modelling carried out as part of the baseline assessment indicated that ambient air quality standards of PM_{10} and SO_2 may be exceeded from time-to-time near Lephalale, Phalaborwa and in the Steelpoort Valley. This implies a potential of Zones 3 or 4 being approached, requiring action by Air Quality Officers. However, as no substantive air quality measurements have been conducted in these areas, other than SO_2 by Palabora Copper, it is suggested that insufficient information exists to indicate which of the two air quality control zones is applicable. It was recommended, therefore, that current monitoring requirements are aimed at a Zone 3 (purple zone) level in those regions. Until better information becomes available, it was recommended that a Zone 2 classification be given to the other areas in the Province.

Waterberg District Municipality Air Quality

The emission summary for the WBPA shows the dominant sectors with regards to the major pollutants considered in the assessment. SO_2 is primarily sourced from industry in the area, with 99.9% of total emissions generated by this sector. Minimal SO_2 contributions are observed from motor vehicles and the residential sectors. Total SO_2 emissions for the priority area are estimated at almost 397 000 tonnes per annum. For NO_x, the industrial contribution to the overall pollutant load is 87%, and the contribution from motor vehicles is 13%. Total WBPA NO_x emissions are estimated at approximately 87 000 tonnes per annum. For PM_{10}, mining contributes the greatest proportion of emissions, approximately 60 000 tonnes per annum, and over 70% of total emissions. Industry contributions are lower but still significant at 27%. Total priority area PM_{10} emissions are estimated at approximately 83 000 tonnes per annum.

Table 9: Total Emissions from WBPA.

Sources	SO_2	%	NO_x	%	CO	%	PM_{10}	%
Industry	393 815	99.9	74 671	86.3	39 309	85.7	19 425	24.2
Mining	-	-	-	-	-	-	59 488	74.2
Residential	21	< 0.1	59	< 0.1	-	-	306	0.4
Motor vehicles	317	< 0.1	11 608	13.4	-	-	435	0.5
Biomass	-	-	202	< 0.1	6 560	14.3	545	0.7
Total	**394 153**		**86 540**		**45 869**		**80 199**	

Notes:
Emissions : Tonnes/annum

An emissions inventory for the Waterberg District was compiled for air pollution sources where information was available or where emission factors could be applied to quantify emissions.

Potential air pollution sources in the Waterberg District have been identified as:

- Power generation – Matimba Power Station is the main source of SO_2 emissions in Lephalale. The new Medupi Power Station will also be a significant source of SO_2 emissions.
- Mining – mainly fugitive dust emissions from mining activities.
- Industrial emissions – mainly emissions from small boiler sources and brickworks in the District. These sources contribute to PM_{10} and SO_2 concentrations.
- Domestic fuel burning – mainly coal and paraffin burning in informal settlements such as Mahwelereng (Mogalakwena), Marapong (Lephalale) and Regorogile and Ipeleng (Thabazimbi).
- Vehicle emissions – from petrol and diesel vehicles along major roads and the N1 highway in the District. Vehicles are not considered to be a significant air pollution source in the District.
- Agricultural activities – although not quantified, agricultural activities are an important source of ambient particulate concentrations.

- Thabazimbi Local Municipality is the main contributor to agricultural activities in the District, contributing to almost 40% of the District's GDP.
- Biomass burning – also not quantified due to the irregular and seasonal nature of this source, but also considered to be an important contributor to ambient particulate concentrations, particularly during the fire-burning season.
- Waste Treatment and Disposal - there are seven licensed disposal facilities (landfills) in the Waterberg District for the disposal of general waste. Incineration occurs on a small scale in the District with medical waste from hospitals and clinics outsourced to Tshumisano Waste Management.
- Vehicle entrainment of dust from paved and unpaved roads - was not quantified as part of the AQMP.
- Other fugitive dust sources such as wind erosion of exposed areas – was not quantified as part of the AQMP.

Particulate and gaseous emissions from industrial operations, domestic fuel burning, and vehicle tailpipe emissions were quantified as part of the AQMP development process, due to the availability of data for these sources. Power generation was identified to be the main contributing source to PM_{10} emissions (68%) in the District, although this is likely to have been overestimated as many mines did not provide their emissions data, and therefore, were not possible to quantify. With the quantification of all mines in the District, mining sources are likely to be the main contributor to PM_{10} emissions in the District. Power generation is the main contributing source to SO_2 and NO_2 emissions in the District, contributing to 95% and 93% respectively.

Based on the available ambient air quality monitoring data and the emissions inventory compiled for the District, air pollution 'hotspots' were identified in the District. Emphasis was placed on areas with high population densities and the spatial distribution of sources in relation to residential areas. Based on the fore mentioned criteria, these areas have been identified to be:

- Lephalale (Lephalale Local Municipality) – One of the largest industrial sources, Matimba Power Station, is in this Municipality. Future developments such as Medupi Power Station and Sasol's Coal-To-Liquids Plant will make this an important industrial area in future years.

- Thabazimbi and Northam (Thabazimbi Local Municipality) – This Local Municipality includes many of the larger opencast mines such as Thabazimbi Mine, Amandelbult Platinum Mine and Northam Platinum.

3.6.4 Pollution Receptors

Receptors are sites (or areas) which may potentially be impacted by the process or activity. In this study, receptors were selected on the basis of available topographical data and mainly comprise of commercial, municipal services, mining and agricultural processes and residential developments up to a distance of 5km from the water treatment works.

Table 10 and **Figure 28** provides a summary of the closest receptors associated with Mokopane WTW.

Table 10: Mokopane WTW Receptors

Description	Distance from the centre of the site
R1 – Residential Lat -24.195331°, Lon 29.045679°	0.3 kilometres north-east
R2 – Residential Lat -24.210211°, Lon 29.042226°	1.6 kilometres south
R3 – Municipal Services Lat -24.197636°, Lon 29.035319°	1.8 kilometres south-west
R4 – Commercial Lat -24.207403°, Lon 29.029192	0.6 kilometres south-west
R5 – Industrial/Commercial Lat -24.204424°, Lon 29.021313°	2.3 kilometres south-west
R6 – Residential Lat -24.192037°, Lon 29.027484°	1.5 kilometres north-west

Figure 28: Mokopane WTW Closest Receptors

3.7 WATERBERG-BONJANALA NATIONAL 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.

The WBPA area was declared in anticipation of the development of air quality problems associated with the development of the Waterberg coal fields. Three monitoring stations were established in Lephalale, Thabazimbi and Mokopane. The monitoring stations measure the concentrations of PM_{10}, $PM_{2.5}$, SO_2, NOx, CO, O_3, BTEX and meteorological parameters.

The initial analysis indicates that the area may already be facing air quality problems, prior to the initiation of the major planned developments in the area. The continued operation of these ambient air quality monitoring stations will be vital in assessing the pollutant concentrations in the area and monitoring how the pollutant levels change with the implementation of the planned developments.

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. Monitoring data from the Mokopane station as included in this study. Local source regions for PM_{10}, $PM_{2.5}$, SO_2, NOx, CO, and O_3 were identified and trends discussed.

3.7.1 Particulate Matter

The average PM_{10} concentration at the three Waterberg stations for the period October 2012 to April 2015 was 52µg/m^3 for Thabazimbi, 40.6µg/m^3 for Mokopane and 26µg/m^3 for Lephalale (**Table 11**). The 90th percentile for the Thabazimbi and Mokopane stations is higher than 100µg/m^3. The average PM_{10} concentration over the 2.5-year measurement period (October 2012 to April 2015) is greater than the annual PM_{10} standard (40µg/m^3).

Table 11: WBPA PM_{10} Measurement Summary (in µg/m^3).

Parameter	Lephalale	Mokopane	Thabazimbi
Number of measurements	20739	19608	15027
% Recovery	92.68%	84.8%	67.2%
Mean	26.04	40.64	52.31
Median	19.11	26.93	30.93
10 percentile	5.94	8.60	8.01
25 percentile	11.03	14.88	16.52
75 percentile	32.95	50.64	59.46
90 percentile	53.37	87.48	115.62

When the relation between the PM_{10} concentrations and the wind speed and wind direction are considered the periods of highest PM_{10} concentration correspond to periods of high wind speed, typically greater than 6m/s. These are periods when the high PM_{10} concentrations are likely to be attributable to the generation of windblown dust.

The trend in the PM_{10} concentrations seems to be decreasing in all three sites where there is a decrease in the PM_{10} concentration of between 4.5 and 6.5 μg/m^3/year. This, however, is only statistically significant at the Lephalale site ($p<0.01$).

The PM_{10} concentrations show a distinct diurnal pattern at all stations, with peaks occurring in the morning (06:00) and in the evening (18:00). The evening peak is greater than the morning peak. This pattern holds for all the stations and is likely linked to domestic combustion or traffic sources. The seasonal cycle shows a strong peak during the winter months from April to October, which corresponds to the periods where there is increased atmospheric stability over the interior of the country, increased biomass burning and domestic combustion for space heating.

A strong diurnal pattern in the PM_{10} concentrations was observed occurring in the early morning and in the evening. This is strongest at the Thabazimbi and Mokopane stations where the evening peak PM_{10} concentration is considerably greater than the morning peak. To further allude to the domestic combustion component of the PM_{10} source a day of week pattern was also observed at all the stations, with higher average PM_{10} concentrations being observed between Monday and Friday, followed by decreases on Saturday and Sunday, especially in the morning peak over the weekend. This could indicate that the behaviour patterns of the people in these areas change over the weekends and there is less vehicular traffic and the timing of activities may be more staggered than during the work week. For all the sites there is a strong contrast in the temporal profiles of PM_{10} and SO_2, indicating that these pollutants are generated at different sources.

The mean $PM_{2.5}$ concentration at the three Waterberg monitoring stations ranges from 12.3µg/m^3 for Lephalale to 20µg/m^3 and 20.3µg/m^3 for Thabazimbi and Mokopane respectively (**Table 12**). Thabazimbi and Mokopane showed the highest $PM_{2.5}$ values. For the 2.5-year monitoring period considered here the average $PM_{2.5}$ concentration at all the sites is below the national standard for the period of the measurement (25µg/m^3), however for Mokopane and Thabazimbi it exceeds the stricter standard (20µg/m^3) that came into effect at the beginning of 2016.

The periods of highest $PM_{2.5}$ concentration is associated with periods of high wind speed (> 6m/s). At the Mokopane station there is a hotspot of high $PM_{2.5}$ concentration associated with moderate wind speeds (4-6m/s) from the southwest and north-west. This wind direction corresponds to the location of the low-income residential areas and associated agricultural areas of Sekgakgapeng and Masodi, respectively.

The trend analysis for $PM_{2.5}$ shows no significant trends in the $PM_{2.5}$ concentrations at any of the sites. This contrasts with the PM_{10} concentrations which show a mean decrease at all sites and which is statistically significant at the Lephalale site. This could indicate that the sources of PM_{10} and $PM_{2.5}$ at Waterberg sites are different and therefore different management interventions are needed to address them.

Table 12: WBPA $PM_{2.5}$ Measurement Summary (in $\mu g/m^3$).

Parameter	Lephalale	Mokopane	Thabazimbi
Number of measurements	20743	19633	14687
% Recovery	92.70%	85.0%	65.6%
Mean	12.34	20.29	19.98
Median	9.49	12.88	10.74
10 percentile	2.50	3.90	1.92
25 percentile	4.93	7.29	5.35
75 percentile	16.54	22.86	20.85
90 percentile	25.79	43.95	43.56

In terms of time variation, there is a clear seasonal pattern, with the highest $PM_{2.5}$ concentrations recorded during the winter period. A strong diurnal pattern exists with morning and evening peaks and there is a weekly cycle where an increase in the $PM_{2.5}$ concentrations is observed between Monday and Friday followed by a large decrease over the weekend, with an especially large reduction in the morning peak over the weekends.

Figure 29 shows the 24-hour average PM_{10} concentrations (blue line) for the Mokopane monitoring station.

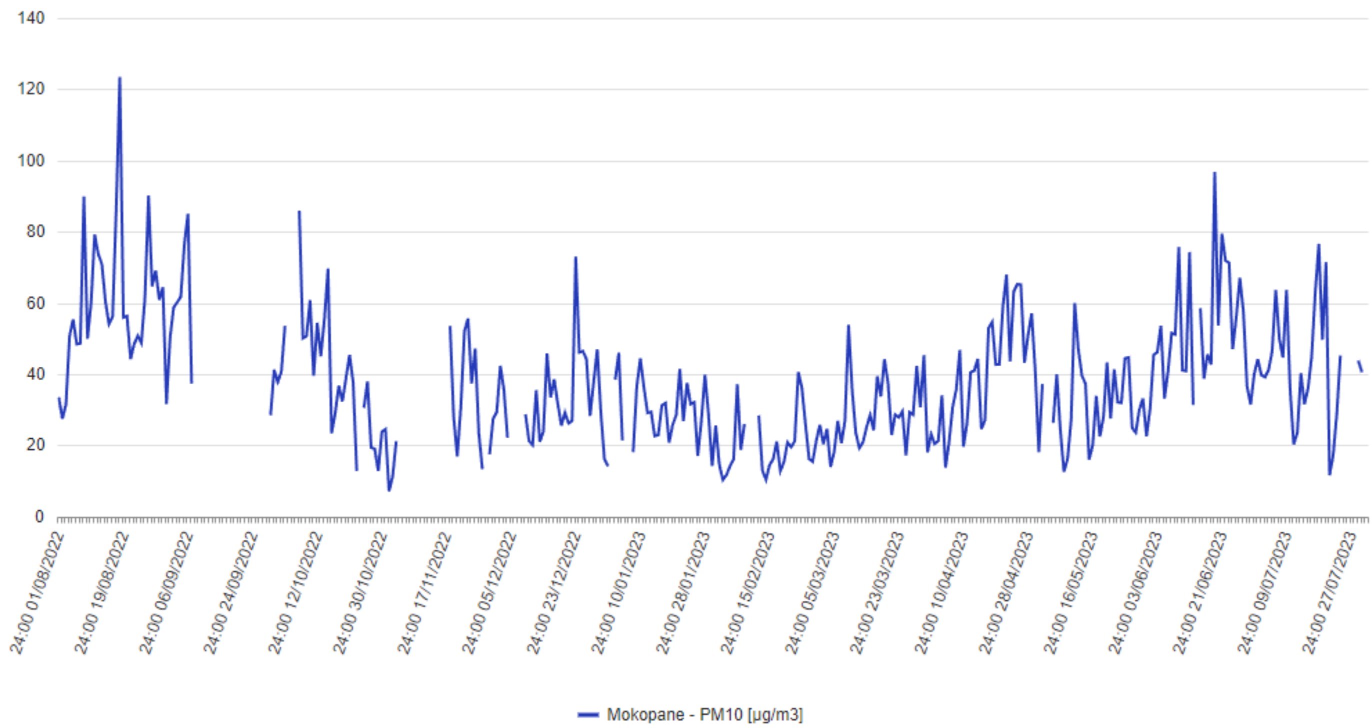

Figure 29: Mokopane Daily Average PM_{10} Concentration (SAAQIS, 2023)

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.

$PM_{2.5}$ describes all particulate matter in the atmosphere with a diameter equal to 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.

Figure 30 shows the 24-hour average $PM_{2.5}$ concentrations (blue line) for the Mokopane monitoring station.

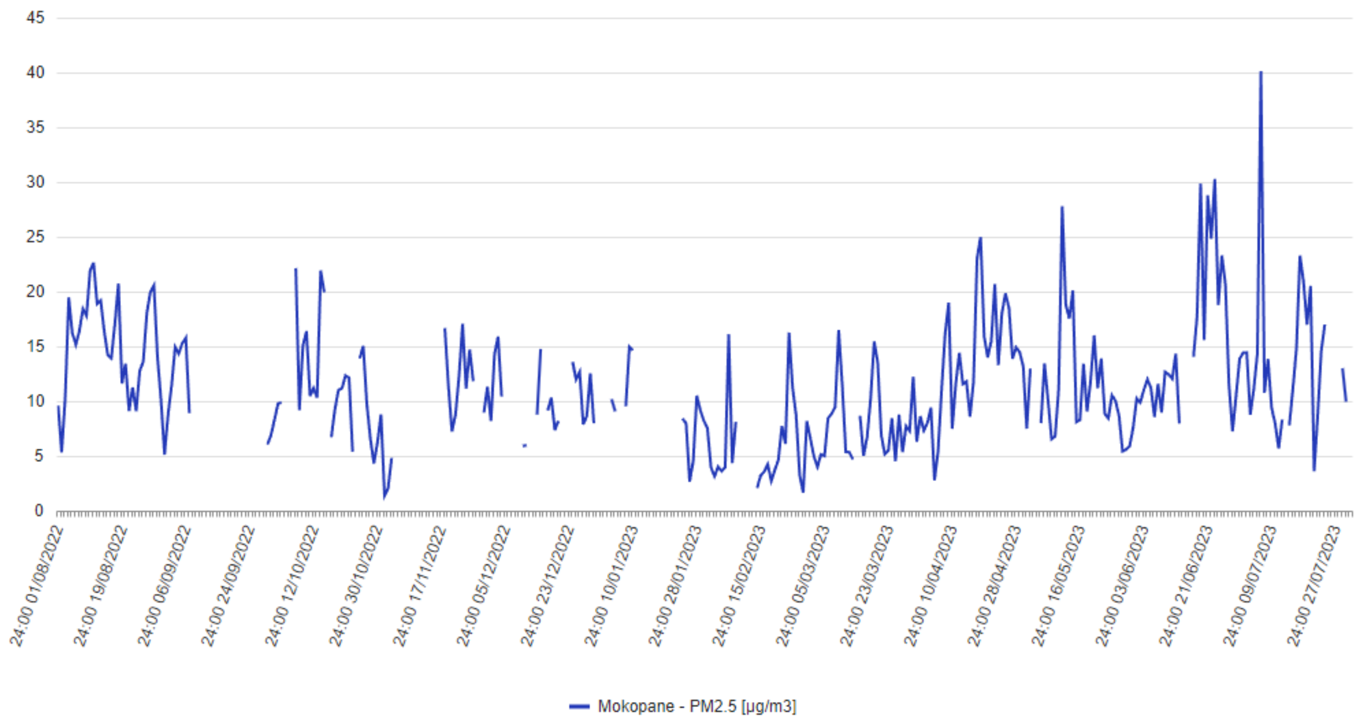

Figure 30: Mokopane Daily Average $PM_{2.5}$ Concentration (SAAQIS, 2023)

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.

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. $PM_{2.5, \text{which}}$ 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 for 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

The concentration of SO_2 at the monitoring stations is presented in **Table 13**. The ambient SO_2 concentrations over the period are low with mean values in the range of 1 to 1.5ppb. The 90 percentiles at all the stations do not exceed 5ppb. In comparison the annual National standard is 19ppb. A strong peak in the SO_2 concentrations during the day was noted at the Thabazimbi station; this is typical of sites influenced by pollution from industrial stack emissions, which is brought to the surface during periods of high convection.

Table 13: WBPA SO_2 Measurement Summary (in µg/m3).

Parameter	Lephalale	Mokopane	Thabazimbi
Number of measurements	21280	20053	21250
% Recovery	95.1%	86.8%	95.0%
Mean	2.19	1.68	2.14
Median	0.82	0.97	1.11
10 percentile	0.278	0.45	0.38
25 percentile	0.48	0.64	0.63
75 percentile	1.7	1.82	2.25
90 percentile	3.30	3.56	4.52

Figure 31 shows the 24-hour average SO_2 concentrations (blue line) for the Mokopane monitoring station.

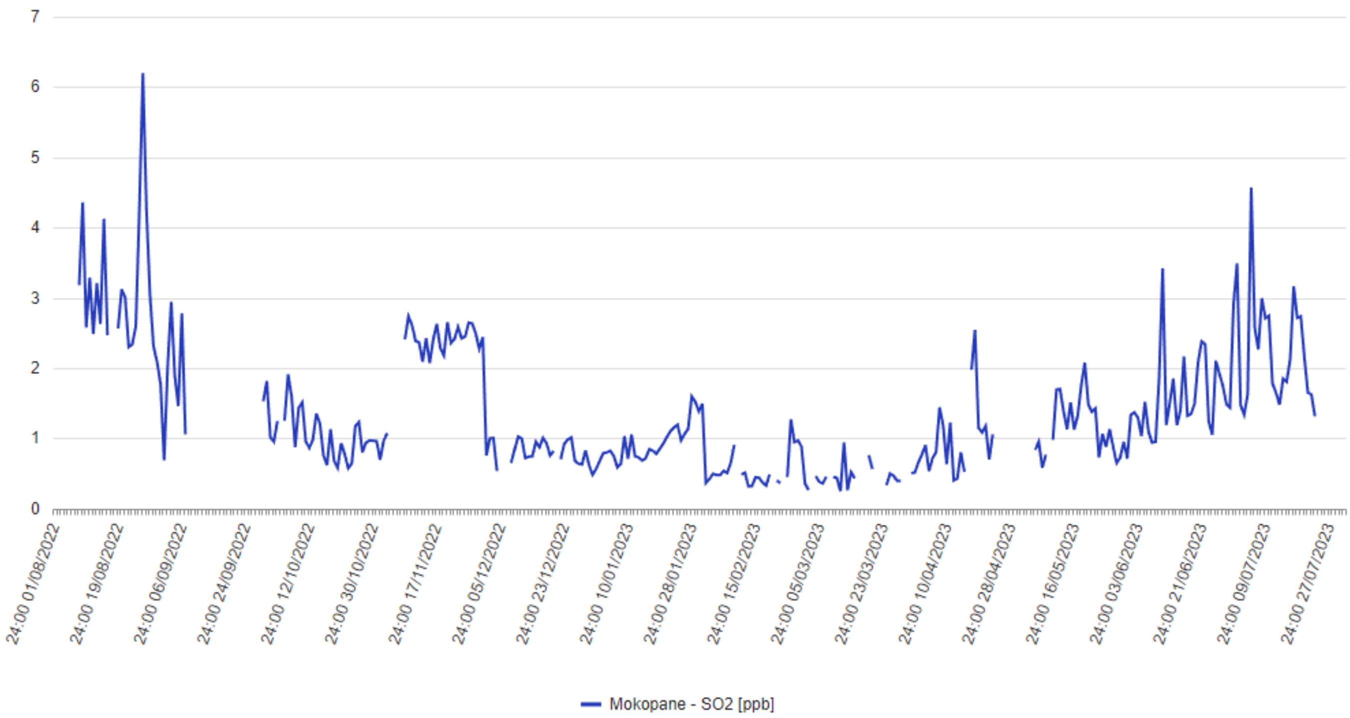

Figure 31: Mokopane Daily Average SO_2 Concentration (SAAQIS, 2023)

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. 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

Ambient concentrations of NO_2 in air are highly variable. Natural background concentrations can range from less than 0.4 $\mu g/m^3$ to more than 9 $\mu g/m^3$. In cities, ambient annual mean concentrations can range from 20 to 90 $\mu g/m^3$ with hourly maximum concentrations from 75 to 1 000$\mu g/m^3$.

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.

Figure 32 shows the 24-hour average NO_x concentrations (blue line) for the Mokopane monitoring station.

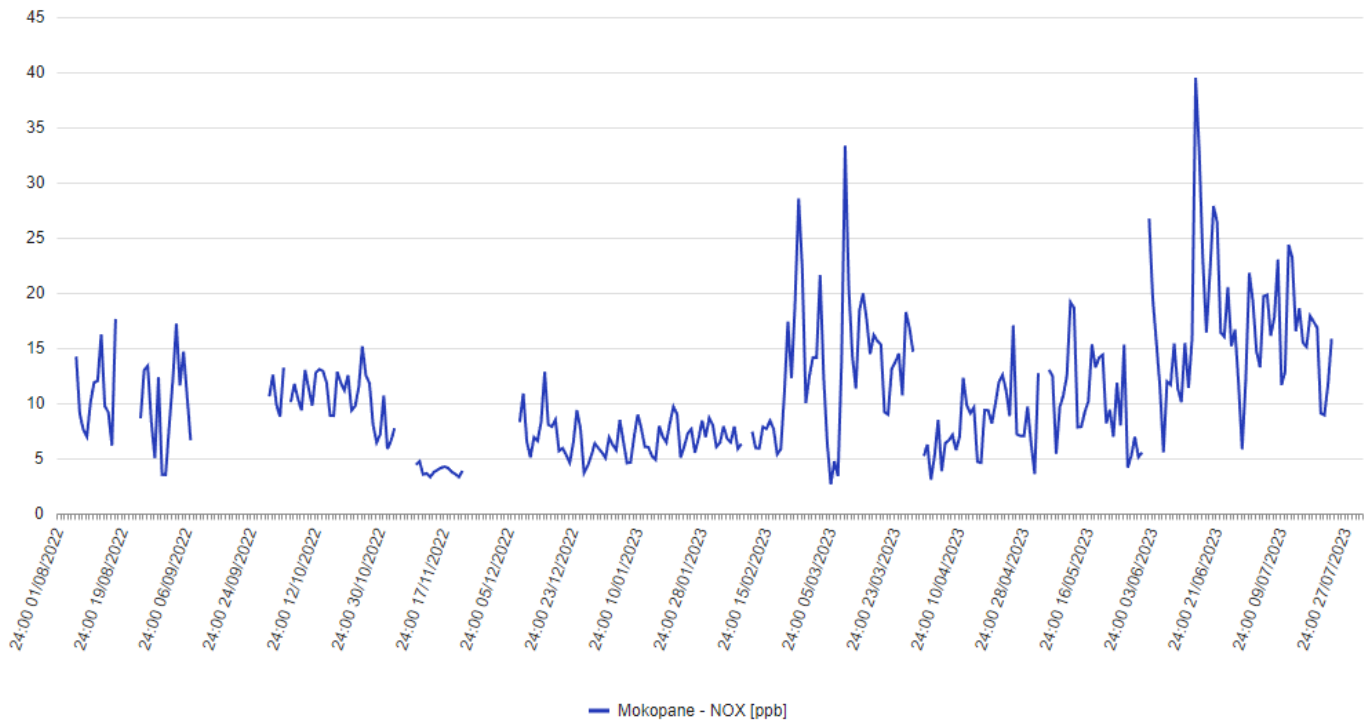

Figure 32: Mokopane Daily Average NO_x Concentration (SAAQIS, 2023)

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 of 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.

Figure 33 shows the 24-hour average CO concentrations (blue line) for the Mokopane monitoring station.

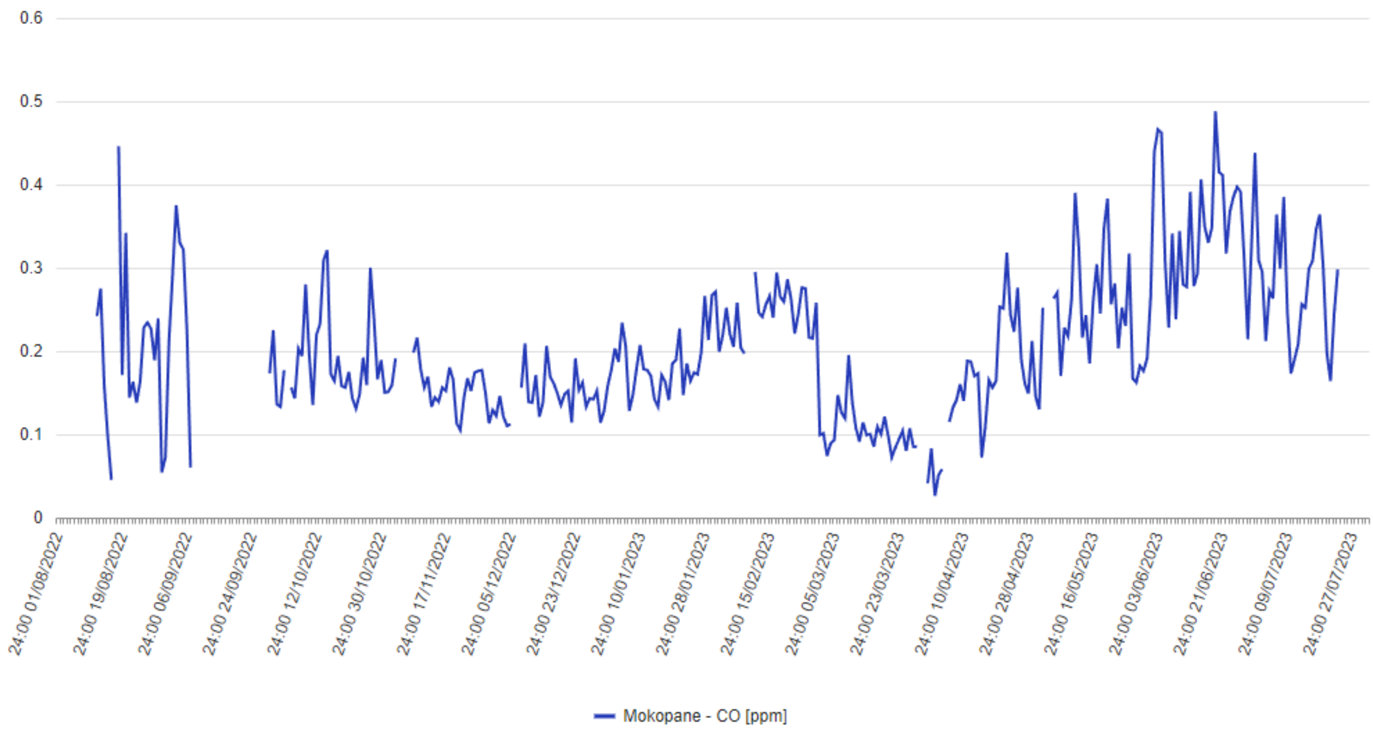

Figure 33: Mokopane Daily Average CO Concentration (SAAQIS, 2023)

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.

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

The mean ozone concentrations recorded over the period ranges between 24.2 parts per billion (ppb) (Lephalale) to 28.2 ppb (Mokopane and Thabazimbi) (**Table 14**). The periods of high ozone concentration are typically associated with periods of relatively strong winds, specifically from the north westerly sectors for Lephalale and Mokopane. For all the sites during periods of very low wind (as is typical of nighttime conditions) the ozone concentrations are very low. The periods of high ozone concentration at the Thabazimbi site are associated with winds from the northeast and easterly directions.

Table 14: WBPA O_3 Measurement Summary (in ppb).

	Lephalale	Mokopane	Thabazimbi
Number of measurements	21061	20708	20255
% Recovery	94.12%	89.6%	90.5%
Mean	24.27	28.20	28.21
Median	23.52	27.23	27.88
10 percentile	4.81	11.88	7.44
25 percentile	12.65	18.62	16.18
75 percentile	34.07	36.65	38.52
90 percentile	43.57	45.41	48.78

The trend analysis indicates that over the monitoring time there is a statistically significant increase in the monthly ozone concentration ($P < 0.05$) at the Mokopane and Thabazimbi stations. This increase is 0.94ppb/year and 1.48ppb/year for the Mokopane and Thabazimbi station, respectively. There is a strong seasonal trend in the ozone concentrations observed at all the stations, with peaks in the ozone concentrations being observed in the September/October periods.

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.

Figure 34 shows the 24-hour average O_3 concentrations (blue line) for the Mokopane monitoring station.

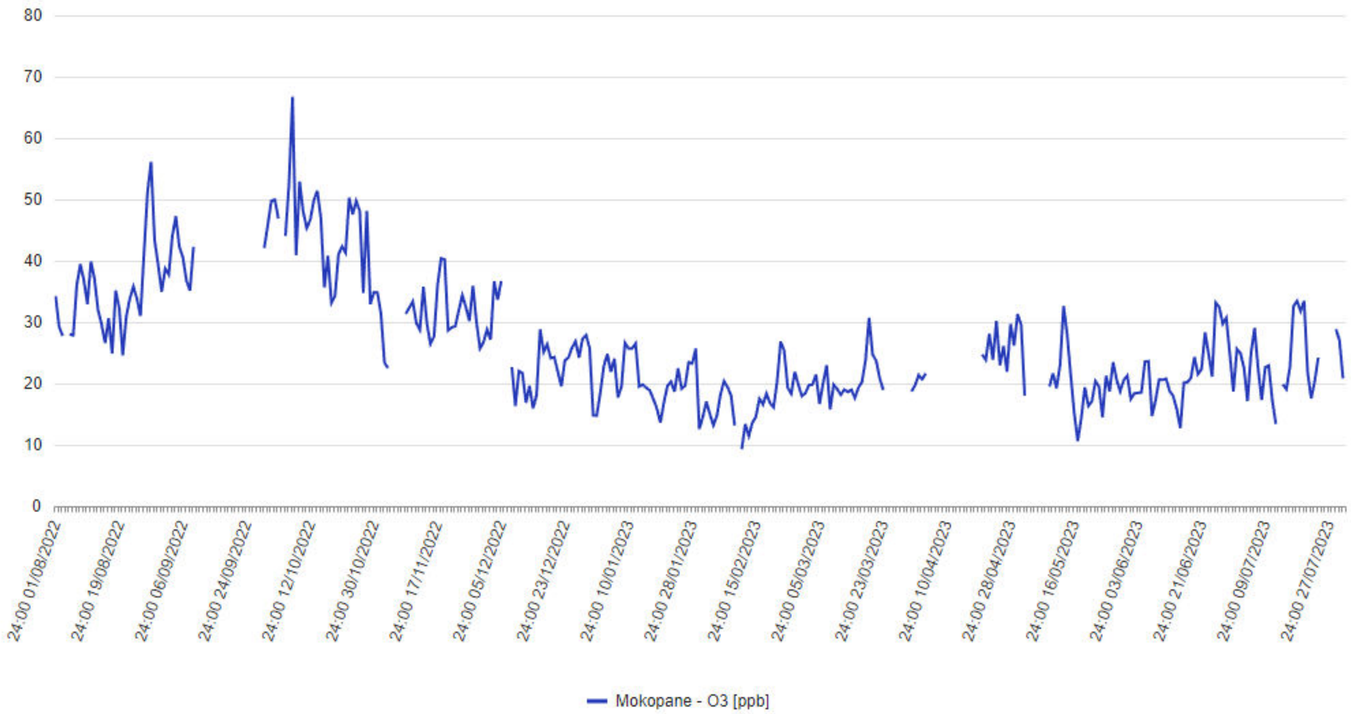

Figure 34: Mokopane Daily Average O_3 Concentration (SAAQIS, 2023)

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 provided in **Table 15**.

Table 15: Stability Class Variation Constants

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.

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

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 Mokopane WTW was modelled using the following inputs:

- Source Pathway –Source emission rates and variables contained in **Table 3** and **Table 4**.
- Receptor Pathway – Complex terrain option. All receptors up to 1km loaded as discrete receptors. A nested Cartesian grid with a resolution of 20m by 20m for the first 200m and thereafter 100m by 100m.
- Terrain Grid Pathway – SRTM1/SRTM3 digital elevation model data (~30m).
- Meteorology Pathway – Site specific Unified Model data for the period 1 July 2022 to 30 June 2023 supplied by Meteoblue.

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 Mokopane WTW are presented for the following scenarios:

- Construction/rehabilitation phase of the water treatment works.
- Operational phase of the water treatment works.

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

4.2.1 Construction/Rehabilitation Phase

Dispersion model output plots for dust deposition during the construction/rehabilitation phase of the project are reflected in **Figure 36** and **Figure 35**. The results for the Mokopane WTW were evaluated in terms of current South African National Standards and are presented for the project independently (i.e. incremental).

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/rehabilitation vehicle inventory could not be established at this stage.

Predicted incremental dust deposition rates during construction/rehabilitation is expected to remain at current levels at all the closest receivers identified as shown in **Figure 36** and **Figure 35**. Maximum onsite deposition rates are expected to range between 539 and 906mg/m^2/day.

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 sensitive receivers.

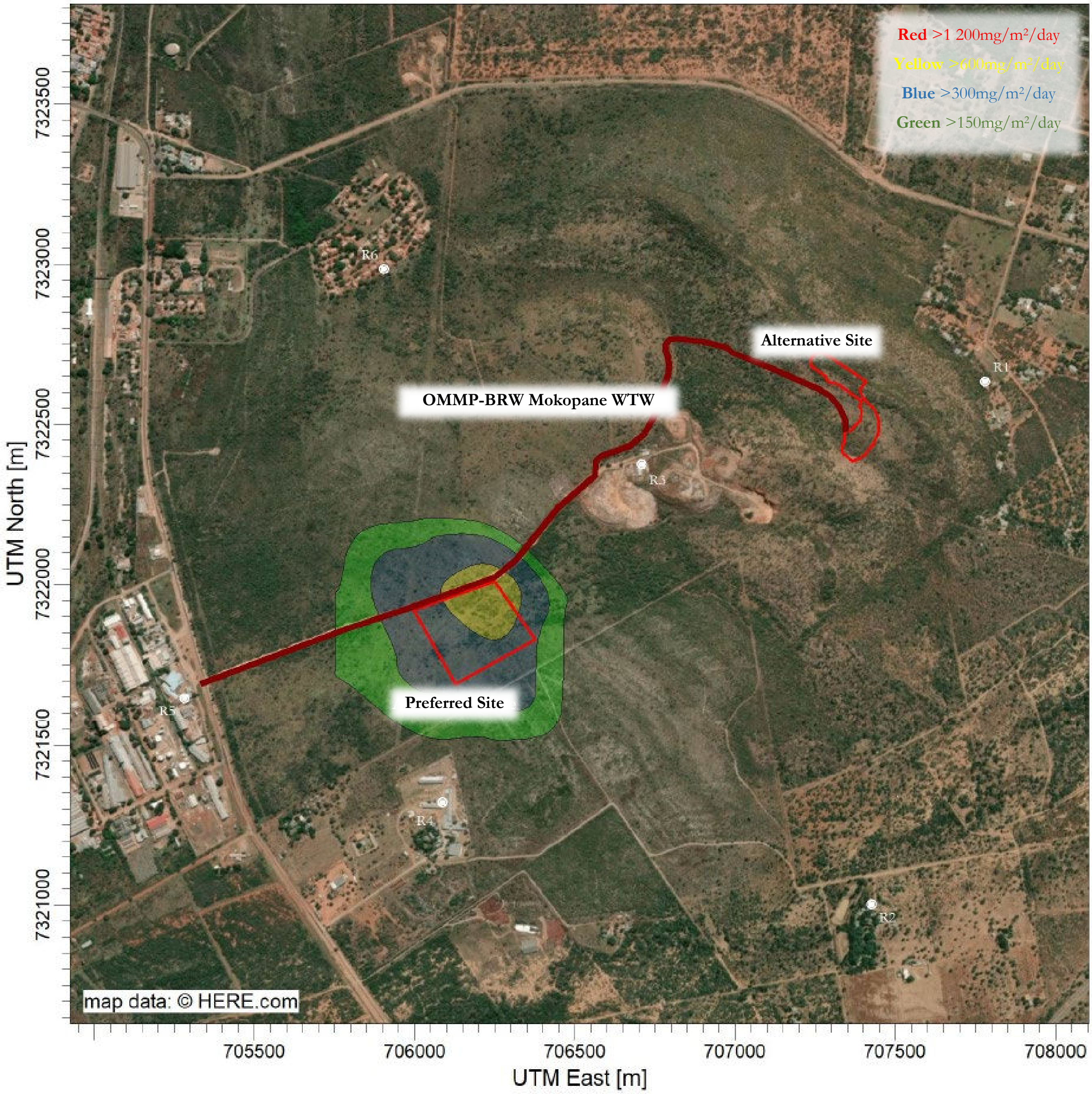

Figure 35: Daily Average Dust Deposition Rate – Construction/Rehabilitation at Preferred Site (Non-residential Standard – 1 200mg/m^2/day, Residential Standard – 600mg/m^2/day)

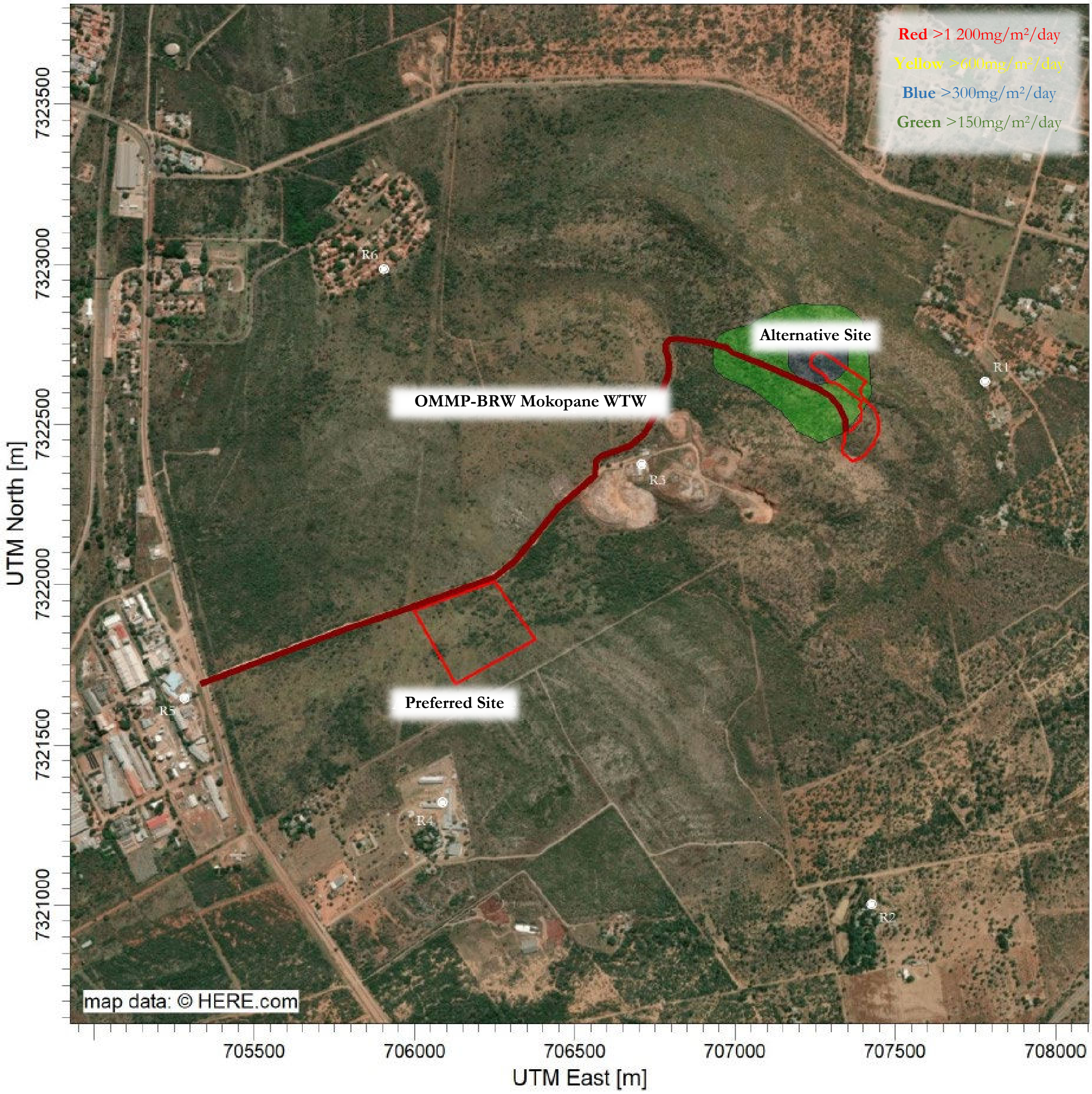

Figure 36: Daily Average Dust Deposition Rate – Construction/Rehabilitation at Alternative Site (Non-residential Standard – 1 200mg/m²/day, Residential Standard – 600mg/m²/day)

4.2.2 Operational Phase

Dispersion model output plots for chlorine concentrations during normal operations are reflected in **Figure 38** and **Figure 37**.

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

Predicted incremental annual average chlorine concentrations will probably be above 10% of the adopted guideline at the nearest receivers south of the preferred site and south west of the alternative site.

The disinfection process, utilising chlorine gas, will most likely be the largest source of ambient pollution (67.1%), followed by vehicle transport emissions and material handling (30.9%).

Incremental daily and annual average total suspended particulates and $PM_{10/2.5}$ concentrations during normal operations will probably remain below 10% of the relevant standards at the closest sensitive receivers.

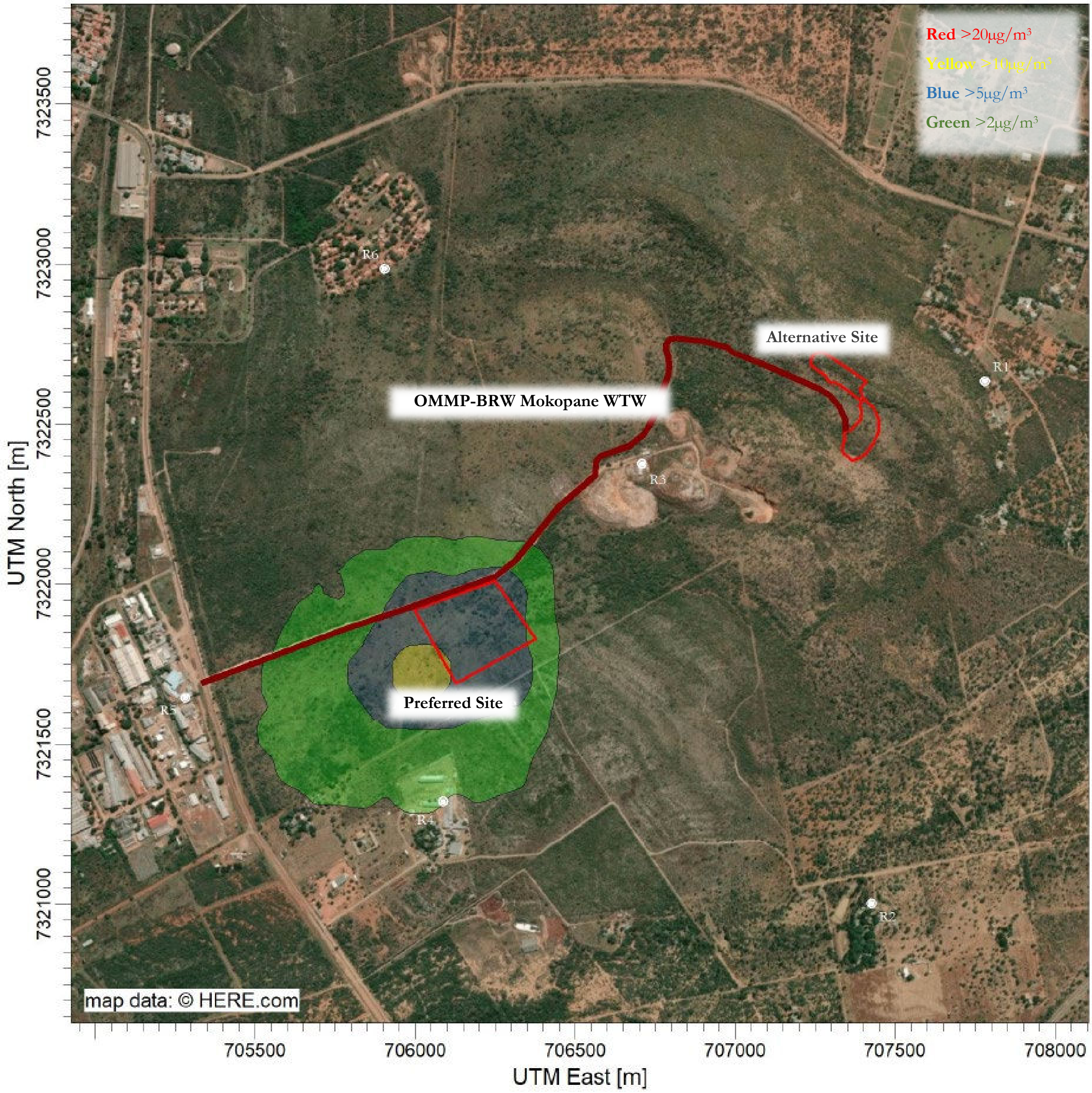

Figure 37: Annual Average Chlorine Concentration – Operations at Preferred Site (US EPA RfC – 20 µg/m³)

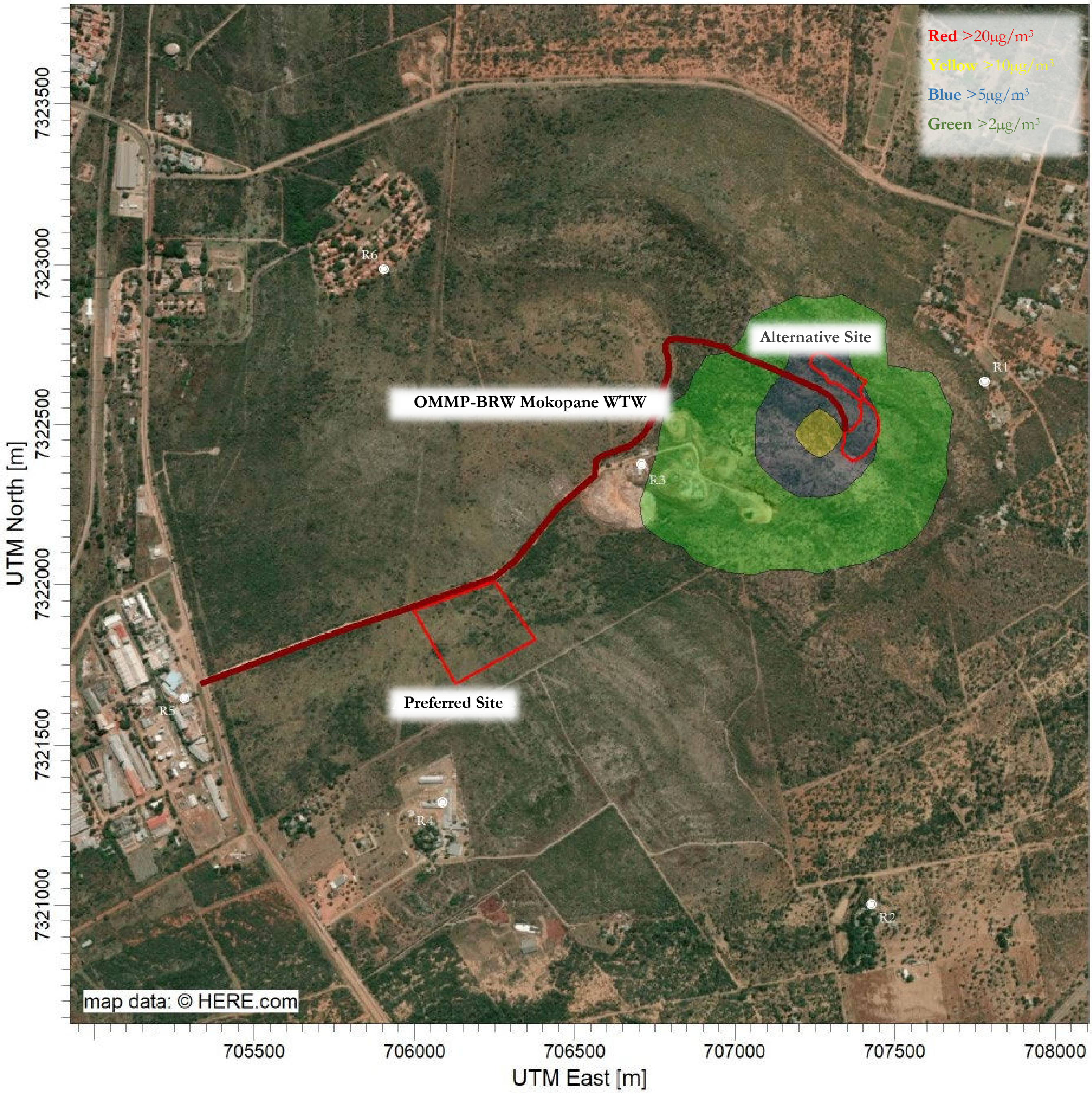

Figure 38: Annual Average Chlorine Concentration – Operations at Alternative Site (US EPA RfC – 20 µg/m³)

4.4 SIGNIFICANCE ANALYIS

4.4.1 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 and World Bank/IFC requirements. For each predicted impact, criteria are applied to establish the significance of the impact based on likelihood and consequence firstly in the case of no mitigation and then with the most effective mitigation measure(s) in place.

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 16** to **Table 18**). The consequence is then established using the formula:

Consequence = intensity + duration + extent

Table 16: 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 17: 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 18: 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 19**.

Table 19: 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 20** and applied with the consequence according to the following equation:

Significance = consequence x probability

Table 20: 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 22**) 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 21: 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, in order 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 is able to comment on the confidence its findings based on the availability of data and the certainty of their findings (see **Table 22**).

Table 22: 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.

4.4.2 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 23: Mokopane WTW Construction/Rehabilitation Significance Analysis

Item/Receptor	Impact of total suspended particulate, fine particulates and gaseous emissions during construction/ rehabilitation at both sites	Consequence Intensity + Duration + Extent				Significance Consequence x Probability			Motivation
		Intensity	Duration	Extent	Rating	Consequence	Probability	Rating	
R1, R2, R3, R4, R5 & R6	Incremental	-1	-2	-3	Slight	-6	4	-24	Negligible damage to natural or social systems or resources. Impact could continue for up to 2 years. The impact could extend across the site 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	-2	-2	-3	Slight	-7	4	-28	

Table 24: Mokopane WTW Operations Particulate Emissions Significance Analysis

Item/Receptor	Impact of total suspended - and fine particulate emissions during operations	Consequence Intensity + Duration + Extent				Significance Consequence x Probability			Motivation
		Intensity	Duration	Extent	Rating	Consequence	Probability	Rating	
R1, R2, R3, R4, R5 & R6	Incremental	-1	-4	-2	Slight	-7	4	-28	Negligible damage to natural or social systems or resources. Impact could continue for 6 to 15 years. The impact will be limited to the site. Mitigation through administrative control and best industry practise (see Section 5.2). Residual impact at background levels. High assessment confidence.
	Cumulative	-2	-4	-2	Slight	-8	4	-32	

Table 25: Mokopane WTW Operations Gaseous Emissions Significance Analysis

Item/Receptor	Impact of gaseous emissions during operations	Consequence Intensity + Duration + Extent				Significance Consequence x Probability			Motivation
		Intensity	Duration	Extent	Rating	Consequence	Probability	Rating	
R1, R2, R5 & R6	Incremental	-0	-4	-3	Slight	-7	4	-28	Negligible to minor damage to natural or social systems or resources. Impact could continue for 6 to 15 years. The impact could extend across the site boundary to nearby properties. Mitigation through administrative control, best industry practise and supplemented with engineering control measures (see Section 5.2). Residual impact at background levels. High assessment confidence.
	Cumulative	-1	-4	-3	Slight	-8	4	-32	
R3 & R4	Incremental	-1	-4	-3	Slight	-8	4	-32	
	Cumulative	-2	-4	-3	Slight	-9	4	-36	

In support of an emission reduction strategy, Mokopane WTW 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 the following observations can be made:

- A total emission rate of 0.29 gram per second was calculated for operations.
- The disinfection process, utilising chlorine gas, will most likely be the largest source of ambient pollution (67.1%) followed by vehicle transport emissions (30.9%).
- Particulate matter comprises approximately 32.9% of the pollution load. PM_{10} is the criteria pollutant of concern and contributes about 4.98% of the pollution load. Total suspended particulates and $PM_{2.5}$ contribute 26.72% and 1.2% respectively.
- All emissions were regarded as fugitive.

From the impact significance analysis, the following observations can be made:

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

5. EPILOGUE

5.1 AIR QUALITY MANAGEMENT APPROACH

Mokopane WTW' 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. Mokopane WTW 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 39**).

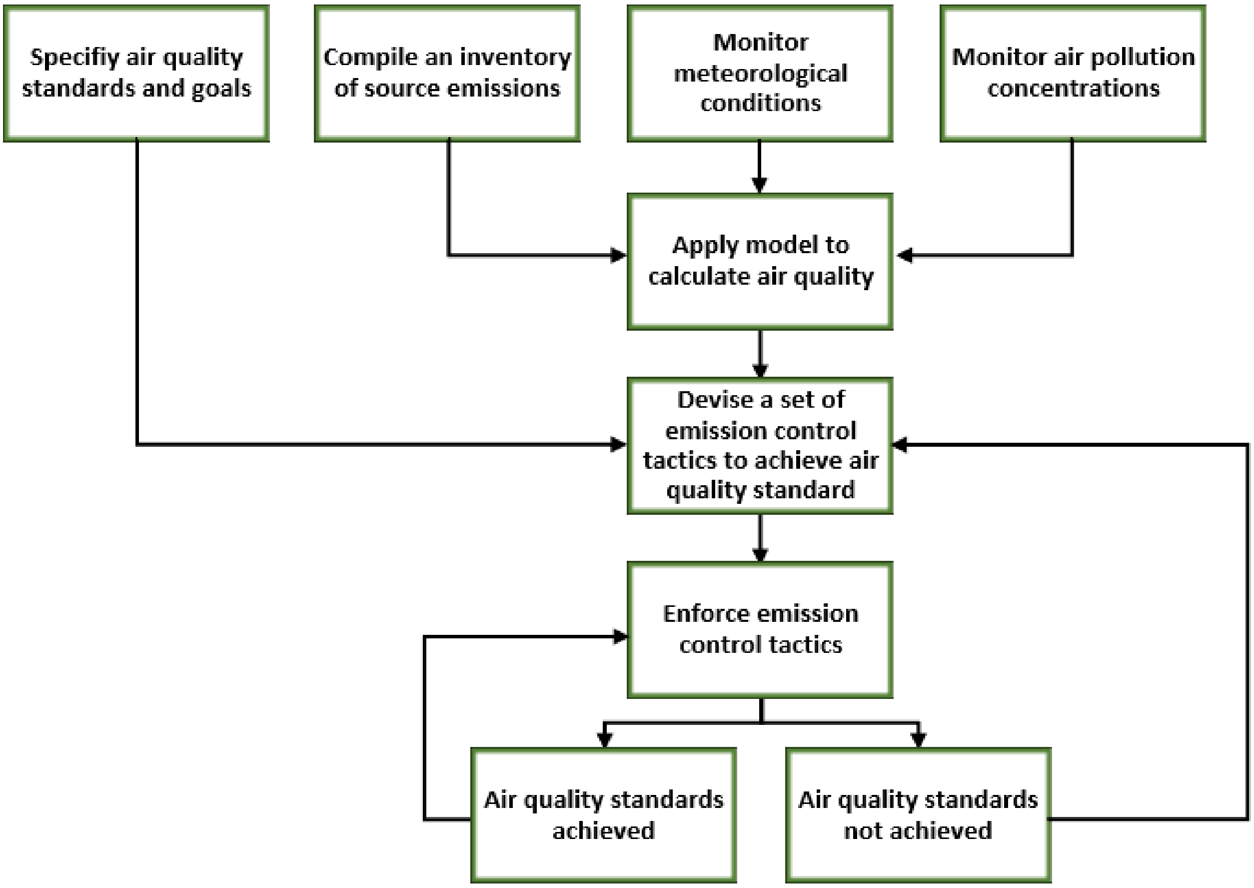

Figure 39: Air Quality Management Strategy

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 Mokopane WTW 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 could 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

According to SANS 1929:2011 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 Mokopane WTW, the following is recommended:

- An emissions inventory and modelling regime should be undertaken at least bi-annually throughout the life of the project, or if the capacity of the facility is increased dramatically.

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 hope to 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.

5.2.2 Emissions Monitoring

In the initial stages of treatment hydrogen sulphide might be stripped from raw water by aeration. The concentrations of hydrogen sulphide can best be determined by sampling and analysing raw and post-aeration water. The emission to air is calculated from analyses of the water by means of a mass balance method.

The quantity released can be calculated as:

$$Q = (C_{in} – C_{out}) \times V$$

Where

Q	=	quantity is hydrogen sulphide emitted (t/yr)
C_{in}	=	concentration of hydrogen sulphide in raw water pre-aeration (mg/L)
C_{out}	=	concentration of hydrogen sulphide in the water post-aeration (mg/L)
V	=	volume of water that is aerated (GL/yr)

5.2.3 Best Available Industry Techniques

Gaseous Emissions from Operations

Chlorine will be drawn from the chlorine drums as a gas via a vacuum created by a venturi system. The vacuum-based system will reduce the chance of chlorine gas leaks.

The chlorine containers should be stored in a dry area away from sources of heat and protected from direct sunlight and precipitation. Daily inspections for leaks should be performed. Leaking or damaged containers should be moved to an isolated location and removed as quickly as possible.

Fugitive Emissions from Paved Surfaces

The following measures are aimed at reducing fugitive dust emissions from paved surfaces:

- Construction integrity of all paved areas should be regularly inspected and frequently repaired if required.
- Control load size and set an acceptable speed limit for all onsite vehicles.
- Minimise travelling distance and unnecessary traffic through good site layout and process design.
- Measures which entail periodic removal of deposited material, i.e. broom and vacuum sweeping, may also be adopted to reduce dust generation.

5.3 KEY FINDINGS

The air quality impact study concludes the following:

- The process falls within the Mokgalakwena Local Municipality (MLM), in the Waterberg District Municipality (WDM) of the Limpopo Province.
- Ambient monitoring data from the WBPA Mokopane station was included in the study.
- A total emission rate of 0.29 gram per second was calculated for operations.
- The disinfection process, utilising chlorine gas, will most likely be the largest source of ambient pollution (67.1%).
- Particulate matter comprises approximately 32.9% of the pollution load. PM_{10} is the criteria pollutant of concern and contributes about 4.98% of the pollution load. Total suspended particulates and $PM_{2.5}$ contribute 26.72% and 1.2% respectively.
- Dispersion of 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 annual averages.

- Ground level concentrations were predicted for atmospheric conditions based on local meteorological data for the period 1 July 2022 to 30 June 2023.
- For the reporting period winds were mostly from the north easterly sector 60.47%. Calm periods were the exception (1.2%) and wind speeds were most often brisk above 3.6m/s (42.4%). Moderate winds between 2.1 and 3.6m/s occurred 37.6% and light winds, between 0.5 and 2.1m/s 18.6%.
- Predicted incremental dust deposition rates during construction/rehabilitation are expected to remain at current levels and at all the closest receivers. Incremental daily and annual average $PM_{10/2.5}$ concentrations will probably remain below 10% of the relevant standards.
- Predicted incremental dust deposition rates during operations are expected to remain at background levels at all sensitive receivers beyond the project boundary.
- Predicted incremental annual average chlorine concentrations will probably exceed 10% of the adopted guideline at the nearest receivers south of the preferred site and south west of the alternative site.
- Incremental daily and annual average total suspended particulates and $PM_{10/2.5}$ concentrations during normal operations will probably remain below 10% of the relevant standards at the closest sensitive receivers.
- The incremental impact of all pollutants during construction/rehabilitation is expected to be 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 particulate pollutants during normal operations is expected to be 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 gaseous pollutants during normal operations is expected to be negligible to minor. Current industry standard techniques should be maintained and supplemented with administrative control measures and engineering control to maintain the residual impact at the nearest sensitive receivers at current background levels.

- Both the preferred and alternative sites will have a similar impact on the surrounding community.
- Emission inventory and dispersion modelling should be used in combination to assess the effectiveness of control measures at source and receivers, on an annual basis.
- Monitoring of ambient air quality will assist effective air quality management and open communication to all stakeholders.

5.4 ABBREVIATIONS

AEL	:	Atmospheric emission license
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
DEA	:	Department of Environmental Affairs
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 mean 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 license means an atmospheric emission license 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 are 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 mean 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 smoke stacks 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 mean 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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